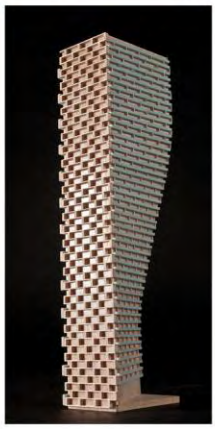
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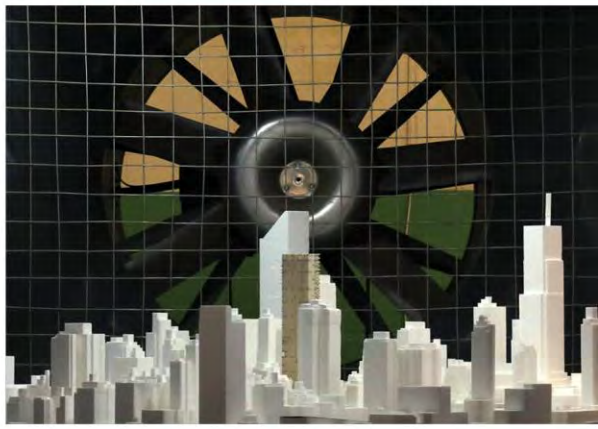
PEDESTRIAN LEVEL WIND STUDY

141-153 Plains Road West
Burlington, Ontario

Report: 23-143-PLW-2024







January 16, 2024

PREPARED FOR
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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study to satisfy concurrent Official Plan Amendment (OPA) and Zoning By-Law Amendment (ZBLA) application resubmission requirements for the proposed mixed-use residential development located at 141-153 Plains Road West in Burlington, Ontario (hereinafter referred to as the "subject site" or "proposed development"). Our mandate within this study is to investigate wind conditions within and surrounding the subject site, and to identify areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where required.

The study involves simulation of wind speeds for sixteen (16) 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 conditions within and surrounding the subject site according to City of Burlington wind comfort and safety criteria. A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-4B, and is 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, neighbouring existing surface parking lots, surface parking, drive aisles, walkways, and in the vicinity of building access points, are considered acceptable.

2) The common amenity terraces at Level 7 and the common amenity terrace along the west and north elevations at Level 11 were modelled with 1.8-m-tall wind screens along their full perimeters. Wind comfort conditions within the amenity terraces serving the proposed development during the summer season and recommendations regarding mitigation, where required, are described as follows:

    a. **West Level 7 Amenity Terrace**: With the noted 1.8-m-tall perimeter wind screen, wind comfort conditions are predicted to be suitable for mostly sitting with isolated regions suitable for standing to the north and south of the terrace.

- Depending on programming, the noted conditions may be considered acceptable. Specifically, if the two isolated windier areas will not accommodate seating or more sedentary activities, the noted wind conditions would be considered acceptable.

b. **Northeast Level 7 Amenity Terrace**: With the noted 1.8-m-tall perimeter wind screen, conditions are predicted to be suitable for sitting over a majority of the terrace with an isolated region suitable for standing near the northeast corner of the building.

c. **East Level 11 Amenity Terrace:** Wind conditions within the terrace along the east elevation of Level 11 are expected to be suitable for mostly sitting, which is considered acceptable.

d. **Northwest Level 11 Amenity Terrace**: With the noted 1.8-m-tall perimeter wind screen, wind conditions are predicted to be suitable for mostly standing, with conditions suitable for sitting predicted to the east and south of the terrace.

e. To improve comfort levels within the northeast Level 7 and northwest Level 11 amenity terraces, mitigation inboard of the terrace perimeters targeted around sensitive areas is recommended, in combination with tall wind screens (that is, greater than 1.8 m as measured from the local walking surface) along the perimeters of the terraces. This inboard mitigation could take the form of inboard wind screens or other common landscape elements.

f. The extent of mitigation measures is dependent on the programming of the noted terraces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses. This work is expected to support the future Site Plan Control application.

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 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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Appendix A – Simulation of the Atmospheric Boundary Layer

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by 2412947 Ontario Limited to undertake a pedestrian level wind (PLW) study to satisfy concurrent Official Plan Amendment (OPA) and Zoning By-Law Amendment (ZBLA) application resubmission requirements for the proposed mixed-use residential development located at 141-153 Plains Road West in Burlington, Ontario (hereinafter referred to as the "subject site" or "proposed development"). A PLW study was conducted in June 2023[1] for the previous design of the proposed development. Our mandate within this study is to investigate pedestrian wind conditions within and surrounding the subject site, and to identify areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where required.

The study is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, City of Burlington wind comfort and safety criteria, architectural drawings provided by AAA Architects Inc. in January 2024, surrounding street layouts and existing and approved future building massing information obtained from the City of Burlington, and recent site imagery.

2. TERMS OF REFERENCE

The subject site is located at 141-153 Plains Road West in Burlington, situated approximately 75 metres (m) to the west-southwest of the intersection of Plains Road West and Howard Road on a parcel of land bounded by Plains Road West to the southeast, low-rise buildings to the northeast and southwest, and a warehouse and industrial lot to the north and northwest. Throughout this report, Plains Road West is referred to as project south.



Architectural Rendering, Southeast Perspective (Courtesy of AAA Architects Inc.)

[1] Gradient Wind Engineering Inc., '*141-153 Plains Road West – Pedestrian Level Wind Study*', [June 15, 2023]

The proposed development comprises a near rectangular 11-storey mixed-use residential building, topped with a mechanical penthouse (MPH). Excluding the MPH, the building height is 36.1 m above local grade, while inclusive of the MPH, the building height above local grade is 41.4 m.

