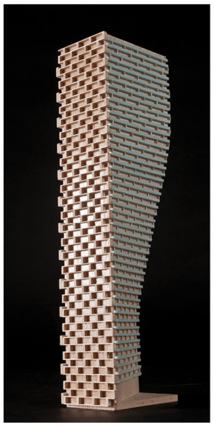
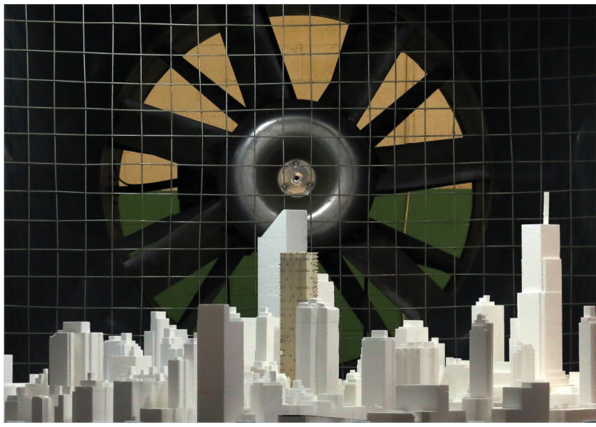
GRADIENTWIND
ENGINEERS & SCIENTISTS

PEDESTRIAN LEVEL WIND STUDY

335 Roosevelt Avenue
Ottawa, Ontario

Report: 20-091-PLW





July 30, 2020

PREPARED FOR
Uniform Urban Developments
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PREPARED BY
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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study to satisfy the requirements for a joint Official Plan Amendment (OPA) and Zoning By-Law Amendment (ZBA) application for a proposed multi-building residential development located at 335 Roosevelt Avenue in Ottawa, Ontario (hereinafter referred to as "subject site"). Our mandate within this study is to investigate pedestrian wind comfort and safety within and surrounding the subject site, and to identify any areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, as required.

The study involves simulation of wind speeds for selected wind directions in a three-dimensional (3D) computer model using the computational fluid dynamics (CFD) technique, combined with meteorological data integration, to assess pedestrian wind comfort and safety within and surrounding the subject site according to City of Ottawa wind comfort and safety criteria. The results and recommendations derived from these considerations are detailed in the main body of the report, illustrated in Figures 3A-6C, and summarized as follows:

1) All grade-level pedestrian sidewalks, pathways, and walkways will achieve City of Ottawa wind comfort criteria and will be suitable for their intended uses throughout the year.

2) Areas to the south and northeast of both proposed high-rise buildings are predicted to receive accelerated wind flow from northwest quadrant winds. While wind comfort is predicted to meet City of Ottawa criteria, as noted in Section 5.1, these areas may also be uncomfortable during periods of strong wind activity.

3) The building entrances along the south elevation of the West building are predicted to receive accelerated wind flow for northwesterly winds. It may be necessary to recess these entrances into the building façade by a minimum of 1.5 metres (m). This could be confirmed for the future site plan control application (SPA) submission.

4) Except for the building entrances noted in (3), all other building entrances are predicted to experience conditions suitable for standing, or better, throughout the year, which is acceptable.

5) Conditions within the grade level amenity area at the northeast of the site will be mostly suitable for standing during the summer. If possible, it may be preferable to locate the amenity area near the southeast corner of the East building, where conditions are somewhat calmer, and where less extensive mitigation would be required. A specific mitigation strategy will be developed for the future SPA submission, which will require the support of a detailed study.

6) Conditions within most of the potential amenity area at the southwest of the subject site will be suitable for sitting during the summer, with conditions near the southeast corner of the area suitable for standing. It is recommended that seating areas be located over the western portion of the area.

7) The outdoor amenity terraces at Level 5 of both proposed high-rise buildings will require mitigation to achieve sitting conditions at least 80% of the time during the summer. A specific mitigation strategy will be developed for the future SPA submission, which will require the support of a detailed study.

8) The west terraces at the Mechanical Penthouse Level of both proposed high-rise buildings are predicted to be suitable for a mix of sitting and standing during the summer. The introduction of wind screens along the limits of the amenity terraces is expected to provide conditions suitable for sitting during the typical use period of late spring to early autumn. The height of the wind screens required could be confirmed for the future SPA submission.

9) Conditions within the east terraces at the Mechanical Penthouse Level of both proposed high-rise buildings will be suitable for sitting during the summer, which is acceptable.

10) Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no pedestrian areas surrounding the subject site at grade level or within the common amenity terraces were found to experience conditions that could be considered uncomfortable or dangerous.

11) Regarding primary and secondary building access points, wind conditions predicted in this study are only applicable to pedestrian comfort and safety. As such, the results should not be construed to indicate wind loading on doors and associated hardware.

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Uniform Urban Developments to undertake a pedestrian level wind (PLW) study to satisfy the requirements for a joint Official Plan Amendment (OPA) and Zoning By-Law Amendment (ZBA) application for a proposed multi-building residential development located at 335 Roosevelt Avenue in Ottawa, Ontario (hereinafter referred to as "subject site"). Our mandate within this study is to investigate pedestrian wind comfort and safety within and surrounding the subject site, and to identify any areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, as required.

Our work is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, City of Ottawa wind comfort and safety criteria, architectural drawings of the subject site prepared by Hobin Architecture Inc. in June 2020, surrounding street layouts and existing and approved future building massing information obtained from the City of Ottawa, as well as recent satellite imagery.

2. TERMS OF REFERENCE

The subject site is located at 335 Roosevelt Avenue in Ottawa on an irregular parcel of land bounded by Roosevelt Avenue to the west, the OC Transpo Transitway to the north, and occupying land on either side of Winston Avenue that divides the site.

Architectural Rendering, West Perspective
(Courtesy of Hobin Architecture Inc.)

The subject site comprises two high-rise buildings at the north, of 21 storeys (West Building) and 18 storeys (East Building), and four low-rise residential buildings to the south (Blocks A-D). The two high-rise buildings have irregular planforms at grade, with sawtooth patterns along their north elevations which follow the orientation of the OC Transpo Transitway. The buildings step back from all elevations at Level 5, and amenity space is provided atop the podia roofs. At Level 7, the buildings step out to the east, to cantilever over the amenity terraces. The floorplate remains consistent from Level 7 to Levels 16 and 19 on the East and West buildings, respectively. The top two levels of each building feature setbacks from the north and west elevations, and both buildings are topped by mechanical penthouses. One-storey outbuildings are located at the west of either building. Blocks A-D are three-storey constructions, featuring residential suites.

The two taller buildings within the proposed development feature amenity, lobby, lounge, bike storage, and building services space on the ground floor, and residential units above. Building entrances are located at the west, and along the south elevation of either building. A grade-level amenity is located at the eastern extent of the property, and a second grade-level amenity may be located to the southwest of the West Building. Elevated common amenity terraces are located on the podium roofs and on the high roofs of either building.

The near-field surroundings (defined as an area within 200 metres (m) of the subject site) are composed of low-rise residential dwellings in all directions, and a mid-rise residential building directly to the northeast. The OC Transpo Transitway runs southwest-northeast directly to the north of the site. The far-field surroundings (defined as an area beyond the near-field but within a 5-kilometre (km) radius of the subject site) contribute primarily suburban wind exposures from the northeast clockwise to southwest, and hybrid open-suburban exposures from the southwest clockwise to northeast, owing to the Ottawa River and Gatineau beyond.

Key areas under consideration include surrounding sidewalks, walkways, building access points and outdoor amenity areas. Figure 1 illustrates the subject site and surrounding context, while Figures 2A-2D illustrate the computational model used to conduct the study.

3. OBJECTIVES

The principal objectives of this study are to (i) determine pedestrian level wind comfort and safety conditions at key areas within and surrounding the development site; (ii) identify areas where wind conditions may interfere with the intended uses of outdoor spaces; and (iii) recommend suitable mitigation measures, where required.

4. METHODOLOGY

The approach followed to quantify pedestrian wind conditions over the site is based on CFD simulations of wind speeds across the study site within a virtual environment, meteorological analysis of the Ottawa area wind climate, and synthesis of computational data with City of Ottawa wind comfort and safety criteria[1]. The following sections describe the analysis procedures, including a discussion of the noted pedestrian wind criteria.

4.1 Computer-Based Context Modelling

A computer based PLW study was performed to determine the influence of the wind environment on pedestrian comfort over the proposed development site. Pedestrian comfort predictions, based on the mechanical effects of wind, were determined by combining measured wind speed data from CFD simulations with statistical weather data obtained from Ottawa Macdonald-Cartier International Airport. The general concept and approach to CFD modelling is to represent building and topographic details in the immediate vicinity of the study site on the surrounding model, and to create suitable atmospheric wind profiles at the model boundary. The wind profiles are designed to have similar mean and turbulent wind properties consistent with actual site exposures.

An industry standard practice is to omit trees, vegetation, and other existing and planned landscape elements from the model due to the difficulty of providing accurate seasonal representation of vegetation. The omission of trees and other landscaping elements produces slightly more conservative (i.e., windier) wind speed values.

4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the site for 12 wind directions. The CFD simulation model was centered on the study building, complete with surrounding massing within a diameter of approximately 820 m.

Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds on

[1] City of Ottawa Terms of References: Wind Analysis
https://documents.ottawa.ca/sites/default/files/torwindanalysis_en.pdf

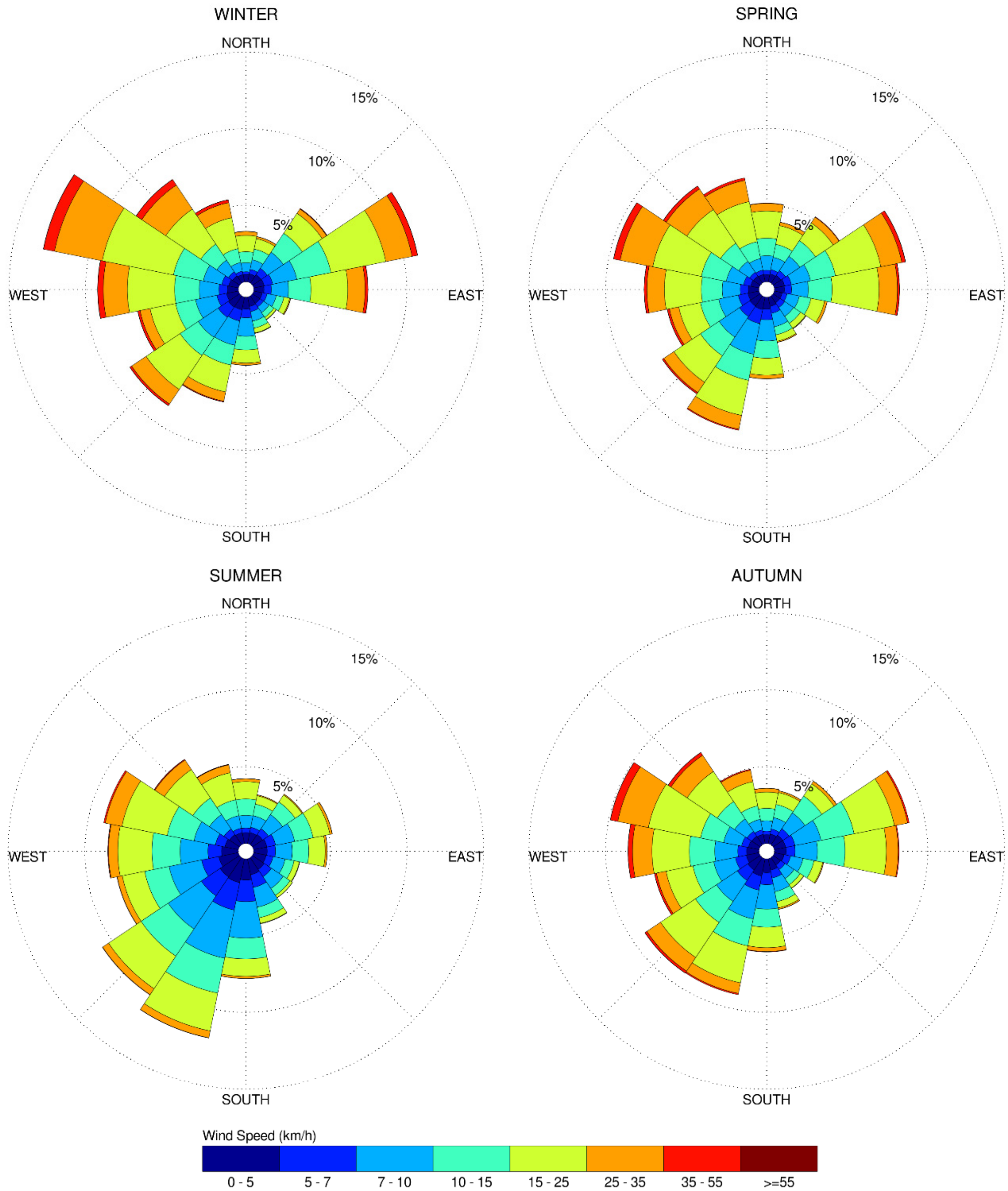
a continuous measurement plane 1.5 m above local grade, and 1.5 m above the amenity terraces, were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. The gradient height represents the theoretical depth of the boundary layer of the earth's atmosphere, above which the mean wind speed remains constant. Further details of the CFD wind flow simulation technique are presented in Appendix A.

4.3 Meteorological Data Analysis

A statistical model for winds in Ottawa was developed from approximately 40 years of hourly meteorological wind data recorded at Ottawa Macdonald-Cartier International Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were analyzed for each month of the year to determine the statistically prominent wind directions and corresponding speeds, and to characterize similarities between monthly weather patterns. Based on this portion of analysis, the four seasons are represented by grouping data from consecutive months based on similarity of weather patterns, and not according to the traditional calendar method. The winter season is defined as December-March, spring as April-May, summer as June-September, and autumn as October-November.

The statistical model of the Ottawa area wind climate, which indicates the directional character of local winds on a seasonal basis, is illustrated on the following page. The plots illustrate seasonal distribution of measured wind speeds and directions in kilometers per hour (km/h). Probabilities of occurrence of different wind speeds are represented as stacked polar bars in sixteen azimuth divisions. The radial direction represents the percentage of time for various wind speed ranges per wind direction during the measurement period. The preferred wind speeds and directions can be identified by the longer length of the bars. For Ottawa, the most common winds occur for westerly wind directions, followed by those from the east, while the most common wind speeds are below 36 km/h. The directional preference and relative magnitude of wind speed changes somewhat from season to season.

SEASONAL DISTRIBUTION OF WIND
OTTAWA MACDONALD-CARTIER INTERNATIONAL AIRPORT



Notes:

1. Radial distances indicate percentage of time of wind events.
2. Wind speeds are mean hourly in km/h, measured at 10 m above the ground.

4.4 Pedestrian Comfort and Safety Criteria – City of Ottawa

Pedestrian comfort and safety criteria are based on the mechanical effects of wind without consideration of other meteorological conditions (i.e., temperature, relative humidity). The comfort criteria assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Five pedestrian comfort classes are based on 80% non-exceedance mean wind speed ranges, which include (1) Sitting; (2) Standing; (3) Strolling; (4) Walking; and (5) Uncomfortable. More specifically, the comfort classes and associated mean wind speed ranges are summarized as follows:

1) **Sitting:** Mean wind speeds no greater than 10 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 16 km/h.

2) **Standing:** Mean wind speeds no greater than 14 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 22 km/h.

3) **Strolling:** Mean wind speeds no greater than 17 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 27 km/h.

4) **Walking:** Mean wind speeds no greater than 20 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 32 km/h.

5) **Uncomfortable:** Uncomfortable conditions are characterized by predicted values that fall below the 80% target for walking. Brisk walking and exercise, such as jogging, would be acceptable for moderate excesses of this criterion.

The pedestrian safety wind speed criterion is based on the approximate threshold that would cause a vulnerable member of the population to fall. A 0.1% exceedance gust wind speed of 90 km/h is classified as dangerous. The gust speeds, and equivalent mean speeds, are selected based on 'The Beaufort Scale', presented on the following page, which describes the effects of forces produced by varying wind speed levels on objects. Gust speeds are included because pedestrians tend to be more sensitive to wind gusts than to steady winds for lower wind speed ranges. For strong winds approaching dangerous levels, this effect is less important because the mean wind can also create problems for pedestrians. The mean gust speed ranges are selected based on 'The Beaufort Scale', which describes the effect of forces produced by varying wind speeds on levels on objects.

THE BEAUFORT SCALE

Number	Description	Wind Speed (km/h)		Description
		Mean	Gust	
2	Light Breeze	6-11	9-17	Wind felt on faces
3	Gentle Breeze	12-19	18-29	Leaves and small twigs in constant motion; wind extends light flags
4	Moderate Breeze	20-28	30-42	Wind raises dust and loose paper; small branches are moved
5	Fresh Breeze	29-38	43-57	Small trees in leaf begin to sway
6	Strong Breeze	39-49	58-74	Large branches in motion; Whistling heard in electrical wires; umbrellas used with difficulty
7	Moderate Gale	50-61	75-92	Whole trees in motion; inconvenient walking against wind
8	Gale	62-74	93-111	Breaks twigs off trees; generally impedes progress

Experience and research on people's perception of mechanical wind effects has shown that if the wind speed levels are exceeded for more than 80% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if a mean wind speed of 10 km/h was exceeded for more than 20% of the time most pedestrians would judge that location to be too windy for sitting. Similarly, if mean wind speed of 20 km/h at a location were exceeded for more than 20% of the time, walking or less vigorous activities would be considered uncomfortable. As most of these criteria are based on subjective reactions of a population to wind forces, their application is partly based on experience and judgment.

Once the pedestrian wind speed predictions have been established throughout the site, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for discrete regions within and surrounding the subject site. This step involves comparing the predicted comfort classes to the desired comfort classes, which are dictated by the location type for each region (i.e., a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their desired comfort classes are summarized on the following page.

DESIRED PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES

Location Types	Desired Comfort Classes
Primary Building Entrance	Standing
Secondary Building Access Point	Standing / Strolling / Walking
Primary Public Sidewalk	Strolling / Walking
Secondary Public Sidewalk / Bicycle Path	Walking
Outdoor Amenity Space	Sitting / Standing / Strolling
Café / Patio / Bench / Garden	Sitting
Transit Stop	Sitting / Standing
Public Park / Plaza	Standing / Strolling
Garage / Service Entrance	Walking
Parking Lot	Strolling / Walking
Vehicular Drop-Off Zone	Standing / Strolling / Walking

5. RESULTS AND DISCUSSION

The following discussion of predicted pedestrian wind conditions is accompanied by Figures 3A-3D (following the main text) illustrating the seasonal wind conditions at grade level, Figures 4A-4D illustrating conditions on the Level 5 Amenity, and Figures 5A-5D illustrating conditions on the amenity terraces on the Mechanical Penthouse Level serving the East and West buildings. The wind conditions are presented as continuous contours of wind comfort within and surrounding the subject site.

The colour contours indicate various comfort classes predicted for certain regions. Wind conditions comfortable for sitting or more sedentary activities are represented by the colour green, standing are represented by yellow, strolling by orange, walking by blue, while uncomfortable conditions are represented by the colour magenta. Pedestrian comfort is summarized below for each area of interest.

