The Boundary Layer Wind Tunnel Laboratory

Pedestrian Level Wind Assessment (CFD)

25 Rymal Road W
Hamilton, Ontario

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Submitted To:

Kyle Reinders
Reinders+Law
64 Ontario Street N
Milton, Ontario, L9T 2T1 Canada

Submitted By:

The Boundary Layer Wind Tunnel Laboratory
The University of Western Ontario
Faculty of Engineering
London, Ontario
N6A 5B9

A. Gairola, Project Specialist
P. Case, Director
D. Garnham, Project Manager

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1 INTRODUCTION

The Boundary Layer Wind Tunnel Laboratory (BLWTL) was retained by Reinders+Law to conduct a pedestrian wind assessment for the proposed 25 Rymal Road West development in Hamilton, Ontario. This is done in support of the Zoning By-law Amendment (ZBA) application. For this purpose, a Computational Fluid Dynamics (CFD) study was performed for the 25 Rymal Road West development. The CFD approach provides a description of potential wind conditions related to pedestrian comfort, identifies areas of accelerated flows, and provides conceptual mitigation strategies. This assessment is based on drawings received by the BLWTL on July 10, 2024.

The project site is located southeast of the intersection of Rymal Road West and Upper James Street in Hamilton, Ontario. The general site surroundings are reflective of a typical suburban area, dominated by a mixture of 1-2 storey residential buildings and low retail-type buildings within about a 350m radius of the site. There are some open expanses in the immediate vicinity of the site, including parking lots located directly northwest, north and east of the site. In the presence of open areas in close proximity of a site, it can be expected that windspeeds will be marginally higher than that of a typical suburban environment. Beyond these more immediate areas, the region is largely characterized by typical suburban exposure to the north of the site and open exposure to the south of the site for approximately 8-10 km. Beyond this distance for next 50 km, the surroundings are typically open country for most directions, except for a sector to the northeast, which is characterized water (Lake Ontario).

With the objective of providing an assessment of the wind-impact of the proposed development to the pedestrian wind environment at the nearby areas, CFD assessments were made for both the Existing site configuration and the Proposed site configuration to permit a comparative analysis.

Existing Site - The site at 25 Rymal Road West consists of an empty lot, surrounded by low-rise retail buildings immediately next to the site. A street level view of the block from Rymal Road West can be seen in the image below.

Existing Site *c*

Proposed Site – The proposed development consists of a 36m tall, 12-storey mixed-use commercial/residential building to be constructed in the empty space on the west side of the 25 Rymal Road West lot. The Proposed building location is shown in Figure 1. A north elevation of the proposed development is shown below.

North Elevation of Proposed Development

Images of the massing model used in the CFD simulations are shown in Figure 3. All buildings that exist or are known to be currently under construction were included in the surroundings massing model.

This analysis with the proposed building relies on the drawings provided by Reinders+Law on July 10, 2024, which included a 3D Revit model.

2 THE WIND CLIMATE FOR HAMILTON

2.1 Meteorological Data

The Integrated Surface Data (ISD) records are maintained by the National Climatic Data Center (NCDC) and provide a climatological database of approximately 20,000 stations around the world. The ISD contains many meteorological variables, typically recorded at intervals of 1 hour.

An analysis of historical wind data from the John C. Monro Hamilton International Airport (ISD Station 712630) was performed to develop a statistical wind climate for Hamilton. Based on the analysis of hourly wind records, annual and seasonal histograms of wind speed and wind direction are developed.

The daytime (06:00 to 11:00) windroses in Figure 2 are graphical representations of the seasonal histogram wind data and show the distribution of wind speed frequency by direction for two seasons, i.e., Summer (May-Oct) and Winter (Nov-Apr). For both the summer and winter seasons south-westerly to westerly winds are predominant for frequent winds. Figure 2 shows this wind directionality for different ranges of wind speeds. Winds over 8.4 m/s (30 km/hr.) are shown as the outermost colour zone in the contour plots.

The winds presented in the windrose data are measured at 10m for an open country terrain. Representative ground level winds (1.5m to 2m) might then be expected to be somewhat lower than those indicated on the windrose for a uniform open terrain. The local wind climate at the site is dependent on wind direction and will be influenced by and dependent upon the terrain type over which it travels.

3 CFD MODELLING

3.1 Approach

A pedestrian level wind assessment was conducted using computational fluid dynamics (CFD). There are inherent limitations with CFD modeling techniques including obtaining the correct simulation of turbulence (gustiness) of the wind. Nonetheless, CFD analysis is a useful methodology to identify potential wind issues, especially when assessing mean wind speeds. The results of CFD modeling are a good means of identifying relative changes in wind conditions associated with the Existing and Proposed site configurations.

3.2 Methodology

CFD simulations are used to derive predictions of wind comfort just above ground level (1.5 m) around the development site. Building drawings, including floor plans and elevations and 3D Revit model of the proposed building were provided by Reinders+Law on July 10, 2024. A view of the 3D model developed for use in the computer wind comfort simulation is shown in Figure 3. This model included surrounding buildings within 350 m from the study building centre. The assessment simulations were performed using UrbaWind, a CFD software developed by Meteodyn Inc.

The computational domain is discretized using a structured 3-D mesh. The upstream roughness used in the assessment is adjusted by altering the aerodynamic roughness height for each simulation direction to reflect the appropriate approach upwind conditions that are representative of the actual site. Wind flow simulations were conducted for 16 compass directions at 22.5° increments. The CFD solver computes the wind speed at each one of the mesh grid points. Although wind speeds are calculated for a broader modeled area, wind comfort conditions are only plotted for the area immediately surrounding the proposed development.

Virtual wind flow fields were simulated for each of the 16 compass directions for both the Existing site and the Proposed site. The directional CFD-estimated wind speeds for were then combined with the wind climate for Hamilton region to provide wind speed predictions. These can then be compared against established criteria to assess pedestrian wind comfort and safety.

Developing these simulations and predictions for both the Existing site and the Proposed site permits a comparative basis to make assessment of the wind-impact that the proposed development has on the local area.

4 PEDESTRIAN-LEVEL WIND SPEEDS

4.1 Pedestrian-Level Wind Criteria

Assessment for pedestrian safety is based on the gust wind speed, defined as $U_{gust} = U_{mean} + 3U_{rms}$, predicted to exceed more than 9 hours in a year based on wind records for 24 hours a day. Assessment for pedestrian comfort is based on the Gust Equivalent Mean (GEM) wind speed predicted to be exceeded 20% of the time based on wind records between 6 am and 11 pm daily. The Gust Equivalent Mean wind speed is defined as the maximum of the mean wind speed and $\frac{U_{gust}}{1.85}$.

