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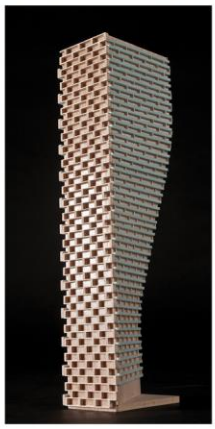
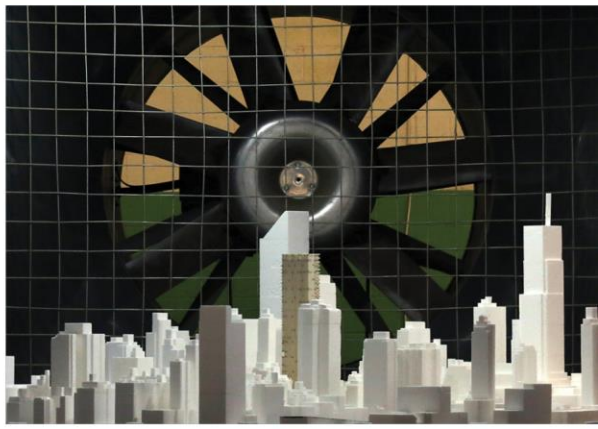
PEDESTRIAN LEVEL WIND STUDY

265 Catherine Street
Ottawa, Ontario

Report: 23-055-PLW





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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy concurrent Zoning By-law Amendment and Site Plan Control application submission requirements for the proposed multi-building development located at 265 Catherine Street 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-10, and summarized as follows:

1) All 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, existing surface parking, proposed walkways, and in the vicinity of building access points, are considered acceptable. A few exceptions are as follows:

    a. Wind conditions with the existing massing (that is, prior to the introduction of the proposed development) over the neighbouring areas of the Glashan Public School yard to the east of the subject site are predicted to be suitable for sitting throughout the year. Following the introduction of the proposed development, conditions 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. These conditions are expected following the introduction of a tall building development.

    b. Conditions in the vicinity of the building access points situated along the west elevation of Building A are predicted to be suitable for standing during the summer, becoming suitable for strolling, or better, throughout the remainder of the year. With the exception

of the entrance to the artspace, which is served by a sliding door, to ensure safe operability throughout the year, it is recommended that the primary entrances along the west elevation of Building A be recessed into the building façade by at least 2 m.

- Additionally, due to the predicted acceleration of winds between Buildings A and B, stress on the hardware supporting the swing doors along the west elevation of Building A is expected to be large. The use of robust hardware is recommended to support the noted doors.

c. Wind conditions over the grade-level amenity spaces are predicted to be mostly suitable for a mix of sitting and standing during the typical use period.

- The publicly accessible open space is predicted to be suitable for sitting within the majority of the area, with standing conditions to the east. Comfort levels around seating areas to the east may be improved with strategically placed north-south orientated high-back seating, in combination with landscaping treatments such as coniferous plantings in dense arrangements around seating areas.
- Conditions are predicted to be suitable for mostly standing over the central woonerf-style vehicular driveway and pedestrian open space, with an isolated region suitable for strolling between Buildings A and B. As pedestrian usage through the space is expected to comprise mostly strolling and walking with limited seating or lounging activities, the noted conditions are considered acceptable for the intended pedestrian uses.
- Conditions over the parkland dedication are predicted to be suitable for sitting within the majority of the area with isolated standing conditions to the west and along the east elevation. Where conditions are suitable for standing, they are also suitable for sitting at least 78% of the time to the west and 77% of the time to the east, where the target is 80% to achieve the sitting comfort criterion; the noted exceedances of the sitting criterion may be considered as minor. Furthermore, landscaping elements that could not be implemented in the simulation model (that is, dense plantings and trees), as

described in Section 4.1, which are expected to improve comfort levels over the parkland dedication during the typical use period.

- Conditions within the seating areas adjacent to the restaurants at the northeast corner of Building A and at the southwest corner of Building B are predicted to be suitable for a mix of sitting and standing during the typical use period. These conditions could be improved by implementing landscaping features, such as a combination of 1.8-m-tall wind screens and planters with coniferous plantings in dense arrangements around sensitive areas.
- The extent of the mitigation measures is dependent on the programming of the noted spaces. The mitigation strategy will continue to be developed and refined in collaboration with the building and landscape architects as the design of the proposed development progresses.

2) Regarding the Level 7 common amenity terraces serving Buildings A and B, wind conditions during the typical use period and recommendations regarding wind mitigation are described as follows:

   a. **Building A, Level 7 Common Amenity Terrace and Extended Walkways.** Wind comfort conditions are predicted to be suitable for sitting along the Tower 1 elevations and near the northwest corner; elsewhere, conditions are predicted to be suitable for standing with an isolated region suitable for strolling to the west. Conditions over the extended walkways connecting Buildings A and B are predicted to be suitable for a mix of standing and strolling.

   b. **Building B, Level 7 Common Amenity Terrace.** Conditions are predicted to be suitable for mostly standing, with areas suitable for sitting to the south, east, and north of Tower 2, and to the southwest, east, and north of Tower 3. Conditions suitable for strolling are predicted at the northeast and northwest corners of Tower 2, and at the northwest corner of Tower 3.

   c. To improve comfort levels within the noted amenity terraces, it is recommended that tall wind screens be implemented along the full perimeter of the terraces at the podia roof level. The recommended heights above the local walking surface along each elevation are illustrated in Figure 10.

d. 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, canopies located above designated seating areas, and strategically placed high-back seating.

e. The extent of the mitigation measures is dependent on the programming of the terraces and is described in Section 5.2. An appropriate mitigation strategy will continue to be developed and refined 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.

Addendum: The PLW study was performed based on architectural drawings prepared in March 2023. An updated set of drawings were distributed to the consultant team by BDP Quadrangle in April 2023. Notably, canopies are now included above the main residential entrances serving the proposed development, and the southern bridge connecting the two podia has been removed. These changes are not expected to alter the main conclusions of the study. Additionally, a skylounge amenity has been added to the MPH level of Tower 2, with an adjacent outdoor amenity terrace along the southwest, south, and southeast elevations at the MPH level. A 1.8-m-tall wind screen around the full perimeter of the terrace is expected to create comfortable conditions within the terrace.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by 11034936 Canada Inc. to undertake a pedestrian level wind (PLW) study to satisfy concurrent Zoning By-law Amendment and Site Plan Control application submission requirements for the proposed multi-building development located at 265 Catherine Street 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 BDP Quadrangle 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 Catherine Street in Ottawa, situated within a city block bounded by Arlington Avenue to the north, Kent Street to the east, Catherine Street to the south, and Lyon Street North to the west.

The proposed development comprises three buildings: Building A to the east, comprised of Tower 1 rising to 26-storeys above an 'L'-shaped six-storey podium; Building B to the west, comprised of Towers 2 and 3 rising to 40- and 36-storeys, respectively, above a shared 'L'-shaped six-storey podium; and Building C to the north which is comprised of three-storey townhouses. Building A comprises Phase 1, and Buildings B and C comprise Phase 2 of the proposed development. The podia serving Buildings A and B have their long axes oriented along Catherine Street and are connected at the podium roof level (Level 7) by pedestrian bridges. The buildings share two below-grade parking levels, and the three towers are topped with mechanical penthouses (MPH). A parkland dedication is provided at the northeast corner of the subject site, a woonerf-style vehicular driveway and pedestrian open space is situated between Buildings A and B, and a publicly accessible open space is situated between Buildings B and C.

Above the below-grade parking, the ground floor of Building A includes a residential main entrance to the south, retail spaces to the south and at the southwest corner, a loading space to the west, a retail artspace at the northwest corner, a residential main entrance and retail space to the north, and restaurants along the east elevation. A retail space (market) fronting Arlington Avenue is situated to the north of the artspace, separated from the main massing of Building A by an east-west walkway connecting the central driveway and the parkland dedication. Access to the underground parking is provided by a ramp near the southwest corner of Building A from Catherine Street. The ground floor of Building B includes a residential main entrance, retail spaces, and a management office to the south, a restaurant at the southwest corner, a residential main entrance to the west, a retail space at the northwest corner, a bicycle lobby and café to the north, indoor amenities to the northeast, and a garbage and loading space to the east. Access to the underground parking from Arlington Avenue is provided by a ramp near the centre of the north façade of Building B.

A mezzanine level in both buildings provides bicycle storage facilities. Level 2 of Building A includes an indoor amenity at the northwest corner, and residential units throughout the remainder of the level. Levels 3-6 and Levels 2-6 of Buildings A and B, respectively, are reserved for residential use and Level 7 is comprised of indoor amenities. Building B steps back from the east at Level 2, and both buildings step back from the south at Level 5 to accommodate private terraces. The buildings step back from all elevations at Level 7 to accommodate continuous amenity terraces atop the podia. Towers 1, 2, and 3 rise above the podia with nominally rectangular planforms and are comprised of residential units.

