eCove

SOPA Site 68 Residential

Environmental Wind Study

ESD

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Executive Summary

A summary of findings from the environmental wind analysis is located in the table following. It also includes recommendations for maintaining and possibly improving the environmental wind conditions.

Location	Notes
Site	• Adopted amelioration measures assist in improving the conditions experienced across the site significantly. • Trees incorporated into the landscaping should exhibit a large and dense crown to reduce the likelihood for unfavourable conditions around the base of the tower. • Installation of canopies over the outdoor café seating and entrance lobby assist greatly in reducing the impact of down drafts during prevailing wind conditions.
Wintergardens	• High wind velocities have been noted around the wintergardens and consequently it is recommended that the wintergardens be enclosed to reduce wind comfort and distress.
Café	• Outdoor seating may possibly be impacted from both southerly and northerly winds for a small portion of the year. • Amelioration measures already included, assist in providing a safe environment. • Additional localised wind bluff objects (screens, low level hedges,etc.) may be implemented to improve conditions further for café patrons seated outdoors.
Balconies	• Conditions in the slot balconies have been investigated and generally they show favourable conditions. • Impacts to resident comfort may be impacted at higher levels in the balconies but it is unlikely to impact the occupied levels. • Consideration should be made for structural impact of elements hung in the slot balconies at high level. • General apartment balconies are expected to exhibit better conditions than the slot balconies, however additional screening may be implemented to provide improved amenity – no comfort or safety issues have been identified.
Roof (Halo)	• Conditions at the roof/plant level are not suitable for prolonged occupation.

1 Introduction

Arup have been engaged by eCove to assess the likely wind conditions around the proposed development at Site 68, Sydney Olympic Park. The development is located at in western Sydney and surrounded by suburban areas, parkland and a few high rise buildings. The proposed development includes a high rise residential tower and a landscaped ground plane.

The site is located on a relatively flat landscape; there are no significant topographical features that impact on local wind flows. The massing of development also means that it is relatively open to wind from all directions with a small amount of protection offered to the north by other high rise residential towers. An aerial image of the immediate surrounds in show in Figure 1.

Figure 1 Site and immediate surrounds

2 Measured Wind Data

The statistical wind assessment is based on long-term weather data recorded at Sydney Kingsford Smith for the period 1995 through to 2013. The diagram below provides a summary of all measured data for this period in the form of a wind-rose, which clearly indicates that the strongest and most frequent winds are from the south with secondary winds from the north-east and north-west.

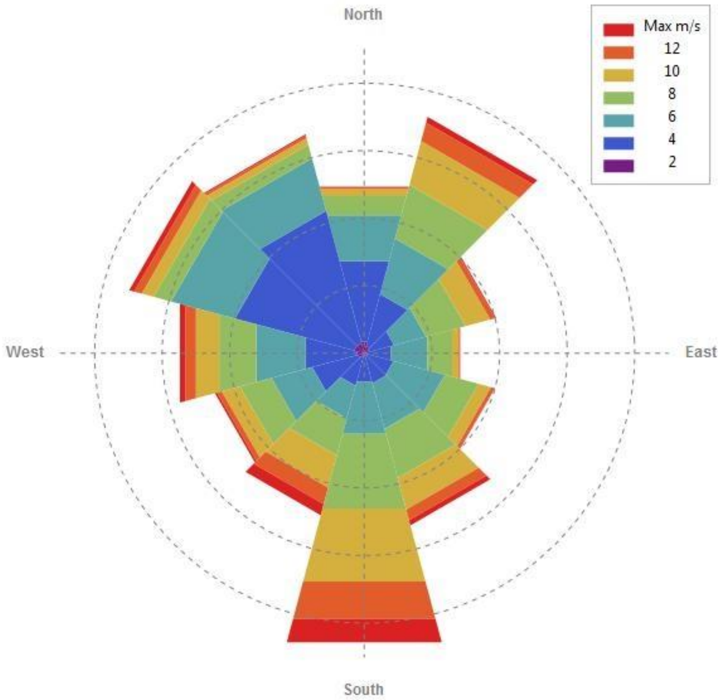

Figure 2 Annual wind rose for data sourced from Sydney Kingsford Smith (1995 through to 2013)

The measured wind data has been processed using an industry-standard approach assuming a Weibull approximation to the statistical wind distribution for each wind direction. The subsequent analysis of wind speed probability is based on this statistical analysis.

The Weibull wind distributions have been transformed from the airport to the site to account for the effects of terrain roughness. The wind transformation has been done in accordance with a well-established approach developed by the UK-based engineering advisory organisation, ESDU.

The methodology for generating wind statistics based on long-term measured data and then transforming this information from the meteorological site is an industry standard. It is the same as the approach used for undertaking wind-tunnel assessments of environmental wind.

3 Numerical Wind

The assessment provided in this report is based on computer simulation of wind flow around the proposed development and the adjacent local developments. The type of software used for this purpose, generally called computational fluid dynamics (CFD), has a long history of application in the aerospace and automotive industries. The accuracy and functionality of CFD software is continually improving and it now finds useful application in a diverse range of industrial applications.

CFD is finding useful application in some specific areas of architectural aerodynamics including the assessment of environmental wind conditions. A number of recent academic studies have looked closely at the strengths and weaknesses of CFD for this purpose and concluded that it provides a valid assessment approach so long as it is used in accordance with best-practice methodologies. CFD can be used to predict the key characteristics of wind flows in urban environments that cause wind nuisance including downdrafts, corner flows, passage flows etc. and is generally most accurate in predicting areas of relatively high-wind speed, thus making it well-suited to evaluating environmental wind conditions that have the strongest effect on wind discomfort (Blocken et al (2012))

Arup have used the recommended best practice approach to wind modelling described in *Best Practice Guideline for the CFD simulation of flows in the urban environment* produced as part of European intergovernmental research organisation COST action 732 (Franke, et al., 2007). A steady state, RANS approach is used for the assessment, which is compatible with the best practice guidelines and in accordance with the methods used by Blocken et al for environmental wind assessment.

A key advantage offered to designers using CFD is the ability to visualise wind speeds in three-dimensional space and also being able to undertake rapid design iterations. Compared to wind tunnel testing, CFD provides the ability to map the whole flow field and then focus on discrete measuring locations. This provides the designer with the ability to generate cross-sectional data and wind streamlines, both of which are useful in aiding the understanding of wind effects and being able to identify design solutions and appropriate wind mitigation strategies.

Vegetation adjacent to the location has been incorporated into the model using the research work of Mochida et al. (2008). A conservative approach has been implemented by implementing a highly porous model with minimal turbulence energy dissipation.

Overall it is this analysis will be more conservative than wind tunnel testing and appropriate for this stage of works.

4 Environmental Wind Speed Criteria

The wind environment becomes less comfortable as wind speeds increase; particular wind speed ranges are considered appropriate for different uses. Above a certain threshold, higher wind speeds start to cause distress and can potentially create unacceptable wind conditions. By its nature, wind speed is not consistent, it fluctuates continuously. Consequently, it is typically for wind comfort and distress criteria to be delivered using statistical analysis.

The choice of wind speed comfort criteria tends to vary from one region to the next and no single standard is mandated. For the assessment of SOPA Site 68, the following criteria for wind comfort is proposed based on the work of Lawson (1975). It is assessed using the mean hourly 5% annual exceedence wind speed. It was also compared to the weekly gust equivalent mean speed (GEM), however the results indicate this to be more conservative and hence the 5% exceedence limit was utilised.

Similarly, the definition of wind distress criteria varies based on assessment the work of Lawson, and assessed for the mean hourly 0.022% exceedence which is equivalent to the probability of this wind speed occurring twice a year.

Table 1: Criteria for wind comfort

Mean hourly wind speed exceeded 5% of the time [m/s]	
2-4	Long periods of standing of sitting
4-6	Short periods of sitting or standing
6-8	Leisurely walking or window shopping
8-10	Fast or business walking
> 10	Uncomfortable for all uses

Table 2: Criteria for wind distress

Mean hourly wind speed exceeded 0.022% of the time (twice per year) [m/s]	
<15	General access
15-20	Acceptable for able-bodied persons (not frail or cyclists)
>20	Unacceptable

A review of the wind statistics indicates that mean wind speed at 10m at the airport is around 6m/s. Transformed to the site at a typical pedestrian height, the mean wind speed is expected to be in the order 3.5m/s with a 5% exceedence speed around 6m/s in a location away from local building effects. This generally indicates suitability for outdoor activities involving short periods of sitting and standing as per the Lawson criteria outlined above and in general agreement with direct experience of the Sydney wind climate.

The results are presented graphically as an exceedence distribution (inverse cumulative) with the comfort and distress criteria overlaid. Given the very small exceedence limit for the distress criteria, this is listed numerically. The plot shown as Figure 3 shows an example of the results presentation for a single location.

