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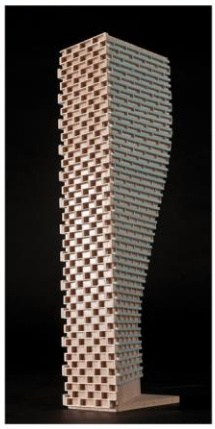
PEDESTRIAN LEVEL WIND STUDY

265 Centrum Boulevard
Ottawa, Ontario

Report: 23-023-PLW



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PREPARED FOR

Bayview Orleans Inc.
108 Chestnut Street
Toronto, ON M5G 1R3

PREPARED BY

Sunny Kang, B.A.S., Project Coordinator
David Huitema, M.Eng., Junior Wind Scientist
Justin Ferraro, P.Eng., Principal

127 WALGREEN ROAD, OTTAWA, ON, CANADA K0A 1L0 | 613 836 0934
GRADIENTWIND.COM

EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy concurrent Zoning By-law Amendment and Site Plan Control application requirements for the proposed multi-building development located at 265 Centrum Boulevard in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate pedestrian wind conditions within and surrounding the subject site, and to identify areas where conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where 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 (Section 5), illustrated in Figures 3A-15, and summarized as follows:

1) Most grade-level areas within and surrounding the subject site are predicted to experience conditions that are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, transit stops, walkways, surface parking, laneways, and the building access points serving the proposed development are considered acceptable. Exceptions are described as follows:

    a. Wind comfort conditions with the existing massing (that is, prior to the introduction of the proposed development) over the neighbouring areas of Cumberland Seniors Park and 22^{e} Régiment Park are predicted to be suitable for a mix of sitting and standing during the typical use period. Following the introduction of the proposed development, conditions during the typical use period are predicted to be suitable for standing.

    b. Conditions in the vicinity of the building access points serving the upper lobby of Tower A and along the southwest elevation of Tower B serving the indoor amenity spaces at the upper grade level are predicted to be suitable for standing during the summer and strolling throughout the remainder of the year.

- It is recommended that the noted building access points be recessed into the building façade by at least 2 m.

c. During the typical use period, conditions over the retail patio, outdoor amenity, and parkette are predicted to be suitable for sitting within the majority of their areas, with regions suitable for standing that are predicted to occur elsewhere. Conditions over the parkland dedication during the same period are predicted to be suitable for sitting to the west, strolling to the north, and for standing throughout the remainder of the area.

    - Depending on the programming of the retail patio, outdoor amenity, and parkette, the noted conditions may be considered acceptable. Specifically, if the windier areas will not accommodate seating or lounging activities, the noted conditions would be considered acceptable.

    - Comfort levels within the parkland dedication, and, if required by programming, within the retail patio, outdoor amenity, and parkette, may be improved by implementing landscaping elements around sensitive areas such as 1.6-m-tall wind screens and planters with coniferous plantings in dense arrangements, in combination with strategically placed seating with high-back benches and other local wind mitigation.

    - The extent of mitigation measures is dependent on the programming of the spaces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design progresses.

d. Owing to the channelling of prominent winds through the development and between the pinch point formed between Towers A and B, in combination with the downwash of higher-level winds incident on Towers A and B, wind conditions over the stair feature linking the lower and upper grade levels at the northeast corner of Tower A are predicted to be uncomfortable for 30% of the time during the winter season.

    - As the stair feature serves as a transition between the grade levels, pedestrian usage is expected to be short and transitory over this area. A freestanding

feature canopy over the stair feature would be beneficial as it would provide pedestrians with a means of protection from the elements, including wind. The canopy will be explored in collaboration with the design team as the design of the proposed development progresses.

2) Regarding the common amenity terraces serving the proposed development, wind conditions during the typical use period and recommendations regarding wind mitigation are described as follows:

   a. **Tower A, Level 7**. Wind comfort conditions are predicted to be suitable for sitting close to the tower elevations, and standing elsewhere, with an isolated region of strolling conditions to the southwest.

   b. **Tower B, Level 21**. Conditions are predicted to be suitable for sitting to the north and east, a mix of standing and strolling to the west, and a mix of standing, strolling, and walking to the northeast.

   c. **Tower C, Level 3**. Conditions are predicted to be suitable for sitting within the majority of the terrace, with conditions suitable for standing to the northeast.

   d. **Tower C, Level 4**. Wind comfort conditions are predicted to be suitable for sitting throughout the majority of the terrace, with sitting conditions along the tower elevations, strolling to the northwest, and standing elsewhere.

   e. Depending on programming, the conditions within the Level 3 amenity terrace serving Tower C may be considered acceptable. Specifically, if the northeast corner of the terrace will not accommodate seating or lounging activities, the noted conditions would be considered acceptable. If required by programming, the introduction of a 1.8-m-tall wind screen along the full perimeter of the terrace would be expected to improve comfort levels at the northeast corner.

   f. To improve conditions within the amenity terraces at Levels 4, 7, and 21, the implementation of tall wind screens, in place of standard height guards, are

recommended along their full perimeters, extending at least 2 m above the local walking surfaces for the amenity terraces serving Towers A and C, and at least 2.4 above the local walking surface for the amenity terrace serving Tower B. The perimeter wind screens are recommended to be considered in combination with mitigation inboard of the perimeters, which could take the form of 1.8-m-tall wind screens or similar architectural features, and canopies located above designated seating areas.

g. Additionally, canopies at the northeast and northwest corners of Tower C and at the southwest corner of Tower A, extending outward from the tower façades by at least 3 m are recommended to deflect downwash incident on the tower façades. The underside of the canopies should have a clear height not exceeding 4 m as measured from the walking surface of the terraces.

h. The extent of the mitigation measures is dependent on the programming of the terraces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses.

3) The foregoing statements and conclusions apply to common weather systems, during which no dangerous wind conditions, as defined in Section 4.4, are expected anywhere over the subject site. During extreme weather events, (for example, thunderstorms, tornadoes, and downbursts), pedestrian safety is the main concern. However, these events are generally short-lived and infrequent and there is often sufficient warning for pedestrians to take appropriate cover.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Bayview Orleans Inc. to undertake a pedestrian level wind (PLW) study to satisfy concurrent Zoning By-law Amendment and Site Plan Control application requirements for the proposed multi-building development located at 265 Centrum Boulevard in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate pedestrian wind conditions within and surrounding the subject site, and to identify areas where conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where 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 prepared by B+H Architects in March 2023, 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 265 Centrum Boulevard in Ottawa, situated at the north intersection of Centrum Boulevard and Prestone Drive on a parcel of land bounded by Centrum Boulevard to the south, Peter D. Clark Place and the Shenkman Arts Centre to the west, and Brisebois Crescent to the north and east. The proposed development comprises three towers: Tower A (35 storeys), Tower B (30 storeys), and Tower C (40 storeys), situated at the southwest corner, to the east, and at the northwest corner, respectively. The subject site comprises a downwards slope towards the north elevation of Brisebois Crescent; the ground floor of Tower C is at the level of Brisebois Crescent and the upper ground floors (Level 2) of Towers A and B are level with Centrum Boulevard. The three towers share three below-grade parking levels and are topped with mechanical penthouses (MPH).

Above the below-grade parking, the lower ground floor of Tower A includes townhouse units at the northwest corner, a residential main entrance to the north, bike storage shared with Tower B to the east, an office lobby at the southeast corner, a loading space to the west, and shared building support spaces throughout the remainder of the level. An outdoor stair feature to the upper ground floor is situated at

the northeast corner. Covered parking is provided along the south elevation of Tower A, and access to the shared underground parking levels is provided by a ramp near the southeast corner of the subject site. Access to the covered parking and parking ramp is provided by laneways from Brisebois Crescent along the east and west elevations of the subject site. The upper ground floor (Level 2) of Tower A includes townhouse units at the northwest corner, a management office, an indoor amenity, and an upper lobby at the northeast corner, retail spaces at the southeast and southwest corners, and a main office entrance at the centre of the south elevation. A retail patio is situated at the southwest corner and a parkland dedication is situated to the east. Levels 3-6 include residential units to the north and office space to the south. Level 7 is reserved for indoor amenities, and the building steps back from the south, west, and north elevations at this level to accommodate an outdoor amenity terrace, and from the east elevation at Level 8 to accommodate a green roof. Levels 8-35 are reserved for residential use.

Architectural Rendering, Southwest Perspective (Courtesy of B+H Architects)

The lower ground floor of Tower B includes a residential main entrance to the southwest, townhouse units to the west and north, a loading space to the east, and shared building support spaces throughout the remainder of the level. A parkette is situated to the north of Tower B. The upper ground floor includes townhouse units to the north and east, indoor amenities to the south, and a management office to the west. An outdoor amenity area is provided to the south. Levels 3-20 and 22-30 are reserved for residential use, while Level 21 includes an indoor amenity to the north and residential units throughout the remainder of the level. Level 21 is also served by an amenity terrace to the north. The building steps back from all elevations at Level 4 to accommodate a green roof and private terraces.

The ground floor of Tower C includes townhouse units to the north and east, a residential main entrance and indoor amenity to the south, a double storey loading space and bike storage room at the southwest corner, and shared building support spaces throughout the remainder of the level. Level 2 includes

townhouse units to the north and east and a management office to the south. Level 3 includes an indoor amenity at the northeast corner fronting an outdoor amenity terrace and residential units throughout the remainder of the level. Level 4 comprises an indoor amenity and the building steps back from all elevations to accommodate an outdoor amenity terrace. Levels 5-40 are reserved for residential use.

The near-field surroundings, defined as an area within 200-metres (m) of the subject site comprise a mix of low-rise suburban massing, surface parking, and green spaces in all directions, with mid-rise buildings to the northeast, east, southwest, and west, and green spaces along Highway 417 which extends from the west to the north-northeast approximately 110 m to the north-northwest. The far-field surroundings, defined as an area beyond the near-field but within a 2-kilometre (km) radius of the subject site, are characterized by low-rise massing in all compass directions, with isolated mid-rise buildings to the northeast and southwest. The Ottawa River flows from the northwest to the north approximately 1.5 km to the north-northwest.

Site plans for the proposed and existing massing scenarios are illustrated in Figures 1A and 1B, while Figures 2A-2H illustrate the computational models used to conduct the study. The existing massing scenario includes the existing massing and any future developments approved by the City of Ottawa.

3. OBJECTIVES

The principal objectives of this study are to (i) determine pedestrian level wind 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.

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

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 stronger wind speeds.

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 radius of 500 m. The process was performed for two context massing scenarios, as noted in Section 2.

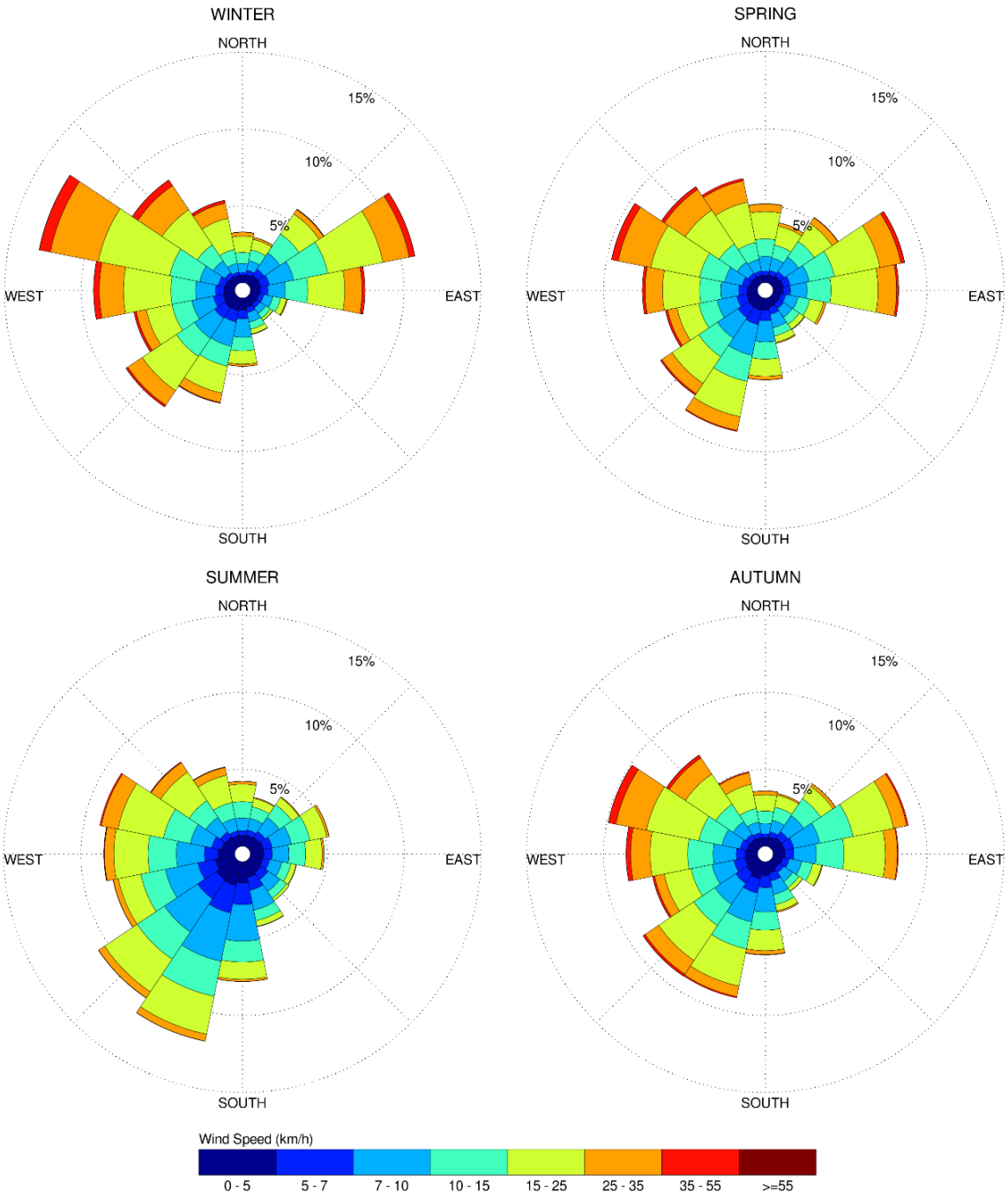
Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and the common amenity terraces serving the proposed development were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. 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 wind flow simulation technique are presented in Appendix A.

4.3 Historical Wind Speed and Direction Data

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.

