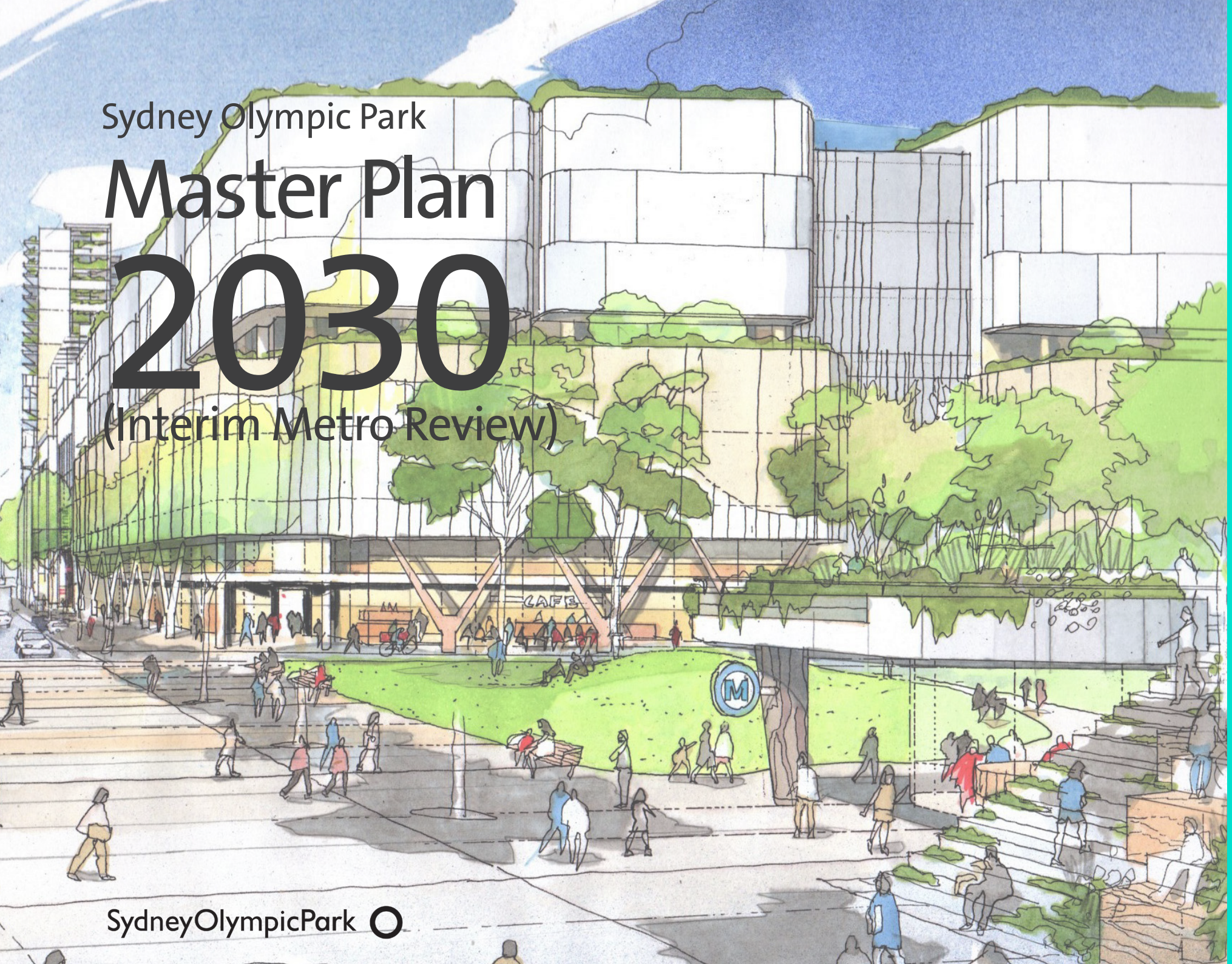
Sydney Olympic Park

Master Plan 2030

(Interim Metro Review)



SydneyOlympicPark

ANNEXURE 9: WIND STRATEGY

Wind Comfort Study for:

Sydney Olympic Park – Central Precinct Metro Review

Sydney Olympic Park, NSW

CPP 15726

Date	Revision	Prepared	Checked	Approved
07 July 2021	Draft Report R00D00	Kenneth Fung CFD Engineer kfung@cppwind.com	Urszula Niedzielska CFD Engineer uniedzielska@cppwind.com	
13 July 2021	Draft Report R00D01 Minor updates	KF		
26 July 2021	Draft Report R00D02 Minor updates	Kenneth Fung CFD Engineer kfung@cppwind.com	Joe Paetzold Engineering Manager jpaetzold@cppwind.com	Joe Paetzold Engineering Manager jpaetzold@cppwind.com
27 July 2021	Draft Report R00D03 Minor updates	KF	JP	JP
04 August 2021	Draft Report R00D03 Minor updates	KF	JP	JP

Executive Summary

This wind assessment study identified wind comfort ratings for the entire Central Precinct and all adjacent areas affected by the proposed Metro precinct changes, as stated by Sydney Olympic Master Plan 2030 (Interim Metro Review).

Comfort conditions within Central Precinct are expected to be suitable for most outdoor activities including café-style seating, with no major areas of concern. The proposed landscaping and natural planting throughout the Central Precinct is expected to reduce wind speeds within the site, resulting in slightly better wind conditions than shown. In general, trees and natural planting that are dense and resilient (e.g. evergreen species) with crowns that are close to the ground provide the most wind protection.

Moveable vertical screens/planter boxes were recommended within the Plaza if these spaces are to be activated for outdoor café-style seating.

When compared to the existing wind conditions, the build-up of high-rise towers within the proposed revisions to the design of the Central Precinct is expected to result in slightly windier conditions within the project site which will be partially reduced by proposed landscaping and natural planting, and can be mitigated if needed by intermittent measures.

Introduction

This wind assessment study seeks to identify wind comfort criteria for the entire Central Precinct and all adjacent areas affected by the proposed Metro precinct changes, as stated by Sydney Olympic Master Plan 2030 (Interim Metro Review)[1].

A computational wind engineering (CWE) study has been conducted to determine the wind conditions around Central Precinct. This CWE study is primarily focused on comfort conditions, with wind tunnel testing being required to accurately assess safety conditions if safety is a concern. As a result, safety conditions are not assessed from the CWE study.

The Central Precinct model used in the simulations was based on a 3D Rhino model[2] provided by SOPA (Sydney Metro West) on 17 June 2021.

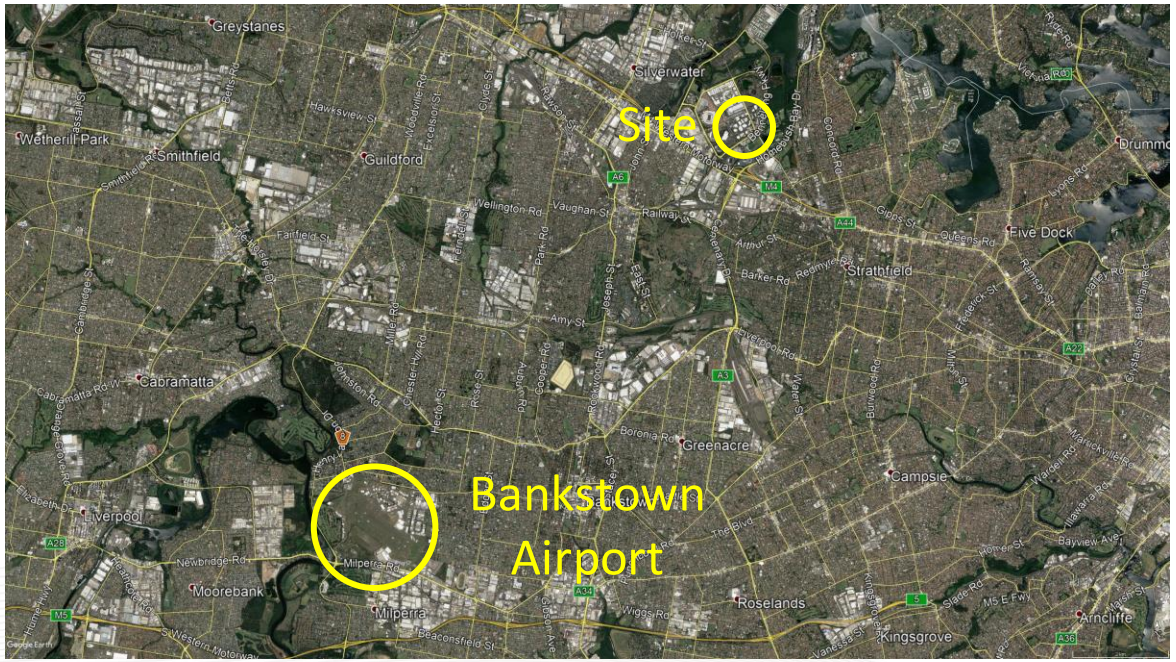
[1]Sydney Olympic Master Plan 2030 Interim Amendment 2021 (April 2021).

[2]*SOPA Central Precinct Base Concept.3dm, Sydney Olympic Park Central Precinct Massing package* (Received 17 June 2021).

Site Location and Wind Data Collection

- The Central Precinct is located in Sydney Olympic Park, approximately 11 km to the north-east of Bankstown Airport, which is the closest reliable wind station. The Central Precinct is surrounded by several large stadia and sporting grounds, with open grassland to the north-east and commercial developments to the south-west.

- The buildings within the Central Precinct are similar in size or larger than most of the surrounding developments, and are exposed to most wind directions. Topography immediately around the Central Precinct is relatively flat, and is expected to have a minimal impact on the local wind conditions.



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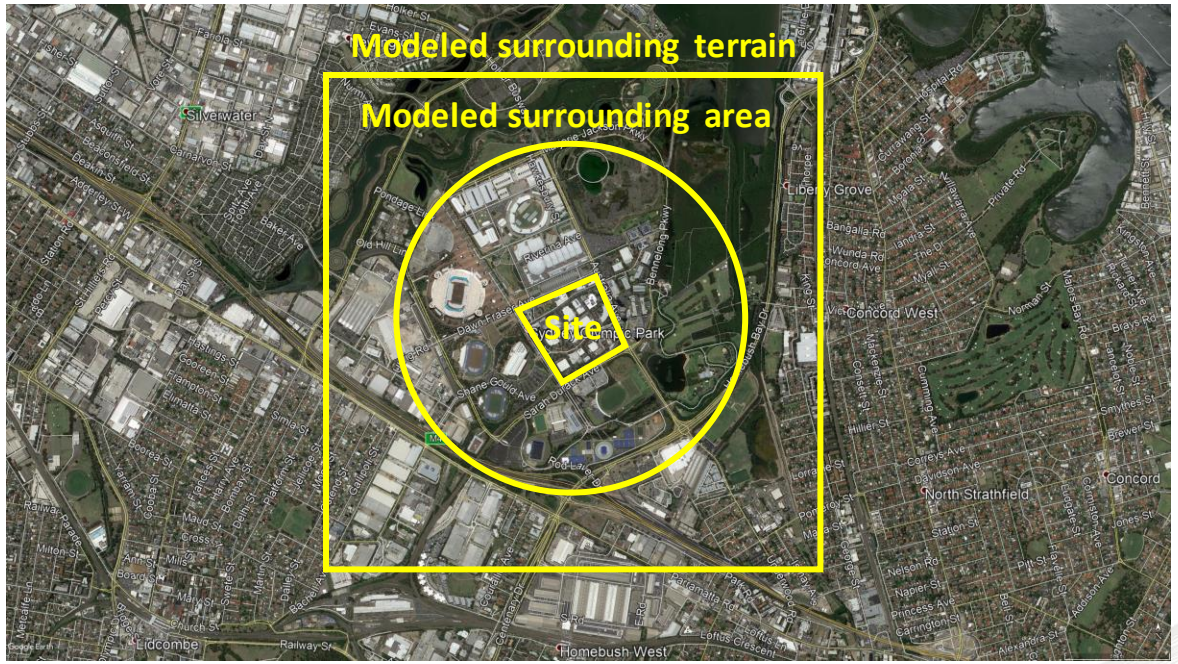
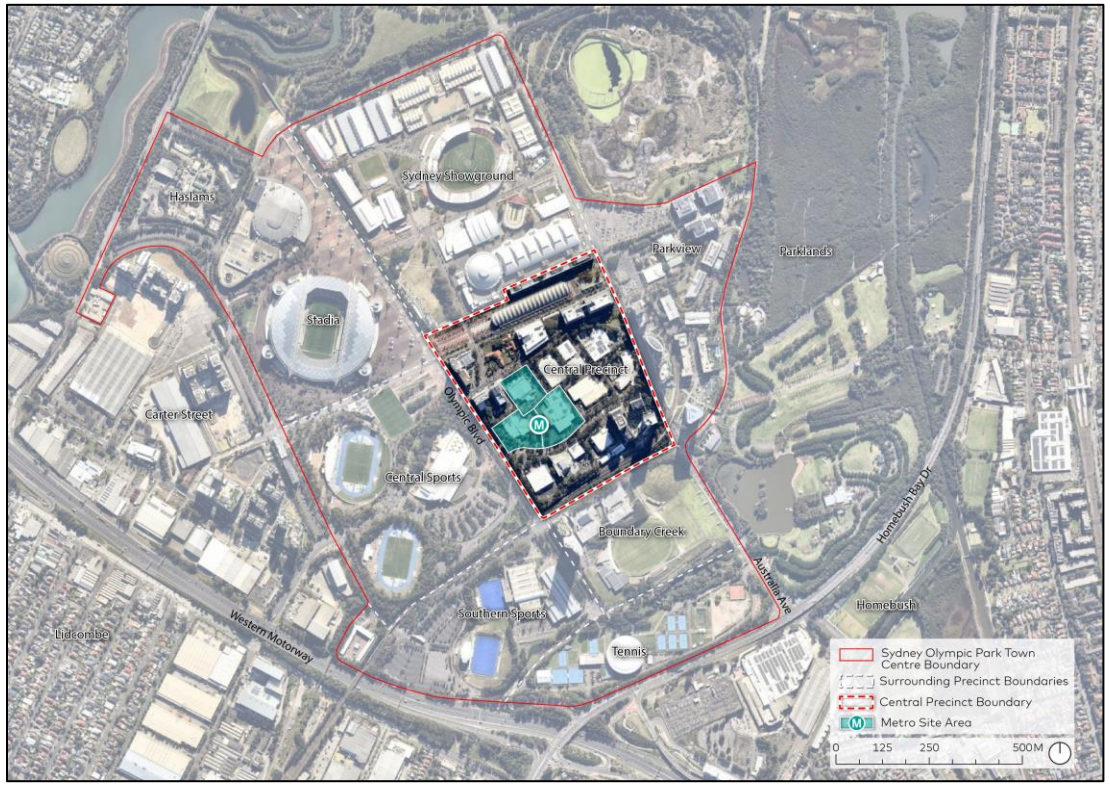


Site Description

N



SOP Central Precinct*.

