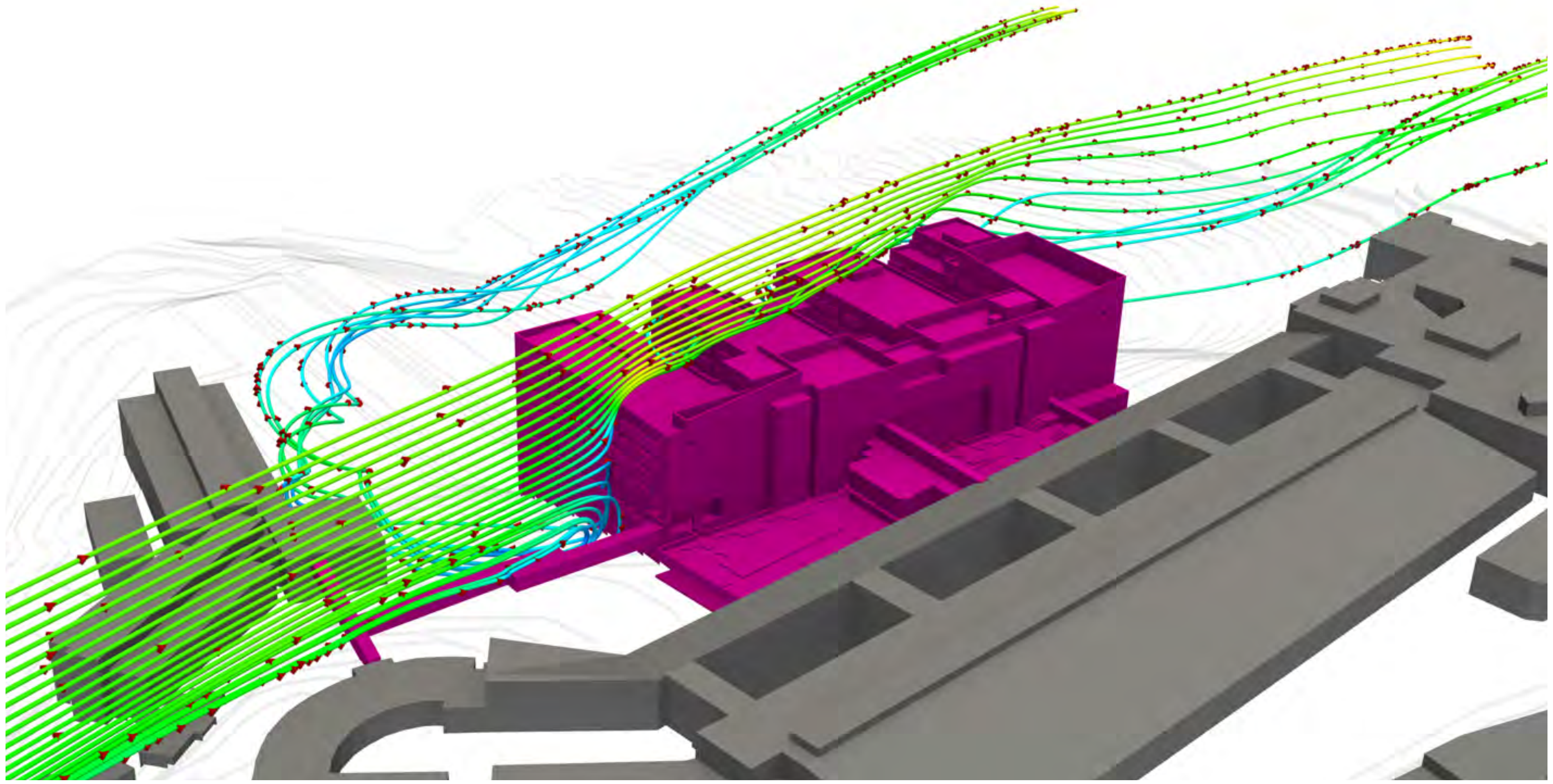
PEDESTRIAN MICROCLIMATE CFD STUDY

JOHN HUNTER HEALTH AND INNOVATION PRECINCT



WF899-01F04(REV5) - WE CFD REPORT
MAY 17, 2021

Prepared for:
Health Infrastructure
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30 YEARS OF EXCELLENCE IN WIND ENGINEERING

Date	Revision History	Non-Issued Revision	Issued Revision	Prepared By (Initials)	Instructed By (Initials)	Reviewed & Authorised By (Initials)
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Executive Summary

Measurements were made in the conducted simulations at trafficable outdoor locations within and around the proposed development from 16 wind directions using a 1:1 scale detailed model. The effect of nearby buildings and land topography has been accounted for through the use of a proximity model, which represents an area within a radius of 400m. The model was based on architectural models, the last of which was received on 11th March 2021.

** Note the model of the development has been tested without the effect of additional forms of wind ameliorating devices, such as screens, balustrades, etc. (Except those already incorporated in the study model). The effect of vegetation within the immediate vicinity of the site was also excluded from the testing.

Presented are results relating to pedestrian amenity, comfort and safety levels for the proposed site and existing site, allowing the impact of the proposed site to be assessed; forming part of the EIA as per SEARS requirement Item 5. Environment Amenity

- Ground level areas across the proposed development are expected to satisfy their respective comfort and safety criteria with the inclusion of the following mitigation measures:
  - Retention and/or inclusion of evergreen trees to the east and west of the proposed site.
  - Inclusion of screens at the east and west entrances of the ground level entrance area at the southern entrance of the proposed site.
- The elevated garden area is expected to satisfy its respective comfort and safety criteria with the inclusion of the following mitigation measures:
  - Retention and/or inclusion of evergreen trees and placement of a canopy across the western elevated garden.
  - Inclusion of impermeable screens on the western balustrades.
- The top level rooftops are understood to be for maintenance and emergency service personal only, and as such are predicted to be suitable for their intended use with no mitigation measures necessary, albeit with safety consideration given to their use during strong wind events.

With the inclusion of the aforementioned mitigation measures, all ground level and elevated areas within and around the proposed site are predicted to be suitable for their intended use cases.

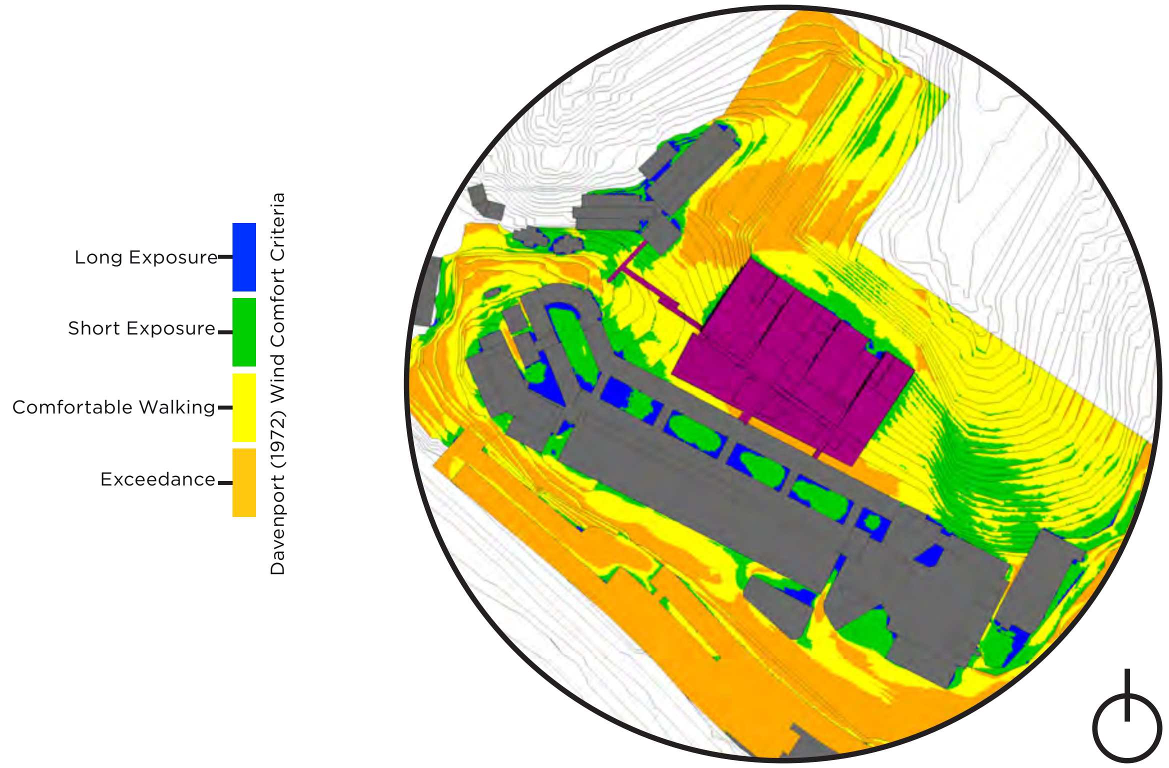

Figure i. Davenport (1972) Comfort Contours for Proposed Site, Annual Condition

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1. Introduction

This assessment has been prepared by WINDTECH Consultants to assess wind microclimate issues around the Proposed Development located in Newcastle, New South Wales.

Overview

In June 2019, the NSW Government announced a significant expansion of the John Hunter and John Hunter Children's Hospitals with the $780 million John Hunter Health and Innovation Precinct (JHHIP) project.

The JHHIP will transform healthcare services for Newcastle, the greater Hunter region and northern NSW communities. The infrastructure will provide additional inpatient capacity to the John Hunter and John Hunter Children's Hospitals and create further opportunities for partnerships with industry and higher education providers.

The JHHIP will deliver an innovative and integrated precinct with industry-leading facilities working in collaboration with health, education and research partners to meet the current and future needs of the Greater Newcastle, Hunter New England and Northern NSW regions.

The John Hunter Health and Innovation Precinct Project is being planned and designed with ongoing communication and engagement with clinical staff, operational staff, the community and other key stakeholders with a strong focus on the following:

- Patient-centred care
- Contemporary models of care
- Future economic, health and innovation development opportunities
- Environmental sustainability

Description of the Proposed Development

The John Hunter Health Campus (JHHC) is located on Lookout Road, Lambton Heights, within the City of Newcastle Local Government Area (LGA), approximately 8km west of the Newcastle CBD. The hospital campus is located approximately 3.5km north of Kotara railway station.

The JHHC comprises the John Hunter Hospital (JHH), John Hunter Children's Hospital (JHCH), Royal Newcastle Centre (RNC), the Rankin Park Rehabilitation Unit and the Nexus Unit (Children & Adolescent Mental Health). JHHC is a Level 6 Principal Referral and tertiary Hospital, providing the clinical hub for medical, surgical, child and maternity services within the Hunter New England Local Health District (HNELHD) and across northern NSW through established referral networks. Other services at the campus include the Hunter Medical Research Institute (HMRI), Newcastle Private Hospital and the HNELHD Headquarters.

SSDA Proposal

Approval is being sought for a new Acute Services Building and refurbishment of existing hospital facilities at John Hunter Hospital comprising:

- Construction and operation of a new seven-storey Acute Services Building (plus 4 semi-basement levels) to provide:
  - An expanded and enhanced Emergency Department;
  - Expanded and enhanced medical imaging services;
  - Expanded and enhanced intensive care services - Adult, Paediatric and Neonatal;
  - Expanded and enhanced Operating Theatres including Interventional Suites;
  - An expanded Clinical Sterilising Department;
  - Women's Services including Birthing Unit, Day Assessment Unit and Inpatient Units;
  - Integrated flexible education and teaching spaces;
  - Expanded support services;
  - Associated retail spaces;
  - New rooftop helipads;
  - New semi-basement car parking;
- Refurbishment of existing buildings to provide:
  - Additional Inpatient Units;
  - Expanded support services;
- A new Hospital entry canopy and works to the existing drop off;
- Link bridge to the Hunter Medical Research Institute (HMRI);
- Campus wayfinding and signage;
- Landscape works;
- Site preparation including bulk earthworks, tree removal, environmental clearing, cut and fill;
- Mines grouting remediation works;
- Construction of internal roads network and construction access roads and works to existing at-grade carparking;
- Connection to the future Newcastle Inner City Bypass; and
- Inground building services works and utility adjustments.

SEARS Requirement

This report comprises of the wind impact assessment, via CFD, as per the SEARS requirement: "Item 5. Environment Amenity" which will be included within the EIS. The impact of the proposed development has with regards to the surrounding site with regards to pedestrian amenity, comfort and safety is considered and detailed herein.

Scope of the CFD Study

Simulations of the wind microclimate were conducted to quantitatively assess the effect of the Proposed Development on pedestrian amenity, comfort and safety levels in and around the Site.

Wind speed contour plots representing the local wind speed-up ratios are derived from the simulations and are combined with a statistical model of the regional wind climate. These wind speed-up ratios are then used in the calculation of the Davenport criteria (1972) for pedestrian wind comfort and safety.