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 prominent 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 prominence 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 Wind 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 (that is, 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 20% 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 BEAUFORT SCALE

Number	Description	Gust Wind Speed (km/h)	Description
2	Light Breeze	9-17	Wind felt on faces
3	Gentle Breeze	18-29	Leaves and small twigs in constant motion; wind extends light flags
4	Moderate Breeze	30-42	Wind raises dust and loose paper; small branches are moved
5	Fresh Breeze	43-57	Small trees in leaf begin to sway
6	Strong Breeze	58-74	Large branches in motion; Whistling heard in electrical wires; umbrellas used with difficulty
7	Moderate Gale	75-92	Whole trees in motion; inconvenient walking against wind
8	Gale	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 20% 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 (equivalent gust wind speed of approximately 16 km/h) were 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 (equivalent gust wind speed of approximately 32 km/h) at a location were exceeded for more than 20% of the time, walking or less vigorous activities would be considered uncomfortable. As 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 (that is, a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their typical windiest desired comfort classes are summarized on the following page. Depending on the programming of a space, the desired comfort class may differ from this table.

DESIRED PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES

Location Types	Desired Comfort Classes
Primary Building Entrance	Standing
Secondary Building Access Point	Walking
Public Sidewalk / Bicycle Path	Walking
Outdoor Amenity Space	Sitting / Standing
Café / Patio / Bench / Garden	Sitting / Standing
Transit Stop (Without Shelter)	Standing
Transit Stop (With Shelter)	Walking
Public Park / Plaza	Sitting / Standing
Garage / Service Entrance	Walking
Parking Lot	Walking
Vehicular Drop-Off Zone	Walking

5. RESULTS AND DISCUSSION

The following discussion of the predicted pedestrian wind conditions for the subject site is accompanied by Figures 3A-6B, illustrating wind conditions at grade level for the proposed and existing massing scenarios, and by Figures 8A-8D, 10A-10D, 12A-12D, and 14A-14D illustrating wind conditions over the common amenity terraces serving Tower A at Level 7, Tower B at Level 21, and Tower C at Levels 3 and 4. Conditions are presented as continuous contours of wind comfort throughout the subject site and correspond to the comfort classes presented in Section 4.4. Conditions suitable for sitting are represented by the colour blue, standing by green, strolling by yellow, and walking by orange; uncomfortable conditions are represented by the colour magenta.

Wind comfort conditions at grade level and over the noted common amenity terraces are also reported for the typical use period, which is defined as May to October, inclusive. Figures 7A, 7B, 9, 11, 13, and 15 illustrate comfort conditions consistent with the comfort classes in Section 4.4. The details of these conditions are summarized in the following pages for each area of interest.

5.1 Wind Comfort Conditions – Grade Level

Sidewalks and Existing Surface Parking Along Centrum Boulevard: Following the introduction of the proposed development, wind comfort conditions over the public sidewalks and existing surface parking along Centrum Boulevard are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for strolling, or better, during the autumn, a mix of standing and strolling during the spring, and a mix of standing, strolling, and walking during the winter. The noted conditions are considered acceptable.

Wind conditions over the noted areas along Centrum Boulevard with the existing massing are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, wind comfort conditions with the proposed development are nevertheless considered acceptable.

Sidewalks and Transit Stop Along Prestone Drive: Following the introduction of the proposed development, wind conditions over the public sidewalks and nearby transit stop along Prestone Drive are predicted to be suitable mostly for sitting during the summer, becoming suitable for a mix of sitting and standing during the autumn, and suitable for standing during the winter and spring. The noted conditions are considered acceptable.

Wind conditions over the noted areas along Prestone Drive with the existing massing are predicted to be suitable for sitting during the summer and autumn, becoming suitable a mix of sitting and standing during the winter and spring. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, the noted conditions are nevertheless considered acceptable.

Existing Surface Parking South of Subject Site: Following the introduction of the proposed development, conditions over the existing parking lot to the south of the subject site are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable mostly for strolling, or better, throughout the remainder of the year. The noted conditions are considered acceptable.

Wind conditions over the noted parking lot with the existing massing are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing throughout the remainder

of the year. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, wind comfort conditions are nevertheless considered acceptable.

Existing Laneway, Walkways, and Surface Parking West of Subject Site: Following the introduction of the proposed development, conditions over the existing laneway serving Peter D. Clark Place to the west of the subject site are predicted to be suitable mostly for standing during the summer and autumn, becoming suitable for a mix of standing and strolling during the winter and spring. Conditions over the existing parking lot and walkways serving Peter D. Clark Place are predicted to be suitable for sitting during the summer, becoming suitable for mostly a mix of sitting and standing throughout the remainder of the year. The noted conditions are considered acceptable.

Wind conditions over the noted areas with the existing massing are predicted to be suitable for sitting during the summer and autumn, becoming suitable for a mix of sitting and standing during the winter and spring. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, wind comfort conditions are nevertheless considered acceptable.

Sidewalks Along Brisebois Crescent: Following the introduction of the proposed development, conditions over the public sidewalks along Brisebois Crescent are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for a mostly mix of standing and strolling throughout the remainder of the year. The noted conditions are considered acceptable.

Wind conditions over the public sidewalks along Brisebois Crescent with the existing massing are predicted to be subtle for sitting during the summer, becoming suitable for standing, or better, during the autumn, and suitable for standing during the winter and spring. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, wind comfort conditions are nevertheless considered acceptable.

Cumberland Seniors Park and Royal 22^{e} Régiment Park: Following the introduction of the proposed development, conditions over the neighbouring areas of Cumberland Seniors Park and Royal 22^{e} Régiment Park to the north and northeast of the subject site, respectively, are predicted to be suitable for standing during the typical use period.

Wind conditions during the typical use period over the neighbouring areas of Cumberland Seniors Park and Royal 22^{e} Régiment Park with the existing massing are predicted to be suitable for a mix of sitting and standing.

Laneways and Surface Parking Within the Subject Site: Conditions over the laneway along the east elevation of the subject site are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for strolling, or better, throughout the remainder of the year, with an isolated region suitable for walking during the winter. Conditions over the laneway along the west elevation of the subject site are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for a mix of standing and strolling throughout the remainder of the year. Conditions over the internal laneways and lay-bys situated central to the subject site are predicted to be suitable for mostly standing during the summer, becoming suitable for a mix of standing and strolling during the autumn, and suitable for a mix of mostly strolling and walking during the winter and spring. The noted conditions are considered acceptable.

Central Stair Feature: Owing to the channelling of prominent winds through the development and between the pinch point formed between Towers A and B, in combination with the downwash of higher-level winds incident on Towers A and B, windy conditions are predicted over the stair feature linking the lower and upper grade levels at the northeast corner of Tower A. Conditions over the stair feature are predicted to be suitable for a mix of standing and strolling during the summer and a mix of strolling and standing during the autumn, with the windiest conditions predicted during the winter and spring, where a region of uncomfortable conditions is predicted over the stair feature. Specifically, during the winter season, conditions are predicted to be uncomfortable for 30% of the time. Notably, as the stair feature serves as a transition between the grade levels, pedestrian usage is expected to be short and transitory over this area.

A freestanding feature canopy over the stair feature would be beneficial as it would provide pedestrians with a means of protection from the elements, including wind. The canopy will be explored in collaboration with the design team as the design of the proposed development progresses.

Retail Patio, Parkland Dedication, Outdoor Amenity, and Parkette: Wind comfort conditions and recommendations regarding mitigation over the retail patio, parkland dedication, outdoor amenity, and parkette during the typical use period are described as follows:

- Conditions over the retail patio along the west elevation of Tower A are predicted to be suitable for sitting within the majority of the area, with regions suitable for standing along the south and west perimeters.

- Wind conditions over the parkland dedication along the east elevation of Tower A are predicted to be suitable for sitting to the west, strolling to the north, and standing throughout the remainder of the area.

- Conditions over the outdoor amenity along the south elevation of Tower B are predicted to be suitable for sitting within the majority of the area, with a region suitable for standing to the east.

- Wind conditions within the parkette to the north of Tower B are predicted to be suitable for sitting within the majority of the area, with conditions suitable for standing to the west and northeast.

- Depending on the programming of the spaces within the retail patio, outdoor amenity, and parkette, the noted conditions may be considered acceptable. Specifically, if the noted windier areas will not accommodate seating or lounging activities, the noted conditions would be considered acceptable.

- Comfort levels within the parkland dedication, and, if required by programming, within the retail patio, outdoor amenity, and parkette, may be improved by implementing landscaping elements around sensitive areas such as 1.6-m-tall wind screens and planters with coniferous plantings in dense arrangements, in combination with strategically placed seating with high-back benches and other local wind mitigation.

- The extent of mitigation measures is dependent on the programming of the spaces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses.

Building Access Points: Conditions in the vicinity of the building access point near the northeast corner of Tower A serving the upper lobby and in the vicinity of the indoor amenity access points along the southwest elevation of Tower B at the upper grade level are predicted to be suitable for standing during the summer, and strolling, or better, throughout the remainder of the year. To provide calmer conditions at the noted primary building entrances, it is recommended that the lobby entrance near the northeast corner of Tower A and the indoor amenity entrances along the southwest elevation of Tower B be recessed into the building façades by at least 2 m.

Conditions in the vicinity of the remaining building access points serving the proposed development are predicted to be suitable for standing, or better, throughout the year, with the exception of the secondary building access points at the southwest elevation of Tower B at the lower grade level, which are predicted to be suitable for strolling during the spring, autumn, and winter. The noted conditions are considered acceptable.

5.2 Wind Comfort Conditions – Common Amenity Terraces

The proposed development is served by several common amenity terraces. Wind comfort conditions during the typical use period and recommendations regarding mitigation are described as follows:

- **Tower A, Level 7:** As illustrated in Figure 9, wind comfort conditions within the amenity terrace serving Tower A at Level 7 are predicted to be suitable for sitting along to the tower elevations and standing throughout the remainder of the terrace. An isolated region with conditions suitable for strolling is predicted near the southwest corner of Tower A.

- **Tower B, Level 21**: As illustrated in Figure 11, conditions within the amenity terrace serving Tower B at Level 21 are predicted to be suitable for sitting to the north and east, standing to the northeast, and a mix of standing and strolling to the west and at the northeast corner. An isolated region suitable for walking is predicted at the northeast corner of the terrace.

- **Tower C, Level 3:** As illustrated in Figure 13, conditions within the amenity terrace serving Tower C at Level 3 are predicted to be suitable for sitting within the majority of the area, with conditions suitable for standing at the northeast corner.

- **Tower C, Level 4:** As illustrated in Figure 15, conditions within the amenity terrace serving Tower C at Level 4 are predicted to be suitable for throughout the majority of the terrace, with conditions suitable for standing and strolling along the terrace perimeter and near the northwest corner of the terrace, respectively.

- The windy conditions are attributable to the exposure of the noted terraces to prominent winds from the west, southwest, and easterly directions, in combination with downwash incident on Towers A and C.

- Depending on programming, the wind conditions within the amenity terrace serving Tower C at Level 3 may be considered acceptable. Specifically, if the northeast corner of the terrace will not accommodate seating or lounging activities, the noted conditions would be considered acceptable. If required by programming, the sitting conditions may be extended over the northeast corner with the introduction of a tall wind screen along the full perimeter of the terrace, rising at least 1.8 m above the local walking surface.

- To improve comfort levels within the remaining amenity terraces, it is recommended that tall wind screens, in place of standard height guards, be implemented along their full perimeters, rising at least 2 m and 2.4 m above the local walking surfaces for the amenity terraces serving Towers A and C and Tower B, respectively, in combination with mitigation inboard of the terrace perimeters. This inboard mitigation could take the form of 1.8-m-tall wind screens or clusters of coniferous trees located around sensitive areas, and canopies located above designated seating areas

- Additionally, conditions within the Level 7 and 4 amenity terraces serving Towers A and C could also be improved by introducing canopies at the northeast and northwest corners of Tower C and at the southwest corner of Tower A, extending outward from the tower façades by at least 3 m. The underside of the canopies should have a clear height not exceeding 4 m as measured from the walking surface of the terraces. These canopies are expected to deflect downwash incident on the west and south elevations of Tower A, and the east, north, and west elevations of Tower C.

- The extent of the mitigation measures is dependent on the programming of the terraces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses.

5.3 Wind Safety

Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no pedestrian areas within or surrounding the subject site are expected to experience conditions that could be considered dangerous, as defined in Section 4.4.

5.4 Applicability of Results

Pedestrian wind comfort and safety have been quantified for the specific configuration of existing and foreseeable construction around the subject site. Future changes (that is, 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 subject site would alter the wind profile approaching the subject site; and (ii) development in proximity to the subject site would cause changes to local flow patterns.

6. CONCLUSIONS AND RECOMMENDATIONS

A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-15. 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 numerous similar developments, the study concludes the following:

1) Most grade-level areas within and surrounding the subject site are predicted to experience conditions that are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, transit stops, walkways, surface parking, laneways, and the building access points serving the proposed development are considered acceptable. Exceptions are described as follows:

    a. Wind comfort conditions with the existing massing (that is, prior to the introduction of the proposed development) over the neighbouring areas of Cumberland Seniors Park and 22^{e} Régiment Park are predicted to be suitable for a mix of sitting and standing during the

typical use period. Following the introduction of the proposed development, conditions during the typical use period are predicted to be suitable for standing.

b. Conditions in the vicinity of the building access points serving the upper lobby of Tower A and along the southwest elevation of Tower B serving the indoor amenity spaces at the upper grade level are predicted to be suitable for standing during the summer and strolling throughout the remainder of the year.

    - It is recommended that the noted building access points be recessed into the building façade by at least 2 m.

c. During the typical use period, conditions over the retail patio, outdoor amenity, and parkette are predicted to be suitable for sitting within the majority of their areas, with regions suitable for standing that are predicted to occur elsewhere. Conditions over the parkland dedication during the same period are predicted to be suitable for sitting to the west, strolling to the north, and for standing throughout the remainder of the area.

    - Depending on the programming of the retail patio, outdoor amenity, and parkette, the noted conditions may be considered acceptable. Specifically, if the windier areas will not accommodate seating or lounging activities, the noted conditions would be considered acceptable.

    - Comfort levels within the parkland dedication, and, if required by programming, within the retail patio, outdoor amenity, and parkette, may be improved by implementing landscaping elements around sensitive areas such as 1.6-m-tall wind screens and planters with coniferous plantings in dense arrangements, in combination with strategically placed seating with high-back benches and other local wind mitigation.

    - The extent of mitigation measures is dependent on the programming of the spaces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design progresses.

d. Owing to the channelling of prominent winds through the development and between the pinch point formed between Towers A and B, in combination with the downwash of higher-level winds incident on Towers A and B, wind conditions over the stair feature linking the lower and upper grade levels at the northeast corner of Tower A are predicted to be uncomfortable for 30% of the time during the winter season.