The Central Precinct of Sydney Olympic Park (SOP) will undergo significant redevelopment as part of the SOP Master Plan 2030. A number of amendments are proposed to the Central Precinct layout, land use, and building massing to facilitate the delivery of a Sydney Metro West station and its integration with this precinct.

The proposed massing in the Central Precinct comprises of retail, commercial and residential developments. Many of the existing low-rise buildings will be replaced with high-rise towers, with several of these towers being up to 45-storeys in height.

This study focuses on quantifying the wind conditions within and around the proposed revisions to the Central Precinct where significant use is expected. Mitigation measures are proposed to reduce wind speeds in areas where appropriate.

**Central Precinct_Metro Wider Context-01.jpg, Central Precinct Base Plans* (Received 23 June 2021)

Central Precinct Overview

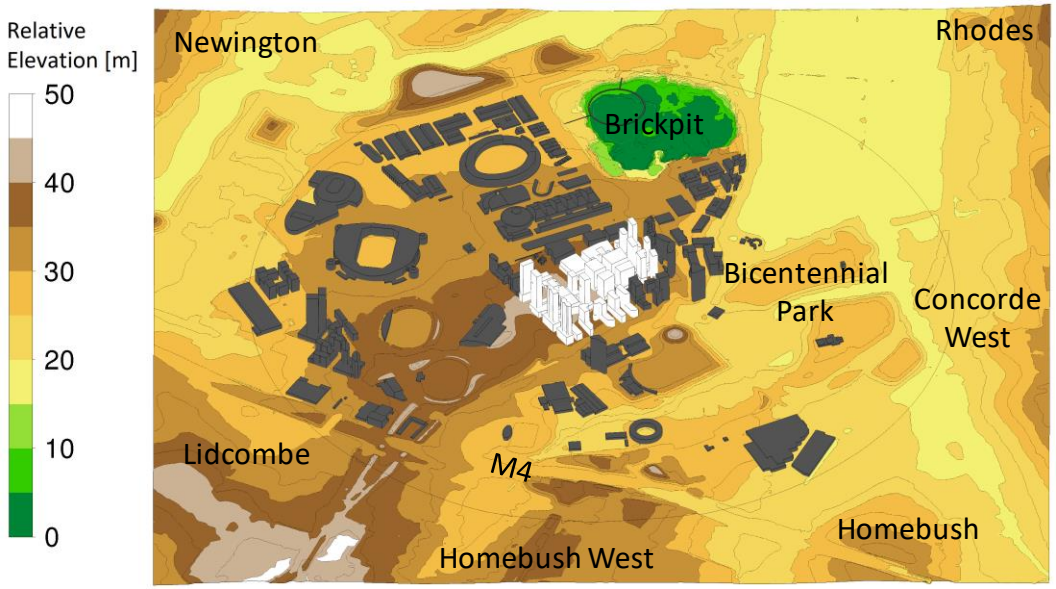
SOP Central Precinct[1]. Trees and landscaping were not modelled in this study and therefore the results are considered to be conservative.

SOP Central Precinct layout[2].

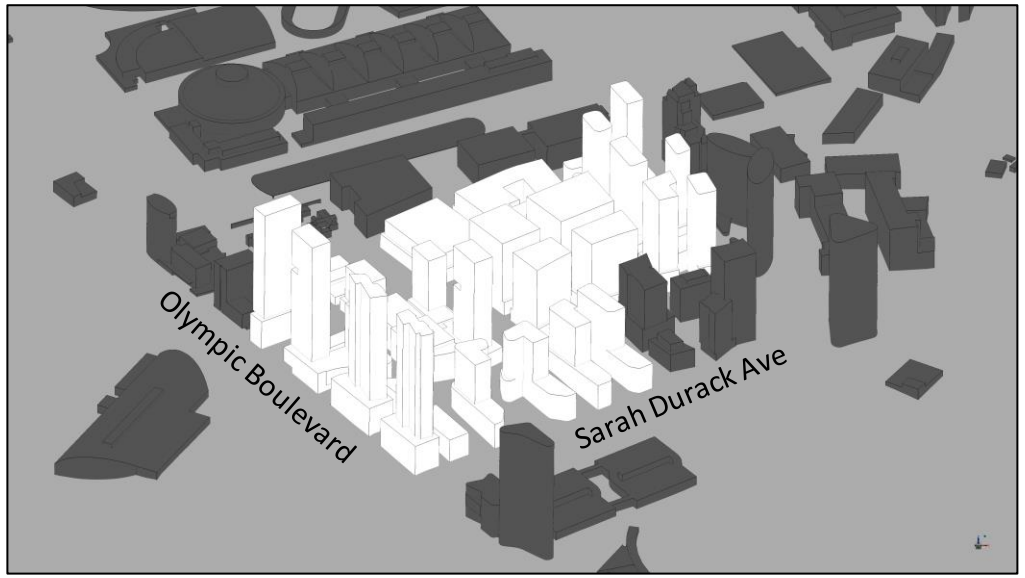
[1] *210723_SOP_PDF masterplan, Consultant Package* (Received 23 July 2021).

[2] *SOP PDF_DES_DWG_001_Masterplan_Rev H-Masterplan.pdf , Consultant Package* (Received 23 July 2021).

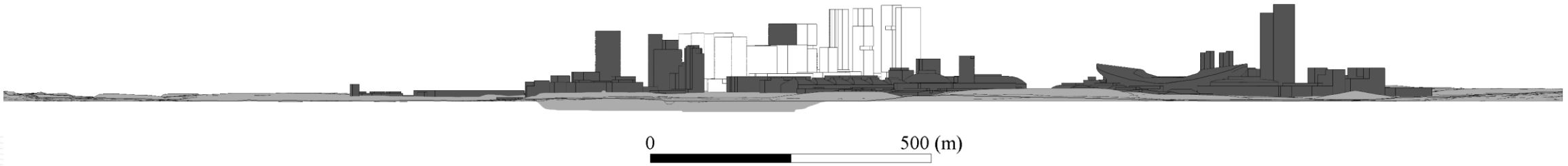
Model Geometry



South overhead view. Contour lines indicate a 2.5 m change in height.



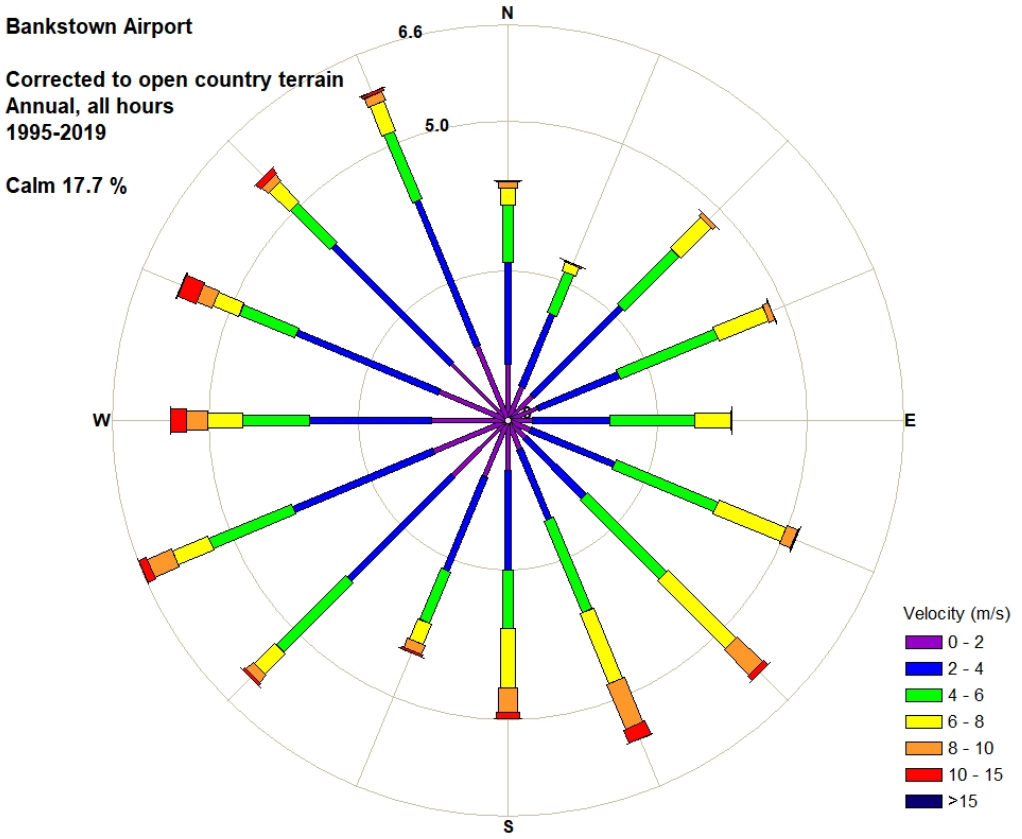
South close-up.



North elevation. All relevant surrounding buildings were included to a radius of approximately 1000 m. Surrounding terrain and representative roughness was modeled out to a radius of approximately 1400 m.

Bankstown Wind Climate

- Wind climate data from Bankstown Airport is considered applicable to the site location. The wind data was corrected to account for the differences between the airport surroundings and site surroundings (i.e. approach roughness correction).
- Winds are calm approximately 18% of the time.
- The wind climate is biased away from the north-east quadrant, with strong winds (orange/red), moderate winds (yellow) and light winds (blue/green) skewed towards the other quadrants.
- The wind analysis presented in this report is based on the annual wind climate and hourly mean wind speeds.



