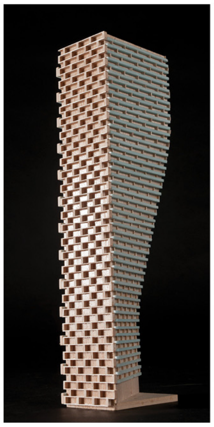
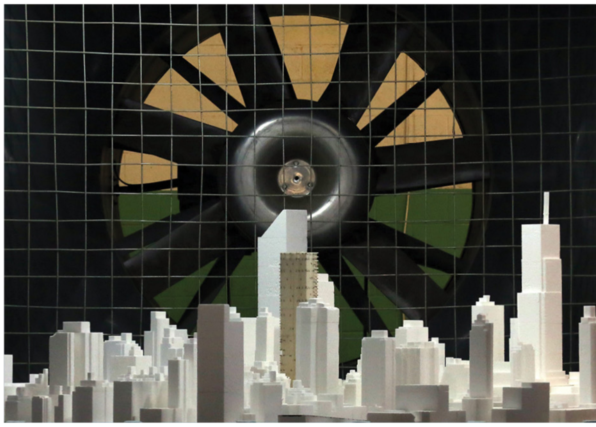
PEDESTRIAN LEVEL WIND STUDY

6333 Hurontario Street
Mississauga, Ontario

Report: 21-007-PLW





February 8, 2021

PREPARED FOR
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EXECUTIVE SUMMARY

This report summarizes the results of a comparative computer based pedestrian level wind (PLW) study undertaken to satisfy Zoning By-law Amendment (ZBA) requirements for the proposed development at 6333 Hurontario Street in Mississauga, Ontario. This work is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, City of Mississauga wind comfort and safety criteria, architectural drawings provided by TACT Architecture in January 2021, surrounding street layouts and existing and approved future building massing information obtained from the City of Mississauga, as well as recent site imagery.

A complete summary of the predicted wind comfort and safety conditions is provided in Section 5 of this report and illustrated in Figures 3A-5B, following the main text. Based on CFD test results, interpretation, and experience with similar developments, we conclude the following:

1) All grade level areas within and surrounding the development site are predicted to be acceptable for the intended pedestrian uses following the introduction of the proposed development. While the wind conditions at grade are generally predicted to be somewhat windier than the existing conditions, the increases in wind speed at grade are consistent with expectations for a tall building in an open or suburban context. Specifically, wind conditions over surrounding sidewalks, walkways, transit stops, and building access points are considered acceptable.

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

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

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Dymon Capital Corporation to undertake a comparative pedestrian level wind (PLW) study to satisfy Zoning By-law Amendment (ZBA) requirements for the proposed development at 6333 Hurontario Street in Mississauga, Ontario (hereinafter referred to as the "subject site"). Our mandate within this study is to investigate pedestrian wind comfort within and surrounding the subject site, and to identify any areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where necessary.

Our work is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, City of Mississauga wind comfort and safety criteria, architectural drawings provided by TACT Architecture Inc., in January 2021, surrounding street layouts and existing and approved future building massing information obtained from the City of Mississauga, as well as recent site imagery.

2. TERMS OF REFERENCE

The subject site is located on a parcel of land situated near the southeast corner of the intersection of Hurontario Street and World Drive. Throughout this report, the Hurontario Street elevation is referred to as the west elevation.

The proposed development comprises a 7-storey building with a nearly rectangular floor plan at grade. Above two storeys of underground parking, the ground floor comprises Dymon reception and retail space, self-storage, loading area, at-grade parking, and lobby space, while the second through sixth floors comprise office and self-storage space, with floor plates setting back on floors 5, 6, and 7. Floor 7 comprises self-storage facility space exclusively, with floor plates setting back on the west side, setting off the tower from the office component. Vehicular access to loading/parking is accessible via an internal laneway off Hurontario Street to the west.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within 200-metres (m) of the site) are characterized by mostly low-rise commercial massing in all directions. The far-field surroundings (defined as the area beyond the near field and within a two-kilometer (km) radius) are similar to the near-field, comprising mostly low-rise commercial massing in all directions, with some isolated taller buildings to the south-southeast, and some low-rise residential massing to the west-southwest. The MacDonald-Cartier Freeway runs southwest-northeast approximately 450 m to the southeast.

Site plans for the proposed and existing massing scenarios are illustrated in Figures 1A and 1B, respectively, while Figures 2A-2D illustrate the computational models used to conduct the study.

3. OBJECTIVES

The principal objectives of this study are to: (i) determine comparative pedestrian level wind comfort and safety conditions at key outdoor areas; (ii) identify areas where future 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 subject site is based on CFD simulations of wind speeds across the subject site within a virtual environment, meteorological analysis of the Mississauga wind climate, and synthesis of computational data with industry-accepted criteria[1]. The following sections describe the analysis procedures, including a discussion of the comfort criteria.

[1] Mississauga, Urban Design Terms of Reference, *Pedestrian Wind Comfort and Safety Studies*, June 2014

4.1 Computer-Based Context Modelling

A computer based PLW wind 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 historical weather data obtained from Lester B. Pearson International Airport in Mississauga, Ontario.

The general concept and approach to CFD modelling is to represent building and topographic details in the immediate vicinity of the study site on the surrounding model, and to create suitable atmospheric wind profiles at the model boundary. The wind profiles are designed to have similar mean and turbulent wind properties consistent with actual site exposures. An industry standard practice is to omit trees, vegetation, and other existing and planned landscape elements from the model due to the difficulty of providing accurate seasonal representation of vegetation. The omission of trees and other landscaping elements produces slightly more conservative (i.e., windier) wind speed values.

