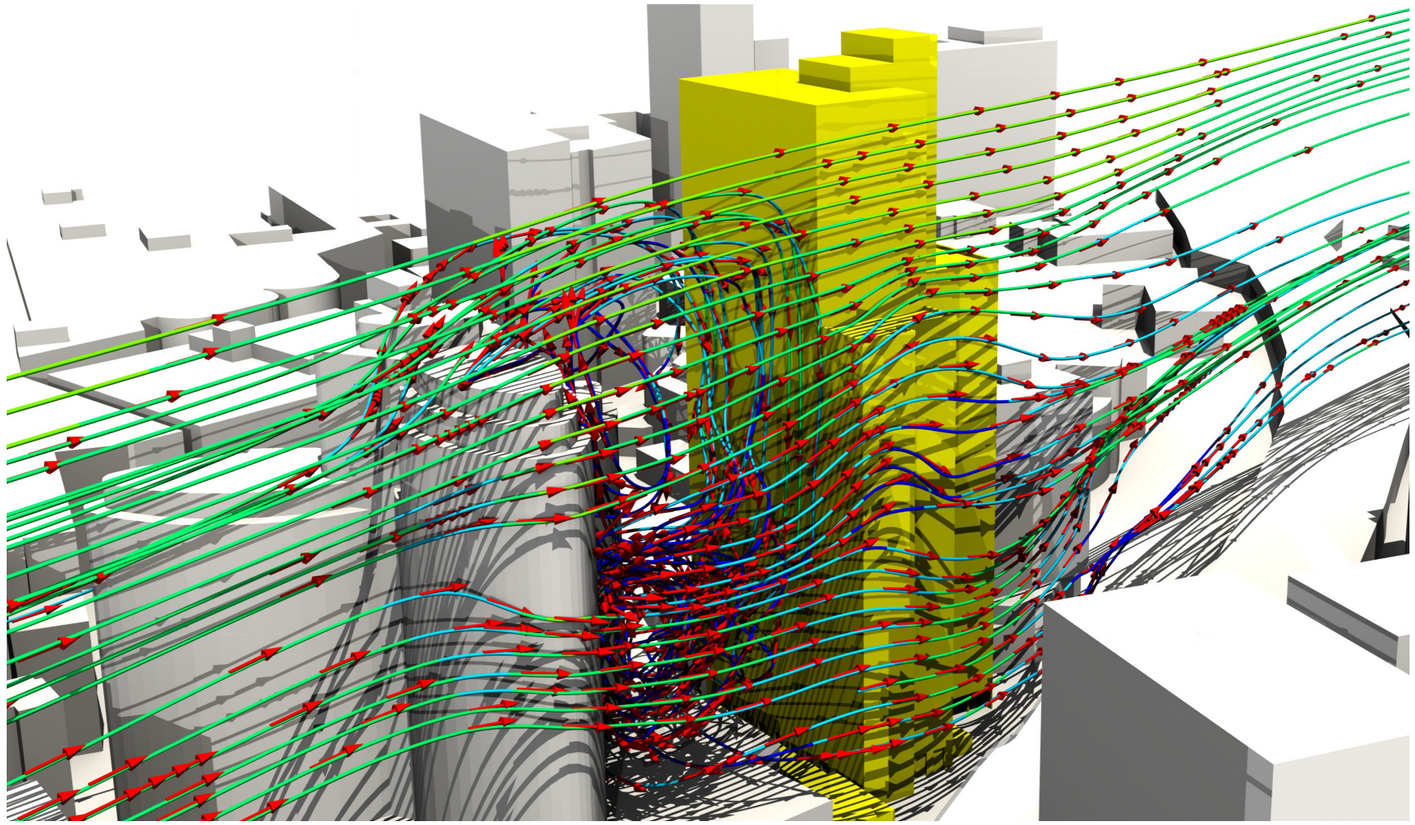
WINDTECH

WIND MICROCLIMATE CFD STUDY

HARLECH COURT, CARDIFF



WI442-02F02(REV0) - WE CFD REPORT
JUNE 12, 2024

Prepared for:
Expedite Project Services
8 Village Way, Green Meadows
Springs Business Park, Cardiff, CF15

Date	Revison History	Non-Issued Revision	Issued Revison	Prepared By	Instructed By	Reviewed & Authorised By
12/06/2024	Initial	-	0	SR	NO	NO

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Executive Summary

The key findings from the study are as follows:

- For the ground level, the wind conditions are safe within the site boundary for proposed development. However, there is one small isolated area in the extended surrounds where the wind conditions are unsafe. It is our understanding that this isolated area is not accessible to any members of the public.
- On the elevated levels of the proposed development, the wind conditions are safe in most areas. However, there are isolated areas on the roof terraces of the 20th floor and 21st floor where the wind conditions are unsafe.
- The wind conditions at many entrances of the proposed development are suitable for the intended use. However, there are also multiple entrances that are not suitable for the intended use.
- The wind conditions at the seating areas to the north of the development are not suitable for the intended use.
- The wind conditions along the thoroughfares and the roads within the vicinity of the proposed development are suitable for the intended use in most areas. However, there are isolated areas along the thoroughfares of south-western and north-eastern facade of the proposed development where the wind conditions are not suitable for the intended use.
- There are isolated areas on the roof terraces of the 20th floor and 21st floor where the wind conditions are not suitable for the intended use.
- The wind conditions remain approximately the same following the introduction of the Future Surrounds.

In the areas where the wind conditions are unsafe and/or unsuitable for the intended use, it is recommended that mitigation measures are implemented. It is also recommended that the effectiveness of the mitigation measures is demonstrated with further testing.

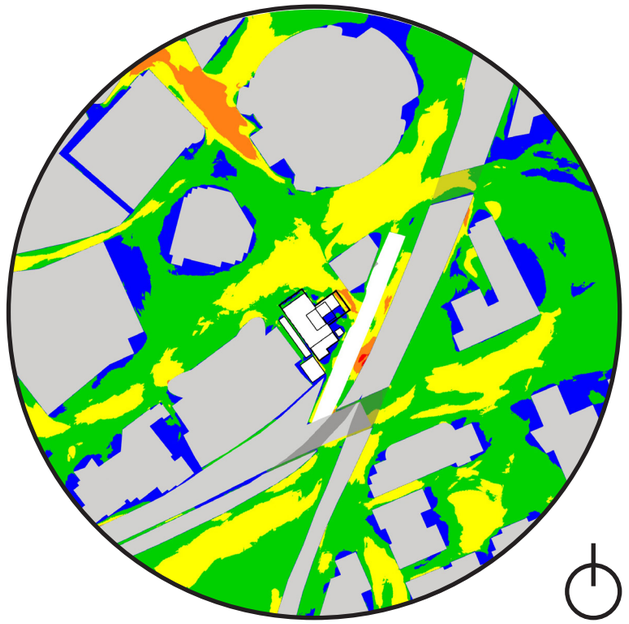


Figure 1. Lawson Comfort Contours, Proposed Site with Existing Surrounds, Winter Condition

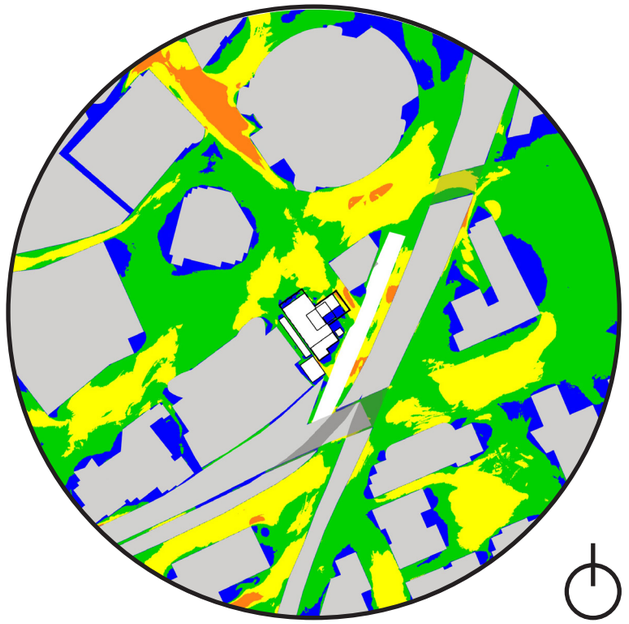


Figure 2. Lawson Comfort Contours, Proposed Site with Future Surrounds, Winter Condition

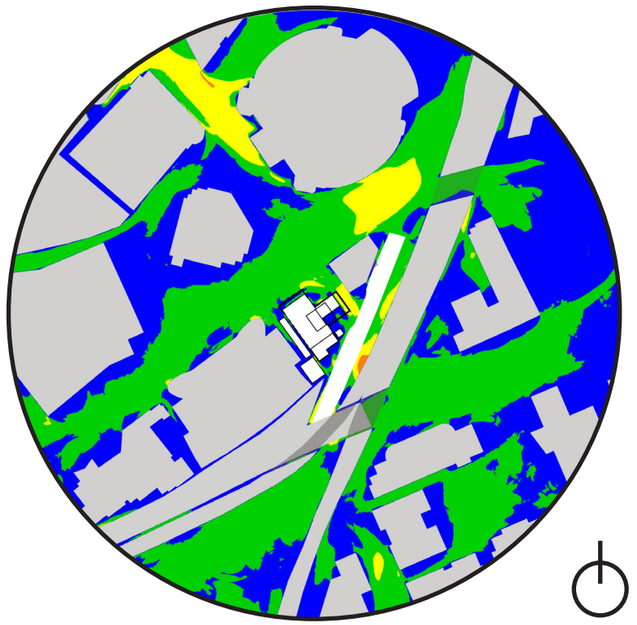


Figure 3. Lawson Comfort Contours, Proposed Site with Existing Surrounds, Summer Condition

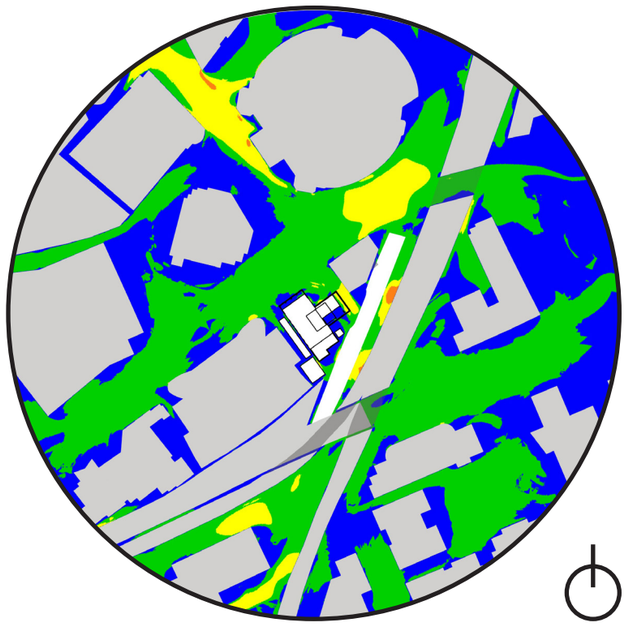


Figure 4. Lawson Comfort Contours, Proposed Site with Future Surrounds, Summer Condition

CONTENTS

1. Introduction

This study has been undertaken by WINDTECH Consultants to assess the wind microclimate around the proposed Harlech Court development in Cardiff. The model of the proposed development has been based upon the architectural drawings and the 3D model received on 23rd April 2024, 25th April 2024 and 9th May 2024.

Description of the Site

The Site for the proposed development is at the intersection of A4160 and Mary Ann Street. The surrounding areas predominantly consist of low-to-mid-rise buildings in the extended surrounds and mid-to-high-rise builidngs close to the site. Figure 5 shows the Existing Site. Figure 6 shows the Proposed Site.

Scope of the CFD Study

The simulations of the wind microclimate were conducted to quantitatively assess the effect of the proposed development on the wind conditions in and around the Site.

The assessment was undertaken through Computational Wind Engineering (CWE), which uses Computational Fluid Dynamic (CFD) techniques to model a 'virtual wind tunnel' and simulate conditions around the site. This report contains the methodology and results from these simulations.

Wind speed contour plots representing the local wind speed-up ratios are derived from the simulations and combined with a statistical model of the regional wind climate (which accounts for the directional strength and frequency of occurrence of the prevailing regional winds). These wind speed-up ratios are then used in conjuction with the Lawson Criteria (2001) for pedestrian wind comfort and safety.

The assessment was carried out in the following configurations:

1) The Existing Site with Existing Surrounds.
2) The Proposed Site with Existing Surrounds.
3) The Proposed Site with Future Surrounds.

The cumulative schemes included within the Future Surrounds are outlined in Appendix C. Renders of the recommended mitigations have been provided in Appendix D.

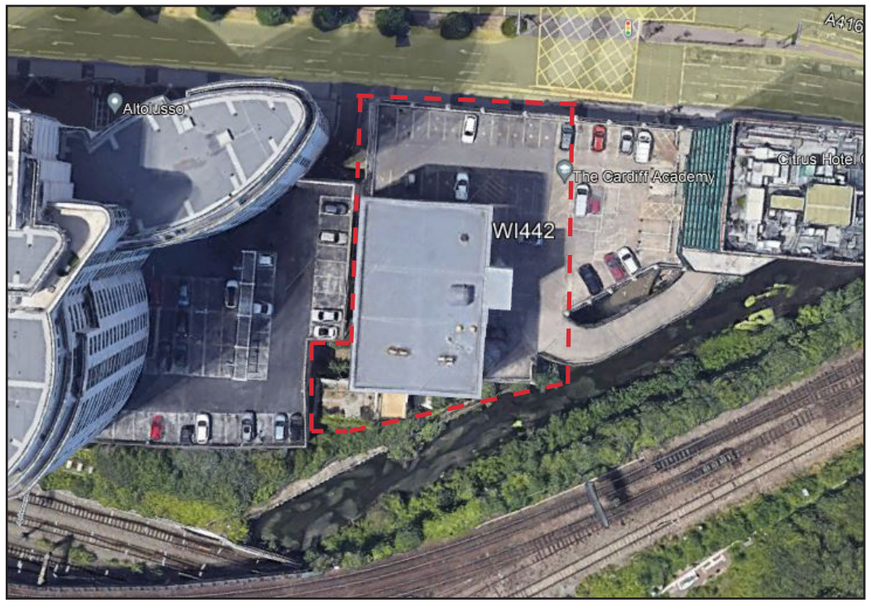


Figure 5. Existing Site

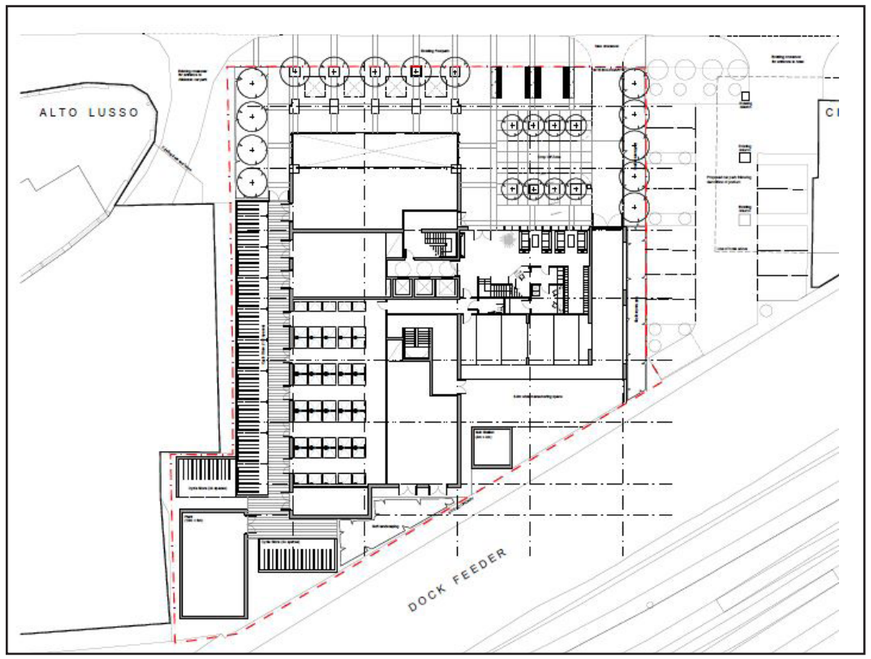


Figure 6. Proposed Site

2. Environmental Wind Speed Criteria

Wind Effects on People

The acceptability of wind in any area is dependent upon its use. For example, people walking or window-shopping will tolerate higher wind speeds than those seated at an outdoor restaurant. Various researchers, such as A.G. Davenport, T.V. Lawson, W.H. Melbourne, A.D. Penwarden, etc., have published criteria for pedestrian comfort in outdoor spaces for various types of activities.

A.D. Penwarden (1975) Criteria for Gust Wind Speeds

The following table developed by A.D. Penwarden (1975) is a modified version of the Beaufort Scale, and describes the effects of various wind intensities on people. Note that the effects column relates to wind conditions that occur frequently (approximately once per week on average). Higher ranges of wind speeds can be tolerated for rarer events.

Type of Winds	Wind	Wind Speed (m/s)	Effect
Calm, light air	1	0-1.5	Calm, no noticable wind
Light breeze	2	1.6-3.3	Wind felt on face
Gentle breeze	3	3.4-5.4	Hair is disturbed, Clothing flaps
Moderate breeze	4	5.5-7.9	Raises dust, dry soil and loose paper. Hair disarranged
Fresh breeze	5	8.0-10.7	Force of wind felt on body
Strong breeze	6	10.8-13.8	Umbrellas used with difficulty, hair blows straight, difficult to walk steadily. Wind noise on ears unpleasant
Near gale	7	13.9-17.1	Inconvenience felt when walking
Gale	8	17.2-20.7	Generally impeedes progress. Great difficulty with balance
Strong gale	9	20.8-24.4	People blown over by gusts

Table 1. Summary of Wind Effects on People (A.D. Penwarden, 1975)

T.V. Lawson Criteria for Mean Wind Speeds

In 1973, T.V. Lawson quotes that A.D. Penwarden's Beaufort 4 (as listed in Table 1) would be acceptable if it is not exceeded for more than 4% of the time; and Beaufort 6 would be unacceptable if it is exceeded more than 2% of the time. Later, in 1975, T.V. Lawson presented a set of criteria very similar to those of A.G. Davenport's. These are presented in Tables 2 and 3.

Classification	Activities	Annual Maximum Mean
Safety (all weather areas)	Accessible by the general public	15m/s
Safety (fair weather areas)	Private outdoor areas (balconies, terraces etc.)	20m/s

Table 2. Safety Criteria by T.V. Lawson (1975)

Classification	Activities	95th Percentile Maximum Mean (approx once per week)
Business Walking	Objective walking from A to B	8m/s < V < 10m/s
Pedestrian Walking	Slow walking etc.	6m/s < V 8m/s
Short Exposure Activities	Pedestrian standing or sitting for short times	4m/s < V < 6m/s
Long Exposure Activities	Pedestrian sitting for a long duration	V < 4m/s

Table 3. Comfort Criteria by T.V. Lawson (1975)

T.V. Lawson (1980) presented a further set of criteria that has been widely adopted in the UK. These criteria are based on Beaufort scale levels and have a variable probability of exceedance. These criteria are based on mean wind speeds and are outlined in Table 4 below.

Classification	Human Activities	Percentage of Exceedance and Beaufort Scale
Roads and Carparks	Difficult to walk steadily	2% > Beaufort 6
Business Walking	Unacceptable as main public access ways	2% > Beaufort 5
Pedestrian Walking	Acceptable for walking, main public access ways	4% > Beaufort 4
Sitting	Generally acceptable for walking & short duration stationary activities such as window-shopping, standing or sitting in plazas	6% > Beaufort 3

Table 4. Comfort Criteria by T.V. Lawson (1980)

Wind Speed Criteria Used for this Study

For this study, the measured wind conditions for the various critical outdoor trafficable areas within and around the proposed development are compared against the Lawson Criteria (2001).

These criteria were firstly developed by Tom Lawson, who was a Professor of Industrial Aerodynamics at Bristol University, and have been widely adopted by planning authorities in the UK. The 2001 Lawson Criteria comprise both comfort and safety criteria. The comfort criteria sets out distinct pedestrian activities, with less active pursuits requiring more benign wind conditions; while the safety criteria relate to the wind speed at which a person is likely to be blown over. The comfort and safety criteria have been provided in Tables 5 and 6.