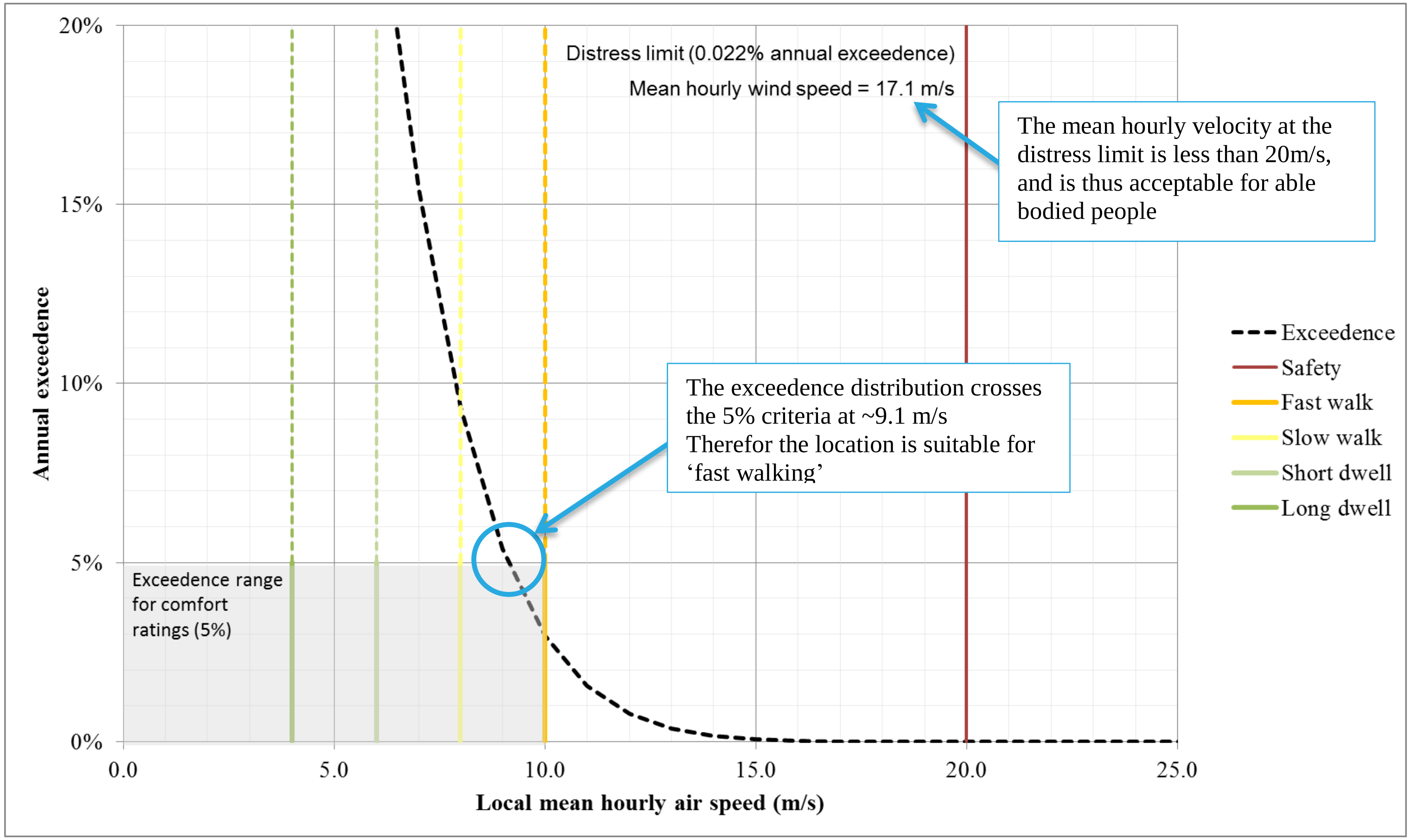

Figure 3 Example results presentation plot

5 Results

5.1 Local Massing Comparison

The site is part of a larger masterplanned development containing a number of new buildings which are not yet developed. The first set of results focussed on determining how the new development would impact the proposed development. CFD analyses were undertaken for the proposed massing immediately following completion of the development. This was compared to the indicative massing for the planned development to understand the influence, the key development being Site 67 which is immediately to the north of the proposed Site 68 building.

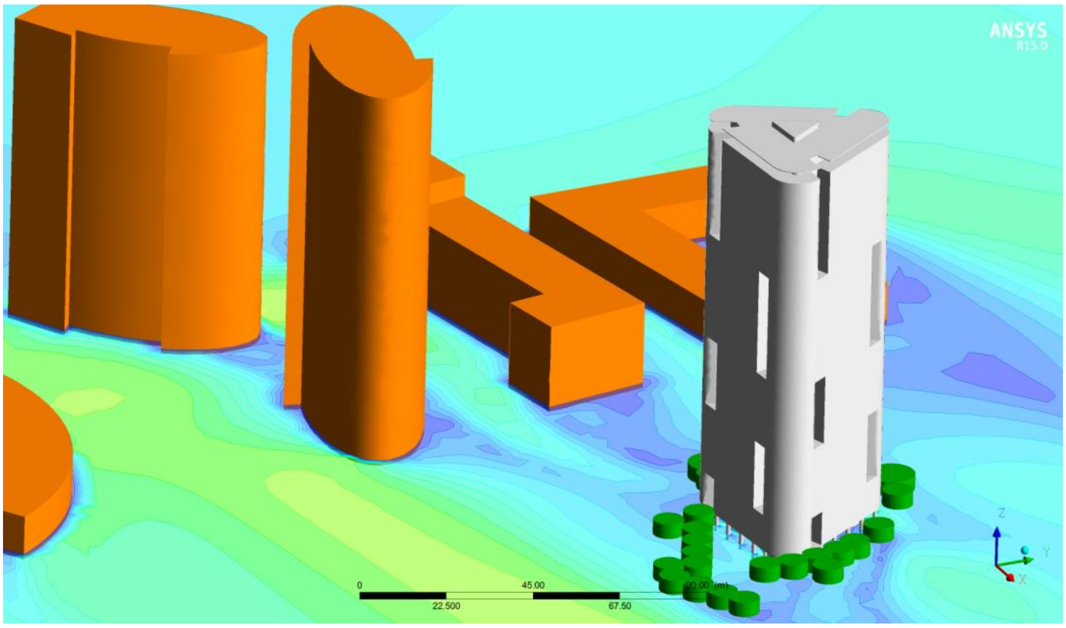

Figure 4 Site image with adjacent Site 67 development (viewed from south west)

The results of the study show that the site receives significant protection from the extreme wind conditions from the proposed developments. An example of the output from the comparison study is shown in Figure 5. Note that the velocities calculated at the site are generally lower across the whole site, this was noted for all wind directions. Given the relatively large spacing and small massing of the developments, this is expected. The analysis was thus completed utilising the conservative assessment of not including the masterplanned developments. Hence the results presented in this report represent the opening day conditions.

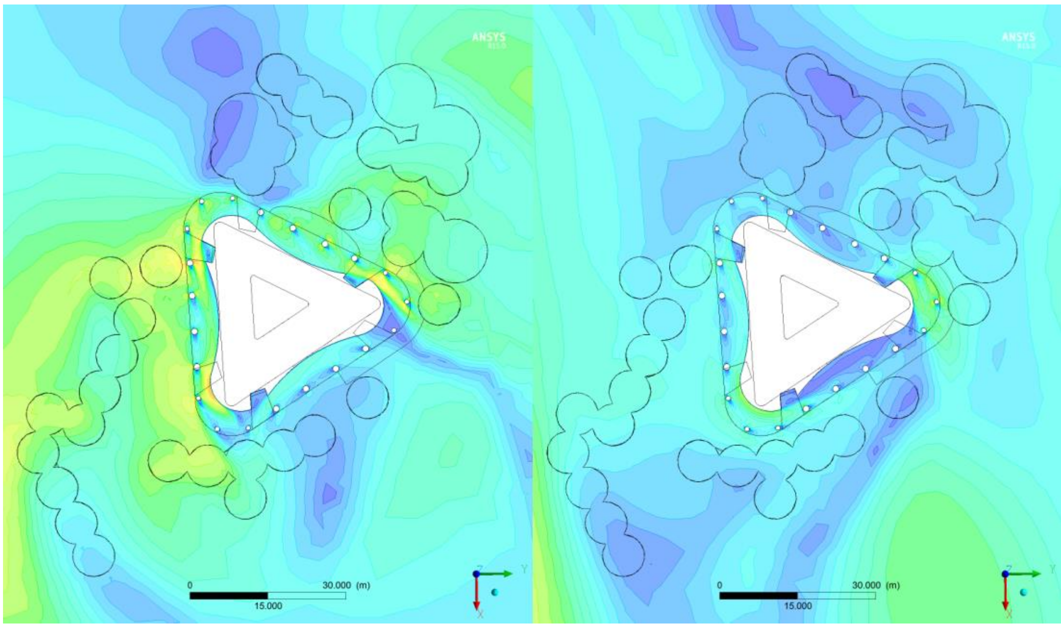

Figure 5 Detail comparison for the site without (left) and with (right) the Site 67 development

5.2 Site Amelioration

With the surrounding massing developed, the proposed development was then tested with and without proposed amelioration measures to determine performance against the wind comfort and distress criteria.

Initial studies of the building showed poor performance at the ground plane, and consequently the following amelioration measures have been proposed.

1. Canopy over entrance to reduce downwash impact
2. Canopy over the café at the eastern point of the ground floor plate to prevent downwash
3. Extensive planting to all sides of the development, close to the tower, to assist in lifting the boundary layer flow away from regularly occupied areas.

A site plan showing these amelioration measures is presented as Figure 6. Specific locations for measurement of wind comfort are also selected and noted in this figure. Additional resolution of results is important for the outdoor dining location outside the café near the eastern point of the foorplate; consequently additional measurement points are indicated in this area. Conditions improve significantly as you move further away from the building, hence the specific measurement locations are focused around the base of the building.

The following example images illustrate the relative impact of combined set of amelioration measures on the ground plane. For each image, the left hand image is without amelioration and on the right with. The four worst case wind directions are presented, other wind directions show similar or greater improvement in wind conditions. These four wind directions also represent the strongest prevailing winds. All results are presented for the air speed at 1.5m above ground plane.