4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the site for 12 wind directions and two massing scenarios, as noted in Section 2. The simulation model was centered on the subject site and included surrounding massing within a diameter of 410 m.

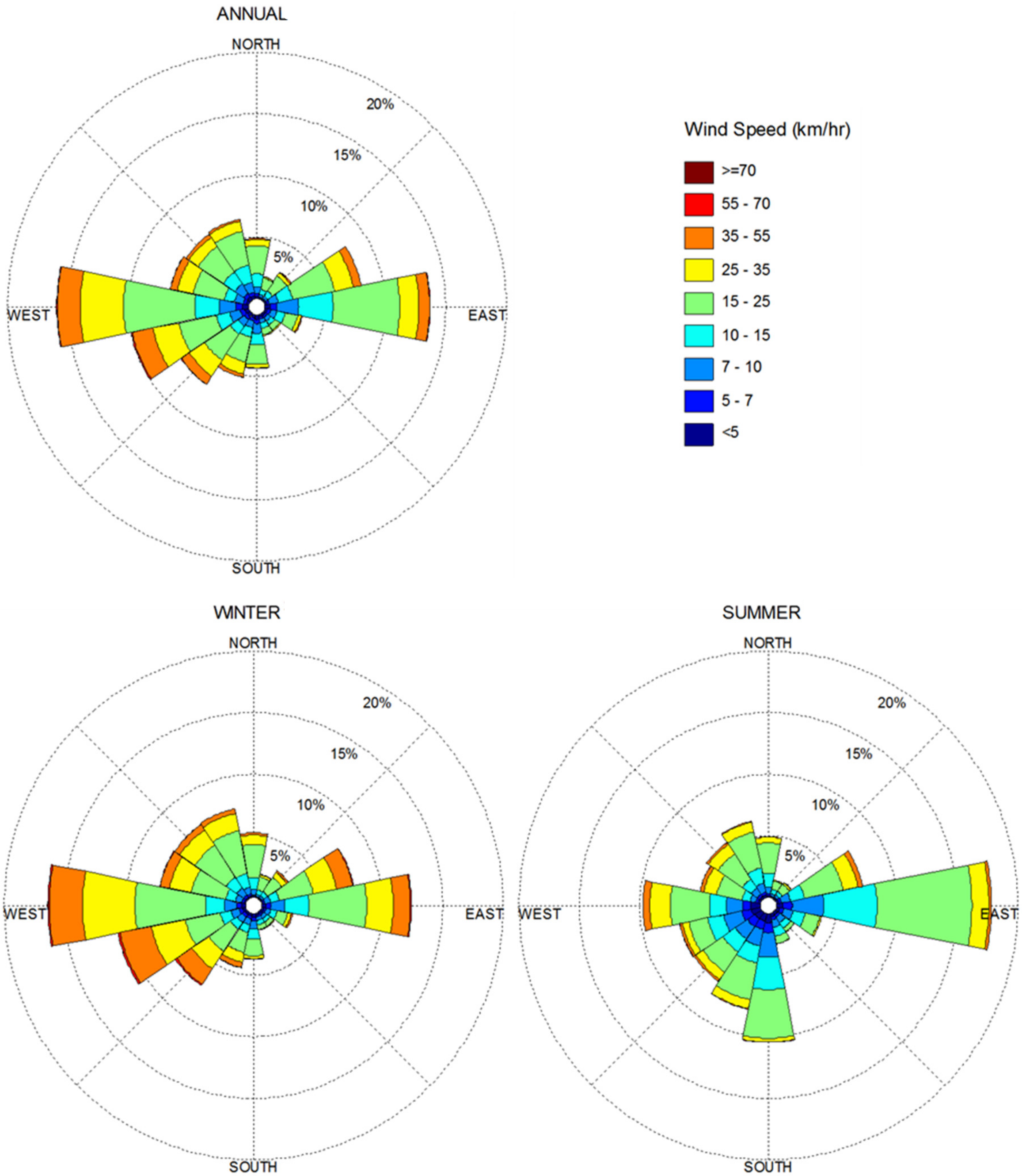
Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds on a continuous measurement plane 1.5 m above local grade were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. The gradient height represents the theoretical depth of the boundary layer of the earth's atmosphere, above which the mean wind speed remains constant. Further details of the CFD wind flow simulation technique are presented in Appendix A.

4.3 Meteorological Data Analysis

A statistical model for winds in Mississauga was developed from approximately 40 years of hourly meteorological wind data recorded at Lester B. Pearson International Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were analyzed during the appropriate hours of pedestrian usage (i.e., 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 Mississauga 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 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 Mississauga (north of the Queen Elizabeth Way, or QEW), the common winds concerning pedestrian comfort occur from the south clockwise to the north, as well as those from the east. The directional preference and relative magnitude of the wind speed varies somewhat from season to season, with the summer months displaying the calmest winds relative to the remaining seasonal periods.

SEASONAL DISTRIBUTION OF WIND
LESTER B. PEARSON INTERNATIONAL AIRPORT, MISSISSUAGA, 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 Mississauga

Pedestrian wind comfort criteria are based on mechanical wind effects without consideration of other meteorological conditions (i.e., temperature and relative humidity). The criteria provide an assessment of comfort, assuming 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 Mississauga Urban Design Terms of Reference. More 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 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.

Four pedestrian comfort classes and corresponding gust wind speed ranges are used to assess pedestrian comfort, which include: (i) Sitting; (ii) Standing; (iii) Walking; and (iv) Uncomfortable. Specifically, the comfort classes, associated wind speed ranges, and limiting criteria are summarized as follows:

(i) **Sitting** – GEM wind speeds no greater than 10 km/h (i.e., 0-10 km/h) occurring at least 80% of the time would be considered acceptable for sedentary activities, including sitting.