Within the following report the safety and comfort conditions are presented using the colour-coded diagrams in Figure 7.

Classification	Activities	Mean and GEM wind speed (5% exceedance)
Sitting	Acceptable for outdoor sitting use, e.g. restaurant or cafe	< 4.0m/s
Standing	Acceptable for entrances, bus stops, covered walkways or passageways	< 6.0m/s
Strolling	Acceptable for external pavements or walkways for leisure use	< 8.0m/s
Business Walking	Acceptable for external pavements or walkways for locomotion only	< 10.0m/s
Uncomfortable	Not comfortable for regular pedestrian access	> 10.0m/s

Table 5. Lawson Comfort Criteria (2001)

Classification	Activities	Mean and GEM wind speed (0.023% exceedance)
Unsafe Frail	Presents a safety risk, especially to more vulnerable members of the public	15m/s
Unsafe All	Presents a safety risk to all members of the public	20m/s

Table 6. Lawson Safety Criteria (2001)

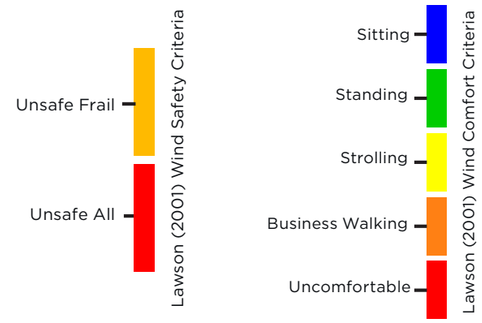


Figure 7. Lawson Contours

3. CFD Methodology

Numerical Setup

The numerical modelling was conducted using the HELYX 3.4.0 computational package. A detailed wind driven flow simulation was conducted in order to assess the wind speeds throughout the lobby space. The characteristics of the CFD simulation are detailed in Table 7 below.

Solver	Coupled
Formulation	Implicit
Time	Steady
Operating Conditions	Pressure
Viscous Model	KOmegaSST Standard Wall Functions
Pressure-Velocity Coupling	Coupled
Discretization	Pressure (Standard) Momentum (Second Order Upwind)
Boundary Conditions	Velocity Normal Inlet Outlets
Under Relaxation Factors	0.4 for the pressure 0.7 for momentum
Residuals	0.001 for Continuity, Momentum, K, Epsilon Equations

Table 7. CFD Simulation Setup

Boundary Conditions

The wind velocity inside and outside the development was evaluated by solving the Reynolds' Averaged Navier Stokes (RANS) equations for the flow. A cylindrical computational domain with a height of 375 meters and a radius of 475 meters was generated, as shown in Figures 8 and 9. The side walls of the computational domain were used as the computed inlet and outlet for the boundary layer input. 16 wind directions were analysed across the seasonal cases for this study for each site configuration.

Computational Mesh and Grid Independence Study

A grid independence study was undertaken for the external wind speeds of the computational model, for the Southerly wind case. Results from the two grids employed (G1 & G2) were measured at chosen located for various heights. These included y=10m, y=22.5m as well as y=30m. The grid properties and grid independence results are summarised in Tables 8 and 9. G1 was choosen for simulation in order to maximise computational efficiency.

Grid	Element	Base Mesh Size (m)	Cell Count (x10E6)
G1	Hexahedral	0.28	9.07
G2	Hexahedral	0.32	10.4

Table 8. Grid Properties

Grid	G1 Velocity Magnitude (m/s)	G2 Velocity Magnitude (m/s)	Percentage Difference (%)
G1	3.53	3.59	-1.78
G2	5.33	5.28	-1.05

Table 9. Grid Independence Results

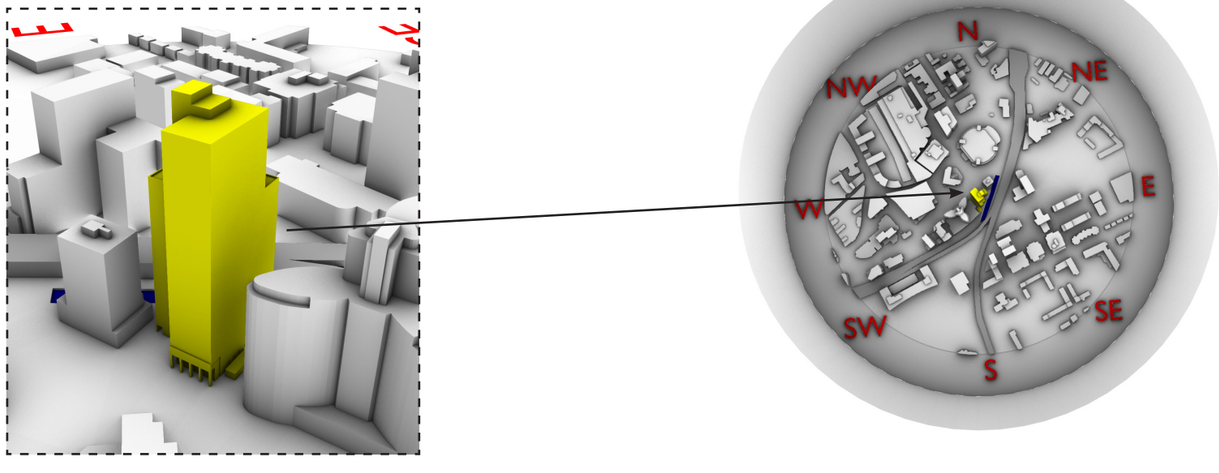


Figure 8. Computational Domain (Proposed Site with Existing Surrounds)

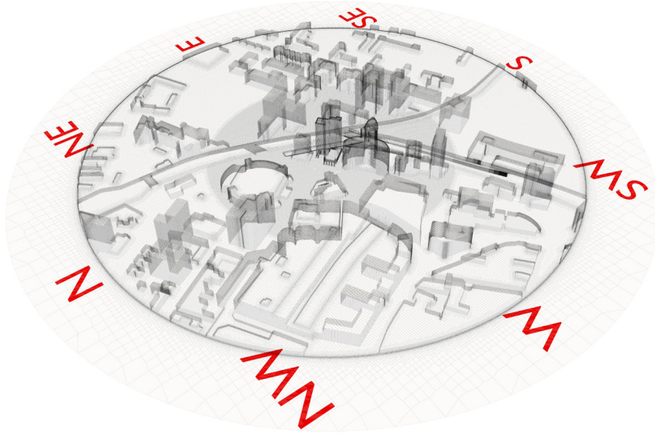


Figure 9. Computational Grid (Proposed Site with Existing Surrounds)

4. Meteorological Data for Cardiff

Meteorological Data

Details of the wind climate for the Cardiff region have been determined from a detailed statistical analysis of measured mean wind speed data from the meteorological stations at Cardiff Airport. 23 years of wind climate data has been collected from this station and the data has been corrected so that it represents winds over standard open terrain at a height of 10m above ground. The directional wind speeds and the directional frequency of occurrences of the regional winds are provided in Table 10 and shown in Figures 10 and 11. The data indicates that the maximum wind speeds for the region are from the west and that the most frequent winds are also from the west.

Wind Direction	Daily Average Mean Wind Speeds (m/s)	Weekly (5%) Wind Speeds (GEM) (m/s)	1 Year Wind Speeds (PEAK) (m/s)	% of all observations
N	3.7	4.1	8.1	3.3
NNE	4.1	4.3	8.9	2.8
NE	5.5	7.9	11.4	6.2
ENE	5.7	8.7	11.9	8.7
E	4.9	6.3	9.6	4.9
ESE	4.5	6.0	9.3	5.1
SE	4.1	5.0	8.6	3.8
SSE	4.4	5.2	8.4	3.5
S	4.6	5.5	8.8	3.6
SSW	4.7	5.6	9.0	3.8
SW	5.0	6.6	10.4	5.3
WSW	6.2	9.5	13.4	10.0
W	6.2	10.1	13.8	16.7
WNW	5.4	8.8	12.3	13.2
NW	4.5	6.2	9.9	6.2
NNW	4.0	4.3	9.0	3.0

Table 10. Wind Speeds and Frequencies of Occurrence for the Cardiff Region

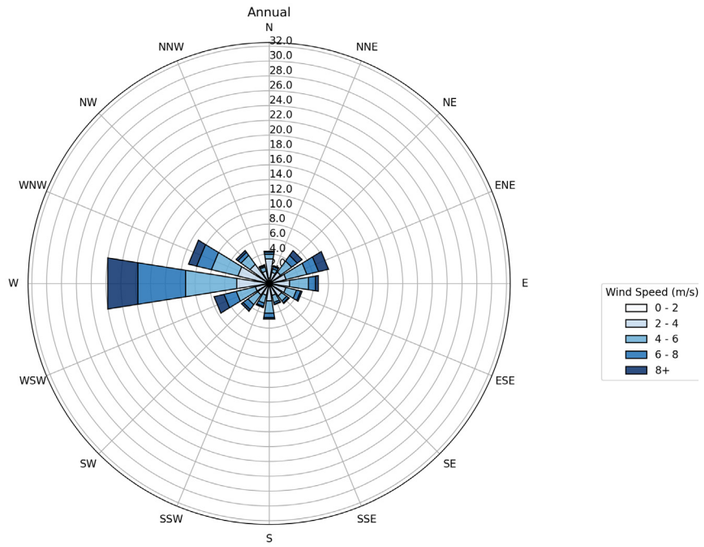


Figure 10. Wind Speeds and Frequencies of Occurrence for the Cardiff Region (corrected to open terrain at 10m)

Approaching Wind Speeds

The approaching wind terrain category was assessed using the terrain descriptions from Eurocode 1: Actions on Structures – Part 1-4: General Actions-Wind Actions (BS EN 1991-1-4:2005) and International Standard Wind Actions on structure (ISO 4354). For each wind direction, the approaching terrain profiles were combined with the local wind climate to determine the site wind speeds. The site wind speeds and terrain categories are presented in Table 11 for a selection of wind directions. The site wind speeds are used to determine the inputs conditions for the CFD simulations. The site hourly mean wind speeds are used when determining the speedup ratio for a given wind direction, a speed up ratio of zero implies no speed up compared to the boundary condition whereas a speed up ratio of one predicts the wind speed at a point is 100% that of the inlet condition.

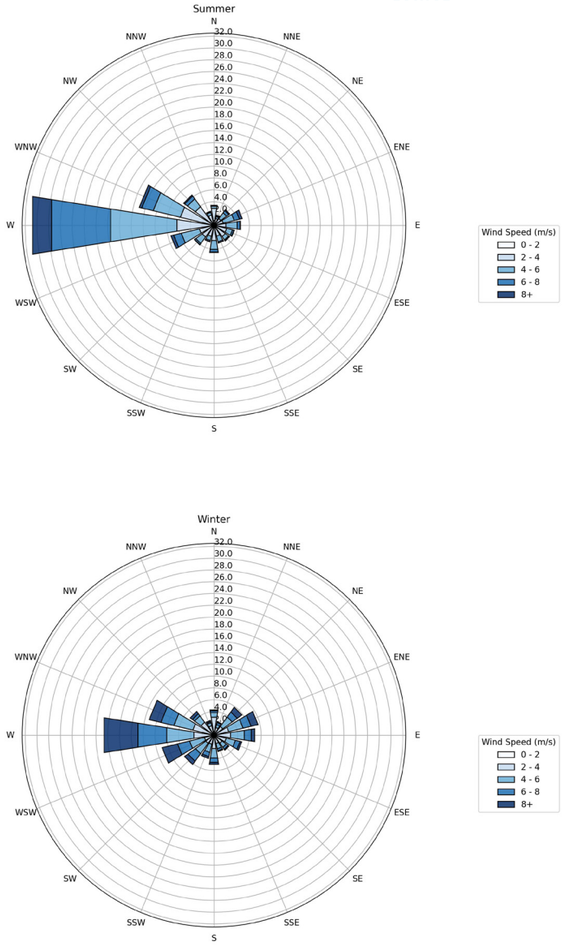


Figure 11. Summer (top) and Winter (bottom) Wind Speeds and Frequencies of Occurrence for the Cardiff Region (corrected to open terrain at 10m)

Wind Direction	Terrain Category (EN 1991-1-4, ISO 4354)	Basic Hourly Mean Wind Speed at 10m Height (m/s)	Site Hourly Mean Wind Speed at 10m Height (m/s)
S	2.5	5.5	5.2
SW	2.5	6.6	6.0
W	3	10.1	8.5

Table 11. Hourly Mean Site Wind Speeds

5. Results and Discussion
Annual Safety Contours

The Annual Safety Contours are shown in Figures 12 through 14.

Observations

- In the Proposed Site with Existing Surrounds configuration, the wind conditions are safe in most areas. However, there is one small isolated area to the south-east of the proposed development where the wind conditions are unsafe. It is our understanding that this isolated area is not accessible to any members of the public.

- In the Proposed Site with Future Surrounds configuration, the wind conditions are safe.

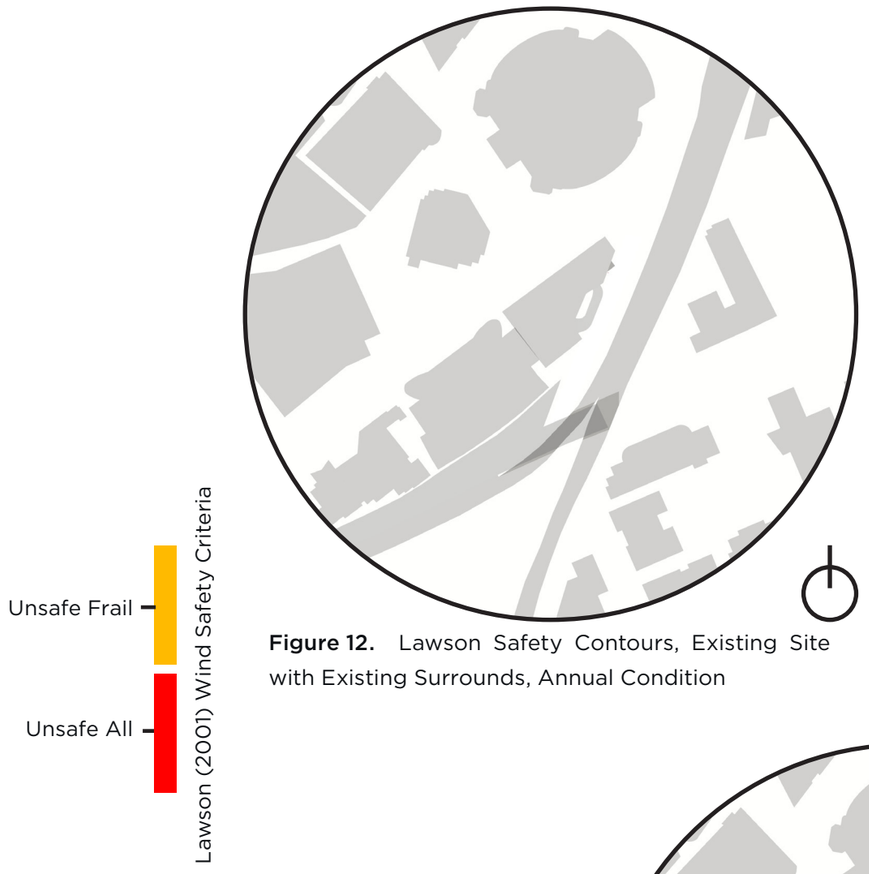


Figure 12. Lawson Safety Contours, Existing Site with Existing Surrounds, Annual Condition

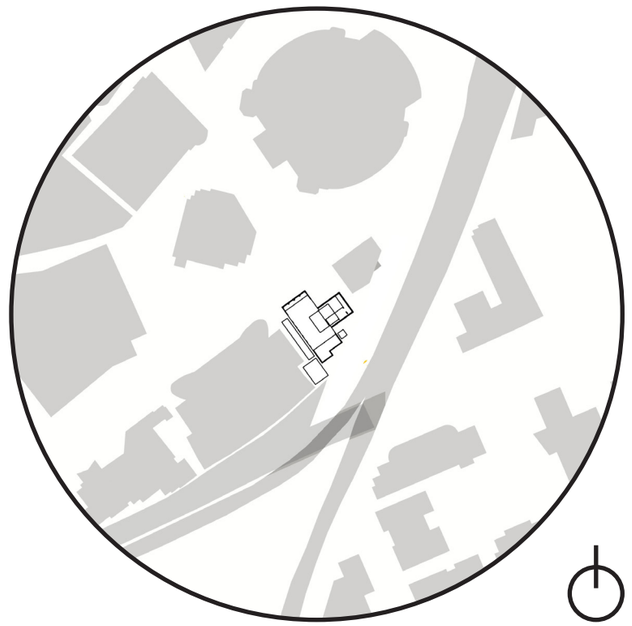


Figure 13. Lawson Safety Contours, Proposed Site with Existing Surrounds, Annual Condition

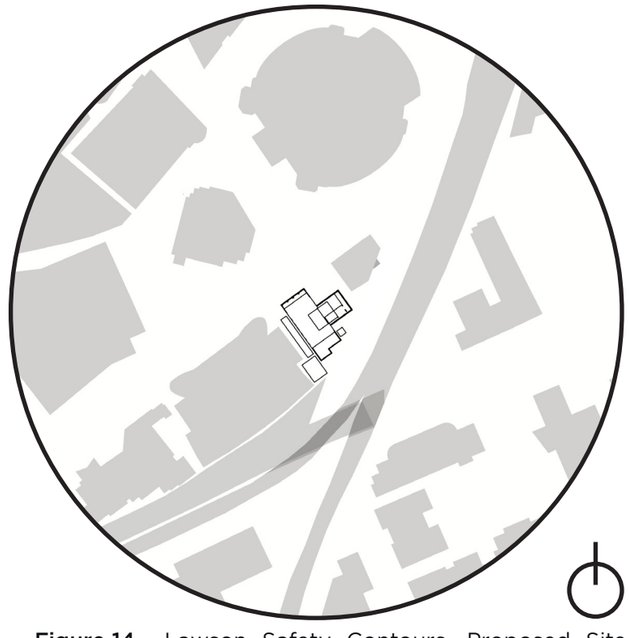


Figure 14. Lawson Safety Contours, Proposed Site with Future Surrounds, Annual Condition

5. Results and Discussion
Annual Safety Contours

The Annual Safety Contours are shown in Figures 15 through 17.

Observations

- In the Proposed Site with Existing Surrounds configuration, the wind conditions are safe in most areas. However, there is one small isolated area to the south-east of the proposed development where the wind conditions are unsafe. It is our understanding that this isolated area is not accessible to any members of the public.

- In the Proposed Site with Future Surrounds configuration, the wind conditions are safe.