In total, two surrounds configurations were tested in the simulations, which are as follows:

1. Existing
2. Proposed - inclusive of the development of new acute services building (Figure 1)

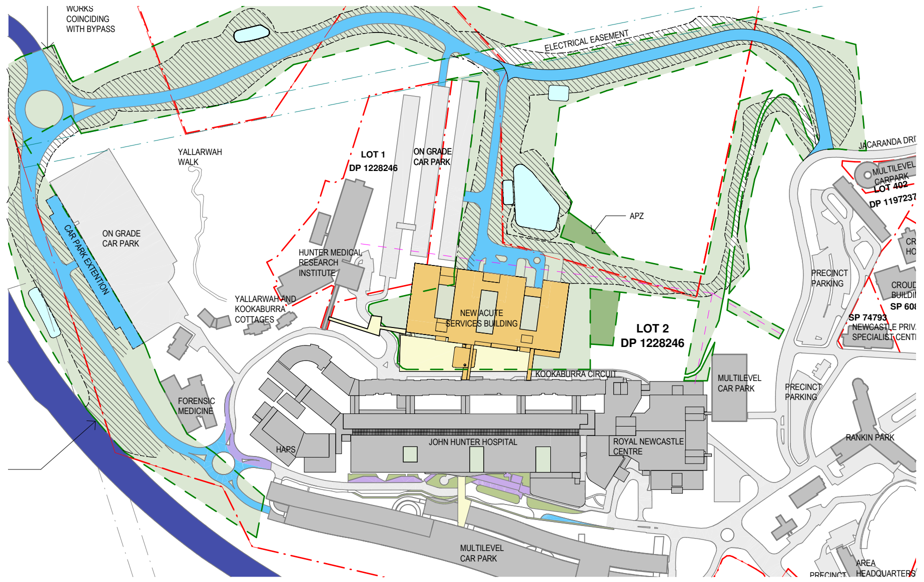

Figure 1. Proposed Site (based on drawings received 11/03/2021)

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 other researchers, such as A.G. Davenport, T.V. Lawson, W.H. Melbourne, A.D. Penwarden, etc., Have published criteria for pedestrian comfort for pedestrians in outdoor spaces for various types of activities.

Wind Speed Criteria Used for this Study

For this study the measured wind conditions of the trafficable areas are compared against the Davenport Criteria for pedestrian comfort and the Melbourne Criteria for pedestrian safety.

For pedestrian comfort the A.G. Davenport (1972) criteria is used in conjunction with the GEM wind speed using a 5% probability of exceedance. Research by A.W. Rofail (2007) has shown that the A.G. Davenport (1972) criteria, when used in conjunction with a GEM wind speed, has proven over time and through field observations to be a reliable indicator of pedestrian comfort. The Davenport comfort criteria are outlined in Table 1. With colour scales used for comfort contours shown in Figure 2.

For pedestrian safety the W.H. Melbourne (1978) criteria is used in conjunction with the annual maximum peak wind speed using a 0.1% probability of exceedance that a wind speed of 23m/s is exceeded. The Melbourne safety criteria are outlined in Table 2. With colour scales used for safety contours shown in Figure 2.

Classification	Description	Maximum 5% Exceedance GEM Wind Speed (m/s)
Long Exposure	Long duration stationary activities such as in outdoor restaurants and theatres, etc.	< 3.5m/s
Short exposure	Short duration stationary activities (generally less than 1 hour), including window shopping, waiting areas etc.	< 5.5m/s
Comfortable Walking	For pedestrian thoroughfares, private swimming pools, most communal areas, private balconies and terraces etc.	< 7.5m/s

Table 1. Comfort Criteria (A.G. Davenport, 1972)

Classification	Activities	Annual Maximum Gust Wind Speed (m/s)
Unsafe	Presents a safety risk to all members of the public	23m/s

Table 2. Safety Criterion (W.H. Melbourne, 1978)

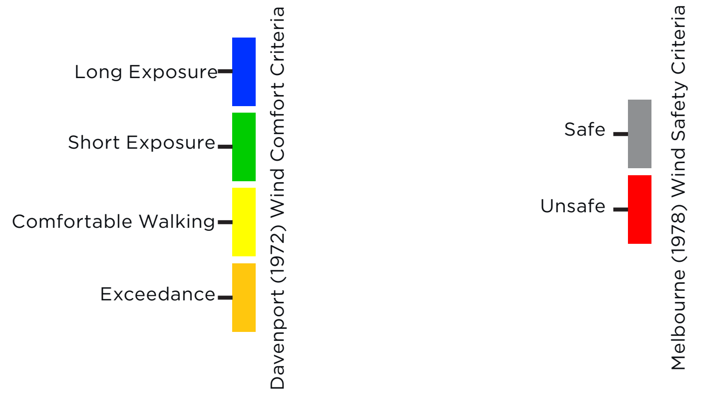

Figure 2. Davenport (1972) and Melbourne (1978) comfort and safety criteria contours used in this study

3. CFD Methodology

Numerical Setup

The numerical modelling was conducted using the HELYX 3.2.1 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 3 below.

Solver	Coupled
Formulation	Implicit
Time	Steady
Operating Conditions	Pressure
Viscous Model	Realizable K-Epsilon (2 Equation) 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 3. CFD Simulation Setup

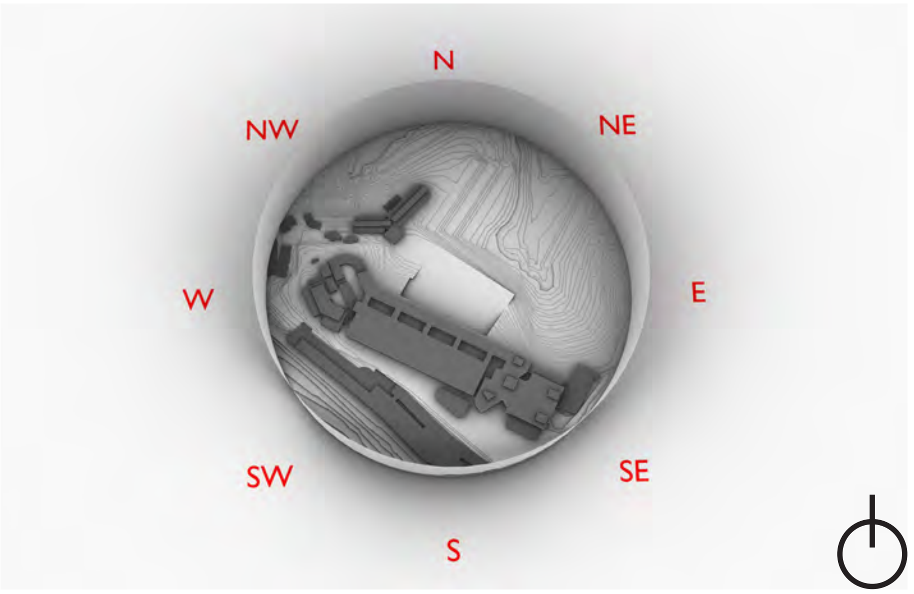

Figure 3. Computational Domain (Existing Site)

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 200 meters (accounting for 4 times the height of the tallest building within the domain) and a radius of 400 meters was generated, as shown in Figure 3 and Figure 4 The side walls of the computational domain were used as the computed inlet and outlet for the boundary layer input. In total, 16 wind directions were analysed across the seasonal cases for this study for each site configuration.

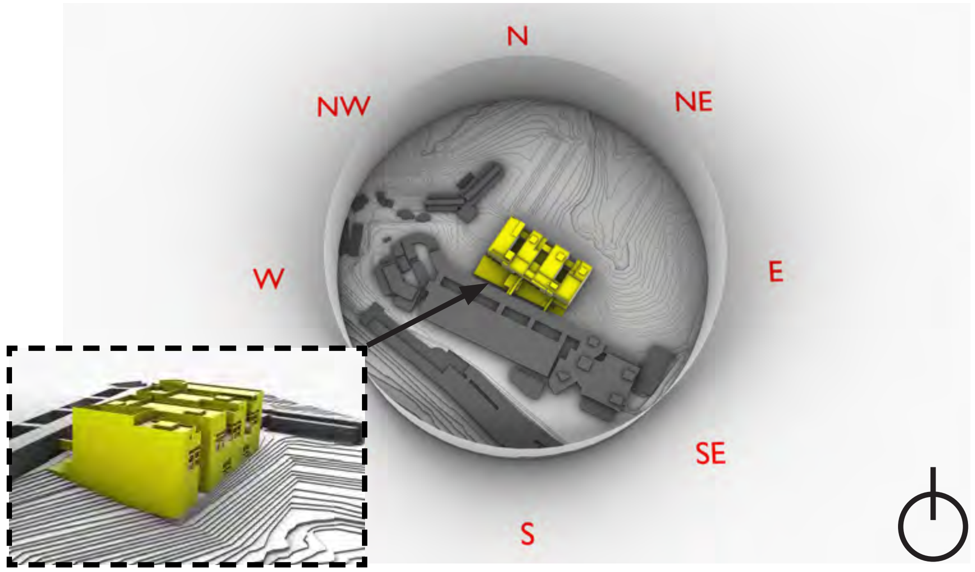

Figure 4. Computational Domain (Proposed Site)

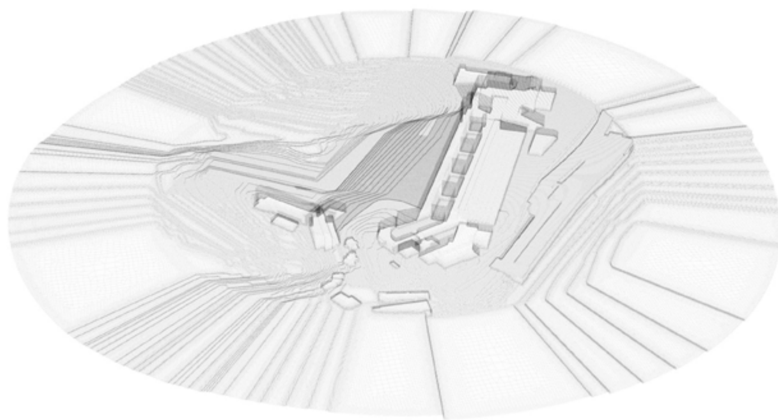

Figure 5. Computational Grid (Existing Site)

The surface roughness of the outer ground boundary was set to model the effect of the vegetation which surrounds the site. The surface roughness is based on the description for vegetation as described in AS1170.2:2011.

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 result are summarised in Table 4 and Table 5 below. G2 was taken for use in order to maximise computational efficiency.

Grid	Element	Base Mesh Size (m)	Cell Count (x10E6)
G1	Hexahedral	26	43.4
G2	Hexahedral	28	40.1

Table 4. Grid Properties for domains tested

Grid	G1 Velocity Magnitude (m/s)	G2 Velocity Magnitude (m/s)	Percentage Difference (%)
G1	5.6	5.5	1.2
G2	8.0	7.8	1.9

Table 5. Grid Independence Results for this Study

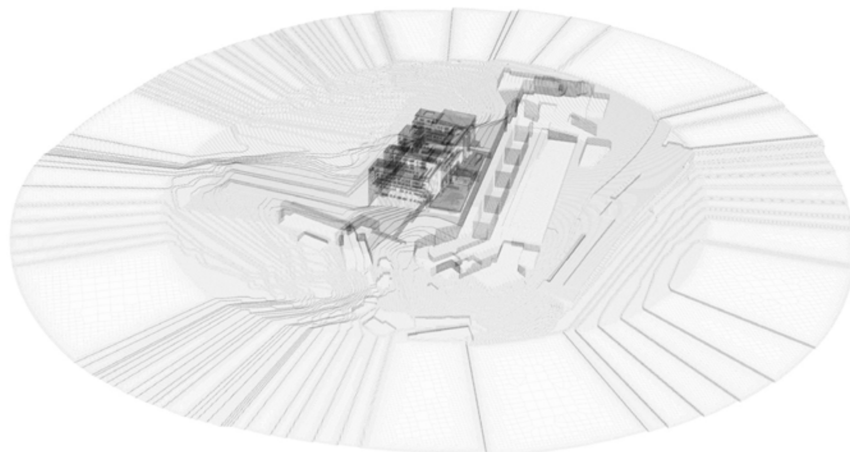

Figure 6. Computational Grid (Proposed Site)

4. Meteorological Data for Newcastle

Meteorological Data

Details of the wind climate of the Newcastle region have been determined from a detailed statistical analysis of measured mean wind speed data from Williamtown RAAF, 55 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 corrected data is summarised in Table 6 for the estimated weekly and annual return periods in the form of hourly means and the corresponding 3-second gust values. These directional wind speeds are also presented in Figure 10 (referenced as hourly mean wind speeds) for the Newcastle Region. The directional frequency of occurrences of the regional winds is also shown in Figure 7. The data indicate that the maximum wind speeds for the region are from the west-north-west. Additionally, the most frequent winds for the region occur from the north and western quadrants.