The predicted wind speeds are obtained by combining the histogram for wind speed by direction (see Section 2) with the simulated wind speed data determined from the CFD analysis (see Section 3). Two types of prediction are provided:

1. Wind speeds exceeded during 20% of the time on an annual basis (comfort).
2. Wind speeds exceeded more than 9 hours (0.1% of the time) in a year (safety).

Criteria for pedestrian comfort and safety, for temperate climates are as follows:

DESCRIPTION / ACTIVITY	GUST EQUIVALENT MEAN WIND SPEED EXCEEDED 20% OF THE TIME
Sitting	**≤ 10 km/hr**
Standing	**≤ 15 km/hr**
Walking	**≤ 20 km/hr**
Uncomfortable	**> 20 km/hr**

CRITERIA	GUST WIND SPEED EXCEEDED MORE THAN 9 HOURS IN A YEAR
Exceeded ('Unsafe')	**> 90 km/hr**

To give these some perspective, broad descriptions of the comfort categories are as follows:

- **Sitting:** Light breezes desired for outdoor seating areas where one can read a paper without having it blown away.
- **Standing:** Gentle breezes suitable for passive pedestrian activities where a breeze may be tolerated.
- **Walking:** Relatively high speeds that can be tolerated during intentional walking, running and other active movements.
- **Uncomfortable:** Strong winds considered a nuisance for most activities.

The safety categories are established to recognize that strong winds may cause a loss of balance or the toppling of an infirm or elderly person. More stringent safety requirements are recommended for essential areas which are expected to be used in all weather conditions. The following gives a description of the levels for evaluating safety:

- **Exceeded ('Unsafe'):** Excessive gust speeds that can adversely affect safety and a pedestrian's balance and footing. Wind mitigation is typically required.

These criteria are consistent with those of the City of Hamilton "*Terms of Reference: Pedestrian Level Wind Study for Downtown Hamilton"* [Ref. 1].

4.2 Results and Discussion

The colour-coded contour diagrams provided in Figure 4 present a comparison of the Existing configuration and the Proposed configuration with respect to pedestrian-level safety.

For comfort considerations, a comparison between the Existing and Proposed Configurations for the summer and winter seasons are presented in Figures 5 and 6, respectively. Figure 7 presents the comfort for summer and winter seasons at regions close to the building and relevant to entrances of the proposed building. The comfort and safety categories used in these figures correspond to those summarized in the tables above (see Section 4.1).

The tested configurations are as follows:

1. Existing site Configuration- The block of the existing site (25 Rymal Road West) consists of an empty lot with low-rise retail buildings immediately adjacent to the site.
2. Proposed site Configuration – The proposed development consists of a 36 m tall, 12-storey multi-unit residential building to be constructed in the empty space at the west side of the 25 Rymal Road West lot. The tower was placed at the location as previously indicated.

4.2.1 Existing Site Configuration

With respect to pedestrian safety:

1. All areas in the immediate vicinity of the site meet the recommendations for pedestrian safety.

With respect to pedestrian comfort:

1. In most areas in the local vicinity of the site, winds are broadly rated for standing activities in the summer season.
2. During the winter season, most areas are generally rated in the walking category. In the immediate vicinity of many buildings, conditions fall into the standing category.

The simulated wind speeds for the existing site and nearby areas are consistent with a typical suburban environment that has nearby open fetches, like previously anticipated.

4.2.2 Proposed Development Configuration

Simulations for the development were carried out with the Proposed 25 Rymal Road W building. As with the Existing Configuration, the simulations were performed without landscaping. Thus, wind conditions, particularly for any months where foliage is most dense, can expect some improvement beyond the findings herein.

With respect to pedestrian safety:

1. Within the simulation area around the Proposed development, the northwest corner of the Proposed building has a small, localized region that exceeds the recommended safety criterion. Note that this speed-up is most likely the result of downwash wind off the building for the frequent southwest wind directions. Localized mitigation in the form of evergreens is expected to be effective. Other effective measures can include a canopy along the west face of the building to deflect the downwash.

With respect to pedestrian comfort:

1. **General:** Compared to the Existing configuration, the conditions in the summer and winter (see Figures 5 and 6, respectively) largely remain unchanged in the immediate vicinity of the site and further beyond. The exception is near the northwest corner of the building. In the summer this area near the northwest corner of the proposed building becomes rated for walking, and in winter it can become uncomfortable.
2. **Sidewalks:** In general, it is recommended that sidewalks be comfortable for walking or better throughout the year. All sidewalks around the site are rated walking or better in the summer. In the winter, a short section of the sidewalk on Rymal Road W, adjacent to the northwest corner of the

proposed building, is rated uncomfortable. Consequently, mitigation may be required to improve the local wind conditions during the winter. Localized mitigation in the form of evergreens or wind screens can be effective for areas close to this area. A canopy along the west face of the building can also be effective at deflecting building downwash.

3. **Entrances:** The winds in the immediate vicinity of the building are rated in the sitting category year-round, as seen from Figure 7. Therefore, winds at expected entry areas indicated by arrows in Figure 7 are suited for their intended usage.

4. **Adjacent properties:** The predicted comfort categorizations at nearby properties largely remain unchanged from the existing conditions. A small region at the southeast corner of the adjacent building to the east the classifications does shift from standing to walking in the summer and from walking to uncomfortable in the winter. Existing landscaping in this area (not modelled in the simulation) is expected to provide necessary protection to this area.

4.2.3 Seasonal Differences

The amount and type of activity for a given location can vary by season. For example, an outdoor amenity area may have limited or restricted usage during the winter season. Thus, in some cases it is valuable to look at the wind speeds and the corresponding classification of pedestrian comfort on a more detailed season-by-season basis. In general, compared to annual wind speeds, wind speeds during the winter months are typically about 10% higher, and in the summer, they are about 4% lower.

4.3 Summary Remarks

General Overview

The introduction of a mid-rise building development in a suburban environment invariably creates local wind speed-ups for some wind directions, particularly near building corners or in spaces between nearby buildings. With the expectation of increased local winds, the focus is not to return wind conditions to an 'as-it-was' state, but rather, and if necessary, identify and develop strategies to make wind conditions suitable for the intended usage. For example, entry areas should have a comfort category consistent with standing activities, while sidewalks should meet the condition of being comfortable for walking. Appendix A illustrates some common problems and solutions to wind effects around buildings.