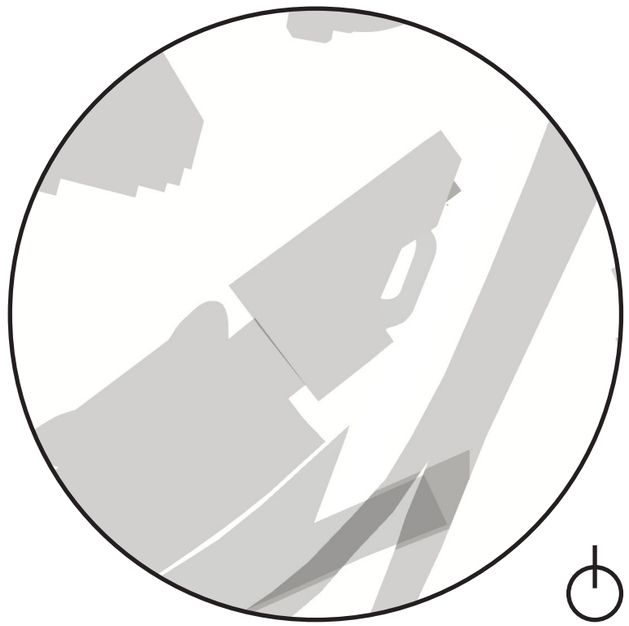


Figure 15. Lawson Safety Contours, Existing Site with Existing Surrounds, Annual Condition, Zoomed

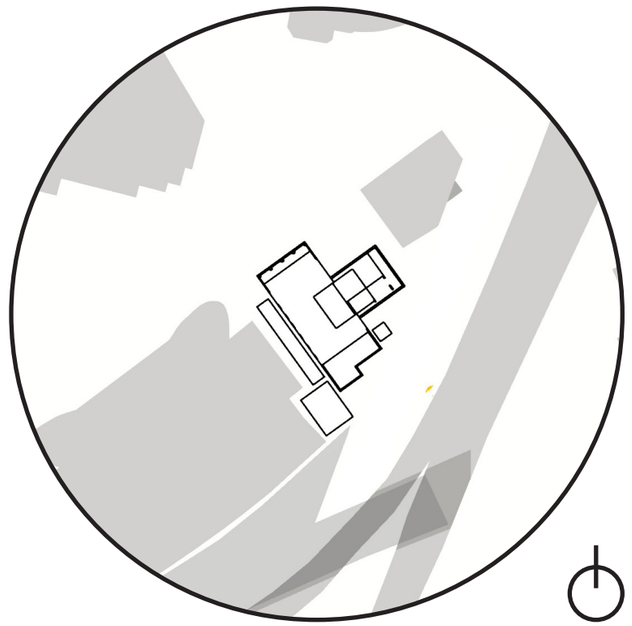


Figure 16. Lawson Safety Contours, Proposed Site with Existing Surrounds, Annual Condition, Zoomed

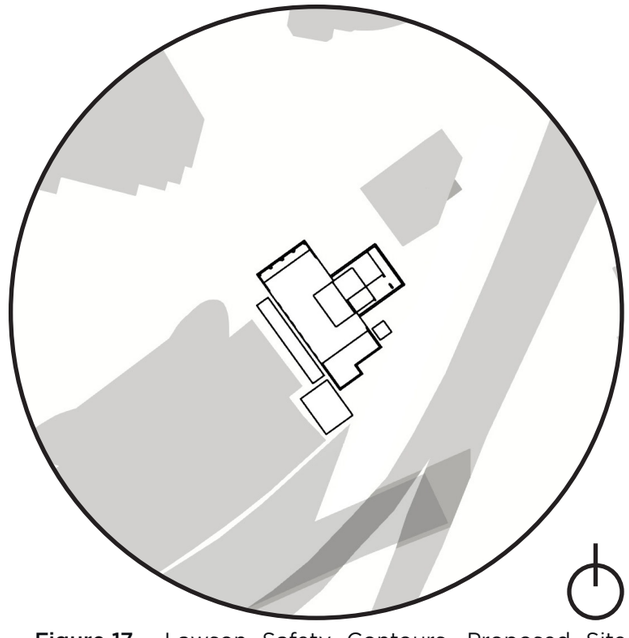


Figure 17. Lawson Safety Contours, Proposed Site with Future Surrounds, Annual Condition, Zoomed

5. Results and Discussion
Annual Safety Contours

The Annual Safety Contours for the elevated levels are shown in Figures 18 and 19.

Observations

- In the Proposed Site with Existing Surrounds configuration, the wind conditions on the elevated level of the 20th floor are safe in most areas. However, there are also isolated areas where the wind conditions are unsafe. The wind conditions on the elevated level of the 21st floor are safe.

- In the Proposed Site with Future Surrounds configuration, the wind conditions on the elevated level of the 20th floor are safe in most areas. However, there are also isolated areas where the wind conditions are unsafe. The wind conditions on the elevated level of the 21st floor are safe.

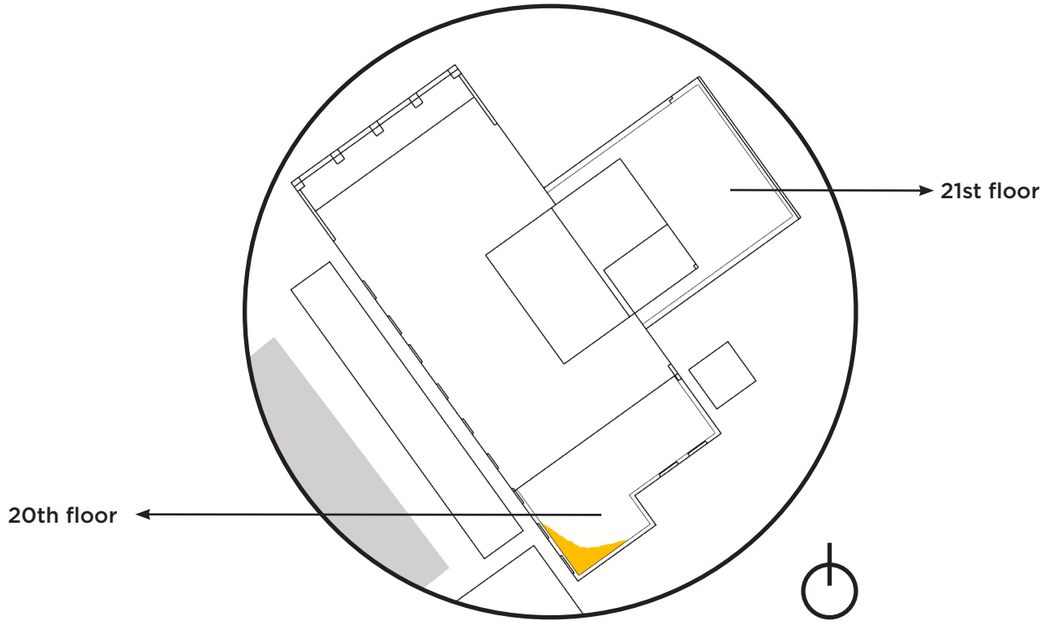


Figure 18. Lawson Safety Contours, Proposed Site with Existing Surrounds, Annual Condition, Elevated

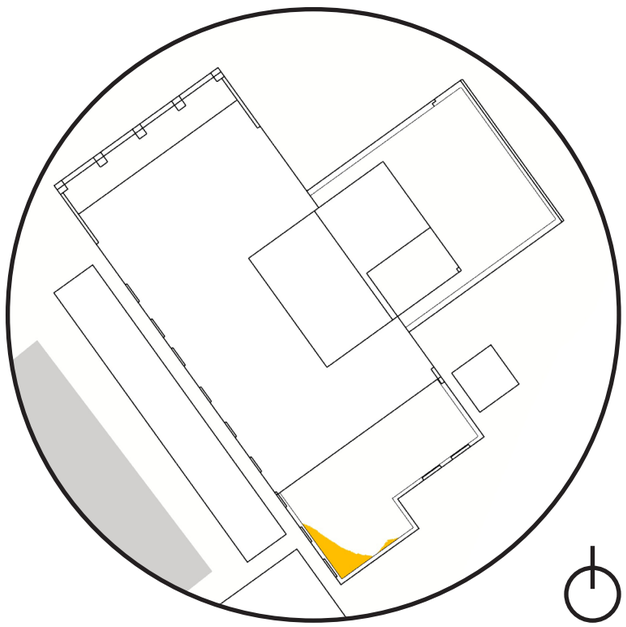


Figure 19. Lawson Safety Contours, Proposed Site with Future Surrounds, Annual Condition, Elevated

5. Results and Discussion
Winter Comfort Contours

The Winter Comfort Contours are shown in Figures 20 through 22.

Observations

- At the ground level, the key intended uses during the Winter are Standing at entrances, Strolling along thoroughfares, and Business Walking along roads.
- In the Proposed Site with Existing Surrounds configuration, the wind conditions are suitable for a combination of Sitting, Standing, Strolling, Business Walking and Uncomfortable.
- Following the introduction of the Proposed Development with Future Surrounds, the wind conditions remain similar.
- The wind conditions at many entrances of the proposed development are suitable for the intended use. However, there are also several entrances that are not suitable for its intended use.
- The wind conditions along the thoroughfares are suitable for the intended use in most areas near the vicinity of the proposed development.
- The wind conditions along the roads are suitable for the intended use near the vicinity of the proposed development.
- The areas where the wind conditions are not suitable for the intended use are listed as follows:
    - Multiple entrances to the proposed development marked as A in Figure 24.
    - Isolated areas along the thoroughfares of south-western (marked as B in Figure 24) and north-eastern facade of the proposed development.
    - Isolated areas near the entrance of the Citrus Hotel.
    - Isolated areas along the thoroughfare of Altolusso Building.
    - Entrances of all the shops along the eastern facade of Cineworld Building.

It is worth noting that for areas where the wind conditions are unsuitable in the extended surrounds, these are mostly existing conditions. However, for the areas that are unsuitable within the site boundary, it is recommended that mitigation measures are implemented and tested.

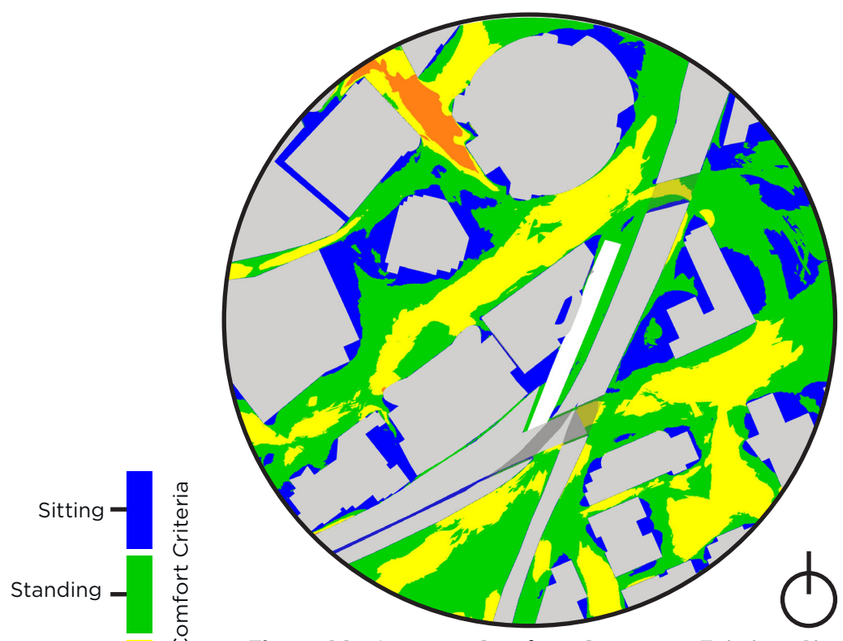


Figure 20. Lawson Comfort Contours, Existing Site with Existing Surrounds, Winter Condition

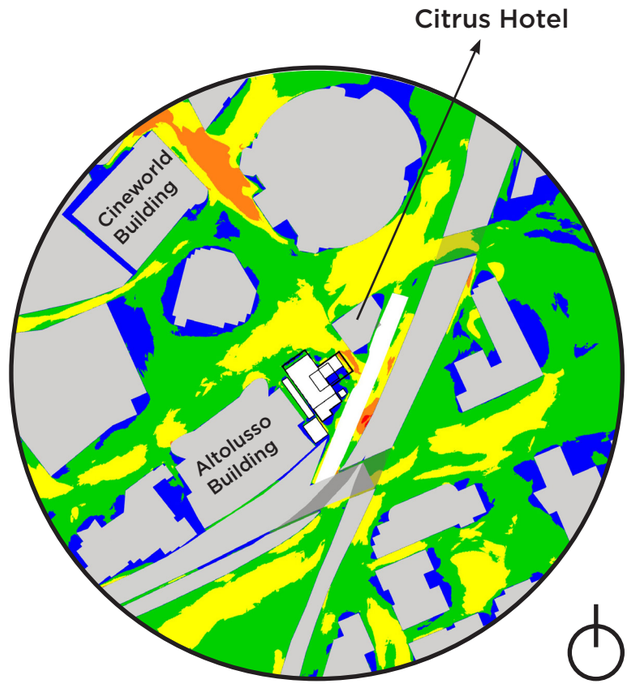


Figure 21. Lawson Comfort Contours, Proposed Site with Existing Surrounds, Winter Condition

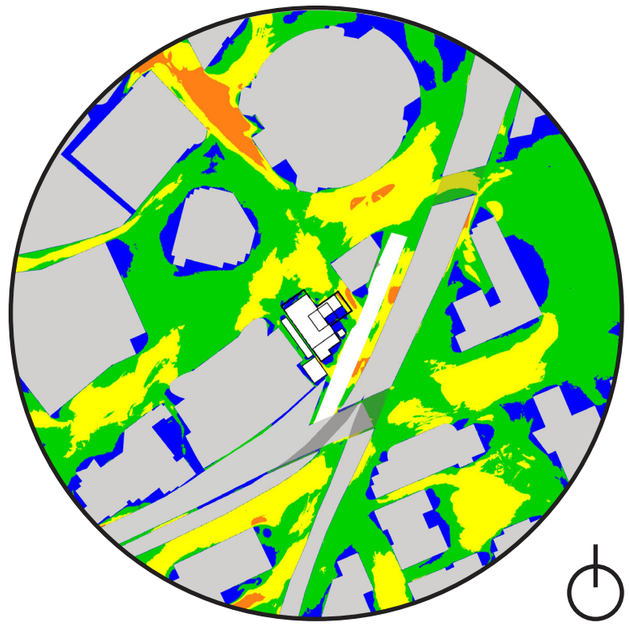


Figure 22. Lawson Comfort Contours, Proposed Site with Future Surrounds, Winter Condition

5. Results and Discussion
Winter Comfort Contours

The Winter Comfort Contours are shown in Figures 23 through 25.

Observations

- At the ground level, the key intended uses during the Winter are Standing at entrances, Strolling along thoroughfares, and Business Walking along roads.
- In the Proposed Site with Existing Surrounds configuration, the wind conditions are suitable for a combination of Sitting, Standing, Strolling, Business Walking and Uncomfortable.
- Following the introduction of the Proposed Development with Future Surrounds, the wind conditions remain similar.
- The wind conditions at many entrances of the proposed development are suitable for the intended use. However, there are also several entrances that are not suitable for its intended use.
- The wind conditions along the thoroughfares are suitable for the intended use in most areas near the vicinity of the proposed development.
- The wind conditions along the roads are suitable for the intended use near the vicinity of the proposed development.
- The areas where the wind conditions are not suitable for the intended use are listed as follows:
    - Multiple entrances to the proposed development marked as A in Figure 24.
    - Isolated areas along the thoroughfares of south-western (marked as B in Figure 24) and north-eastern facade of the proposed development.
    - Isolated areas near the entrance of the Citrus Hotel.
    - Isolated areas along the thoroughfare of Altolusso Building.
    - Entrances of all the shops along the eastern facade of Cineworld Building.

It is worth noting that for areas where the wind conditions are unsuitable in the extended surrounds, these are mostly existing conditions. However, for the areas that are unsuitable within the site boundary, it is recommended that mitigation measures are implemented and tested.

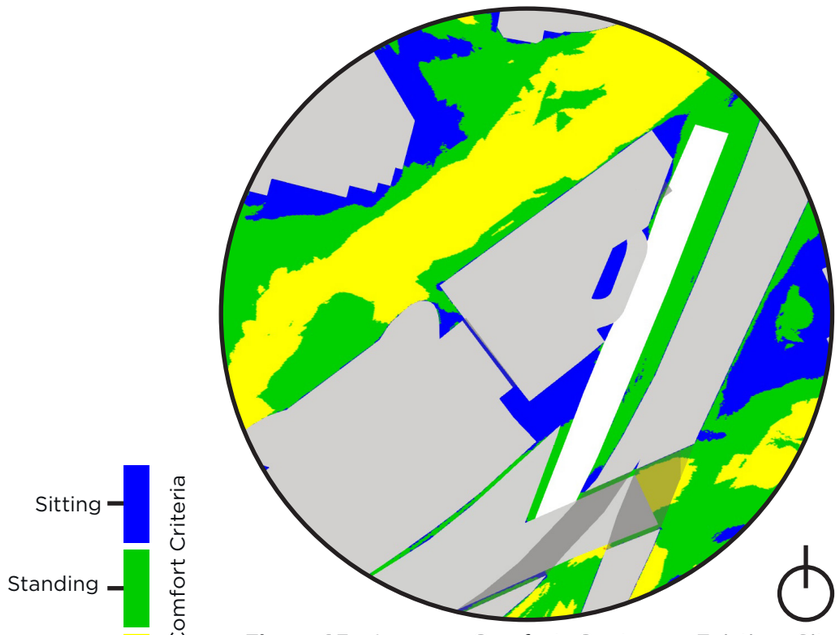


Figure 23. Lawson Comfort Contours, Existing Site with Existing Surrounds, Winter Condition, Zoomed

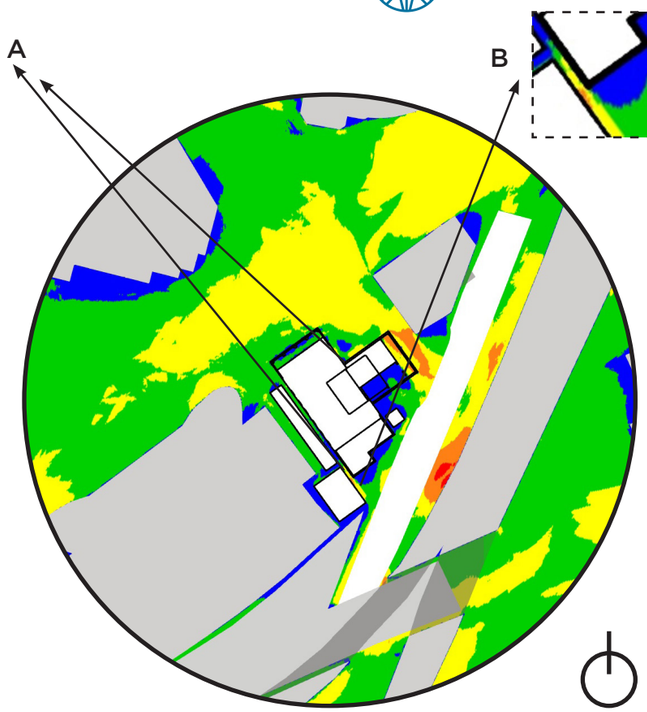


Figure 24. Lawson Comfort Contours, Proposed Site with Existing Surrounds, Winter Condition, Zoomed

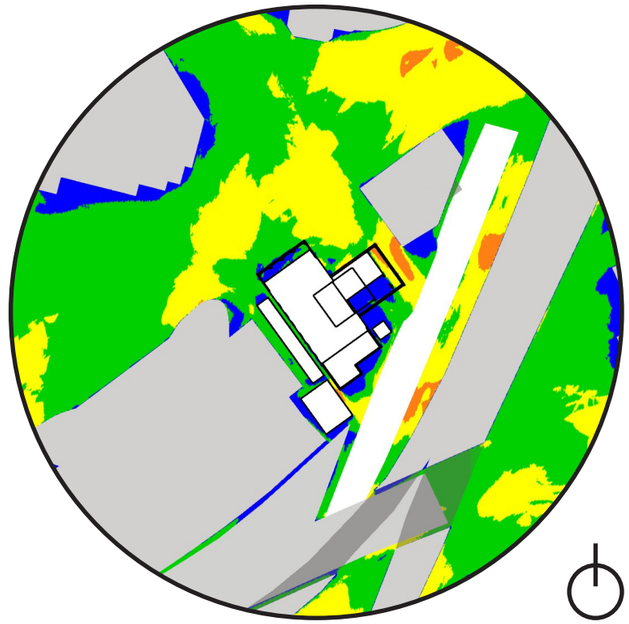


Figure 25. Lawson Comfort Contours, Proposed Site with Future Surrounds, Winter Condition, Zoomed

5. Results and Discussion
Summer Comfort Contours

The Summer Comfort Contours are shown in Figures 26 through 28.

Observations

- At the ground level, the key intended uses during the Summer are Sitting in outdoor seating areas and Standing in amenity areas.
- In the Proposed Site with Existing Surrounds configuration, the wind conditions are suitable for a combination of Sitting, Standing, Strolling and Business Walking.
- Following the introduction of the Proposed Development with Future Surrounds, the wind conditions remain similar.
- The areas where the wind conditions are not suitable for their intended use both within the immediate and extended surrounds of the proposed development are listed below:
    - All the seating areas to the north of the development.
    - Seating areas across the Citrus Hotel.
    - Seating areas infront of tesco in Treetop Golf Building to the north west of the development.
    - Seating areas to the north of No. 3 Capital Quarter Building.

