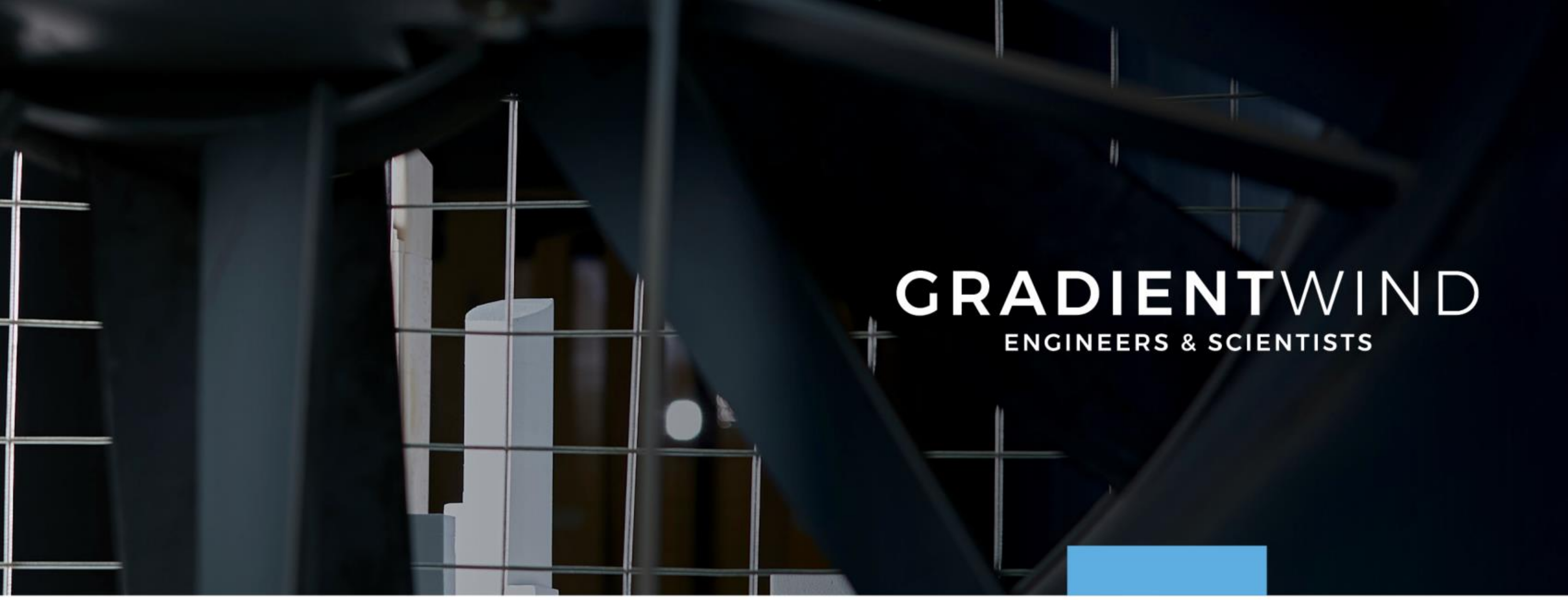
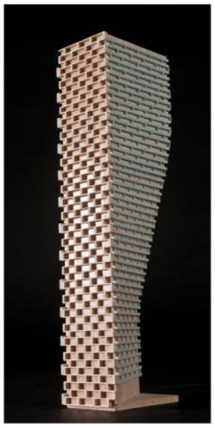
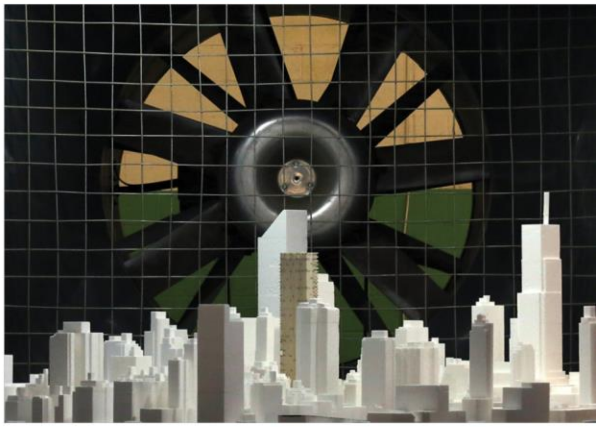


PEDESTRIAN LEVEL WIND STUDY

1407 Lakeshore Road East
Mississauga, Ontario

Report: 21-431-PLW





March 31, 2022

PREPARED FOR
1407 Lakeshore Developments Inc.
8 Steelcase Road West
Markham, ON L3R 1B2

PREPARED BY
Daniel Davalos, MESc., Junior Wind Scientist
Steven Hall, M.A.Sc., P.Eng., Senior Wind Engineer

EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study to satisfy concurrent Zoning By-law Amendment and Site Plan Control application requirements for the proposed mixed-use residential development located at 1407 Lakeshore Road East in Mississauga, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate pedestrian wind comfort and safety 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 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. A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-5B, and is summarized as follows:

1) All areas within and surrounding the subject site are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, walkways, building access points, surface parking areas, and Lakeshore Park are considered acceptable.