(ii) **Standing** – GEM wind speeds no greater than 15 km/h (i.e., 0-15 km/h) occurring at least 80% of the time are acceptable for activities such as standing, strolling or more vigorous activities.

(iii) **Walking** – GEM wind speeds no greater than 20 km/h (i.e., 0-20 km/h) occurring at least 80% of the time are acceptable for walking or more vigorous activities.

(iv) **Uncomfortable** – Uncomfortable conditions are characterized by predicted values that fall below the 80% criterion 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, 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.

THE BEAUFORT SCALE

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

Experience and research on people's perception of mechanical wind effects has shown that if the wind speed levels are exceeded for more than 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 or more sedentary activities. 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 site, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for discrete regions within and surrounding the subject site. This step involves comparing the predicted comfort classes to the desired comfort classes, which are dictated by the location type for each region (i.e., a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their desired comfort classes are summarized on the following page.

DESIRED PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES

Location Types	Desired Comfort Classes
Primary Building Entrance	Standing
Secondary Building Access Point	Standing / Walking
Public Sidewalks / Pedestrian Walkways	Walking
Outdoor Amenity Spaces	Sitting / Standing
Cafés / Patios / Benches / Gardens	Sitting / Standing
Plazas	Sitting / Standing / Walking
Transit Stops	Sitting / Standing
Public Parks	Sitting / Standing / Walking
Garage / Service Entrances	Walking
Vehicular Drop-Off Zones	Standing / Walking
Laneways / Loading Zones	Walking

5. RESULTS AND DISCUSSION

The following discussion of the predicted pedestrian wind conditions for the subject site is accompanied by Figures 3A-4B, which illustrate seasonal wind conditions at grade level for the proposed and existing massing scenarios. The wind conditions are presented as continuous contours of wind comfort within and surrounding the subject site. The colour contours indicate predicted regions of the various comfort classes noted in Section 4.4. Wind conditions suitable for sitting are represented by the colour green, standing by yellow, and walking by blue.

5.1 Wind Comfort Conditions

Sidewalk and Building Entrances along Hurontario Street: Following the introduction of the proposed building, the sidewalk along Hurontario Street is predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for a mix of sitting, standing, and walking in the winter. Owing to the protection of the building façade, conditions in the vicinity of building entrances along Hurontario Street are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing during the winter. The noted conditions are considered acceptable.

The introduction of the proposed building results in similar or slightly windier conditions along the Hurontario Street sidewalk, in comparison to existing conditions. Under the existing massing scenario, conditions are suitable for a mix of sitting and standing during the summer, becoming suitable for mostly standing during the winter. The increases in wind speed at grade are consistent with expectations for a tall building in an open or suburban context.

Laneway, Parking, and Building Entrances Along South Elevation: Conditions over the laneway and parking along the south elevation are predicted to be suitable for mostly sitting during the summer, becoming suitable for a mix of sitting, standing, and walking during the winter, with the walking conditions located to the southeast and southwest corners of the laneway. Owing to the protection of the building façade, conditions in the vicinity of building entrances are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable.

Laneway, Parking, and Secondary Building Entrances Along East Elevation: Conditions over the laneway and parking along the east elevation are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for a mix of sitting, standing, and walking during the winter, with the walking conditions located near the northwest corner of the building. Owing to the protection of the building façade, conditions in the vicinity of the secondary building entrances along the east elevation are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable.

Laneway and Secondary Building Entrances Along North Elevation: Conditions over the laneway along the north elevation are predicted to be suitable for mostly sitting during the summer, with standing conditions near the northeast and northwest corners of the building, becoming suitable for mostly standing during the winter, with walking conditions near the northeast and northwest corners of the building. Owing to the protection of the building façade, conditions in the vicinity of the secondary building entrances along the north elevation are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing during the winter. The noted conditions are considered acceptable according to the comfort guidelines in Section 4.4.

5.2 Wind Safety

The forgoing statements and conclusions apply to common weather systems, during which no dangerous or consistently strong wind conditions are expected anywhere over the subject site. During extreme weather events, (e.g., 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.

5.3 Applicability of Results

The introduction of the proposed development is not expected to significantly influence pedestrian wind comfort over neighbouring areas. Nearby building entrances, sidewalks, laneways, parking areas, transit stops, and other pedestrian-sensitive areas beyond the development site are expected to continue to receive wind conditions similar to those that presently exist prior to the introduction of the proposed development.

Pedestrian wind comfort and safety have been quantified for the specific configuration of existing and foreseeable construction around the study site. Future changes (i.e., construction or demolition) of these surroundings may cause changes to the wind effects in two ways, namely: (i) changes beyond the immediate vicinity of the site would alter the wind profile approaching the site; and (ii) development in proximity to the site would cause changes to local flow patterns. In general, development in urban centers creates reduction in the mean wind speeds and localized increases in the gustiness of the wind.

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

6. SUMMARY AND RECOMMENDATIONS

This report summarizes the results of a comparative computer based PLW study undertaken to satisfy Zoning By-law Amendment (ZBA) requirements for the proposed development at 6333 Hurontario Street in Mississauga, Ontario. This work is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, City of Mississauga wind comfort and safety criteria, architectural drawings provided by TACT Architecture Inc., in January 2021, surrounding street layouts and existing and approved future building massing information obtained from the City of Mississauga, as well as recent site imagery.