    - As the stair feature serves as a transition between the grade levels, pedestrian usage is expected to be short and transitory over this area. A freestanding feature canopy over the stair feature would be beneficial as it would provide pedestrians with a means of protection from the elements, including wind. The canopy will be explored in collaboration with the design team as the design of the proposed development progresses.

2) Regarding the common amenity terraces serving the proposed development, wind conditions during the typical use period and recommendations regarding wind mitigation are described as follows:

    a. **Tower A, Level 7**. Wind comfort conditions are predicted to be suitable for sitting close to the tower elevations, and standing elsewhere, with an isolated region of strolling conditions to the southwest.

    b. **Tower B, Level 21**. Conditions are predicted to be suitable for sitting to the north and east, a mix of standing and strolling to the west, and a mix of standing, strolling, and walking to the northeast.

    c. **Tower C, Level 3**. Conditions are predicted to be suitable for sitting within the majority of the terrace, with conditions suitable for standing to the northeast.

    d. **Tower C, Level 4**. Wind comfort conditions are predicted to be suitable for sitting throughout the majority of the terrace, with sitting conditions along the tower elevations, strolling to the northwest, and standing elsewhere.

e. Depending on programming, the conditions within the Level 3 amenity terrace serving Tower C may be considered acceptable. Specifically, if the northeast corner of the terrace will not accommodate seating or lounging activities, the noted conditions would be considered acceptable. If required by programming, the introduction of a 1.8-m-tall wind screen along the full perimeter of the terrace would be expected to improve comfort levels at the northeast corner.

f. To improve conditions within the amenity terraces at Levels 4, 7, and 21, the implementation of tall wind screens, in place of standard height guards, are recommended along their full perimeters, extending at least 2 m above the local walking surfaces for the amenity terraces serving Towers A and C, and at least 2.4 above the local walking surface for the amenity terrace serving Tower B. The perimeter wind screens are recommended to be considered in combination with mitigation inboard of the perimeters, which could take the form of 1.8-m-tall wind screens or similar architectural features, and canopies located above designated seating areas.

g. Additionally, canopies at the northeast and northwest corners of Tower C and at the southwest corner of Tower A, extending outward from the tower façades by at least 3 m, are recommended to deflect downwash incident on the tower façades. The underside of the canopies should have a clear height not exceeding 4 m as measured from the walking surface of the terraces.

h. The extent of the mitigation measures is dependent on the programming of the terraces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses.

3) The foregoing statements and conclusions apply to common weather systems, during which no dangerous wind conditions, as defined in Section 4.4, are expected anywhere over the subject site. During extreme weather events, (for example, thunderstorms, tornadoes, and downbursts), pedestrian safety is the main concern. However, these events are generally short-lived and infrequent and there is often sufficient warning for pedestrians to take appropriate cover.

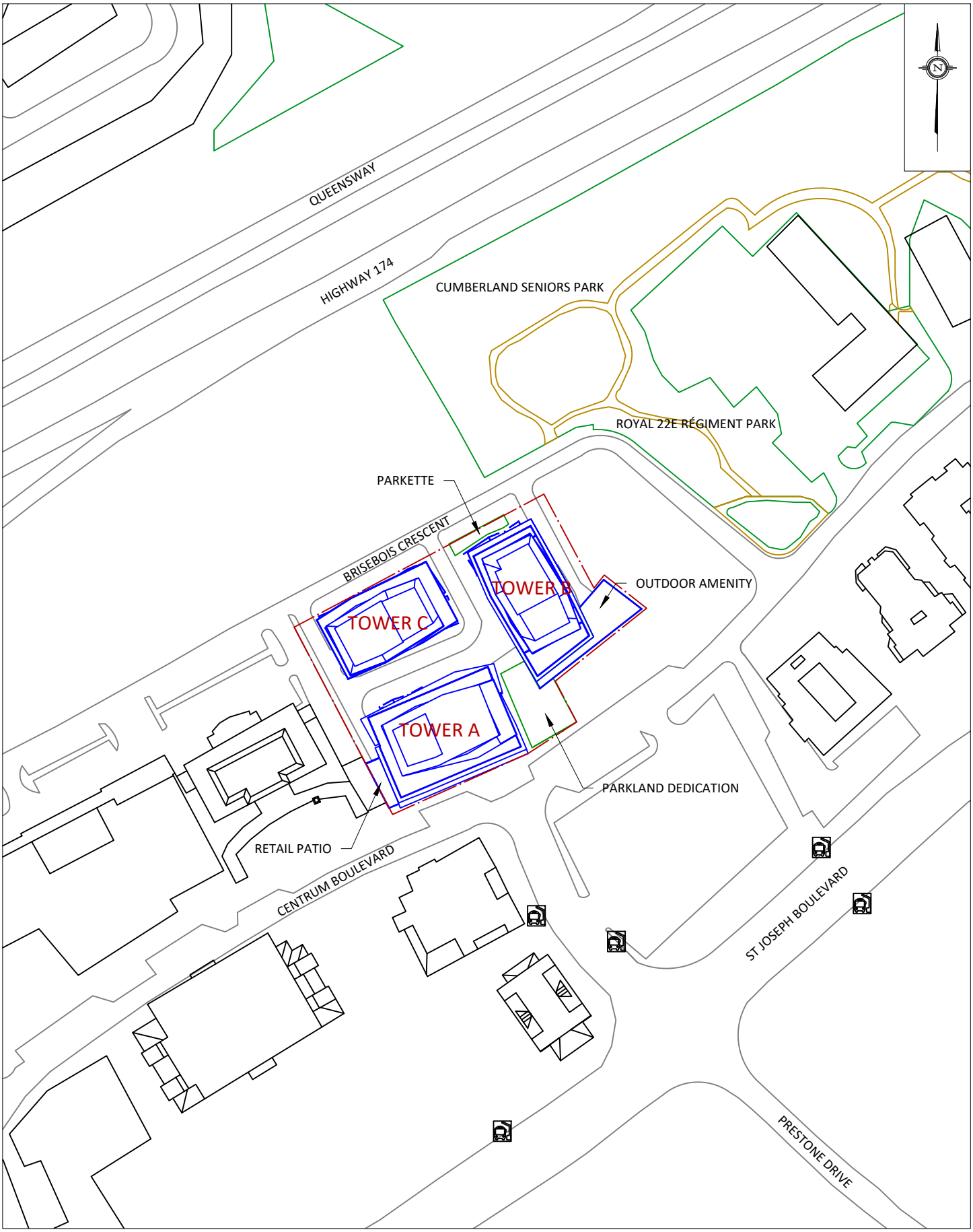
Sincerely,

Gradient Wind Engineering Inc.

David Huitema, M.Eng.
Junior Wind Scientist

Justin Ferraro, P.Eng.
Principal

Sunny Kang, B.A.S.
Project Coordinator



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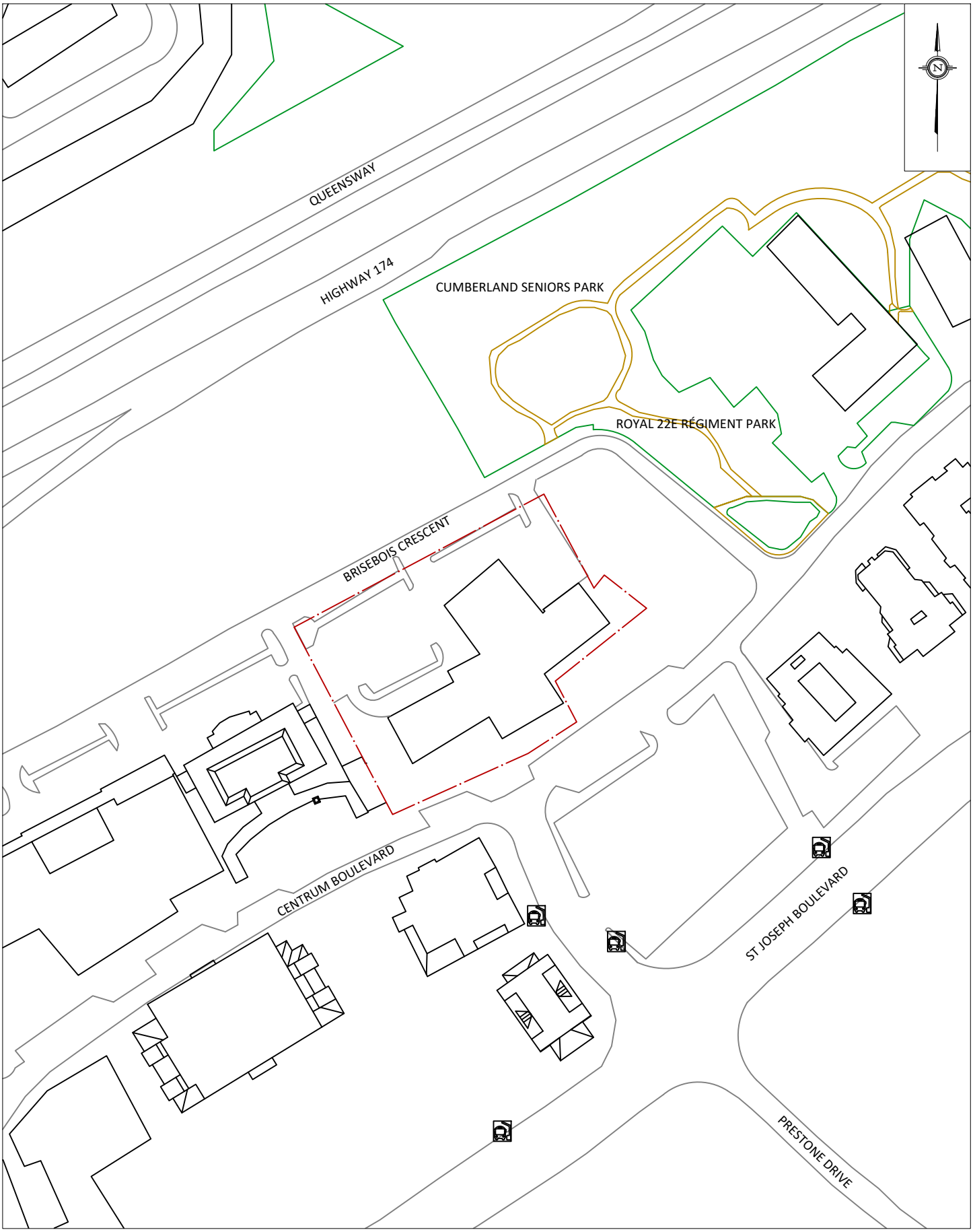
PROJECT	265 CENTRUM BOULEVARD, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:2000
DRAWING NO.	23-023-PLW-1A
DATE	MARCH 29, 2023
DRAWN BY	A.K.
DESCRIPTION	FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT



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PROJECT	265 CENTRUM BOULEVARD, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:2000
DRAWING NO.	23-023-PLW-1B
DATE	MARCH 29, 2023
DRAWN BY	A.K.