2) Conditions over the Level 9 amenity terrace are predicted to be suitable for sitting during the summer, which is considered acceptable according to the comfort guidelines in Section 4.4.

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, (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.

Addendum: The detailed PLW study was performed based on architectural drawings received in December 2021. An update from RAW Design Inc. on February 14, 2022, indicated only minor changes which are not expected to change the main conclusions of the study. One notable change is that the entrances along Lakeshore Road East are now recessed, which will provide a small beneficial effect near the entrances.

GRADIENTWIND
ENGINEERS & SCIENTISTS

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by 1407 Lakeshore Developments Inc. to undertake a pedestrian level wind (PLW) study to satisfy concurrent Zoning By-law Amendment and Site Plan Control application requirements for the proposed mixed-use residential development located at 1407 Lakeshore Road East in Mississauga, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate pedestrian wind comfort and safety 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.

Our work is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, industry standard wind comfort and safety guidelines, architectural drawings prepared by RAW Design Inc., in December 2021, surrounding street layouts and existing and approved future building massing information obtained from the City of Mississauga, recent satellite imagery, and experience with numerous similar developments.

2. TERMS OF REFERENCE

The subject site is situated at 1407 Lakeshore Road East in Mississauga on the southwest corner of a nominally rectangular parcel of land bordered by Lakeshore Road East to the south, Orchard Hill Road to the north, Deta Road to the east, and Cherriebell Road to the west. The proposed development comprises a nine-storey building plus mechanical penthouse level, with a nominally "L" shaped planform, with its long axis-oriented along Cherriebell Road. Throughout this report, the Lakeshore Road East elevation is referred to as the south elevation.

Above two levels of below-grade parking, the ground floor comprises retail space along the south elevation, a residential lobby and residential space along the west elevation, loading access and bicycle storage along the north elevation, and access to the underground parking at the northeast corner of the building. From Level 2 through 8, the building includes residential space and private terraces. The north elevation of the building steps back at each level from Level 4 to the roof, which creates a 45-degree angular plane. At Level 9, the building steps back along the south and west elevations to provide an outdoor amenity. The remainder of the level includes indoor amenity space along the south and west elevations, and the mechanical penthouse at the northeast corner of the floor.

Regarding wind exposures, the near-field surroundings (defined as an area falling within a 200-metre (m) radius of the subject site) include the open exposure of the Lakeshore Park to the southeast of Lakeshore Road East, and mostly low-rise buildings for the remaining directions. Notably, the Lakeshore Park is located to the immediate southeast of the subject site, and the Orchard Hill Park is located approximately 180 m to the north-northeast. The far-field surroundings (defined as the area beyond the near field and within a 2-kilometre (km) radius) include a mix of mostly low-rise massing and green space from the north clockwise to the east-northeast, a mix of green space and the open exposure of Lake Ontario from the east-northeast clockwise to the south-southwest, and a mix of low-rise massing and green space for the remaining compass directions. Notably, the Lakeview Golf Course is located from the west clockwise to the north approximately 400 m from the subject site. The Queen Elizabeth Way runs southwest-northeast approximately 2 km to the northwest, and Lake Ontario is located approximately 700 m to the southeast.

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 changes which have been approved by the City of Mississauga.

3. OBJECTIVES

The principal objectives of this study are to (i) determine pedestrian level wind comfort and safety conditions at key areas within and surrounding the 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 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 Mississauga area wind climate, and synthesis of computational data with industry-accepted guidelines[1]. The following sections describe the analysis procedures, including a discussion of the noted pedestrian wind guidelines.

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 Billy Bishop Toronto City 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.

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 slightly more conservative (i.e., windier) wind speed values.

[1] Mississauga, Urban Design Terms of Reference, *Pedestrian Wind Comfort and Safety Studies*, June 2014 https://www.mississauga.ca/wp-content/uploads/2020/02/06113559/Pedesterian-Level-Wind-Comfort-Studies.pdf [accessed Jan 12, 2022]

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 12 wind directions. The CFD simulation model was centered on the proposed development, complete with surrounding massing within a diameter of 1020 m.