The near-field surroundings, defined as an area within 200-metres (m) of the subject site, include low-rise massing in all compass directions, Glashan Public School to the northeast, and isolated mid-rise buildings to the east, southeast, and west. Notably, a 16-storey mixed-use development is approved at 30-48 Chamberlain Avenue (ZBLA), approximately 190 m to the southeast. 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 and isolated mid- and high-rise buildings from the east-northeast clockwise to the west-northwest, low- and mid-rise massing following by the urban massing of the Ottawa downtown core from the west-northwest clockwise to the northeast, and a mix of low-, mid-, and high-rise massing in the remaining compass directions. The Ottawa downtown core is situated approximately 1.1 km to the north, and Dow's Lake is approximately 1.5 km to the south-southwest.

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 subject 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 subject 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.

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

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 proposed development, complete with surrounding massing within a radius of 515 m. The process was performed for two context massing scenarios, as noted in Section 2.

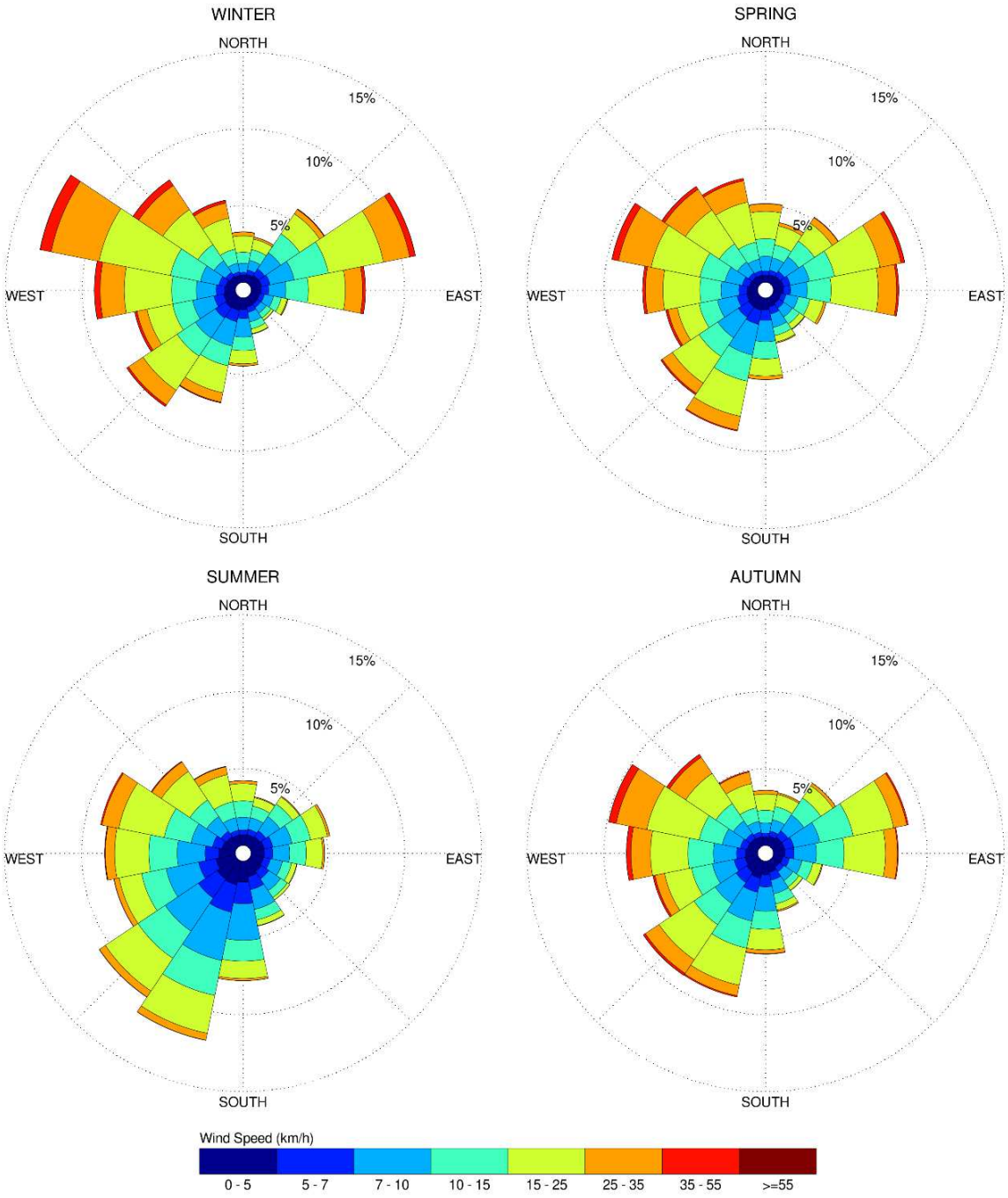
Mean and peak wind speed data obtained over the subject site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and the numerous elevated common amenity terraces serving the 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, illustrating wind conditions over the numerous elevated common amenity terraces serving Buildings A and B. 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 are also reported for the typical use period, which is defined as May to October, inclusive. Figures 7 and 9 illustrate comfort conditions at grade level and over the noted amenity terraces, respectively, 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 Transit Stop along Catherine Street: Following the introduction of the proposed development, conditions over the public sidewalks along Catherine Street 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 at the intersection of Catherine Street and Lyon Street North during the winter. Conditions in the vicinity of the nearby transit stop along Catherine Street are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable.

Wind conditions over the public sidewalks along Catherine Street and in the vicinity of the nearby transit stop with the existing massing are predicted to be suitable for sitting throughout 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 Surface Parking South of Subject Site: Following the introduction of the proposed development, conditions over the existing surface parking lots situated to the south of the subject site are predicted to be suitable for mostly sitting during the summer, becoming suitable for a mix of mostly sitting and standing throughout the remainder of the year. The noted conditions are considered acceptable.

Wind conditions over the noted surface parking lots with the existing massing are predicted to be suitable for mostly sitting throughout the year, with isolated regions suitable for standing during the winter. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, wind comfort conditions are nevertheless considered acceptable.

Sidewalks and Existing Surface Parking along Lyon Street North: Following the introduction of the proposed development, conditions over the public sidewalks along Lyon Street North and over the surface parking lots to the west 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. The noted conditions are considered acceptable.

Wind conditions over the noted areas with the existing massing are predicted to be suitable for sitting throughout the year. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, wind comfort conditions are nevertheless considered acceptable.

Sidewalks and Existing On-Street Parking along Arlington Avenue: Following the introduction of the proposed development, conditions over the public sidewalks and existing on-street parking along Arlington Avenue are predicted to be suitable for a mix of sitting and standing throughout the year, with conditions suitable for strolling at the intersection of Lyon Street North and Arlington Avenue during the spring and winter. The noted conditions are considered acceptable.

Wind conditions over the public sidewalks and on-street parking along Arlington Avenue with the existing massing are predicted to be suitable for sitting throughout 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 Parking Lot Northeast of Subject Site: Following the introduction of the proposed development, conditions over the existing parking lot situated to the northeast of the subject site 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. The noted conditions are considered acceptable.

Wind conditions over the noted parking lot with the existing massing are predicted to be suitable for sitting throughout the year. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, wind comfort conditions are nevertheless considered acceptable.

Sidewalks along Kent Street: Following the introduction of the proposed development, conditions over the public sidewalks along Kent Street are predicted to be suitable for a mix of sitting and standing during the summer and autumn, with an isolated region suitable for strolling during the autumn, becoming suitable for strolling, or better, during the winter and spring, with an isolated region suitable for walking during the winter. The noted conditions are considered acceptable.

Wind conditions over the public sidewalks along Kent Street with the existing massing are predicted to be suitable for sitting throughout the year. While the introduction of the proposed development produces

windier conditions in comparison to existing conditions, wind comfort conditions are nevertheless considered acceptable.

Glashan Public School Yard: Wind conditions over the neighbouring areas of the Glashan Public School yard to the east of the subject site with the existing massing are predicted to be suitable for sitting throughout the year. Following the introduction of the proposed development, wind comfort conditions over the noted area are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for a mix of sitting, standing, and strolling throughout the remainder of the year. These conditions are expected following the introduction of a tall building development.

Publicly Accessible Open Space, Parkland Dedication, and Driveway and Pedestrian Open Space: The proposed development is served by several outdoor areas. Notably, a landscape design concept for the ground floor was collaboratively developed by the landscape architects[2]. Wind comfort conditions during the typical use period, as illustrated in Figure 7, and recommendations regarding mitigation are described as follows:

- **Publicly Accessible Open Space**: Wind comfort conditions within the publicly accessible open space situated between Buildings B and C are predicted to be suitable for sitting within the majority of the area with standing conditions to the east. Comfort levels around sensitive areas to the east may be improved with strategically placed north-south orientated high-back seating, in combination with other local wind mitigation such as coniferous plantings in dense arrangements.

- **Driveway and Pedestrian Open Space**: Wind comfort conditions within the driveway and pedestrian open space are predicted to be suitable for sitting at the northeast corner and to the west, and suitable for standing throughout the remainder of the area with an isolated region suitable for strolling between Buildings A and B. As pedestrian usage through the space is expected to comprise mostly strolling and walking with limited seating or lounging activities, the noted conditions are considered acceptable for the intended pedestrian uses.