DESCRIPTION

FIGURE 1B:
EXISTING SITE PLAN AND SURROUNDING CONTEXT

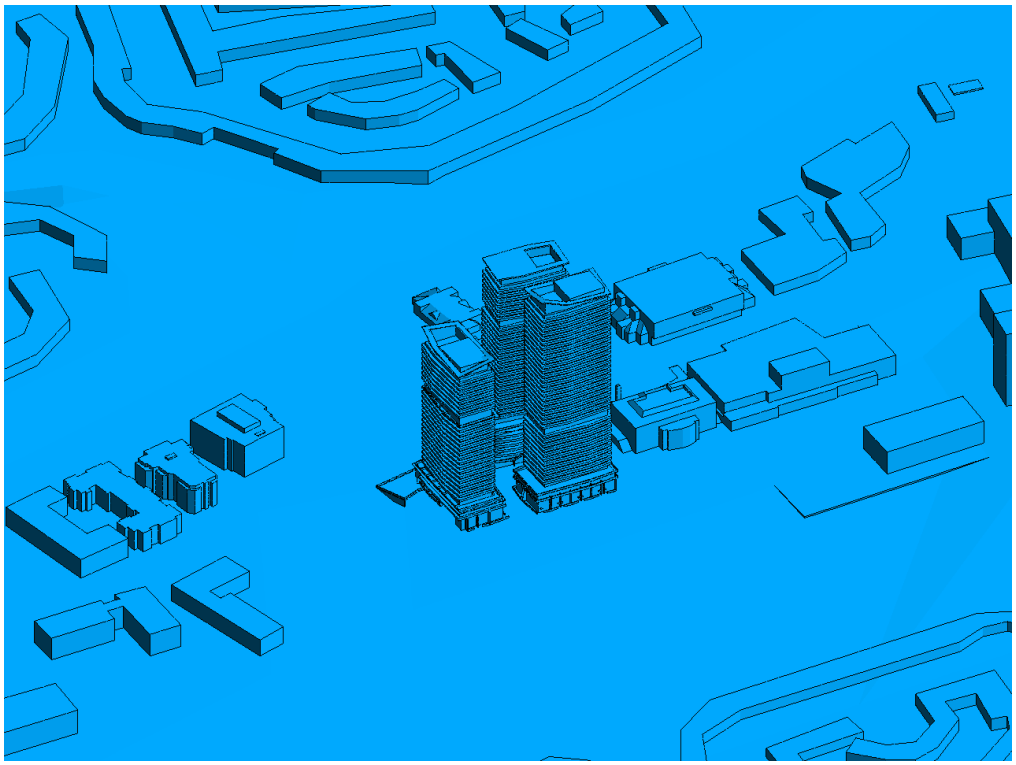


FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTH PERSPECTIVE

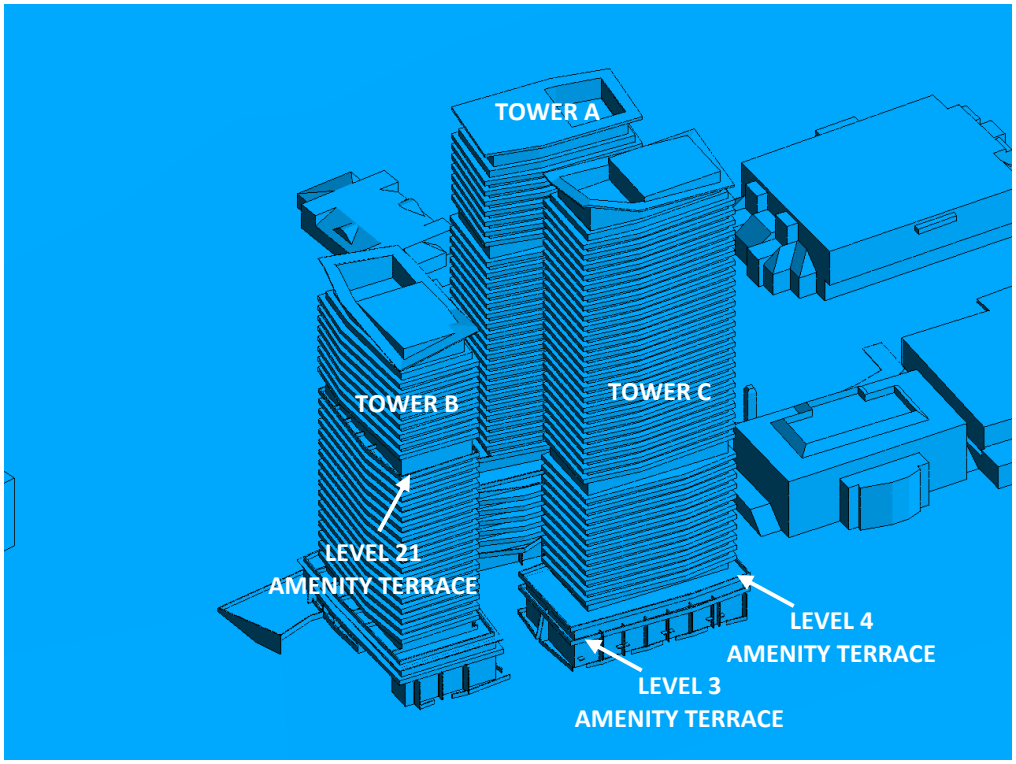


FIGURE 2B: CLOSE UP OF FIGURE 2A

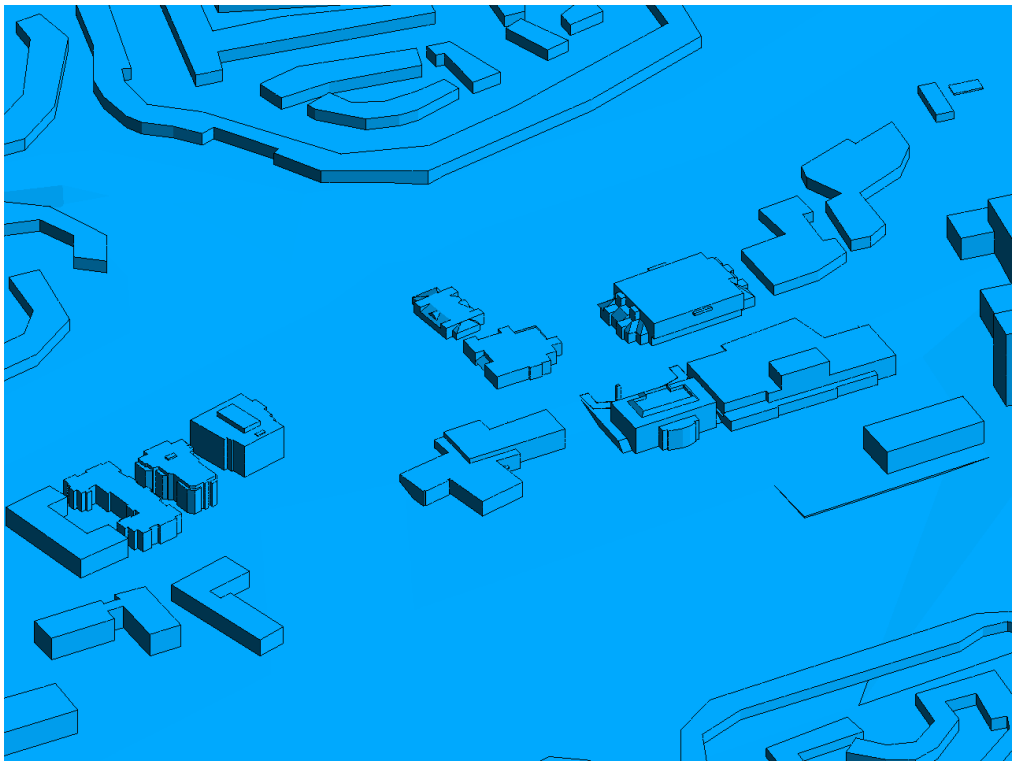


FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, NORTH PERSPECTIVE

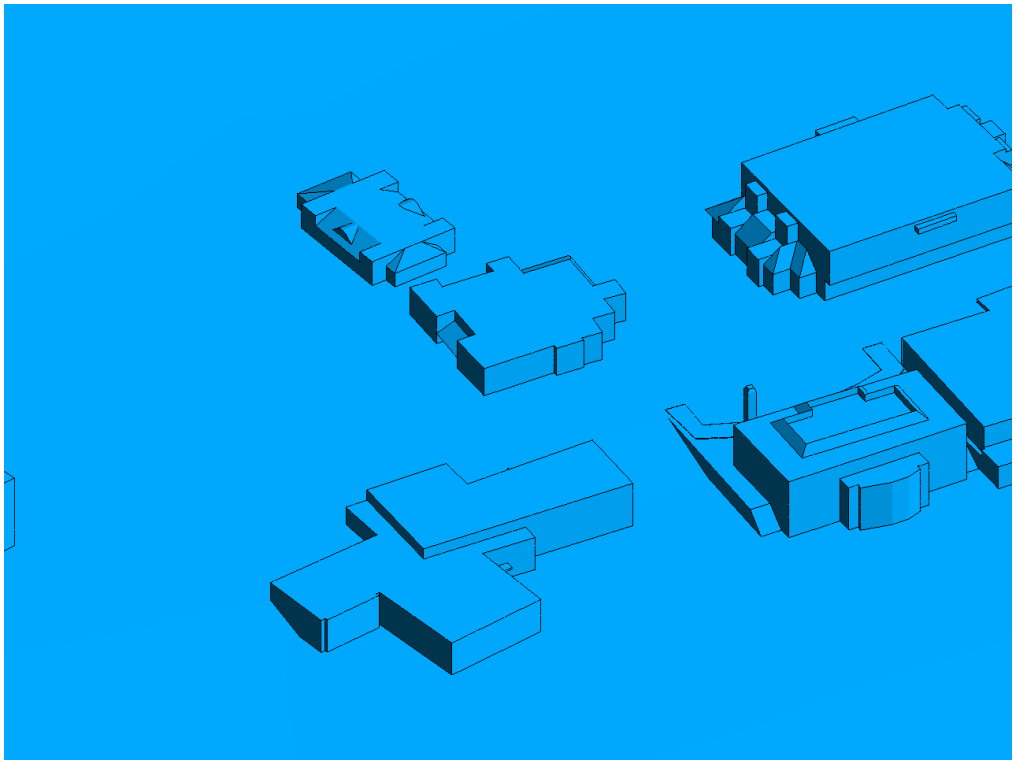


FIGURE 2D: CLOSE UP OF FIGURE 2C

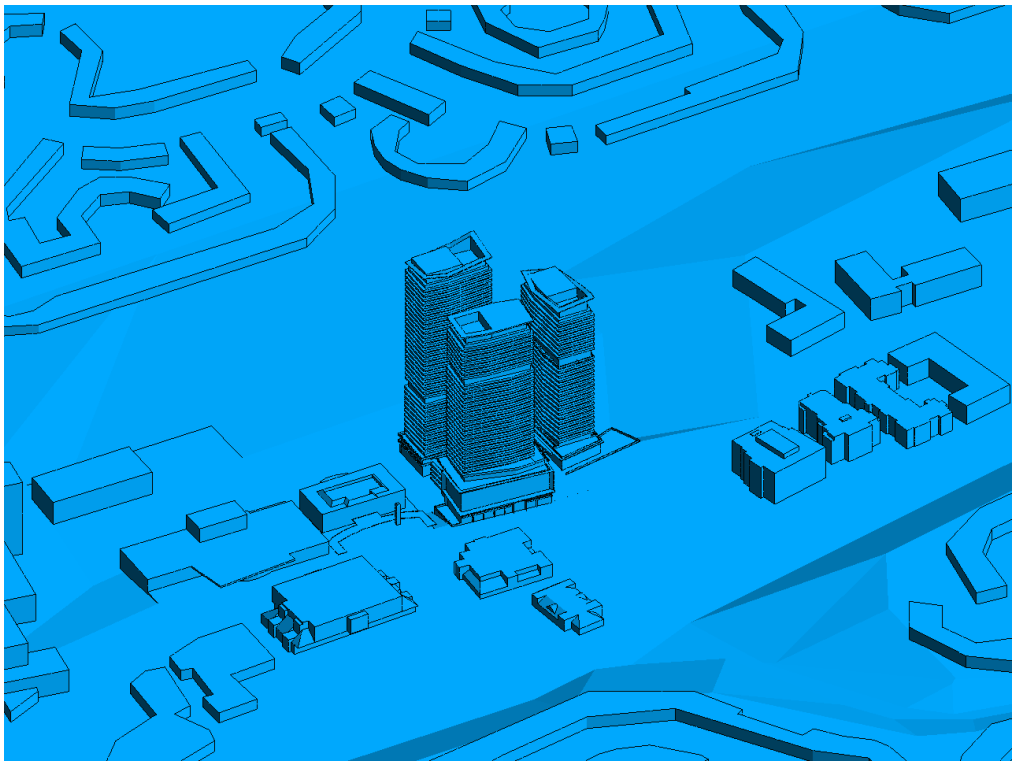


FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTH PERSPECTIVE

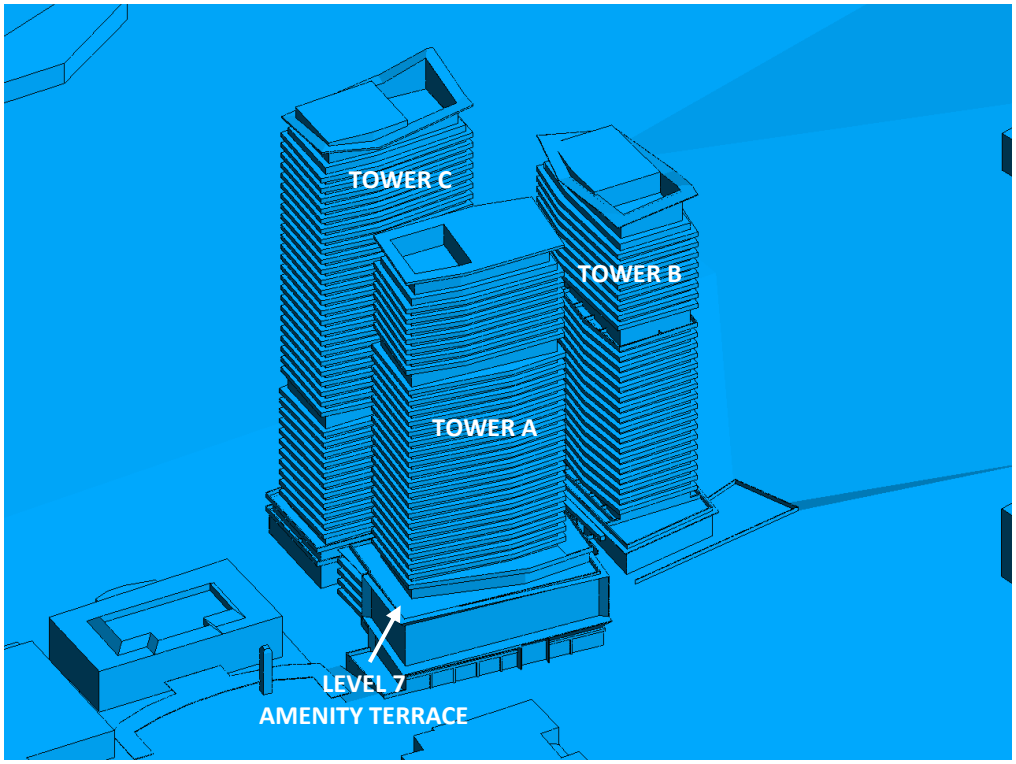


FIGURE 2F: CLOSE UP OF FIGURE 2E

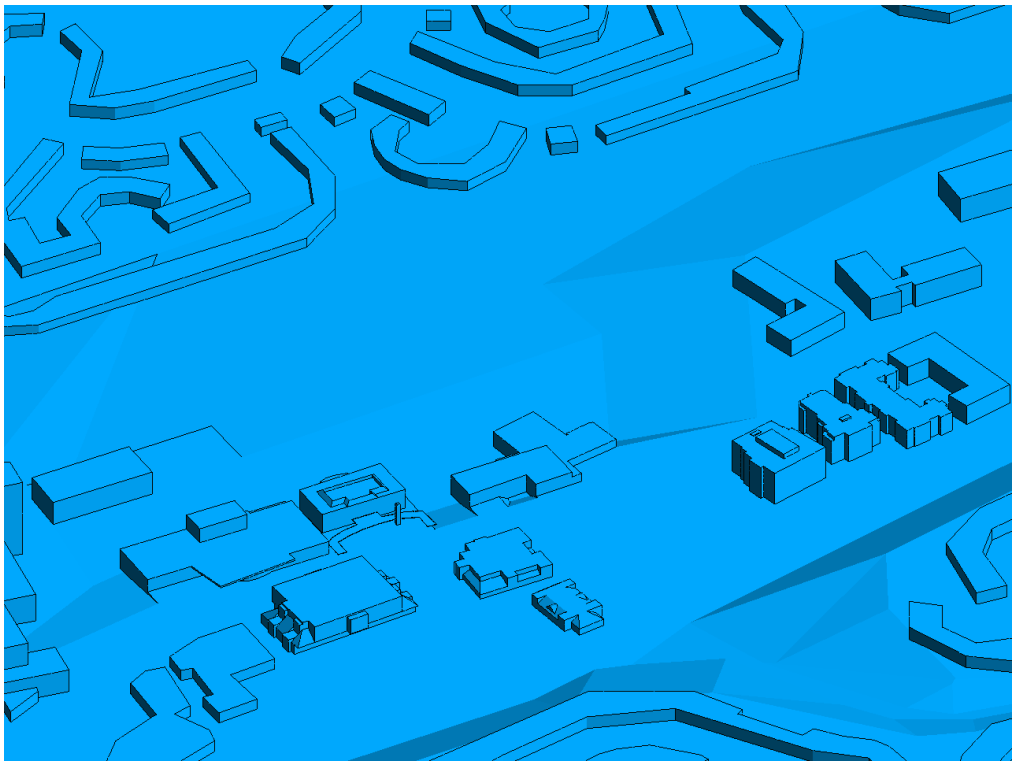


FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTH PERSPECTIVE

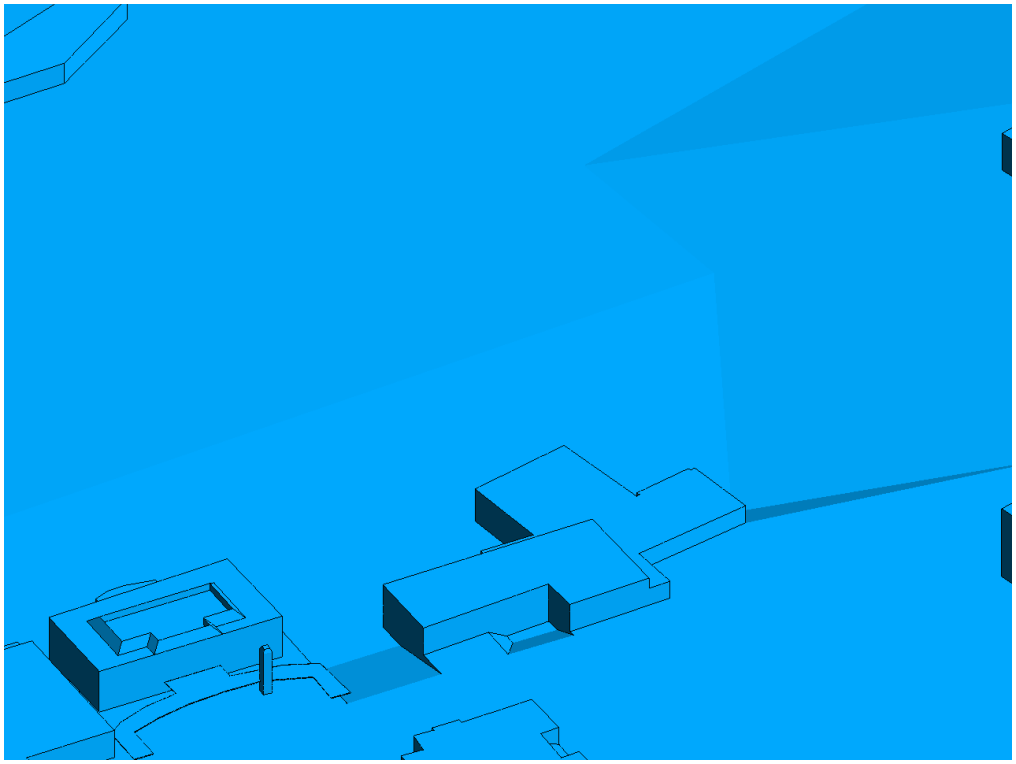


FIGURE 2H: CLOSE UP OF FIGURE 2G

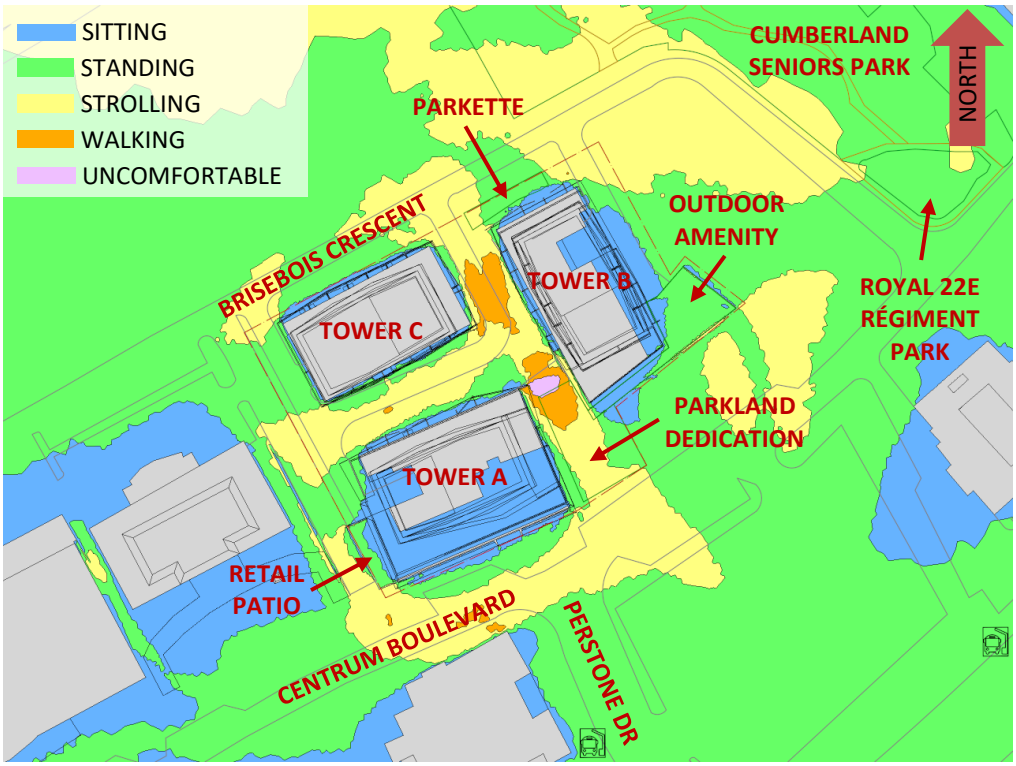


FIGURE 3A: SPRING – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