Above two underground parking levels, the ground floor of the proposed development includes an admin office and a residential lobby to the east, with a main entrance at the southeast corner and a secondary entrance at the northeast corner, a guest elevator lobby to the south, a retail space at the southwest corner, and a loading area, a staging area, and shared building support spaces to the north. A driveway from Plains Road West provides access to surface parking along the west elevation and to the parking ramp at the northwest corner of the proposed development. At Level 2, the building extends from the west elevation over the driveway. Levels 2-10 are reserved for residential use. The building steps back from the southwest elevation at Level 5 and from the east and west elevations at Level 7, accommodating common amenity terraces at Level 7. Level 11 includes indoor amenities to the north and residential units to the south. The building steps back from the south, west, and north elevations at this level. A large common amenity terrace extends along the west and north elevations at this level and a common amenity terrace is located along the northeast elevation.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within a 200 m radius of the subject site) are characterized by a mix of mid- and high-rise buildings from the east-northeast clockwise to the south-southwest and low-rise buildings in the remaining compass directions. The far-field surroundings (defined as the area beyond the near field and within a two-kilometre (km) radius) include low-rise massing from the north-northeast clockwise to the southwest, the open exposure of Lake Ontario, which is situated approximately 750 m to the southeast, from the east clockwise to the south-southwest, and a mix of low-rise massing, vacant lots, and green space in the remaining directions. Isolated mid-rise buildings and an isolated cluster of mid-rise buildings are situated to the northeast and to the south-southwest, respectively, along Plains Road West.

A site plan for the proposed massing scenario is illustrated in Figure 1, while Figures 2A-2D illustrate the computational model used to conduct the study.

3. OBJECTIVES

The principal objectives of this study are to (i) determine pedestrian level wind conditions at key areas within and surrounding the subject 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 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 Burlington area wind climate, and synthesis of computational data with City of Burlington wind criteria[2]. 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 John C. Munro Hamilton International Airport in Hamilton, Ontario. 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.

An industry standard practice is to omit trees, vegetation, and other existing and proposed 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 stronger wind speed values.

[2] City of Burlington, *Pedestrian Level Wind Study Guidelines and Terms of Reference,* June 2020

4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the subject site for 16 wind directions. The CFD simulation model was centered on the proposed development, complete with surrounding massing within a radius of 480 m.

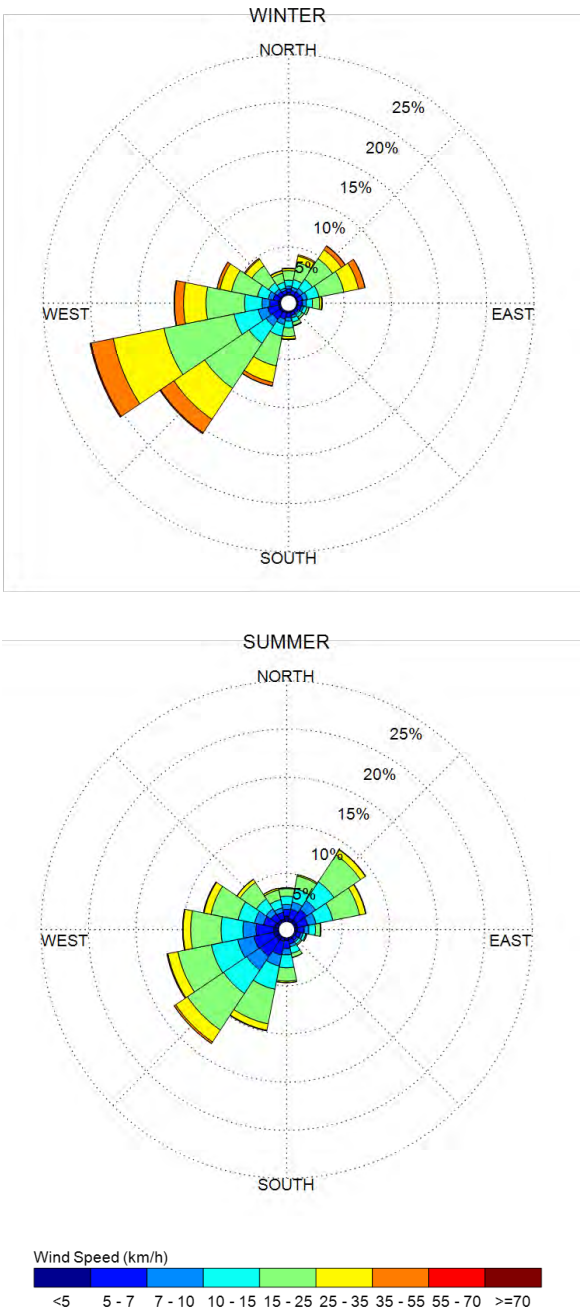
Mean and peak wind speed data obtained over the subject site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and the common amenity terraces serving the proposed development 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 Hamilton, representative of Burlington, was developed from approximately 50 years of hourly meteorological wind data recorded at John C. Munro Hamilton International Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were analyzed during the appropriate hours of pedestrian usage (that is, between 06:00 and 23:00) and divided into two distinct seasons, as stipulated in the wind criteria. Specifically, the summer season is defined as May through October, while the winter season is defined as November through April, inclusive.

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

SEASONAL DISTRIBUTION OF WIND
JOHN C. MUNRO HAMILTON INTERNATIONAL AIRPORT, HAMILTON, ONTARIO



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 Burlington

Pedestrian wind criteria are based on the mechanical effects of wind without consideration of other meteorological conditions, such as temperature and relative humidity. The comfort criteria assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Since both mean and gust wind speeds affect pedestrian comfort, their combined effect is defined in the City of Burlington Pedestrian Level Wind Study Guidelines and Terms of Reference. Specifically, the criteria are defined as a Gust Equivalent Mean (GEM) wind speed, which is the greater of the mean wind speed or the gust wind speed divided by 1.85. The wind speed ranges are based on the Beaufort scale, which describes the effects of forces produced by varying wind speed levels on objects. Five pedestrian comfort classes and corresponding gust wind speed ranges are used to assess pedestrian comfort: (1) Sitting; (2) Standing; (3) Leisurely Walking; (4) Fast Walking; and (5) Uncomfortable. Wind conditions suitable for sitting are represented by the colour purple, standing by blue, leisurely walking by green, and fast walking by yellow; uncomfortable conditions are represented by the colour red, consistent with the graphical standards of the City of Burlington Pedestrian Level Wind Study Guidelines and Terms of Reference. Specifically, the comfort classes, associated wind speed ranges, and limiting criteria are summarized as follows:

PEDESTRIAN WIND COMFORT CLASS DEFINITIONS

Wind Comfort Class	GEM Speed (km/h)	Description
SITTING	≤ 10	GEM wind speeds no greater than 10 km/h occurring at least 80% of the time would be considered acceptable for sedentary activities, including sitting.
STANDING	≤ 14	GEM wind speeds no greater than 14 km/h occurring at least 80% of the time are acceptable for activities such as standing or more vigorous activities.
LEISURELY WALKING	≤ 17	GEM wind speeds no greater than 17 km/h occurring at least 80% of the time are acceptable for leisurely walking, strolling, or more vigorous activities.
FAST WALKING	≤ 20	GEM wind speeds no greater than 20 km/h occurring at least 80% of the time are acceptable for fast walking or more vigorous activities.
UNCOMFORTABLE	> 20	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.

Regarding wind safety, gust wind speeds greater than 90 km/h, occurring more than 0.1% of the time on an annual basis (based on wind events recorded for 24 hours a day), are classified as dangerous. From calculations of stability, it can be shown that gust wind speeds of 90 km/h would be the approximate threshold wind speed that would cause an average elderly person in good health to fall.

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 GEM wind speeds of 10 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 GEM wind speeds of 20 km/h at a location were exceeded for more than 20% of the time, walking or less vigorous activities would be considered uncomfortable. As 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 subject 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 target 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 target comfort classes are summarized below. Depending on the programming of a space, the desired comfort class may differ from this table.

TARGET PEDESTRIAN WIND COMFORT CLASSES FOR VARIOUS LOCATION TYPES

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

5. RESULTS AND DISCUSSION

The following discussion of the predicted pedestrian wind conditions for the subject site is accompanied by Figures 3A-B, which illustrate wind conditions at grade level for the proposed massing scenario, and by Figures 4A-B, which illustrate conditions over the common amenity terraces serving the proposed development at Levels 7 and 11. Conditions are presented as continuous contours of wind comfort within and surrounding the subject site and correspond to the various comfort classes noted 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 Plains Road West and Howard Road: Following the introduction of the proposed development, wind conditions over the nearby public sidewalks along Plains Road West are predicted to be suitable for standing, or better, during the summer, becoming suitable for a mix of standing and leisurely walking during the winter. Wind conditions over the nearby public sidewalks along Howard Road are predicted to be suitable for standing, or better, during the summer, becoming suitable for leisurely walking, or better, during the winter. Conditions in the vicinity of the nearby transit stops along Plains Road West are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for standing during the winter. The noted conditions are considered acceptable.

While the introduction of the proposed development produces windier conditions over Plains Road West and Howard Road in comparison to existing conditions (refer to Section 5 of the noted previous PLW report mentioned in Section 1 for a detailed description of the predicted wind comfort conditions for the existing massing scenario), wind comfort conditions with the proposed development are nevertheless considered acceptable.

Neighbouring Existing Surface Parking Lots: Following the introduction of the proposed development, wind conditions over the neighbouring existing commercial parking lot situated to the north of the subject site are predicted to be suitable for standing, or better, during the summer, becoming suitable for a mix of mostly standing and leisurely walking during the winter. Conditions over the neighbouring existing parking lots situated to the east and west of the subject site are predicted to be suitable for standing, or better, throughout the year. The noted conditions are considered acceptable.

While the introduction of the proposed development produces windier conditions over the noted areas in comparison to existing conditions (refer to Section 5 of the noted previous PLW report mentioned in Section 1 of the present study for a detailed description of the predicted wind comfort conditions for the existing massing scenario), wind comfort conditions are nevertheless considered acceptable.

Surface Parking, Driveway, and Walkways within Subject Site: Wind comfort conditions over the surface parking along the west elevation of the subject site are predicted to be suitable for standing during the summer with an isolated region suitable for leisurely walking, becoming suitable for leisurely walking during the winter with an isolated region suitable for fast walking. Conditions over the driveway and walkways within the subject site are predicted to be suitable for standing, or better, during the summer with isolated regions suitable for leisurely walking, becoming suitable for leisurely walking, or better, during the winter with isolated regions suitable for fast walking. The noted conditions are considered acceptable.

Building Access Points: Wind conditions in the vicinity of the secondary building access points to the covered drive aisle along the west elevation of the proposed development are predicted to be suitable for leisurely walking, or better, throughout the year, while wind 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 common amenity terraces at Level 7 and the common amenity terrace along the west and north elevations at Level 11 were modelled with 1.8-m-tall wind screens along their full perimeters. Wind comfort conditions during the summer season within the common amenity terraces serving the proposed development and recommendations regarding mitigation, where required, are described as follows:

West Level 7 Amenity Terrace: With the noted wind mitigation along the terrace perimeter as described in the introductory paragraph, wind comfort conditions within the amenity terrace serving the proposed development at Level 7 to the west are predicted to be suitable for mostly sitting with isolated regions suitable for standing to the north and south of the terrace, as illustrated in Figure 4A. Where conditions are suitable for standing, they are also suitable for sitting for at least 79% of the time to the south and 77% of the time to the north during the same period, where the target is 80% to achieve the sitting comfort criterion.

Depending on the programming of the west Level 7 amenity terrace, the noted conditions may be considered acceptable. Specifically, if the two isolated windier areas will not accommodate seating or more sedentary activities, the noted wind conditions would be considered acceptable.