Comfort Assessment Definitions

Wind speed that occurs 5% of the time	Lawson Comfort Rating	Suitable activities
2 m/s	Outdoor dining*	Long-term sitting with high expectations of comfort, and with little or no opportunity to move to another location. Napkins should not blow away and hair is not ruffled.
4 m/s	Pedestrian sitting	Eating fast food, reading a magazine on a bench, quick coffee, pool decks
6 m/s	Pedestrian standing	Short-term standing activities, such as queueing or waiting for a bus. Pedestrians will feel comfortable enough to stop and look into shop windows
8 m/s	Pedestrian walking	In transit, but some wind comfort desired, e.g., walking through a park
10 m/s	Business walking	Any activities where the person intends to transit through the space where comfort and leisure is not a requirement, such as crossing a road
> 10 m/s	Uncomfortable	People will purposefully avoid the space

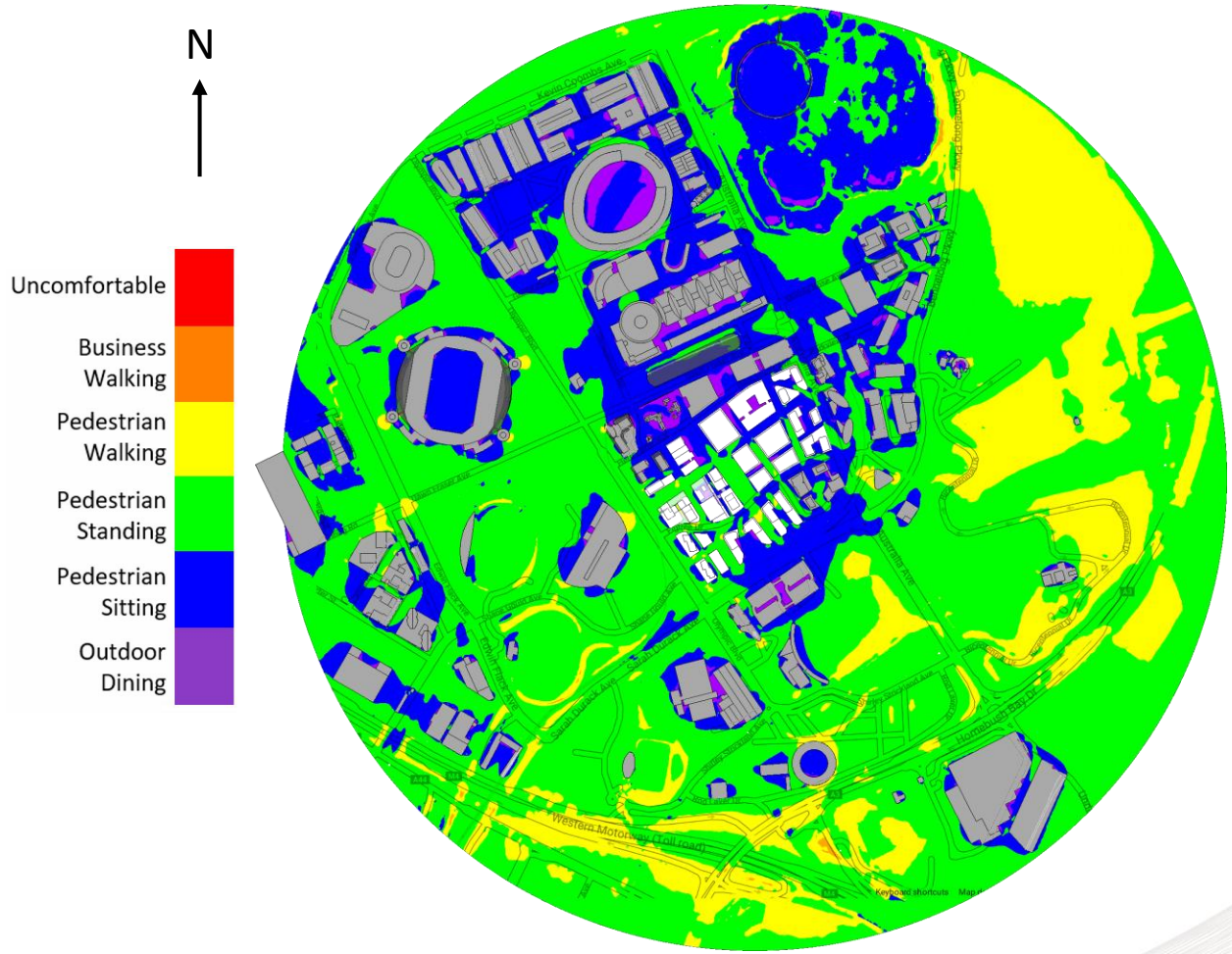
See Appendix A for further details about the Lawson Comfort Ratings.

* This is an experienced-based rating developed by CPP

Comfort Results

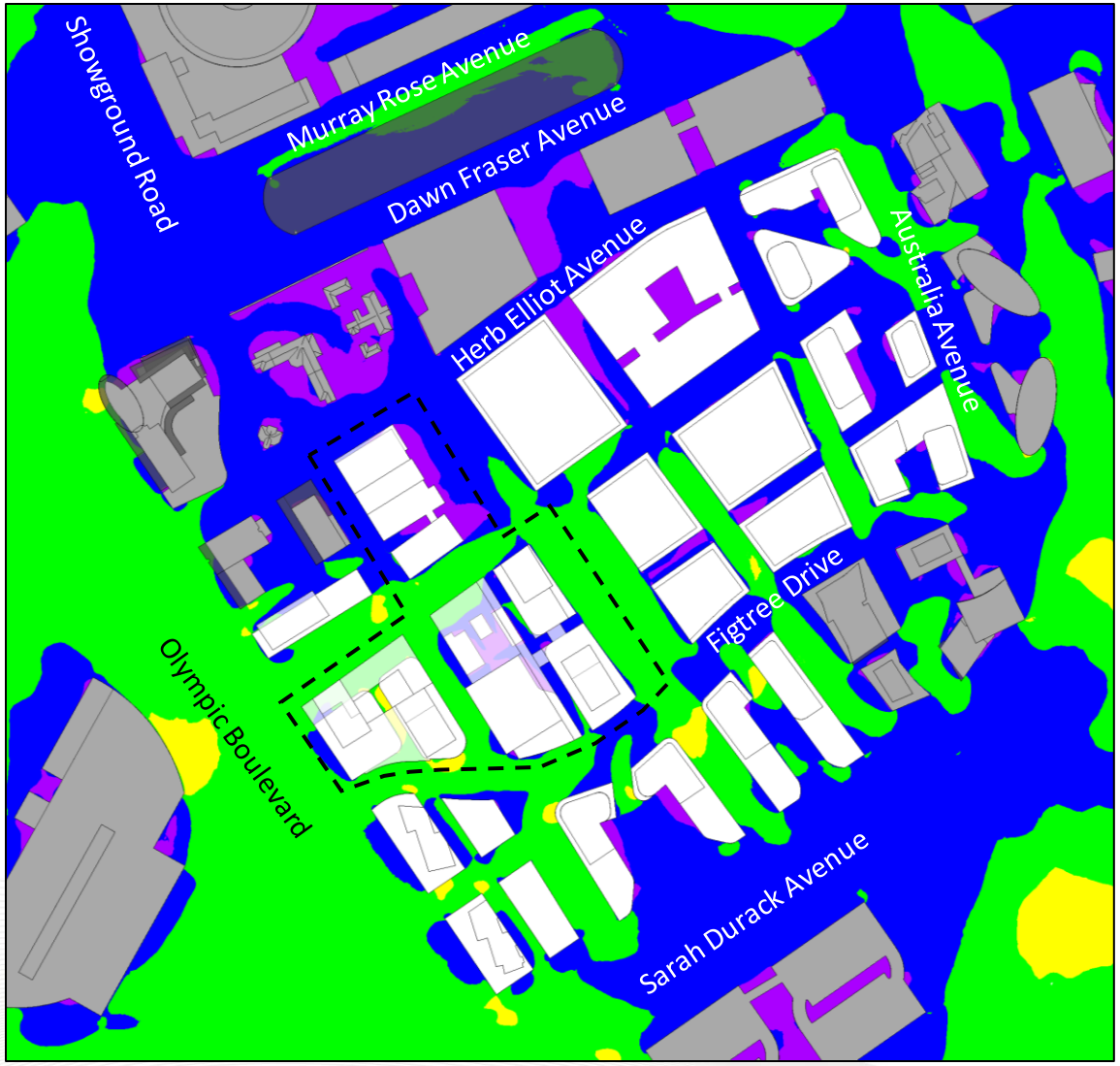
For each area of interest, comfort ratings are shown followed by flow patterns illustrating the dominant mechanisms driving the comfort conditions.

- Comfort conditions at remote street-level locations are predominantly driven by winds from the south and west quadrants.
- Most open street-level locations are rated *Pedestrian Standing*, with sheltered locations between buildings rated *Pedestrian Sitting* and more exposed locations rated *Pedestrian Walking*.
- The dense buildup of sporting stadia around the Central Precinct provides protection to areas within the Central Precinct from most wind directions.
- In the following pages, flow mechanisms responsible for the wind conditions around the Central Precinct are shown as 3D streamlines colored by velocity ratio*.



*Velocity ratio is the local wind speed divided by the remote approach wind speed at 150 m. The local wind speed is the greater of the mean or gust-equivalent mean. See Appendix A for details.

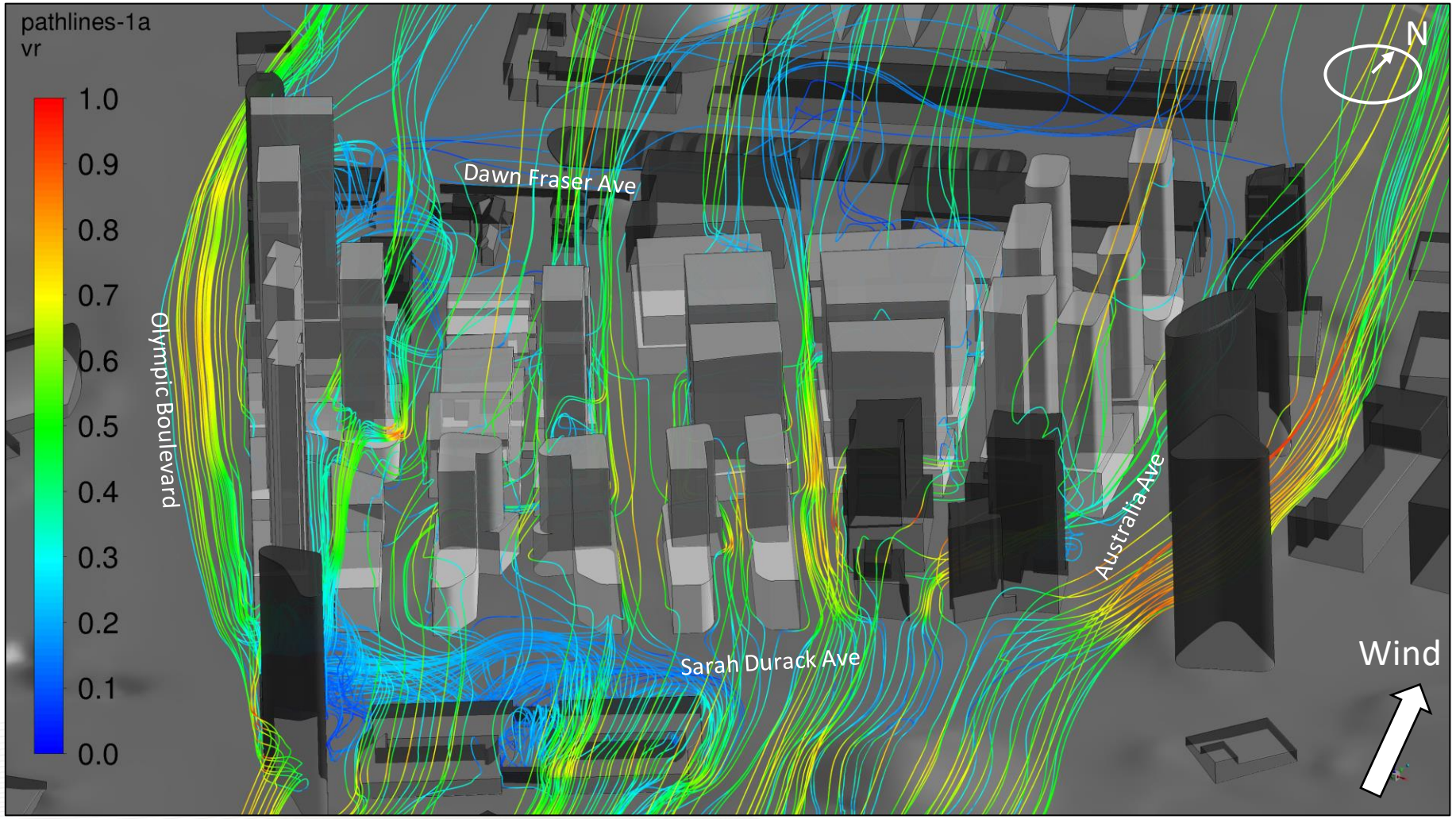
Site: Street Level



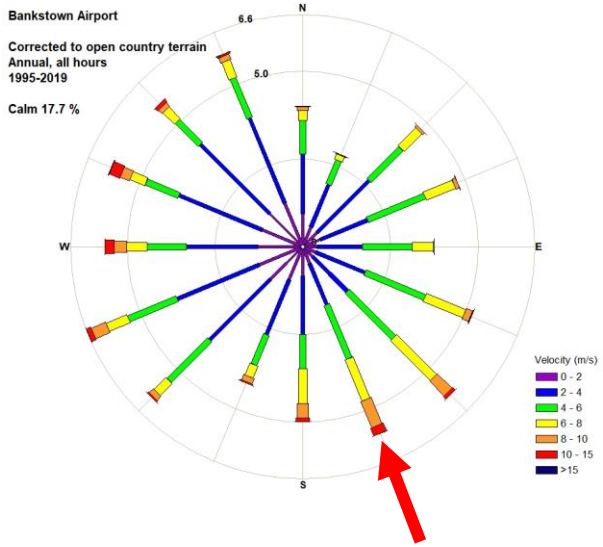
- - - - - Metro site area

- Wind comfort within the Central Precinct varies from *Outdoor Dining* to *Pedestrian Standing*. Comfort conditions within Central Precinct are expected to be suitable for most outdoor activities (see page 9 "*Comfort Assessment Definitions*" for further details).
- Small areas around building corners are slightly windier, rated *Pedestrian Walking* (yellow areas on adjacent image), due to flow accelerating around these locations. Any long-term stationary activities should be moved away from these windier locations.
- A significant proportion of the Central Precinct is rated *Pedestrian Sitting* or *Outdoor Dining*, which would be suitable for most outdoor activities (e.g. outdoor café-style seating).
- The south-western quadrant of Central Precinct is windier than the rest of the site, being mostly rated *Pedestrian Standing.* Comfort conditions around this area are predominantly driven by winds from the south and west. These winds channel down the major roadways (such as Figtree Drive and Olympic Boulevard) that are aligned with these wind directions.
- The dense buildup of high-rise buildings would likely lead to increased flow channelling between buildings, as well as stronger downwash onto ground level. Thus, when compared to existing wind conditions, the build-up of high-rise towers is expected to result in slightly windier conditions within the Central Precinct.