Influence of Proposed Development and Conceptual Mitigation Ideas

The introduction of the proposed development demonstrates a modest influence on local winds. The wind comfort classifications at properties away from the Proposed site remain essentially unchanged from the Existing condition. The influence of the proposed site on winds naturally diminishes as distance away increases.

Near and on the site property, the inclusion of the proposed development is generally seen to create an increase to wind comfort classification from standing to walking in the summer and from walking to uncomfortable in the winter at the northwest corner of the building at Rymal Road. The addition of mitigation elements in the form of densely spaced evergreen plantings (7-8 feet minimum) or windscreens will be helpful to make the sidewalk areas suitable for sidewalk usage along Rymal Road. An overhead canopy along the west side of the proposed building could also be beneficial to deflect suspected downwash wind effects. General strategies are illustrated in Appendix A.

Winds at all identified entrances are expected to be suited for their intended usage year-round.

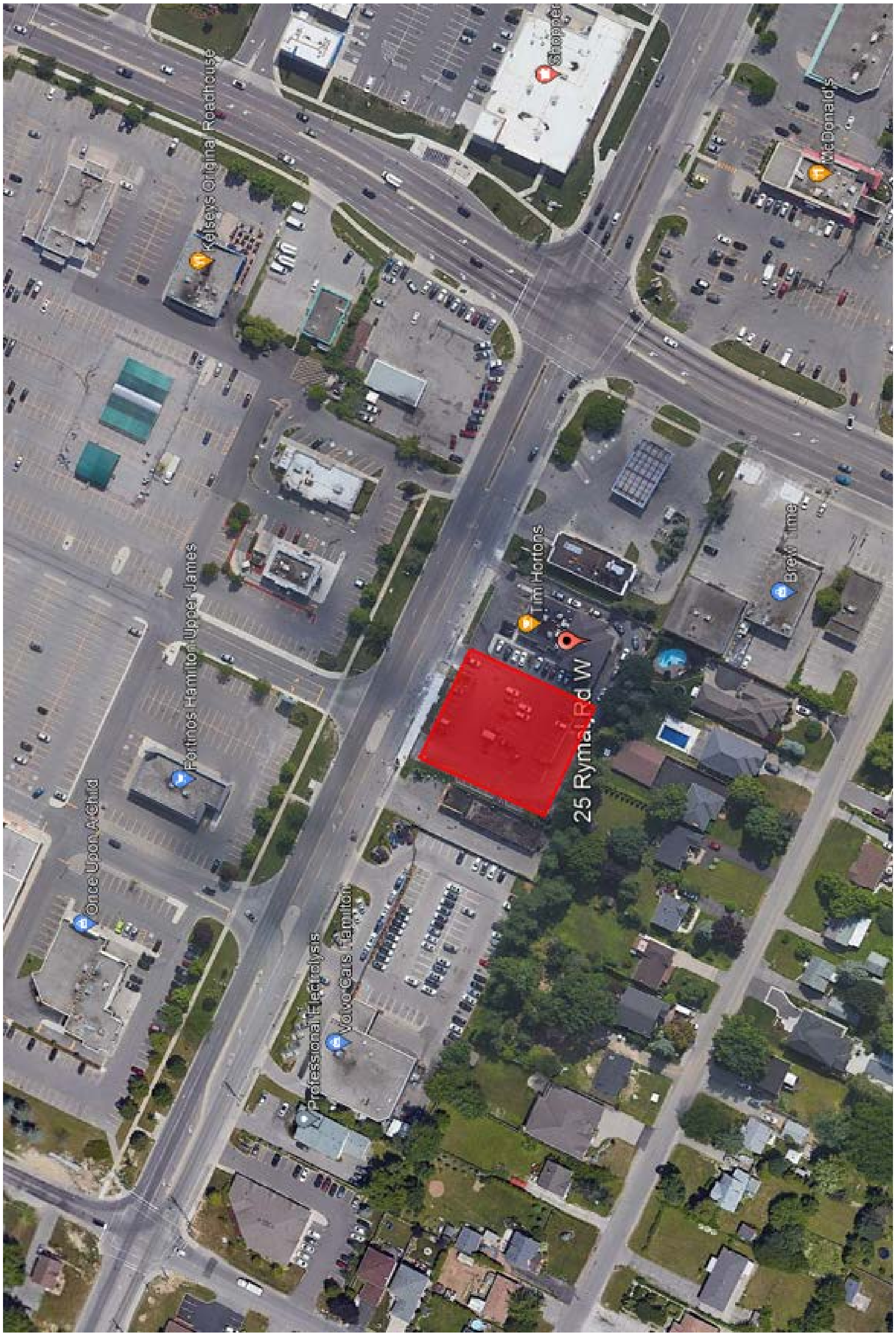
The same region at the northwest corner of the Proposed building experiences a speed-up that results in a marginal exceedance of the safety criterion. The effect is local in nature and could be diminished adopting an appropriate mitigation strategy as described above.

Effectiveness of mitigation measures is best evaluated through quantitative wind tunnel studies where specific elements can be best represented. The BLWTL can work with the design team to develop effective wind control strategies.

REFERENCES

1) *Terms of Reference: Pedestrian Level Wind Study for Downtown Hamilton*, Downtown Hamilton Secondary Plan Appendix “F” to Report PED18074, City of Hamilton Planning and Economic Development Department, 2018.