Additionally, Figures 6A-6C illustrate the percentage of time that areas at grade and on the elevated amenity terraces will be suitable for sitting during the summer season.

5.1 Wind Comfort Conditions – Grade Level

Roosevelt Avenue: The sidewalks along Roosevelt Avenue are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for standing during the spring and autumn, and suitable for a mix of standing and strolling during the winter. In general, the windier conditions are expected to occur southwest of Block A and near the northern end of Roosevelt Avenue (by the rotunda). These windier conditions are caused by acceleration of prominent northerly and northwesterly winds around the northwest corner of the West building. Nevertheless, these conditions are considered acceptable according to the wind comfort criteria in Section 4.4.

Wilmont Avenue: The sidewalks along Wilmont Avenue will be suitable for sitting during the summer and autumn seasons. During the winter and spring seasons, winds from the northwest quadrant will accelerate between the existing buildings at 375 and 369 Wilmont Avenue, creating conditions suitable for standing. These conditions are considered acceptable according to the wind comfort criteria in Section 4.4.

Winston Avenue, including Rotunda Between the East and West Buildings: Wind conditions are predicted to be suitable for standing at the north, and suitable for sitting at the south of the sidewalks along Winston Avenue during the summer. During the autumn, regions at the north, within and around the rotunda, will experience conditions suitable for strolling, which transition to standing and sitting farther south along Winston Avenue. During the winter and spring, walking conditions will develop at the north, to the east of the West building.

The area at the north is expected to receive accelerated wind flow for statistically prominent northwesterly and northeasterly wind directions. While the noted conditions are considered acceptable according to the wind comfort criteria in Section 4.4, the general area may also be uncomfortable during periods of strong wind activity.

Multi-Use Pathway, North of Subject Site: The multi-use pathway, which runs along the south side of the Transitway, is expected to be suitable for standing during the summer and suitable for a mix of standing and strolling during the autumn. During the spring and winter, walking conditions will develop near the northeast corner of both high-rise buildings. Since the pathway will be primarily used for walking or more vigorous activities, the noted conditions are considered acceptable.

Pedestrian Walkways Throughout Subject Site: The pedestrian walkways throughout the subject site will be mostly suitable for standing during the summer, with isolated regions suitable for sitting. During the autumn, conditions will be suitable for a mix of standing and strolling. During the winter, many pedestrian areas will be suitable for walking. This includes areas to the south and northeast of both high-rise buildings as well to the northwest of Block C.

The windy conditions throughout the site are due to the relatively open wind exposures for prominent northwesterly winds, as well as downwash and acceleration of winds around and between the two high-rise buildings. While the noted conditions are considered acceptable according to the wind comfort criteria in Section 4.4, many pedestrian areas within the subject site may also be uncomfortable during periods of strong wind activity.

Building Entrances: The building entrances along the south elevation of the West building will be affected by strong wind accelerations for northwesterly wind directions, which are statistically prominent in Ottawa. Wind is expected to accelerate around the southwest corner of the West building, and channel between the West building and Blocks A and B. This may result in uncomfortable conditions for pedestrians using these entrances, which provide access to the lobby, mail & parcel room, garbage room, move-in space, and bike storage.

It may be necessary to recess the entrances along the south elevation of the West building into the building façade by a minimum of 1.5 m. This can be confirmed for the site plan application submission. All other building access points will experience conditions suitable for standing, or better, throughout the year, which is acceptable.

Amenity Area, Northeast of Subject Site: The grade-level amenity area at the northeast corner of the East building will be suitable for standing during the summer, mostly suitable for strolling during the autumn, and suitable for a mix of strolling and walking during the spring and winter. Figure 6A illustrates that this area will be suitable for sitting at least 65% of the time during the summer season.

Windy conditions throughout this area are due to downwash from the East building of prominent winds from the northwest clockwise to northeast, as well as acceleration between the East building and the neighbouring mid-rise building at 2100 Scott Street. A specific mitigation strategy will be developed for the future site plan control application (SPA) submission, which will require a detailed study.

Potential Amenity Area, Southwest of Subject Site: The area to the southwest of the West building, which may be a designated amenity area, will be mostly suitable for sitting during the summer, with an area near the southeast corner suitable for standing. During the remaining three colder seasons, the area will be mostly suitable for standing, with somewhat windier conditions near the southeast corner. While conditions over most of the area are considered acceptable according to the wind comfort criteria in Section 4.4, it is recommended that seating areas be located over the western portion of the area. If required, a specific mitigation strategy could be developed for the future SPA submission.

5.2 Wind Comfort and Safety Conditions – Elevated Amenity Terraces

Level 5 Terrace, West Building: The terrace on the roof of the podium of the West building will be suitable for a mix of sitting and standing during the summer. Figure 6B illustrates that sitting conditions will be achieved at least 70% of the time over the terrace, excluding areas along the perimeter, which will be suitable for sitting at least 65% of the time during the summer.

Windy conditions are caused by a combination of downwash and acceleration of prominent westerly winds. Mitigation will be required, which may include tall wind barriers along the perimeter of the terrace in place of standard height guardrails, canopies, localized wind barriers inboard of the perimeter, or a combination of the above. A specific mitigation strategy will be developed for the future SPA submission, which will require a detailed study.

Level 5 Terrace, East Building: The terrace on the roof of the podium of the East building will experience similar, but slightly windier conditions to those on the Level 5 terrace of the West building. During the summer, the terrace will be mostly suitable for standing, with sitting conditions under the building overhang and some strolling conditions near the southwest corner. Figure 6B illustrates that the terrace will be suitable for sitting at least 60% of the time during the summer. During the colder months, the terrace will be suitable for a mix of strolling and walking. A specific mitigation strategy will be developed for the future SPA submission, which will require a detailed study.

Mechanical Penthouse Level West Terrace, West Building: The west terrace at the Mechanical Penthouse Level of the West building will be mostly suitable for sitting during the summer, with small regions expected to be suitable for standing. Figure 6C illustrates that the terrace will be suitable for sitting at least 75% of the time during the summer. During the colder months, the terrace will be mostly suitable for standing.

It is expected that the introduction of solid wind barriers along the limits of the terrace would be sufficient to provide sitting conditions throughout the terrace during the typical use period of late spring to early autumn. The required height of the barriers could be confirmed for the future SPA submission.

Mechanical Penthouse Level East Terrace, West Building: The east terrace at the Mechanical Penthouse Level of the West building will be mostly suitable for sitting during the summer months, becoming mostly suitable for standing during the remaining three colder seasons. These conditions are considered acceptable according to the wind comfort criteria in Section 4.4.

Mechanical Penthouse Level West Terrace, East Building: The west terrace at the Mechanical Penthouse Level of the East building will be suitable for a mix of sitting and standing during the summer. Figure 6C illustrates that the terrace will be suitable for sitting at least 70% of the time during the summer. Conditions will become suitable for a mix of standing and strolling during the colder months of the year.

It is expected that the introduction of tall solid wind barriers along the limits of the terrace would be sufficient to provide sitting conditions throughout the terrace during the typical use period. The required height of the barriers can be confirmed at the site plan application stage. Alternatively, the amenity terrace could be located along the south of the Mechanical Penthouse Level, where conditions are considerably calmer.

Mechanical Penthouse Level East Terrace, East Building: The east terrace at the Mechanical Penthouse Level of the East building will be suitable for sitting during the summer season, becoming mostly suitable for standing during the remaining three colder seasons. These conditions are considered acceptable according to the wind comfort criteria in Section 4.4.

5.3 Applicability of Results

Wind conditions over surrounding sidewalks beyond the subject site, as well as at nearby primary building entrances, will be acceptable for their intended pedestrian uses during each seasonal period upon the introduction of the subject site. Pedestrian wind comfort and safety have been quantified for the specific configuration of existing and foreseeable construction around the study site. Future changes (i.e., construction or demolition) of these surroundings may cause changes to the wind effects in two ways, namely: (i) changes beyond the immediate vicinity of the site would alter the wind profile approaching the site; and (ii) development in proximity to the site would cause changes to local flow patterns. In general, development in urban centers generally creates reduction in the mean wind speeds and localized increases in the gustiness of the wind.

Regarding primary and secondary building access points, wind conditions predicted in this study are only applicable to pedestrian comfort and safety. As such, the results should not be construed to indicate wind loading on doors and associated hardware.

6. CONCLUSIONS AND RECOMMENDATIONS

A complete summary of the predicted wind comfort and safety conditions is provided in Section 5 and illustrated in Figures 3A-6C. Based on computer simulations using the CFD technique, meteorological data analysis of the Ottawa wind climate, City of Ottawa wind comfort and safety criteria, and experience with similar developments in Ottawa, we conclude the following:

1) All grade-level pedestrian sidewalks, pathways, and walkways will achieve City of Ottawa wind comfort criteria and will be suitable for their intended uses throughout the year.

2) Areas to the south and northeast of both proposed high-rise buildings are predicted to receive accelerated wind flow from northwest quadrant winds. While wind comfort is predicted to meet City of Ottawa criteria, as noted in Section 5.1, these areas may also be uncomfortable during periods of strong wind activity.

3) The building entrances along the south elevation of the West building are predicted to receive accelerated wind flow for northwesterly winds. It may be necessary to recess these entrances into the building façade by a minimum of 1.5 metres (m). This could be confirmed for the future SPA submission.

4) Except for the building entrances noted in (3), all other building entrances are predicted to experience conditions suitable for standing, or better, throughout the year, which is acceptable.

5) Conditions within the grade level amenity area at the northeast of the site will be mostly suitable for standing during the summer. If possible, it may be preferable to locate the amenity area near the southeast corner of the East building, where conditions are somewhat calmer, and where less extensive mitigation would be required. A specific mitigation strategy will be developed for the future SPA submission, which will require the support of a detailed study.