Site: Street Level

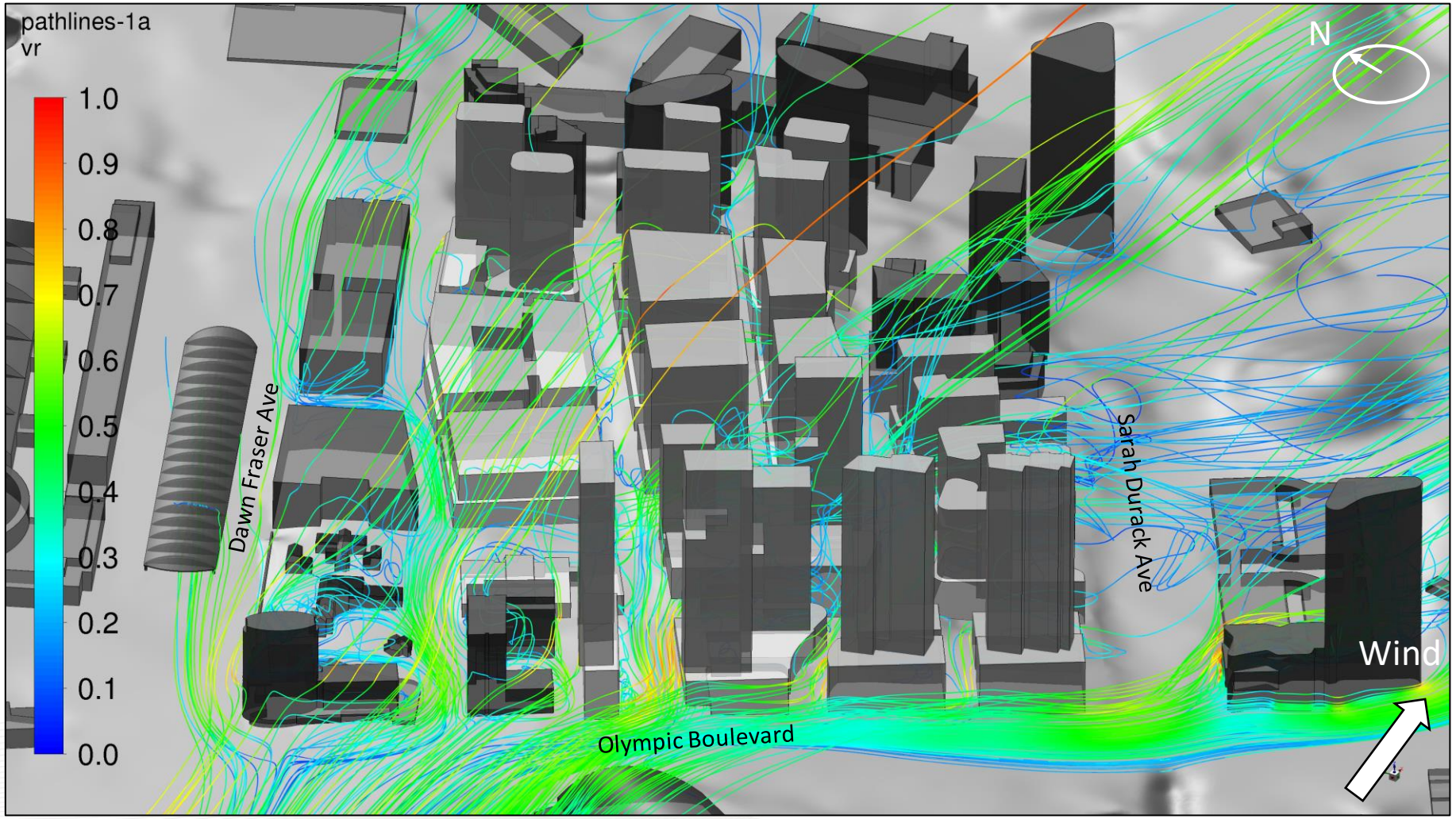


Streamline flow patterns – SSW wind.

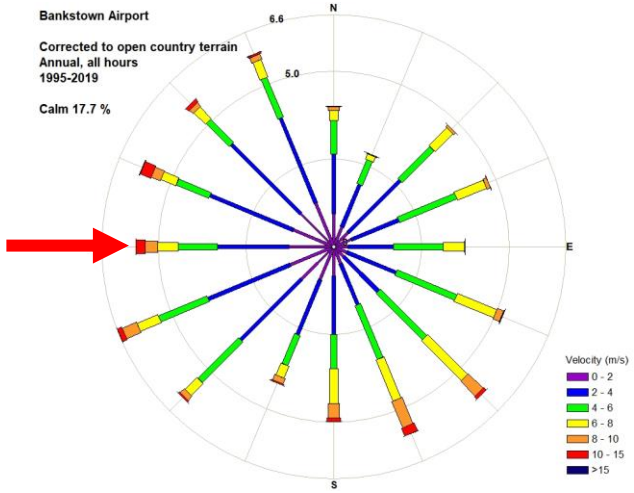


Winds from the SSW channel down the roads aligned SE-NW. The flow accelerates as it channels between the high-rise buildings, and slows down as it expands through the low-rise structures within northern section of Central Precinct. Streamlines coloured by velocity ratio (see page 10 for further details).

Site: Street Level

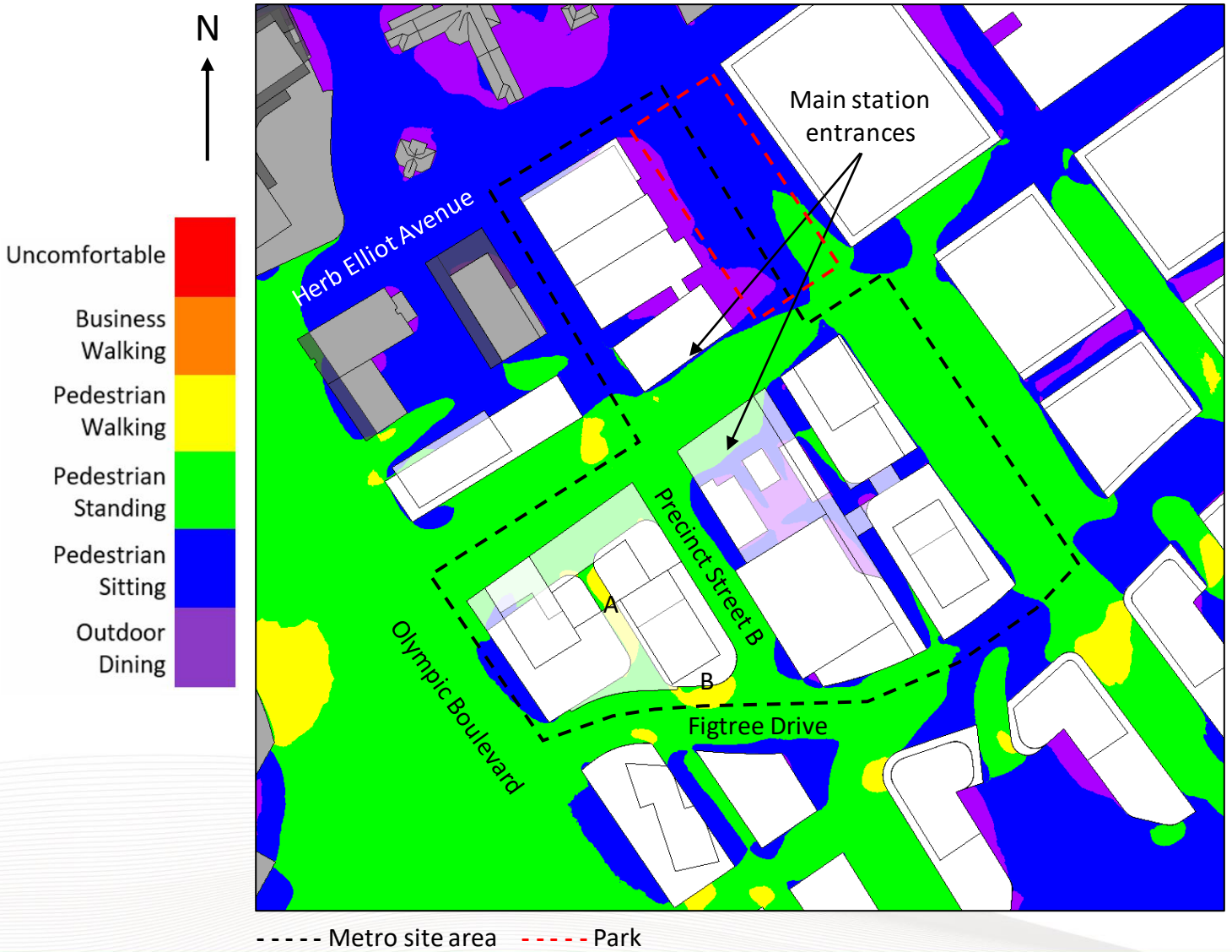


Streamline flow patterns – W wind



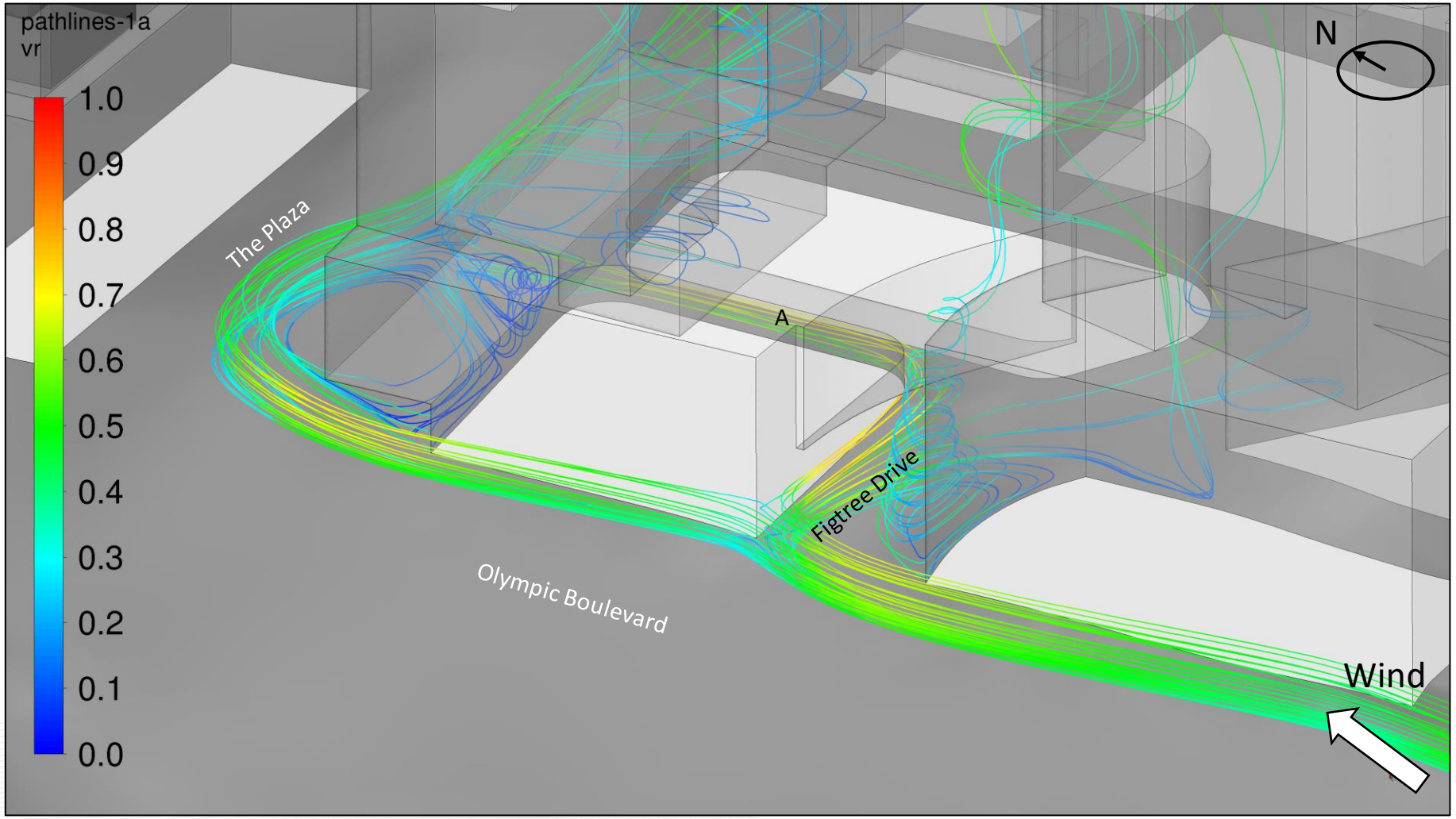
Winds from the W flow along Olympic Boulevard and are redirected through the various roads that are aligned SW-NE. Roads further south towards Sarah Durack Ave experience higher wind speeds than roads further north. This is due to stronger flow channelling effects between the taller buildings to the south.