Northeast Level 7 Amenity Terrace: With the noted wind mitigation along the terrace perimeter as described in the introductory paragraph, conditions within the amenity terrace serving the proposed development at Level 7 at the northeast corner are predicted to be suitable for sitting over the majority of the terrace with an isolated region suitable for standing near the northeast corner of the building. Where conditions are predicted to be suitable for standing, they are also predicted to be suitable for sitting for at least 72% of the time during the same period, where the target is 80% to achieve the sitting comfort criterion.

East Level 11 Amenity Terrace: Wind conditions within the terrace along the east elevation of Level 11 (not shown in Figure 4A) are expected to be suitable for mostly sitting, which is considered acceptable.

Northwest Level 11 Amenity Terrace: With the noted wind mitigation at the terrace perimeter as described in the introductory paragraph, wind conditions within the amenity terrace serving the proposed development along the west and north elevations at Level 11 are predicted to be suitable for mostly standing, with conditions suitable for sitting to the east and south of the terrace. Where conditions are predicted to be suitable for standing, they are also predicted to be suitable for sitting for at least 65% of the time during the same period, where the target is 80% to achieve the sitting comfort criterion.

To improve comfort levels within the amenity terrace serving the proposed development at Level 7 at the northeast corner and within the amenity terrace serving the proposed development at Level 11 along the north and west elevations, mitigation inboard of the terrace perimeters targeted around sensitive areas is recommended, in combination with tall wind screens (that is, greater than 1.8 m as measured from the local walking surface) along the perimeters of the terraces. This inboard mitigation could take the form of inboard wind screens or other common landscape elements.

The extent of mitigation measures is dependent on the programming of the noted terraces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses. This work is expected to support the future Site Plan Control application.

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. SUMMARY AND RECOMMENDATIONS

A complete summary of the predicted wind conditions is provided in Section 5 of this report and illustrated in Figures 3A-4B. Based on computer simulations using the CFD technique, meteorological data analysis, 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, neighbouring existing surface parking lots, surface parking, drive aisles, walkways, and in the vicinity of building access points, are considered acceptable.

2) The common amenity terraces at Level 7 and the common amenity terrace along the west and north elevations at Level 11 were modelled with 1.8-m-tall wind screens along their full perimeters. Wind comfort conditions within the amenity terraces serving the proposed development during the summer season and recommendations regarding mitigation, where required, are described as follows:

    a. **West Level 7 Amenity Terrace**: With the noted 1.8-m-tall perimeter wind screen, wind comfort conditions are predicted to be suitable for mostly sitting with isolated regions suitable for standing to the north and south of the terrace.

        - Depending on programming, the noted conditions may be considered acceptable. Specifically, if the two isolated windier areas will not accommodate seating or more sedentary activities, the noted wind conditions would be considered acceptable.

    b. **Northeast Level 7 Amenity Terrace**: With the noted 1.8-m-tall perimeter wind screen, conditions are predicted to be suitable for sitting over a majority of the terrace with an isolated region suitable for standing near the northeast corner of the building.

    c. **East Level 11 Amenity Terrace:** Wind conditions within the terrace along the east elevation of Level 11 are expected to be suitable for mostly sitting, which is considered acceptable.

d. **Northwest Level 11 Amenity Terrace**: With the noted 1.8-m-tall perimeter wind screen, wind conditions are predicted to be suitable for mostly standing, with conditions suitable for sitting predicted to the east and south of the terrace.

e. To improve comfort levels within the northeast Level 7 and northwest Level 11 amenity terraces, mitigation inboard of the terrace perimeters targeted around sensitive areas is recommended, in combination with tall wind screens (that is, greater than 1.8 m as measured from the local walking surface) along the perimeters of the terraces. This inboard mitigation could take the form of inboard wind screens or other common landscape elements.

f. The extent of mitigation measures is dependent on the programming of the noted terraces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses. This work is expected to support the future Site Plan Control application.

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 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,

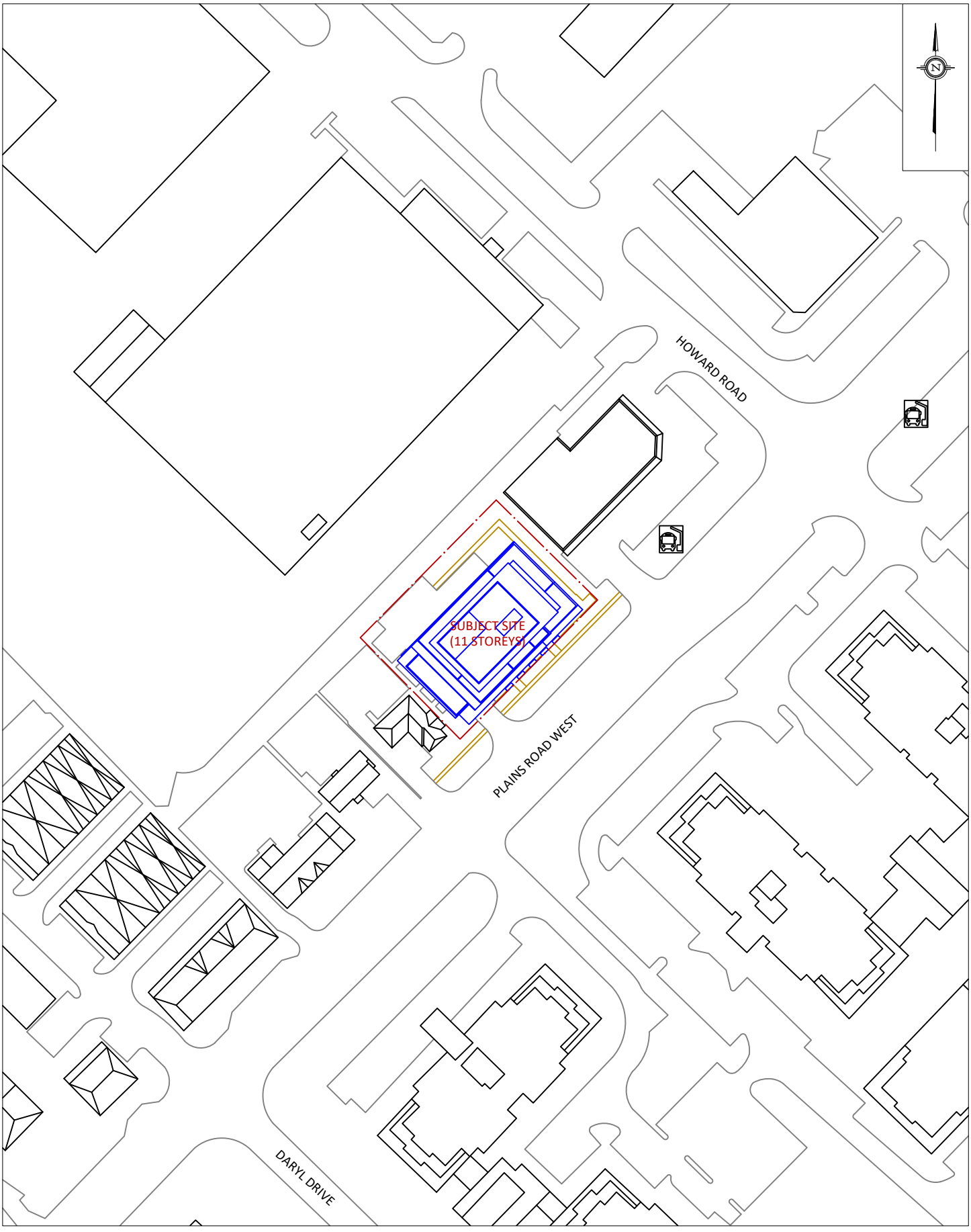
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PROJECT	141-153 PLAINS ROAD WEST, BURLINGTON PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1500
DRAWING NO.	23-143-PLW-2024-1
DATE	JANUARY 16, 2024
DRAWN BY	S.K.