FIGURES



(Photo Credit: Google Earth)

FIGURE 1 AERIAL VIEW OF THE SITE SHOWING LOCATION OF PROPOSED DEVELOPMENT

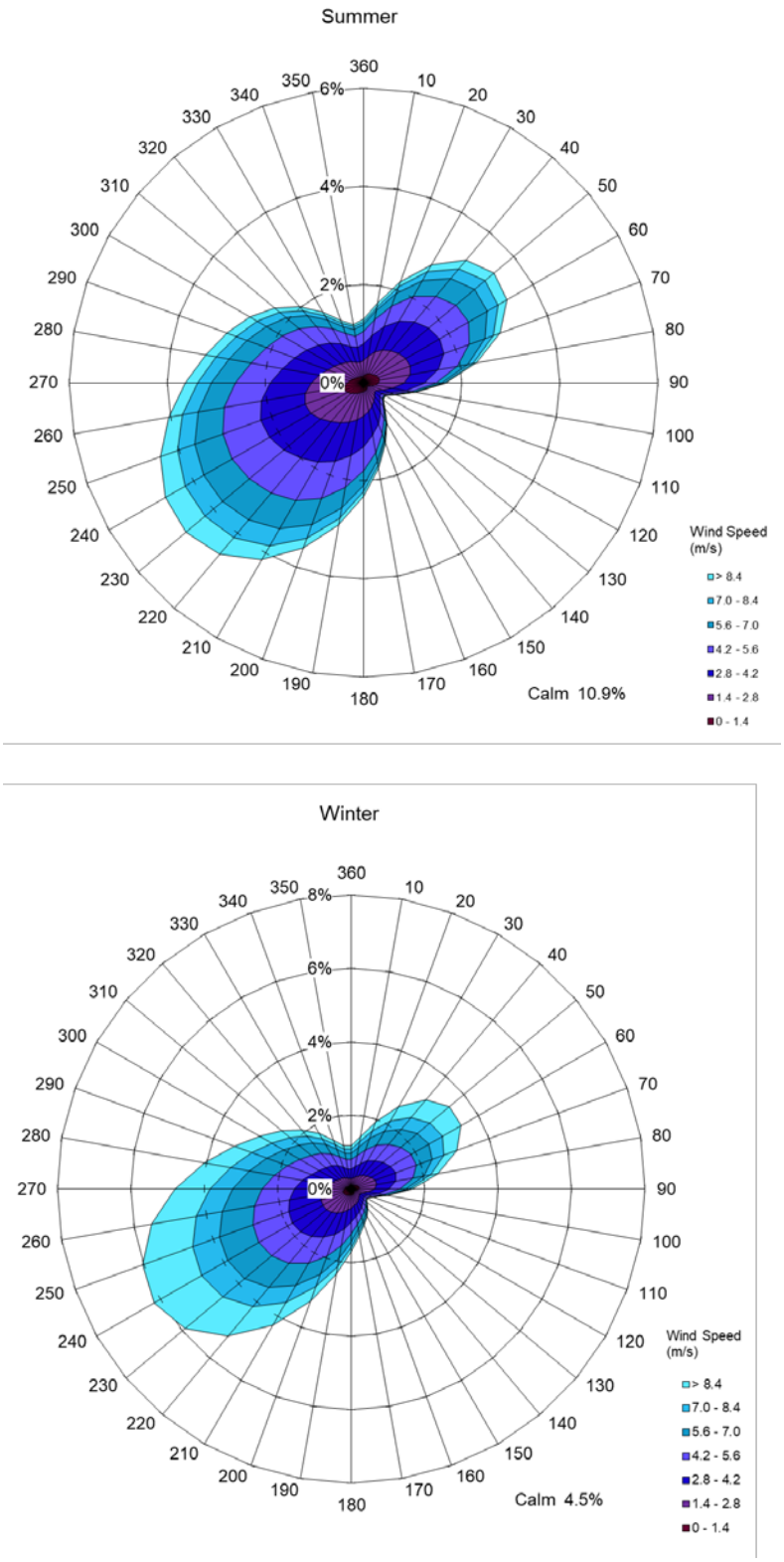


FIGURE 2 WINDROSES SHOWING DIRECTIONAL DISTRIBUTION OF SEASONAL WIND (CENTERED ON A 10° SECTOR)