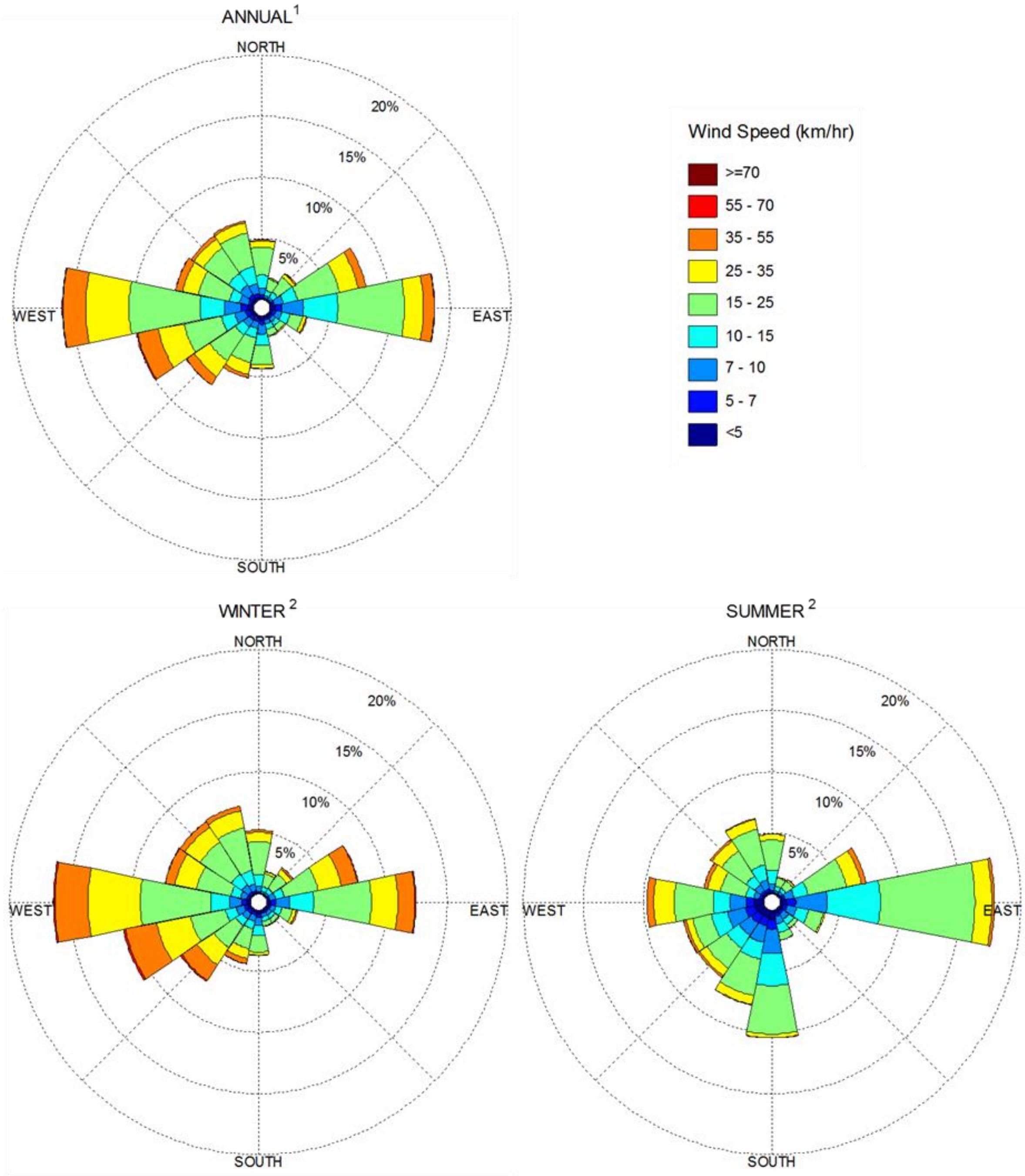
Mean and peak wind speed data obtained over the subject site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and the common amenity terrace were referenced to the wind speed 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 Mississauga was developed from approximately 40 years of hourly meteorological wind data recorded at Billy Bishop Toronto City 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 area wind climate, which indicates the directional character of local winds on a seasonal basis, is illustrated on the following page. The plots illustrate seasonal distribution of measured wind speeds and directions in kilometers per hour (km/h). Probabilities of occurrence of different wind speeds are represented as stacked polar bars in sixteen azimuth divisions. The radial direction represents the percentage of time for various wind speed ranges per wind direction during the measurement period. The preferred wind speeds and directions can be identified by the longer length of the bars. For Mississauga (south of the Queen Elizabeth Way, or QEW), the most common winds occur for westerly wind directions, followed by those from the east, while the most common wind speeds are below 36 km/h. The directional preference and relative magnitude of wind speed changes somewhat from season to season.