It is worth noting that for the areas where the wind conditions are unsuitable in the extended surrounds, these are mostly existing conditions. However, for the areas that are unsuitable within the site boundary, it is recommended that mitigation measures are implemented and tested.

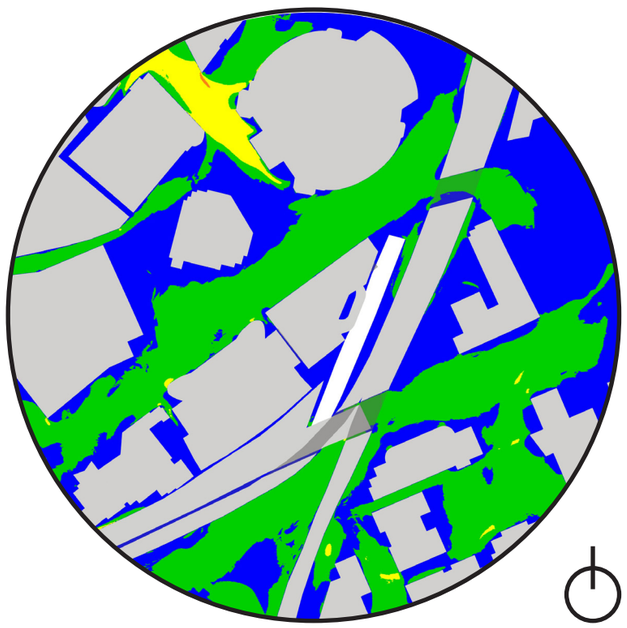


Figure 26. Lawson Comfort Contours, Existing Site with Existing Surrounds, Summer Condition

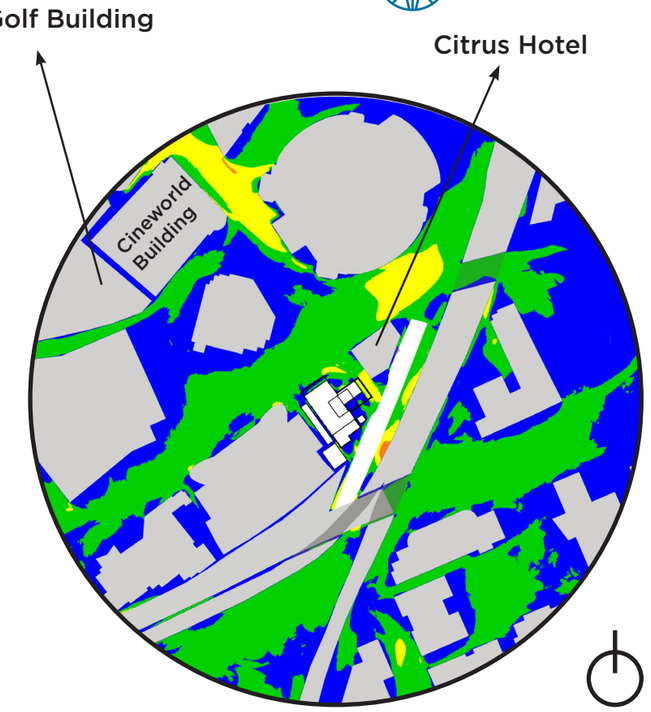


Figure 27. Lawson Comfort Contours, Proposed Site with Existing Surrounds, Summer Condition

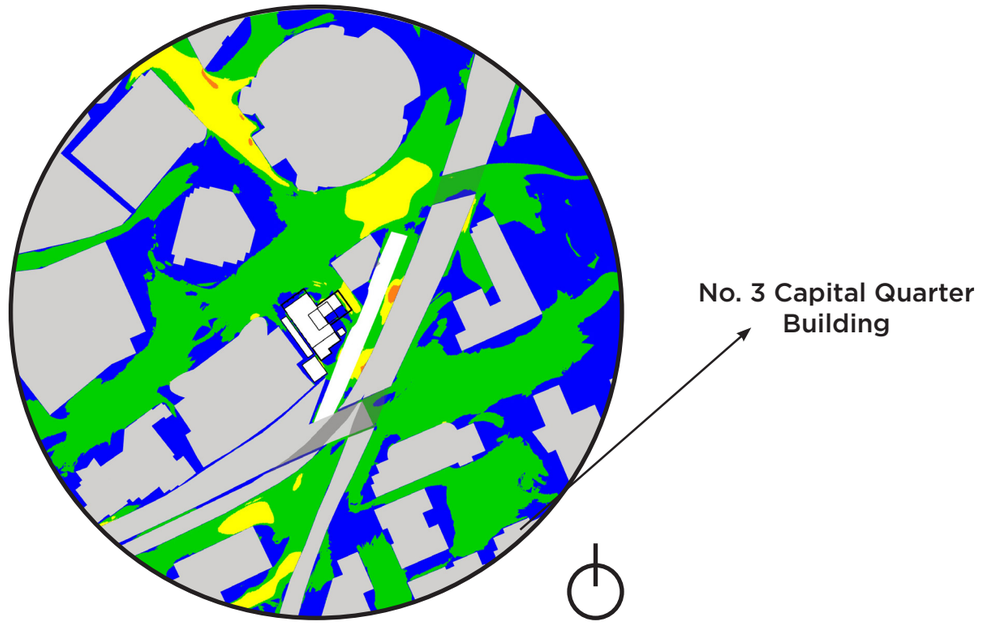


Figure 28. Lawson Comfort Contours, Proposed Site with Future Surrounds, Summer Condition

5. Results and Discussion
Summer Comfort Contours

The Summer Comfort Contours are shown in Figures 29 through 31.

Observations

- At the ground level, the key intended uses during the Summer are Sitting in outdoor seating areas and Standing in amenity areas.
- In the Proposed Site with Existing Surrounds configuration, the wind conditions are suitable for a combination of Sitting, Standing, Strolling and Business Walking.
- Following the introduction of the Proposed Development with Future Surrounds, the wind conditions remain similar.
- The areas where the wind conditions are not suitable for their intended use both within the immediate and extended surrounds of the proposed development are listed below:
    - All the seating areas to the north of the development.
    - Seating areas across the Citrus Hotel.
    - Seating areas infront of tesco in Treetop Golf Building to the north west of the development.
    - Seating areas to the north of No. 3 Capital Quarter Building.

It is worth noting that for the areas where the wind conditions are unsuitable in the extended surrounds, these are mostly existing conditions. However, for the areas that are unsuitable within the site boundary, it is recommended that mitigation measures are implemented and tested.

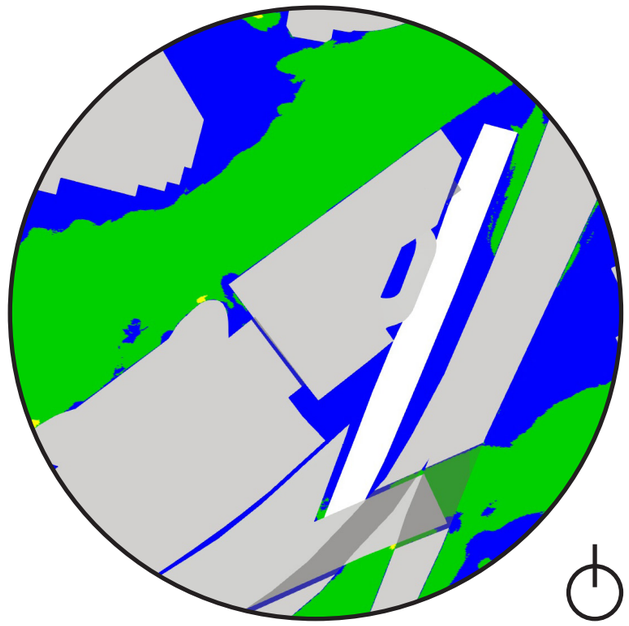


Figure 29. Lawson Comfort Contours, Existing Site with Existing Surrounds, Summer Condition, Zoomed

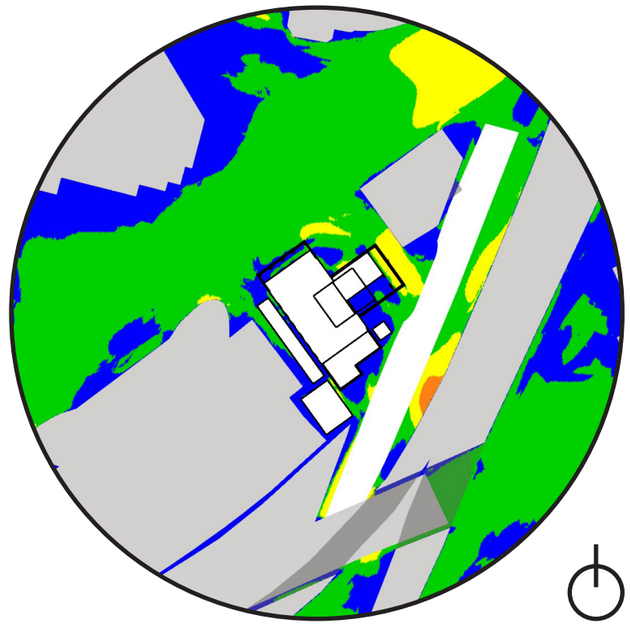


Figure 30. Lawson Comfort Contours, Proposed Site with Existing Surrounds, Summer Condition, Zoomed

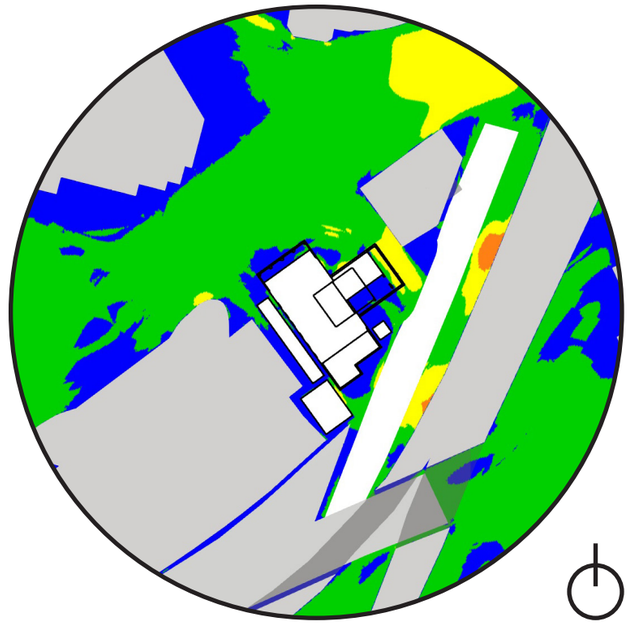


Figure 31. Lawson Comfort Contours, Proposed Site with Future Surrounds, Summer Condition, Zoomed

5. Results and Discussion
Summer Comfort Contours

The Summer Comfort Contours for the elevated levels are shown in Figures 32 and 33.

Observations

- On the elevated levels, the key intended uses during the Summer are Sitting in outdoor seating areas and Standing in amenity areas accessible to the public/occupants.

- Based on the drawings received on 23 and 25 April 2024, it is our understanding that there are roof terraces on the 20th and 21st floor which are accessible for occupants.

- In the Proposed Site with Existing Surrounds configuration, the wind conditions on the elevated level of the 20th floor are suitable for the intended use in some areas. However, there are also areas where the wind conditions are not suitable for the intended use. The wind conditions on the elevated level of the 21st floor are suitable for their intended use in some areas. However, there are also areas where the wind conditions are not suitable for their intended use.

- In the Proposed Site with Future Surrounds configuration, the wind conditions on the elevated level of the 20th floor are suitable for the intended use in some areas. However, there are also areas where the wind conditions are not suitable for the intended use. The wind conditions on the elevated level of the 21st floor are suitable for their intended use in some areas. However, there are also areas where the wind conditions are not suitable for their intended use.

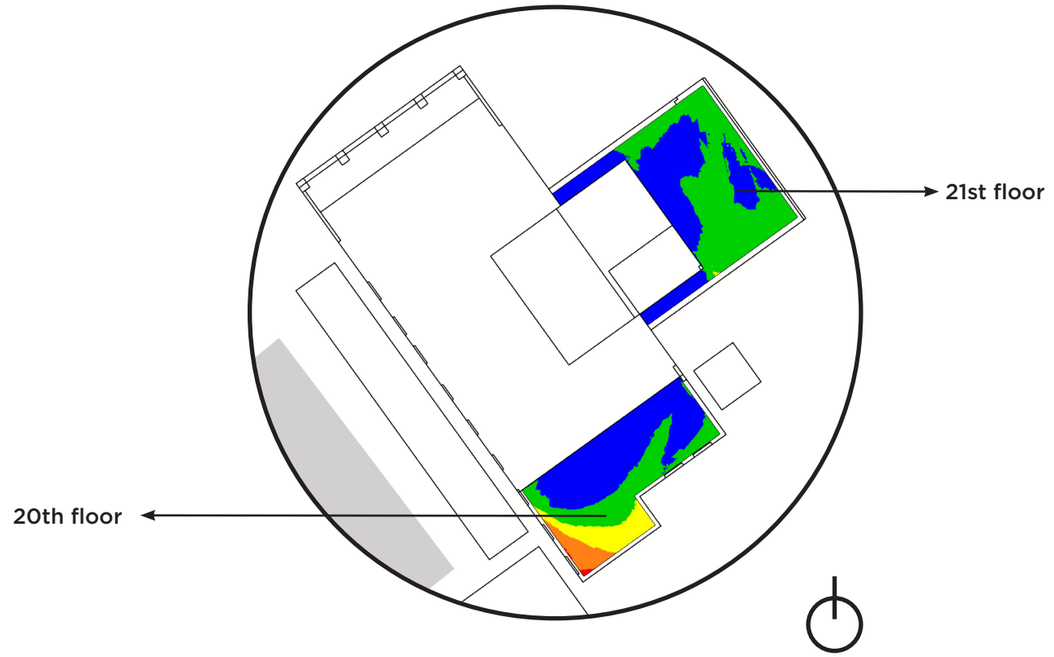


Figure 32. Lawson Comfort Contours, Proposed Site with Existing Surrounds, Summer Condition, Elevated

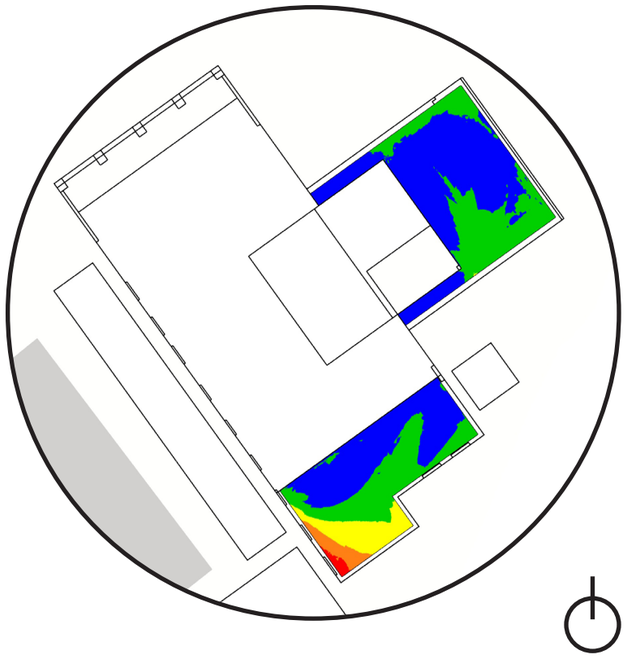


Figure 33. Lawson Comfort Contours, Proposed Site with Future Surrounds, Summer Condition, Elevated

6. Summary and Recommendations

The results of the assessment show that the wind conditions are safe within the site boundary and in the nearby surrounds in most areas. However, there is a small isolated area to the south east of the proposed development where the wind conditions are unsafe. It is our understanding that this isolated area is not accessible to any members of the public.

On the elevated levels of the proposed development, the wind conditions are safe in most areas. However, there are isolated areas on the roof terraces of the 20th and 21st floor where the wind conditions are unsafe.

The results of the assessment also show that the wind conditions at the ground and elevated levels within the site boundary are suitable for the intended use in many areas. However, there are also areas where the wind conditions are unsuitable for the intended use, including:

- Multiple entrances to the proposed development.
- All the seating areas to the north of the development.
- Isolated areas along the thoroughfares of south-western and north-eastern facade of the proposed development.
- Roof terraces of the 20th and 21st floor.

There are several areas in the extended surrounds where the wind conditions are not suitable for the intended use including:

- Isolated areas near the entrance of the Citrus Hotel.
- Isolated areas along the thoroughfare of Altolusso Building.
- Entrances of all the shops along the eastern facade of Cineworld Building.
- Seating areas across the Citrus Hotel.
- Seating areas infront of tesco in Cineworld Building to the north of the development.
- Seating areas to the north of No 3 Capital Quarter Building.

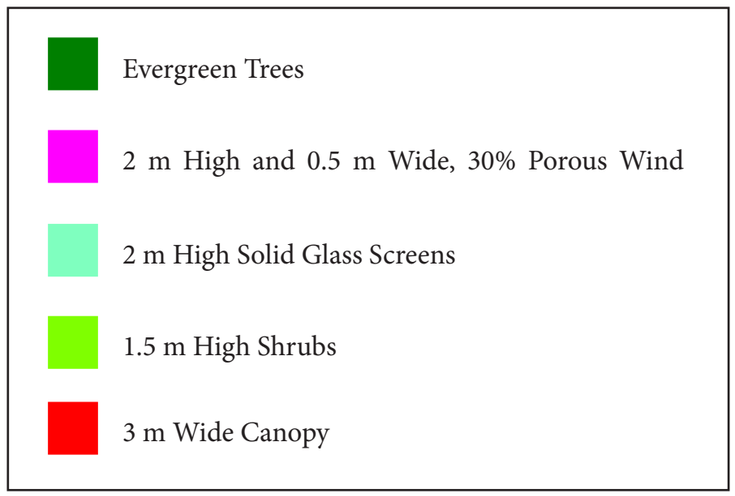
The wind conditions remain approximately the same following the introduction of the Future Surrounds. It is worth noting that the areas that are unsuitable for its intended use in the extended surrounds are mostly existing conditions. Thus the adverse wind conditions could be attributable, or at least partiallly attributable to the general aspects of existing surrounds.

However, for the areas where the wind conditions are unsafe and unsuitable for the intended use within the site boundary, it is recommended that mitigation measures are implemented. It is also recommended that the effectiveness of the mitigation measures is demonstrated with further testing.

The suggested mitigation treatments are as follows:

- Evergreen trees near the seating areas to the north and east of the development.
- 1.5 m high shrubs near the seating area to the north of the development.
- 3 m wide canopy along the northern facade of the development.
- 2 m x 0.5 m wind screens along the thoroughfare to the south western facade of the development (30% porous).
- 2 m high solid glass screen for the roof terraces of the 20th and 21st floor.

The suggested mitigation treatments are outlined in Figure 34. Additional renders of the mitigation measures are provided in Appendix D.