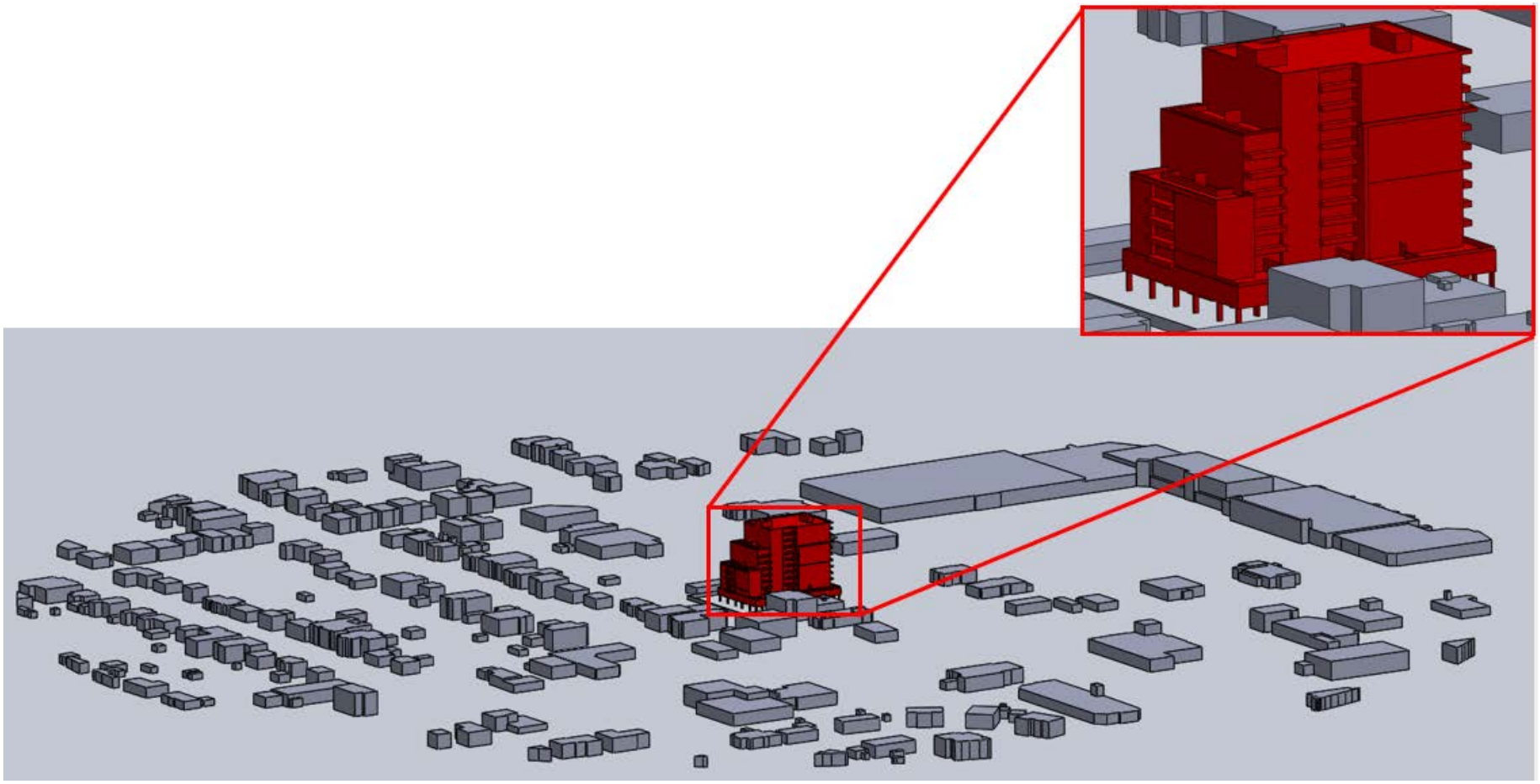


FIGURE 3 MASSING MODEL UTILIZED FOR THE CFD SIMULATION

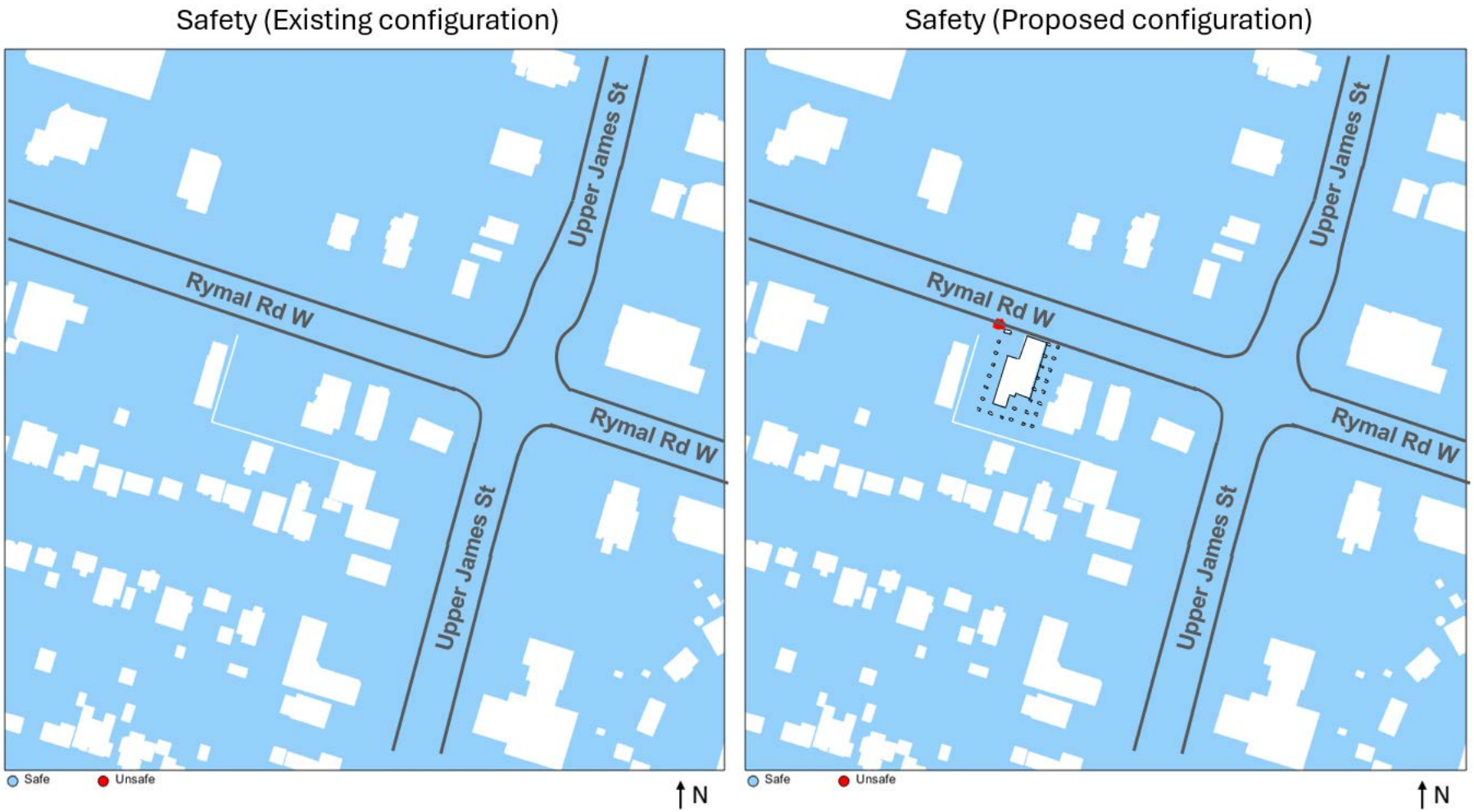


FIGURE 4 SUMMARY OF PREDICTED SAFETY LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – EXISTING SITE VS PROPOSED SITE