6) Conditions within most of the potential amenity area at the southwest of the subject site will be suitable for sitting during the summer, with conditions near the southeast corner of the area suitable for standing. It is recommended that seating areas be located over the western portion of the area.

7) The outdoor amenity terraces at Level 5 of both proposed high-rise buildings will require mitigation to achieve sitting conditions at least 80% of the time during the summer. A specific mitigation strategy will be developed for the future SPA submission, which will require the support of a detailed study.

8) The west terraces at the Mechanical Penthouse Level of both proposed high-rise buildings are predicted to be suitable for a mix of sitting and standing during the summer. The introduction of wind screens along the limits of the amenity terraces is expected to provide conditions suitable for sitting during the typical use period of late spring to early autumn. The height of the wind screens required could be confirmed for the future SPA submission.

9) Conditions within the east terraces at the Mechanical Penthouse Level of both proposed high-rise buildings will be suitable for sitting during the summer, which is acceptable.

10) Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no pedestrian areas surrounding the subject site at grade level or within the common amenity terraces were found to experience conditions that could be considered uncomfortable or dangerous.

This concludes our PLW study and report. Please advise the undersigned of any questions or comments.

Sincerely,

Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
J. D. FERRARO
100158495
July 30, 2020
PROVINCE OF ONTARIO

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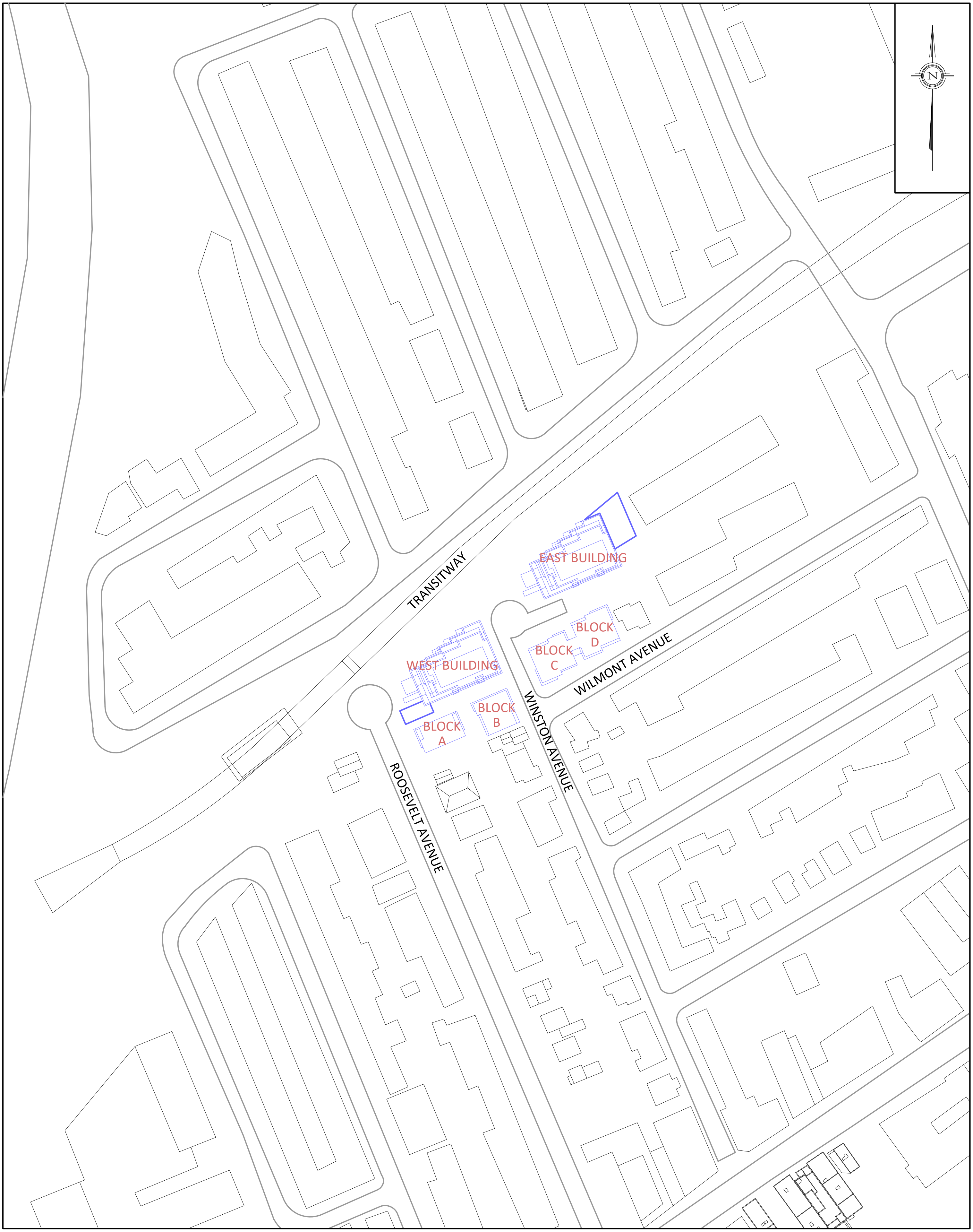

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PROJECT	335 ROOSEVELT AVENUE, OTTAWA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:2500 (APPROX.)	DRAWING NO.	20-091-PLW-1
DATE	JULY 30, 2020	DRAWN BY	S.R.