Wind Direction	Hourly Mean (Weekly Recurrence) (m/s)	3 - Second Gust (Weekly Recurrence) (m/s)	Hourly Mean (Annual Recurrence) (m/s)	3-Second Gust (Annual Recurrence) (m/s)
N	3.4	5.2	6.2	9.5
NNE	4.5	6.9	7.3	11.2
NE	6.5	9.9	9.3	14.1
ENE	7.7	11.7	10.0	15.3
E	6.8	10.3	9.8	14.9
ESE	7.1	10.8	9.6	14.7
SE	7.1	10.8	10.5	16.1
SSE	7.6	11.6	10.4	15.9
S	8.3	12.6	11.5	17.5
SSW	7.7	11.7	11.6	17.8
SW	5.6	8.5	10.4	15.9
WSW	5.1	7.8	10.1	15.4
W	7.9	12.1	12.6	19.2
WNW	11.4	17.4	15.6	23.8
NW	7.8	11.9	13.1	19.9
NNW	3.9	5.9	7.8	11.9

Table 6. Directional Mean and Gust Wind Speeds for the Newcastle Area

Approaching Wind Speeds

The approaching wind terrain category was assessed using the terrain descriptions from International Standard Wind Actions on structure (ISO 4354) using the AS/NZS1170.2:2011 boundary layer transition method. For winds occurring from all directions modelled, the terrain was assessed to be a Suburban Terrain (Terrain Category 3). The approaching terrain profiles were combined with the local wind climate described in Table 6 to determine the site wind speeds. These are presented in Table 7 for the dominant wind directions and are used to determine the inputs conditions for the CFD simulations

The site hourly mean wind speeds are used when determining the speed-up 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 double that of the inlet condition. Speed up contours for both the existing and proposed site can be found in Appendix A.

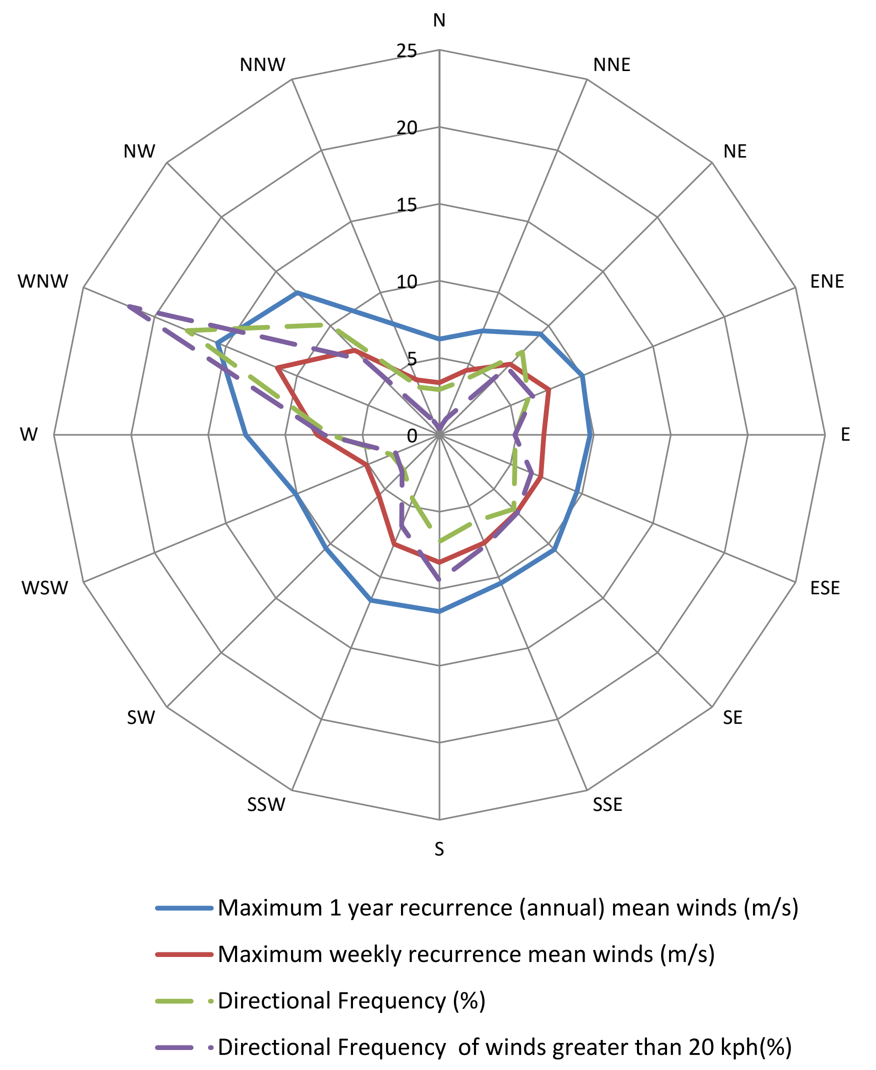

Figure 7. Annual and Weekly Recurrence Mean Wind Speeds, and Frequencies of Occurrence, for the Newcastle Area (Corrected to open terrain at 10m)

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)
WNW	III, 3	15.6	11.2
SSW	III, 3	11.6	8.4
E	III, 3	9.8	7.0

Table 7. Hourly Mean Site Wind Speeds for dominant wind directions

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5. Results and Discussion

Annual Davenport Wind Comfort Criteria Fields - Ground Level Areas

Observations

Between the existing and proposed scenarios, some changes in the pedestrian comfort conditions are observed for the Annual Wind Comfort Criteria (Figures 8 and 9) for the ground plane trafficable areas.

The inclusion of the proposed site (Acute Services Building) leads to a variation in wind comfort conditions; particularly to the north of the existing main John Hunter Hospital Building, on the ground plane.

A. Winds are redirected around the proposed site leading to an increase in wind speeds at the site's northern corners due to corner acceleration. This is particularly prevalent around the north-western corner of the proposed site which results in a large area unsuitable for comfortable walking activities predicted. This area covers the southern end of the car park between the proposed site and the existing buildings to the north-west. This is due to corner acceleration seen when the site is exposed to prevailing north-westerly winds. If this area is intended as a trafficable area to the general public mitigation is recommended here, see Section 6.

B. Corner acceleration is also seen around the north-eastern corner of the proposed development leading to a small region unsuitable for comfortable walking activities when the site is exposed to easterly winds. If this area is intended as a trafficable area to the general public mitigation is recommended here, see Section 6.

C. Funnelling effects are predicted in the area between the proposed development and the existing main hospital building to the south, this results in an area exceeding the comfort criteria. Mitigation is recommended here, see Section 6.

D. Conditions in the sheltered courtyards within the main hospital are predicted to be suitable for short exposure activities. These areas are expected to be suitable for their intended use.

E. Conditions to the south of the main hospital site are relatively unchanged with the inclusion of the proposed development. Wind speeds here are predicted to make conditions unsuitable for comfortable walking activities; this is primarily due to the exposure of the site and the flow accelerating as it climbs up the topography. However, note that these conditions are not impacted by the inclusion of the proposed development.

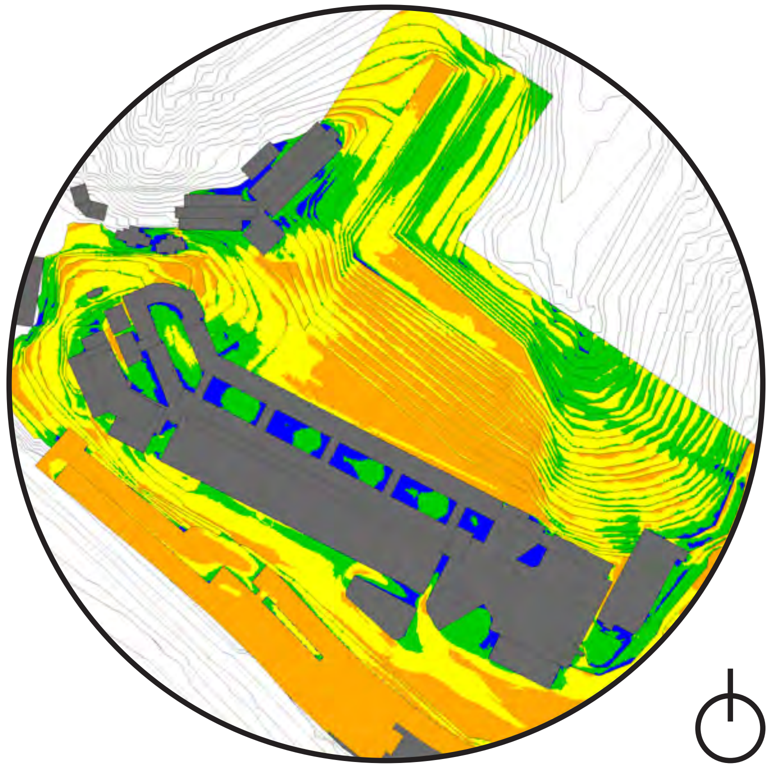


Figure 8. Davenport (1972) Comfort Contours for Existing Site, Annual Condition

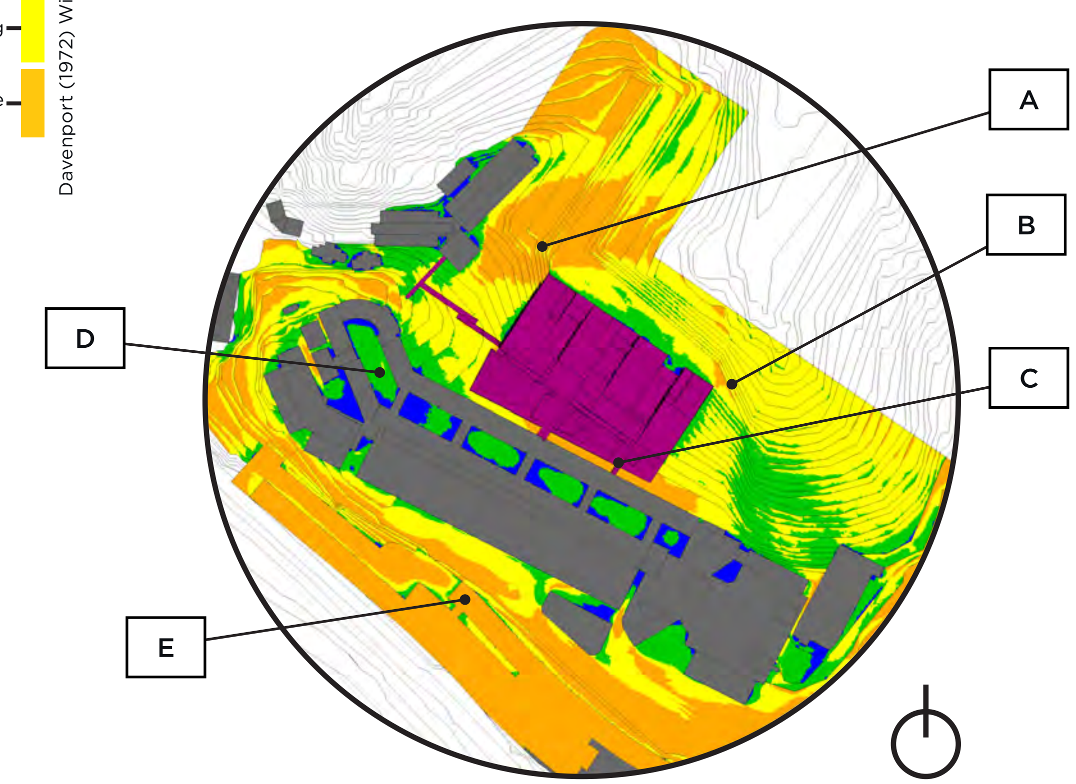


Figure 9. Davenport (1972) Comfort Contours for Proposed Site, Annual Condition

5. Results and Discussion
Annual Melbourne Wind Safety Criteria Fields - Ground Level Areas

Observations

Between the existing and proposed scenarios, some changes in the pedestrian comfort conditions are observed for the Annual Wind Safety Criteria (Figures 10 and 11) for the ground plane trafficable areas.

The inclusion of the proposed site (Acute Services Building) leads to a variation in wind safety conditions; particularly to the north of the existing main John Hunter Hospital Building, on the ground plane.

A. Winds are redirected around the proposed site leading to an increase in wind speeds at the site's corners due to corner acceleration. This is particularly prevalent around the northern corner of the proposed site which results in an area failing the safety criterion. This area covers the southern end of the car park between the proposed site and the existing buildings to the north-west. This is likely due to the effect of corner acceleration seen when the site is exposed to prevailing north-westerly winds. If this area is intended as a trafficable area to the general public mitigation is recommended here, see Section 6.

B. A small region failing the safety criterion is found at the south-east of the proposed site. This is likely an effect of easterly winds accelerating up over the topography and accelerating into the sheltered region downstream. Mitigation is recommended here, see Section 7.

C. Gusts exceeding the safety limit are predicted between existing buildings across the site for both the existing and proposed cases, these are primarily due to funnelling effects. The blockage from the inclusion of the proposed building improves the wind conditions to the east of the existing site (C*).

D. An area to the south of the main hospital site is predicted to exceed the safety criterion for the cases with and without the proposed development. This area covers the car park to the south of the main site. This area is exposed to incoming north-westerly winds which have accelerated around the corner of the main site. Wind speeds throughout this area are on the threshold of becoming passing into the unsafe criterion for both cases analysed, leading to a larger unsafe area predicted for the proposed case. Therefore the increase in safety risk here can be taken to be within the error bounds of a CFD study. Note that these conditions are not thought to be greatly impacted by the inclusion of the proposed development.