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

Sincerely,

Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
J. D. FERRARO
100158495
Feb 8, 2021
PROVINCE OF ONTARIO

Daniel Davalos, MESc.
Junior Wind Scientist

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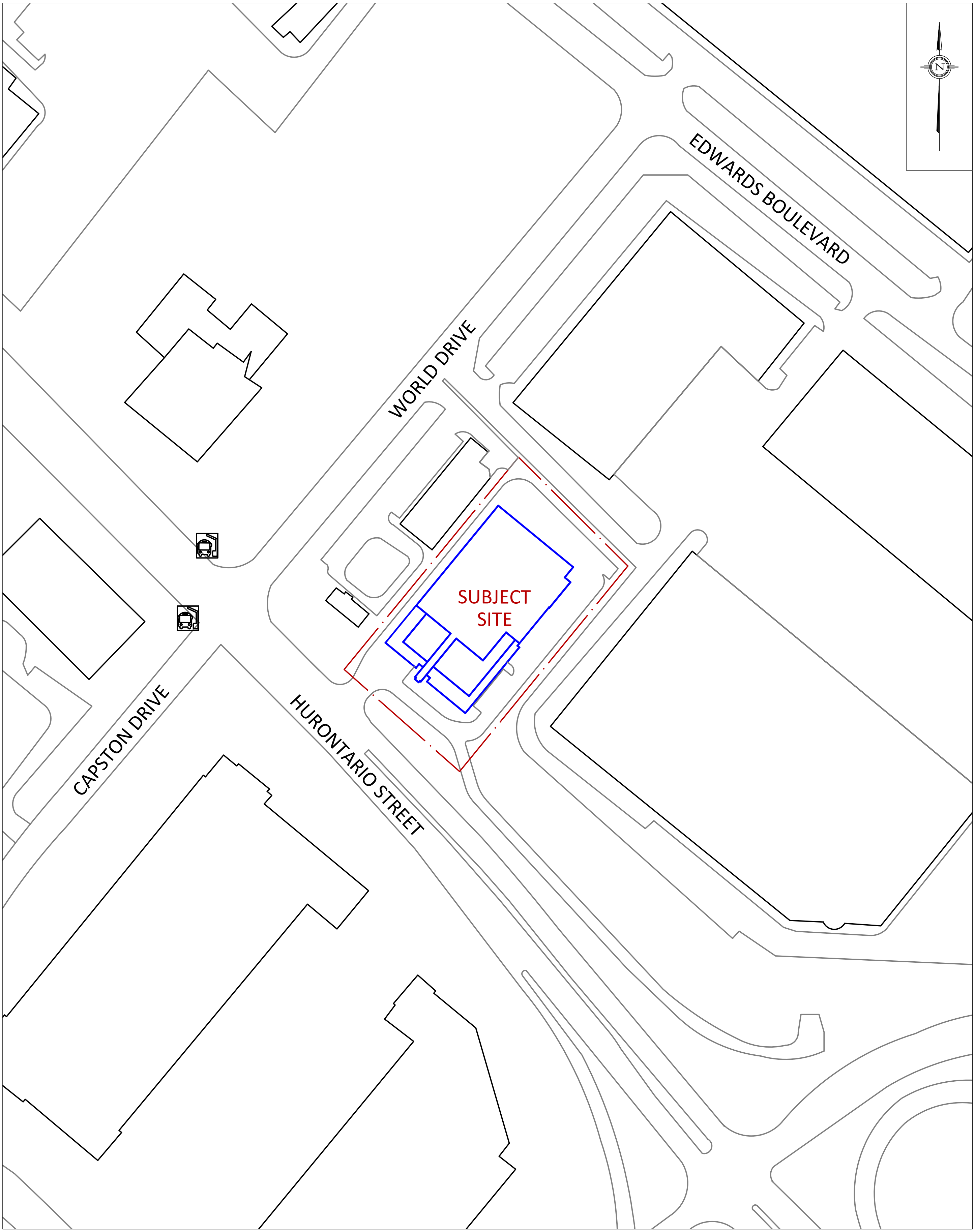