[2] NAK Design Strategies, '*Landscape Design Concept – Ground Floor*' [March 22, 2023]

- **Parkland Dedication**: Wind comfort conditions within the parkland dedication situated at the northeast corner of the subject site are predicted to be suitable for sitting within most of the area with isolated standing conditions to the west and along the east elevation. Where conditions are suitable for standing, they are also suitable for sitting at least 78% of the time to the west and 77% of the time to the east, where the target is 80% to achieve the sitting comfort criterion; the noted exceedances of the sitting criterion may be considered as minor. Furthermore, the standing conditions are expected to be mitigated by landscaping elements that could not be implemented in the simulation model (that is, dense plantings and trees), as described in Section 4.1.

- **Restaurant, Café, and Market Outdoor Seating:** Wind comfort conditions over the programmed seating areas adjacent to the market and the café serving Building B are suitable for sitting during the typical use period, which is considered acceptable. Conditions over the seating areas adjacent to the restaurants at the southwest corner of Building B and at the northeast corner of Building A are predicted to be suitable for a mix of sitting and standing during the same period. Comfort conditions over the windier seating areas could be improved by implementing landscaping features, such as a combination of 1.8-m-tall wind screens and planters with coniferous plantings in dense arrangements around sensitive areas.

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

Walkways within the Subject Site: Wind comfort conditions within the walkways throughout 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 isolated conditions suitable for walking at the east of the subject site and at the southwest corner during the winter season, and between Buildings A and B during the spring and winter seasons. The noted conditions are considered acceptable for walkways.

Building Access: Conditions in the vicinity of the building access points along the west elevation of Building A are predicted to be suitable for standing during the summer, becoming suitable for a mix of standing and strolling during the autumn, and suitable for mostly strolling during the winter and spring seasons.

With the exception of the entrance to the artspace, which is served by a sliding door, to ensure safe operability throughout the year, it is recommended that the primary entrances along the west elevation of Building A be recessed into the building façade by at least 2 m. Additionally, given the predicted acceleration of winds through the driveway between Buildings A and B, stress on the hardware supporting the swing doors along the west elevation of Building A is expected to be large. The use of robust hardware is recommended for the noted doors.

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. The noted conditions are considered acceptable.

5.2 Wind Comfort Conditions – Common Amenity Terraces

The proposed development is served by common amenity terraces atop the podia at Level 7, and a landscape design concept for the noted terraces has been collaboratively developed by the landscape architects[3]. Wind comfort conditions during the typical use period within the Level 7 amenity terraces, as illustrated in Figure 9, and recommendations regarding mitigation where required are described as follows:

Building A, Level 7 Common Amenity Terrace: Wind comfort conditions within the common amenity terrace serving Building A at Level 7 are predicted to be suitable for mostly sitting along the Tower 1 elevations and near the northwest corner and standing throughout the remainder of the area, with an isolated region suitable for strolling to the west. Conditions over the pedestrian bridges connecting Buildings A and B are predicted to be suitable for a mix of standing and strolling.

Building B, Level 7 Common Amenity Terrace: Wind comfort conditions within the common amenity terrace serving Building B at Level 7 are predicted to be suitable for mostly standing, with areas suitable for sitting to the south, east, and north of Tower 2, and to the southwest, east, and north of Tower 3. Conditions suitable for strolling are predicted at the northeast and northwest corners of Tower 2, and at the northwest corner of Tower 3.

[3] NAK Design Strategies, '*Landscape Design Concept – Roof Terrace*' [March 31, 2023]

To improve comfort levels within the noted amenity terraces, it is recommended that tall wind screens be implemented along the full perimeter of the terraces at the podia roof level. The recommended heights above the local walking surface along each elevation are illustrated in Figure 10. Specifically, a perimeter wind screen rising at least 2.4 m above the local walking surface is recommended along the south elevations of the terraces and along the west perimeter of the terrace to the north of Tower 3. A wind screens at least 1.8-m-tall is recommended along the north perimeter of the terrace between Towers 2 and 3. Wind screens rising at least 2.0 m above the local walking surface are recommended for the remaining perimeters.

The terrace areas between Towers 2 and 3 and at the southwest corner of Tower 1 are expected to provide active use spaces. Additionally, an urban farm is programmed at the north elevation of Building A, and the bridges linking the two buildings are comprised of a walking pathway. These areas are considered to have minimal seating or lounging spaces and activities, and conditions following the introduction of the perimeter wind screen are expected to be suitable for the intended pedestrian use within these areas.

Regarding the remaining areas of the terrace serving Building A, mitigation inboard of the perimeter is recommended for the seating and lounging areas at the centre of the terrace and to the north and southwest. Specifically, strategically placed east-west and north-south orientated high-back seating may improve comfort levels around seating areas to the west and southwest. Additionally, a combination of 1.8-m-tall wind screens or clusters of coniferous trees located around sensitive areas, and canopies located above designated seating areas may improve comfort levels centrally throughout the terrace.

Furthermore, mitigation inboard of the perimeter is recommended over the western half of the terrace to the north of Tower 3. 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.

The extent of the mitigation measures is dependent on the programming of the noted spaces. The mitigation strategy will continue to evolve and be refined 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-10. 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) All 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, existing surface parking, proposed walkways, and in the vicinity of building access points, are considered acceptable. A few exceptions are as follows:

    a. Wind conditions with the existing massing (that is, prior to the introduction of the proposed development) over the neighbouring areas of the Glashan Public School yard to the east of the subject site are predicted to be suitable for sitting throughout the year. Following the introduction of the proposed development, conditions 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. These conditions are expected following the introduction of a tall building development.

b. Conditions in the vicinity of the building access points situated along the west elevation of Building A are predicted to be suitable for standing during the summer, becoming suitable for strolling, or better, throughout the remainder of the year. With the exception of the entrance to the artspace, which is served by a sliding door, to ensure safe operability throughout the year, it is recommended that the primary entrances along the west elevation of Building A be recessed into the building façade by at least 2 m.

    - Additionally, due to the predicted acceleration of winds between Buildings A and B, stress on the hardware supporting the swing doors along the west elevation of Building A is expected to be large. The use of robust hardware is recommended to support the noted doors.

c. Wind conditions over the grade-level amenity spaces are predicted to be mostly suitable for a mix of sitting and standing during the typical use period.

    - The publicly accessible open space is predicted to be suitable for sitting within the majority of the area, with standing conditions to the east. Comfort levels around seating areas to the east may be improved with strategically placed north-south orientated high-back seating, in combination with landscaping treatments such as coniferous plantings in dense arrangements around seating areas.

    - Conditions are predicted to be suitable for mostly standing over the central woonerf-style vehicular driveway and pedestrian open space, with an isolated region suitable for strolling between Buildings A and B. As pedestrian usage through the space is expected to comprise mostly strolling and walking with limited seating or lounging activities, the noted conditions are considered acceptable for the intended pedestrian uses.

    - Conditions over the parkland dedication are predicted to be suitable for sitting within the majority of the area with isolated standing conditions to the west and along the east elevation. Where conditions are suitable for standing, they are also suitable for sitting at least 78% of the time to the west and 77% of the time to the east, where the target is 80% to achieve the sitting

comfort criterion; the noted exceedances of the sitting criterion may be considered as minor. Furthermore, landscaping elements that could not be implemented in the simulation model (that is, dense plantings and trees), as described in Section 4.1, which are expected to improve comfort levels over the parkland dedication during the typical use period.

- Conditions within the seating areas adjacent to the restaurants at the northeast corner of Building A and at the southwest corner of Building B are predicted to be suitable for a mix of sitting and standing during the typical use period. These conditions could be improved by implementing landscaping features, such as a combination of 1.8-m-tall wind screens and planters with coniferous plantings in dense arrangements around sensitive areas.

d. The extent of the mitigation measures is dependent on the programming of the noted spaces. The mitigation strategy will continue to be developed and refined in collaboration with the building and landscape architects as the design of the proposed development progresses.

2) Regarding the Level 7 common amenity terraces serving Buildings A and B, wind conditions during the typical use period and recommendations regarding wind mitigation are described as follows:

a. **Building A, Level 7 Common Amenity Terrace and Extended Walkways.** Wind comfort conditions are predicted to be suitable for sitting along the Tower 1 elevations and near the northwest corner; elsewhere, conditions are predicted to be suitable for standing with an isolated region suitable for strolling to the west. Conditions over the extended walkways connecting Buildings A and B are predicted to be suitable for a mix of standing and strolling.

b. **Building B, Level 7 Common Amenity Terrace.** Conditions are predicted to be suitable for mostly standing, with areas suitable for sitting to the south, east, and north of Tower 2, and to the southwest, east, and north of Tower 3. Conditions suitable for strolling are predicted at the northeast and northwest corners of Tower 2, and at the northwest corner of Tower 3.

c. To improve comfort levels within the noted amenity terraces, it is recommended that tall wind screens be implemented along the full perimeter of the terraces at the podia roof level. The recommended heights above the local walking surface along each elevation are illustrated in Figure 10.

d. 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, canopies located above designated seating areas, and strategically placed high-back seating.

e. The extent of the mitigation measures is dependent on the programming of the terraces and is described in Section 5.2. An appropriate mitigation strategy will continue to be developed and refined 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,