DESCRIPTION

FIGURE 1:
PROPOSED SITE PLAN AND SURROUNDING CONTEXT

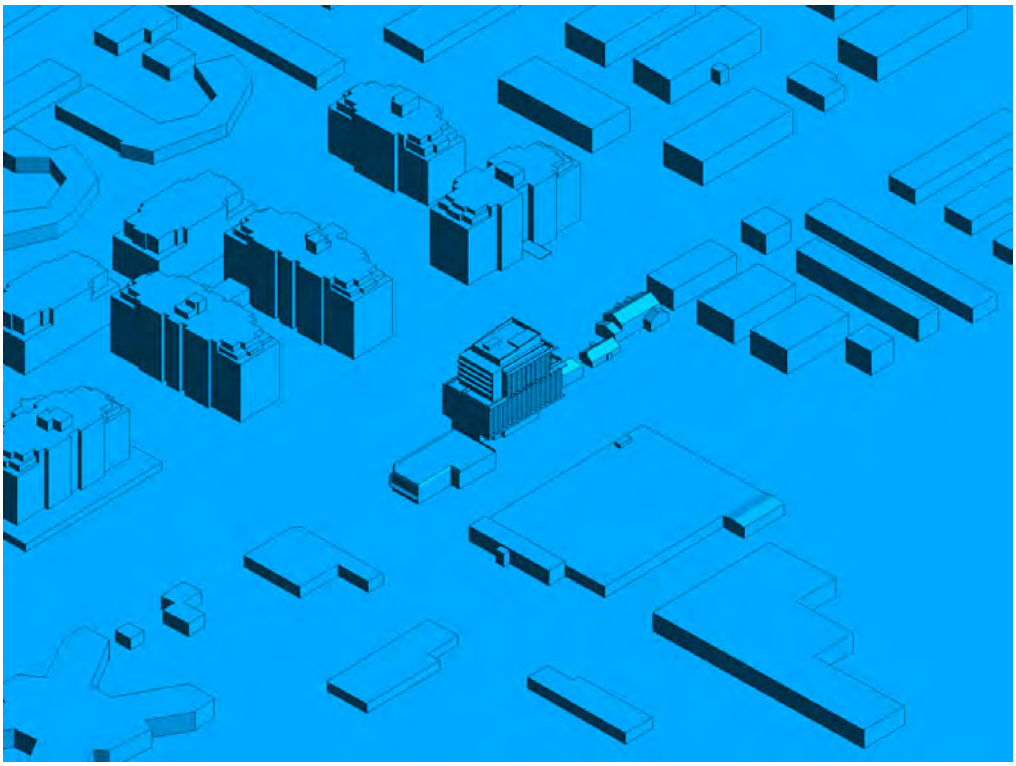


FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTH PERSPECTIVE

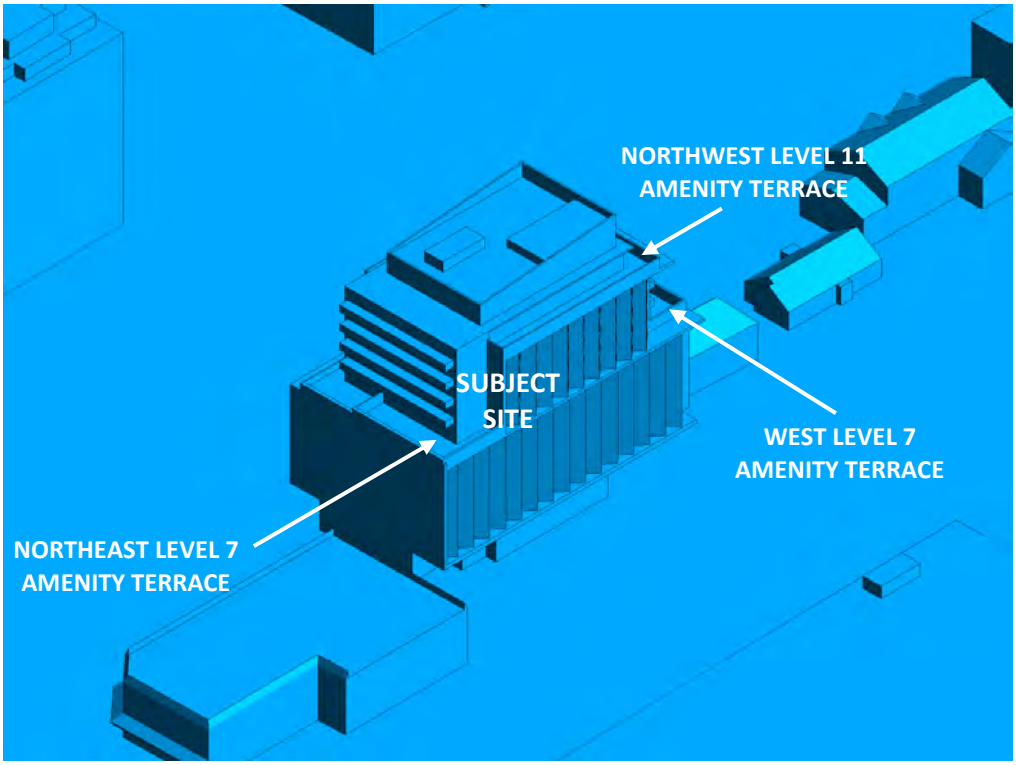


FIGURE 2B: CLOSE-UP VIEW OF FIGURE 2A

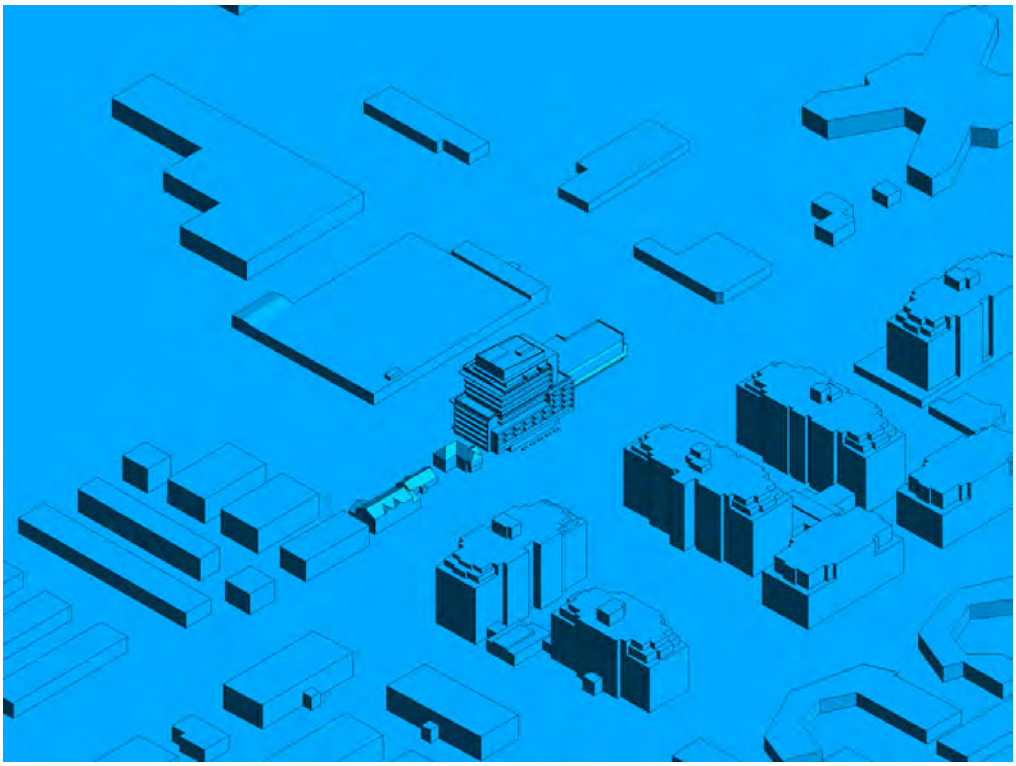


FIGURE 2C: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTH PERSPECTIVE

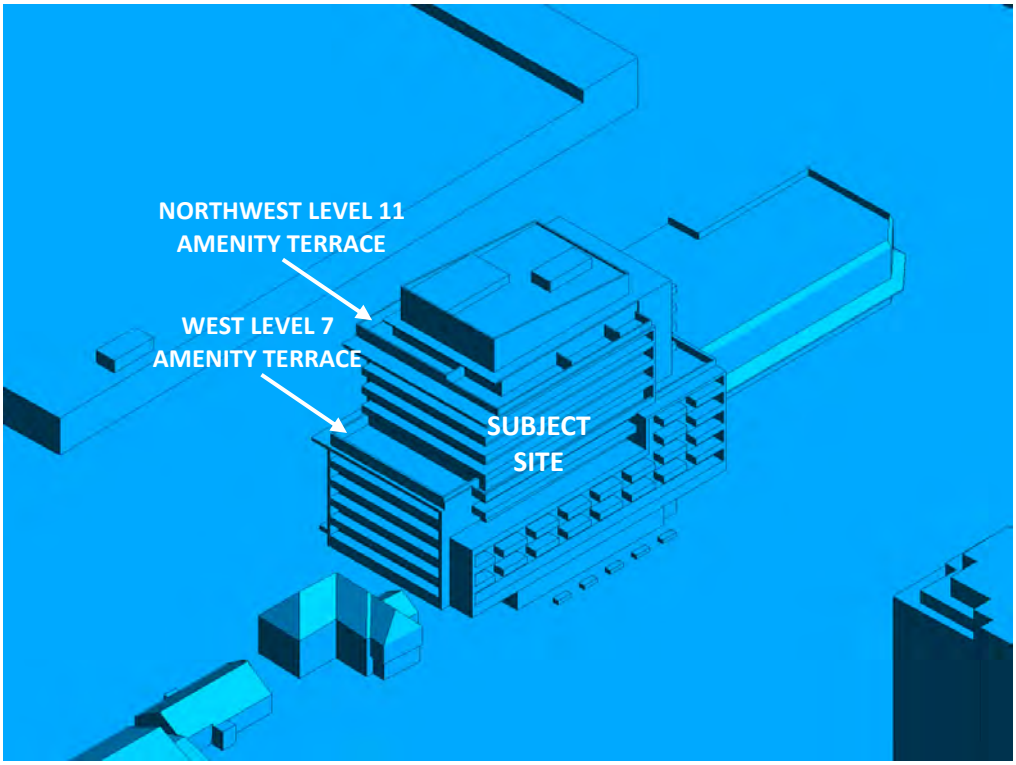