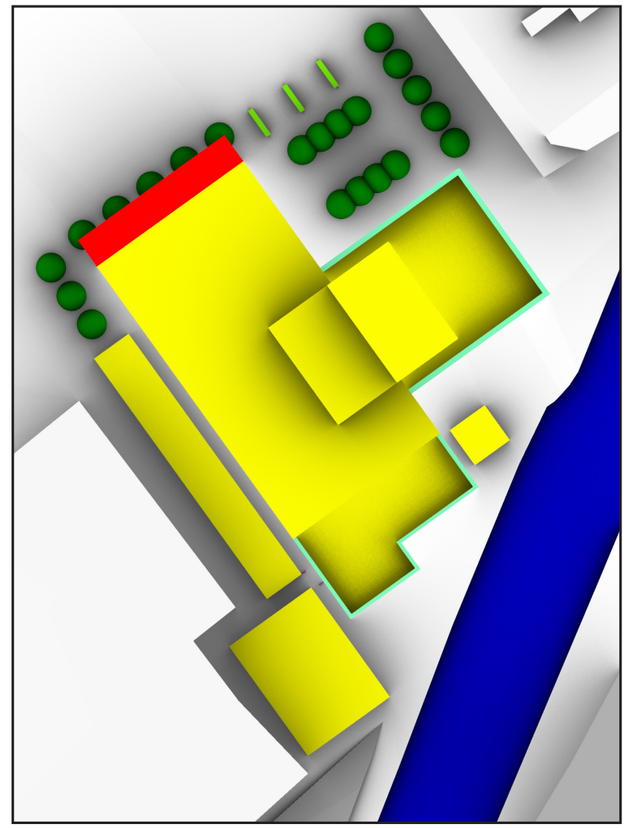


Figure 34. Recommended Mitigation Measures, Plan view

7. References

1. Australian and New Zealand Standard, AS/NZS1170.2:2011, “Structural Design Actions”
2. Aynsley, R.M., Melbourne, W., Vickery, B.J., 1977, “Architectural Aerodynamics”, Applied Science Publishers.
3. Davenport, A.G., 1972, “An approach to human comfort criteria for environmental conditions”, Colloquium on Building Climatology, Stockholm.
4. Davenport, A.G., 1977, “The prediction of risk under wind loading”, 2nd International Conference on Structural Safety and Reliability, September 19-21, 1977, Munich, Germany, pp. 511-538.
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9. Lawson, T.V., 1980, “Wind Effects on Buildings - Volume 1, Design Applications”, Applied Science Publishers Ltd, Ripple Road, Barking, Essex, England.
10. Melbourne, W.H., 1978, “Criteria for Environmental Wind Conditions”, Journal of Wind Engineering and Industrial Aerodynamics, vol.3, pp.241-249.
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12. Penwarden, A.D., and Wise A.F.E., 1975, “Wind Environment Around Buildings”, Building Research Establishment Report, London.
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Appendix A

Wind Effects Glossary

Appendix A - Wind Effects Glossary

A.1 Downwash and Upwash Effects

The downwash wind effect occurs when wind is deflected down the windward face of a building, causing accelerated winds at pedestrian level. This can lead to other adverse effects as corner acceleration as the wind attempts to flow around the building, as seen in Figure A.1.

This can also lead to recirculating flow in the presence of a shorter upstream building, causing local ground level winds to move back into the prevailing wind.

The upwash effect occurs near upper level edge of a building form as the wind flows over the top of the building. This has the potential to cause acceleration of winds near the leading edge, as well as potentially reattaching onto the roof area. This effect causes wind issues particularly near the leading edges of tall building and on the rooftop areas if there is sufficient depth along the wind direction. Upwash is more apparent in taller towers and podia.

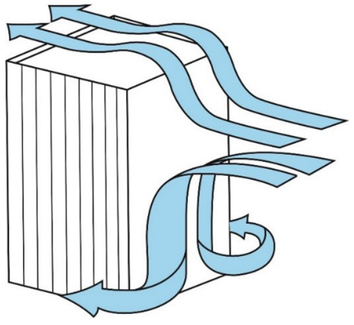


Figure A.1. Downwash Leading to Corner Wind Effect, and Upwash Effects

A.2 Funnelling/Venturi Effect

Funnelling occurs when the wind interacts with two or more buildings which are located adjacent to each other, which results in a bottleneck, as shown in Figure A.2. This causes the wind to be accelerated through the gap between the buildings, resulting in adverse wind conditions and pedestrian discomfort within the constricted space. Funnelling effects are common along pedestrian links and thoroughfares generally located between neighbouring buildings that have moderate gaps between them.

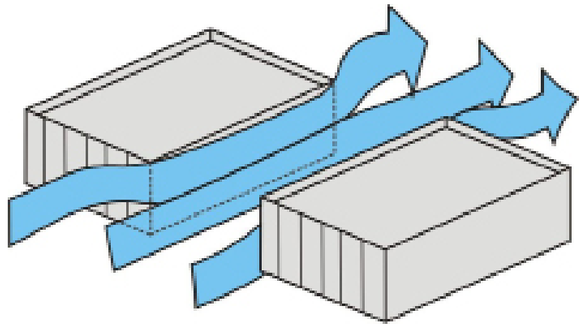


Figure A.2. Funnelling/Venturi Wind Effect

A.3 Gap Effect

The gap effect occurs in small openings in the façade that are open to wind on opposite faces, as seen in Figure A.3. This can involve a combination of funnelling and downwash effects. Presenting a small gap in the façade on the windward aspect as the easiest means through which the wind can flow through can result in wind acceleration through this gap. The pressure difference between the windward façade and the leeward façade also tends to exacerbate the wind flow through this gap.

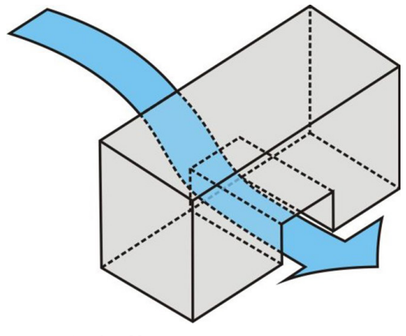


Figure A.3. Gap Wind Effect

A.4 Sidestream and Corner Effects

The sidestream effect is due to a gradual accumulation of wind shearing along the building façade that eventuates in an acceleration corner effect. The flow is parallel to the façade and can be exacerbated by downwash effects as well, or due to corner effect winds reattaching on the façade.

This is shown in Figure A.4. The corner refers to the acceleration of wind at the exterior vertical edge of a building, caused by the interaction of a large building massing with the incident wind, with the flow at the corner being accelerated due to high pressure differentials sets up between the windward façade and the orthogonal aspects. It can be further exacerbated by downwash effects that build up as the flow shears down the façade.

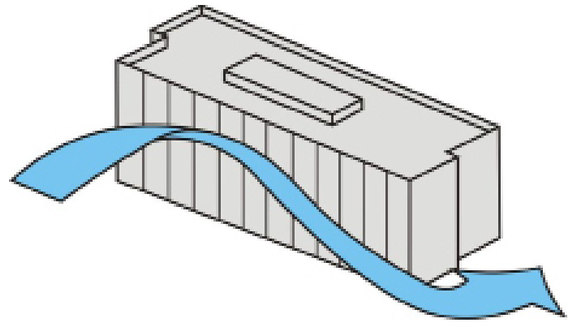


Figure A.4. Sidestream and Corner Wind Effect

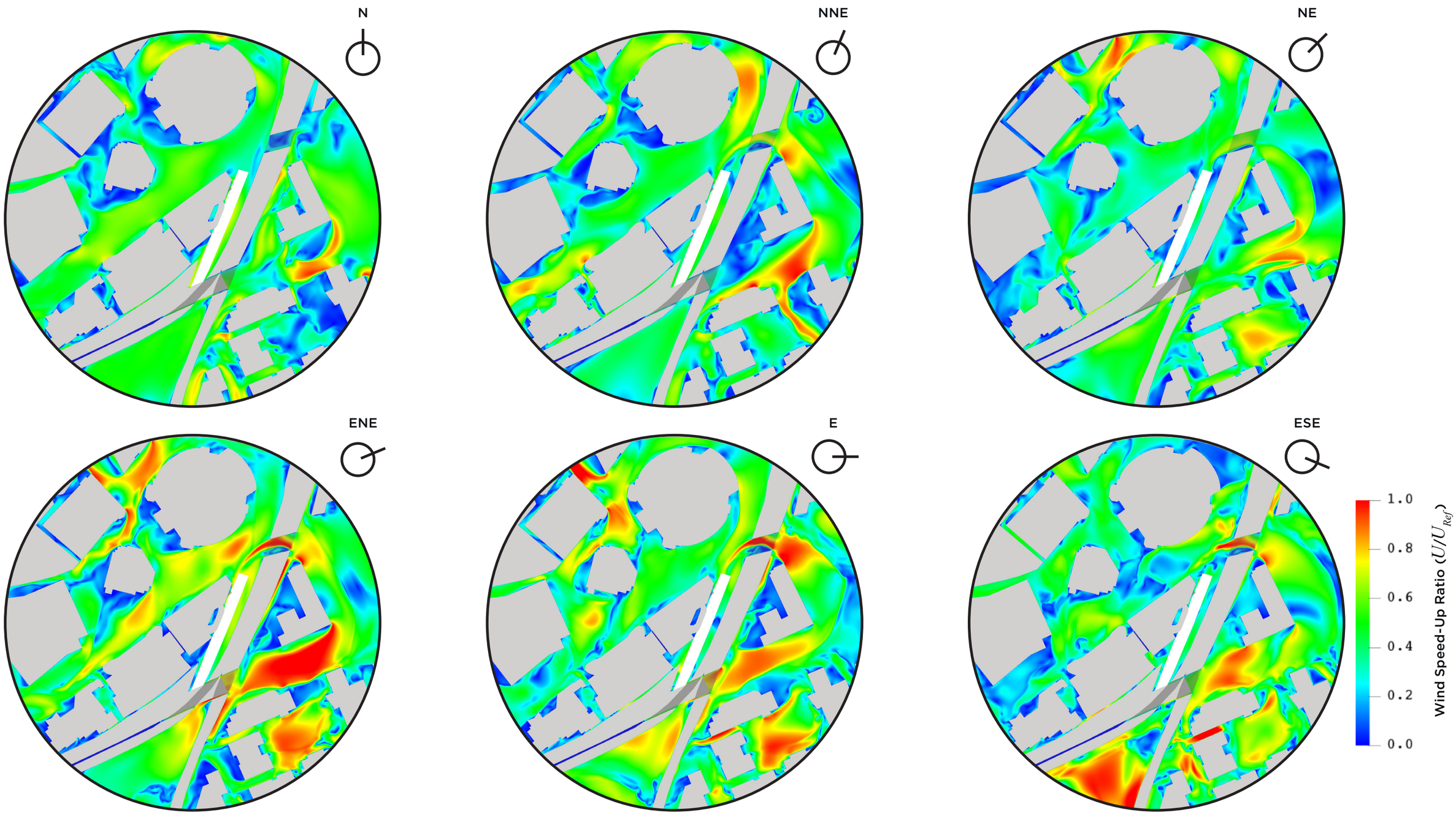
A.5 Stagnation

Stagnation in a region refers to an area where the wind velocity is significantly reduced due to the effect of the flow being impeded by the bluff body. For a particular prevailing wind direction, this is typically located near the middle of the windward face of the building form or over a short distance in front of the windward face of a screen or fence. Concave building shapes tend to create an area of stagnation within the cavity, and wind speeds are generally low in these areas.

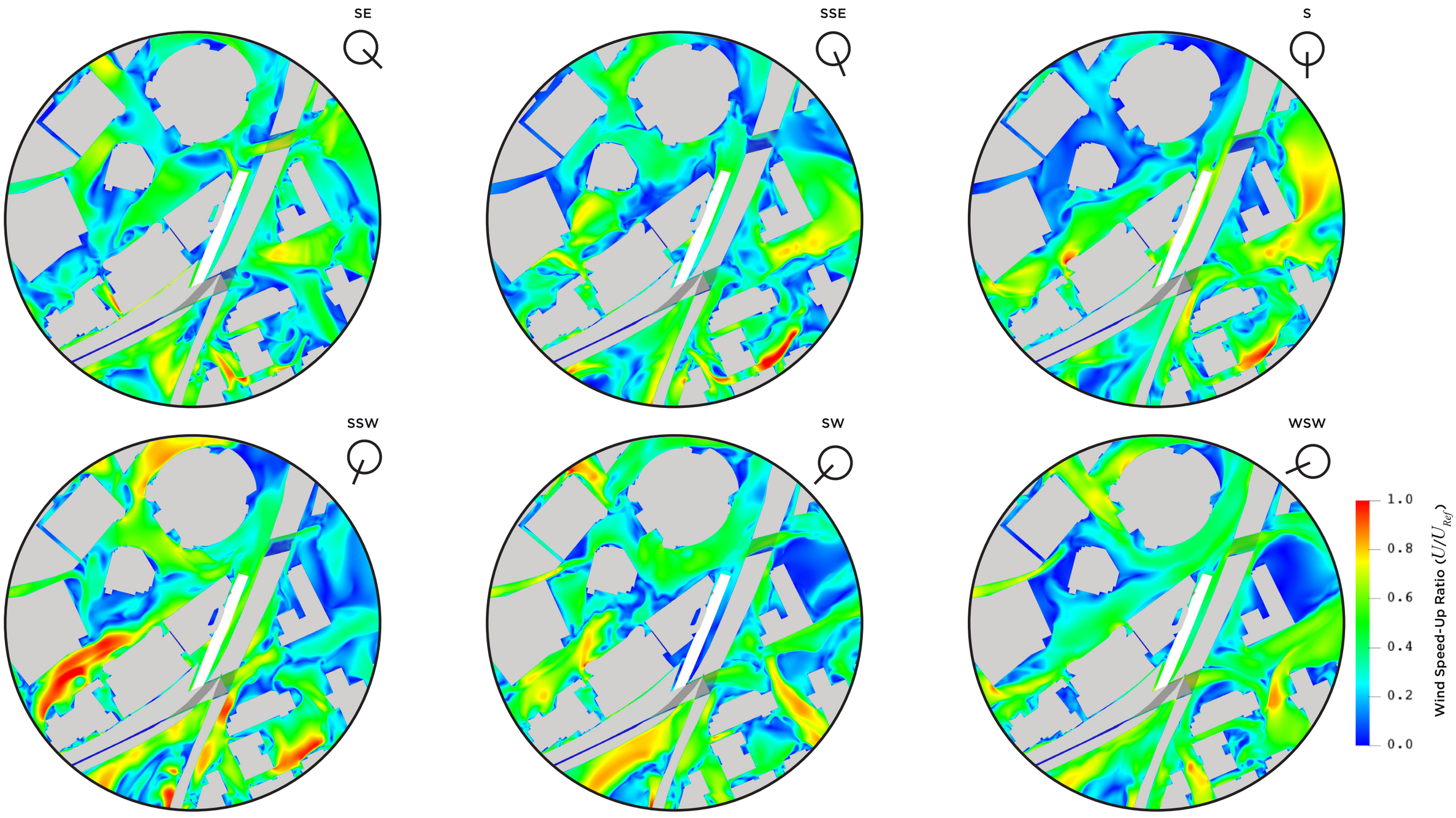
Appendix B

Wind Speed Up Fields

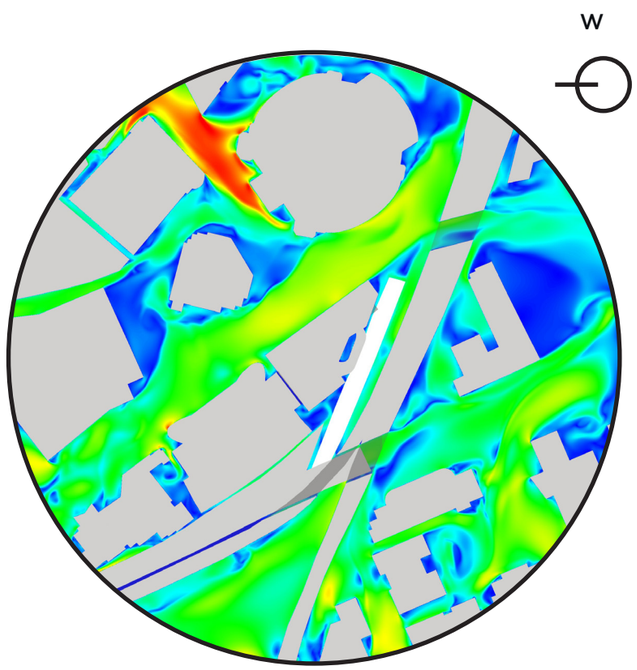
Appendix B - Wind Speed Up Fields - The Existing Site with Existing Surrounds

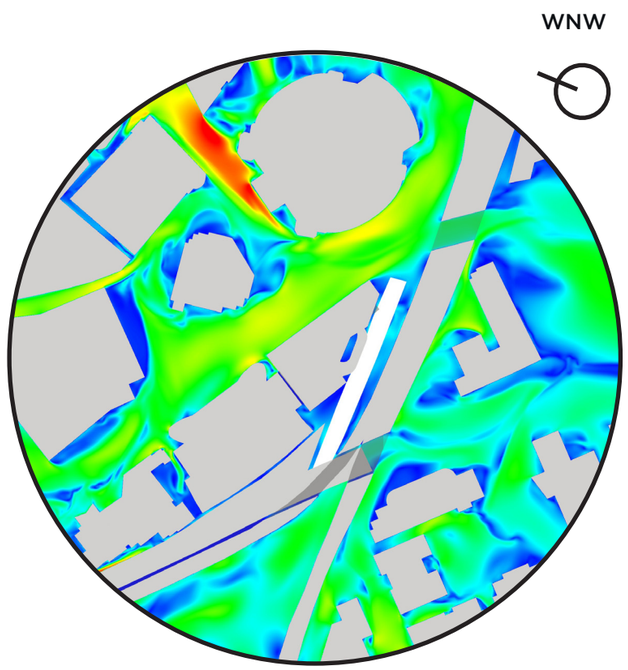


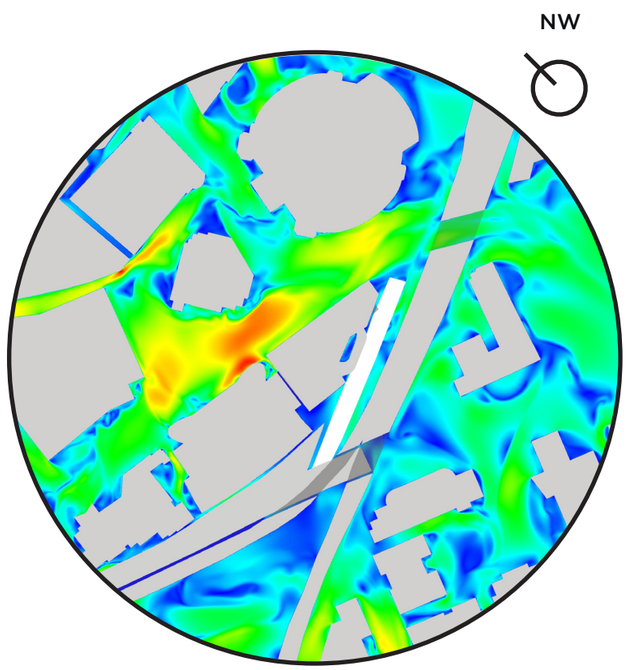
Appendix B - Wind Speed Up Fields - The Existing Site with Existing Surrounds

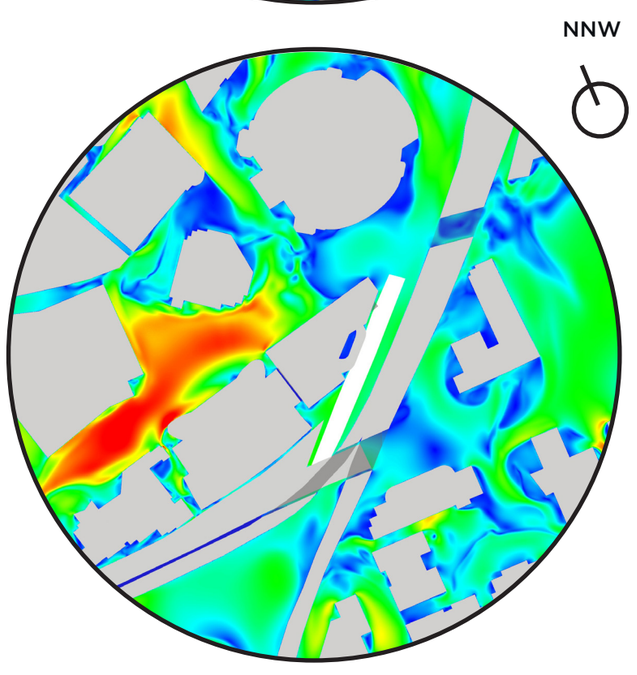


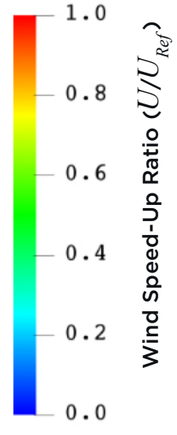
Appendix B - Wind Speed Up Fields - The Existing Site with Existing Surrounds