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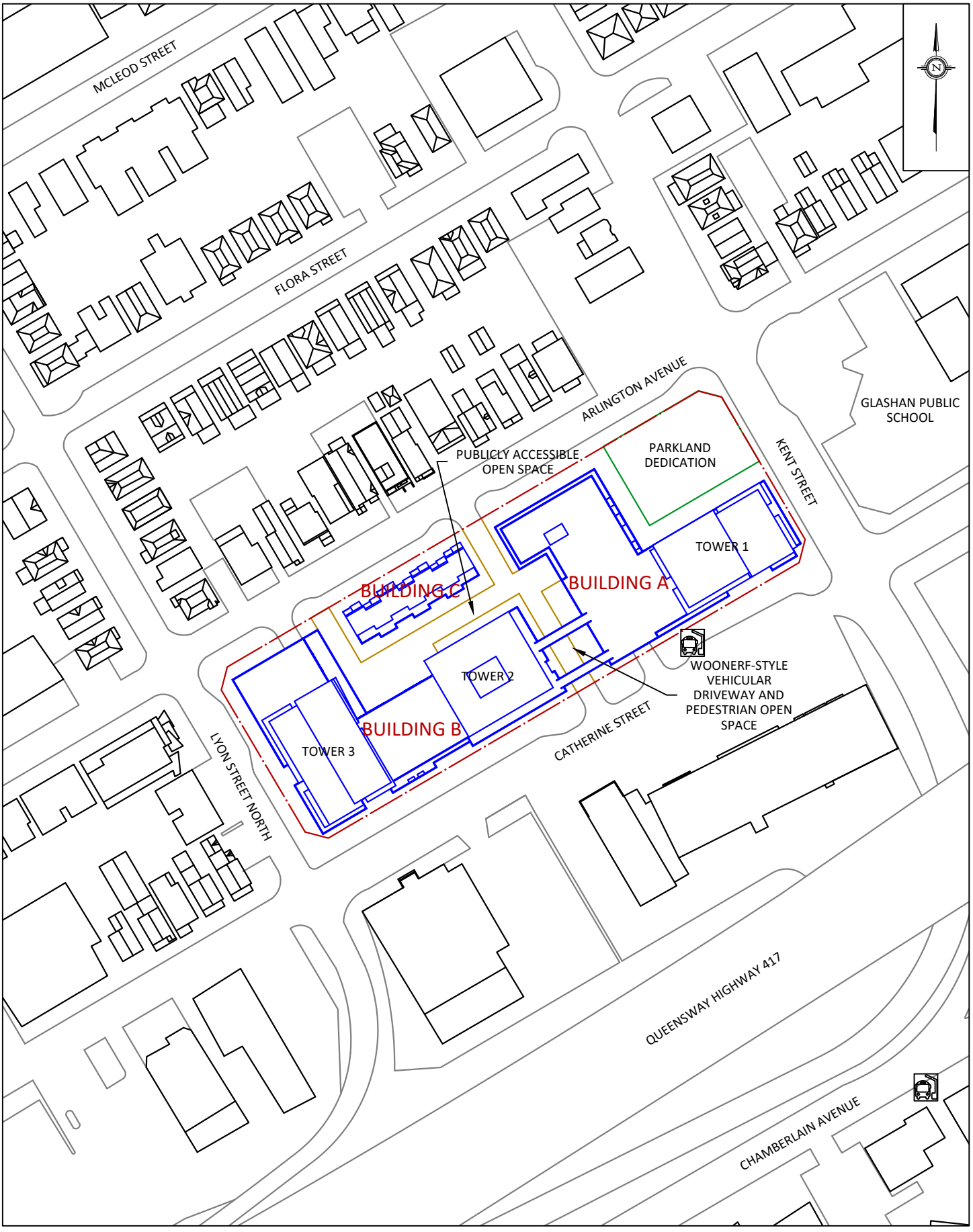

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PROJECT	265 CATHERINE STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1500
DRAWING NO.	23-055-PLW-1A
DATE	APRIL 6, 2023
DRAWN BY	T.K.
DESCRIPTION	FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT

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PROJECT	265 CATHERINE STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1500
DRAWING NO.	23-055-PLW-1B
DATE	APRIL 6, 2023
DRAWN BY	T.K.