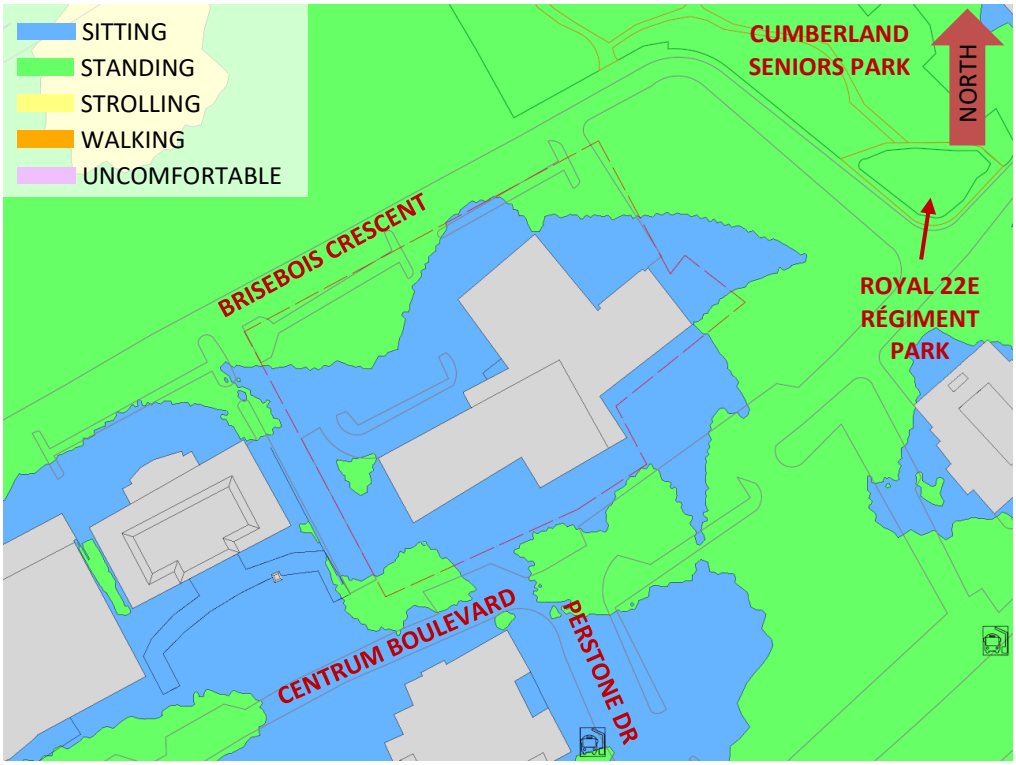


FIGURE 3B: SPRING – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

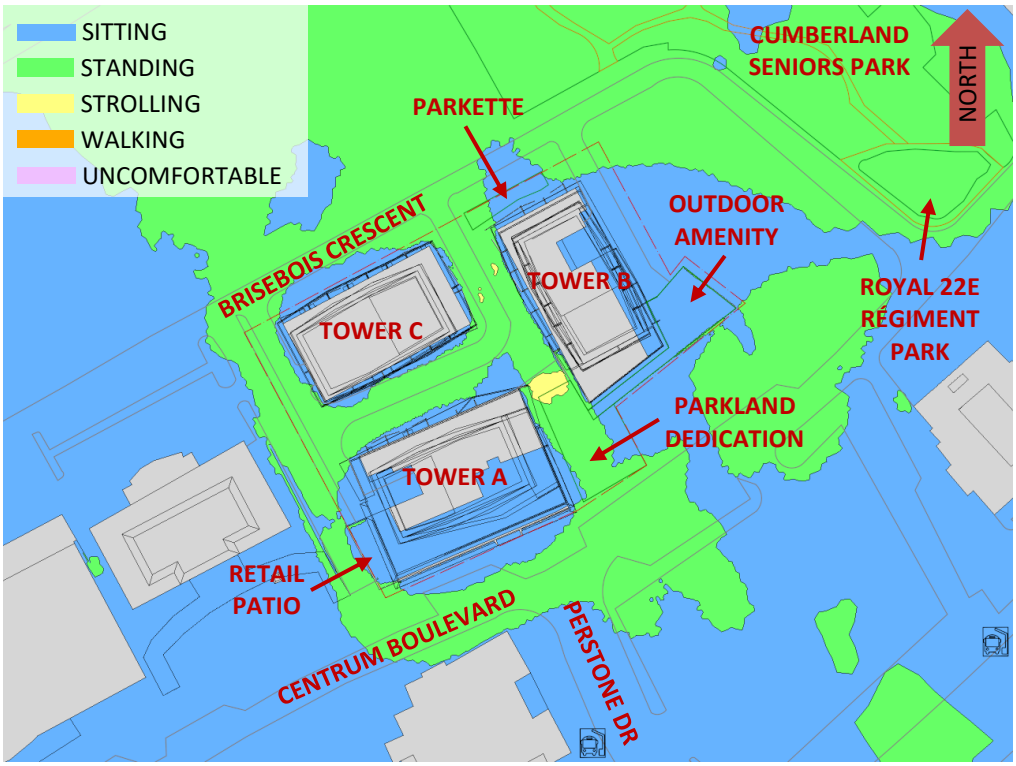


FIGURE 4A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

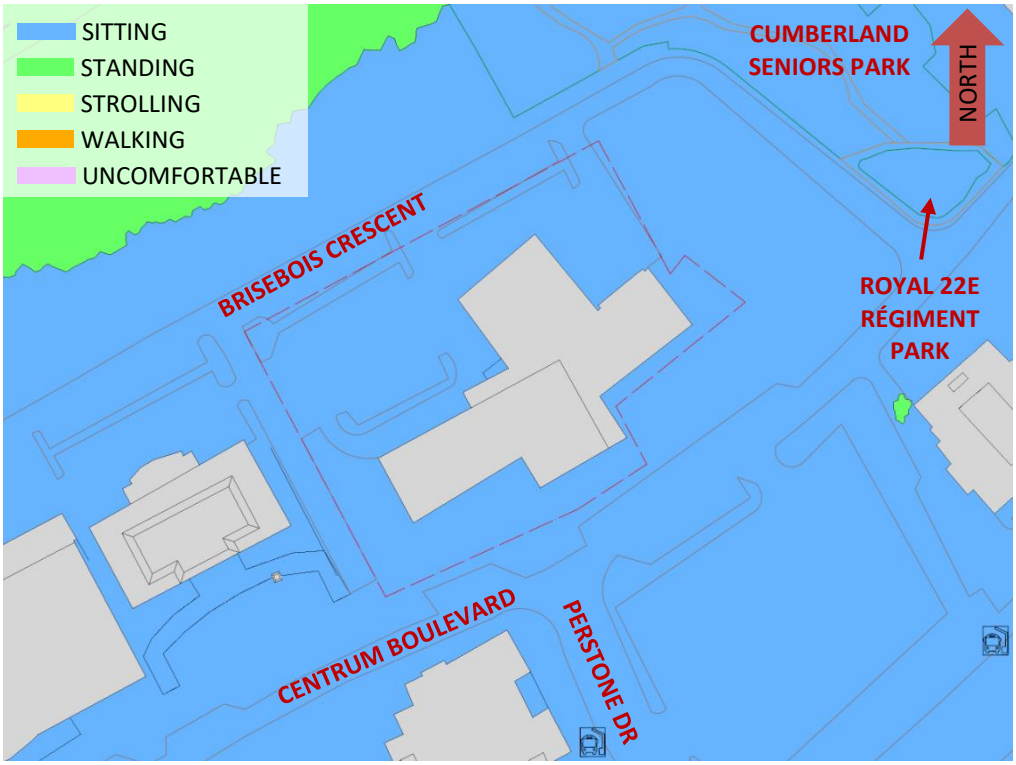


FIGURE 4B: SUMMER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

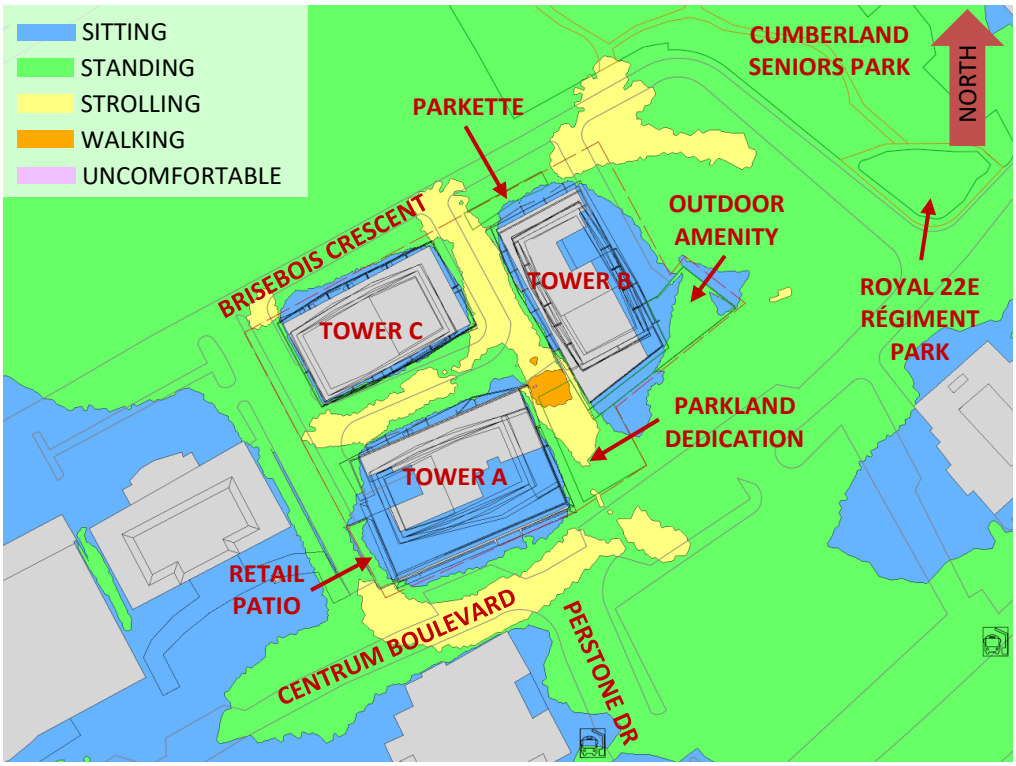


FIGURE 5A: AUTUMN – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

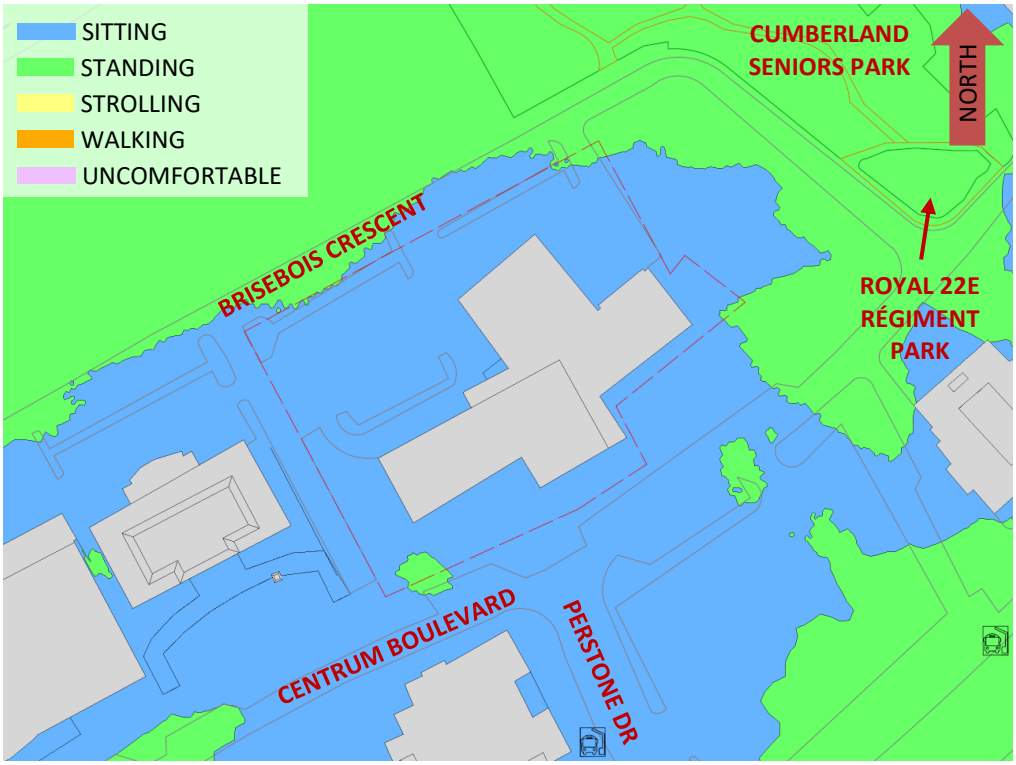


FIGURE 5B: AUTUMN – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

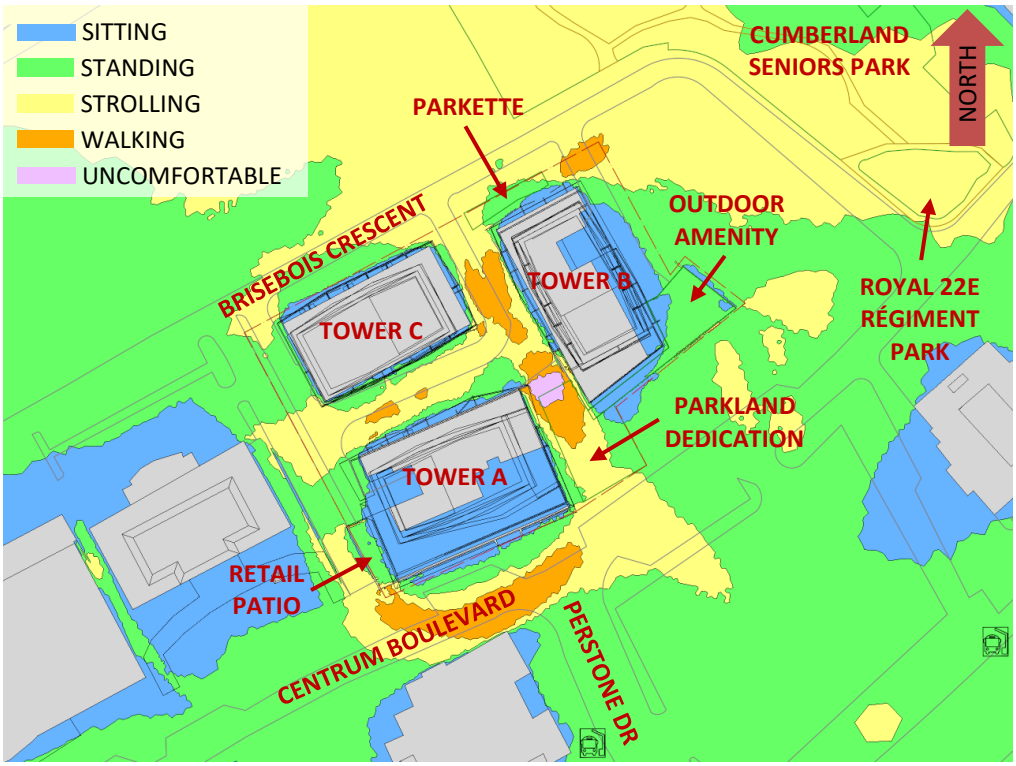


FIGURE 6A: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

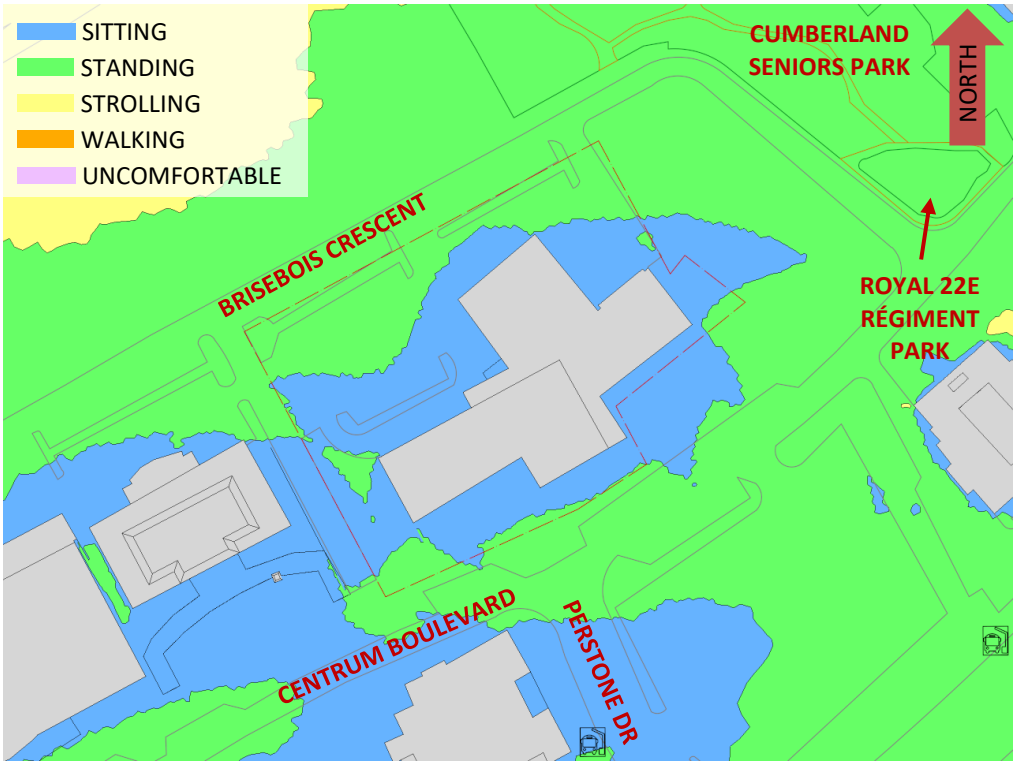


FIGURE 6B: WINTER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

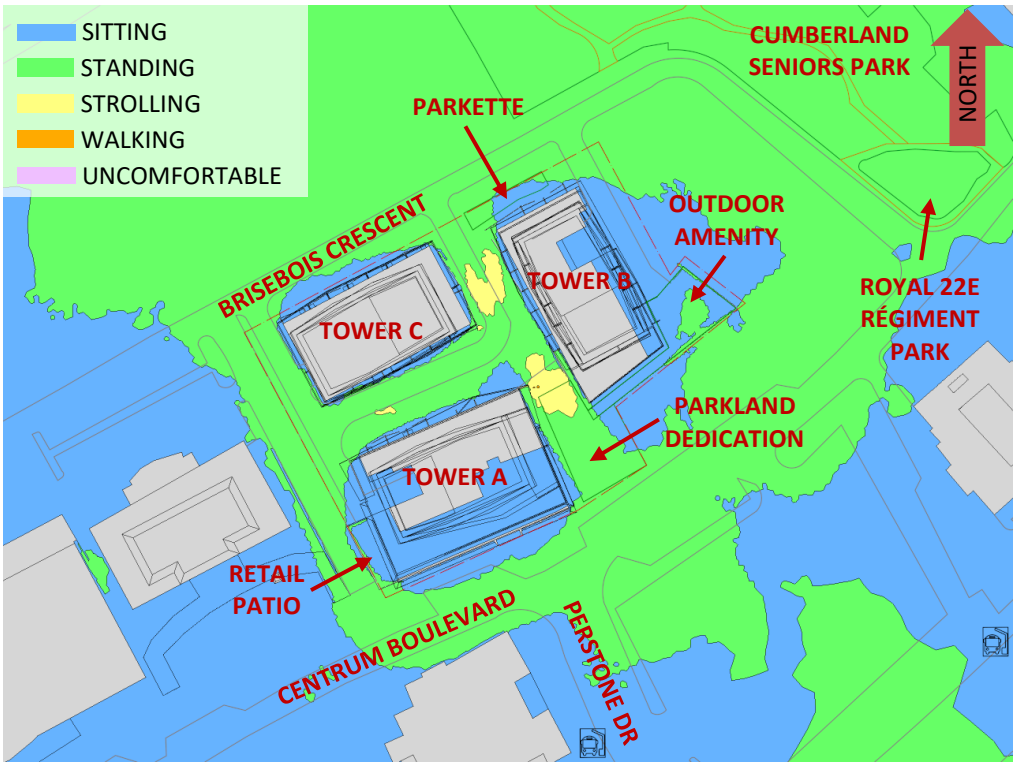


FIGURE 7A: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