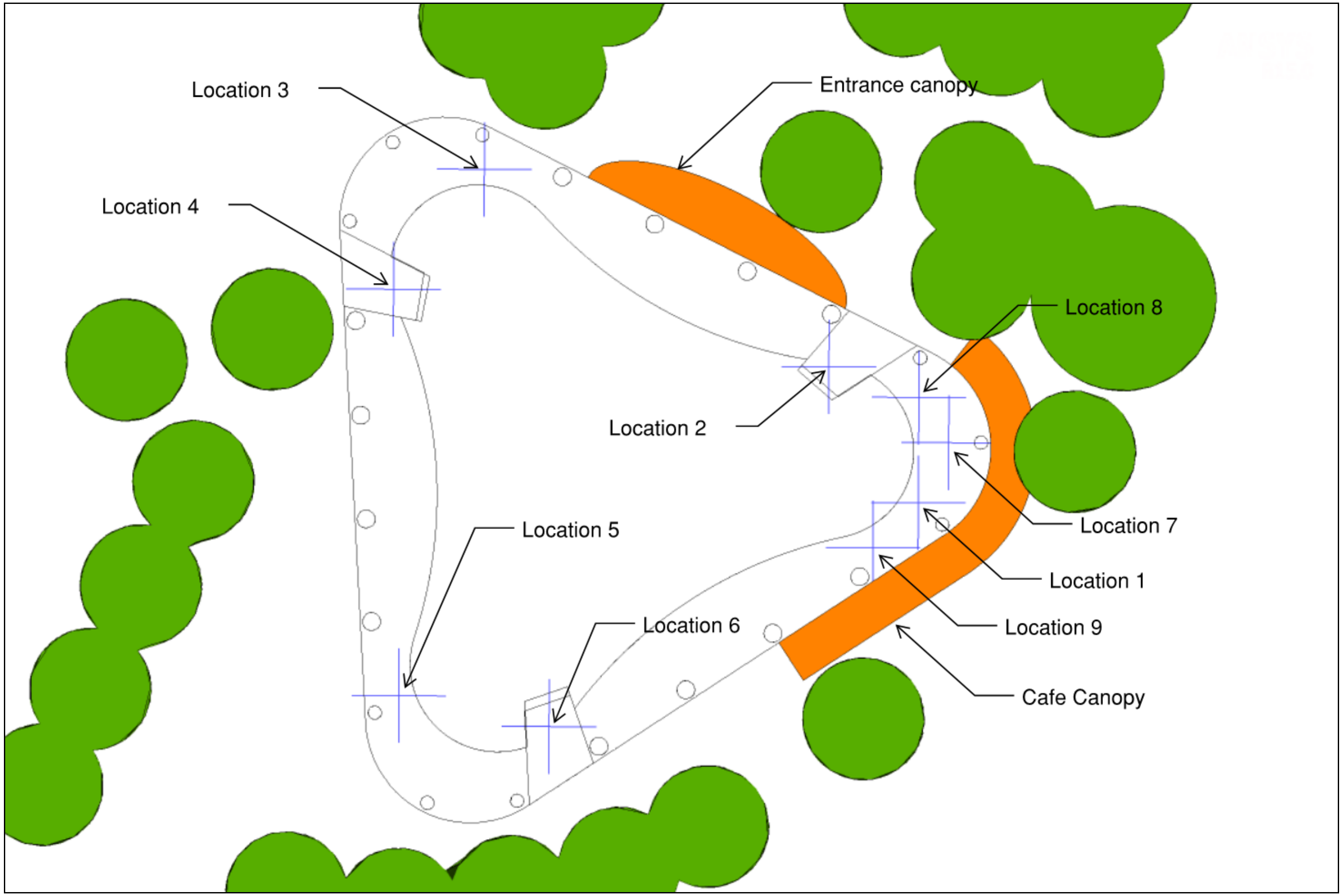

Figure 6 Amelioration measures and specific measurement locations

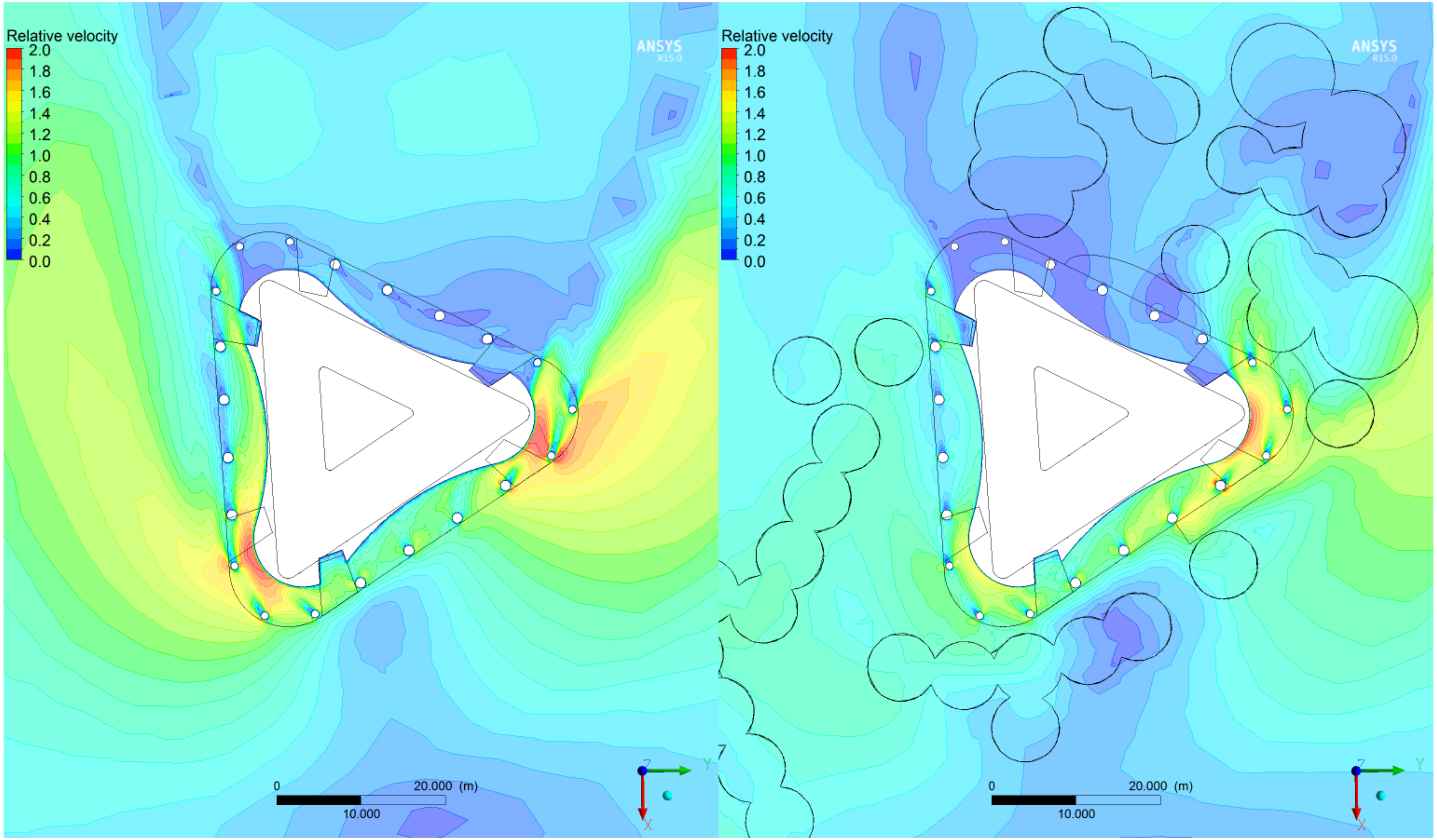

Figure 7 Wind from S - amelioration measure impact

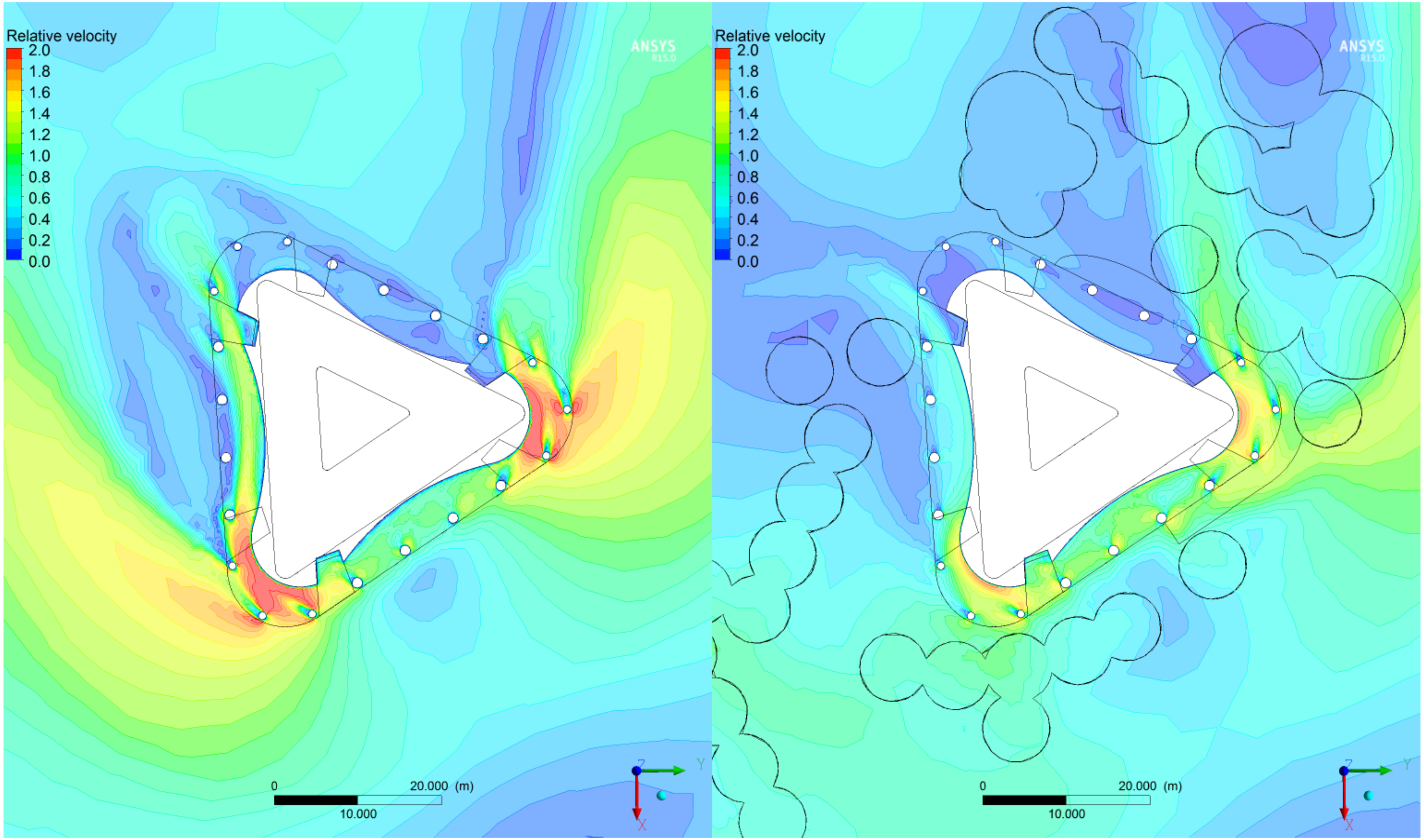

Figure 8 Wind from SSE - amelioration measure impact

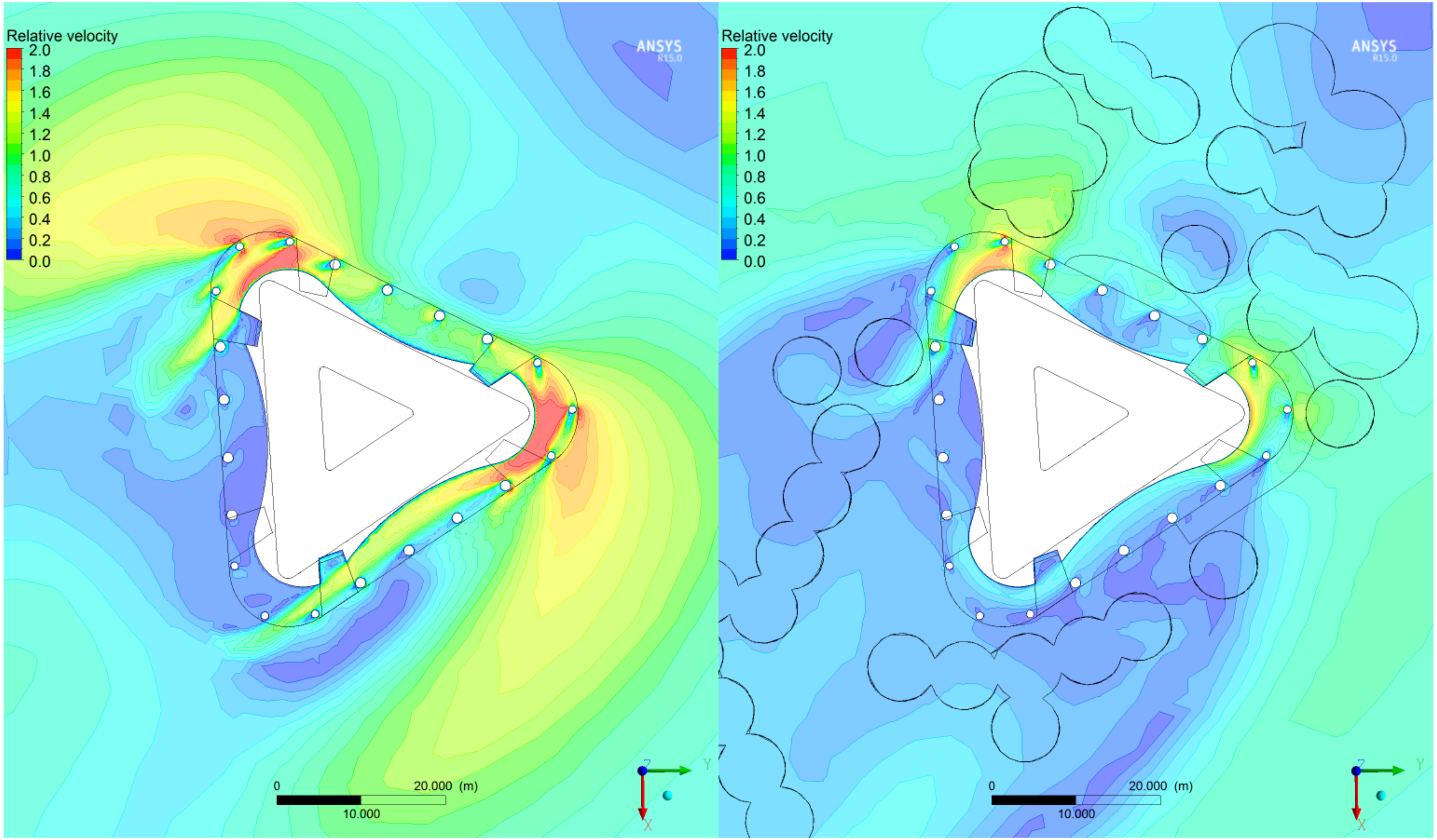

Figure 9 Wind from N - amelioration impact comparison

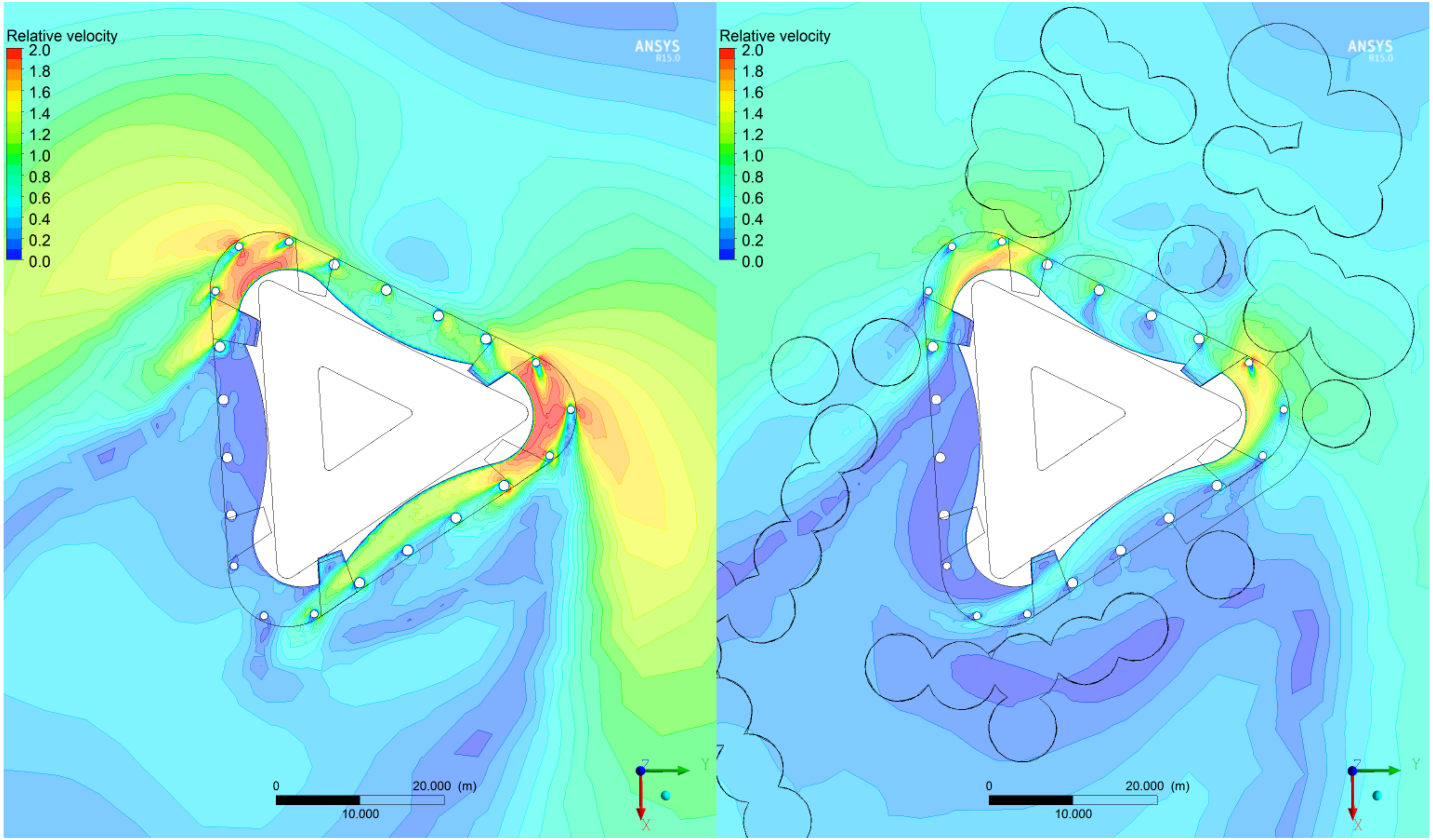

Figure 10 Wind from NNE - amelioration measure impact

5.3 Slot Balconies

Generally, conditions in the slot balconies are good. The relative amount of consistent air movement is limited as the is no cross flow path through the building. There will be opening to control natural ventilation of the corridors, however the amount of air required for this will not result in large velocities at the occupied levels of the slot balconies. Some internal circulation flow is noted on the balconies created by winds running parallel to the façade but these are minor and typical have impact well above the occupied space in the slot.

Result for wind comfort and distress are presented in Appendix A along with those for the ground plane locations.

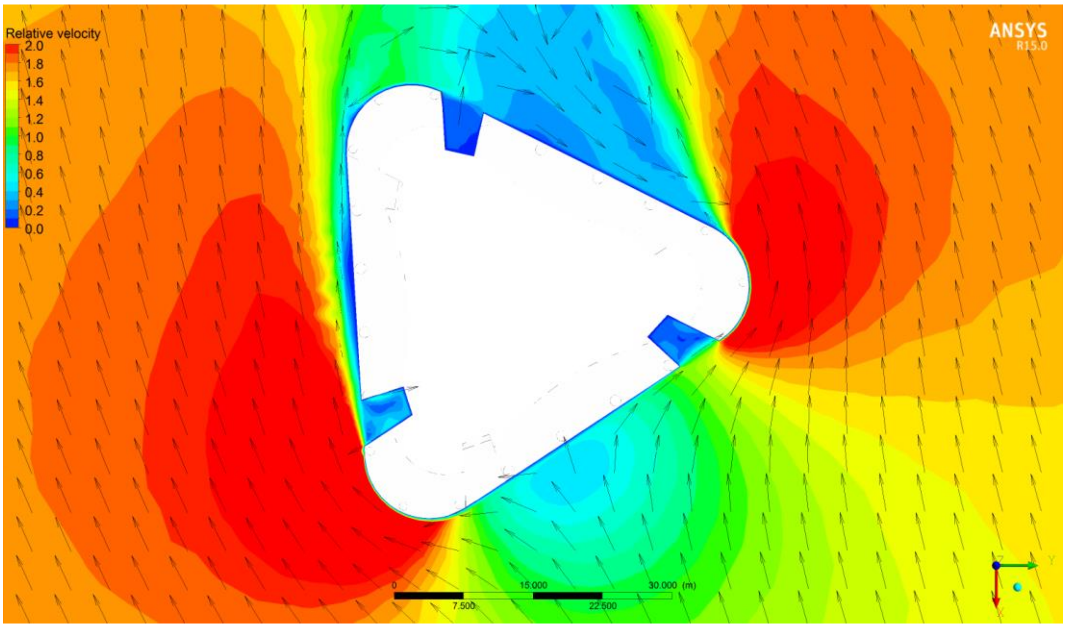

Figure 11 Velocity contour and vectors at slot balcony occupied level