FIGURE 2D: CLOSE-UP VIEW OF FIGURE 2C

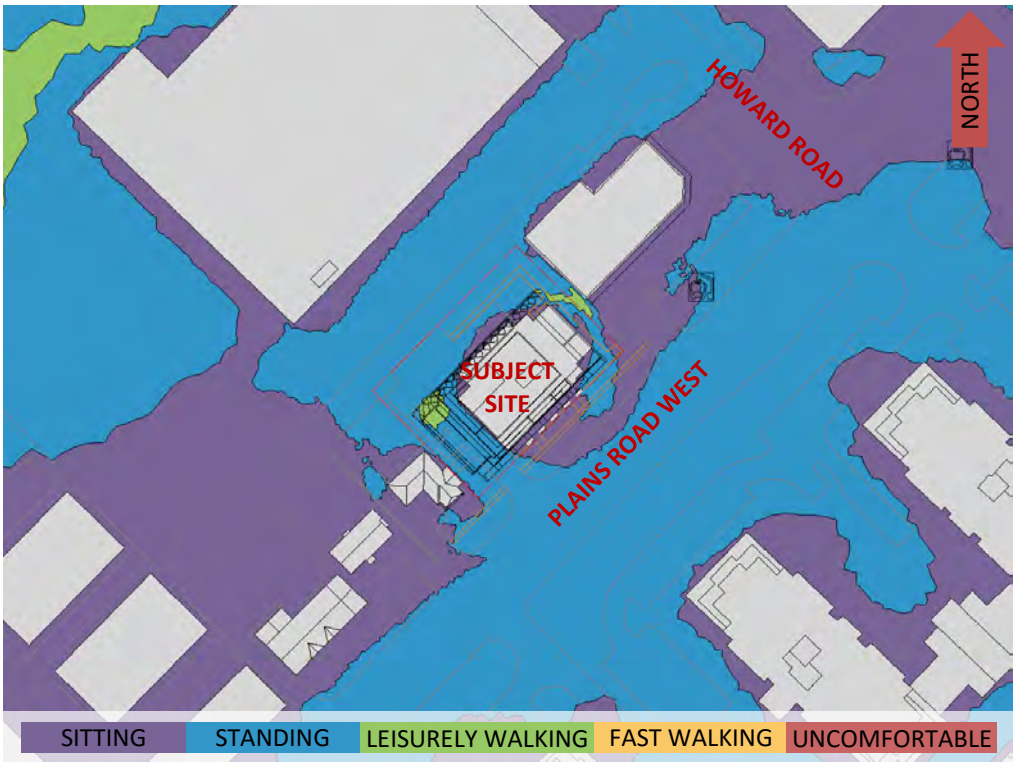


FIGURE 3A: SUMMER – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL

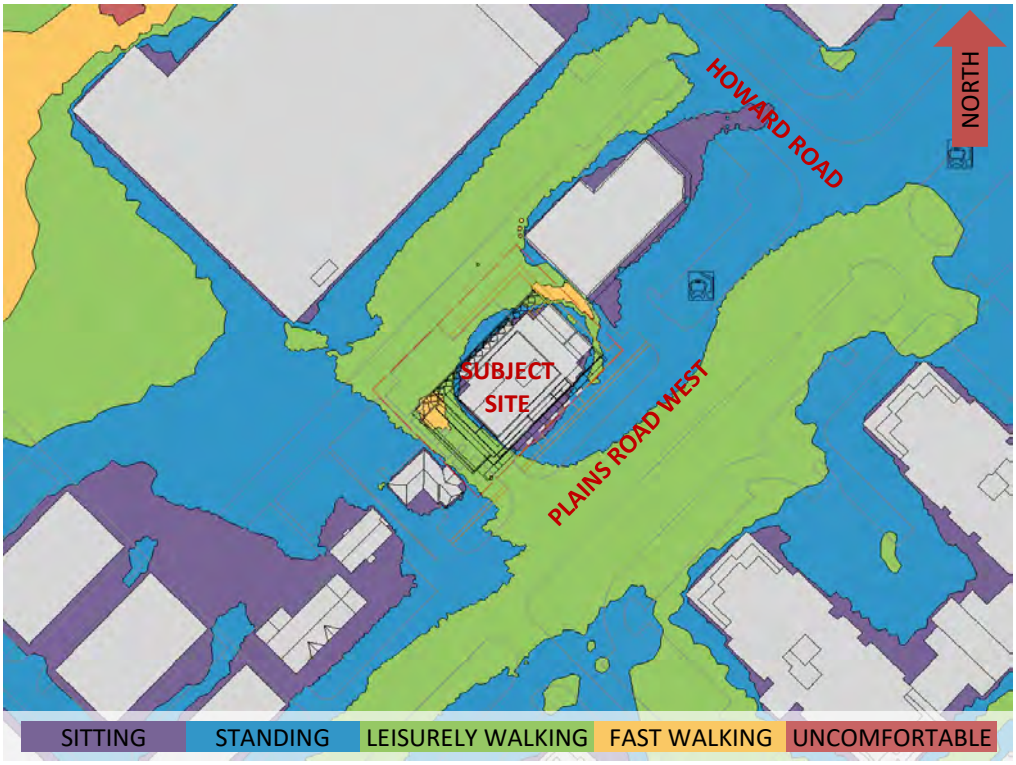


FIGURE 3B: WINTER – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL

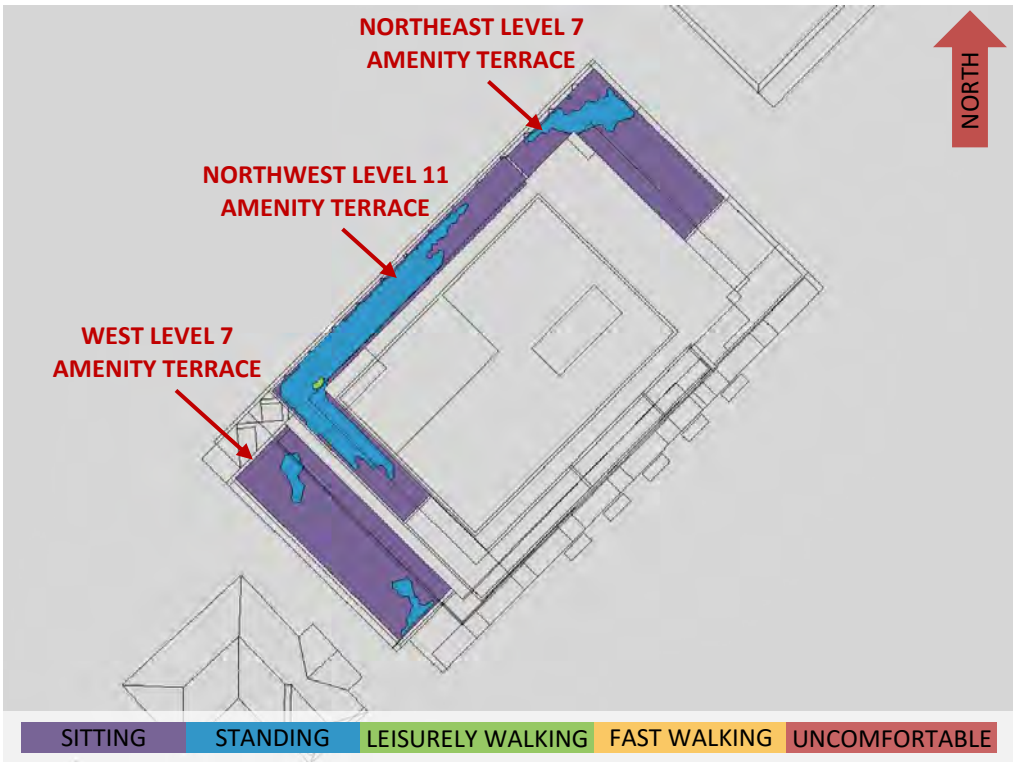


FIGURE 4A: SUMMER – WIND COMFORT, COMMON AMENITY TERRACES

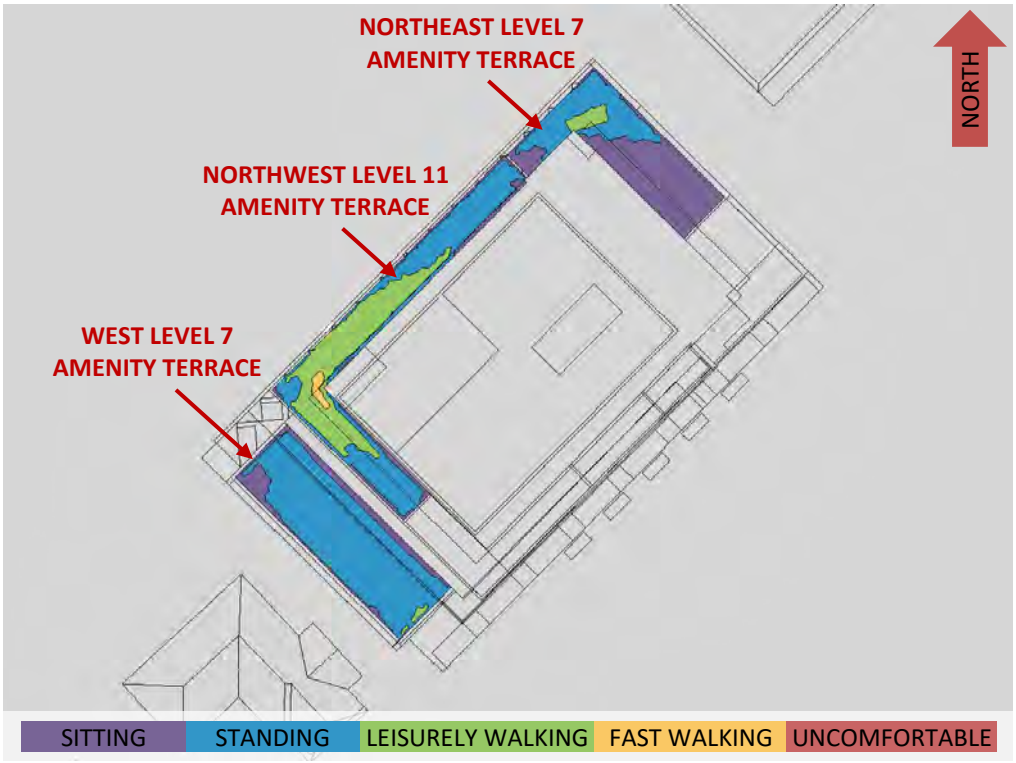


FIGURE 4B: WINTER – WIND COMFORT, COMMON AMENITY TERRACES



APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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

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

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

For the model, U_g is set to 6.5 metres per second (m/s), which approximately corresponds to the 50% mean wind speed for Burlington 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 is 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	0.20
22.5	0.22
45	0.23
67.5	0.23
90	0.20
112.5	0.17
135	0.18
157.5	0.20
180	0.22
202.5	0.22
225	0.21
247.5	0.20
270	0.19
292.5	0.20
315	0.20
337.5	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.

REFERENCES

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

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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.