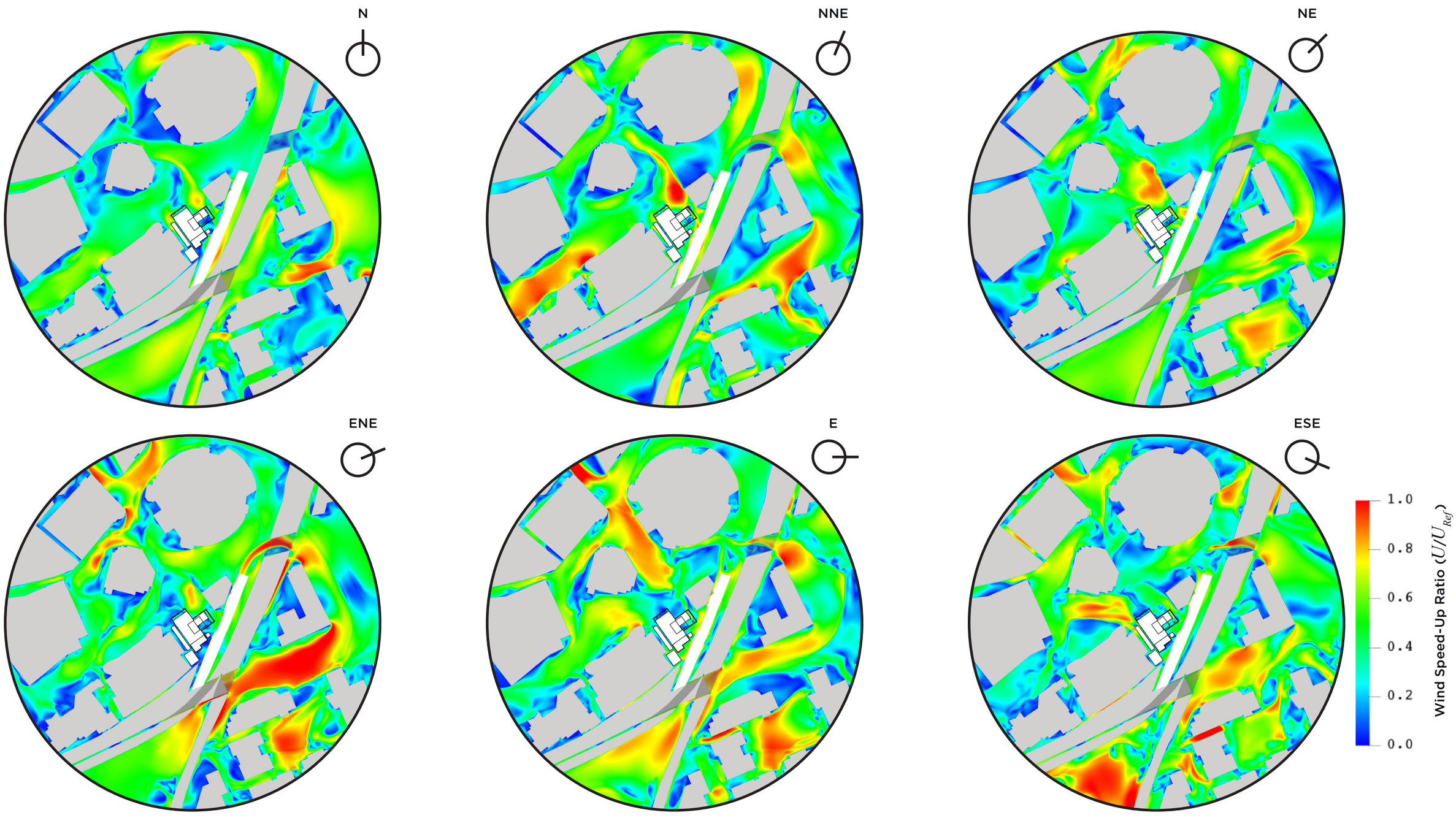




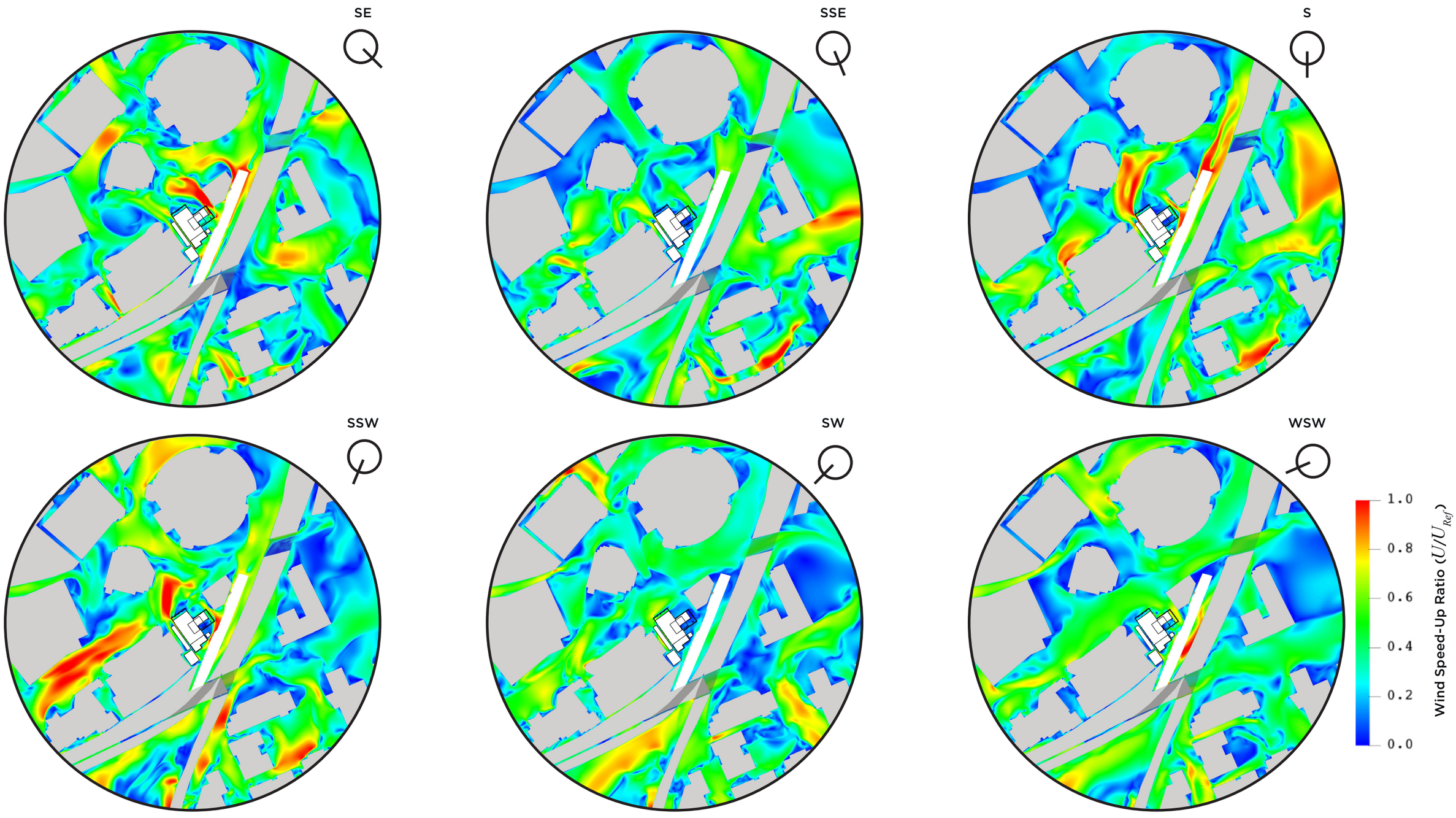




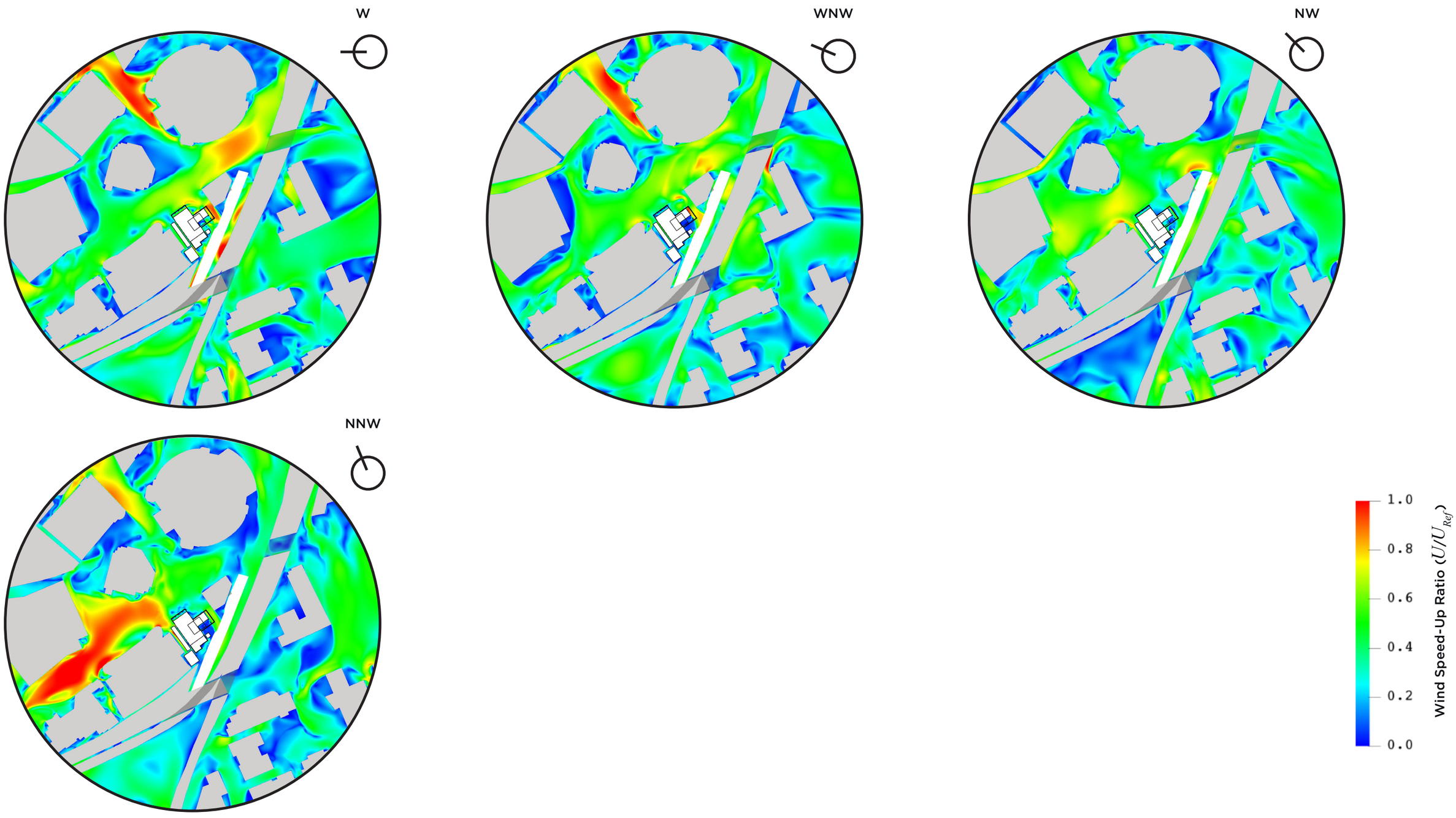
Appendix B - Wind Speed Up Fields - The Proposed Site with Existing Surrounds



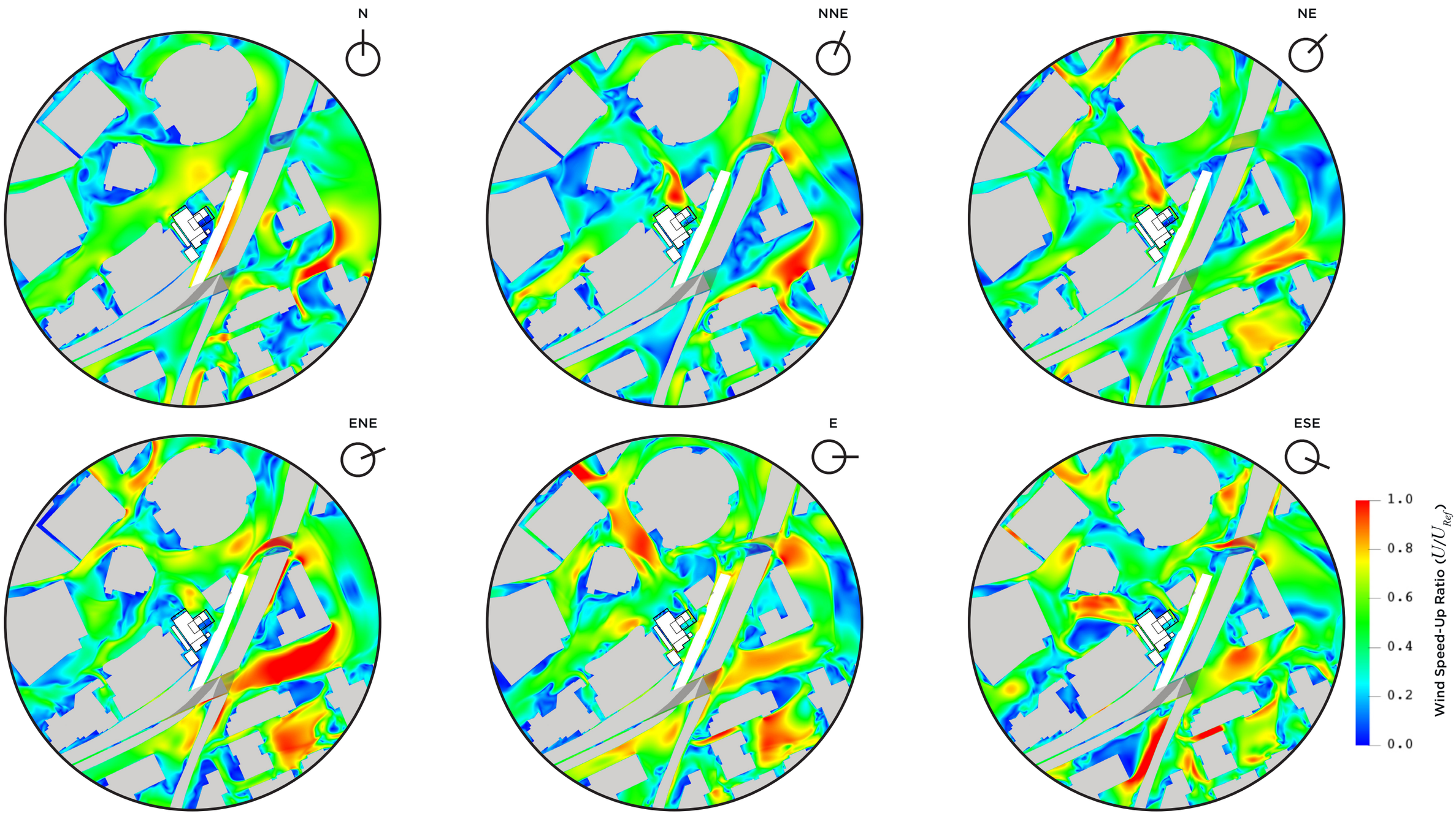
Appendix B - Wind Speed Up Fields - The Proposed Site with Existing Surrounds



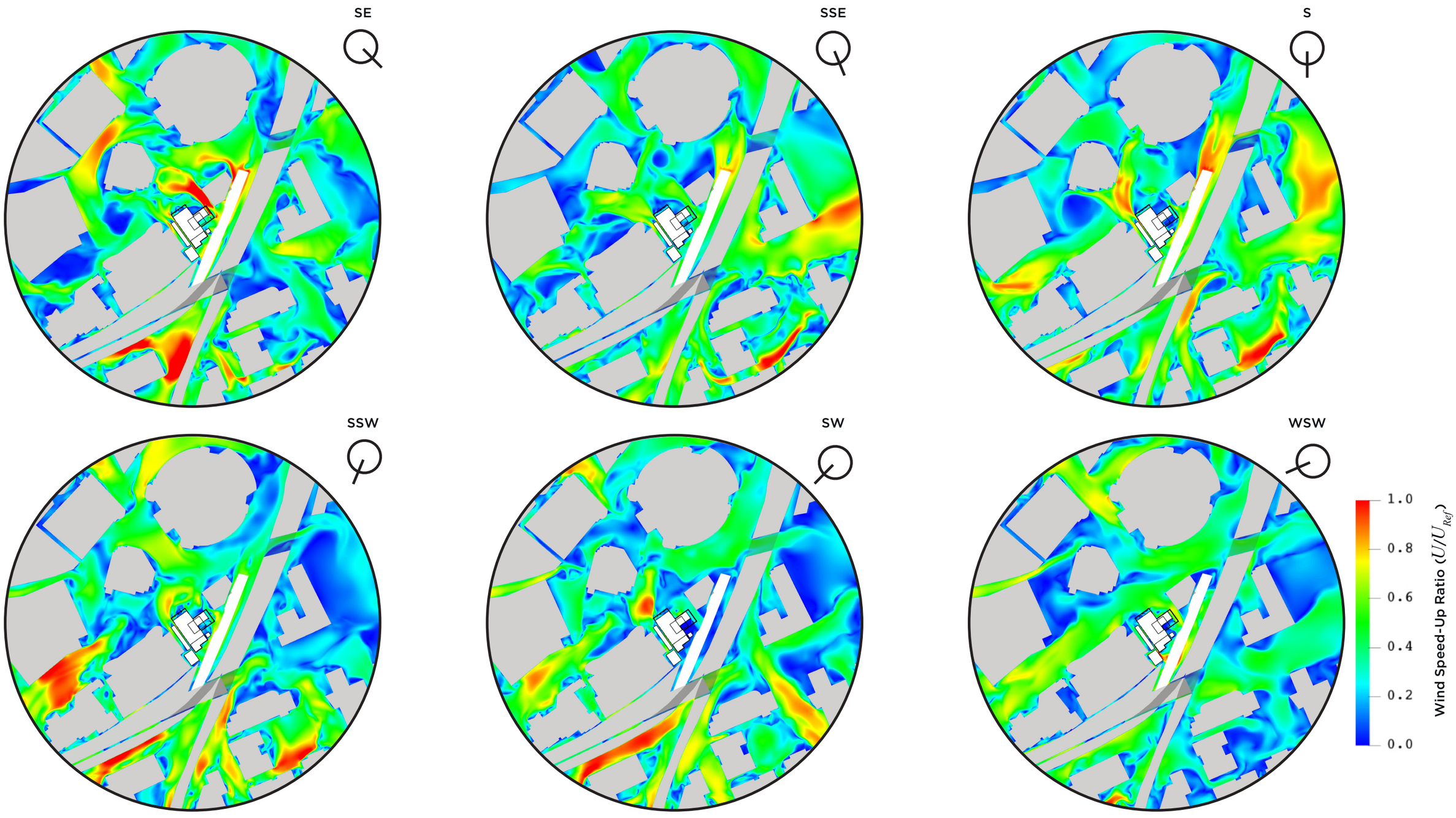
Appendix B - Wind Speed Up Fields - The Proposed Site with Existing Surrounds