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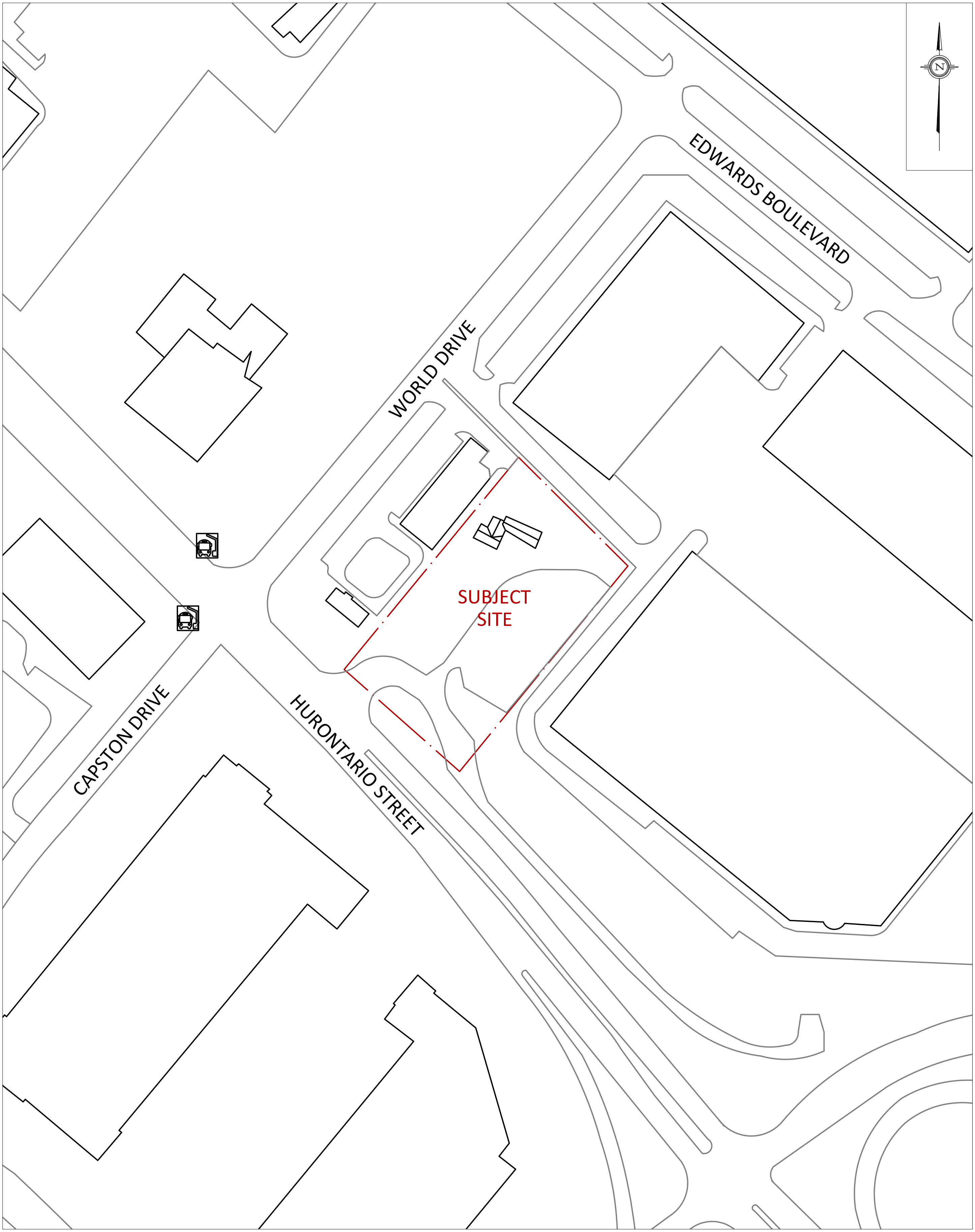
PROJECT	6333 HURONTARIO STREET, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:2500	DRAWING NO.	21-007-PLW-1A
DATE	JANUARY 29, 2021	DRAWN BY	N.M.P.

DESCRIPTION

FIGURE 1A:
PROPOSED SITE PLAN AND SURROUNDING CONTEXT



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PROJECT		DESCRIPTION
6333 HURONTARIO STREET, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		FIGURE 1B: EXISTING SITE PLAN AND SURROUNDING CONTEXT
SCALE: 1:2500	DRAWING NO.: 21-007-PLW-1B	
DATE: JANUARY 29, 2021	DRAWN BY: N.M.P.	

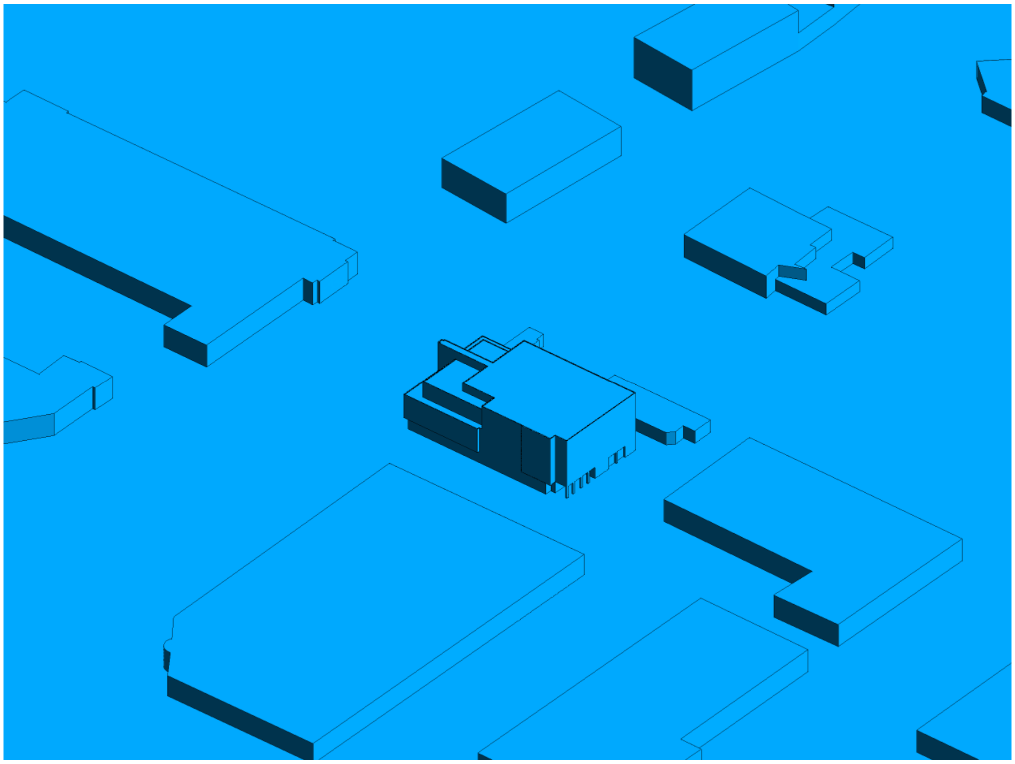

FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING SCENARIO, EAST PERSPECTIVE