DESCRIPTION

FIGURE 1B:
EXISTING SITE PLAN AND SURROUNDING CONTEXT

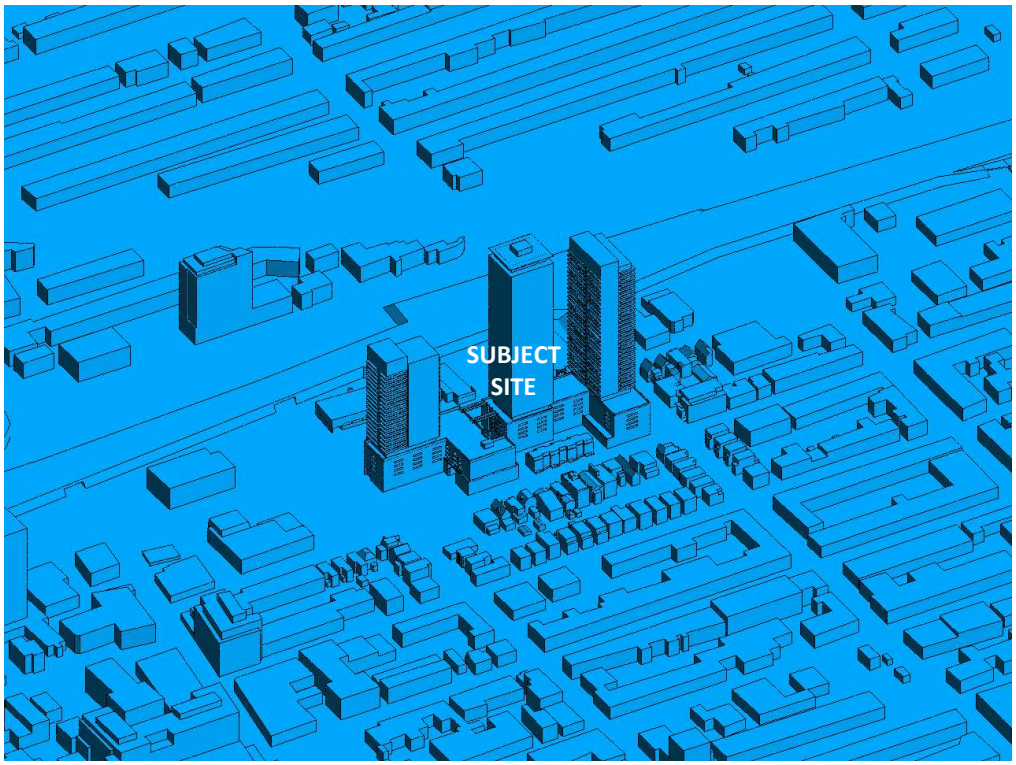

FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTH PERSPECTIVE

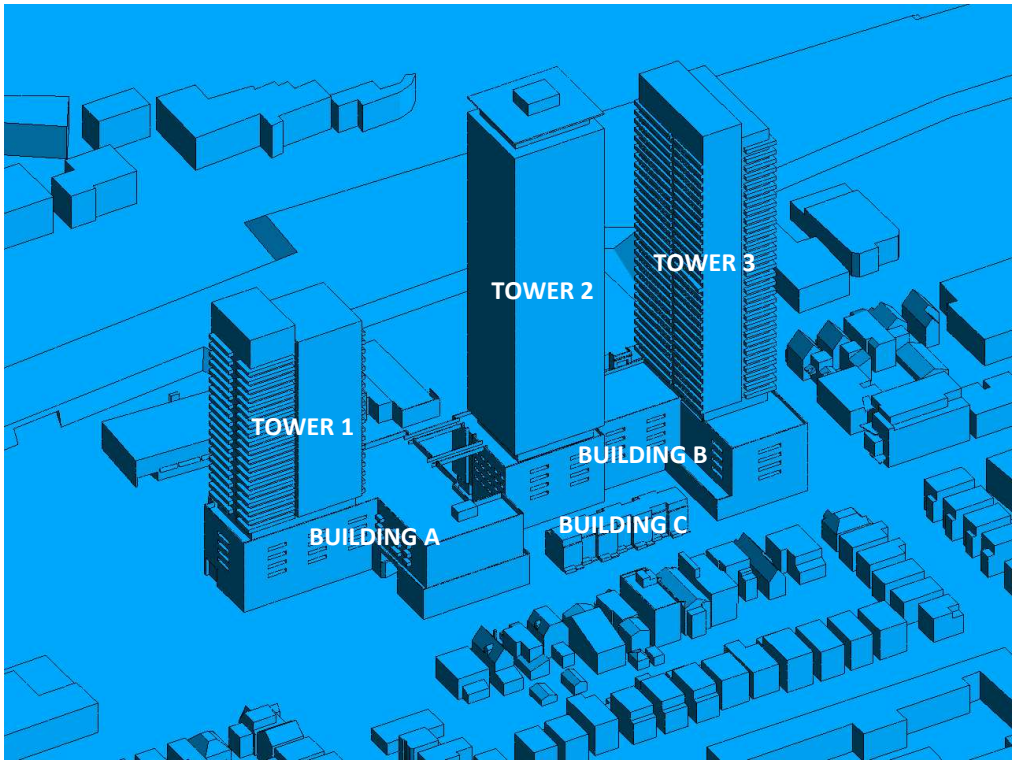

FIGURE 2B: CLOSE UP OF FIGURE 2A

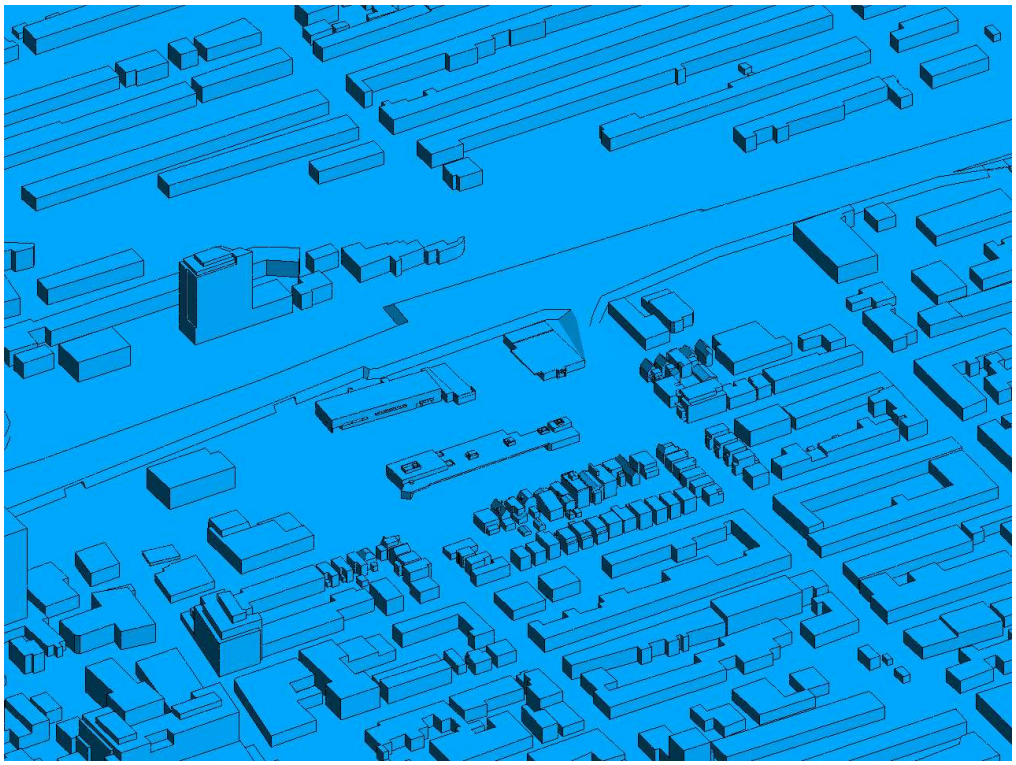

FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, NORTH PERSPECTIVE

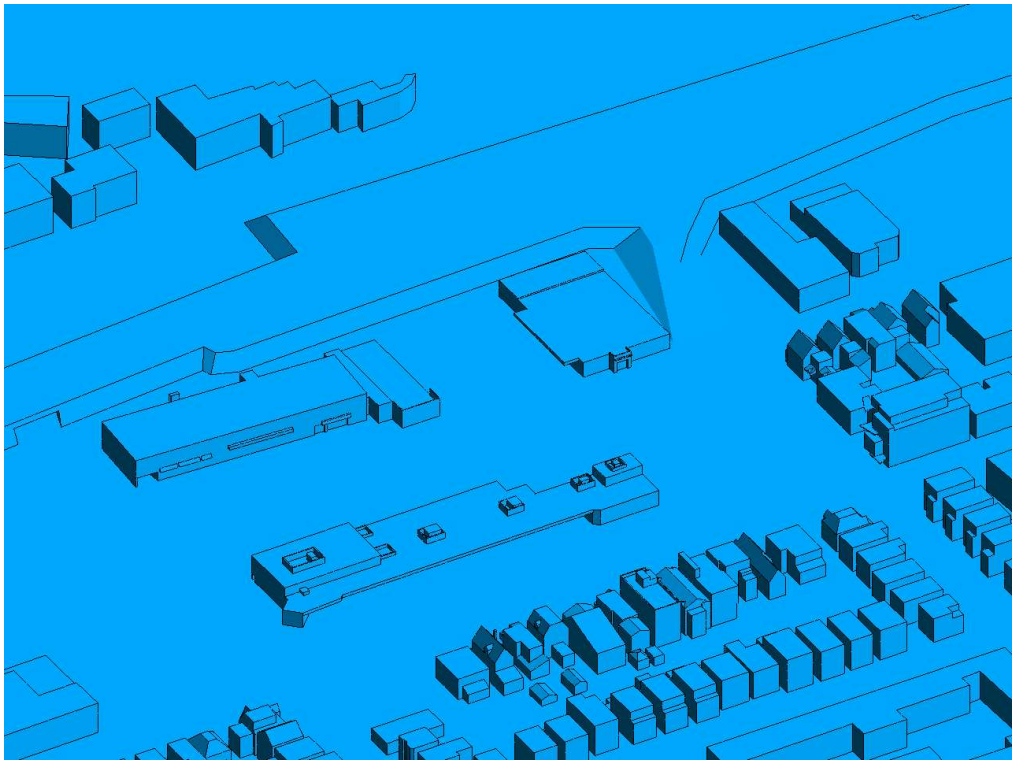

FIGURE 2D: CLOSE UP OF FIGURE 2C

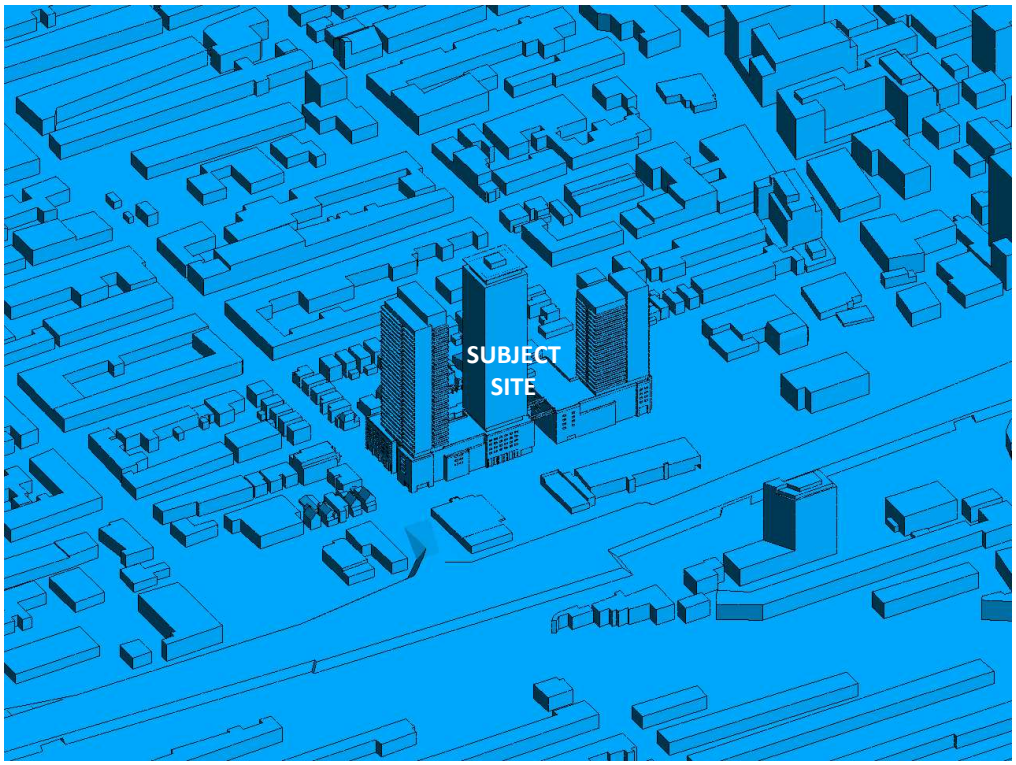

FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTH PERSPECTIVE

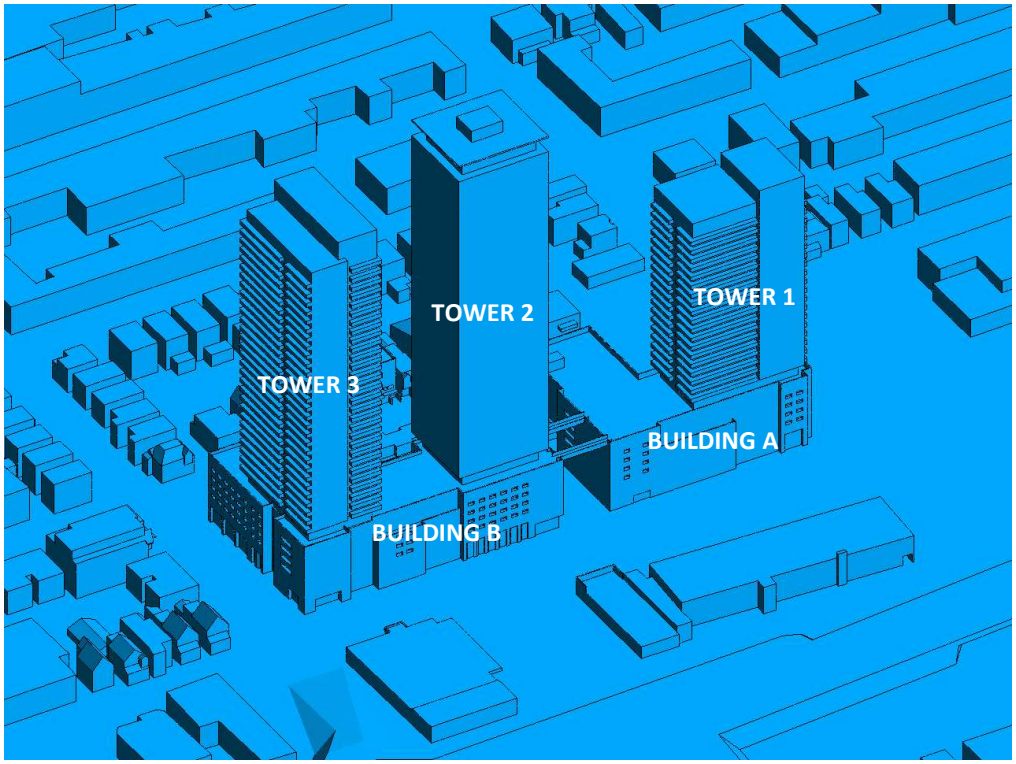