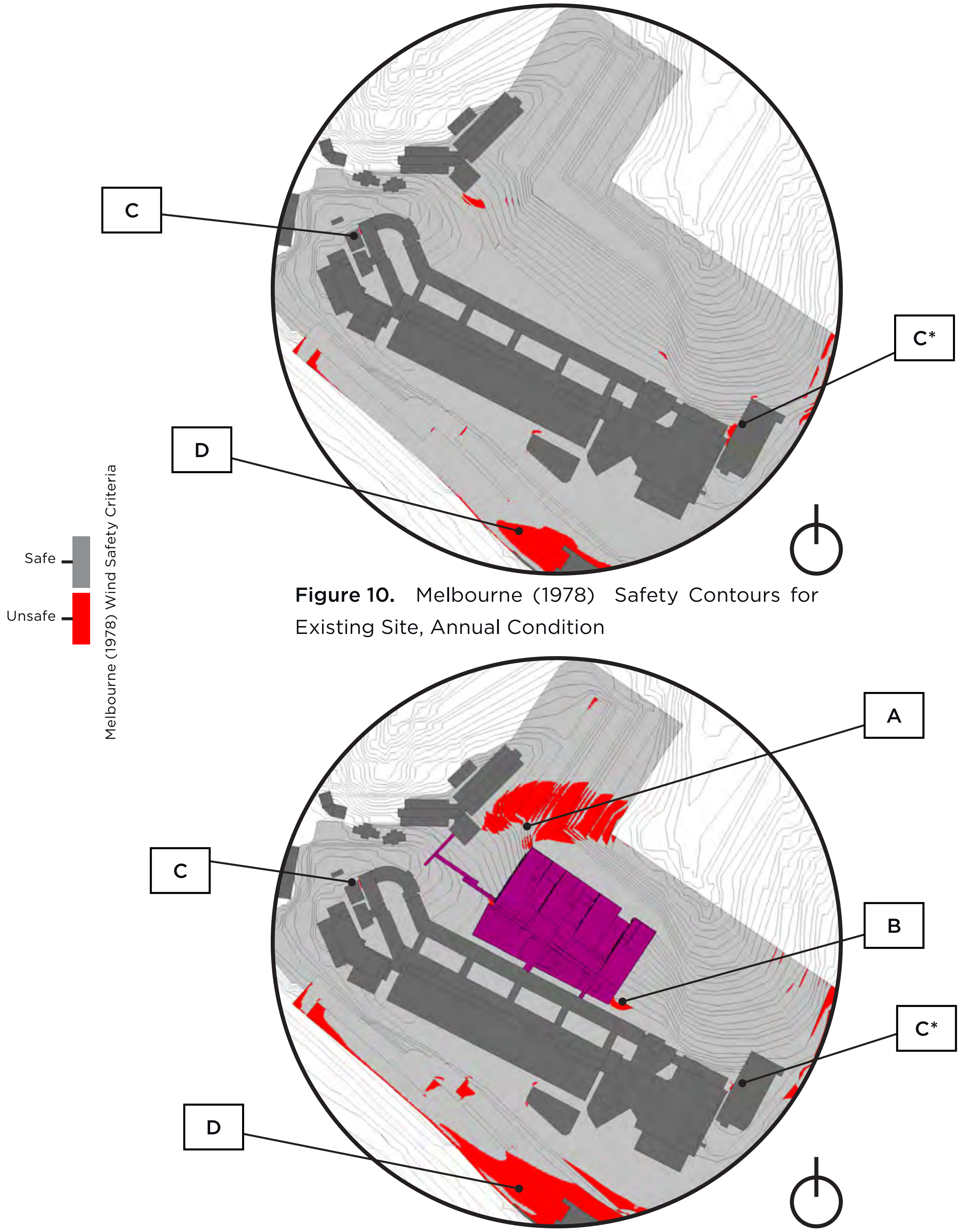


Figure 10. Melbourne (1978) Safety Contours for Existing Site, Annual Condition

Figure 11. Melbourne (1978) Safety Contours for Proposed Site, Annual Condition

5. Results and Discussion
Comfort and Safety - Ground Level Entrance

The ground level (level 0) entrance at the southern aspect of the Acute Services Building is covered by a courtyard terrace on the floor above and as such will be analysed individually within this section.

A. Wind speeds at areas immediately adjacent to the proposed site are well sheltered and are predicted to see wind speeds suitable for short and long exposure activities, on the ground plane.

B. High wind speeds due to corner acceleration are predicted at both the south-eastern and north-western entrances to the ground level entrance area.

B1. The northern entrance is predicted to see unsafe wind speeds when exposed to winds coming in from the north-western quadrant which accelerate around the north-western corner of the proposed building and between the ground level area and the canopy above. Mitigation is recommended here, see Section 6.

B2. The southern entrance is predicted to see unsafe wind conditions when exposed to winds incoming from the eastern quadrant which accelerate around the south-eastern corner of the proposed building and between the ground level area and the canopy above. Mitigation is recommended here, see Section 6.

C. When wind directions align with the north-west to south-east axis high wind speeds are predicted due to funnelling effects between the proposed site and existing main hospital building to the south. Mitigation is recommended here, see Section 6.

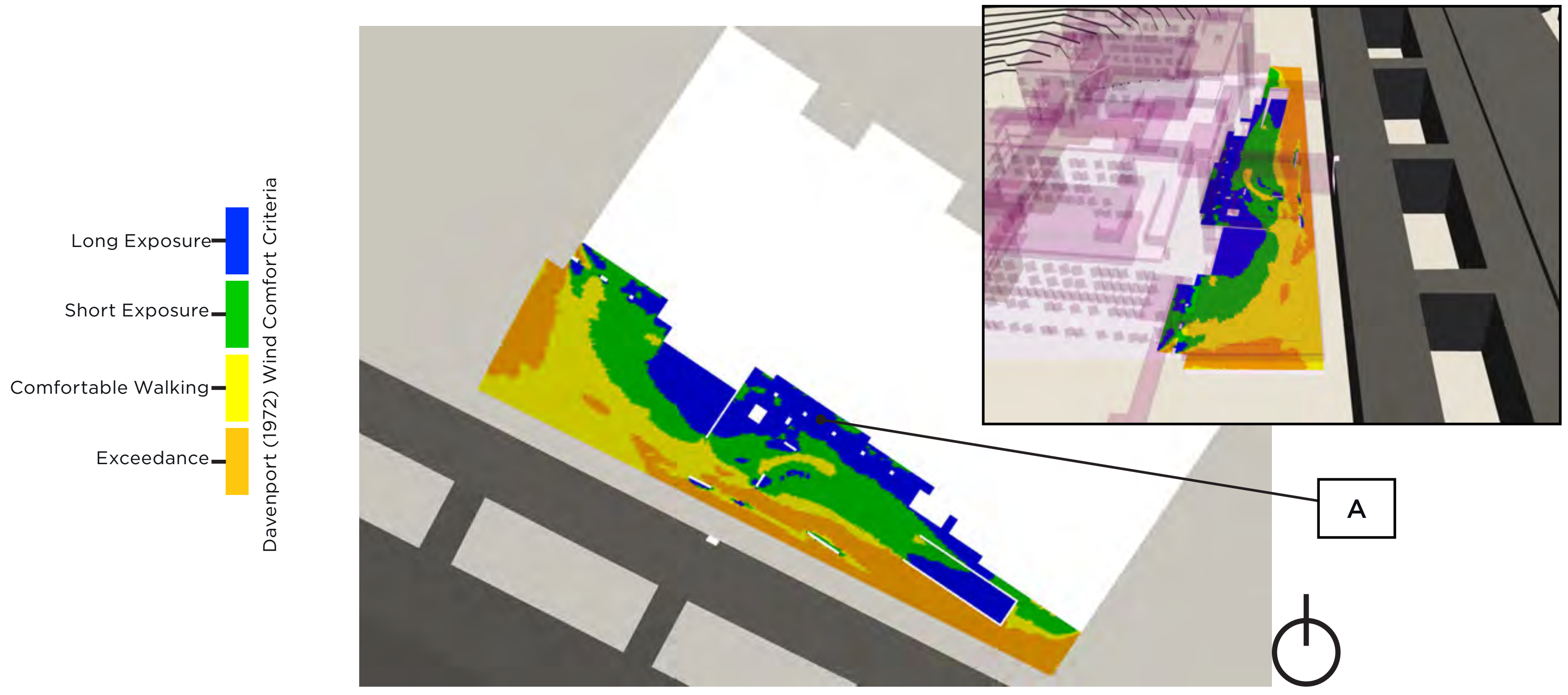


Figure 12. Davenport (1972) Comfort Contours for Proposed Site southern ground level entrances (western aspect shown in inset)

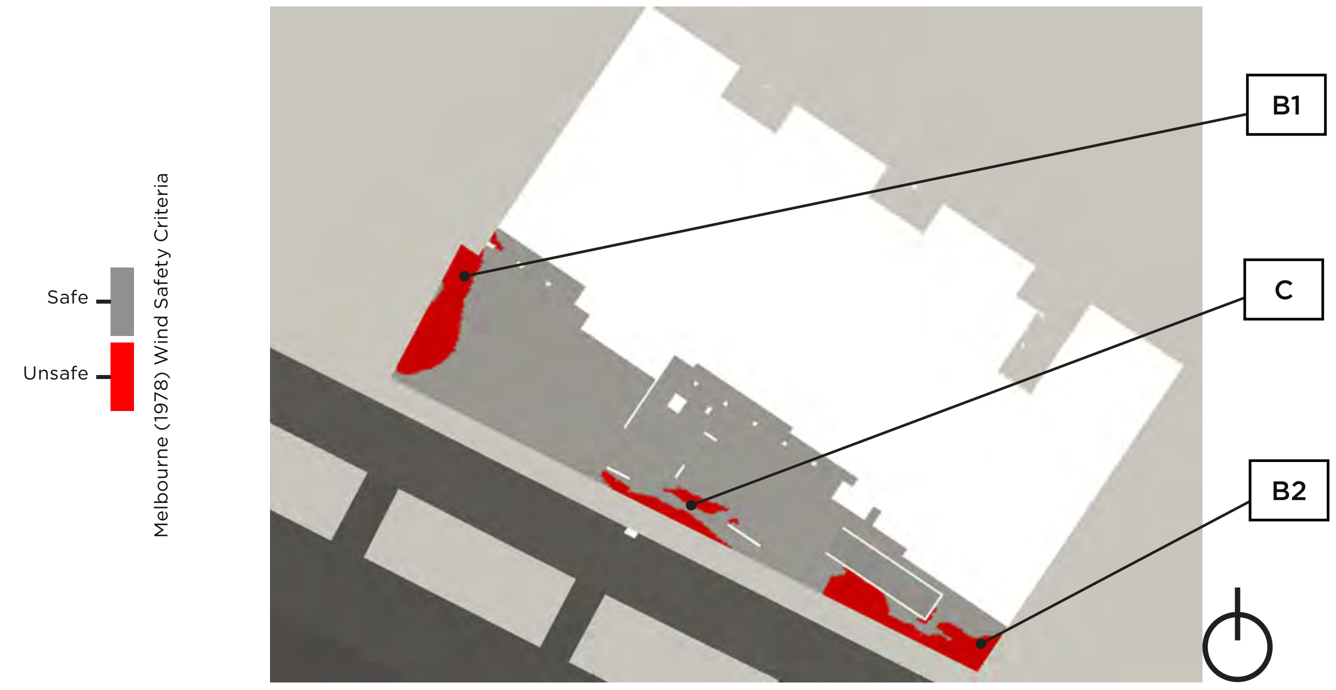


Figure 13. Melbourne (1978) Safety Contours for Proposed Site southern ground level entrances

5. Results and Discussion
Comfort - Elevated Areas

Localised comfort analysis was carried out for the elevated regions within the proposed development in order to identify any sections that may see critical effects from the incoming wind.

A. Upper elevated areas are exposed to incoming flow due to the lack of upstream blockages in any direction which could be provided by existing buildings. As a result the only shelter these areas see is from the proposed building itself, i.e. if they are sunken or have balustrades over 1.5m in height. It is understood that the upper rooftop areas are not intended for frequent pedestrian access, instead intended for plant access, and helipad access in the case of the western rooftop, and as such these areas are prediction to be suitable for use (with safety consideration given to their use during strong wind events) and no mitigation is required.

B. The western section of the elevated garden area is predicted to have areas unsuitable for comfortable walking activities. This is due to exposure to prevailing north-westerly winds as well as corner acceleration around the south-western corner of the proposed development. Mitigation is recommended here, see Section 6.

C. The eastern section of the elevated garden is predicted to have conditions suitable for short exposure activities. This section is sheltered by the proposed development from the majority of wind directions.

D. In general the elevated levels at lower levels see wind conditions suitable for long exposure activities. One exception is the areas which are not alcoves, but which are open to flow traversing through them leading to higher wind speeds (these areas are highlighted in the inset in Figure 18). If these highlighted areas are intended for pedestrian access mitigation is recommended, see Section 6.