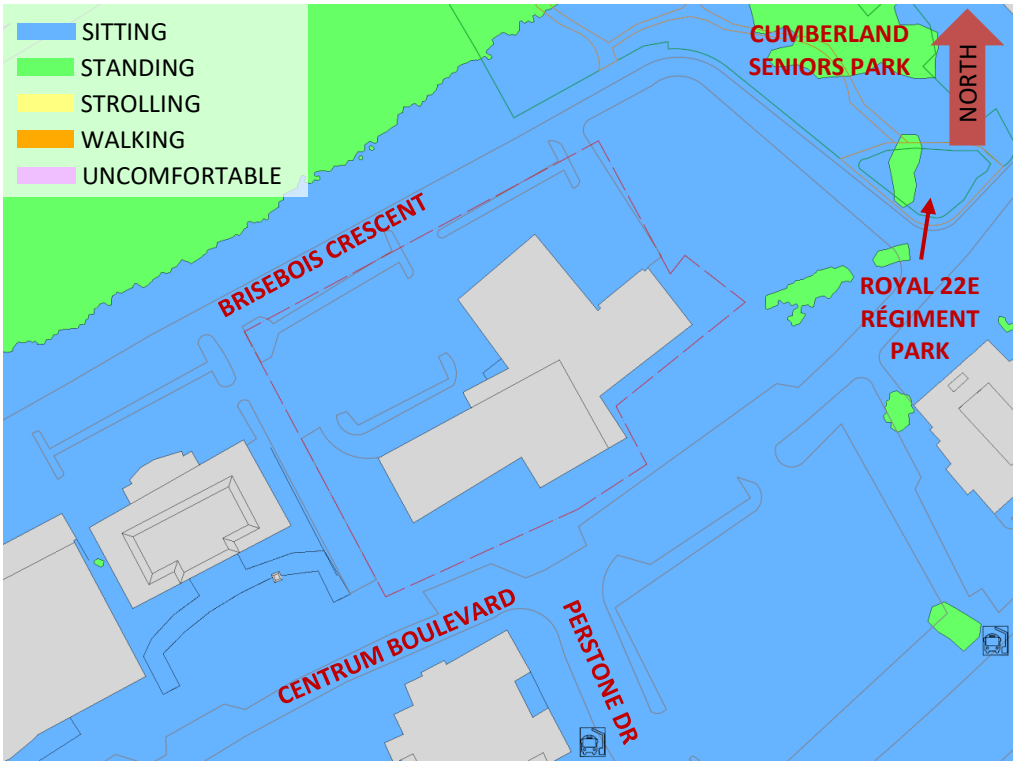


FIGURE 7B: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

FIGURE 8A: SPRING – WIND COMFORT, LEVEL 7 COMMON AMENITY TERRACE

FIGURE 8B: SUMMER – WIND COMFORT, LEVEL 7 COMMON AMENITY TERRACE

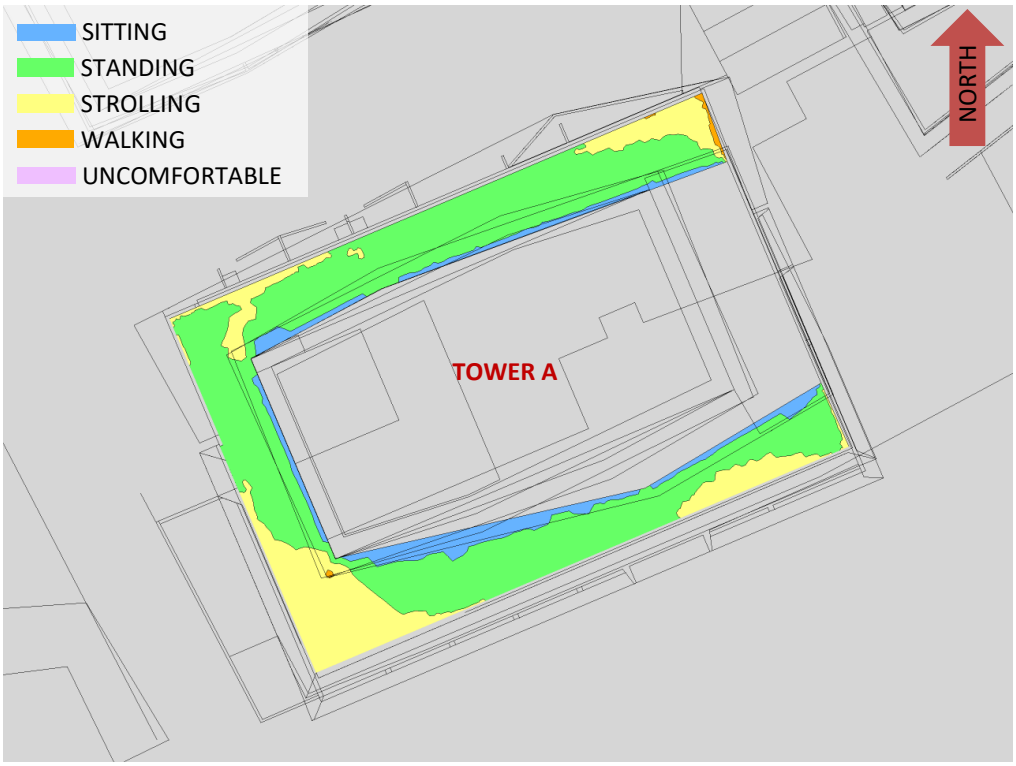


FIGURE 8C: AUTUMN – WIND COMFORT, LEVEL 7 COMMON AMENITY TERRACE

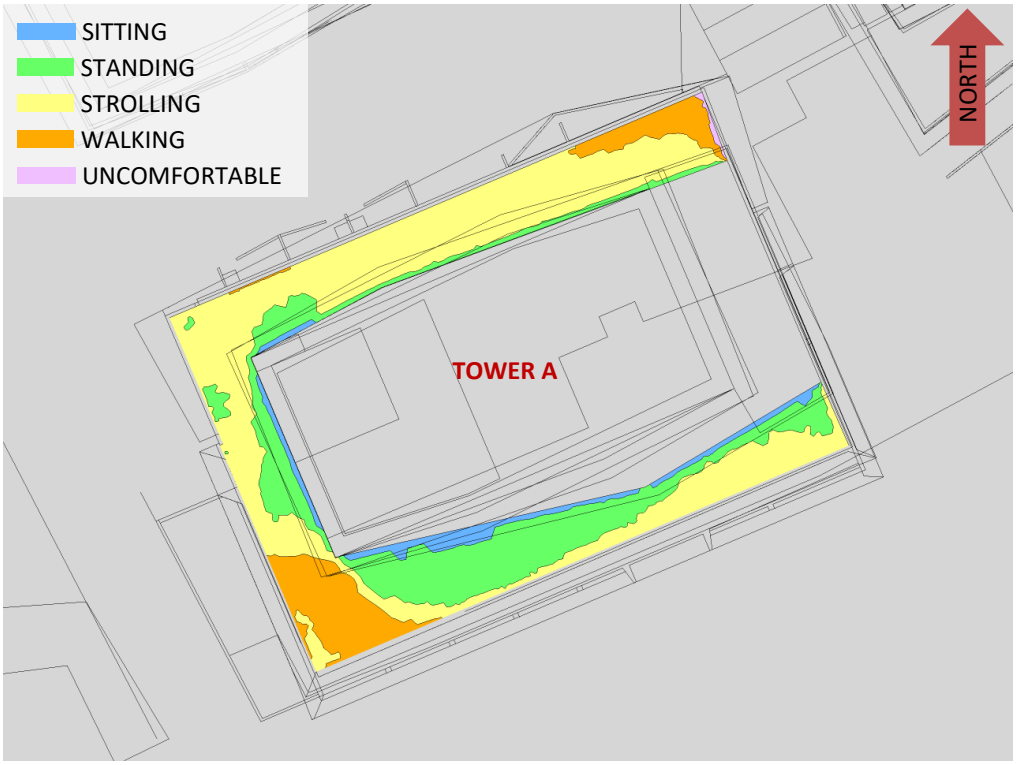


FIGURE 8D: WINTER – WIND COMFORT, LEVEL 7 COMMON AMENITY TERRACE

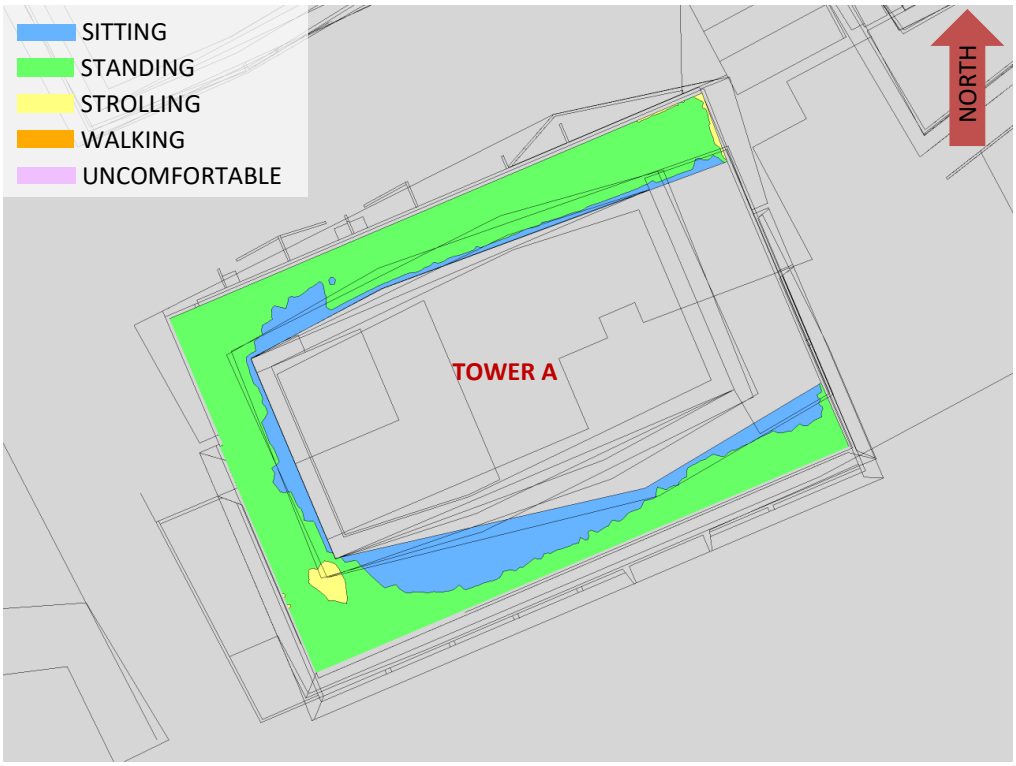


FIGURE 9: TYPICAL USE PERIOD – WIND COMFORT, LEVEL 7 COMMON AMENITY TERRACE

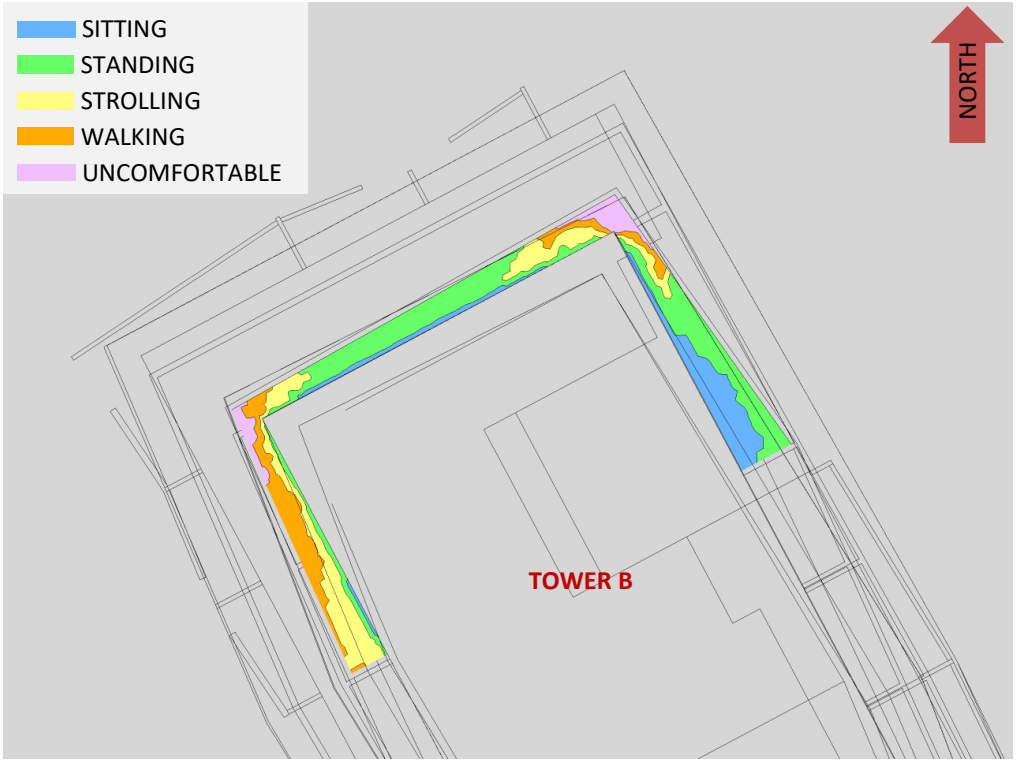


FIGURE 10A: SPRING – WIND COMFORT, LEVEL 21 COMMON AMENITY TERRACE

FIGURE 10B: SUMMER – WIND COMFORT, LEVEL 21 COMMON AMENITY TERRACE

FIGURE 10C: AUTUMN – WIND COMFORT, LEVEL 21 COMMON AMENITY TERRACE

FIGURE 10D: WINTER – WIND COMFORT, LEVEL 21 COMMON AMENITY TERRACE