5.4 Apartment Wintergradens

Given the shape of the building, large accelerations in wind speed are expected at the corner wintergrardens for winds from all directions. The triangular plan means at least one building face is at an acute angle to the wind direction at all times. Consequently, the air is accelerated along the face and separates as it passes around the 'point' of the triangle – the location of the apartment wintergardens. Figure 11 shows this acceleration as the red areas in the contour plot. Figure 12 shows and example of streamlines passing around the corner of the building, also highlighting the increased velocities.

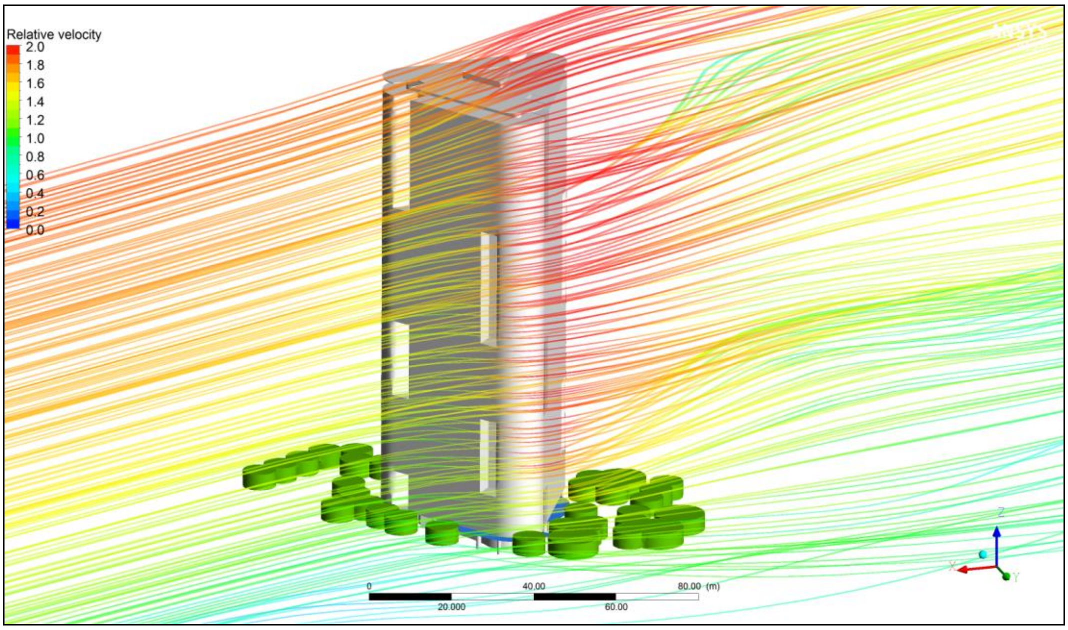

Figure 12 Streamline relative velocity passing around wintergardens

To assist in preventing issues on the corner apartments, it is proposed that the wintergardens are designed to be fully enclosed with operable elements. This allows the residents to enjoy the balcony during wind events but allows the wintergarden to be opened during calmer weather.

6 Summary

6.1 Summary of Findings and Recommendations

A summary of findings from the environmental wind analysis is located in the table following. It also includes recommendations for maintaining and possibly improving the environmental wind conditions.