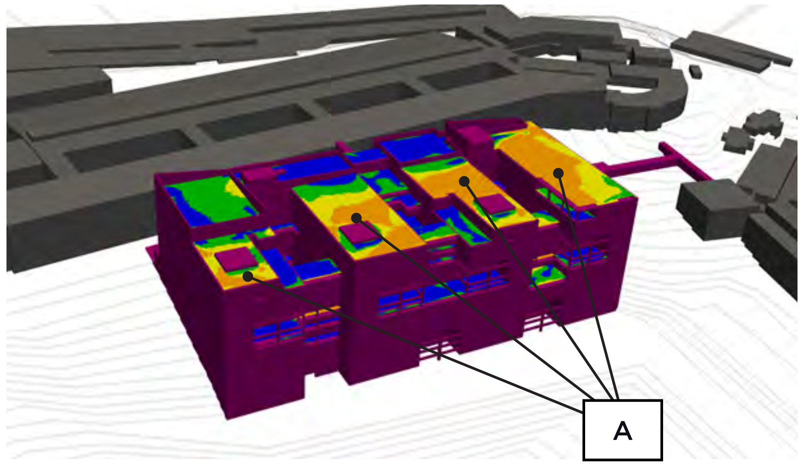


Figure 14. Davenport (1972) Comfort Contours for Proposed Site elevated areas (northern aspect)

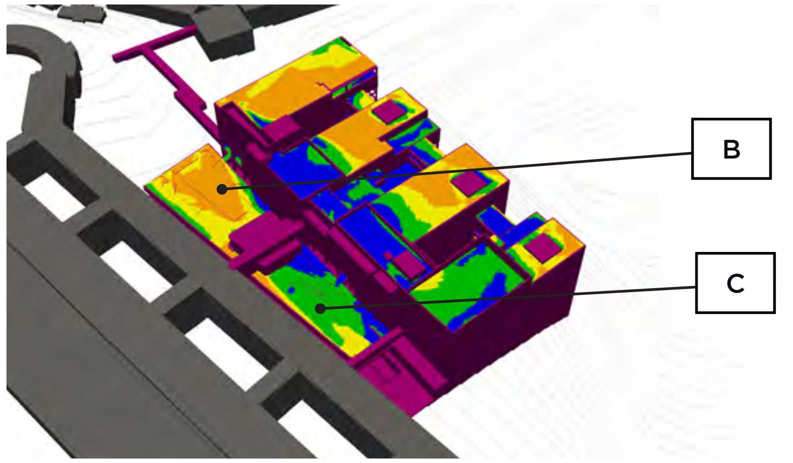


Figure 15. Davenport (1972) Comfort Contours for Proposed Site elevated areas (southern aspect)

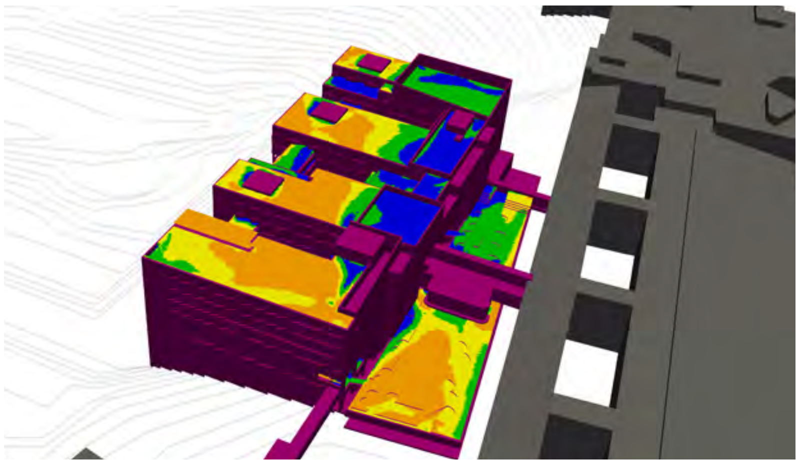


Figure 16. Davenport (1972) Comfort Contours for Proposed Site elevated areas (western aspect)

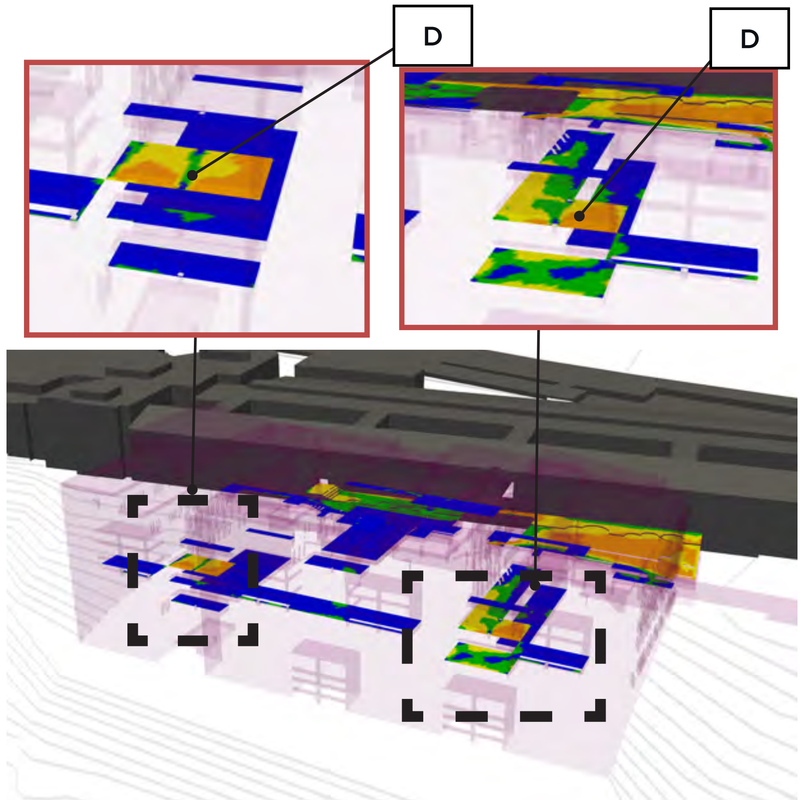


Figure 17. Davenport (1972) Comfort Contours for Proposed Site elevated areas - lower levels (northern aspect)

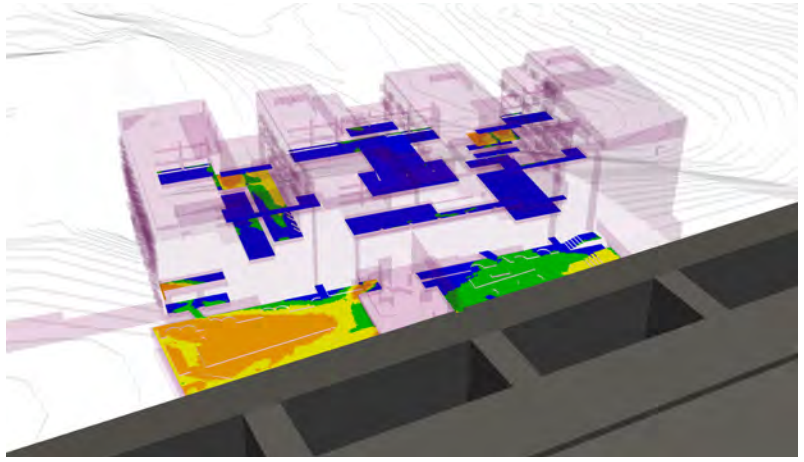


Figure 18. Davenport (1972) Comfort Contours for Proposed Site elevated areas - lower levels (southern aspect)

5. Results and Discussion
Safety - Elevated Areas

Localised safety analysis was carried out for the elevated regions within the proposed development in order to identify any sections that may see critical effects from the incoming wind.

A. Upper elevated areas are exposed to incoming flow due to the lack of upstream blockages in any direction which could be provided by existing buildings. Resulting in the upper rooftops predicted to see wind speeds in exceedance of the safety criterion. It is understood that upper rooftop areas are not intended for frequent pedestrian access, instead intended for plant access and helipad access (in the case of the western rooftop) and as such these areas are suitable for use with safety consideration given to their use during strong wind events.

B. The western section of the elevated garden area is predicted to see wind speeds which exceed the safety criterion. This is due to exposure to prevailing north-westerly winds as well as corner acceleration around the south-western corner of the proposed development. Mitigation is recommended here, see Section 6.

C. The eastern section of the elevated garden is predicted to have a small region of flow which sees wind speeds in exceedance of the safety criterion. This is likely due to funnelling between the ground plane and connection to the main site (for location, see inset image in Figure 21). Corner acceleration is also seen to the north of the building present on the elevated garden (C*). Mitigation is recommended here, see Section 6.

D. In general the elevated levels at lower levels see wind conditions suitable for long exposure activities. One exception is the areas which are not alcoves, but which are open to flow traversing through them leading to higher wind speeds predicted which exceed the gust safety criterion (these areas are highlighted in the inset in Figure 22). If these highlighted areas are intended for pedestrian access mitigation is recommended, see Section 6, if they are intended for maintenance access only then they are predicted to be suitable for use.

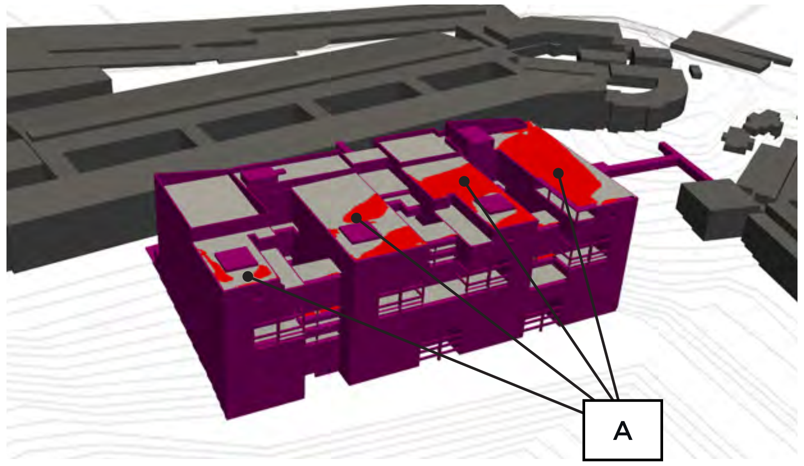


Figure 19. Davenport (1972) Comfort Contours for Proposed Site elevated areas (northern aspect)

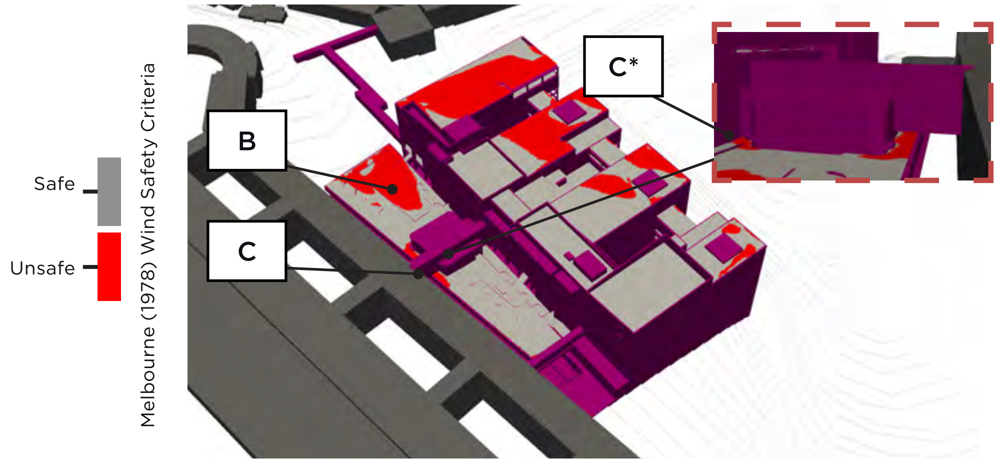


Figure 20. Davenport (1972) Comfort Contours for Proposed Site elevated areas (southern aspect)

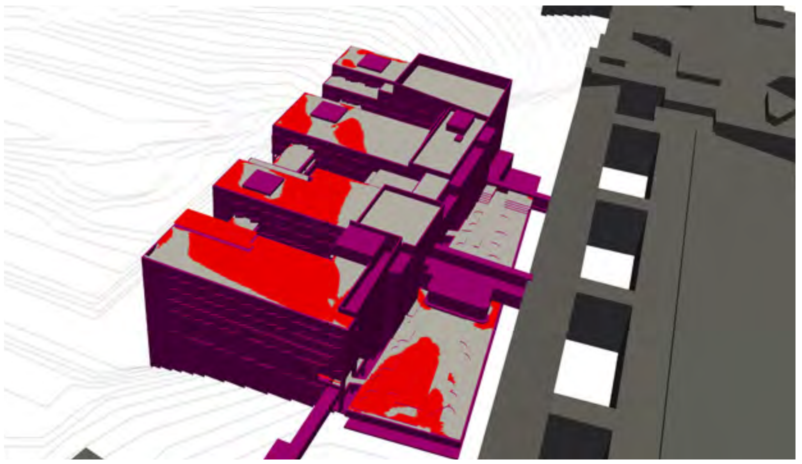


Figure 21. Davenport (1972) Comfort Contours for Proposed Site elevated areas (western aspect)