FIGURE 11: TYPICAL USE PERIOD – WIND COMFORT, LEVEL 21 COMMON AMENITY TERRACE

FIGURE 12A: SPRING – WIND COMFORT, LEVEL 3 COMMON AMENITY TERRACE

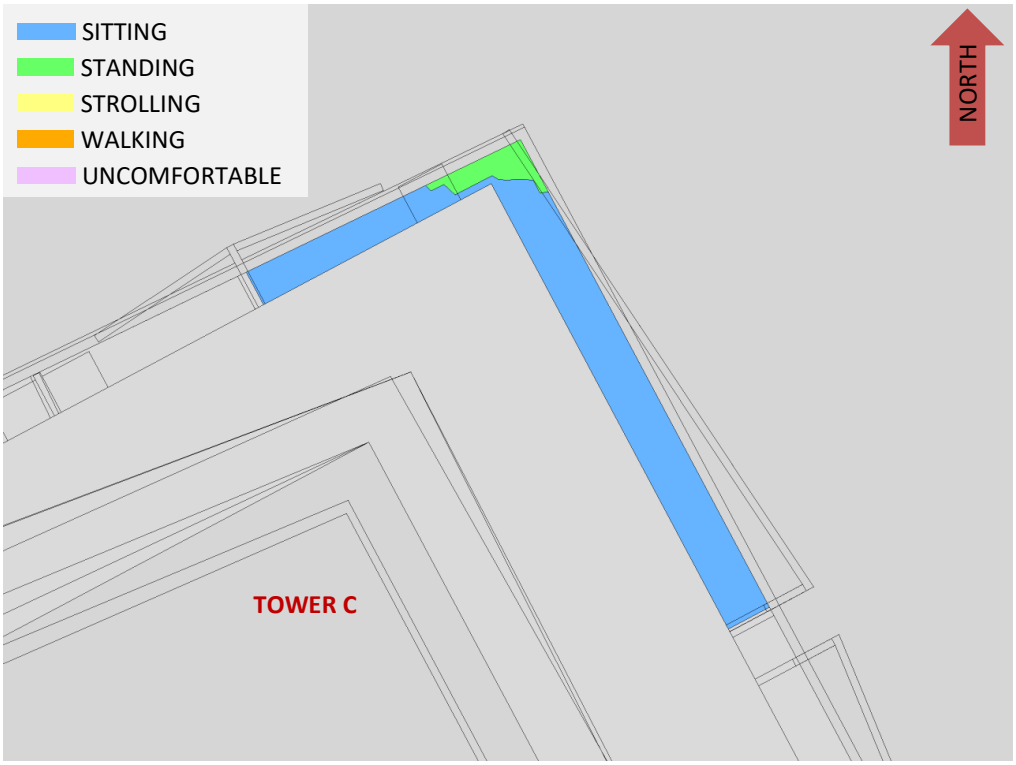


FIGURE 12B: SUMMER – WIND COMFORT, LEVEL 3 COMMON AMENITY TERRACE

FIGURE 12C: AUTUMN – WIND COMFORT, LEVEL 3 COMMON AMENITY TERRACE

FIGURE 12D: WINTER – WIND COMFORT, LEVEL 3 COMMON AMENITY TERRACE

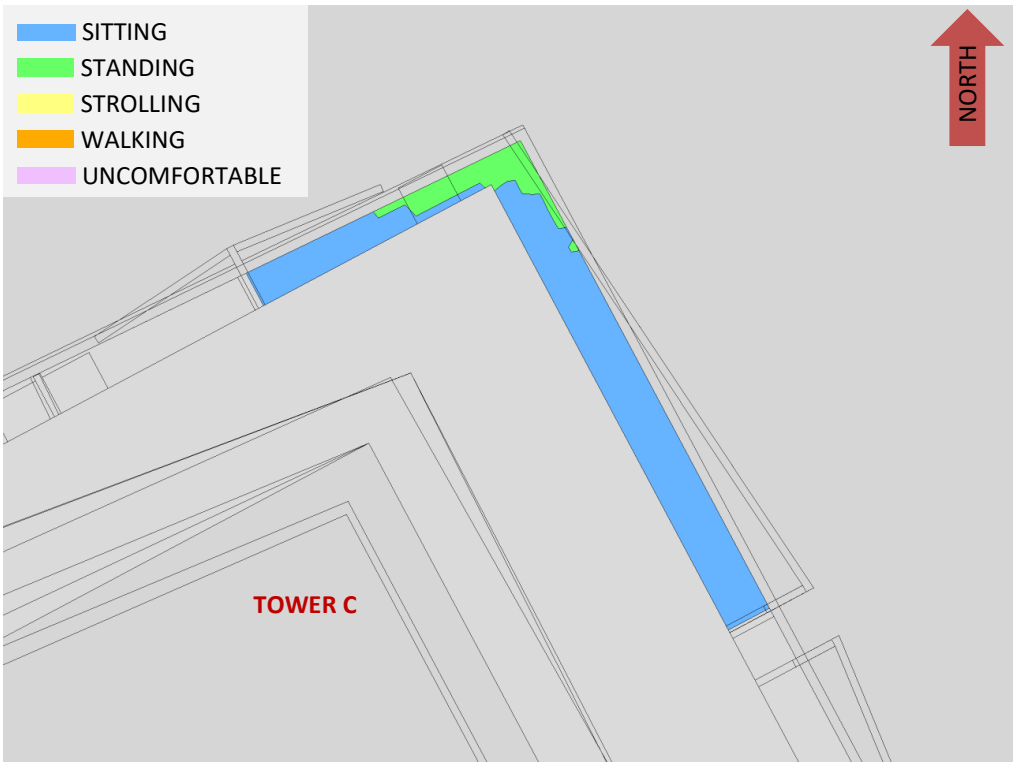


FIGURE 13: TYPICAL USE PERIOD – WIND COMFORT, LEVEL 3 COMMON AMENITY TERRACE

FIGURE 14A: SPRING – WIND COMFORT, LEVEL 4 COMMON AMENITY TERRACE

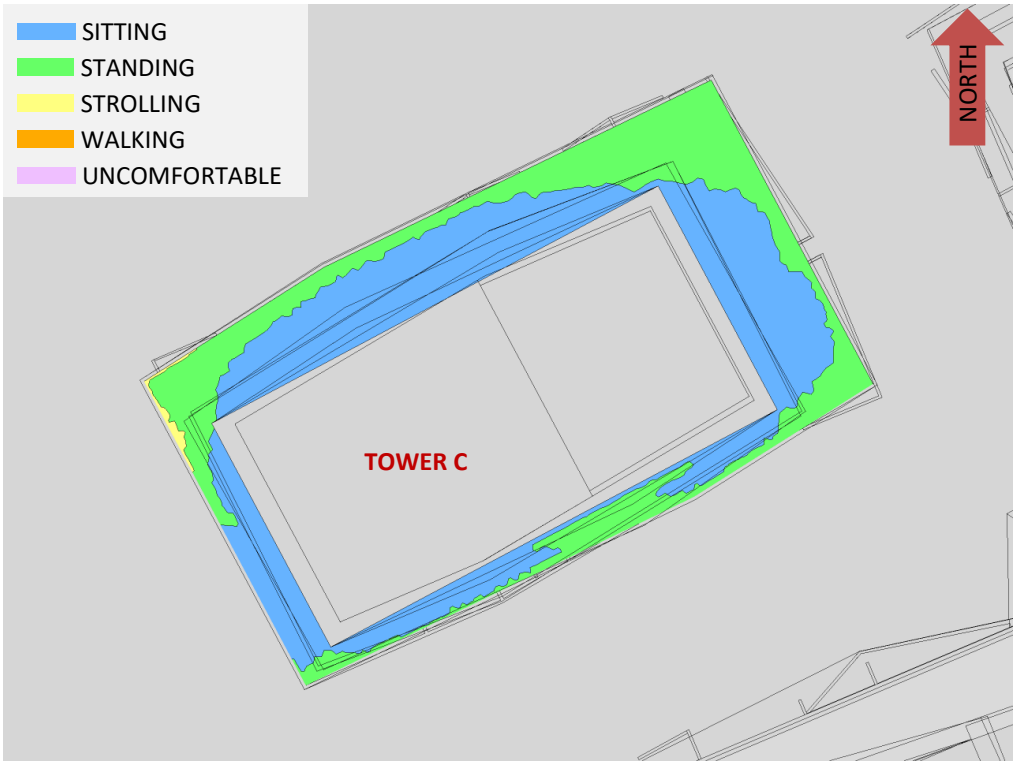


FIGURE 14B: SUMMER – WIND COMFORT, LEVEL 4 COMMON AMENITY TERRACE

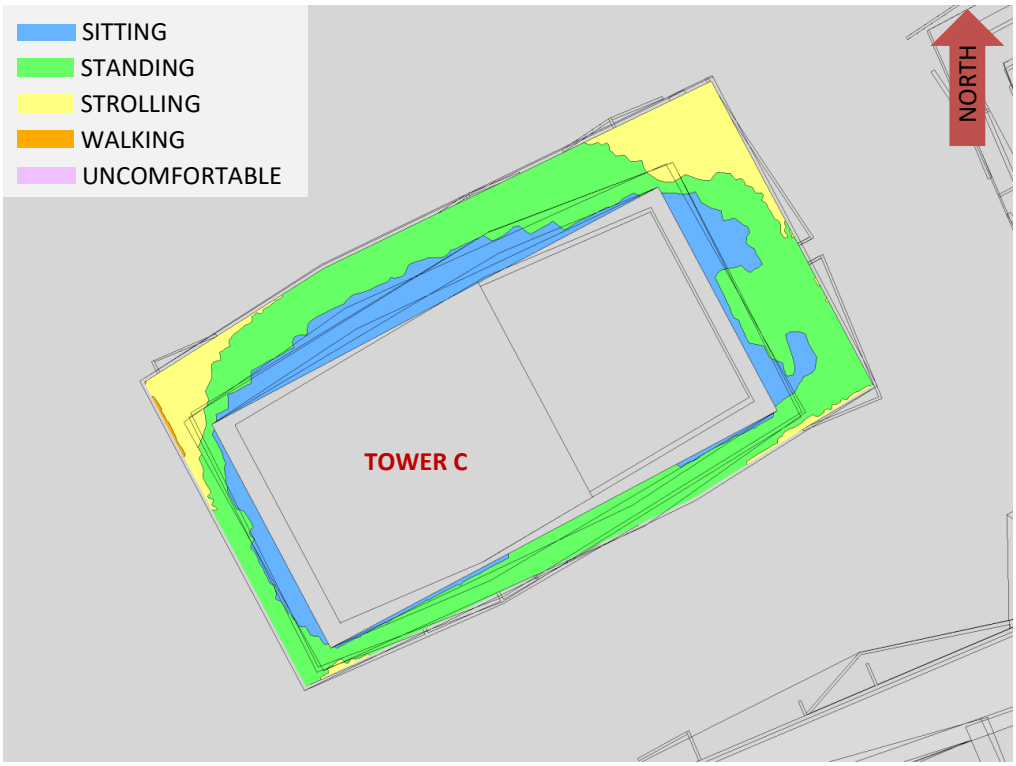


FIGURE 14C: AUTUMN – WIND COMFORT, LEVEL 4 COMMON AMENITY TERRACE

FIGURE 14D: WINTER – WIND COMFORT, LEVEL 4 COMMON AMENITY TERRACE

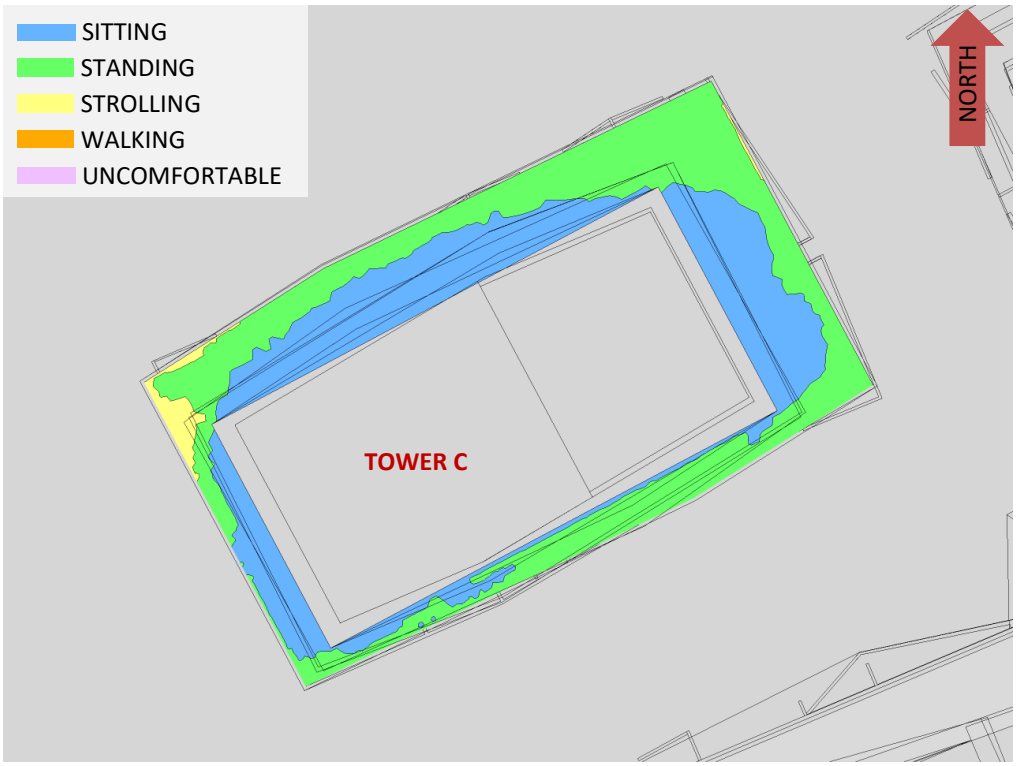
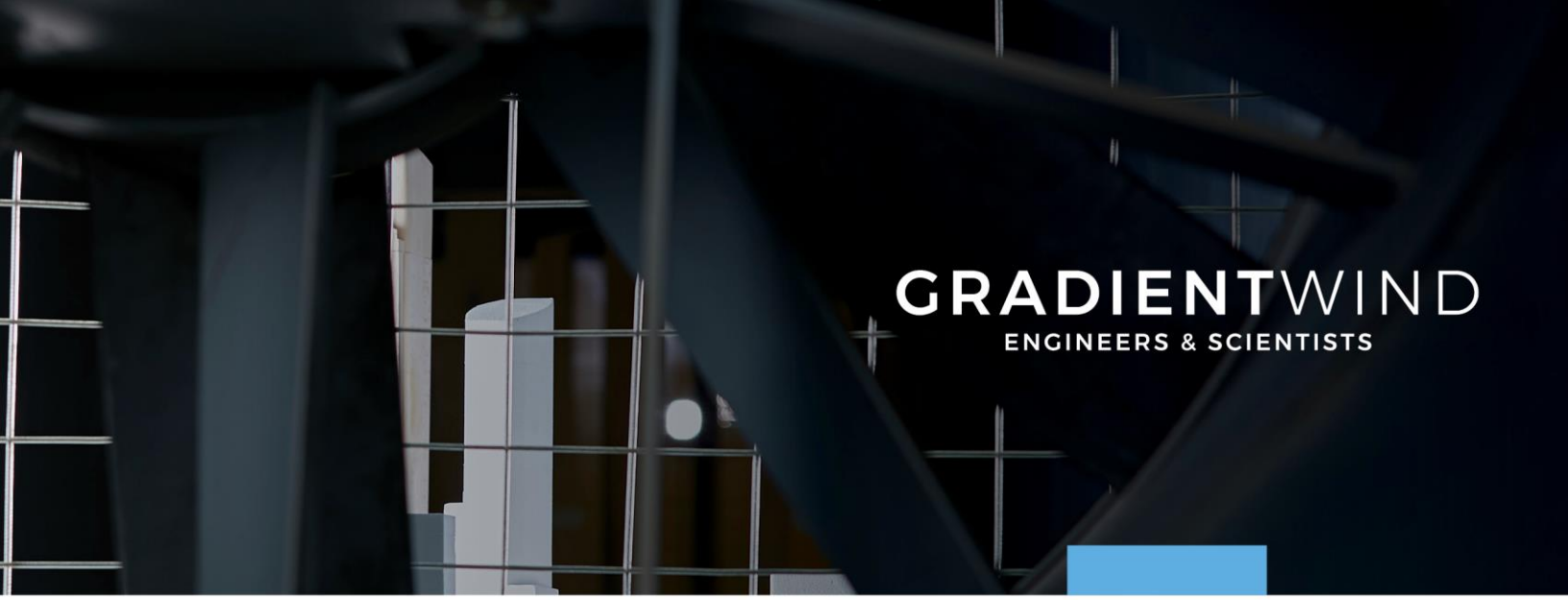