Location	Notes
Site	• Adopted amelioration measures assist in improving the conditions experienced across the site significantly. • Trees incorporated into the landscaping should exhibit a large and dense crown to reduce the likelihood for unfavourable conditions around the base of the tower. • Installation of canopies over the outdoor café seating and entrance lobby assist greatly in reducing the impact of down drafts during prevailing wind conditions.
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Roof (Halo)	• Conditions at the roof/plant level are not suitable for prolonged occupation.

6.2 Additional Work

The results of this report were released in Draft format to the design team for review and subsequently the following amendments were made to the design:

1. The canopy design at the lobby and café areas on the ground plane were extended to increase protection for pedestrians.
This change will improve the overall wind comfort conditions and will not increase the wind distress criteria.

2. Additional planting was proposed over and above the planting already included in the model.
This change will improve the overall wind comfort conditions and will not increase the wind distress criteria.

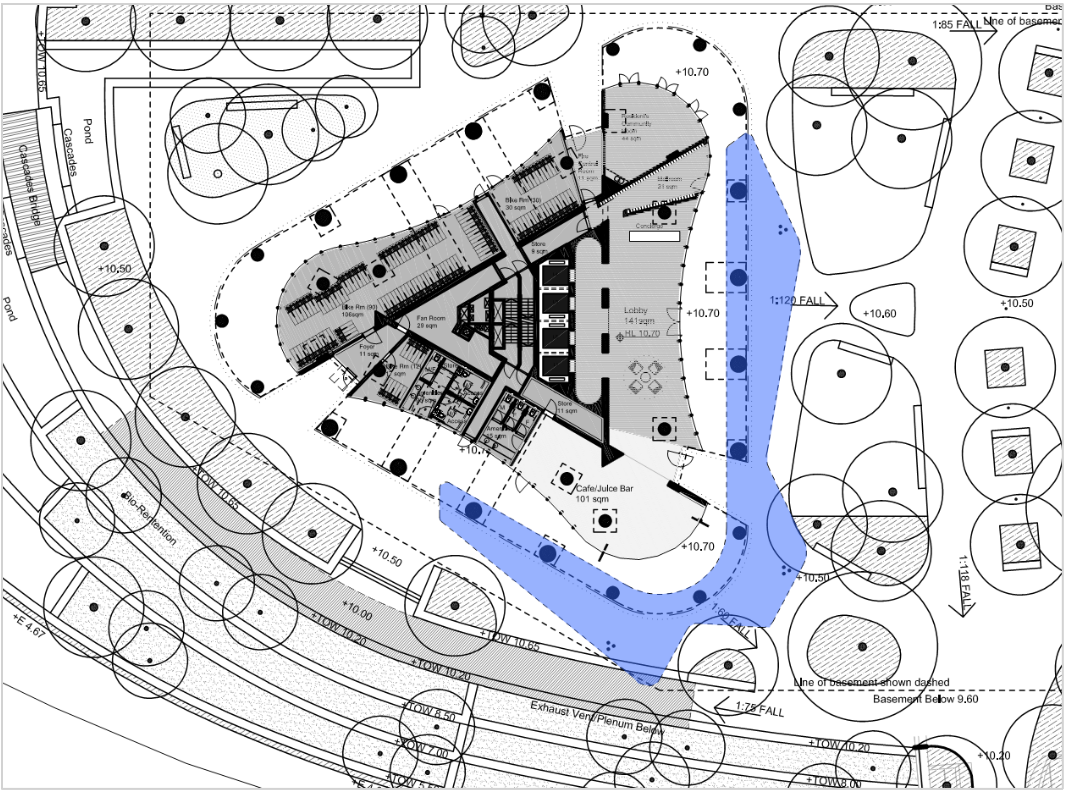


Figure 13 Updated building geometry and planting

7 References

Blocken, B., Janssen, W. D. & van Hooff, T., 2012. CFD simulation for pedestrian wind comfort and wind safety in urban areas: General decision framework and case study for the Eindhoven University Campus. *Environmental Modelling & Software*, Volume 30, pp. 15-34.

Blocken, B., Stathopoulos, T., Carmeliet, J. & Hensen, J., 2011. Application of CFD in building performance simulation for the outdoor environment: an overview. *Building Performance Simulation*, Volume 4, pp. 157-184.

Franke, et al., 2007. *Best Practice Guideline for the CFD Simulation of Flows in the Urban Environment*, s.l.: COST 732: Quality Assurance and Improvement of Microscale Meteorological Models.

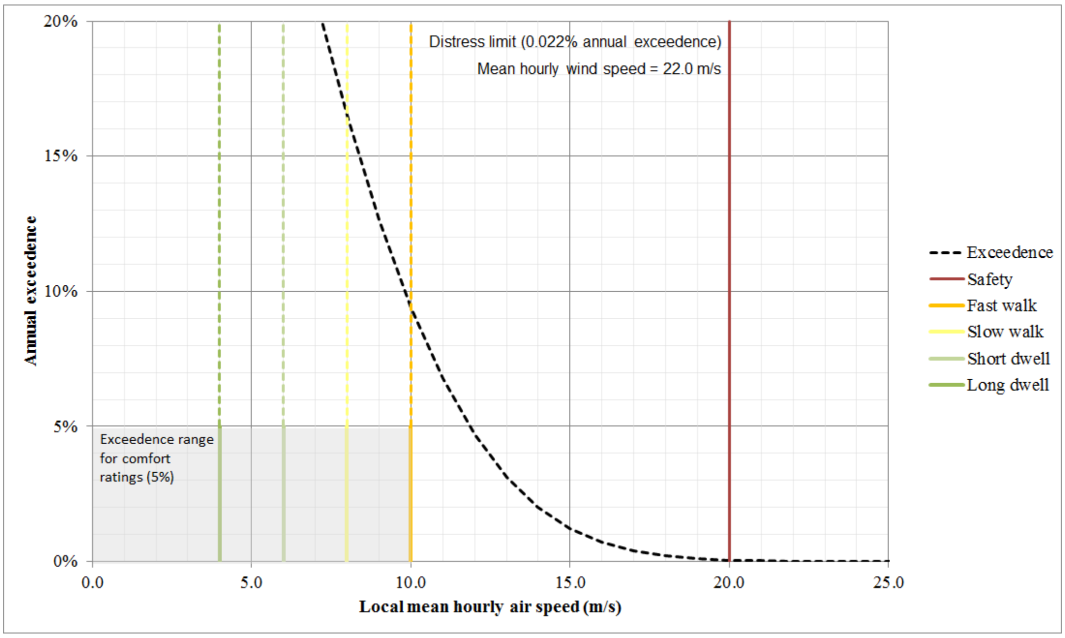
Lawson, T.V., 1975, *The determination of the wind environment of a building complex before construction*, Bristol University, Department of Aeronautical Engineering.

Mochida, A. et al., 2008. *Examining tree canopy models for the CFD prediction of wind environment at pedestrian level*, Journal of Wind Engineering and Industrial Aerodynamics 96, pp1667-1677.

Appendix A

Wind Comfort and Distress Results

Point 1



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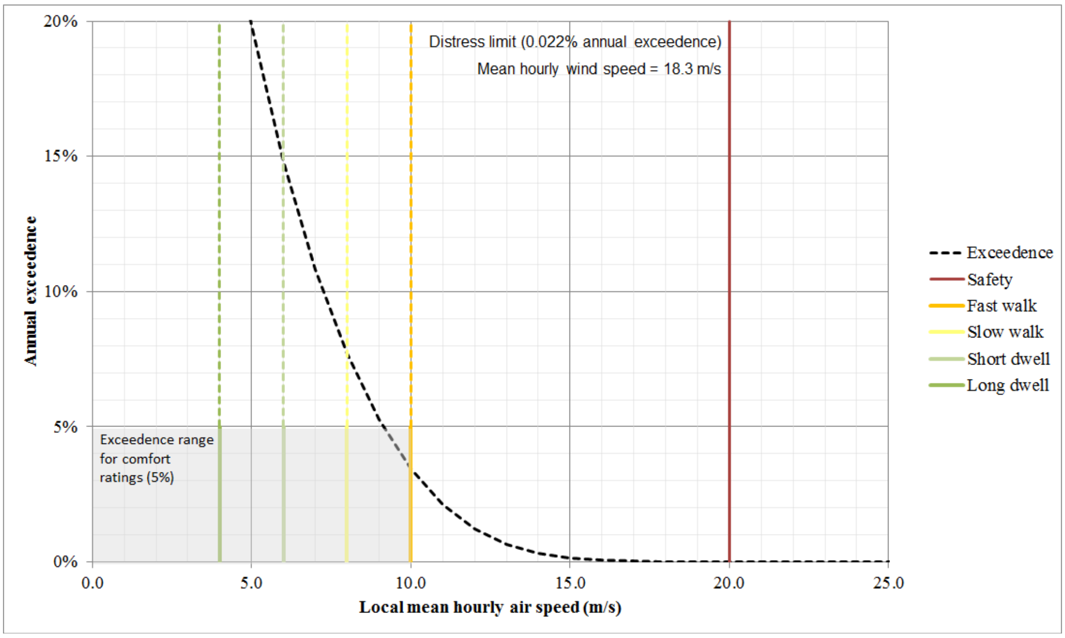
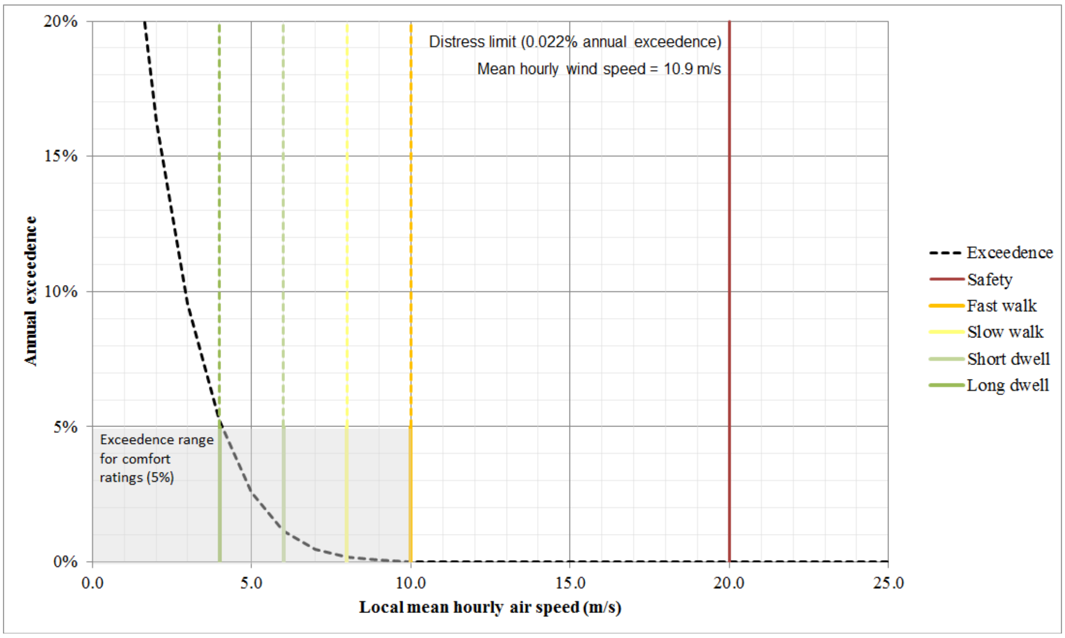