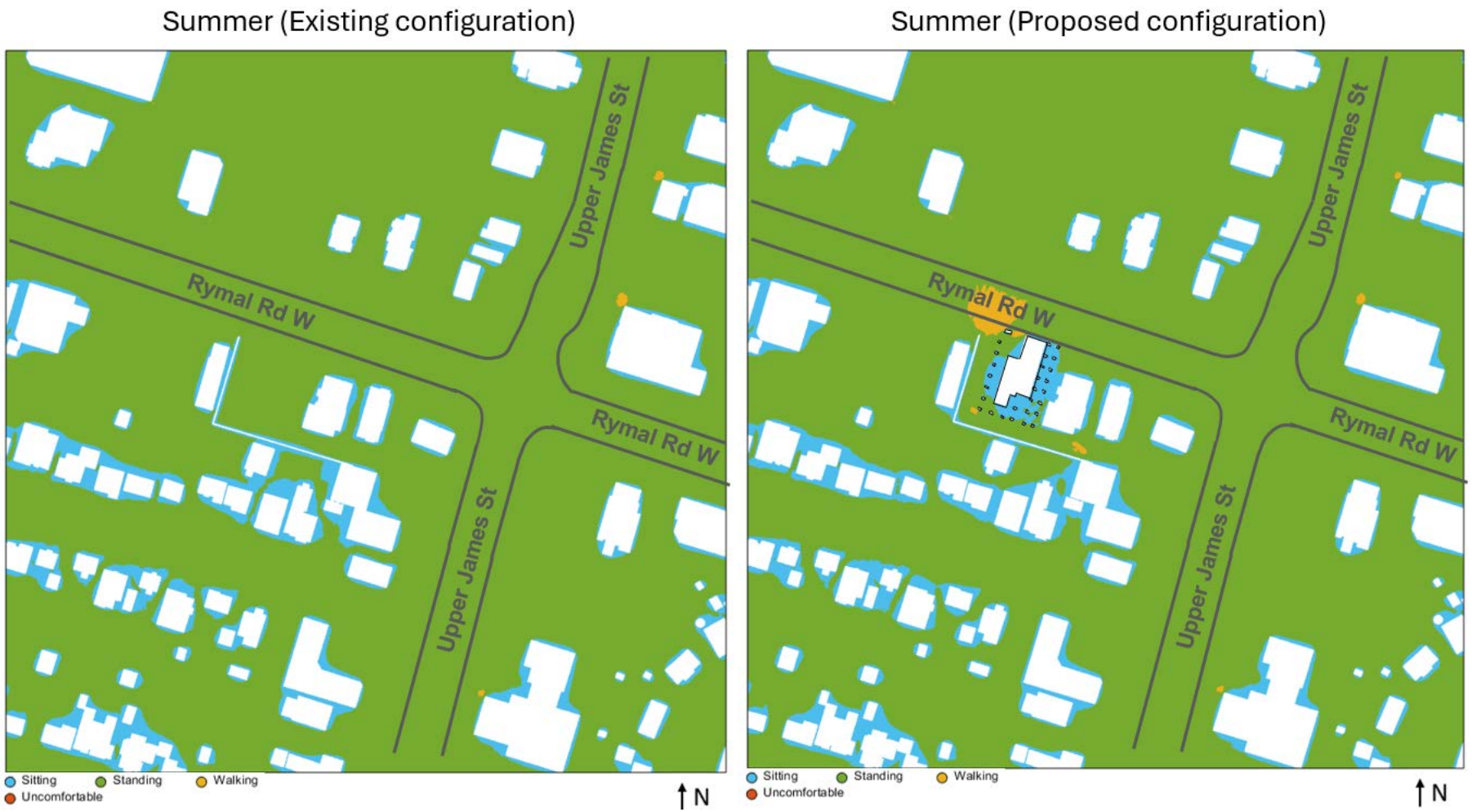


FIGURE 5 SUMMARY OF PREDICTED COMFORT LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – EXISTING SITE VS PROPOSED SITE (SUMMER)

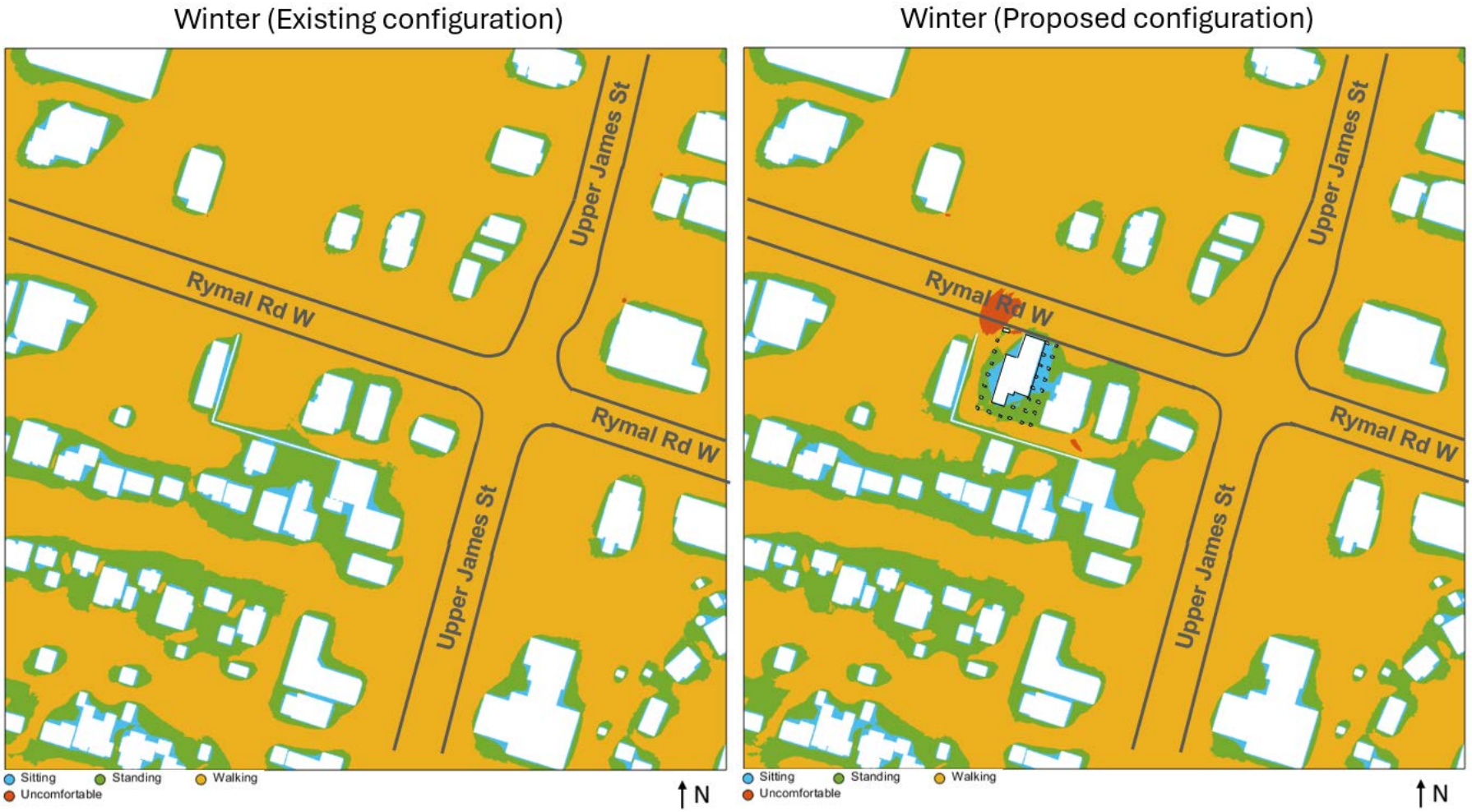


FIGURE 6 SUMMARY OF PREDICTED <u>COMFORT</u> LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – EXISTING SITE VS PROPOSED SITE (WINTER)