Site: Metro Site Area

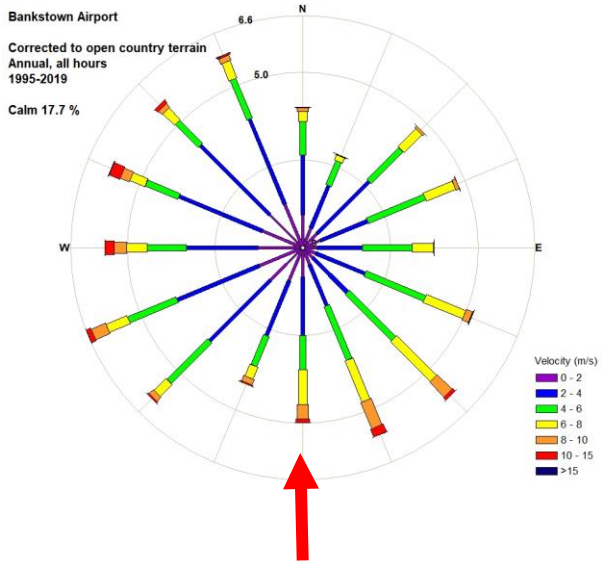


- The Metro site area is generally rated *Pedestrian Standing*, with *Pedestrian Sitting* towards the northern portion and between building complexes and the proposed park.
- Regions A and B are rated *Pedestrian Walking*, and any long-term stationary activities should be located away from these locations.
- Comfort conditions in region A are primarily driven by southerly winds. These winds flow along Olympic Boulevard before diverting onto Figtree Drive and accelerating into region A. The natural planting around the Metro Site Area is expected marginally improve comfort conditions throughout. Trees and natural planting, unless they are extremely dense and resilient (e.g. evergreen species), typically only improve comfort conditions by at most one criterion. In general, trees are most effective in reducing wind speeds when their crowns are dense and close to the ground.
- Comfort conditions in region B are predominantly driven by winds from the WSW. These winds flow along Figtree Drive and accelerate around the building corner onto Precinct Street B. The presence of trees and natural planting along Figtree Drive is expected to marginally improve comfort conditions in region B.

Site: Metro Site Area

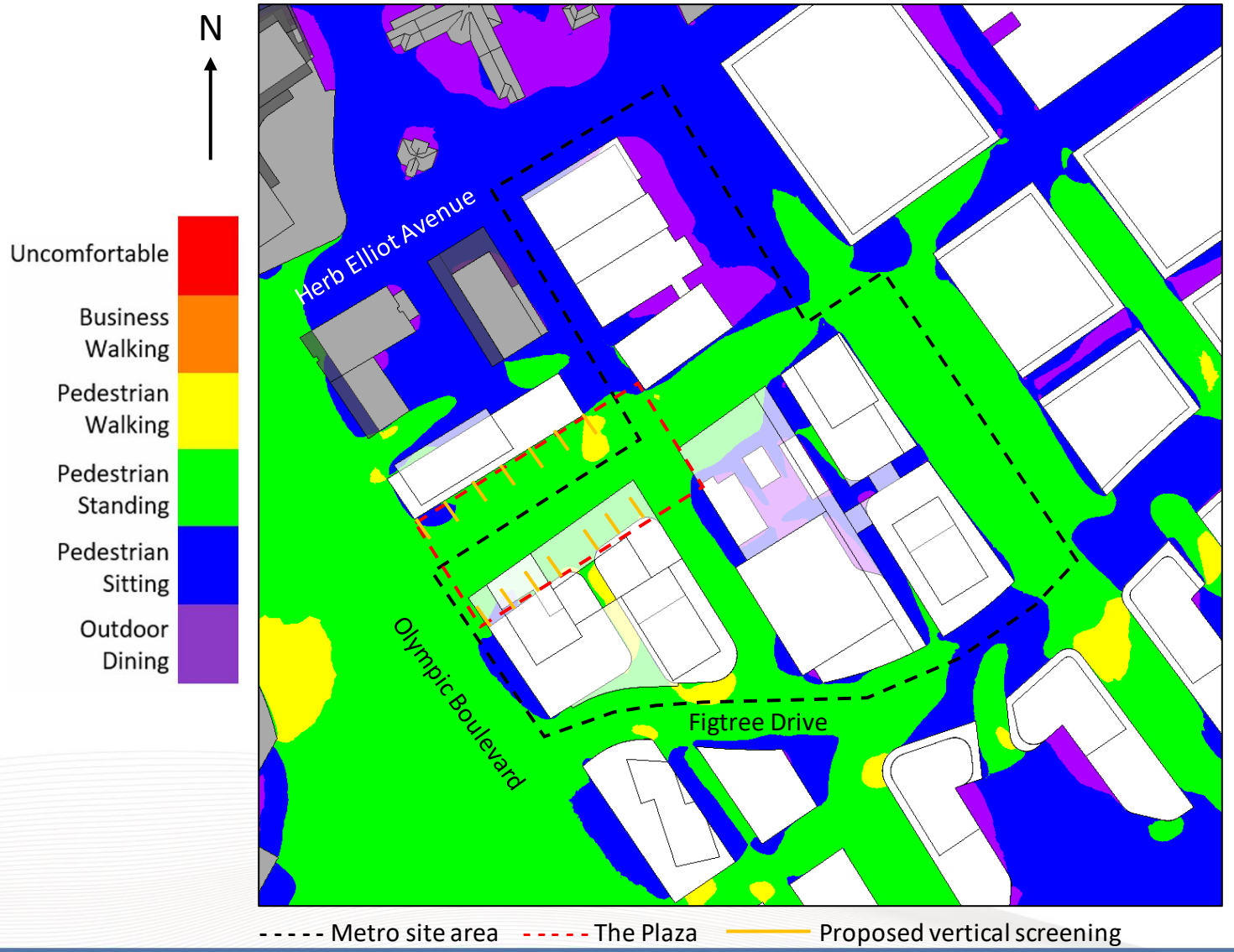


Streamline flow patterns – S wind



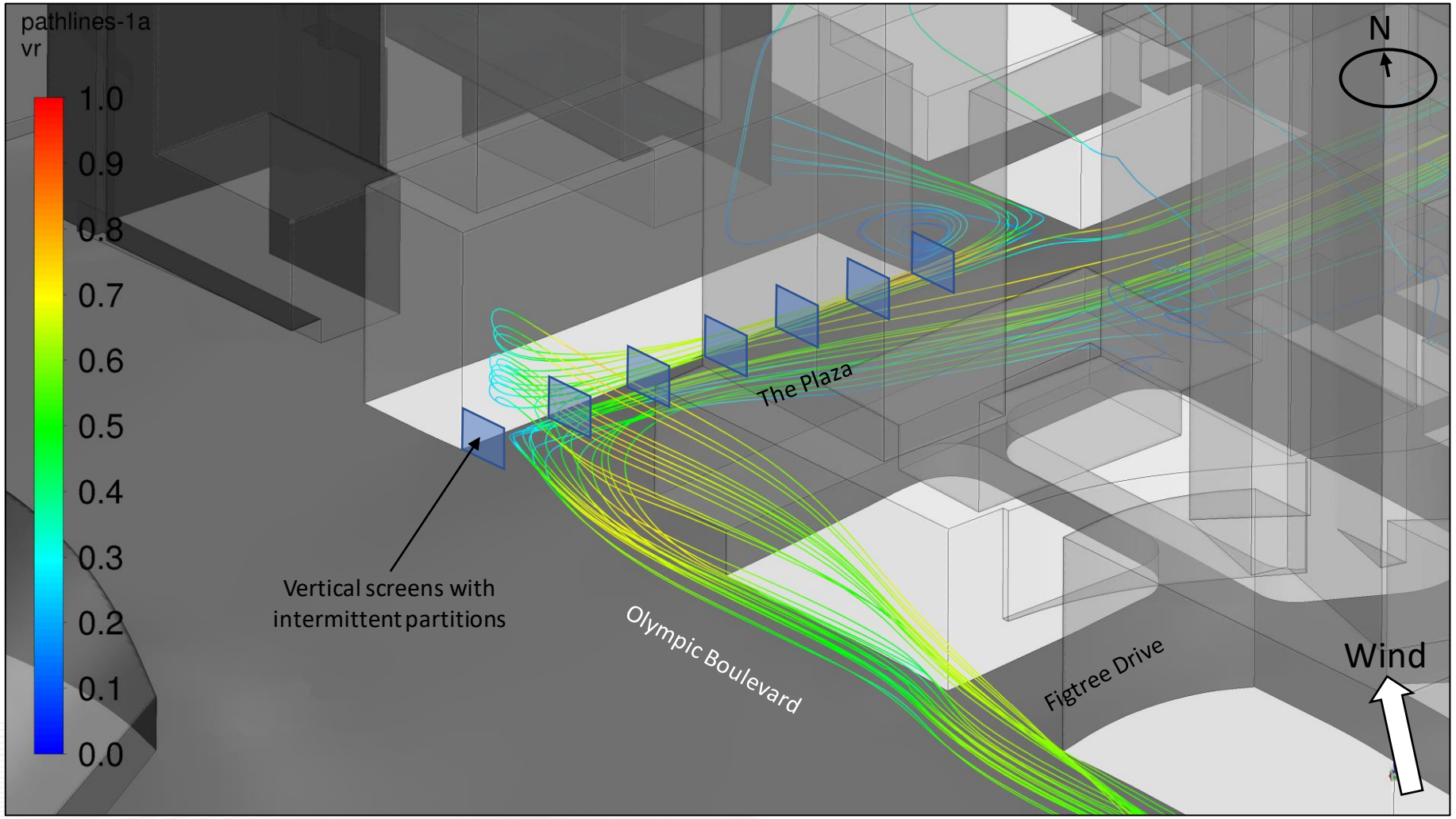
Winds from the S flow along Olympic Boulevard and split off into Figtree Drive before accelerating into region A. If a reduction in wind speeds at this location is desired, dense natural planting along Figtree Drive and Olympic Boulevard is recommended to reduce wind speeds along this road.

Site: The Plaza

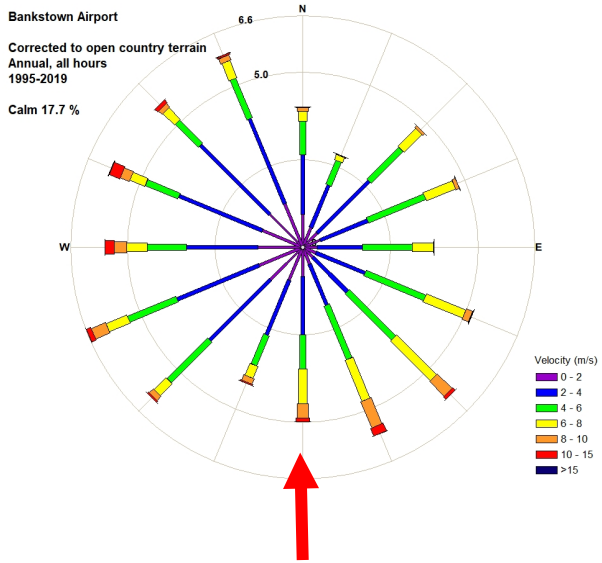


- The Plaza is mostly rated *Pedestrian Standing*. Comfort conditions within the southern portion of the Plaza area is predominantly driven by westerly winds, and comfort conditions within the northern portion of the Plaza are primarily driven by southerly winds. For both these wind directions, the flow within the Plaza is mostly horizontal, with minimal downwards component.
- Southerly winds flowing along Olympic Boulevard accelerate as they turn into the Plaza. Likewise, westerly winds are able to channel into the Plaza and accelerate along the northern façades of the buildings to the south of the Plaza.
- If the northern and southern portions of the Plaza are to be activated for outdoor café-style seating, then local mitigation in the form of vertical screening or natural planter boxes is recommended around these area to create local areas of calm. These screens/planter boxes can be temporary in nature, being deployed as necessary on windier days. Intermittent screens should be placed to partition these protected areas. The screens/planter boxes and will likely need to be at least 1.5 m high if *Pedestrian Sitting* conditions are desired, and at least 2 m high if *Outdoor Dining* conditions are desired.