After amelioration

Point 2



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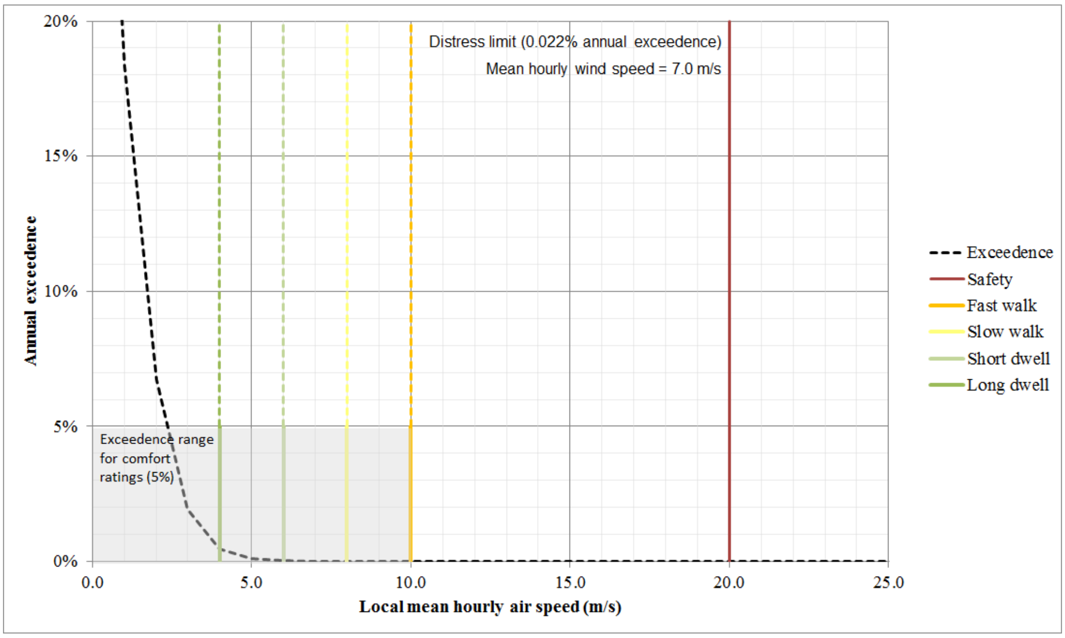

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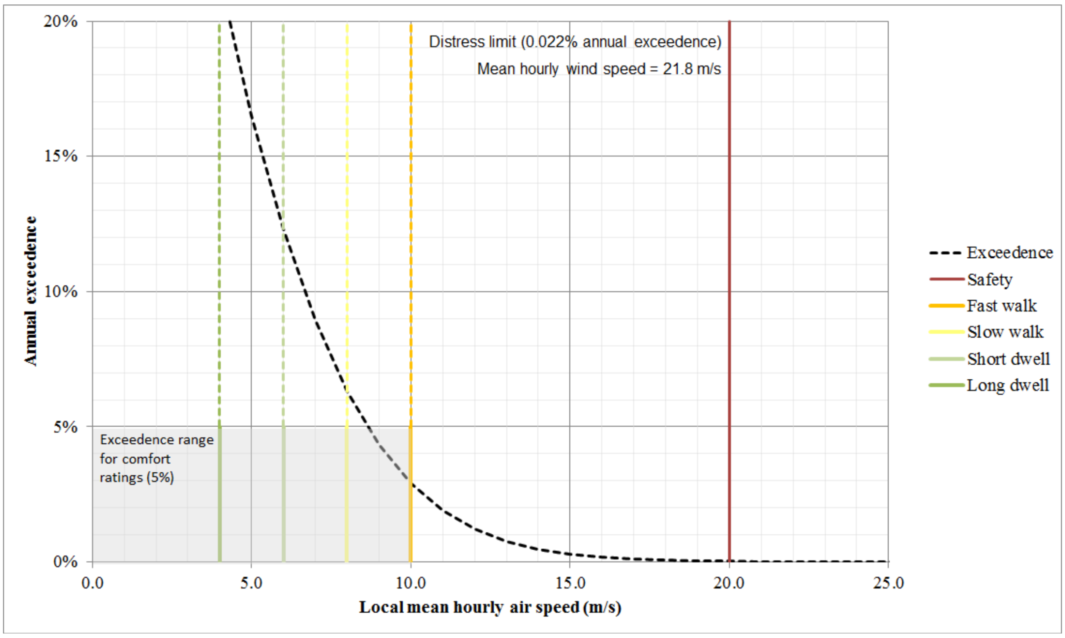

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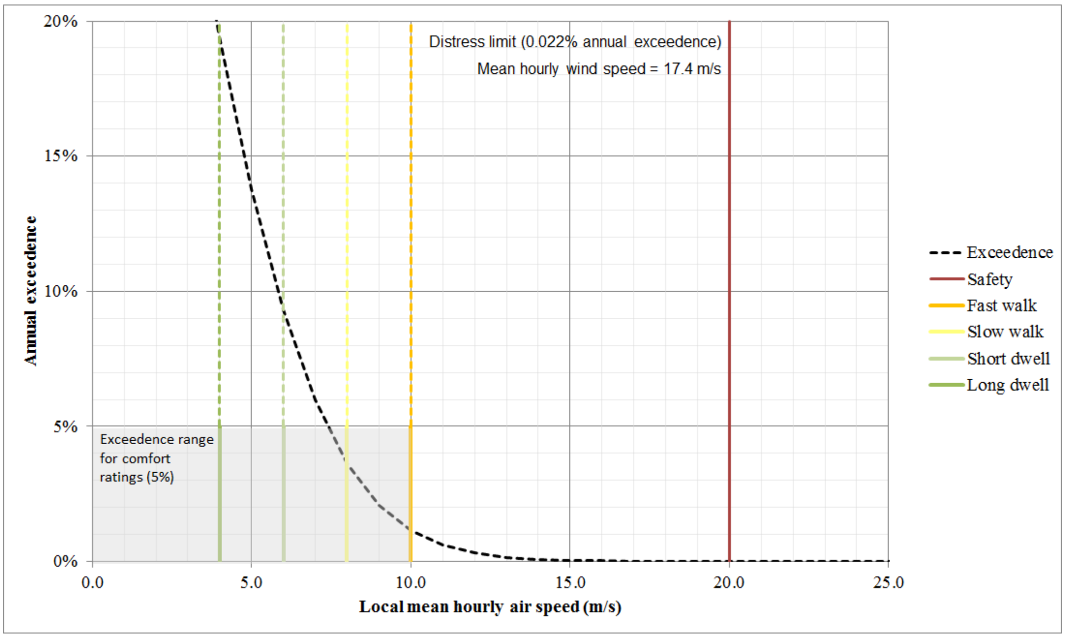

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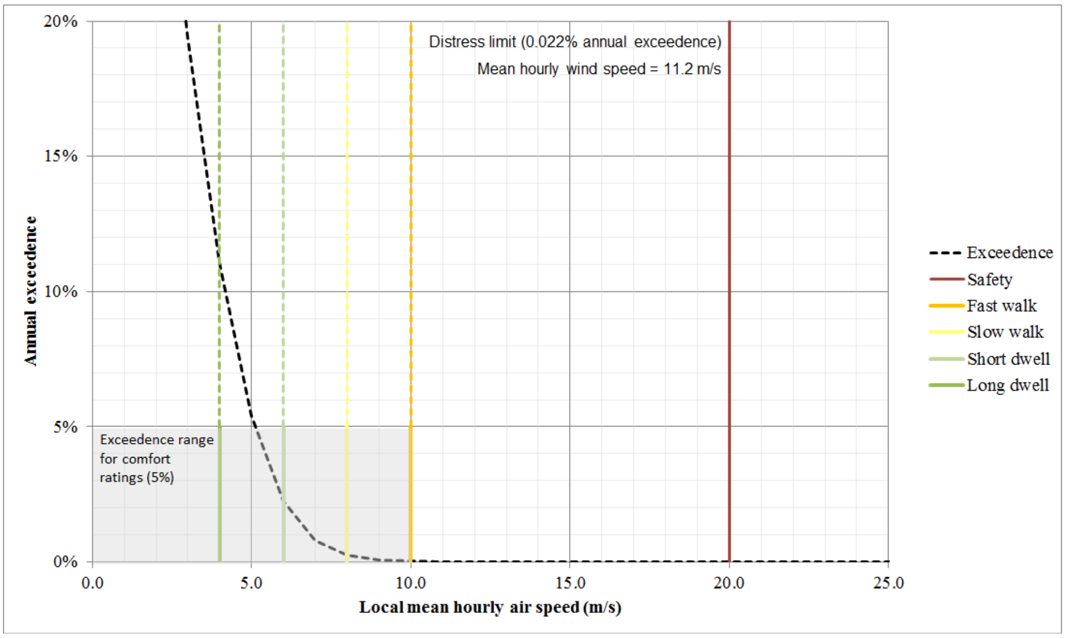

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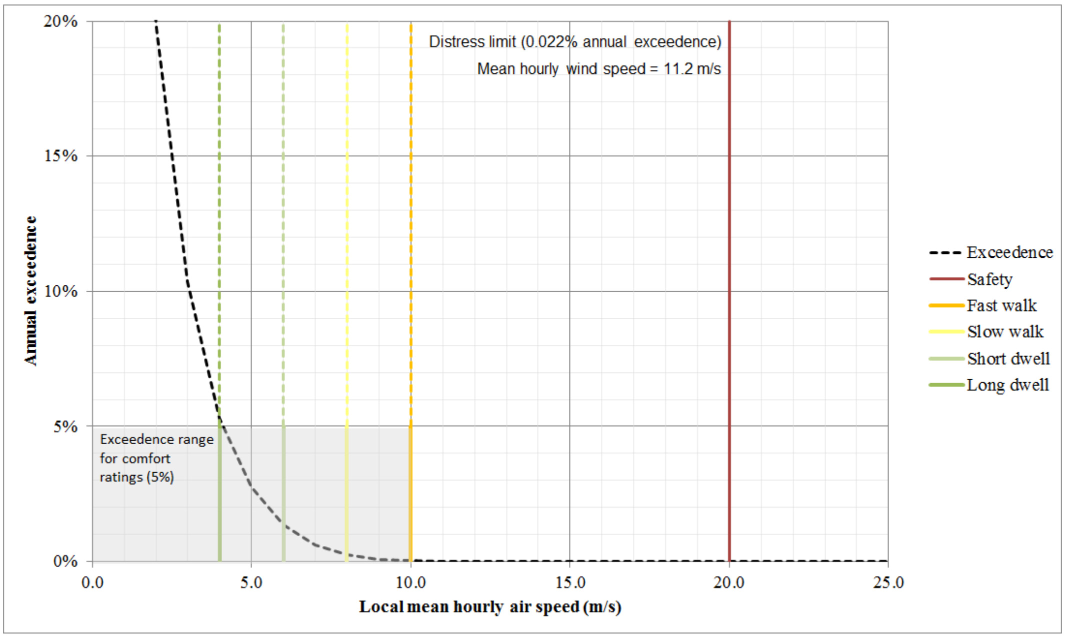