FIGURE 2F: CLOSE UP OF FIGURE 2E

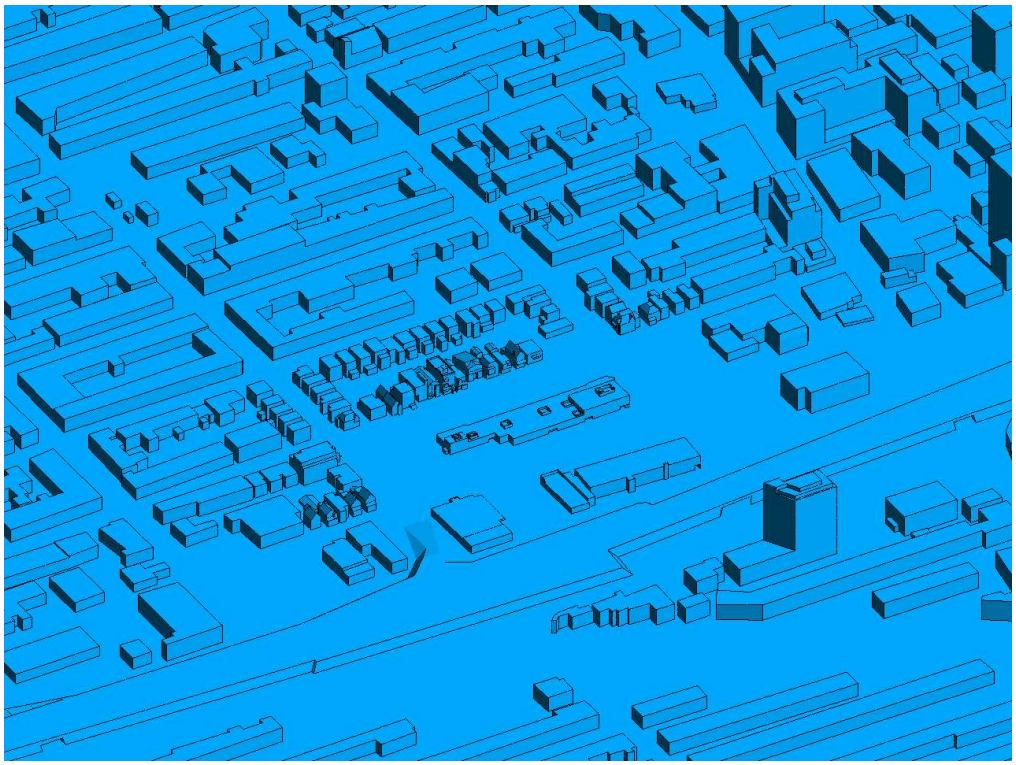

FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTH PERSPECTIVE

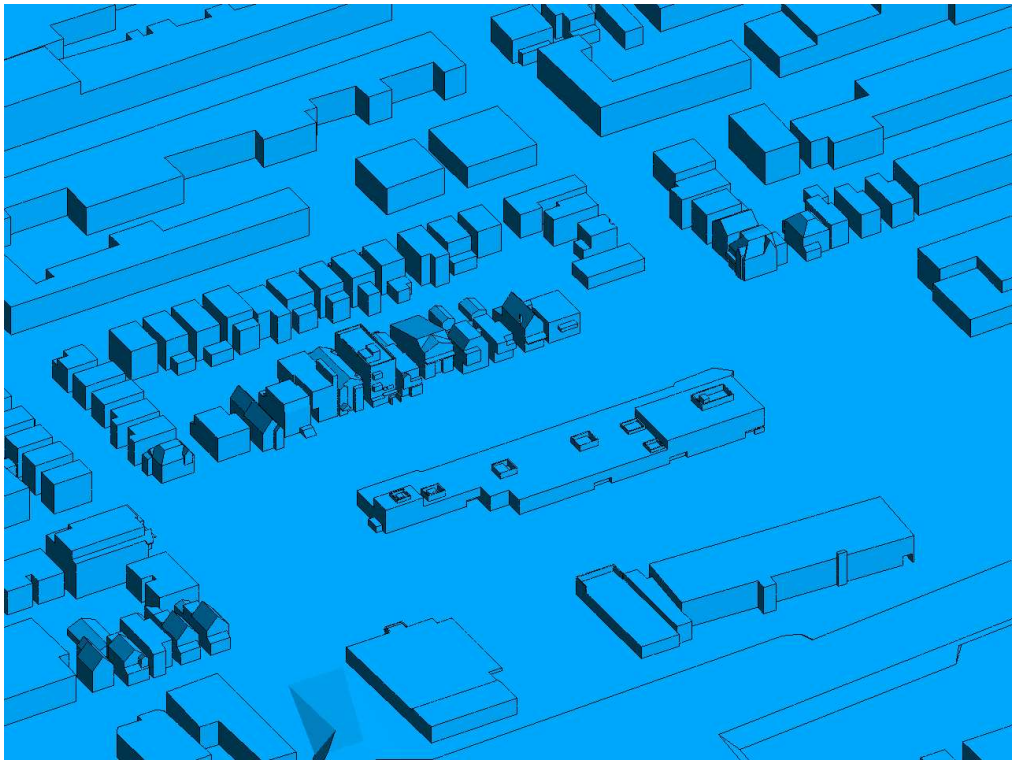

FIGURE 2H: CLOSE UP OF FIGURE 2G

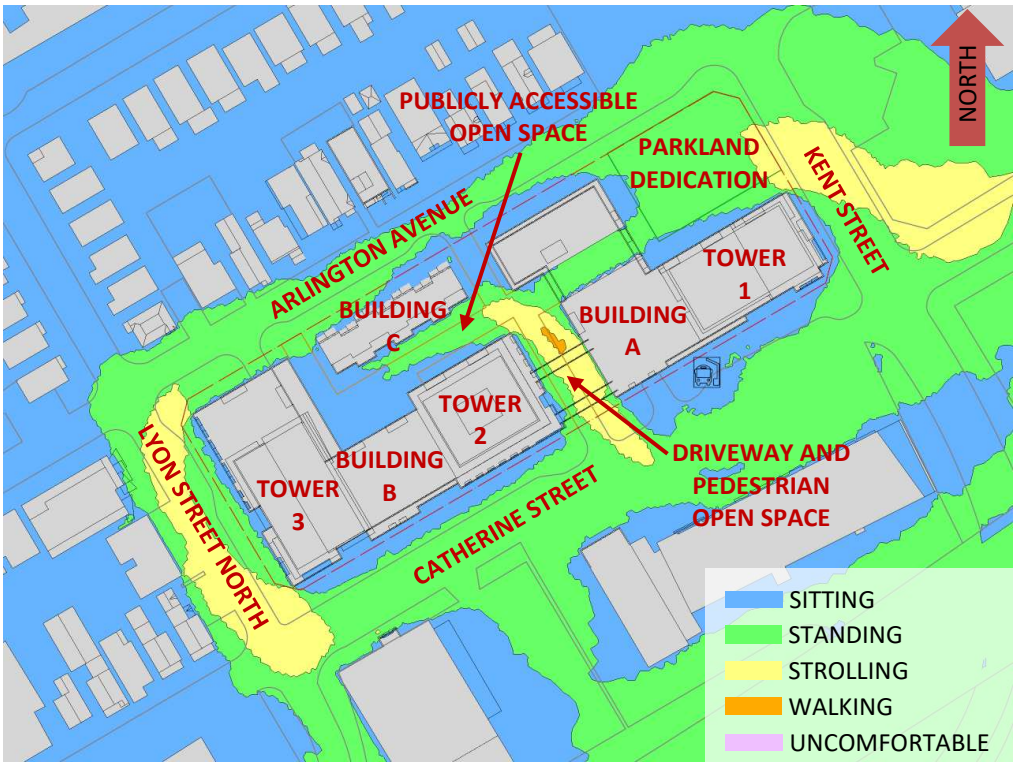

FIGURE 3A: SPRING – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

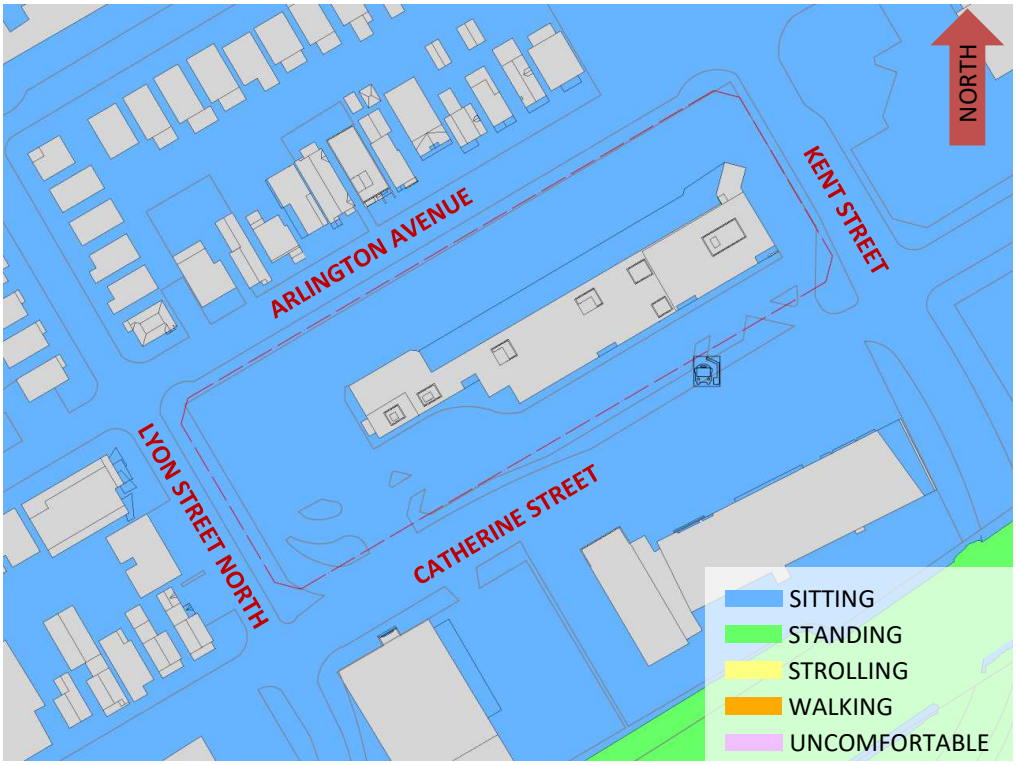

FIGURE 3B: SPRING – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

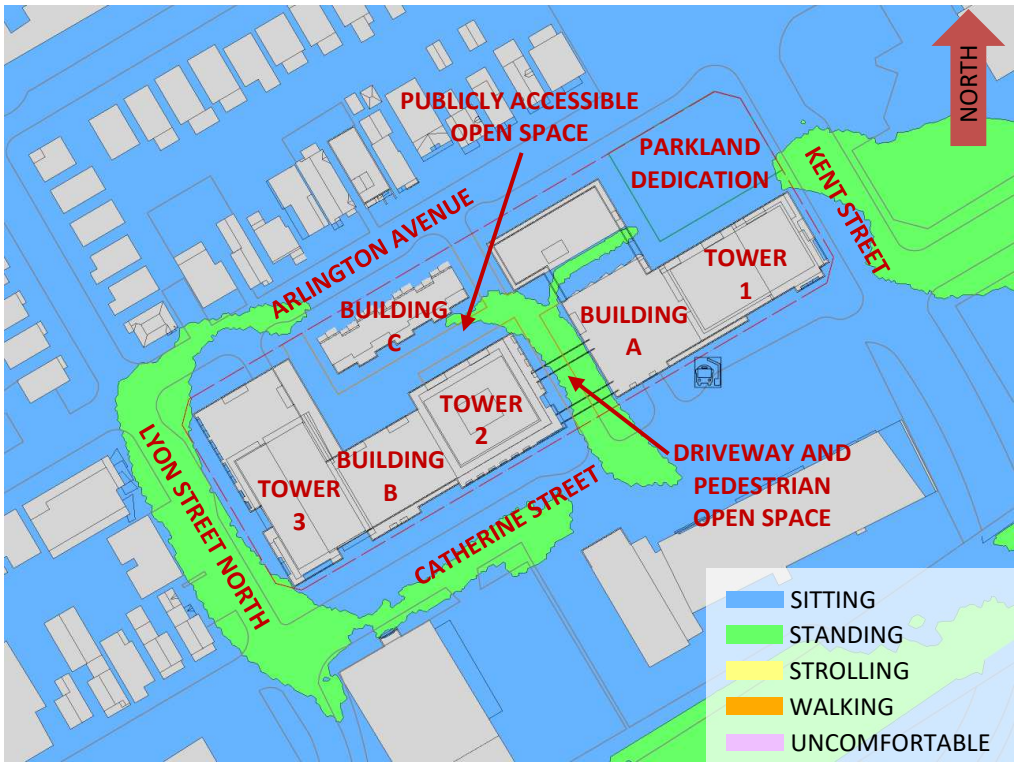

FIGURE 4A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

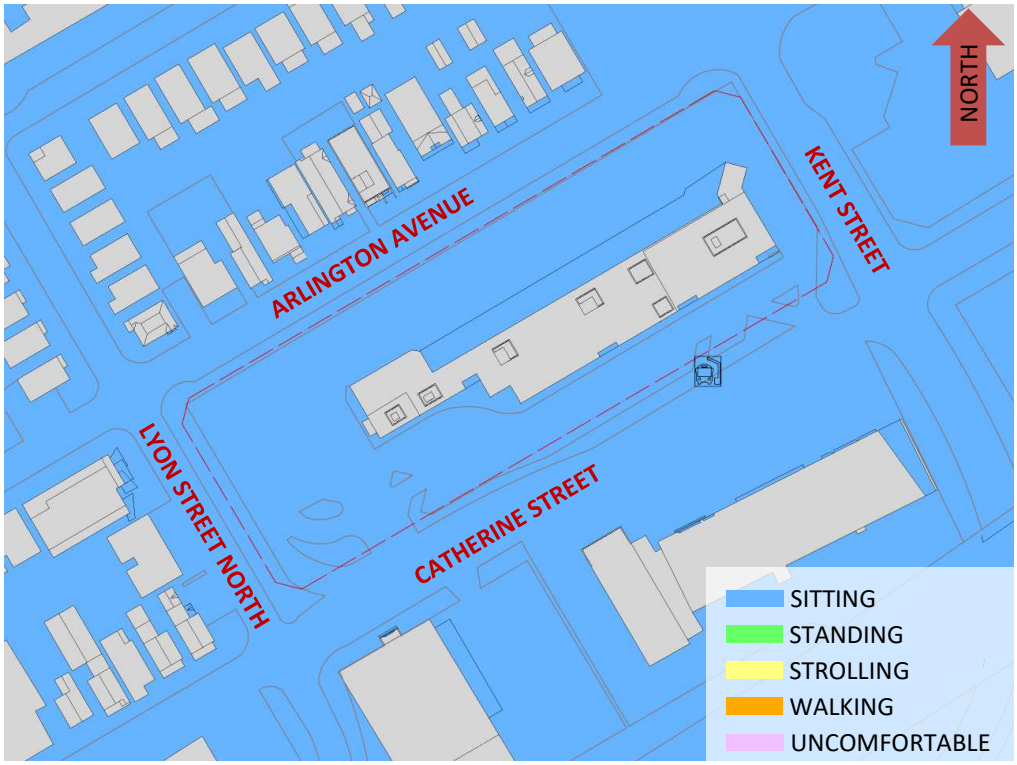