Site: The Plaza

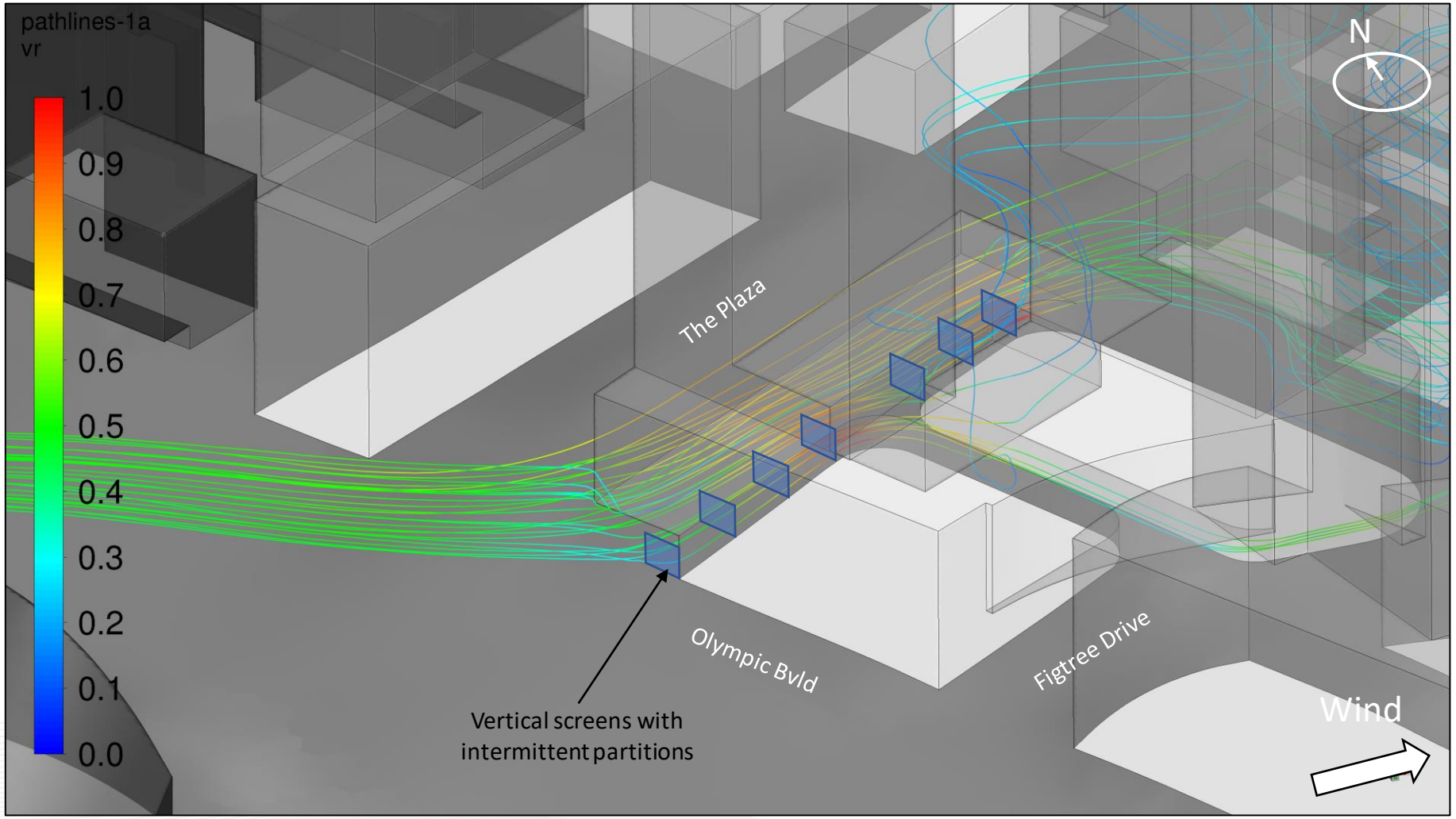


Streamline flow patterns – S wind

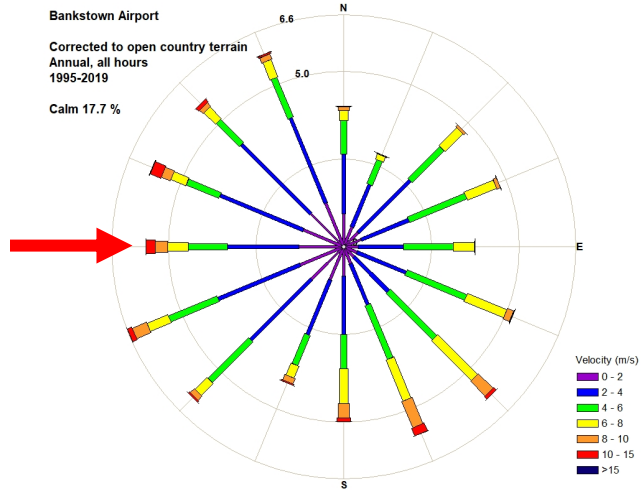


Winds from the S flow along Olympic Boulevard and accelerate into the northern section of the Plaza. To activate this space for outdoor café-style seating, then local mitigation in the form of moveable vertical screens/planter boxes recommended around these areas to create local areas of calm. Intermittent screens should be placed to partition these protected areas.

Site: The Plaza

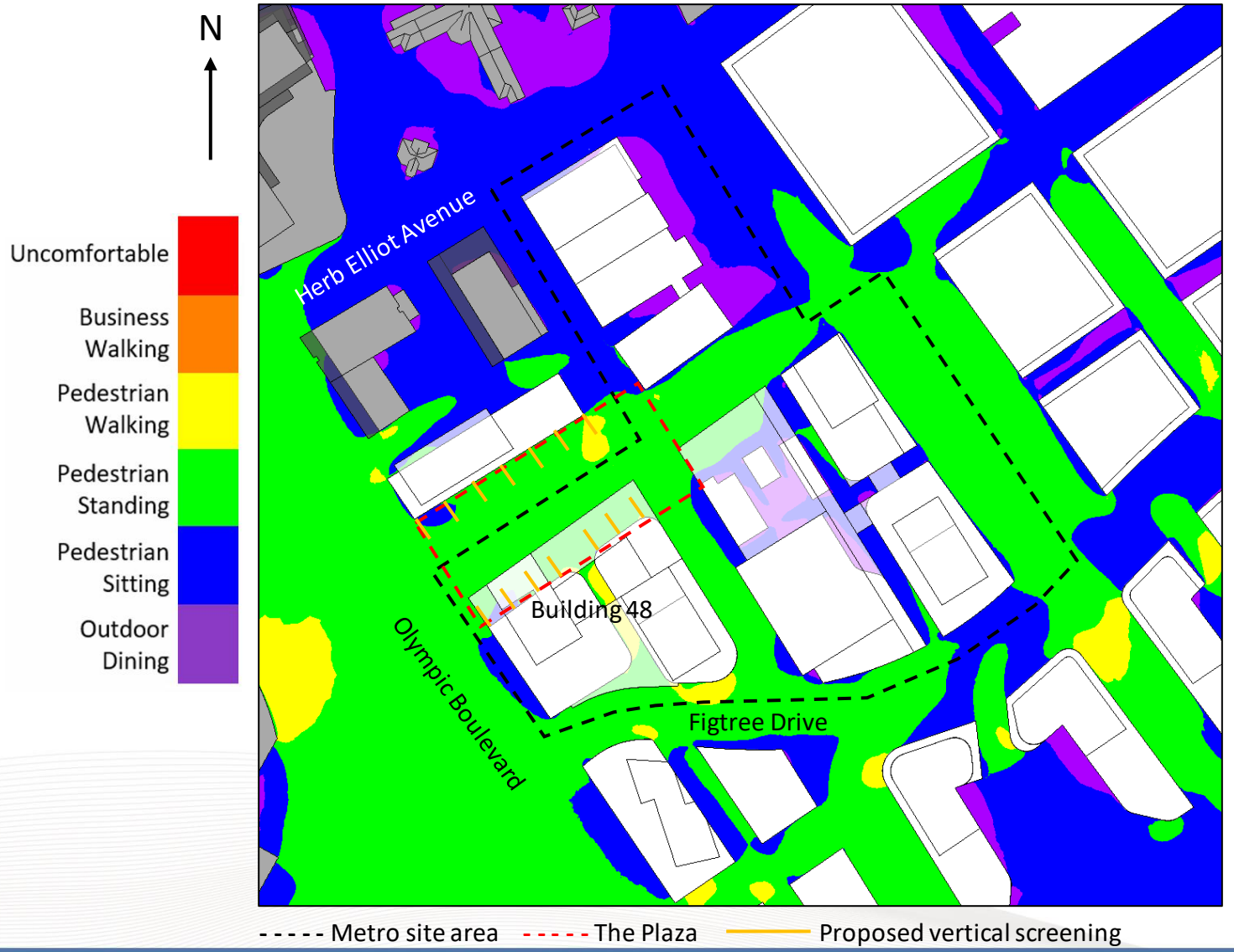


Streamline flow patterns – W wind



Winds from the west accelerate along the northern façades of the buildings to the south of the Plaza. To activate this space for outdoor café-style seating, then local mitigation in the form of vertical screening/planter boxes is recommended around these areas to create local areas of calm. Intermittent screens should be placed to partition these protected areas.

Site: The Plaza



- The model used in the CWE simulations was based on a 3D Rhino model provided by SOPA (Sydney Metro West) on 17 June 2021.
- It is understood that Building 48 does not overhang the Plaza as shown in the CWE model. Additionally, the Plaza width, has also been reduced to 42 m from the modelled average width of 46 m.
- It is expected that removing the Building 48 overhang will not have any significant impact on the comfort conditions. However, reducing the Plaza width will likely result in marginally windier conditions within the Plaza, although it is anticipated that comfort ratings within the Plaza will remain mostly unchanged.
- Overall, it is considered that the wind conditions within the Plaza as modelled would not materially change and the mitigation proposed would be the same. However, a detailed wind study should be undertaken at the SSD stage.

Metro Site Area Wind Criteria

To ensure that wind comfort within the Metro Site Area remains acceptable, it is recommended that future high-rise developments within Central Precinct undergo wind tunnel testing to confirm that any proposed developments do not have any significant adverse impact on existing wind comfort/safety conditions around the site. If the proposed development(s) are found to adversely impact surrounding wind comfort/safety conditions such that they become unsuitable for the intended use of space, then appropriate mitigation strategies should be adopted and tested to ensure that comfort/safety conditions remain suitable for the intended use of space.

Wind comfort/safety should be quantified and assessed against internationally recognised criteria, such as the Lawson criteria. Any wind assessment should be conducted by a suitably qualified wind consultant/engineer in accordance with Quality Assurance Manual (QAM) for Wind Engineering Studies of Buildings by the Australasian Wind Engineering Society[1].

[1]AWES (2001) Quality Assurance Manual for Wind Engineering Studies of Buildings, AWES-QAM-1-2001.

Conclusion

When compared to the existing wind conditions, the build-up of high-rise towers within the proposed revisions to the design of the Central Precinct is expected to result in slightly windier conditions within the project site.

It is understood that Building 48 does not overhang the Plaza. Additionally, the Plaza width, has also been reduced to 42 m from the modelled average width of 46 m. It is expected that removing the Building 48 overhang will not have any significant impact on the comfort conditions. However, reducing the Plaza width will likely result in marginally windier conditions within the Plaza, although it is anticipated that comfort ratings within the Plaza will remain mostly unchanged. Overall, it is considered that the wind conditions within the Plaza as modelled would not materially change and the mitigation proposed would be the same. However, a detailed wind study should be undertaken at the SSD stage.

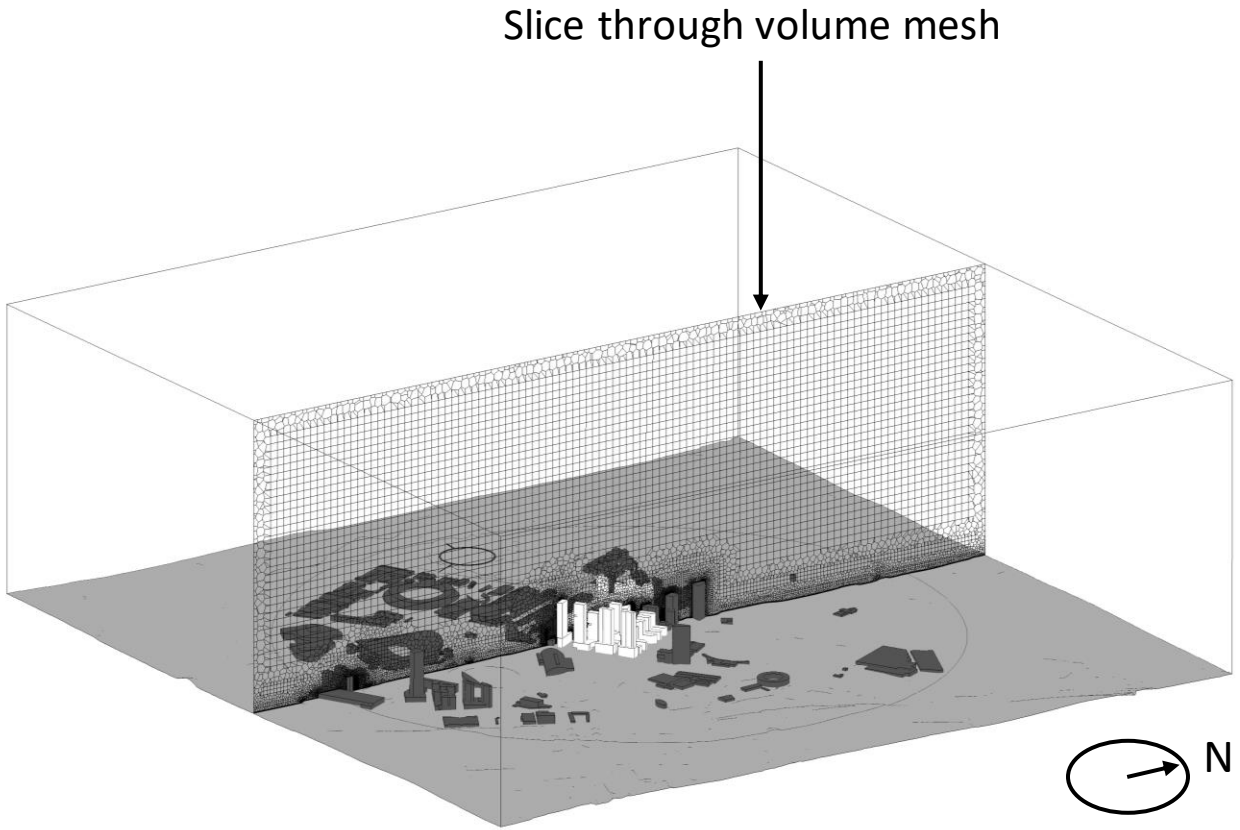
The CWE wind assessment has shown that comfort conditions within Central Precinct are expected to be suitable for most outdoor activities, with no major areas of concern. The proposed landscaping and natural planting throughout the Central Precinct is expected to reduce wind speeds within the site, resulting in slightly better comfort conditions than shown. Mitigation measures in the form of vertical screens/planter boxes were recommended within the Plaza if these spaces are to be activated for outdoor café-style seating.