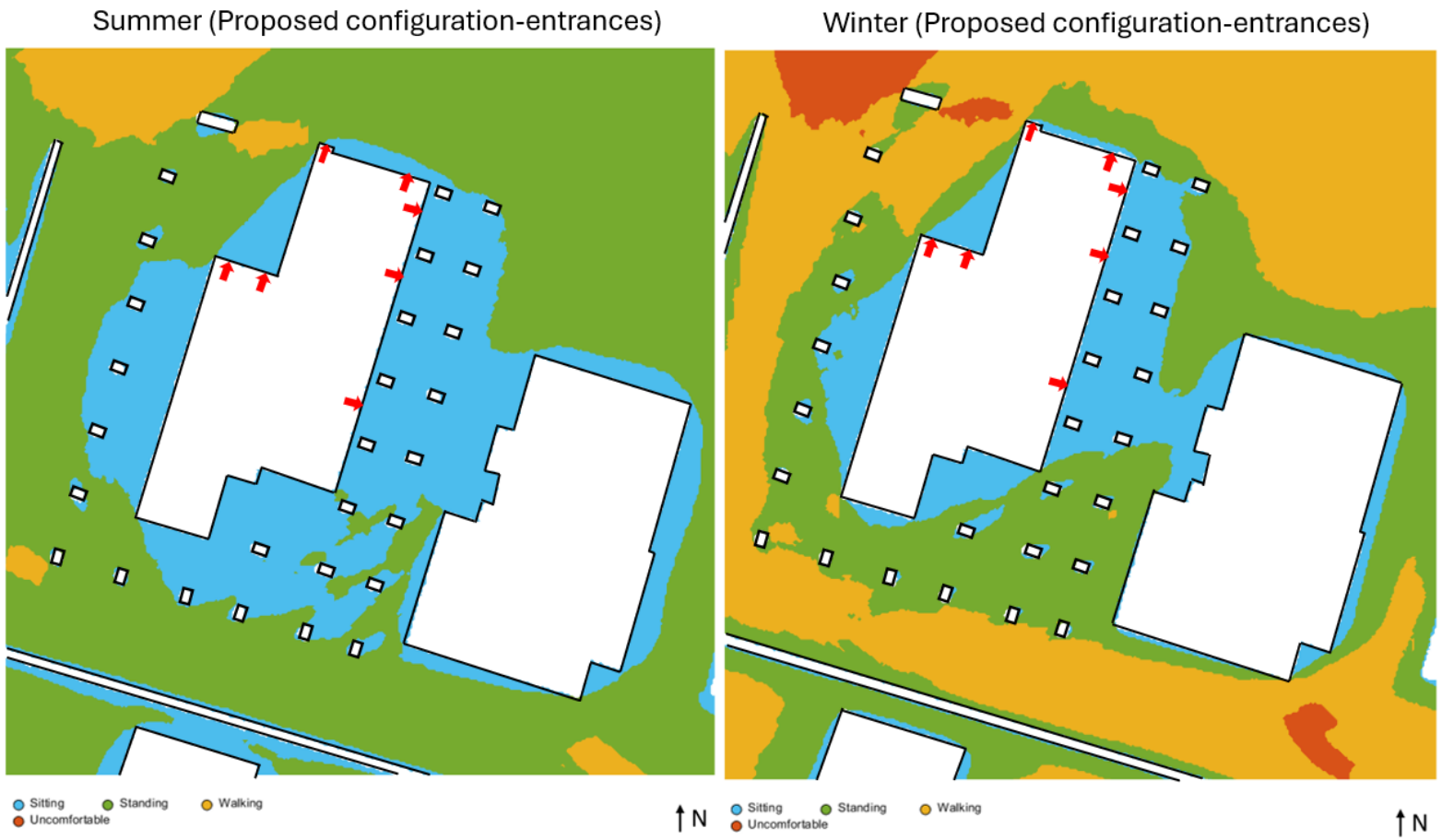
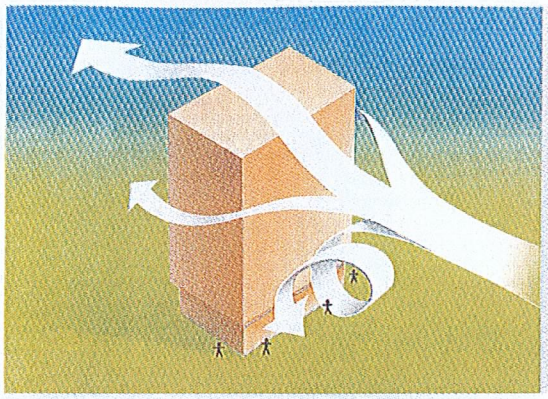


FIGURE 7 SUMMARY OF PREDICTED COMFORT LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – PROPOSED DEVELOPMENT, SUMMER and WINTER – ENTRANCE AREAS