FIGURE 4B: SUMMER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

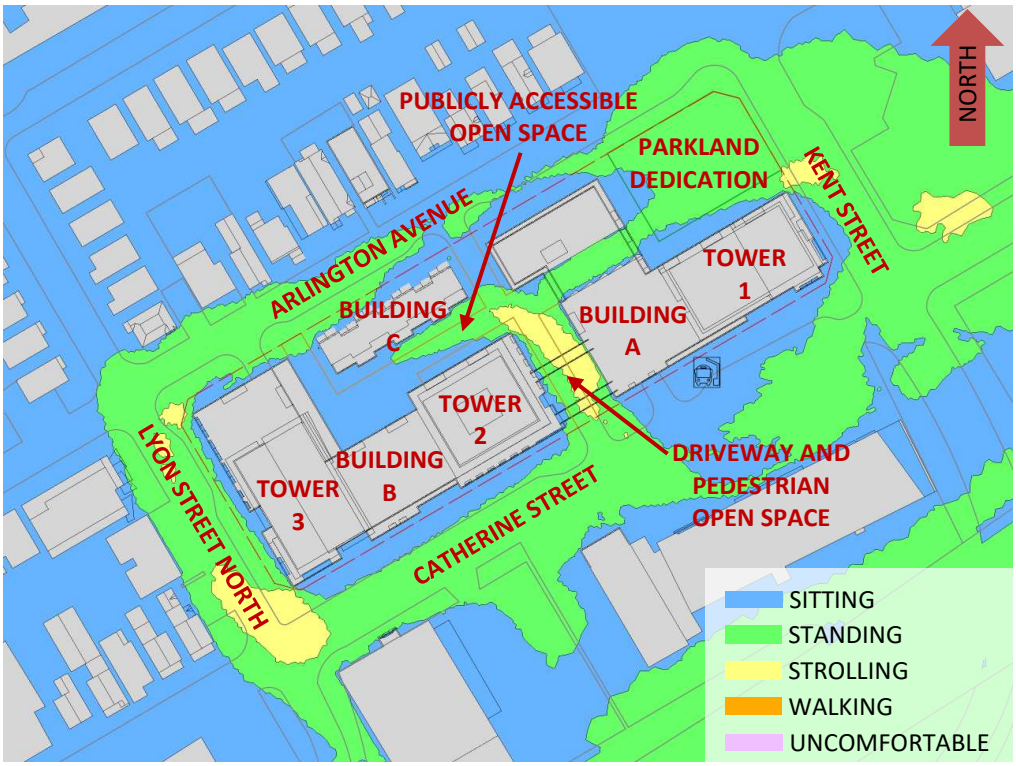

FIGURE 5A: AUTUMN – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

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

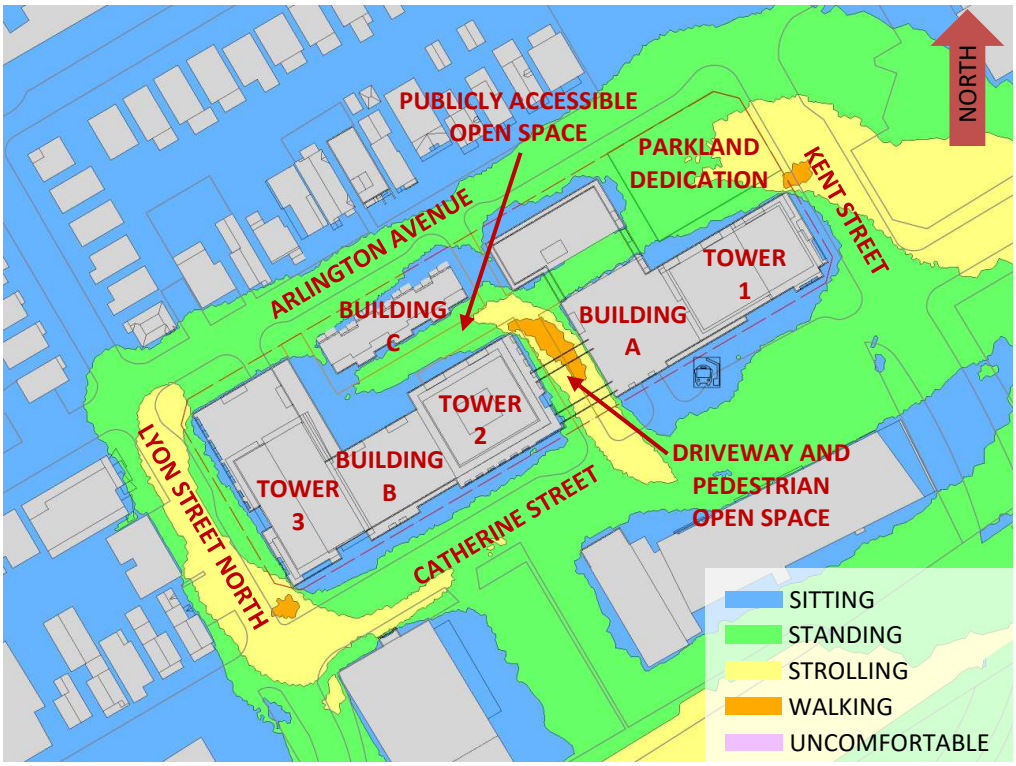

FIGURE 6A: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

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

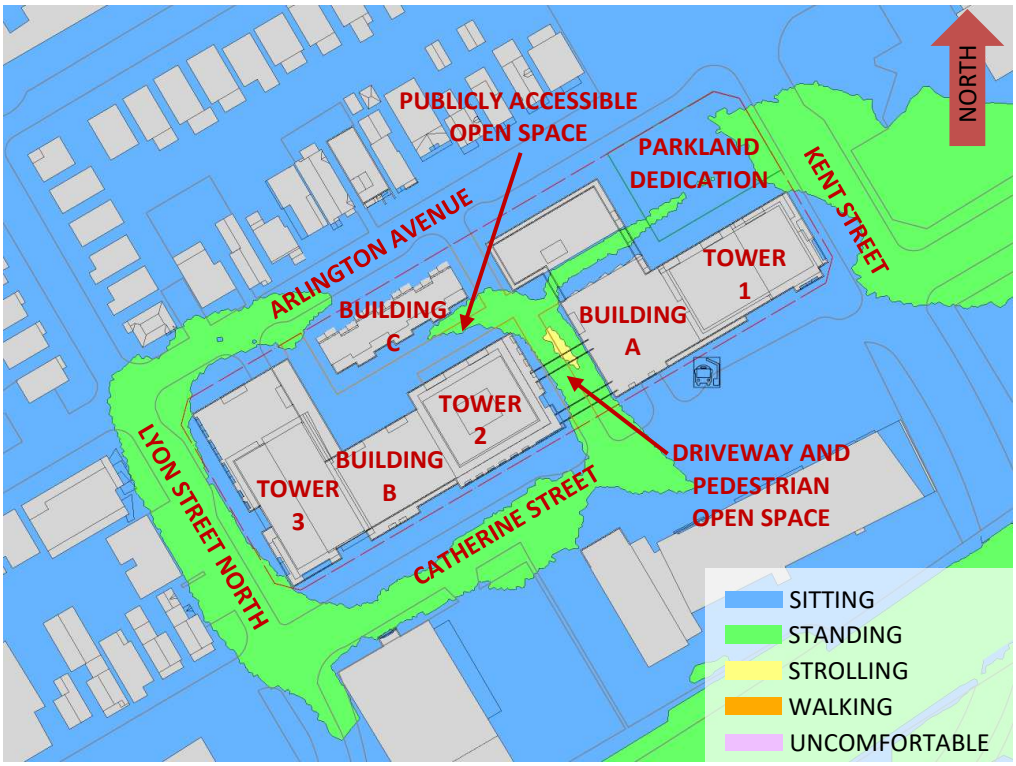

FIGURE 7: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

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

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