Consideration	Considerations met
This wind assessment study seeks to identify wind comfort ratings for the entire Central Precinct and all adjacent areas affected by the proposed development.	This report identified wind comfort for the entire Central Precinct and all adjacent areas affected by the proposed development.

Appendix A:
Computational Model Details

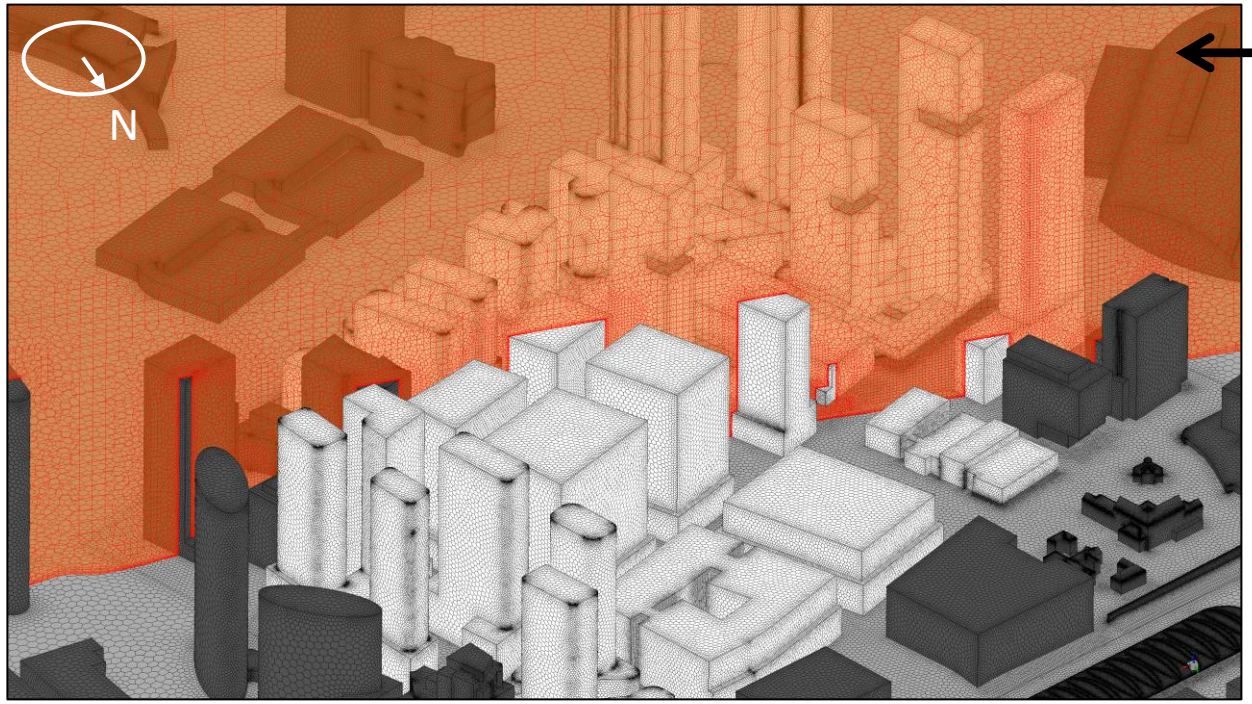
Computational Model

- The domain was discretized into approximately 28 million cells comprising polyhedral and hexahedral cell types.
- The mesh was refined around the site, and inflation layers were included on all walls.
- Sixteen wind directions were simulated, and pressure and momentum quantities solved to first-order accuracy: this mesh has minimal numerical diffusion.
- The SST k-ω turbulence model with curvature correction was used.
- The size of each cell was allowed to range from 0.2 m to 25 m, with maximum cell sizes of 2.5 m for buildings around the site, 4 m for buildings further out, 2.5 m for terrain inside the modelled area, and 5 m for terrain outside the modelled area. A global growth rate of 1.2 was used. The height of the domain is 1000 m, and blockage effects are expected to have a minimal impact on the results.



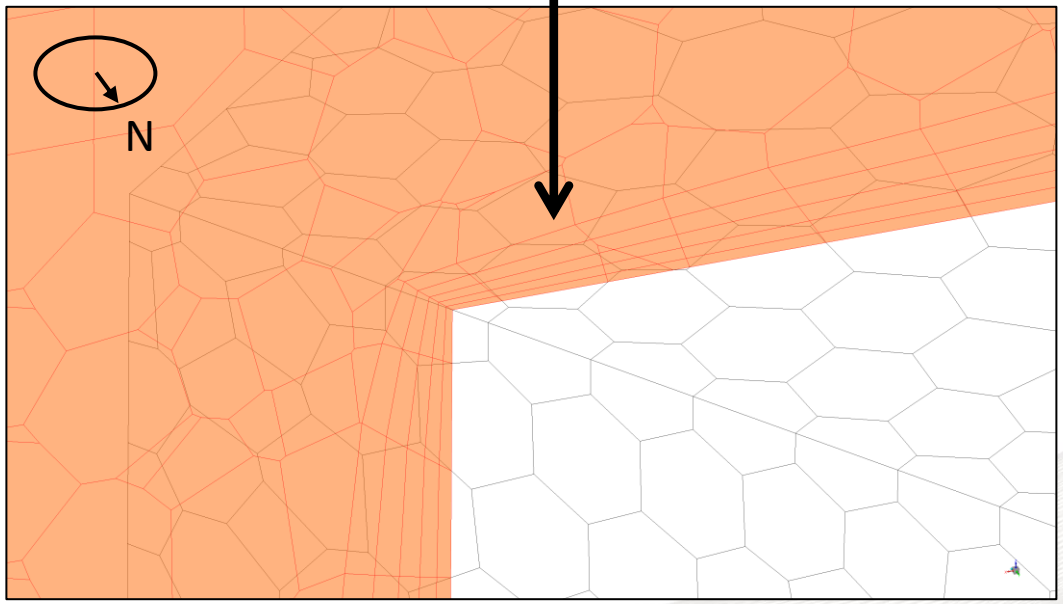
[1]F. R. Menter. "Two-Equation Eddy-Viscosity Turbulence Models for Engineering Applications". AIAA Journal. 32(8). 1598–1605. August 1994.

Computational Model



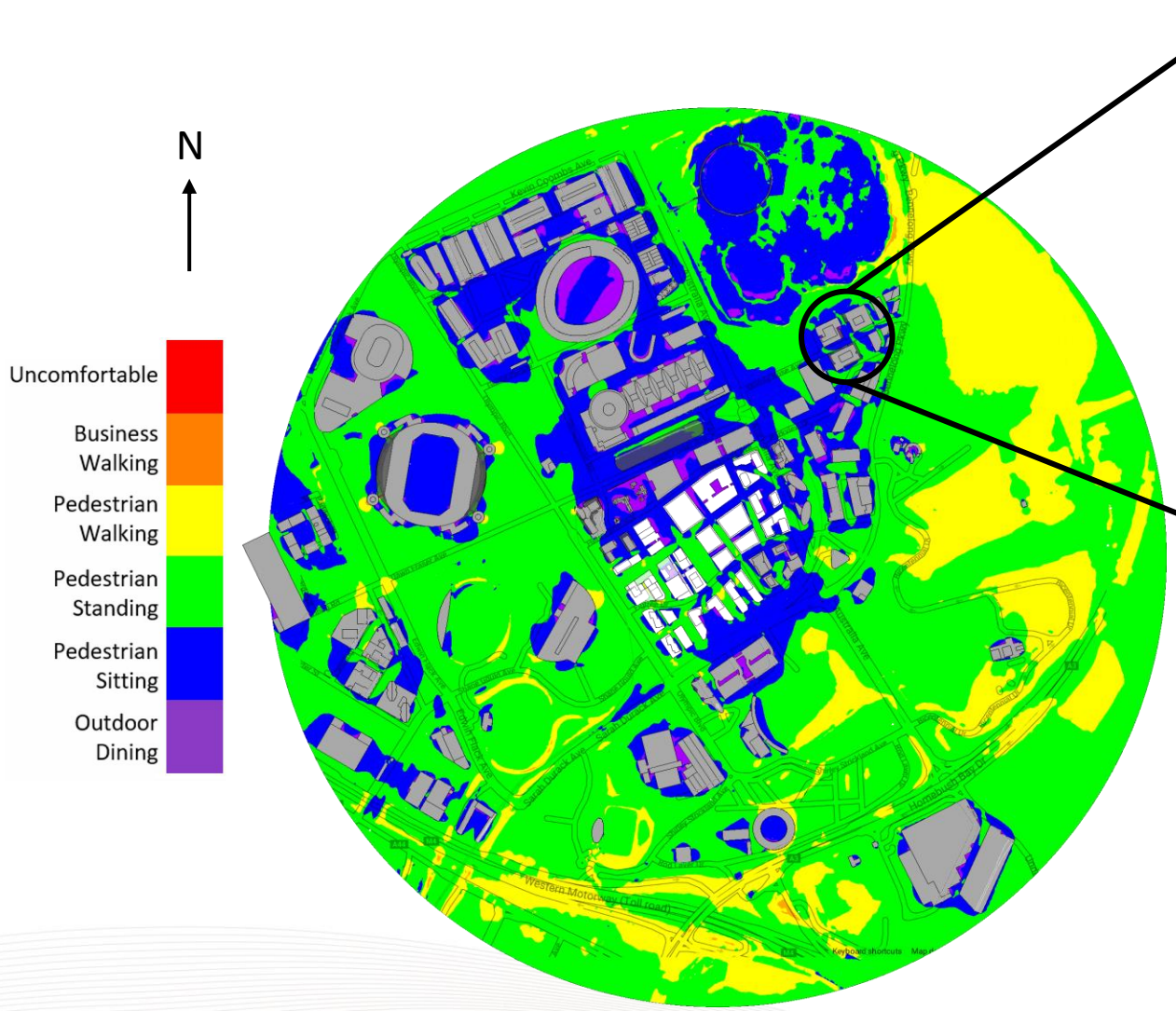
Vertical slice through domain

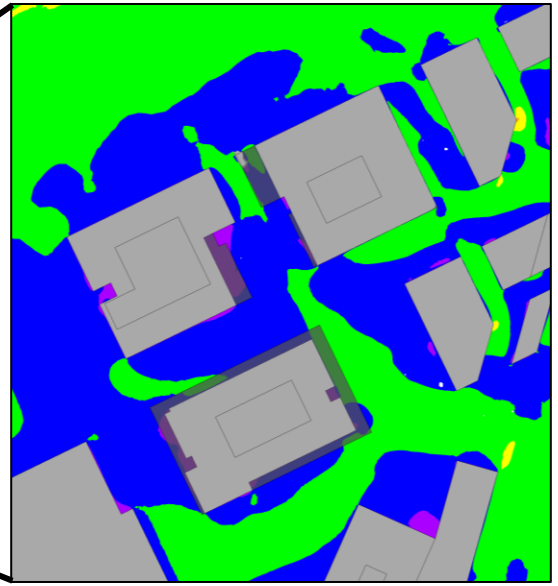
Inflation layers on every wall of domain



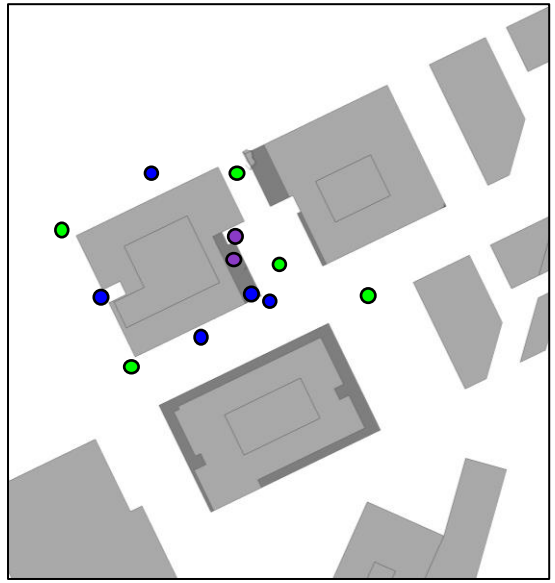
- Refined mesh resolution on areas around the site to capture the flow mechanisms in the areas of interest.
- Five inflation layers on all walls to adequately resolve near wall velocity gradients.