DESCRIPTION

FIGURE 1:
SITE PLAN AND SURROUNDING CONTEXT

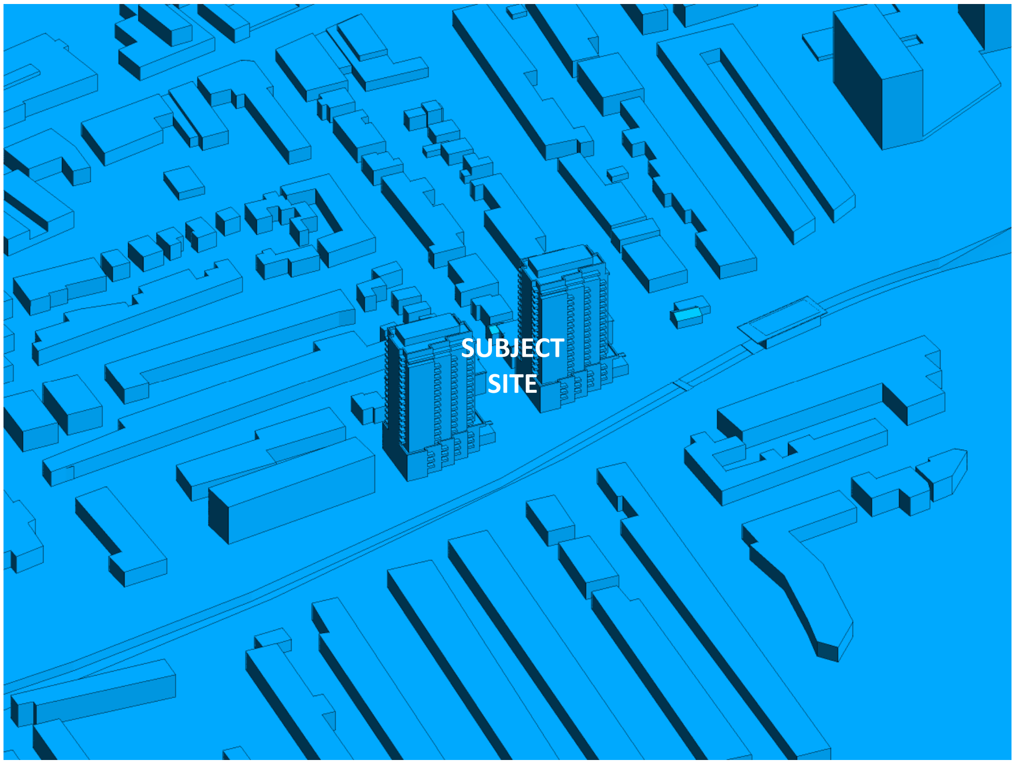


FIGURE 2A: COMPUTATIONAL MODEL, NORTH PERSPECTIVE

FIGURE 2B: CLOSE UP OF FIGURE 2A

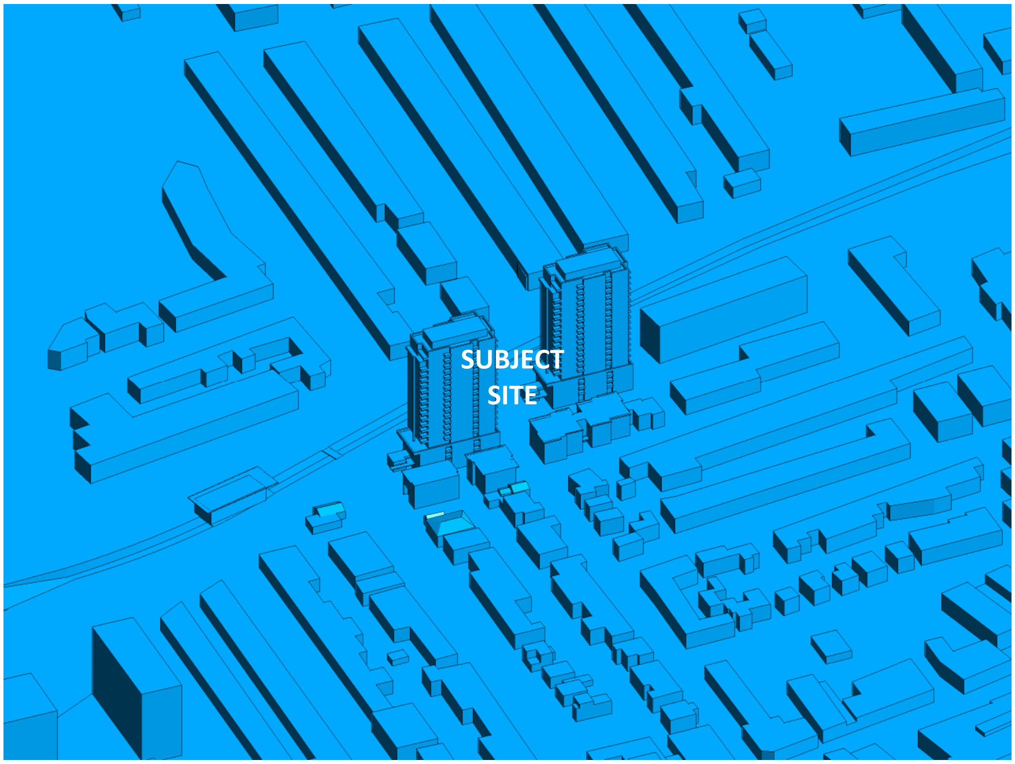


FIGURE 2C: COMPUTATIONAL MODEL, SOUTH PERSPECTIVE

FIGURE 2D: CLOSE UP OF FIGURE 2C

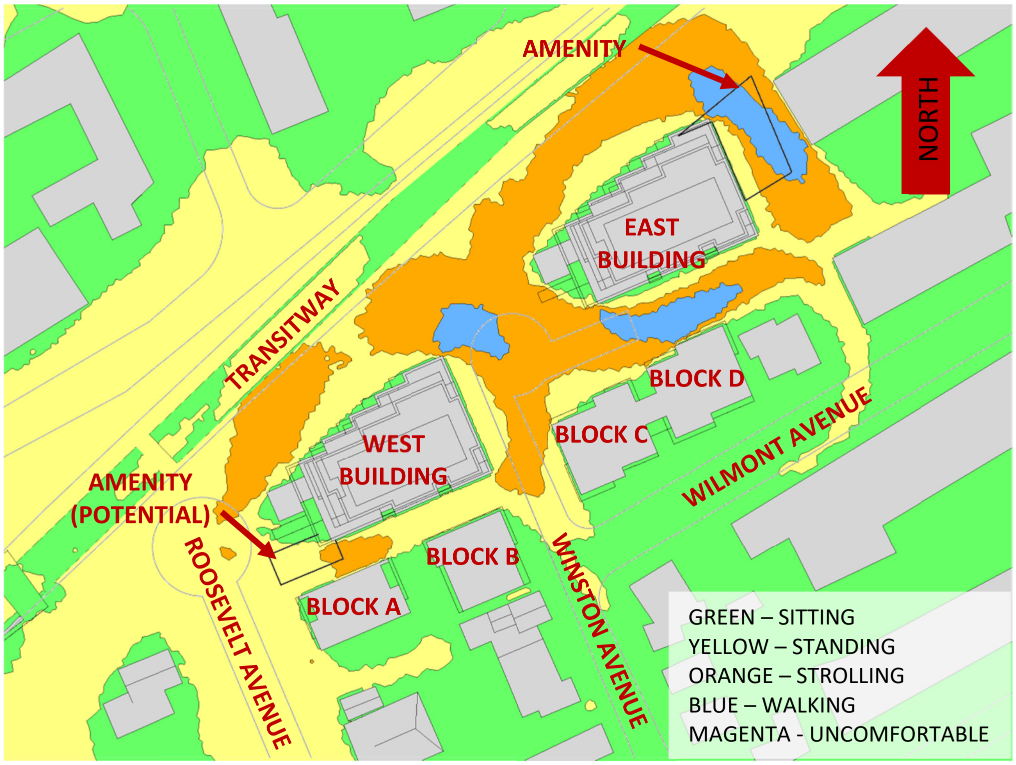


FIGURE 3A: SPRING – WIND CONDITIONS AT GRADE LEVEL

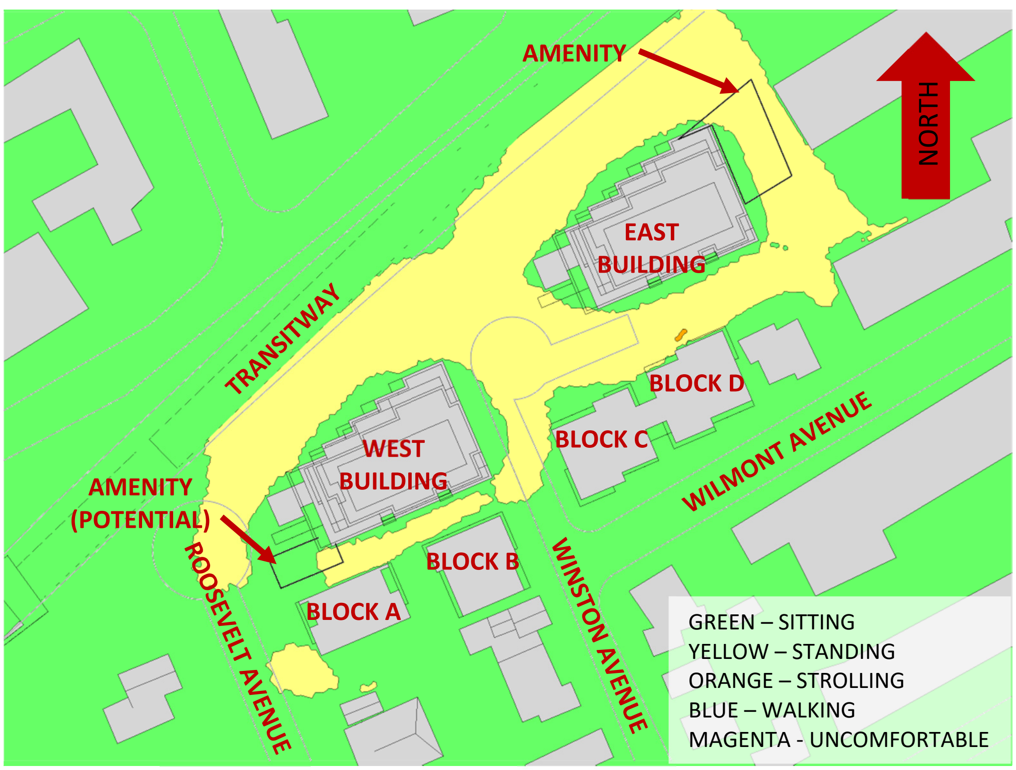


FIGURE 3B: SUMMER – WIND CONDITIONS AT GRADE LEVEL

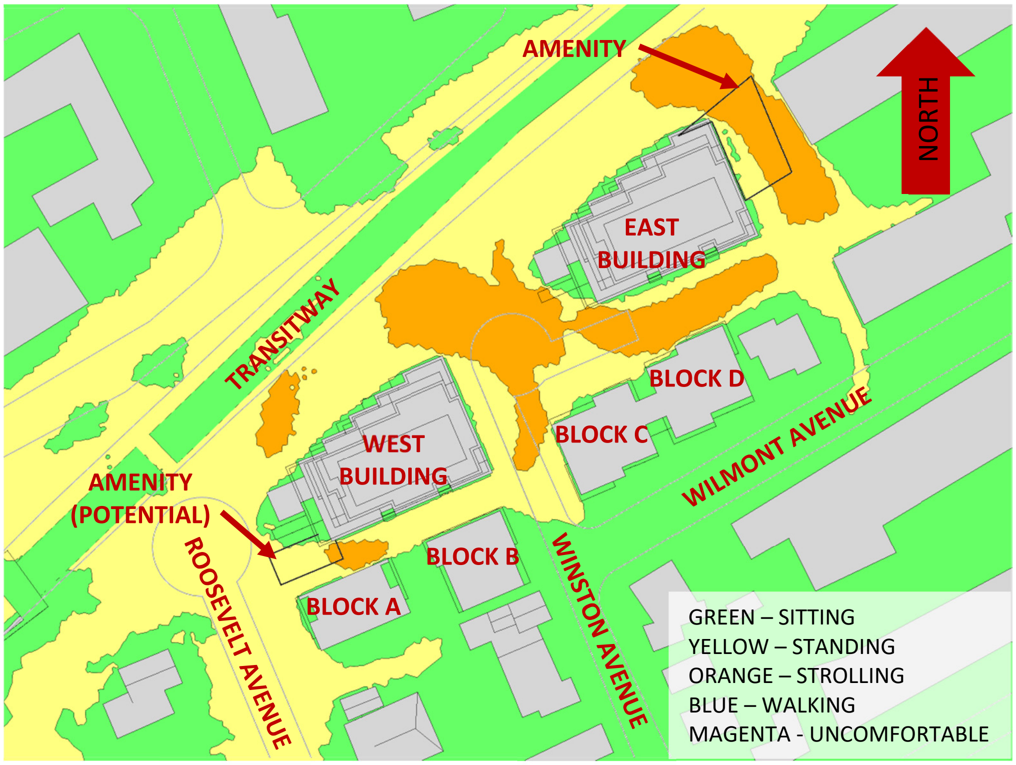


FIGURE 3C: AUTUMN – WIND CONDITIONS AT GRADE LEVEL

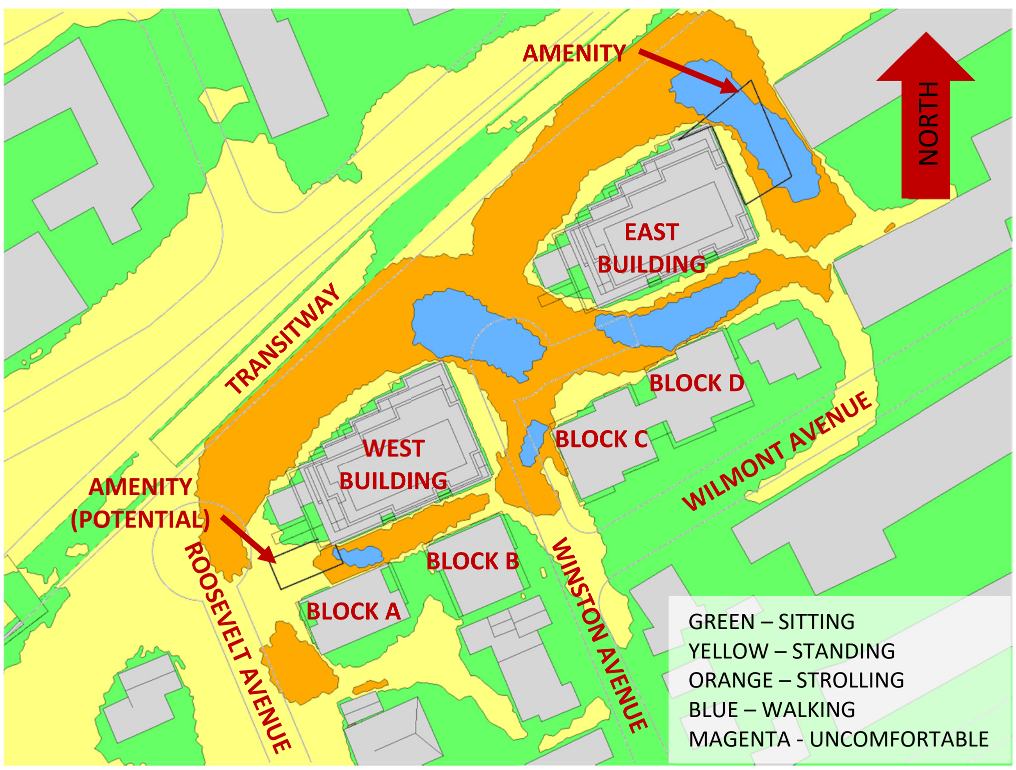


FIGURE 3D: WINTER – WIND CONDITIONS AT GRADE LEVEL

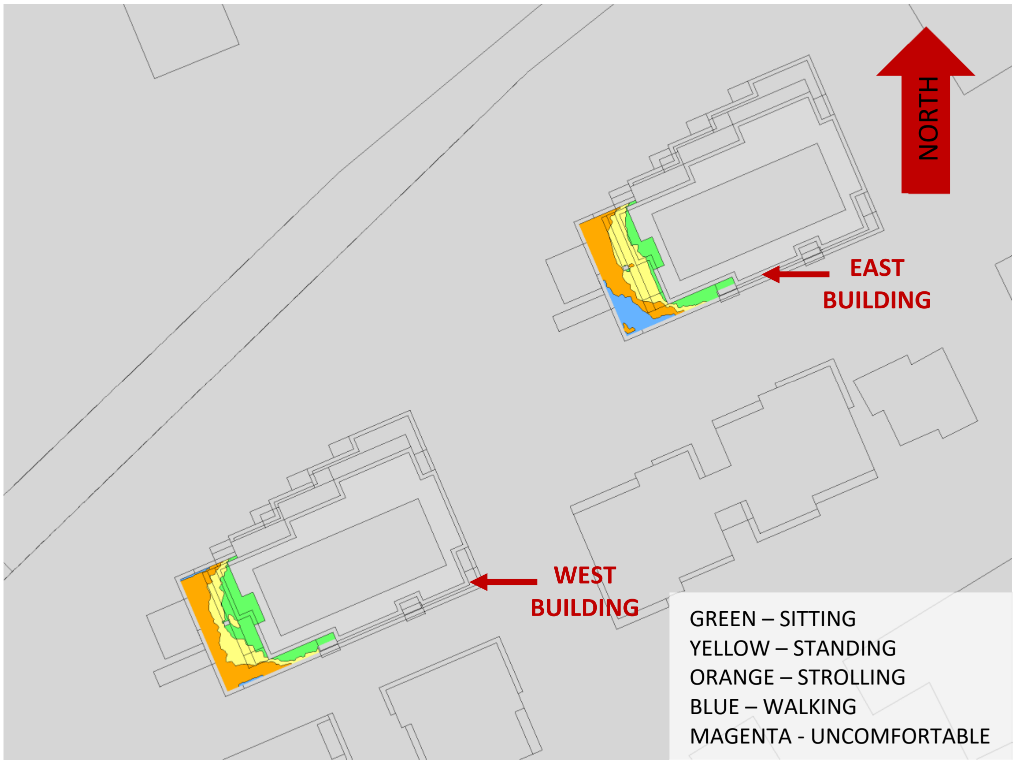


FIGURE 4A: SPRING – WIND CONDITIONS, LEVEL 5 AMENITY TERRACES

FIGURE 4B: SUMMER – WIND CONDITIONS, LEVEL 5 AMENITY TERRACES

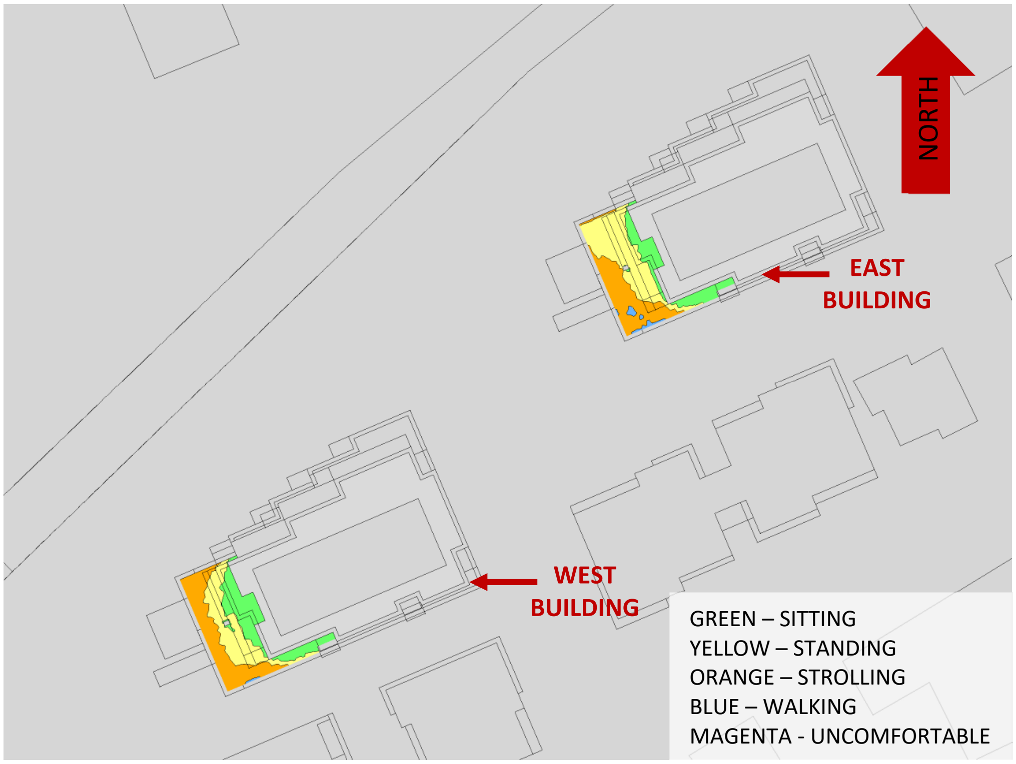


FIGURE 4C: AUTUMN – WIND CONDITIONS, LEVEL 5 AMENITY TERRACES

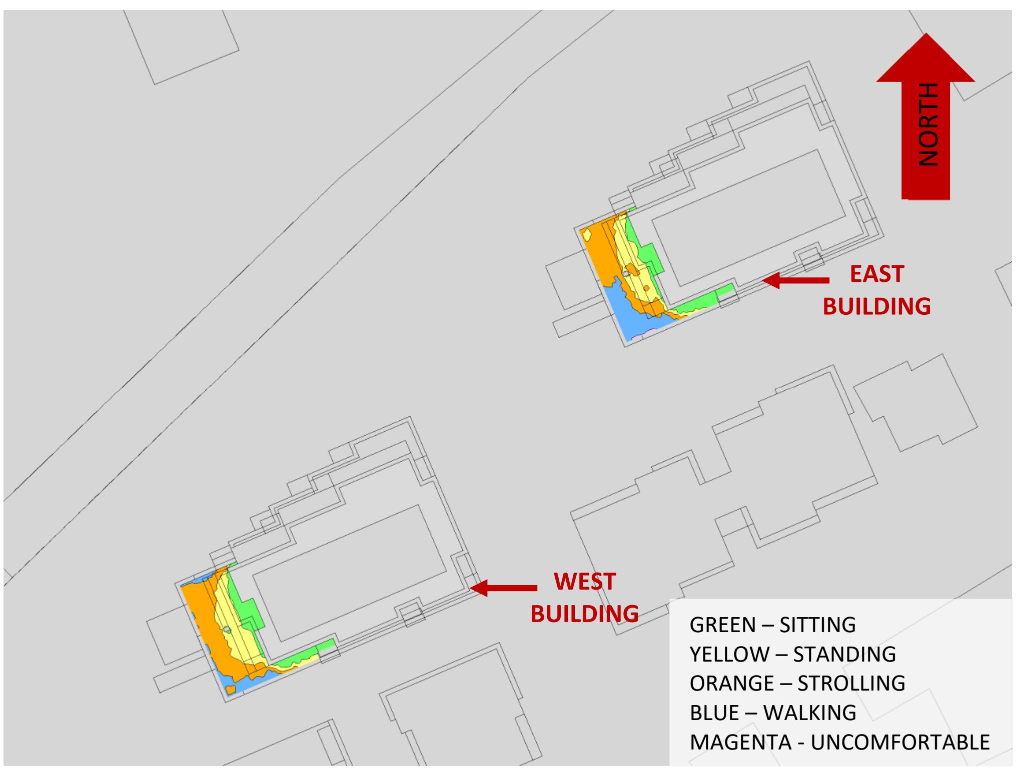


FIGURE 4D: WINTER – WIND CONDITIONS, LEVEL 5 AMENITY TERRACES

FIGURE 5A: SPRING – WIND CONDITIONS, MPH LEVEL AMENITY TERRACES

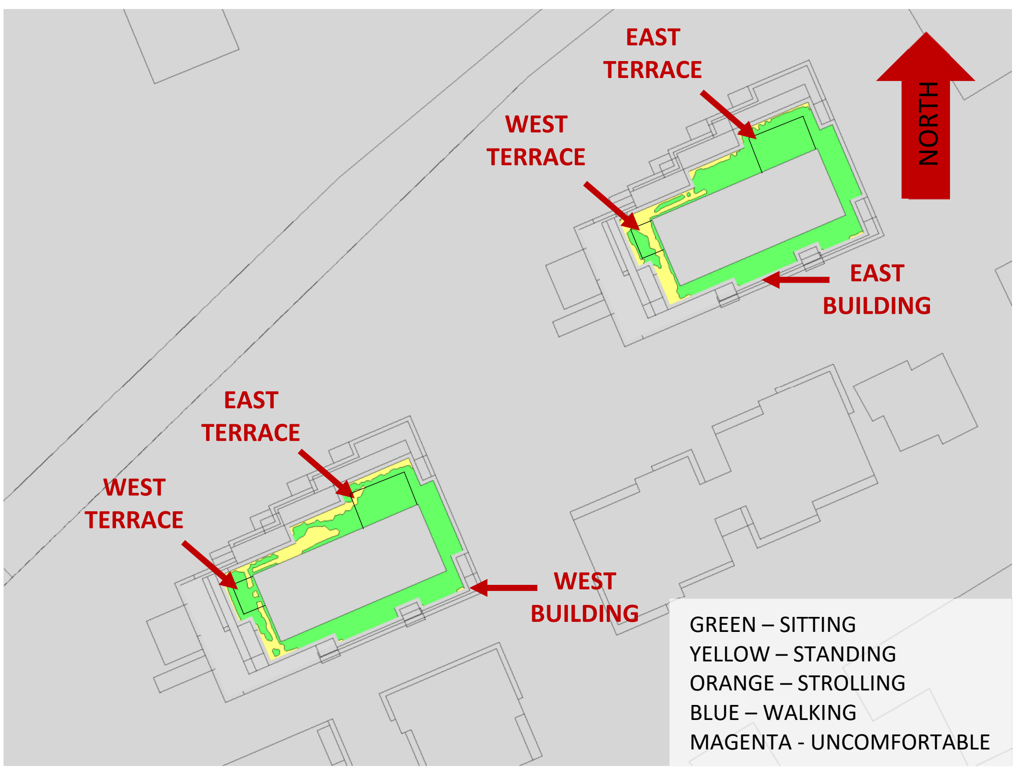


FIGURE 5B: SUMMER – WIND CONDITIONS, MPH LEVEL AMENITY TERRACES

FIGURE 5C: AUTUMN – WIND CONDITIONS, MPH LEVEL AMENITY TERRACES

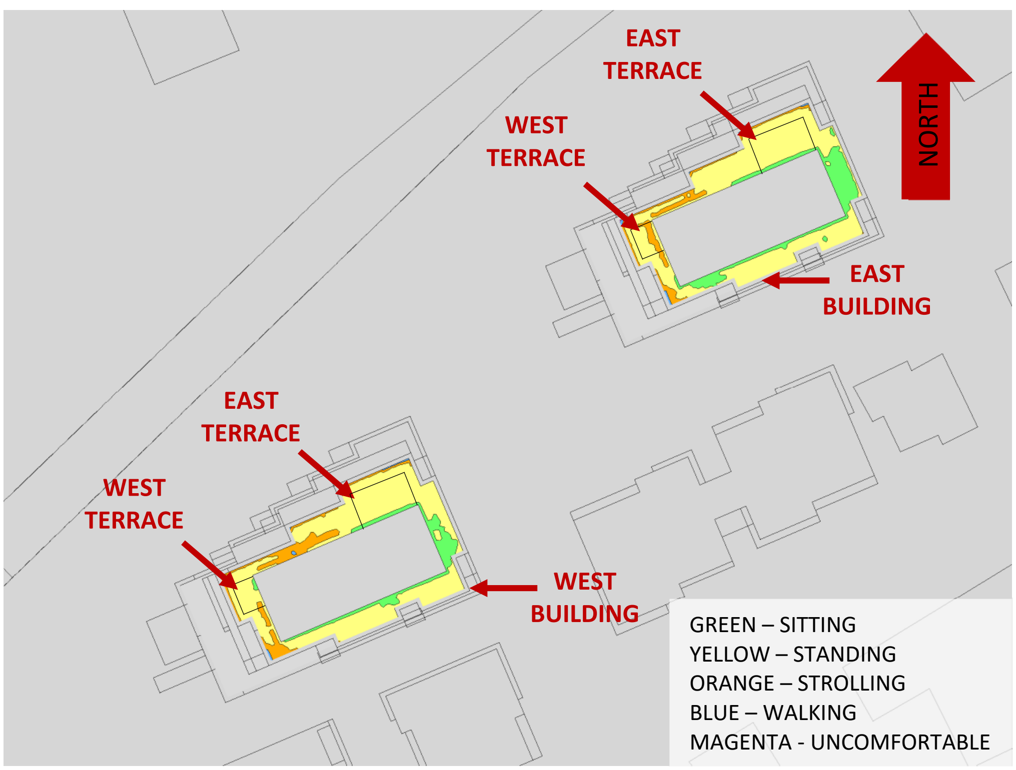


FIGURE 5D: WINTER – WIND CONDITIONS, MPH LEVEL AMENITY TERRACE