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

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

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

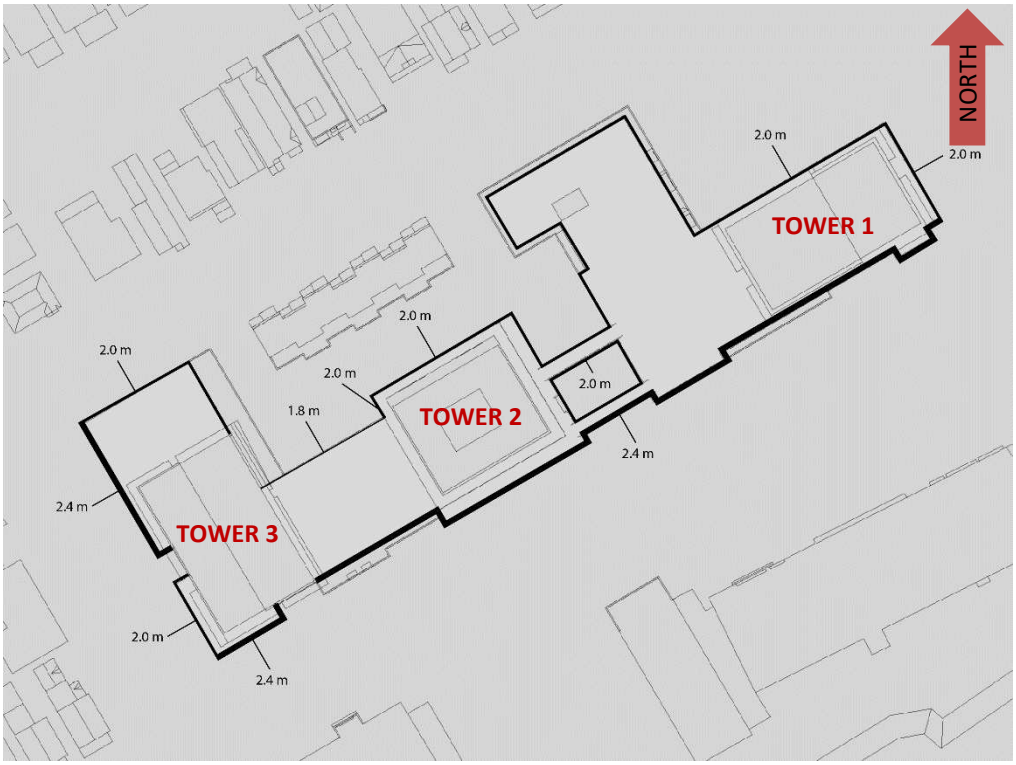

FIGURE 10: RECOMMENDED ROOFTOP PERIMETER WIND SCREENS

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	0.30
49	0.28
74	0.26
103	0.26
167	0.25
197	0.24
217	0.25
237	0.25
262	0.26
282	0.26
301	0.27
324	0.30

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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[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 Engineering Symposium, IWES 2003*, Taiwan, 2003.