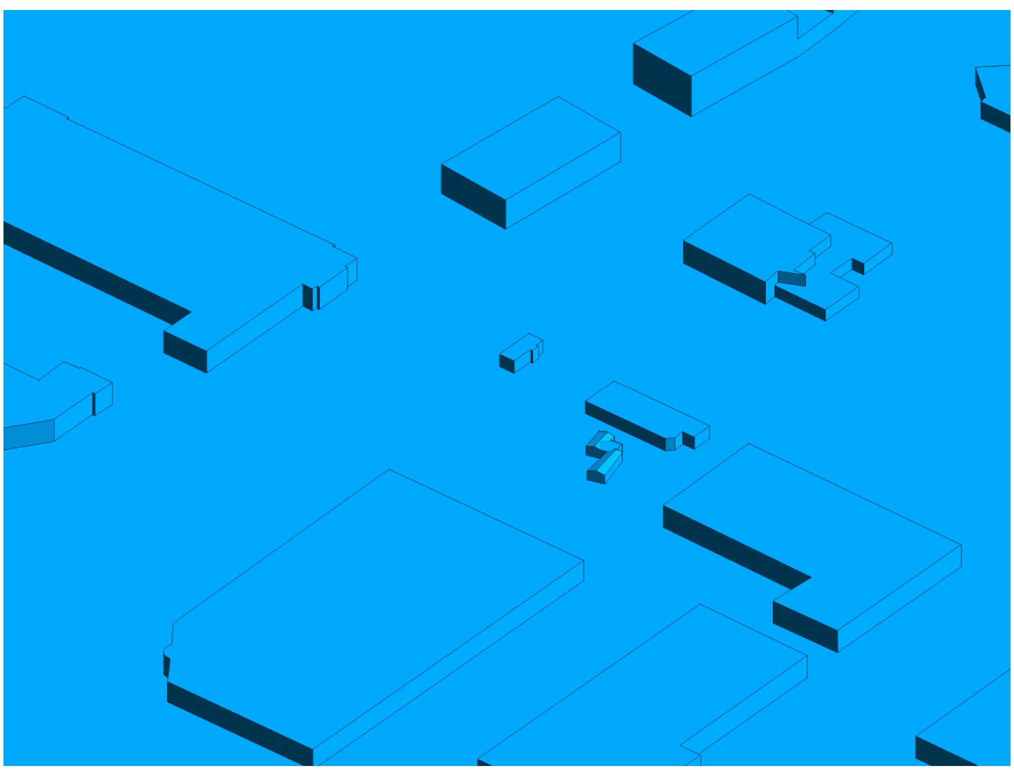

FIGURE 2B: COMPUTATIONAL MODEL, EXISTING MASSING SCENARIO, EAST PERSPECTIVE

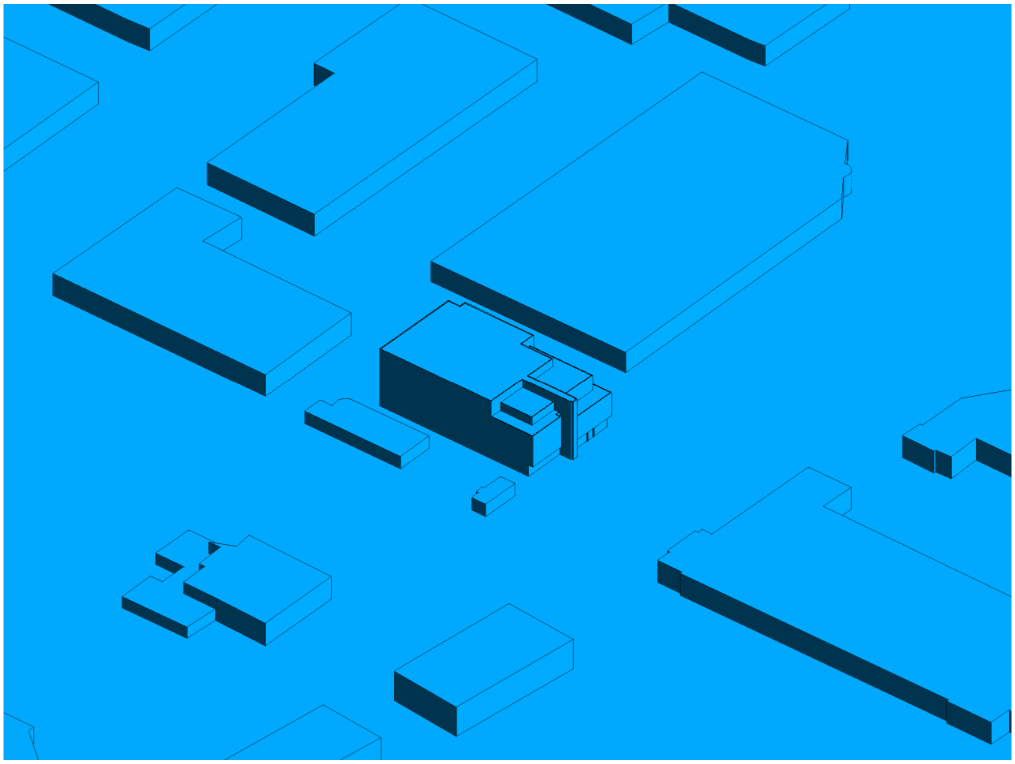

FIGURE 2C: COMPUTATIONAL MODEL, PROPOSED MASSING SCENARIO, WEST PERSPECTIVE

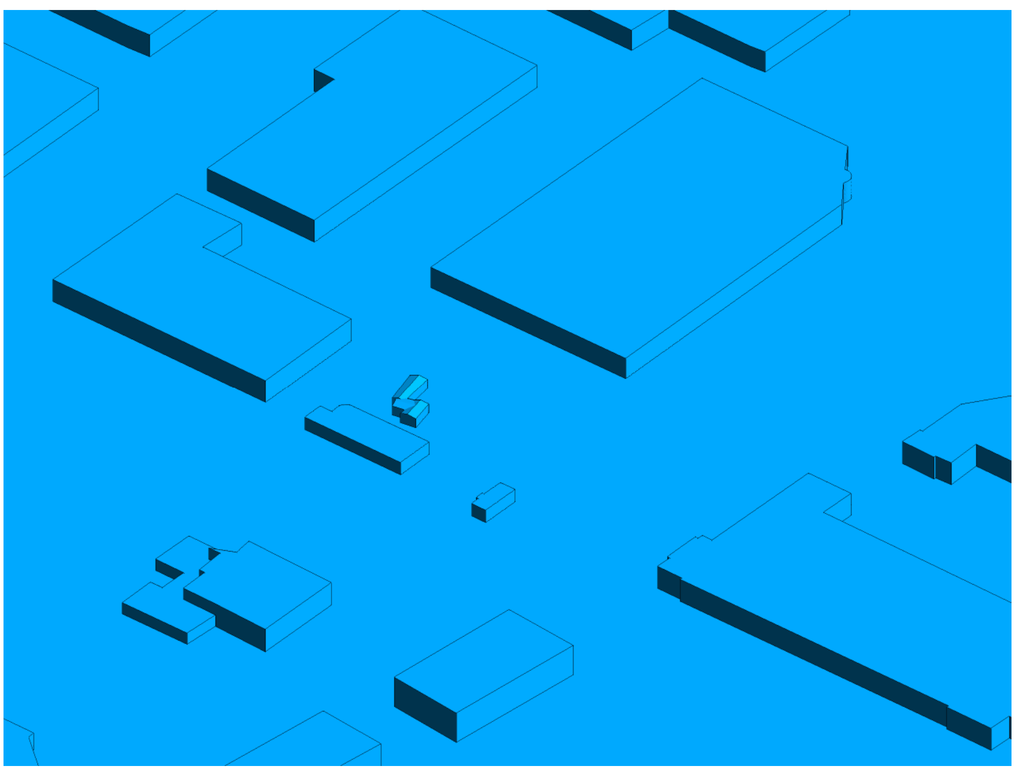

FIGURE 2D: COMPUTATIONAL MODEL, EXISTING MASSING SCENARIO, WEST PERSPECTIVE

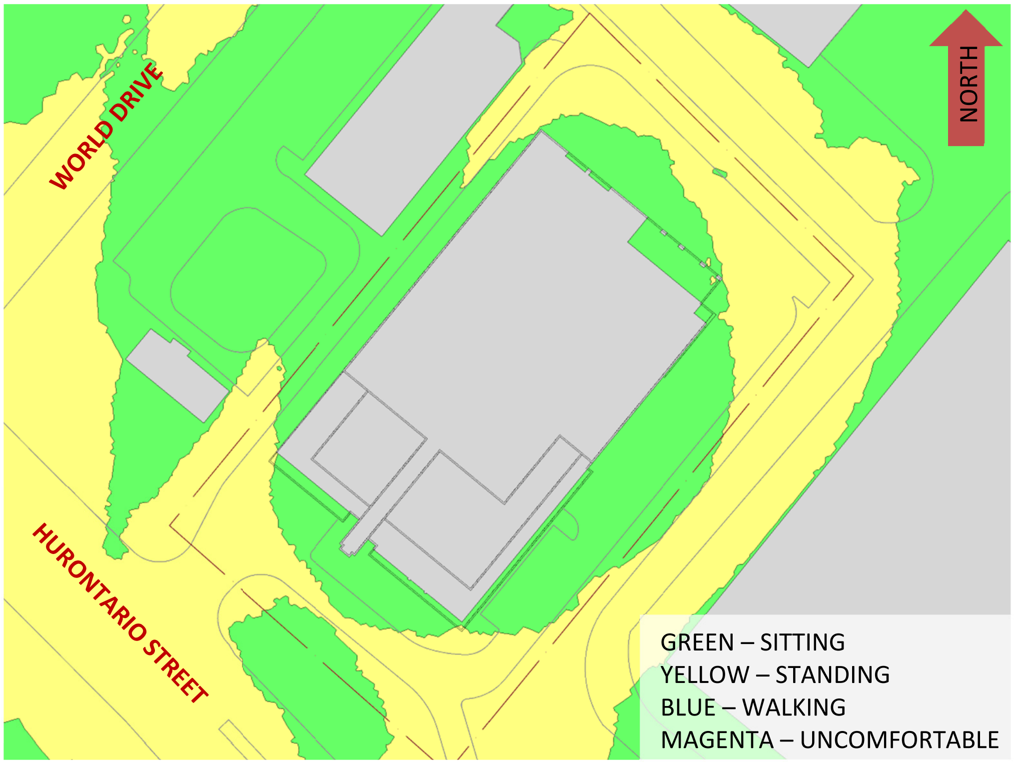

FIGURE 3A: SUMMER – PROPOSED MASSING – WIND COMFORT CONDITIONS, GRADE LEVEL

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

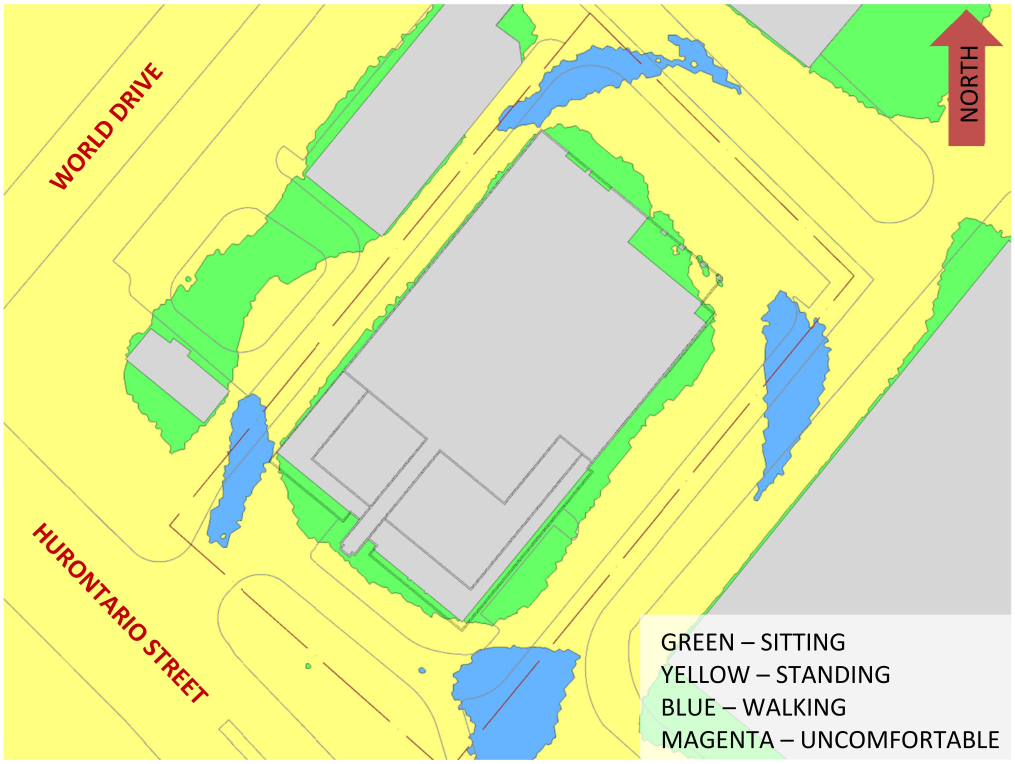