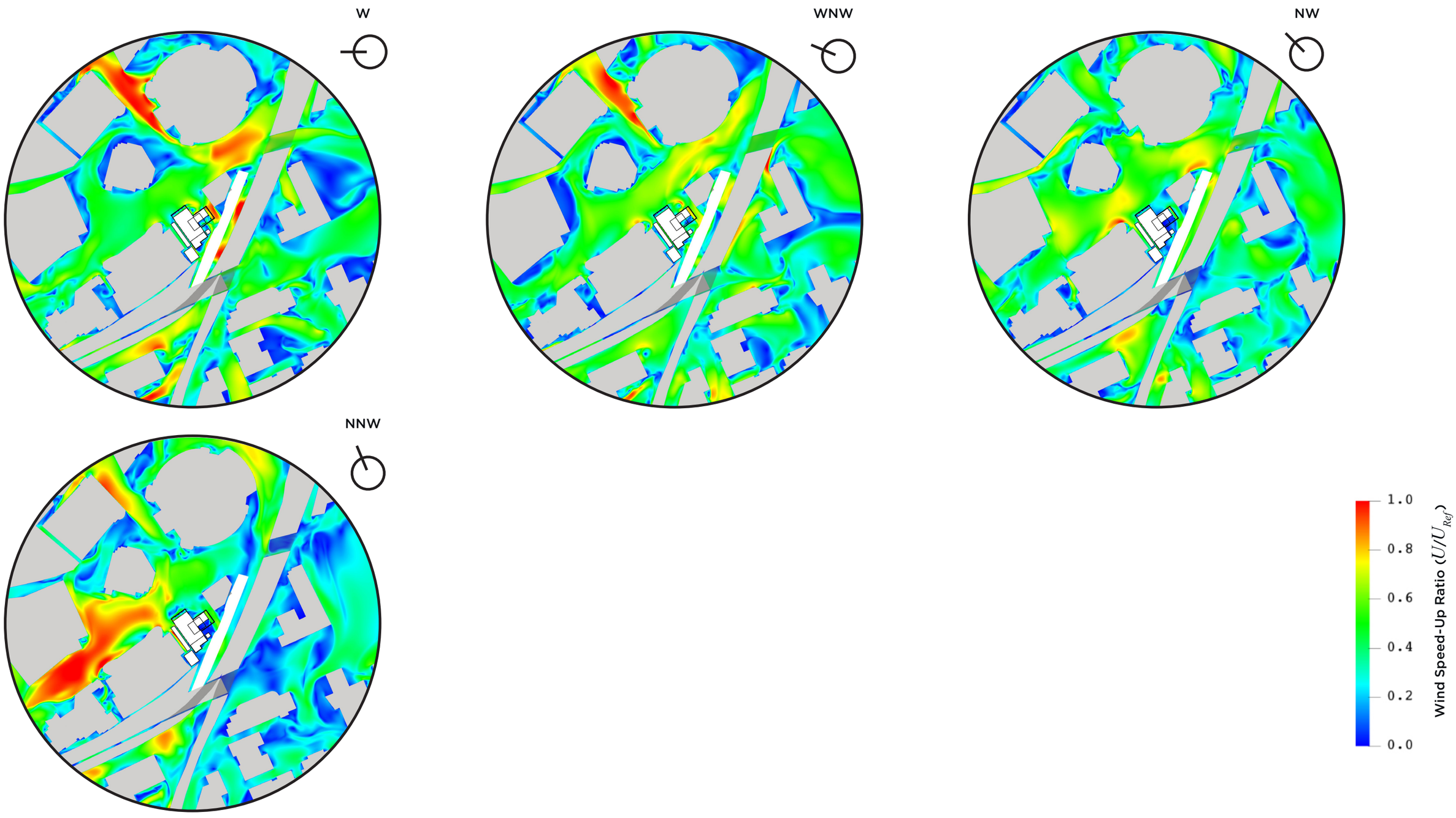
Appendix B - Wind Speed Up Fields - The Proposed Site with Future Surrounds



Appendix B - Wind Speed Up Fields - The Proposed Site with Future Surrounds



Appendix B - Wind Speed Up Fields - The Proposed Site with Future Surrounds



Appendix C

Tested Configurations

Appendix C - Tested Configurations (Existing Site with Existing Surrounds)

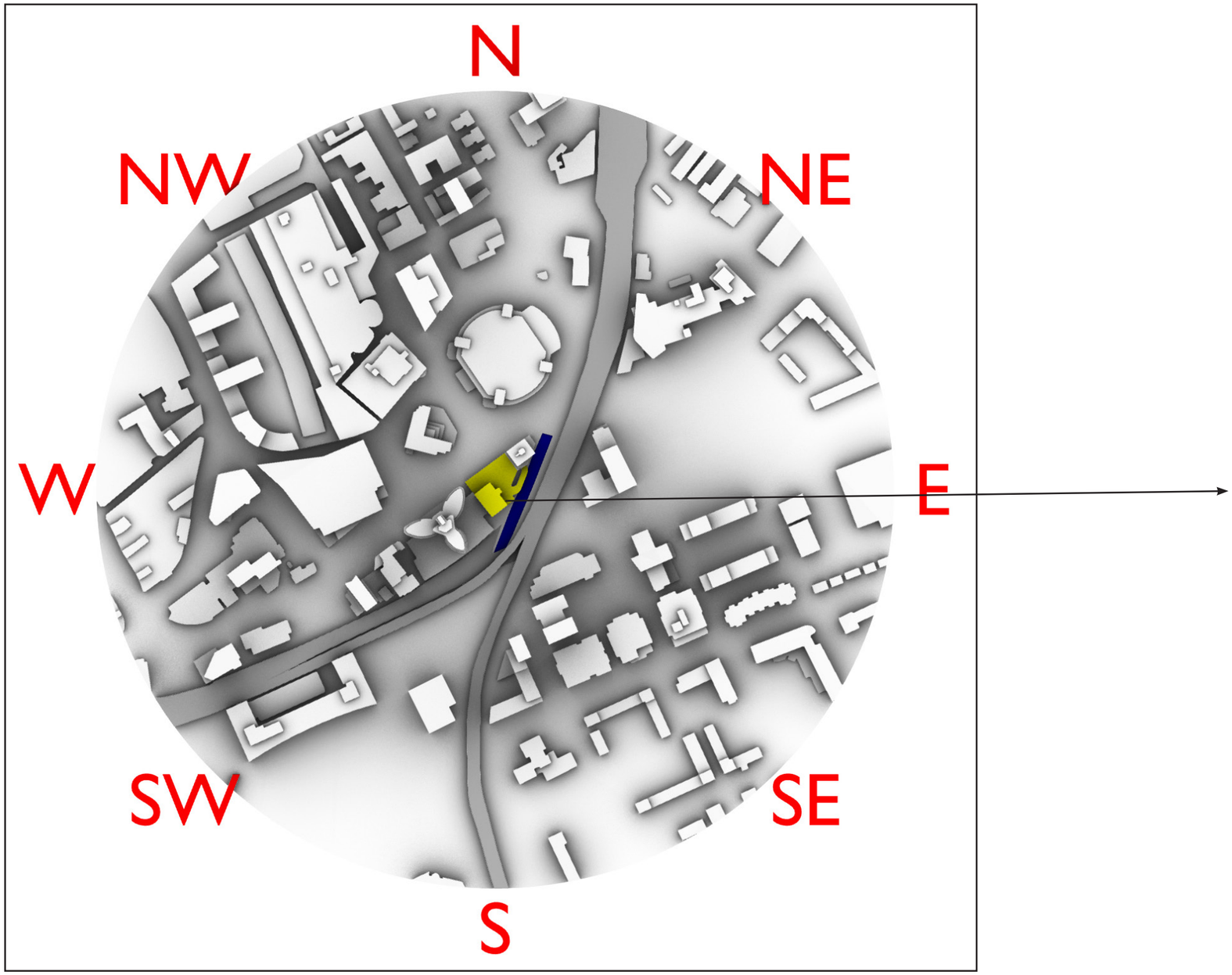
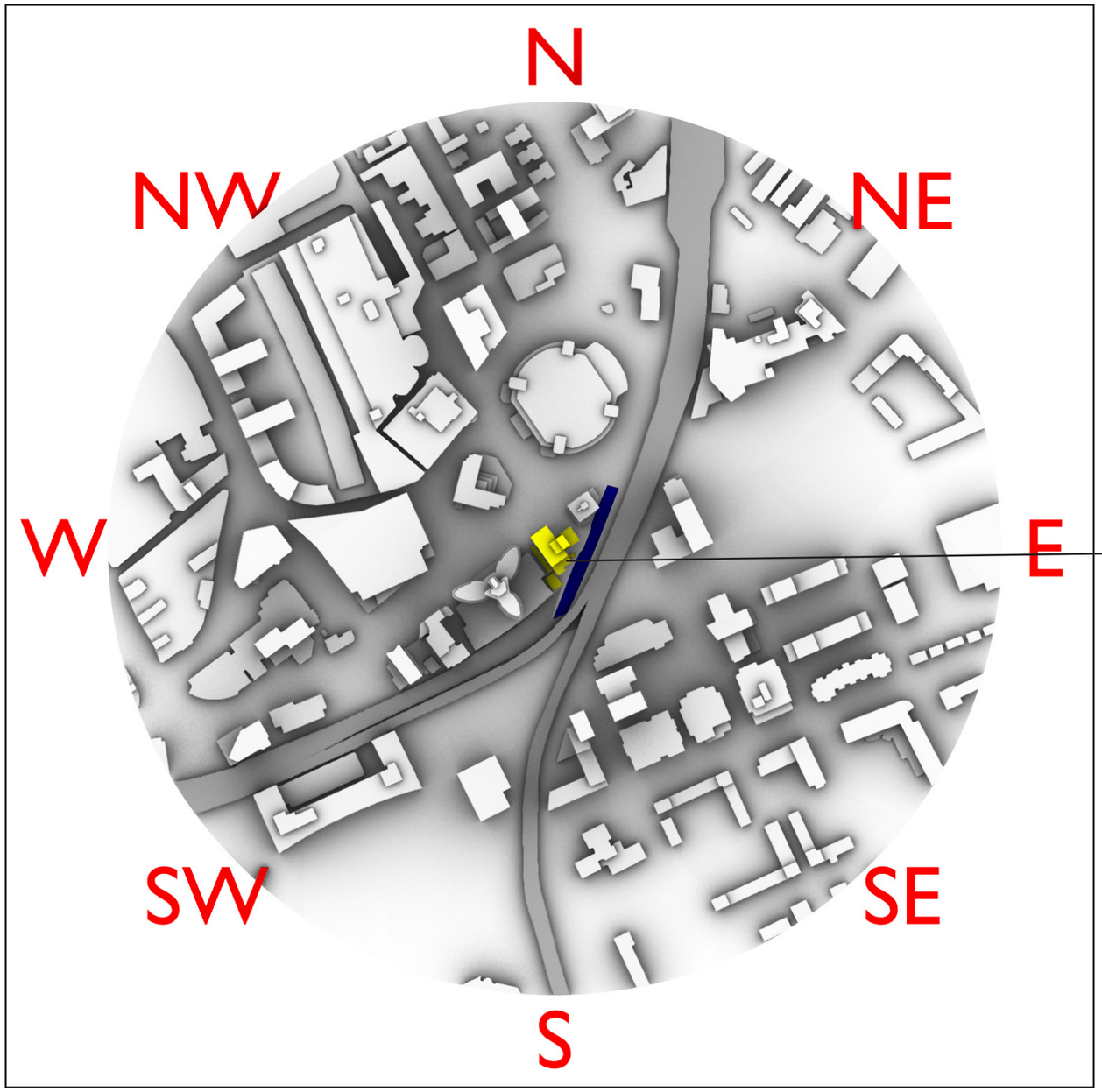


Figure C.1. Existing Site with Existing Surrounding

Appendix C - Tested Configurations (Proposed Site with Existing Surrounds)



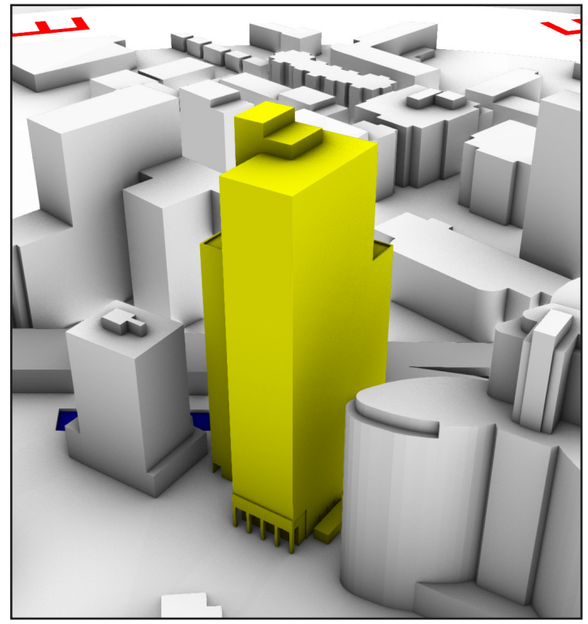
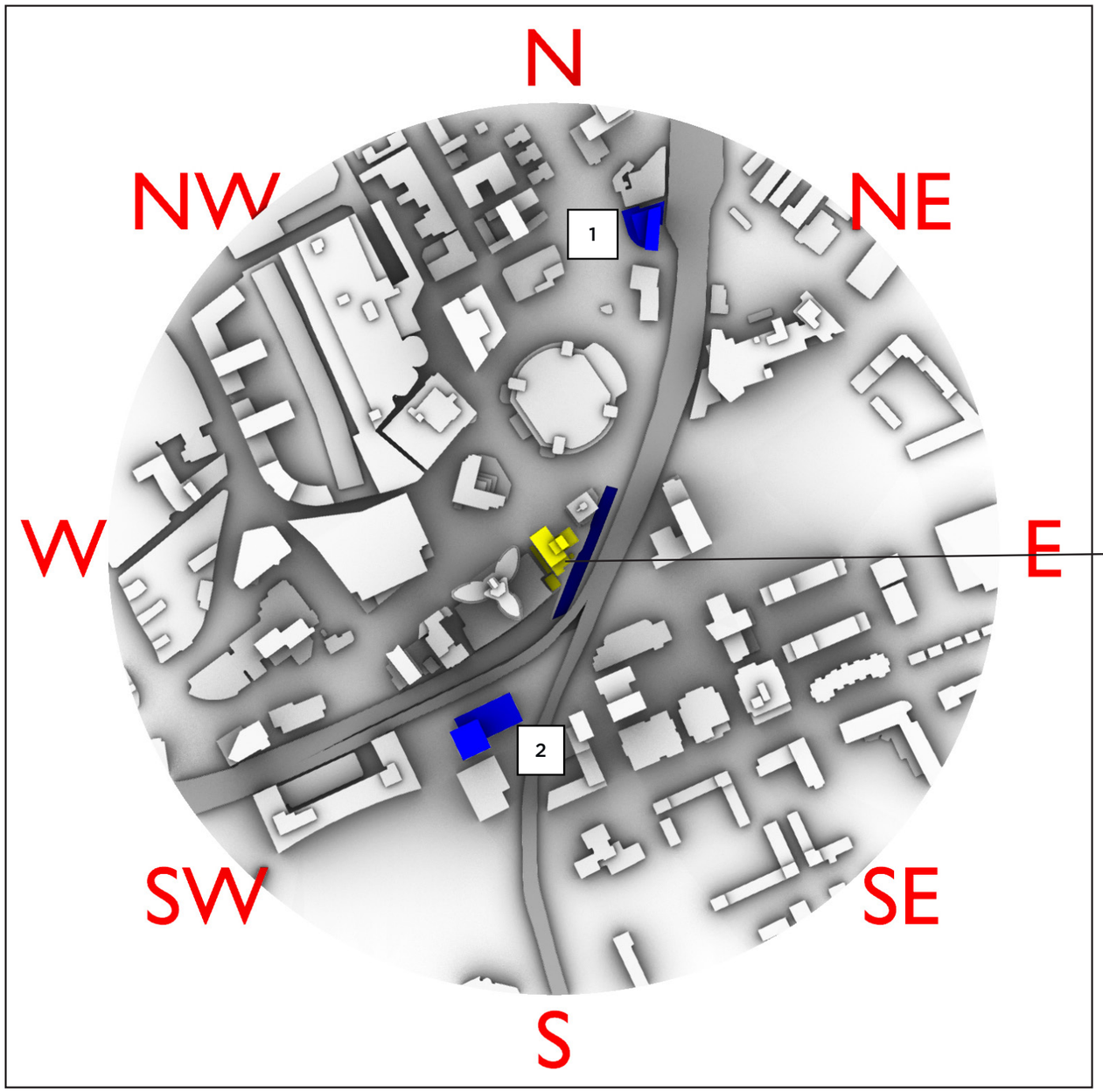


Figure C.2. Proposed Site with Existing Surrounding

Appendix C - Tested Configurations (Proposed Site with Future Surrounds)



1. **Site Of 1-6 Guildford Crescent Cathays Cardiff. (23/00966/NMA)**
2. **Land On The South Side Of John Street Butetown Cardiff. (19/01065/MJR)**