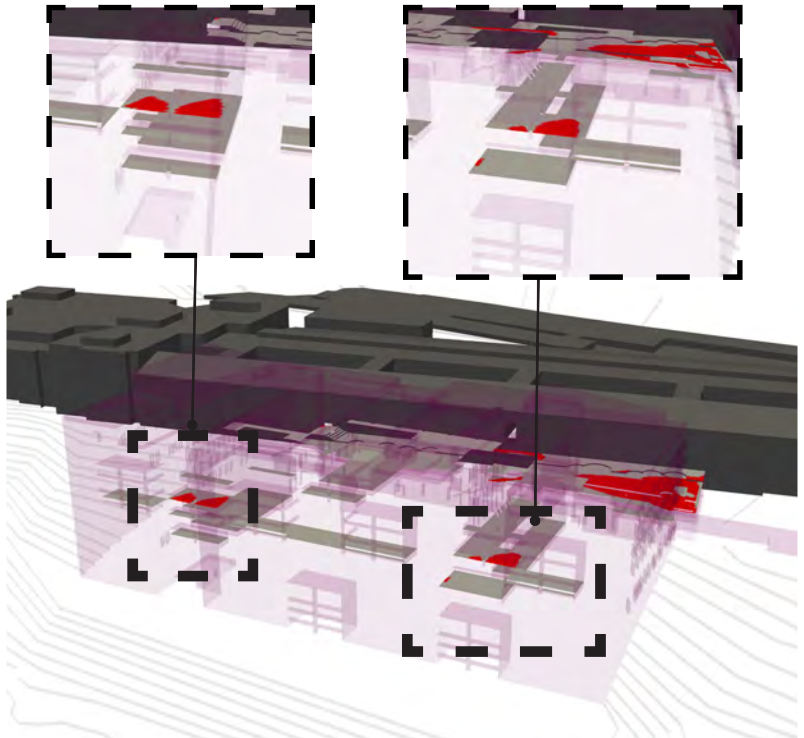


Figure 22. Davenport (1972) Comfort Contours for Proposed Site elevated areas - lower levels (northern aspect)

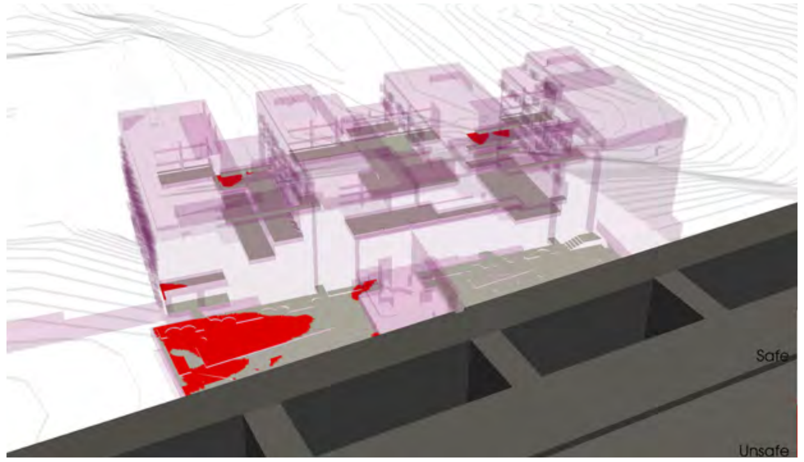


Figure 23. Davenport (1972) Comfort Contours for Proposed Site elevated areas - lower levels (southern aspect)

6. Summary and Suggested Treatments

The results of the study indicate that there are areas of concern several locations. These areas align with points raised in a previous desktop assessment by Windtech upon the site (Doc Ref: WF899-01F03(rev1) - WS, Wind Entry Heli Report). The following treatments are recommended:

A. Retention and/or inclusion of landscaping to the west of the proposed development in order to mitigate down-wash and corner acceleration around the corners of the north-western facade. Landscaping to the west of the ground level entrance would also aid in mitigating high wind speeds within the ground level entrance area. It is suggested that this take the form of trees at least 3-5m high with a densely foliating canopy, with interlocking canopies where possible. An evergreen species is to be recommended when these are used to mitigate a winter wind.

B. Landscaping to the east of the proposed development in order to mitigate corner acceleration around the south-eastern corner of the development which propagates through into the covered ground-level entrance area. If the area to the north of the development is to be frequently accessed then it is suggested that landscaping be extended northwards. It is suggested that this take the form of trees at least 3-5m high with a densely foliating canopy, with interlocking canopies where possible. An evergreen species is to be recommended when these are used to mitigate a winter wind.

C. Screening at both entrances to the ground level entrance area. This would mitigate the effect of the high wind speeds caused via corner acceleration around the southern corners of the proposed site.

C1. 2m to full height porous screens (approximately 30-40% porous) at the eastern and western end of the ground level entrance area

C2. Full height solid screen (0% porous) extending off of the south-western corner of the proposed development. This is to prevent high wind speeds accelerating around this corner propagating through the ground level entrance area.

D. Addition of screens or shrubs within the ground level entrance area would mitigate wind speeds within this region, primarily acting to negate the funnelling effect seen. Such screens are recommended to have a height of 1.5m and a porosity between 30-40%.

Figure 24. Recommended Mitigation Treatments - Ground Level Areas

6. Summary and Suggested Treatments

E. The western section of the elevated garden is recommended to have mitigation m easures applied in order to reduce wind speeds seen here.

An example of a mitigation strategy is shown in Figure 25. The mitigation strategy can be further optimised at a more detailed design stage to ensure safe and comfortable conditions are achieved for the Elevated Garden.

The addition of wind screening on the western aspect and near the corners of the building form is expected to mitigate the corner acceleration and direct wind effects.

The pergola and vegetation can be designed in such a way to prevent the winds from downwashing back onto the pedestrians below after being deflected away by the western wind screening.

Vegetation within the elevated garden can take the form of trees and planter boxes. It is recommended that trees should be densely foliating and evergreen to provide wind mitigation throughout the year. Shrubs under the tree canopies can be implemented to improve wind conditions further. These measures should mitigate corner acceleration and funnelling effects predicted.
Small variations in vegetation can be further optimised at a more detailed design state to ensure safe and comfortable conditions are achieved.

Figure 25. Example of Mitigation Strategy - Elevated Garden

6. Summary and Suggested Treatments

G. It is understood that elevated areas which are open to flow through to the interior of the development are intended for maintenance access only for which they would be suitable for their intended use with safety consideration given to their use during strong wind events. If, in the future these balconies open up to frequent public use th en impermeable balustrades with a height of at least 2m are recommended.

It is understood that the rooftop areas are not intended for frequent pedestrian access (maintenance and emergency services helipad access only) and as such should be suitable for use, with safety consideration given to their use during strong wind events.

Overall, it is expected that the development can achieve conditions that are suitable for its intended activities with the inclusion of the above mentioned recommendations.

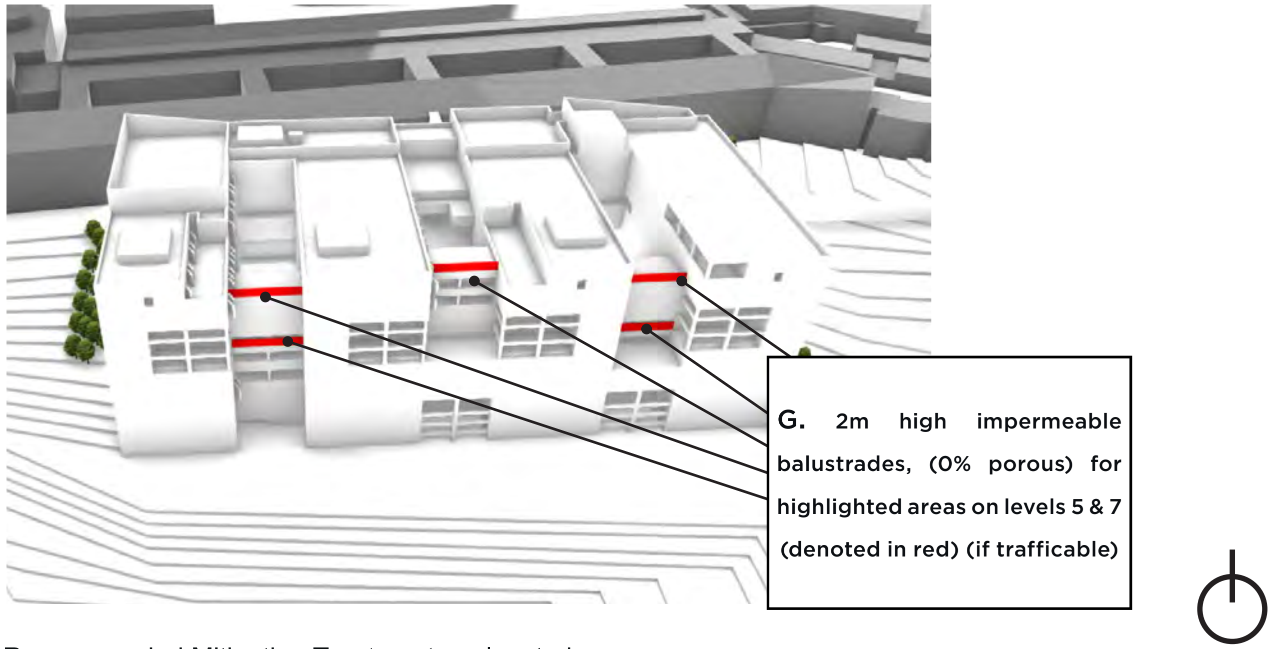


Figure 26. Recommended Mitigation Treatments - elevated areas

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.
5. Deaves, D. M. and Harris, R. I. 1978, "A mathematical model of the structure of strong winds." Construction Industry and Research Association (U.K), Report 76.
6. International Organisation for Standardisation, ISO4354:2009, "Wind Actions on Structures".
7. Lawson, T.V., 1973, "The wind environment of buildings: a logical approach to the establishment of criteria", Bristol University, Department of Aeronautical Engineering.
8. Lawson, T.V., 1975, "The determination of the wind environment of a building complex before construction", Bristol University, Department of Aeronautical Engineering.
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.
11. Melbourne, W.H., 1978, "Wind Environment Studies in Australia", Journal of Wind Engineering and Industrial Aerodynamics, vol.3, pp.201-214.
12. Penwarden, A.D., and Wise A.F.E., 1975, "Wind Environment Around Buildings", Building Research Establishment Report, London.
13. Rofail, A.W., 2007, "Comparison of Wind Environment Criteria against Field Observations", 12th International Conference of Wind Engineering (Volume 2), Cairns, Australia