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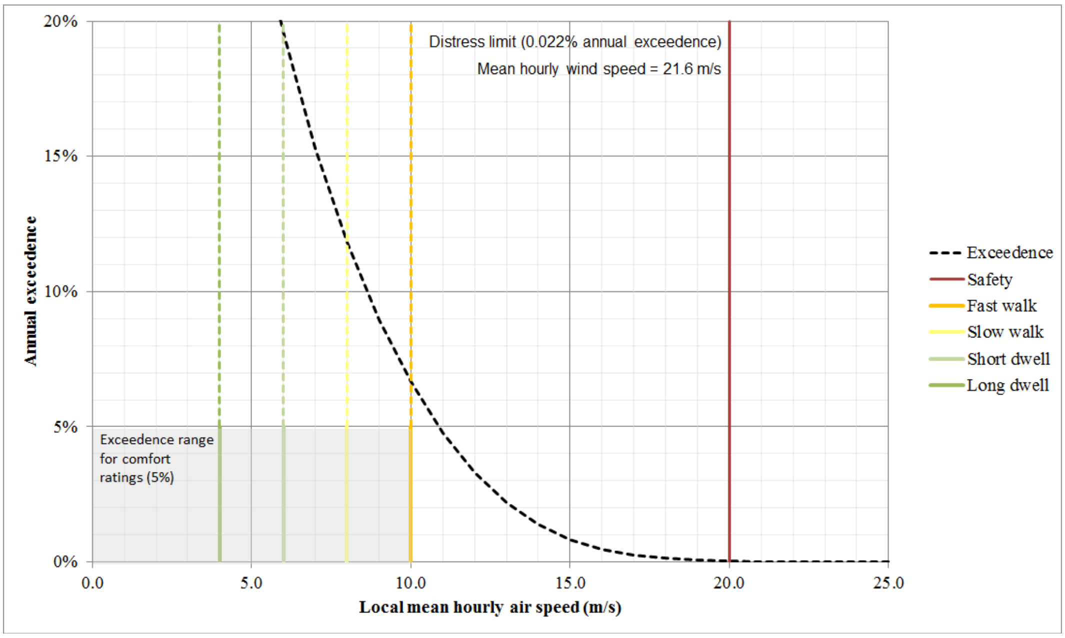

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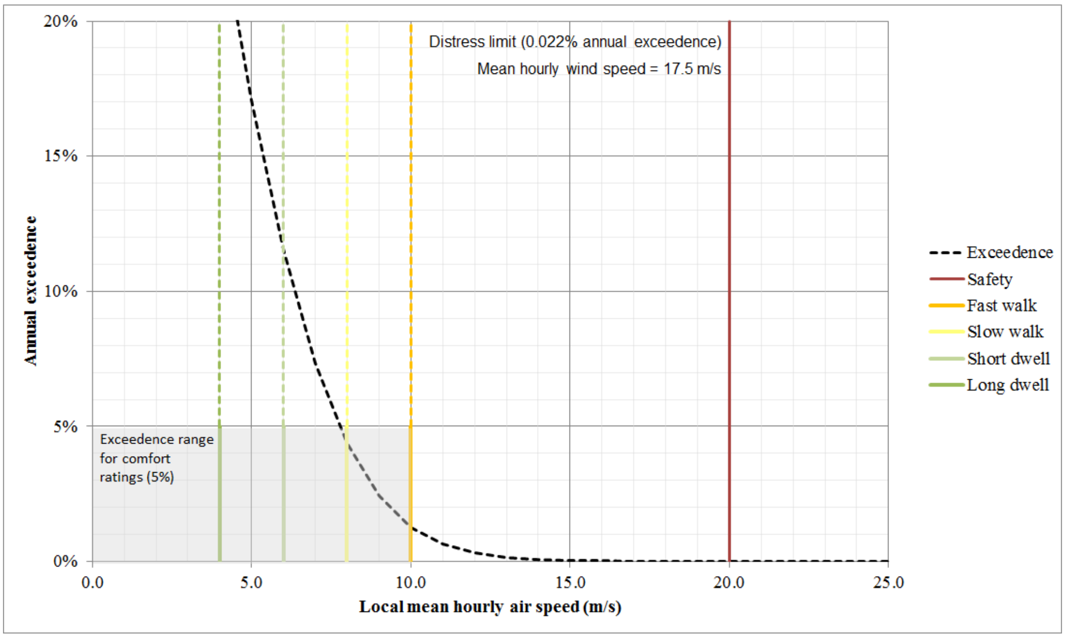

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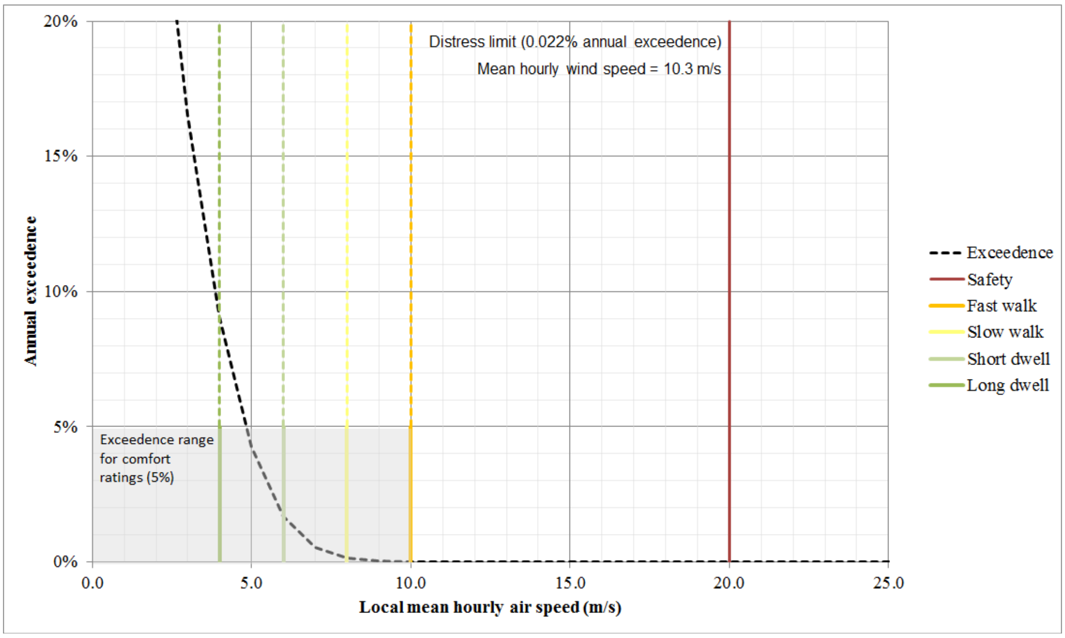

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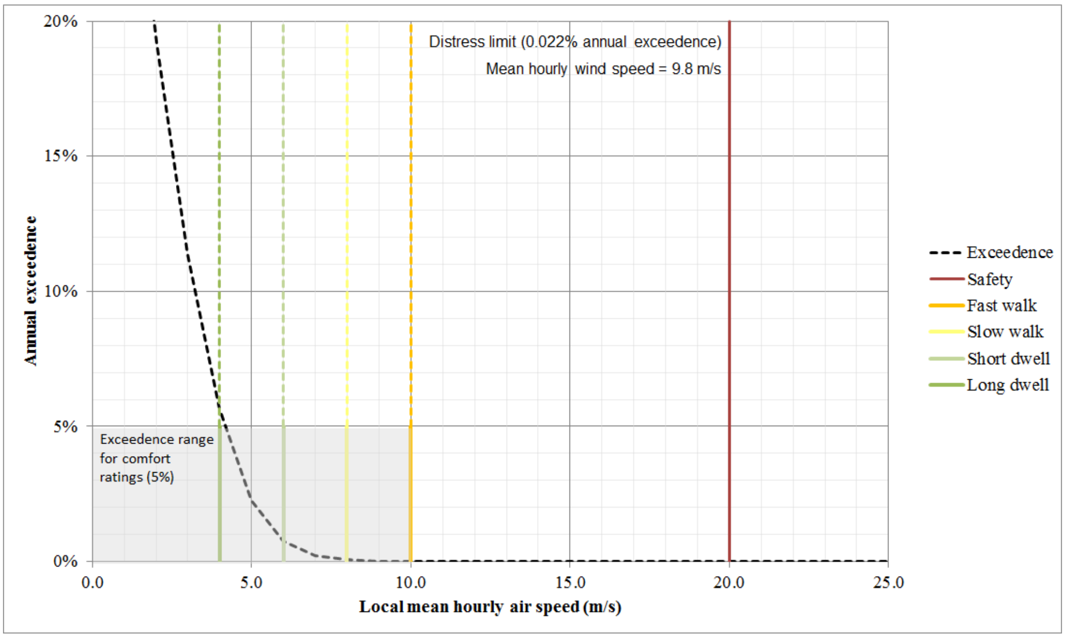

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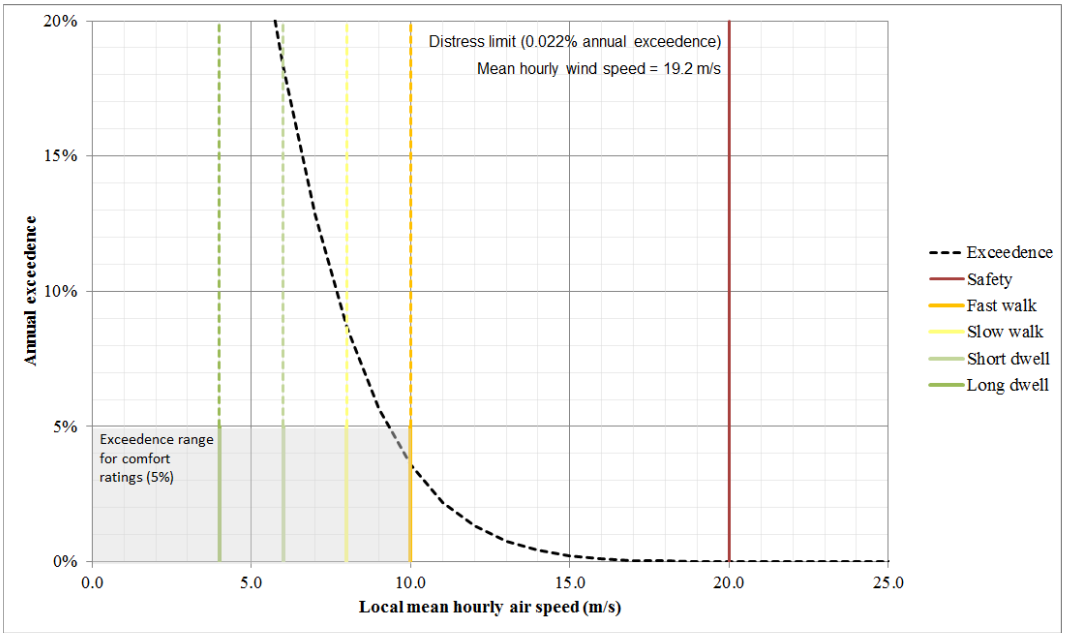