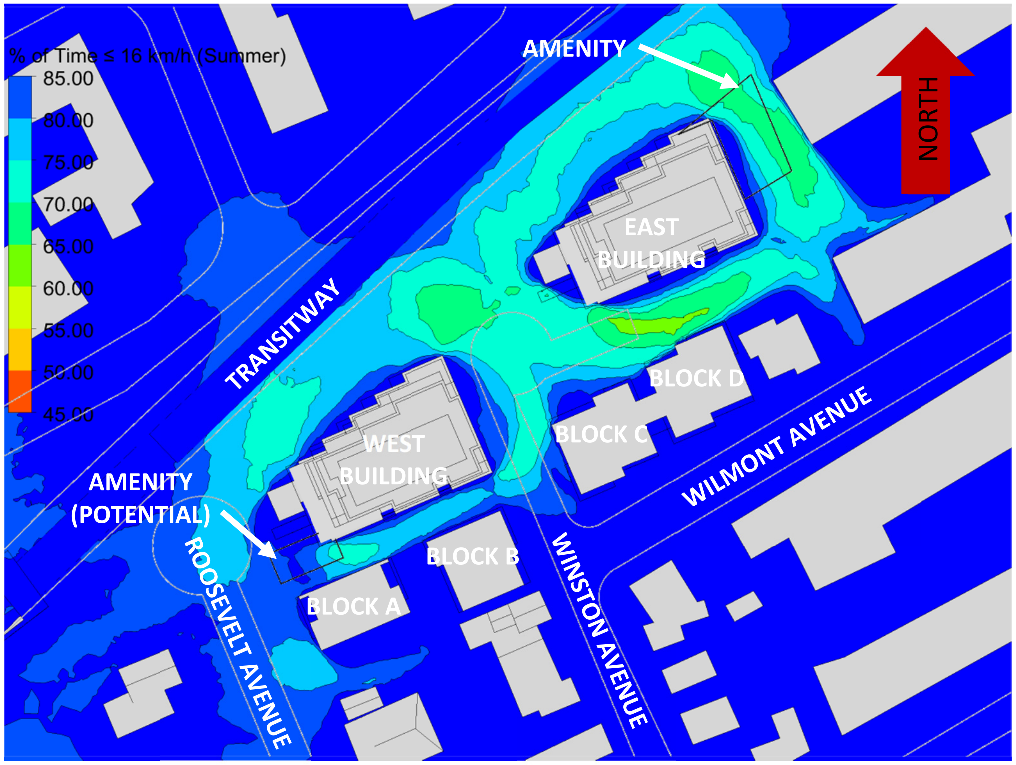


FIGURE 6A: SUMMER – PERCENTAGE OF TIME SUITABLE FOR SITTING, GRADE

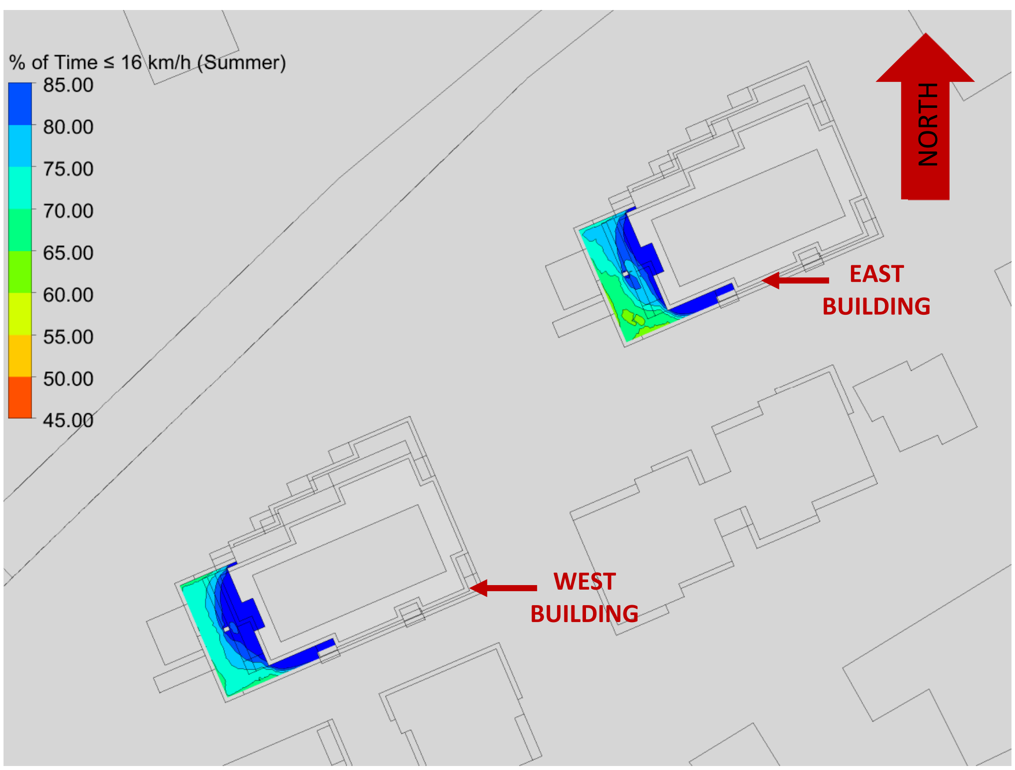


FIGURE 6B: SUMMER – PERCENTAGE OF TIME SUITABLE FOR SITTING, LEVEL 5 TERRACES

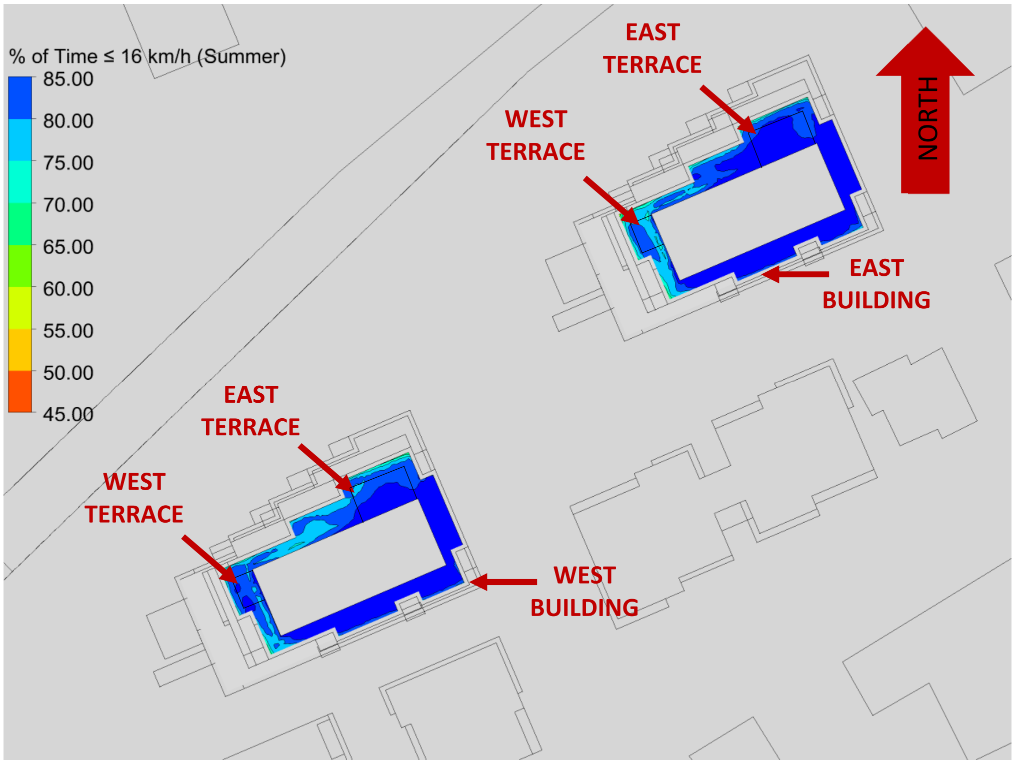
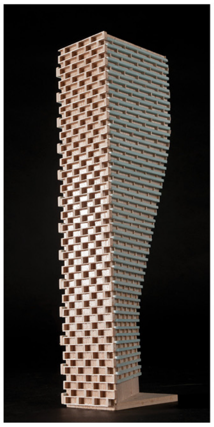
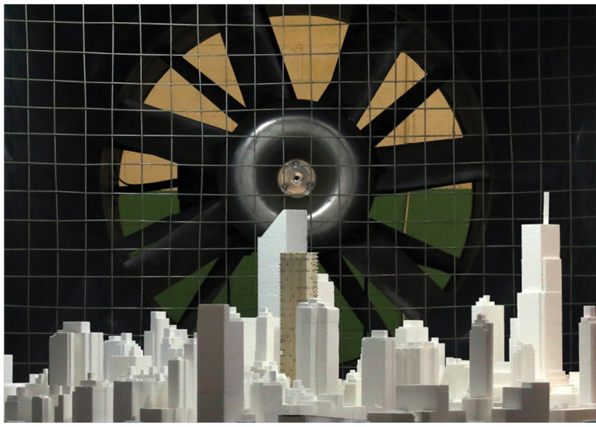


FIGURE 6C: SUMMER – PERCENTAGE OF TIME SUITABLE FOR SITTING, MPH LEVEL TERRACE



APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

The atmospheric boundary layer (ABL) is defined by the velocity and turbulence profiles according to industry standard practices. The mean wind profile can be represented, to a good approximation, by a power law relation, Equation (1), giving height above ground versus wind speed [1], [2].

$$U = U_g \left(\frac{Z}{Z_g}\right)^{\alpha} \qquad \text{Equation (1)}$$

where, $\boldsymbol{U}$ = mean wind speed, $\boldsymbol{U_g}$ = gradient wind speed, $\boldsymbol{Z}$ = height above ground, $\boldsymbol{Z_g}$ = depth of the boundary layer (gradient height), and α is the power law exponent.

For the model, U_g is set to 6.5 metres per second (m/s), which approximately corresponds to the 60% mean wind speed for Ottawa based on historical climate data and statistical analyses. When the results are normalized by this velocity, they are relatively insensitive to the selection of gradient wind speed.