Appendix A

Wind Speed Up Fields

Appendix A - Wind Speed Up Fields
- Existing Site

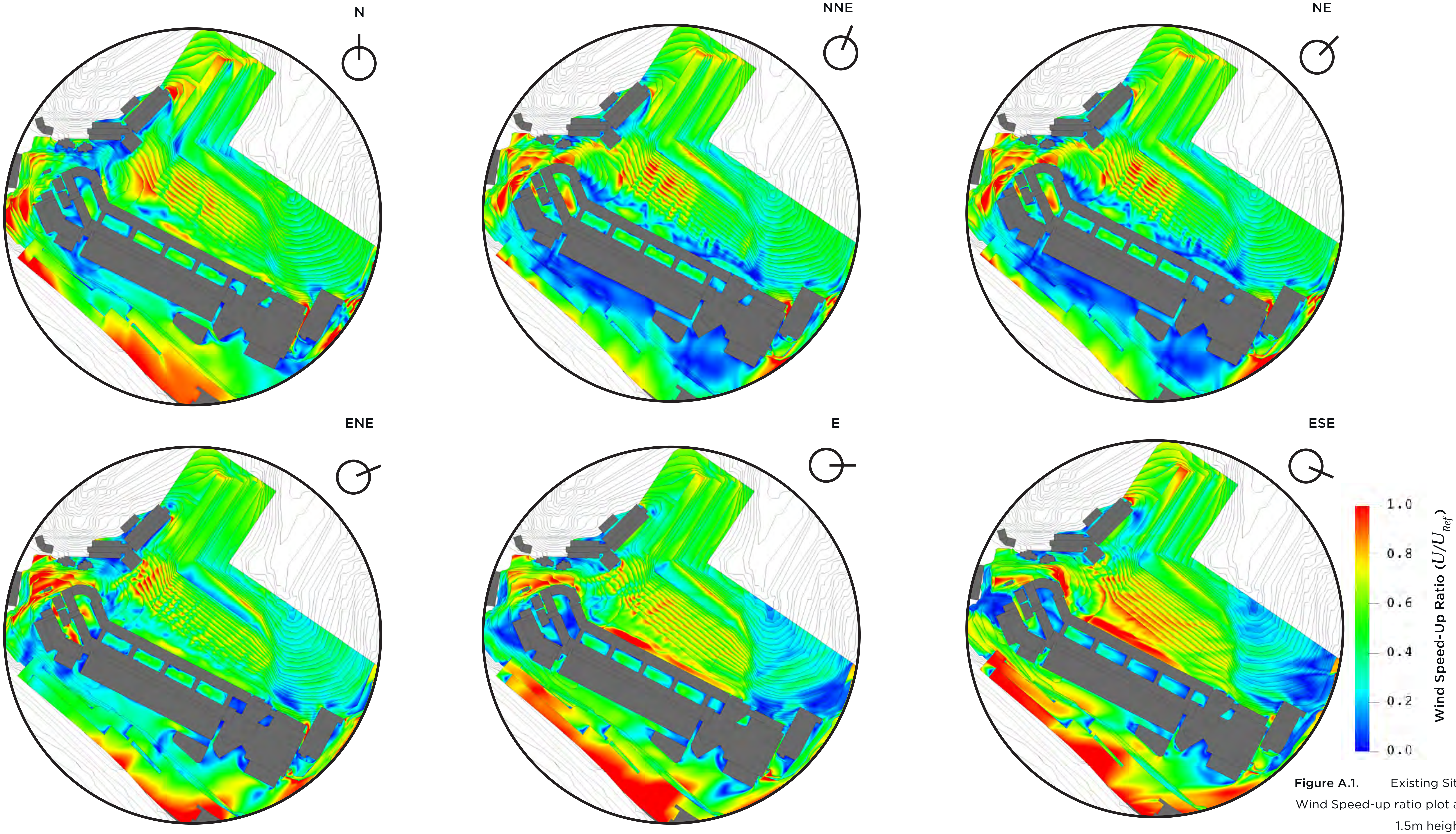


Figure A.1. Existing Site Wind Speed-up ratio plot at 1.5m height

Appendix A - Wind Speed Up Fields - Existing Site

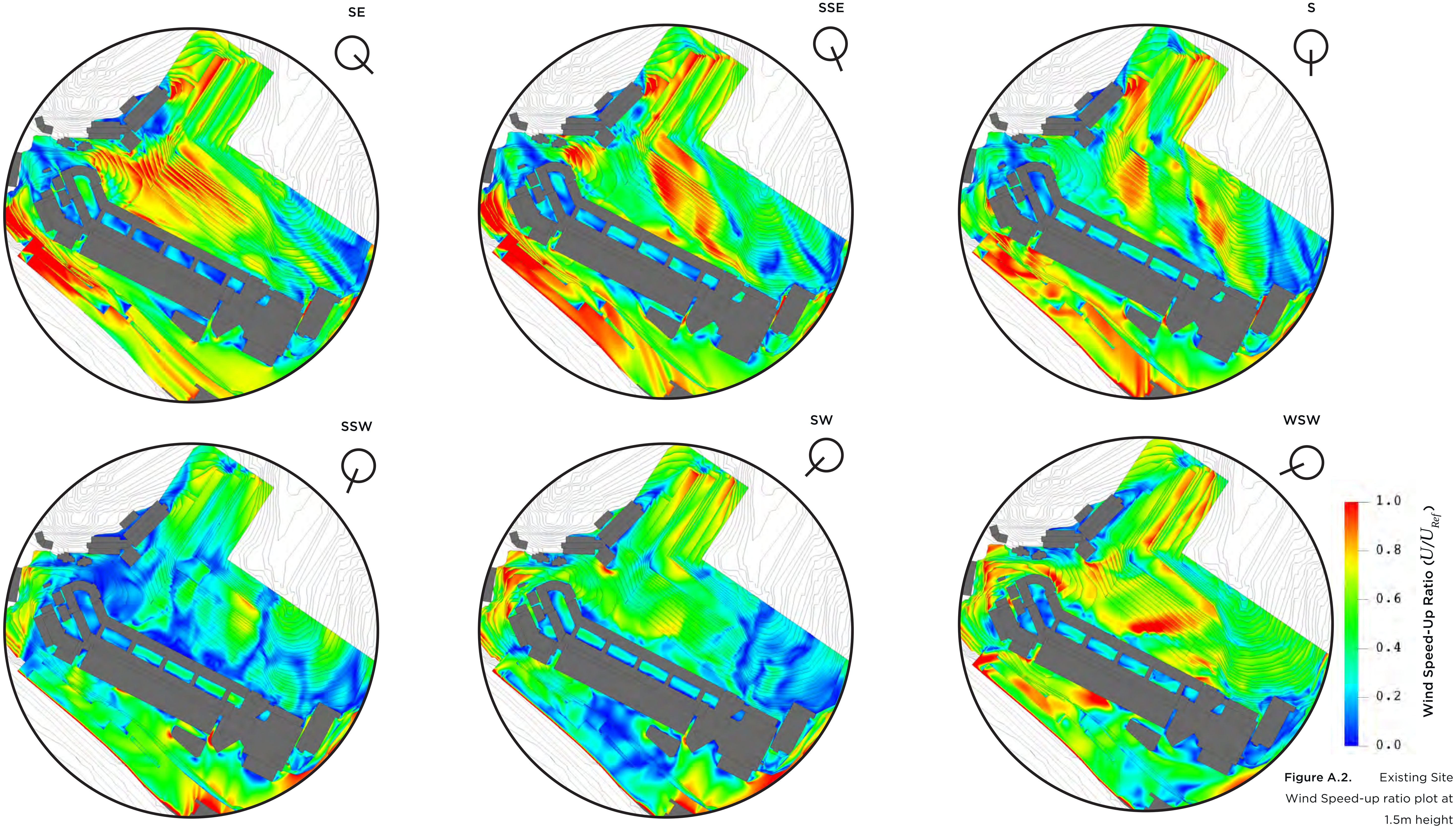


Figure A.2. Existing Site Wind Speed-up ratio plot at 1.5m height

Appendix A - Wind Speed Up Fields - Existing Site

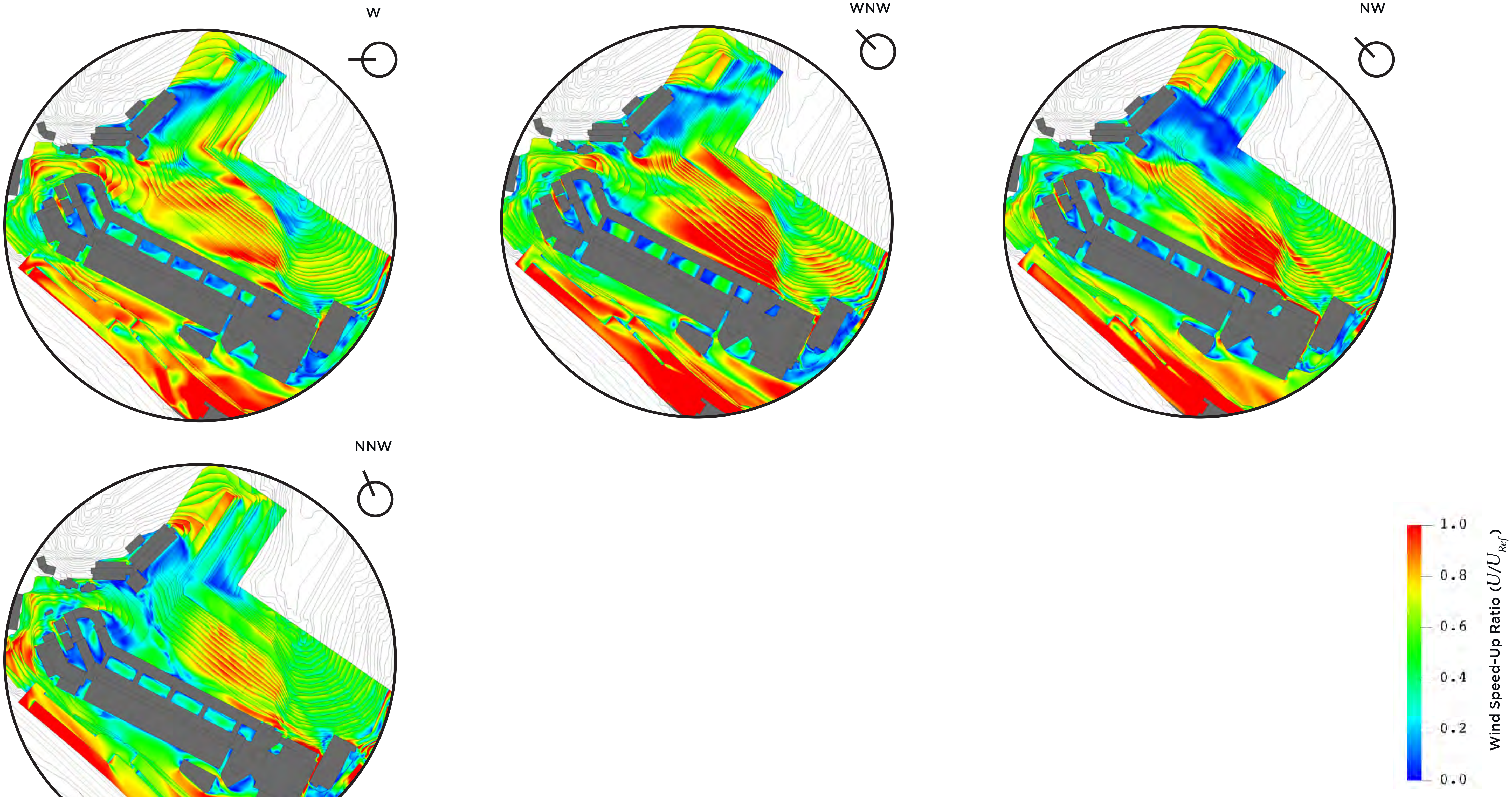


Figure A.3. Existing Site Wind Speed-up ratio plot at 1.5m height

Appendix A - Wind Speed Up Fields - Proposed Site