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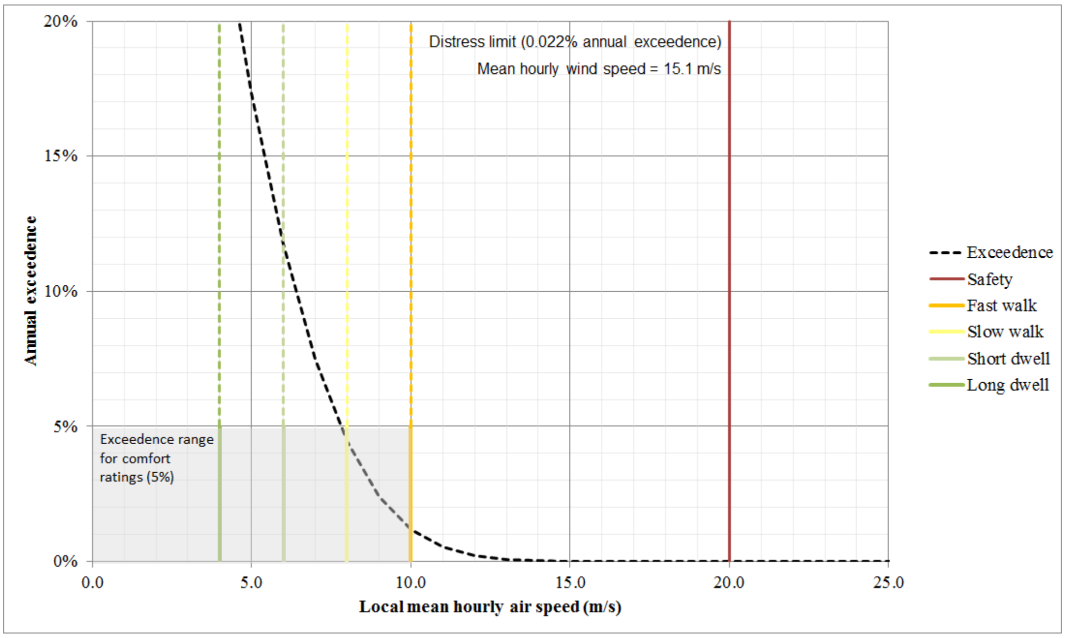

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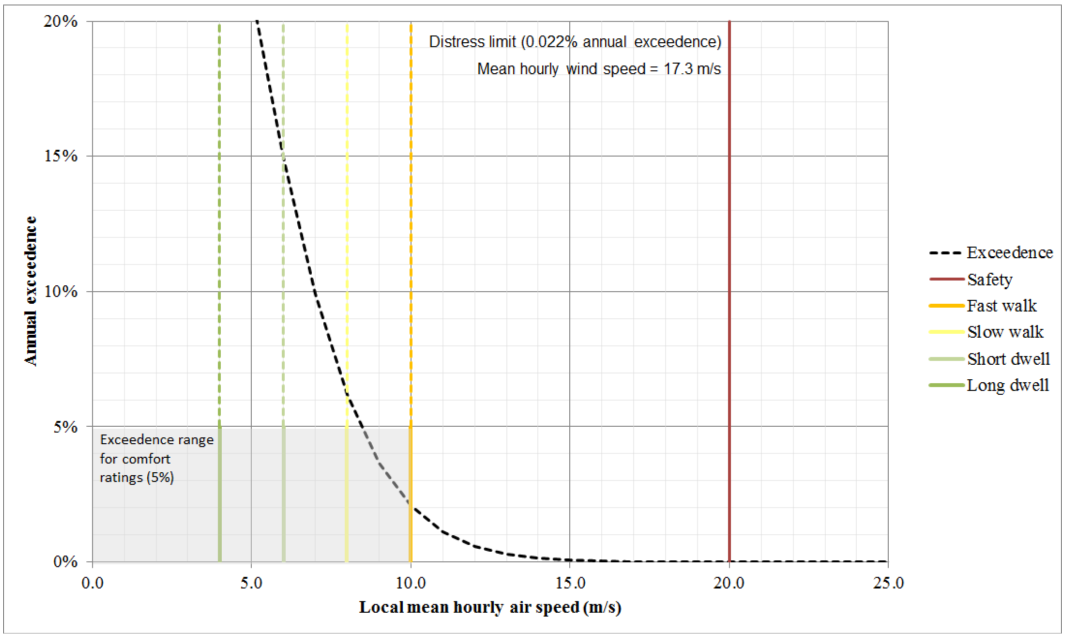

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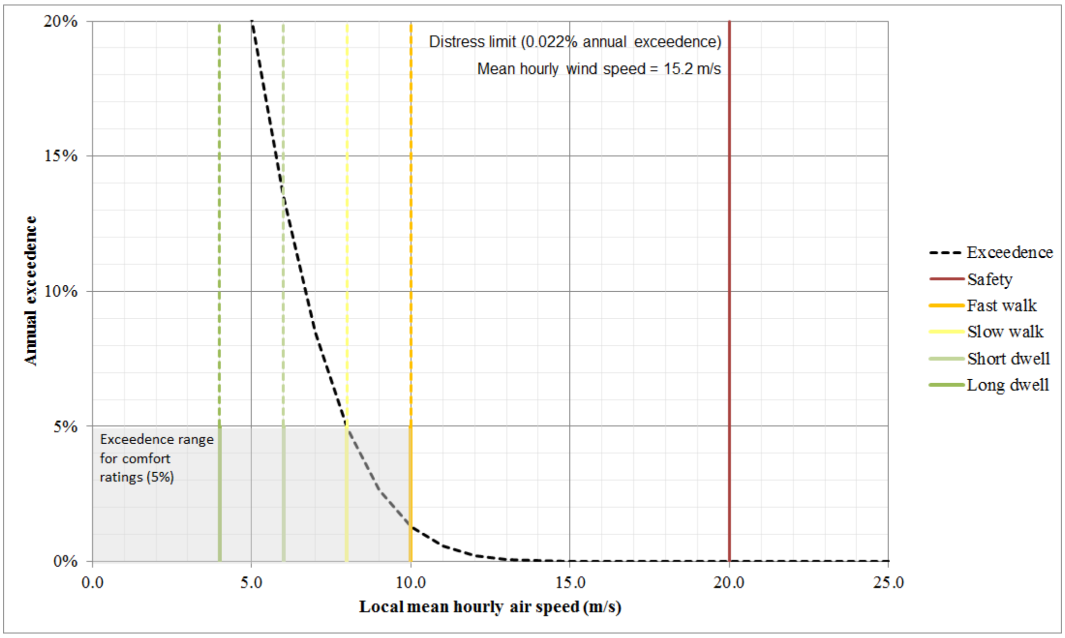

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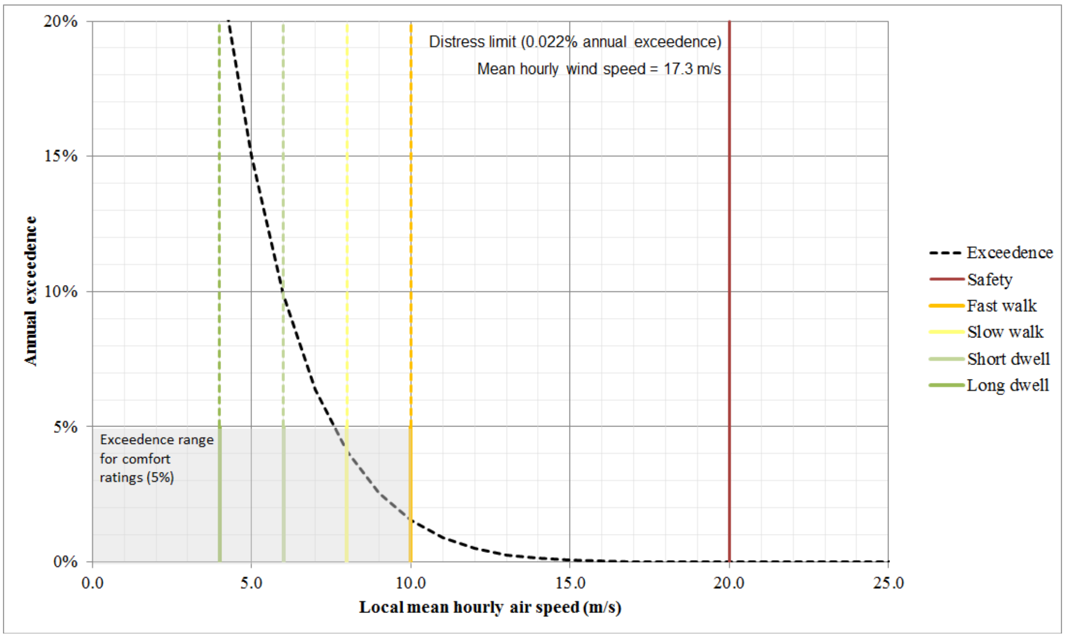
Point 9



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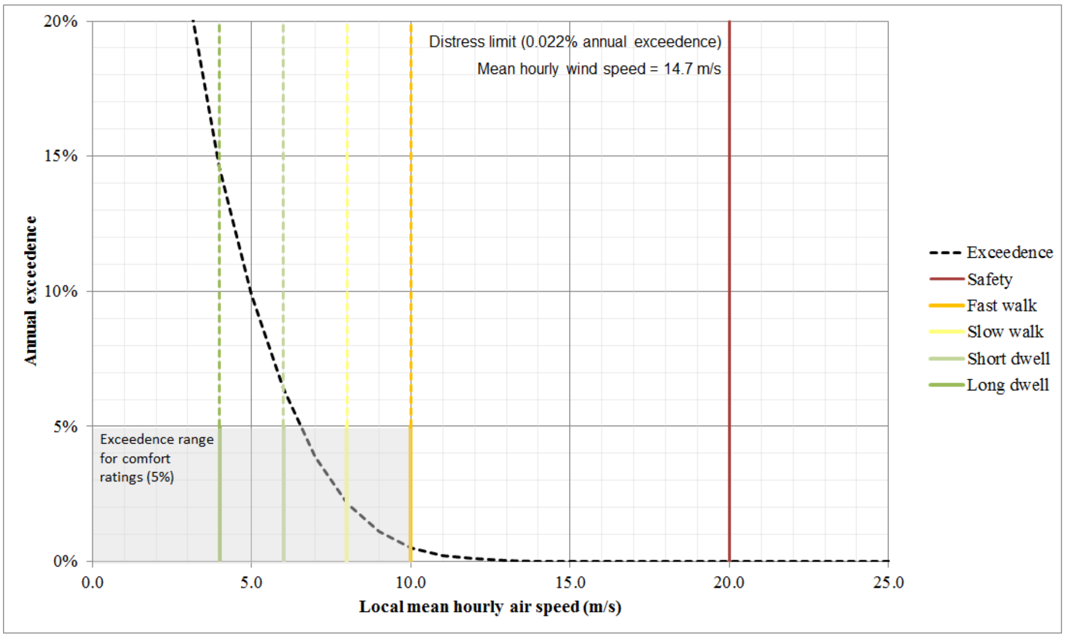

After amelioration