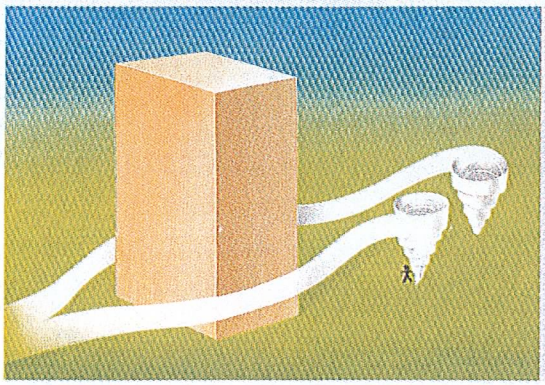
APPENDIX A

ILLUSTRATION OF PROBLEMS AND SOLUTIONS TO WIND EFFECTS AROUND BUILDINGS

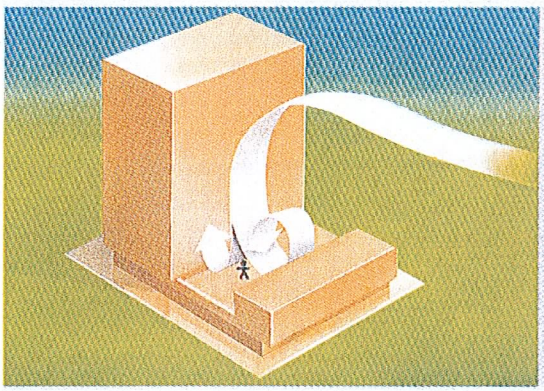
Problems



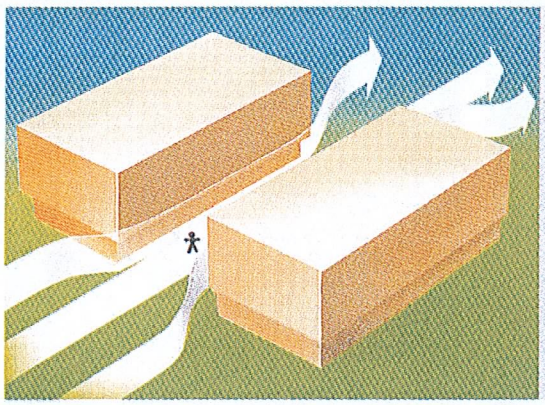
Downwash effect: *wind is deflected to street level.*



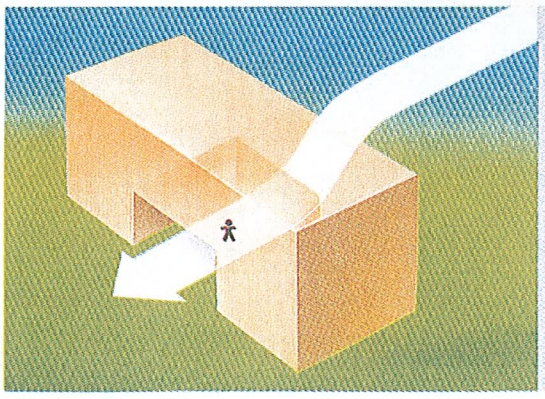
Karman vortex street: *wind swirls after dividing around a building.*



Confined horseshoe vortex: *downwash curls upward on an adjacent building.*



Venturi effect: *wind accelerates to get through narrow openings.*



Passageway effect: *wind accelerates to get through passages.*

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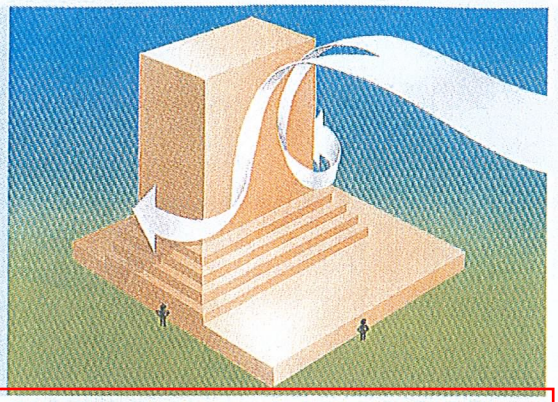
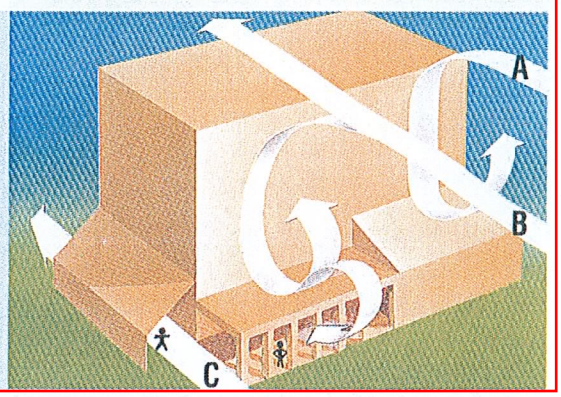
Solutions

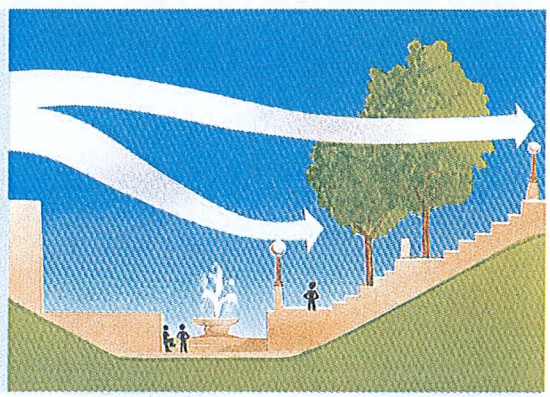
Stepped pedestal: *downwash is prevented from reaching street level.*



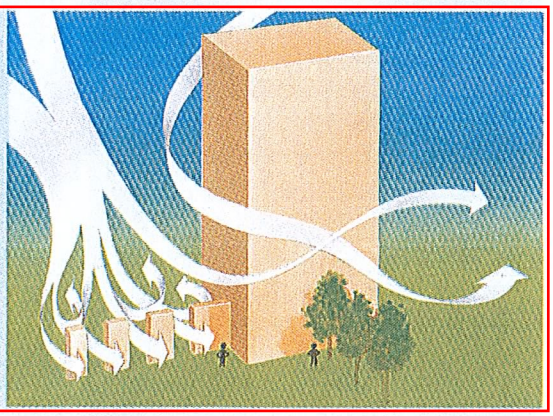
Covered walkways: *(a) enclosed canopy deflects downwash; (b) open sides provide some breeze under the canopy; (c) canopy open at both ends is only a partial solution: if the wind direction is such that it blows right through, a venturi effect is created.*



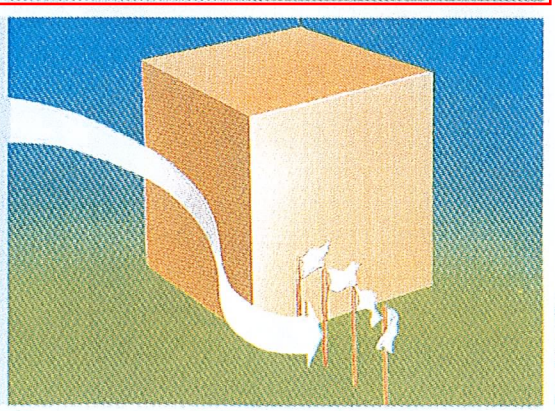
Recessed plaza: *wind passes over lowered area.*



Windscreens and landscaping: *wind is broken up and pedestrians are introduced gradually to windy areas.*



Public indicators: *flags provide warning of unavoidable high-wind areas.*



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