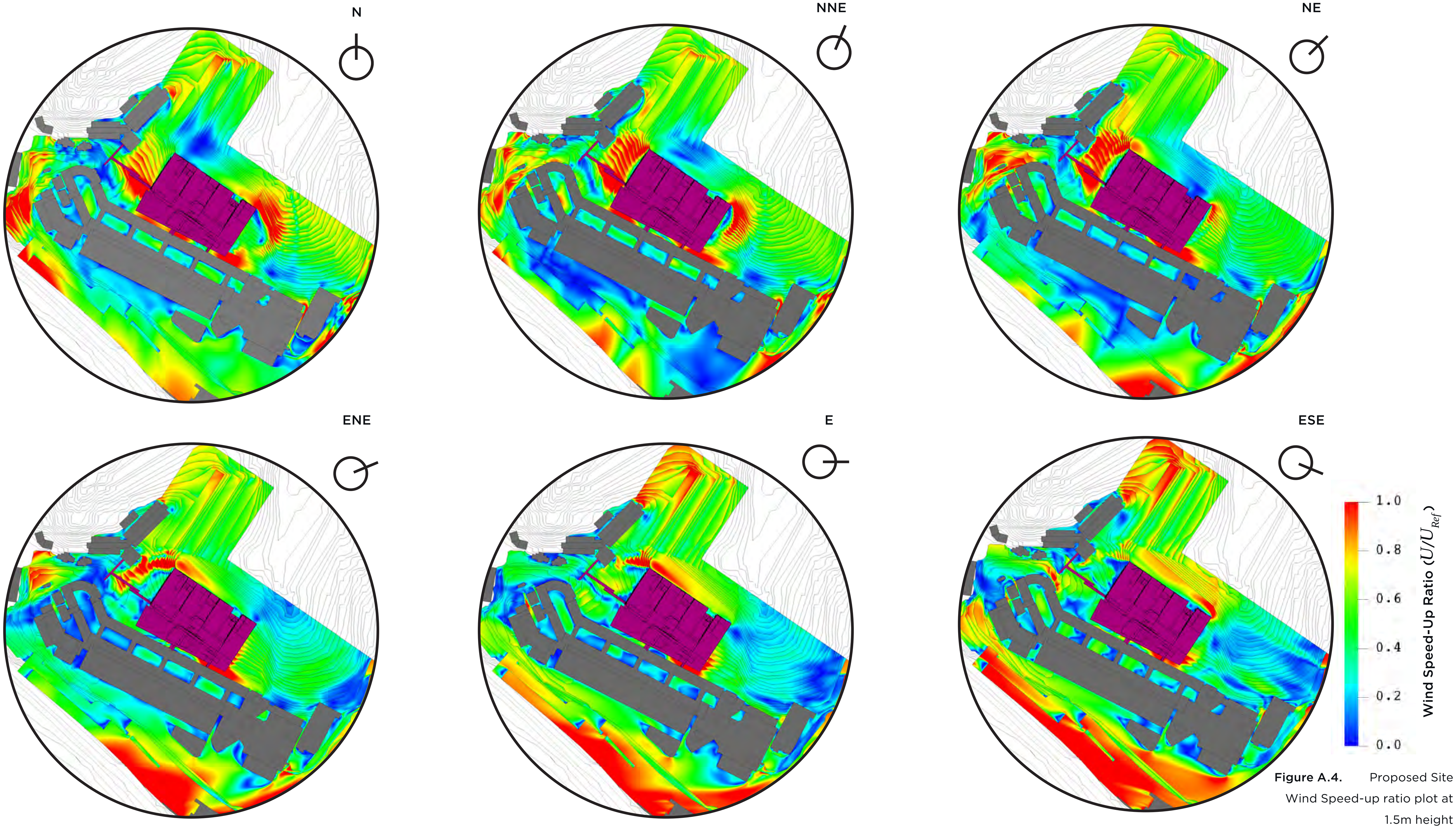


Figure A.4. Proposed Site Wind Speed-up ratio plot at 1.5m height

Appendix A - Wind Speed Up Fields - Proposed Site

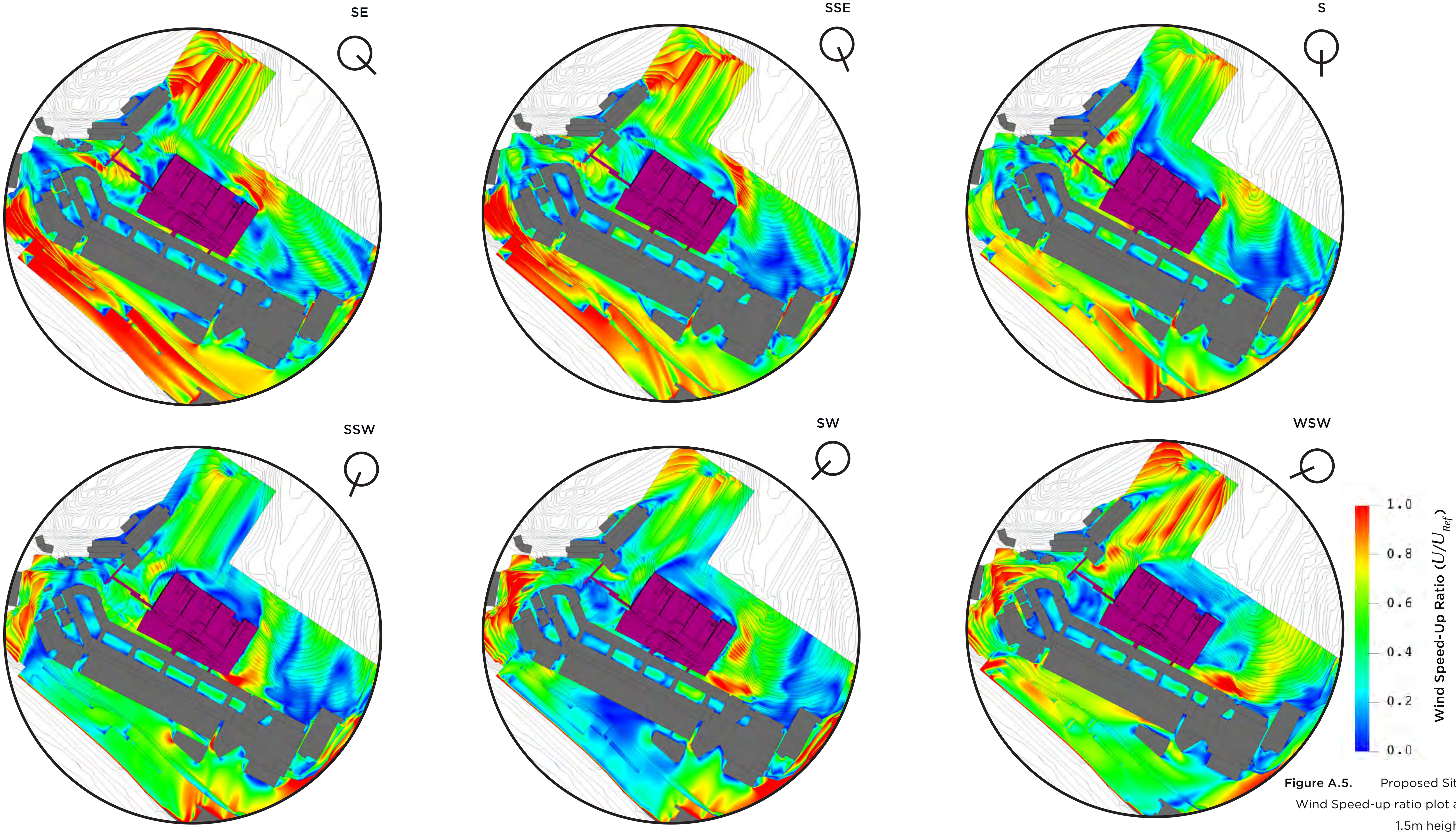
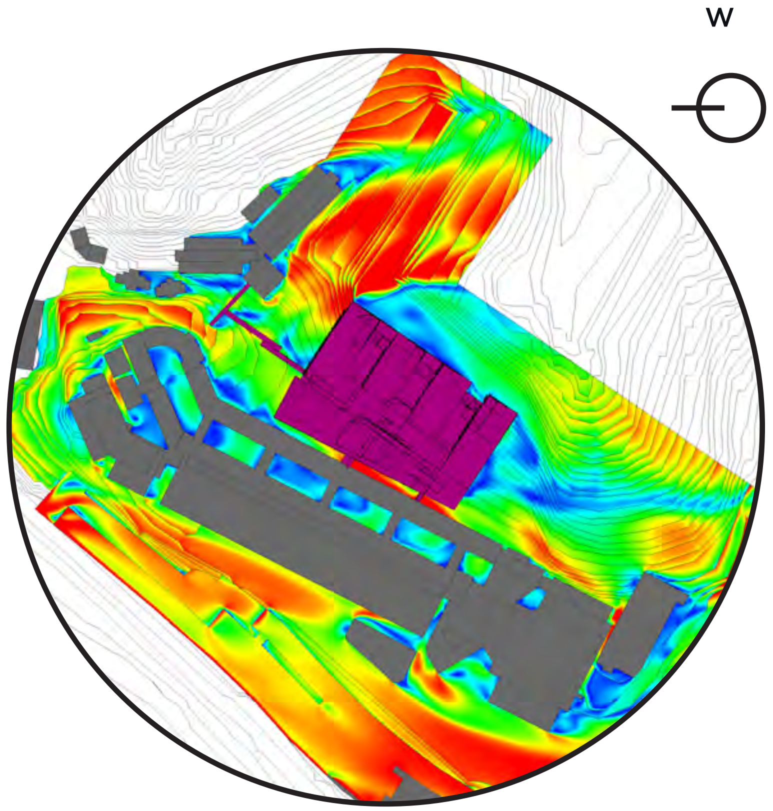
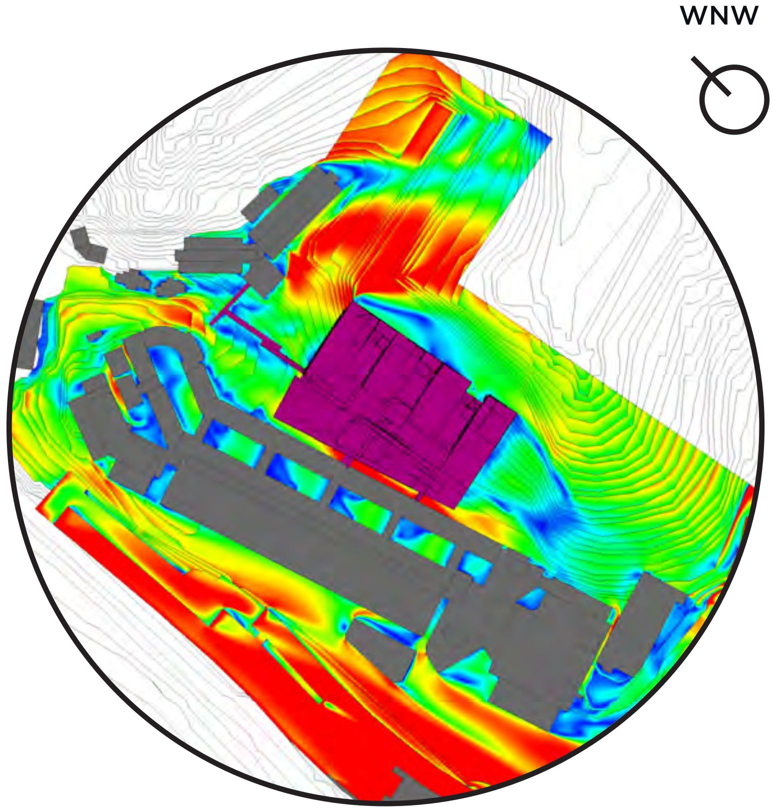
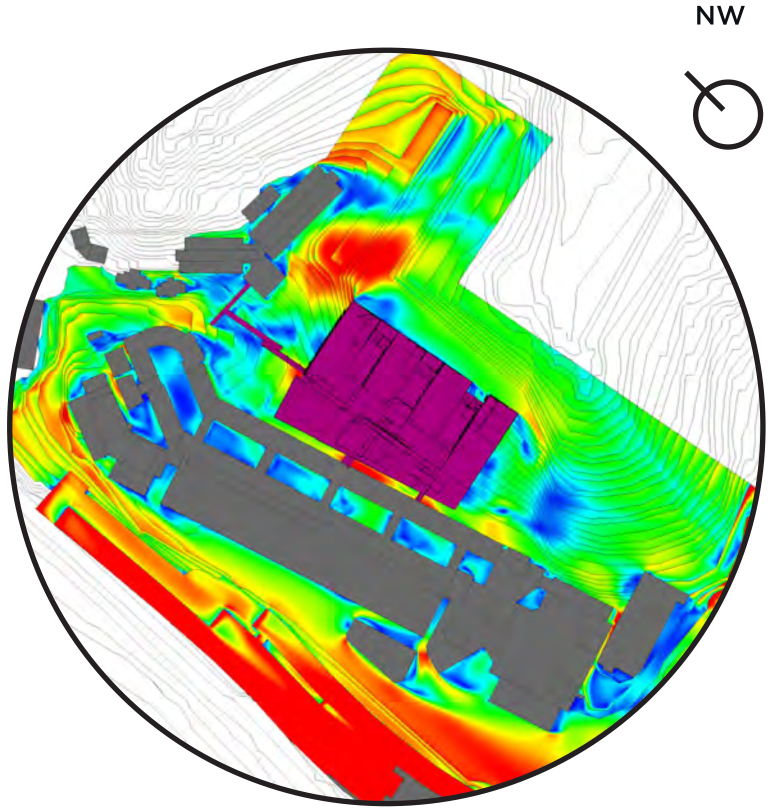


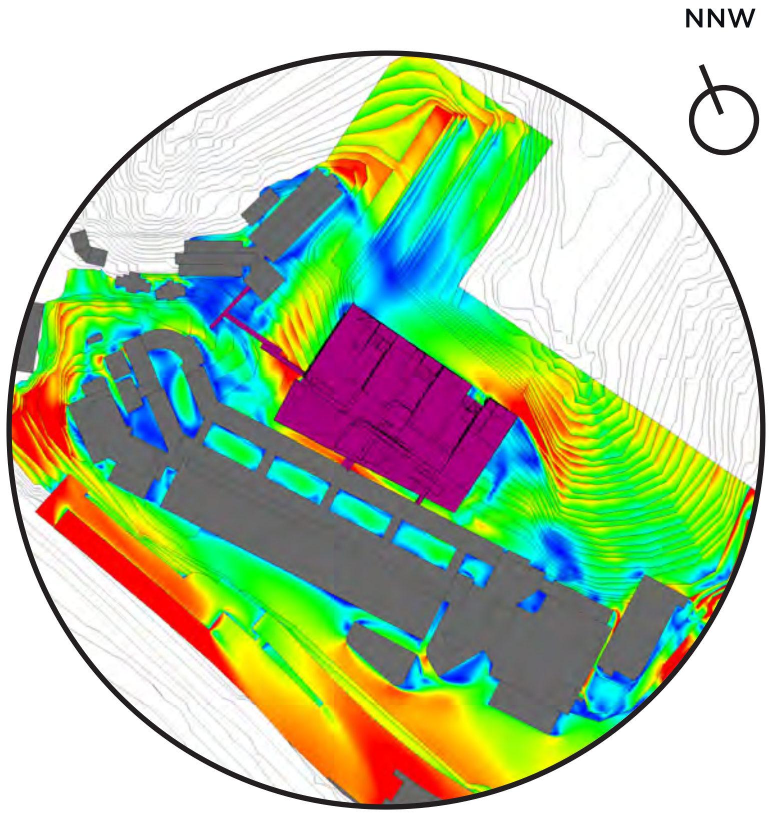
Figure A.5. Proposed Site Wind Speed-up ratio plot at 1.5m height

Appendix A - Wind Speed Up Fields - Proposed Site









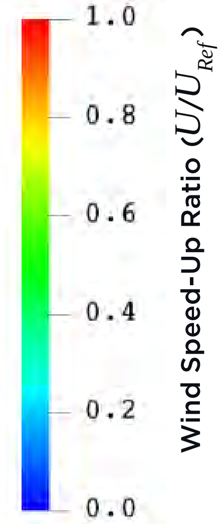


Figure A.6. Proposed Site Wind Speed-up ratio plot at 1.5m height