Validation





CWE results.



Wind tunnel test results.

CPP have previously conducted wind tunnel testing of the area shown above. The points tested in the wind tunnel test are shown on the right above, with the circles colour-coded according to the Lawson comfort rating obtained from the wind tunnel test. Evidently, there is overall a very good agreement between the wind tunnel test results and the CWE results.

Comfort Assessment

- Pedestrian comfort is assessed according to the Lawson Criteria[1,2] at 1.5 m above ground.
- Wind speeds simulated for 16 wind directions are combined with the wind climate to determine the wind speed exceeded 5% of the time.
- Lawson criteria consider both the local mean and gust wind speeds. This report is based on Computational Wind Engineering (CWE). CPP's CWE techniques provide an overall view of the flow field and a reasonable prediction of comfort. However, gust wind speeds are only indicative for this type of study, and *wind tunnel testing is required to accurately assess conditions if safety is a concern.*

1. T.V. Lawson, The Determination of the wind environment of a building complex before construction, Department of Aerospace Engineering, University of Bristol, Report Number TVL 9025 (1990)
2. T.V. Lawson, Building Aerodynamics, (Chapter 4), Imperial College Press, 2001, ISBN 1-86094-187-7

Wind Climate and site roughness corrections

Dir (°)	A	k	C (m/s)	$C_{ref,site}$ (m/s)	Modeled Exposure[1]
0	0.029	1.98	3.81	5.22	3
22.5	0.026	2.25	4.01	5.53	3
45	0.043	2.40	4.46	5.83	3
67.5	0.044	2.41	4.95	6.80	3
90	0.051	2.59	4.82	6.49	3
112.5	0.048	2.63	5.32	6.75	3
135	0.053	2.54	5.90	7.48	3
157.5	0.052	2.22	6.29	7.95	3
180	0.067	1.88	5.14	6.76	3
202.5	0.037	1.70	3.94	5.31	3
225	0.054	1.94	4.18	5.49	3
247.5	0.061	1.82	4.62	5.83	3
270	0.076	1.56	4.63	5.85	3
292.5	0.053	1.66	4.88	6.21	3
315	0.051	1.79	4.19	5.40	3
337.5	0.078	1.93	4.15	5.61	3

H_{ref}	150 m
$\bar{V}_{ref}$	10 m/s

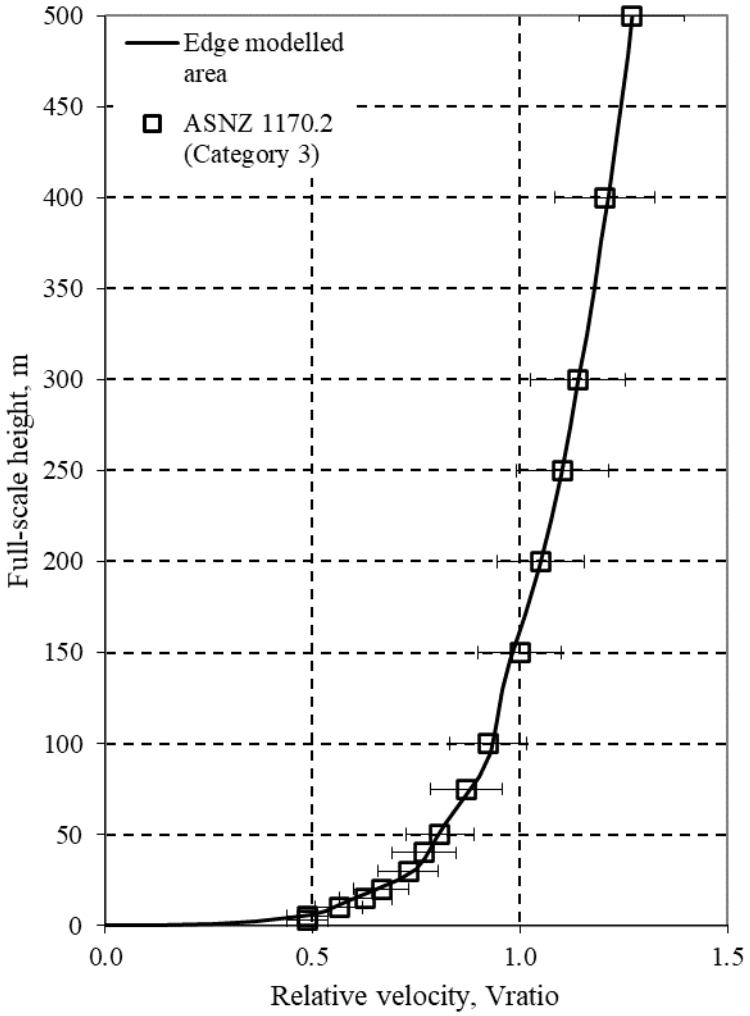
Probability of the wind speed v exceeding V m/s:

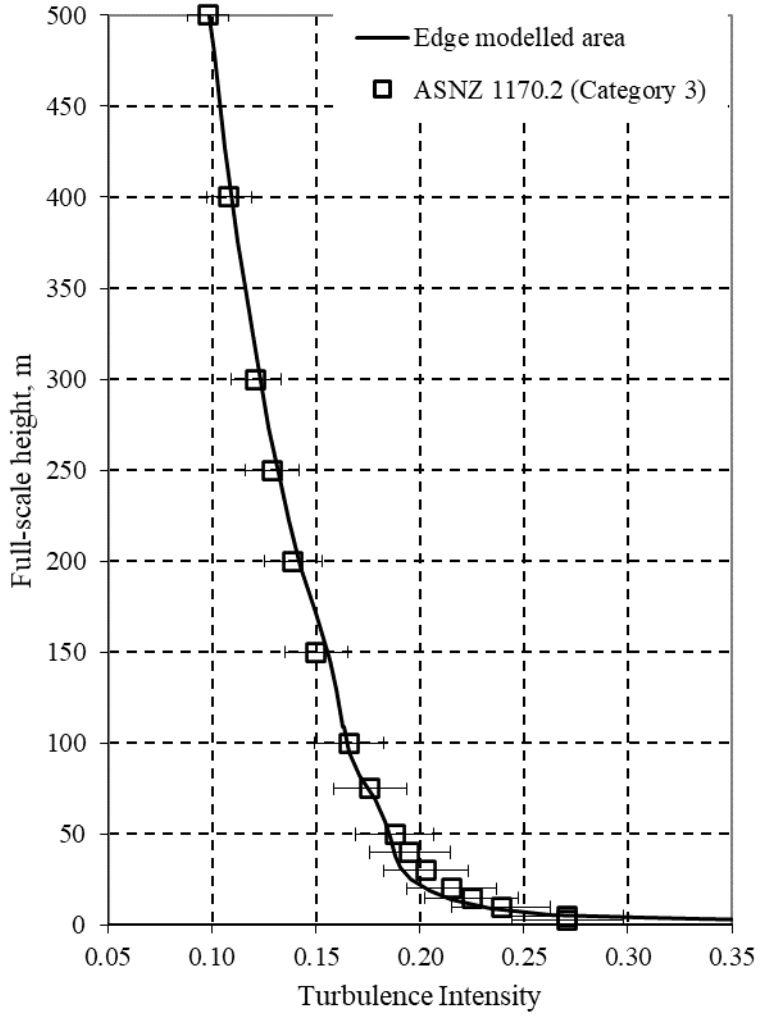
$$\Pr(v > V) = \sum_{1}^{16} A_i \exp\left[-\left(\frac{V}{C_{ref,site,i} V_{r,i}}\right)^{k_i}\right]$$

where V_r is the velocity ratio, as obtained from the CFD simulations.

[1]Standards Australia (2011), Australian/New Zealand Standard, Structural Design Actions, Part 2: Wind Actions (AS/NZS1170 Pt.2).

Atmospheric Boundary Layer Calibration – Terrain Category 3

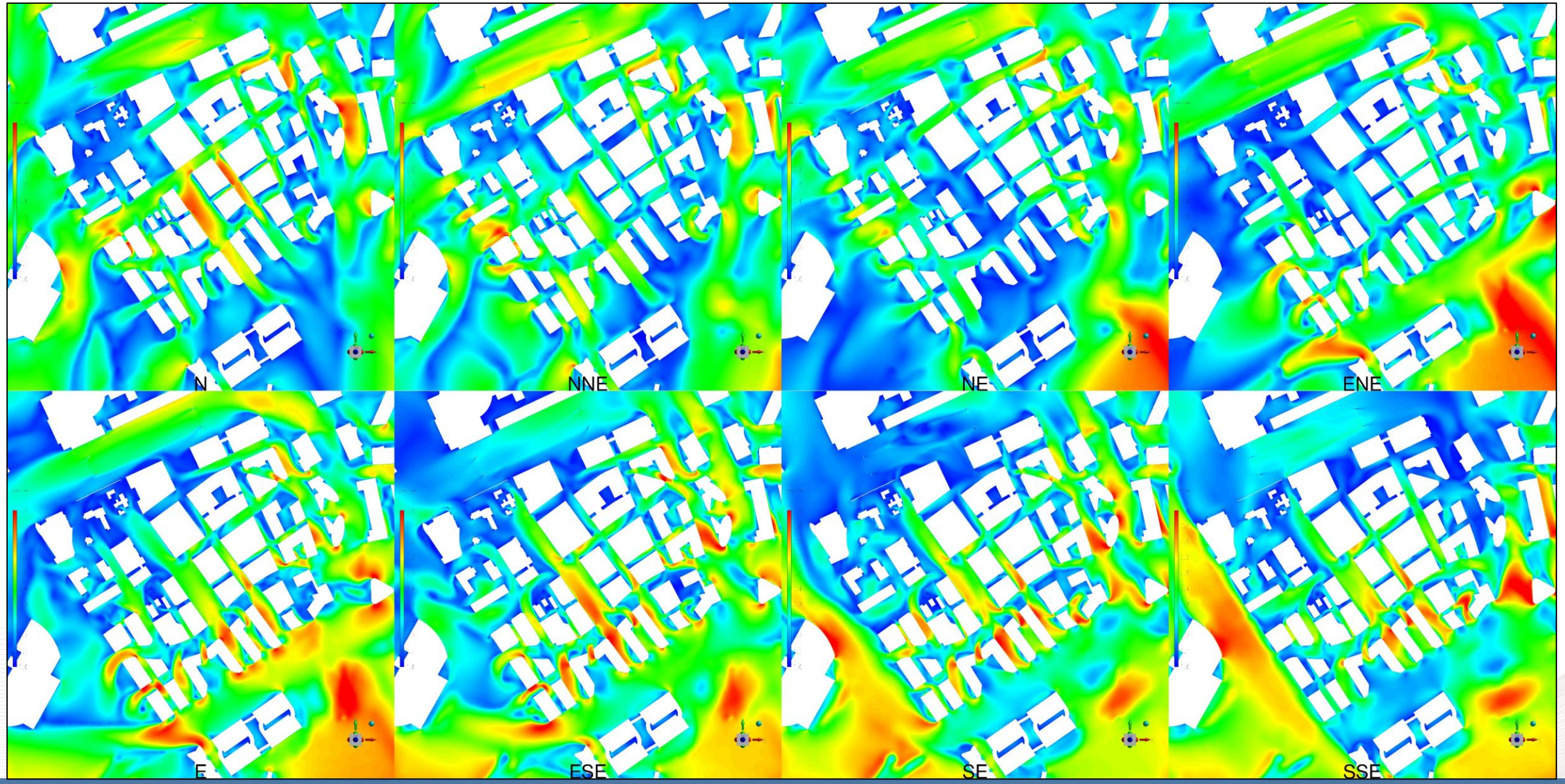




- The left plot shows the variation of wind speed with height on approach to the explicitly modelled area (with ±10% bounds) for Terrain Category 3, as required by AS/NZ 1170.2[1] compared to the domain's inlet boundary condition.
- The right plot shows the variation of turbulence intensity with height.
- Ensuring the propagation of the Atmospheric Boundary Layer (ABL) profile into the domain is a key requirement of conducting reliable CWE simulations. CPP techniques were used to ensure that this requirement was achieved for all wind directions.

[1]Standards Australia (2011), Australian/New Zealand Standard, Structural Design Actions, Part 2: Wind Actions (AS/NZS1170 Pt.2).

Velocity ratio contours (1.5 m)



Velocity ratio contours (1.5 m)