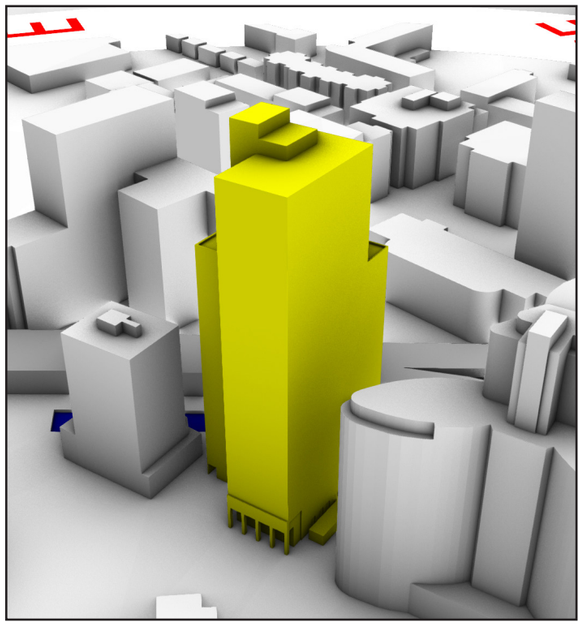


Figure C.3. Proposed Site with Future Surrounding

Appendix D

Recommended Mitigations

Appendix D - Recommended Mitigations

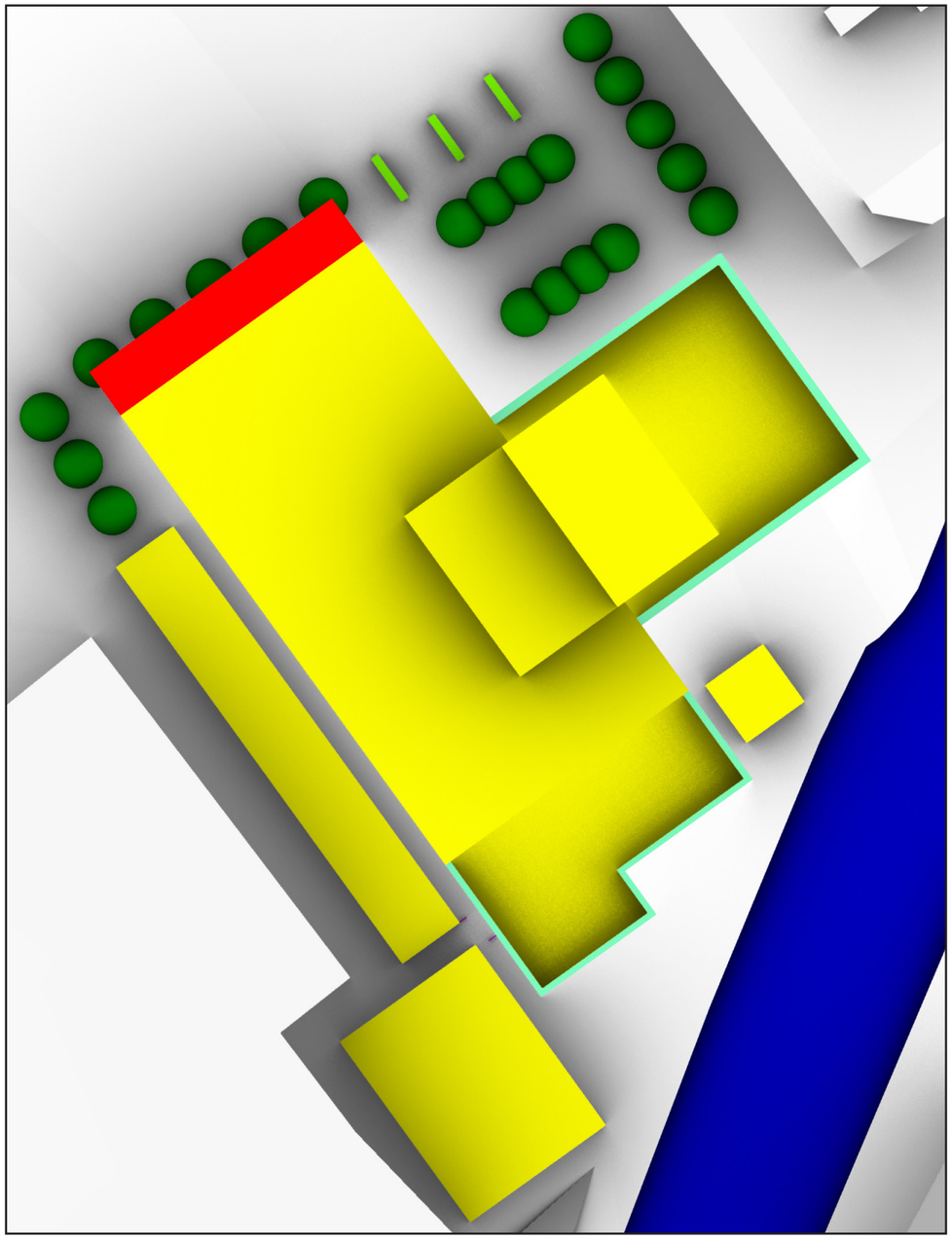
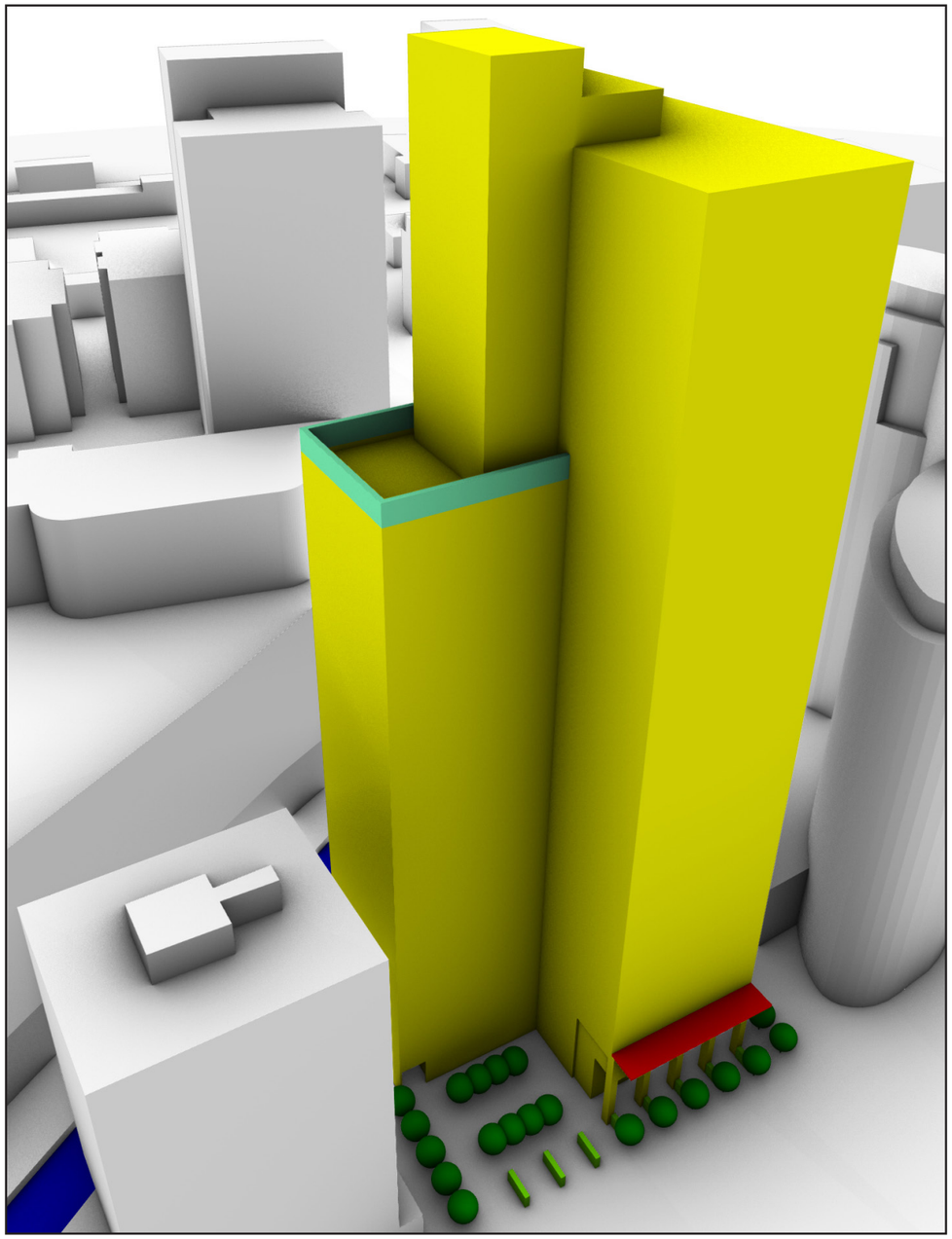


Figure D.4. Plan View

Appendix D - Recommended Mitigations



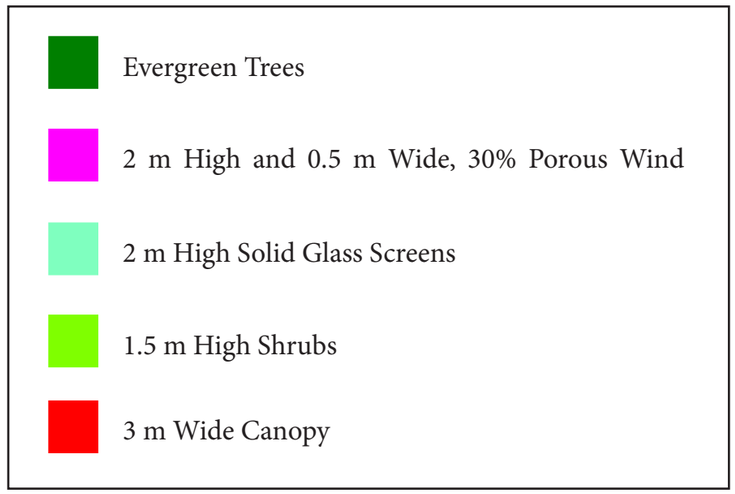
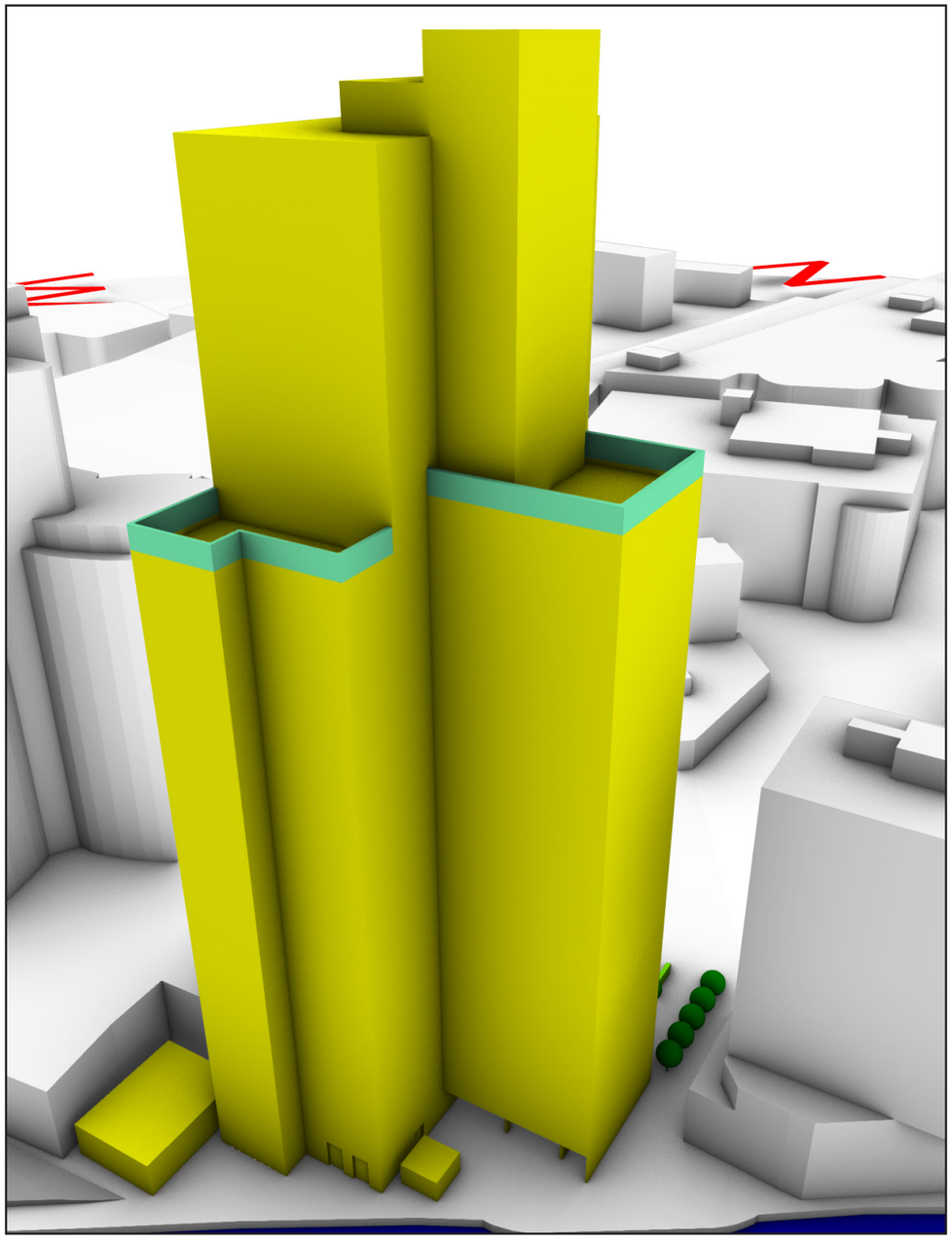


Figure D.5. Northern Aspect

Appendix D - Recommended Mitigations



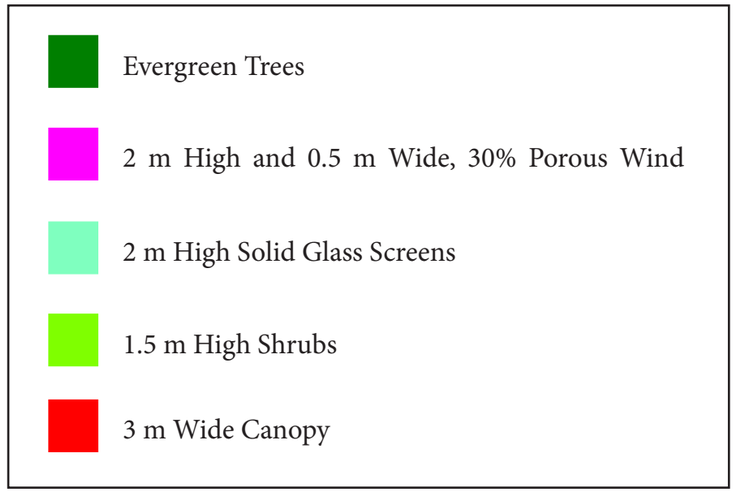
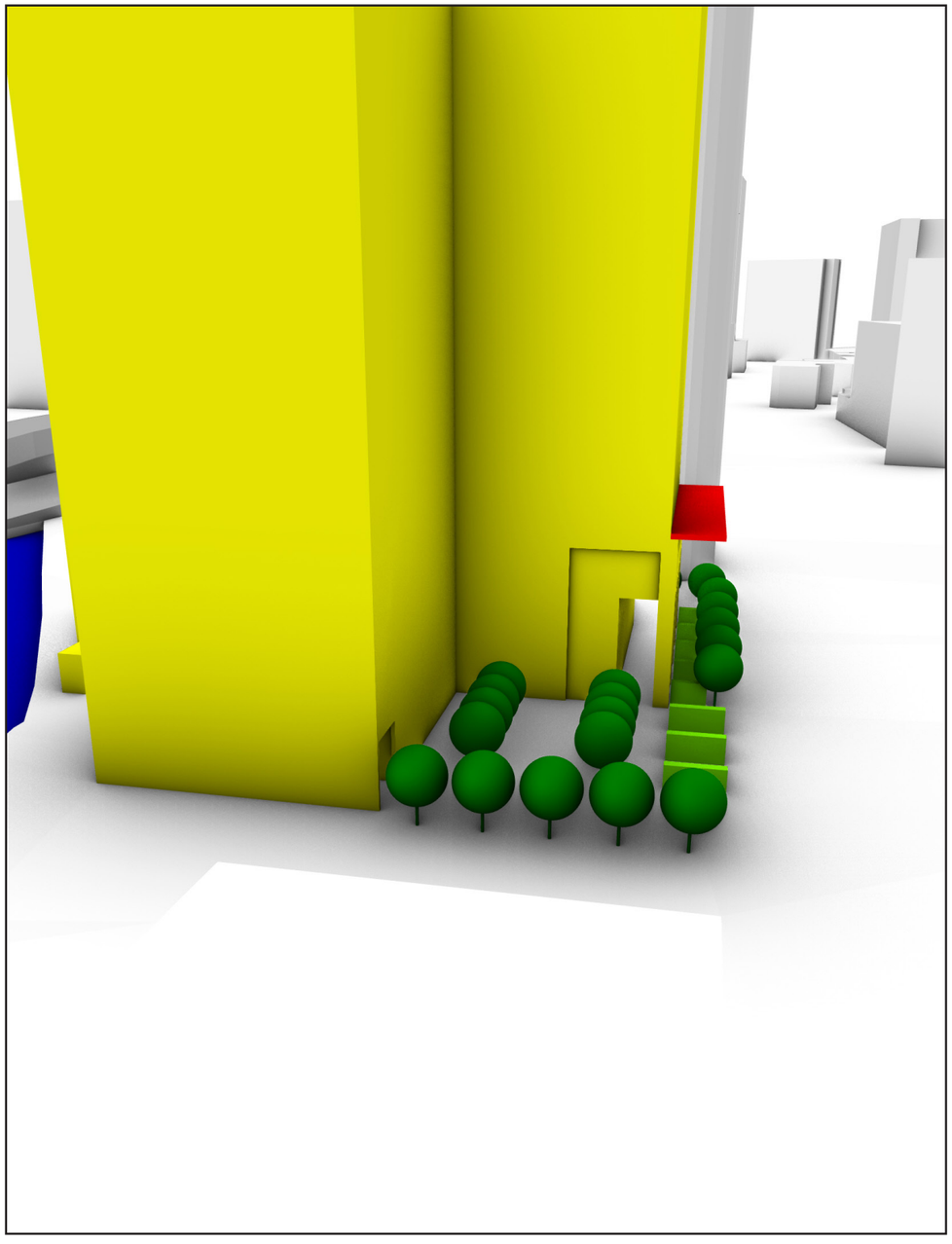


Figure D.6. South-Eastern Aspect

Appendix D - Recommended Mitigations



Evergreen Trees

2 m High and 0.5 m Wide, 30% Porous Wind

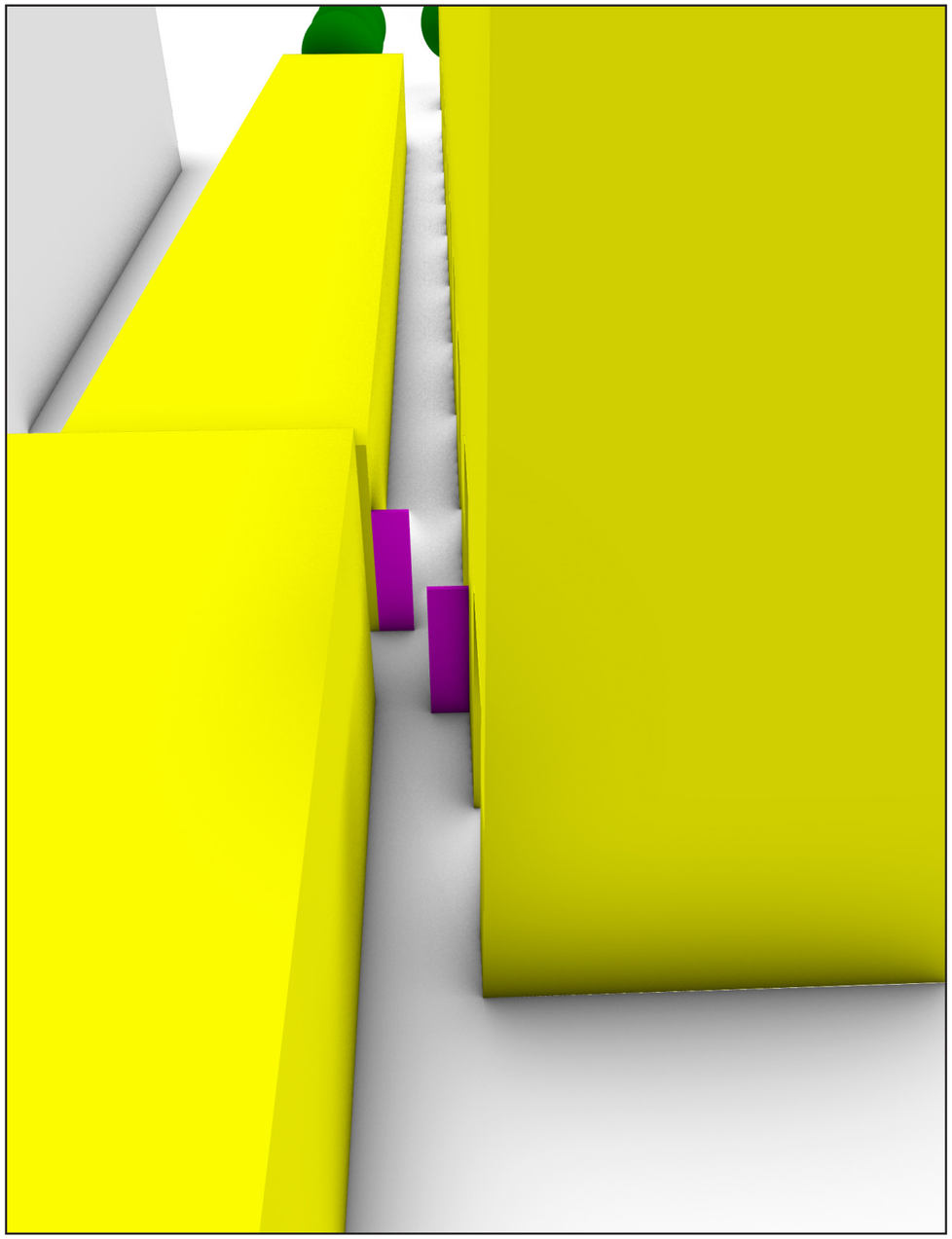
2 m High Solid Glass Screens

1.5 m High Shrubs

3 m Wide Canopy

Figure D.7. North-Eastern Aspect

Appendix D - Recommended Mitigations



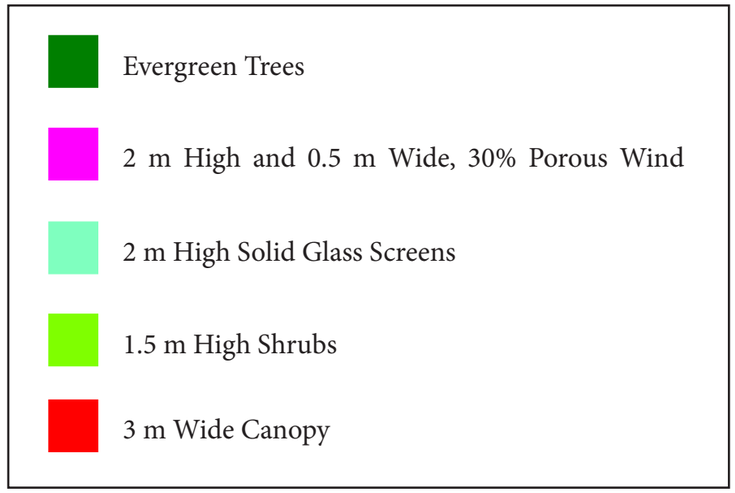


Figure D.8. Southern Aspect