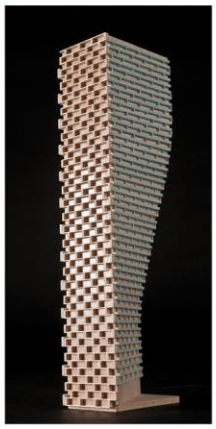
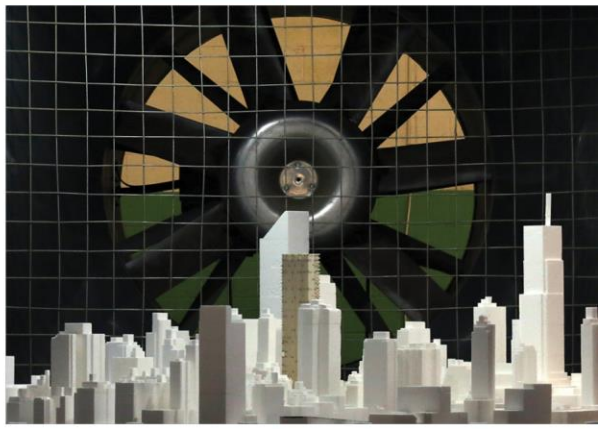


FIGURE 15: TYPICAL USE PERIOD – WIND COMFORT, LEVEL 4 COMMON AMENITY TERRACE







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, 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 (that is, 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 (Degrees True)	Alpha Value (α)
0	0.19
49	0.21
74	0.23
103	0.24
167	0.24
197	0.25
217	0.24
237	0.24
262	0.23
282	0.22
301	0.21
324	0.20

TABLE 2: DEFINITION OF UPSTREAM EXPOSURE (ALPHA VALUE)

Upstream Exposure Type	Alpha Value (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).

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

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

where, I = turbulence intensity, L_t = turbulence length scale, 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.

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