Z_g is set to 540 m. The selection of gradient height is relatively unimportant, so long as it exceeds the building heights surrounding the subject site. The value has been selected to correspond to our physical wind tunnel reference value.

α is determined based on the upstream exposure of the far-field surroundings (i.e., the area that it not captured within the simulation model).

Table 1 presents the values of α used in this study, while Table 2 presents several reference values of α. When the upstream exposure of the far-field surroundings is a mixture of multiple types of terrain, the α values are a weighted average with terrain that is closer to the subject site given greater weight.

TABLE 1: UPSTREAM EXPOSURE (ALPHA VALUE) VS TRUE WIND DIRECTION

Wind Direction (° True)	Alpha (α) Value
0	0.20
49	0.24
74	0.25
103	0.23
167	0.25
197	0.25
217	0.25
237	0.18
262	0.19
282	0.20
302	0.20
324	0.20

TABLE 2: DEFINITION OF UPSTREAM EXPOSURE (ALPHA VALUE)

Upstream Exposure Type	α
Open Water	0.14-0.15
Open Field	0.16-0.19
Light Suburban	0.21-0.24
Heavy Suburban	0.24-0.27
Light Urban	0.28-0.30
Heavy Urban	0.31-0.33

The turbulence model in the computational fluid dynamics (CFD) simulations is a two-equation shear-stress transport (SST) model, and thus the ABL turbulence profile requires that two parameters be defined at the inlet of the domain. The turbulence profile is defined following the recommendations of the Architectural Institute of Japan for flat terrain [3].