FIGURE 4A: WINTER – PROPOSED MASSING – WIND COMFORT CONDITIONS, GRADE LEVEL

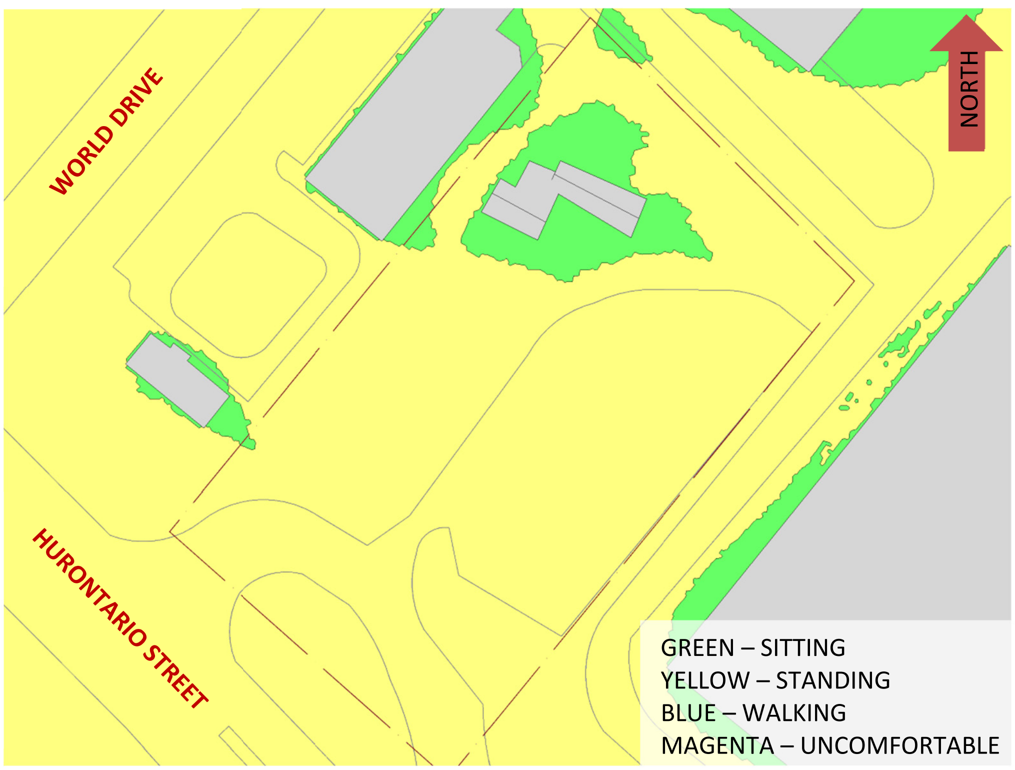

FIGURE 4B: WINTER – EXISTING MASSING – WIND COMFORT CONDITIONS, GRADE LEVEL

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].

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

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 Mississauga based on historical data and statistical analyses. When the results are normalized by this velocity, they are relatively insensitive to the selection of gradient wind speed.

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

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

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

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

Wind Direction (Degrees True)	Alpha Value (α)
0	0.23
40	0.23
97	0.23
136	0.22
170	0.24
210	0.23
237	0.23
258	0.24
278	0.24
300	0.23
322	0.22
341	0.23

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].

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

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

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

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