$$I(Z) = \begin{cases} 0.1\left(\frac{Z}{Z_g}\right)^{-\alpha-0.05}, & Z > 10\text{ m} \\ 0.1\left(\frac{10}{Z_g}\right)^{-\alpha-0.05}, & Z \leq 10\text{ m} \end{cases}$$ Equation (2)

$$L_t(Z) = \begin{cases} 100\text{ m}\sqrt{\frac{Z}{30}}, & Z > 30\text{ m} \\ 100\text{ m}, & Z \leq 30\text{ m} \end{cases}$$ Equation (3)

where, $\boldsymbol{I}$ = turbulence intensity, $\boldsymbol{L_t}$ = turbulence length scale, $\boldsymbol{Z}$ = height above ground, and α is the power law exponent used for the velocity profile in Equation (1).

Boundary conditions on all other domain boundaries are defined as follows: the ground is a no-slip surface; the side walls of the domain have a symmetry boundary condition; the top of the domain has a specified shear, which maintains a constant wind speed at gradient height; and the outlet has a static pressure boundary condition.

REFERENCES

[1] P. Arya, "Chapter 10: Near-neutral Boundary Layers," in *Introduction to Micrometeorology*, San Diego, California, Academic Press, 2001.

[2] S. A. Hsu, E. A. Meindl and D. B. Gilhousen, "Determining the Power-Law WInd Profile Exponent under Near-neutral Stability Conditions at Sea," vol. 33, no. 6, 1994.

[3] Y. Tamura, H. Kawai, Y. Uematsu, K. Kondo and T. Okhuma, "Revision of AIJ Recommendations for Wind Loads on Buildings," in *The International Wind Engieering Symposium, IWES 2003*, Taiwan, 2003.