SEASONAL DISTRIBUTION OF WIND
BILLY BISHOP TORONTO CITY AIRPORT, TORONTO, 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 Comfort and Safety Guidelines – City of Mississauga

Pedestrian wind comfort and safety guidelines are based on the mechanical effects of wind without consideration of other meteorological conditions (i.e., temperature, relative humidity). The comfort guidelines 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 Mississauga Urban Design 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 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. Five pedestrian comfort classes and corresponding gust wind speed ranges are used to assess pedestrian comfort: (1) Sitting; (2) Standing; (3) Strolling, (4) Walking; and (5) Uncomfortable. Specifically, the comfort classes, associated wind speed ranges, and limiting criteria are summarized as follows:

1) **Sitting:** 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.

2) **Standing:** GEM wind speeds no greater than 15 km/h occurring at least 80% of the time are acceptable for activities such as standing, strolling or more vigorous activities.

3) **Strolling:** GEM wind speeds no greater than 17 km/h occurring at least 80% of the time are acceptable for walking or more vigorous activities.

4) **Walking:** GEM wind speeds no greater than 20 km/h occurring at least 80% of the time are acceptable for walking or more vigorous activities.

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.

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	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 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 guidelines 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 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 typical windiest desired comfort classes are summarized on the following table. 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 (During Typical Use Period)
Café / Patio / Bench / Garden	Sitting (Typical Use Period)
Transit Stop (Without Shelter)	Standing
Transit Stop (With Shelter)	Walking
Public Park / Plaza	Sitting (Typical Use Period)
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-4B, which illustrate wind conditions at grade level for the proposed and existing massing scenarios, and by Figures 5A-5B, which illustrate wind conditions over the Level 9 amenity terrace serving the proposed development. 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. Wind 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 magenta.

Conditions at all areas studied are considered acceptable for the intended pedestrian uses. The details of these conditions are summarized in the following pages for each area of interest.

5.1 Wind Comfort Conditions – Grade Level

Building Access Points and Sidewalk along Lakeshore Road East: Conditions over the sidewalk along Lakeshore Road East are predicted to be suitable for a mix of sitting and standing during the summer, becoming mostly suitable for a mix of standing and strolling during the winter. During the winter, conditions near the southwest corner of the subject site are predicted to be suitable for walking. Conditions in the vicinity of the building access points along Lakeshore Road East 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.

Conditions over the sidewalk along Lakeshore Road East with the existing massing are predicted to be suitable for sitting during the summer, becoming suitable for standing during the winter. While the introduction of the proposed development results in windier conditions in comparison to existing conditions, wind conditions with the proposed development are considered acceptable according to the comfort guidelines in Section 4.4.

Building Access Points and Sidewalk along Cherriebell Road: Conditions over the sidewalk along Cherriebell Road are predicted to be suitable for a mix of sitting and standing during the summer, becoming mostly suitable for a mix of standing and strolling during the winter. During the winter, conditions near the southwest corner of the subject site are predicted to be suitable for walking. Conditions in the vicinity of the building access points on the west elevation are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the comfort guidelines in Section 4.4.

Conditions over the sidewalk along Cherriebell Road with the existing massing are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing during winter. While the introduction of the proposed development results in windier conditions in comparison to existing conditions, wind conditions with the proposed development are considered acceptable according to the comfort guidelines in Section 4.4.

Driveway and Building Access Points Along North Elevation: Conditions over the driveway along the north elevation are predicted to be suitable for sitting during the summer, with an isolated region suitable for standing at the northeast corner of the building. During the winter, conditions are predicted to be suitable for a mix of sitting and standing. Conditions in the vicinity of the building access points are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the comfort guidelines in Section 4.4.

Driveway and Parking Access along East Elevation: Conditions over the driveway and access ramp along the east 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.

Lakeshore Park: Following the introduction of the proposed development, conditions over the nearby portion of Lakeshore Park to the south are predicted to be suitable for standing during the summer and winter. Conditions in the same area with the existing massing are predicted to be suitable for standing during the summer and winter. Since the wind conditions over Lakeshore Park are predicted to be the same for both the proposed and existing massing scenarios, the noted conditions may be considered acceptable.

5.2 Wind Comfort Conditions – Common Amenity Terrace

Level 9 Amenity Terrace: Conditions over the level 9 amenity terrace are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing with a small region near the southwest corner being suitable for strolling during the winter. The noted conditions are considered acceptable according to the comfort guidelines in Section 4.4.

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 were found 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 (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 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.

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

6. CONCLUSIONS AND RECOMMENDATIONS

A complete summary of the predicted wind conditions is provided in Section 5 of this report and illustrated in Figures 3A-5B. Based on computer simulations using the CFD technique, meteorological data analysis of the Mississauga wind climate, industry standard wind comfort and safety guidelines, and experience with numerous similar developments, the study concludes the following:

1) All areas within and surrounding the subject site are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, walkways, building access points, surface parking areas, and Lakeshore Park are considered acceptable.

2) Conditions over the Level 9 amenity terrace are predicted to be suitable for sitting during the summer, which is considered acceptable according to the comfort guidelines in Section 4.4.

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, (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.

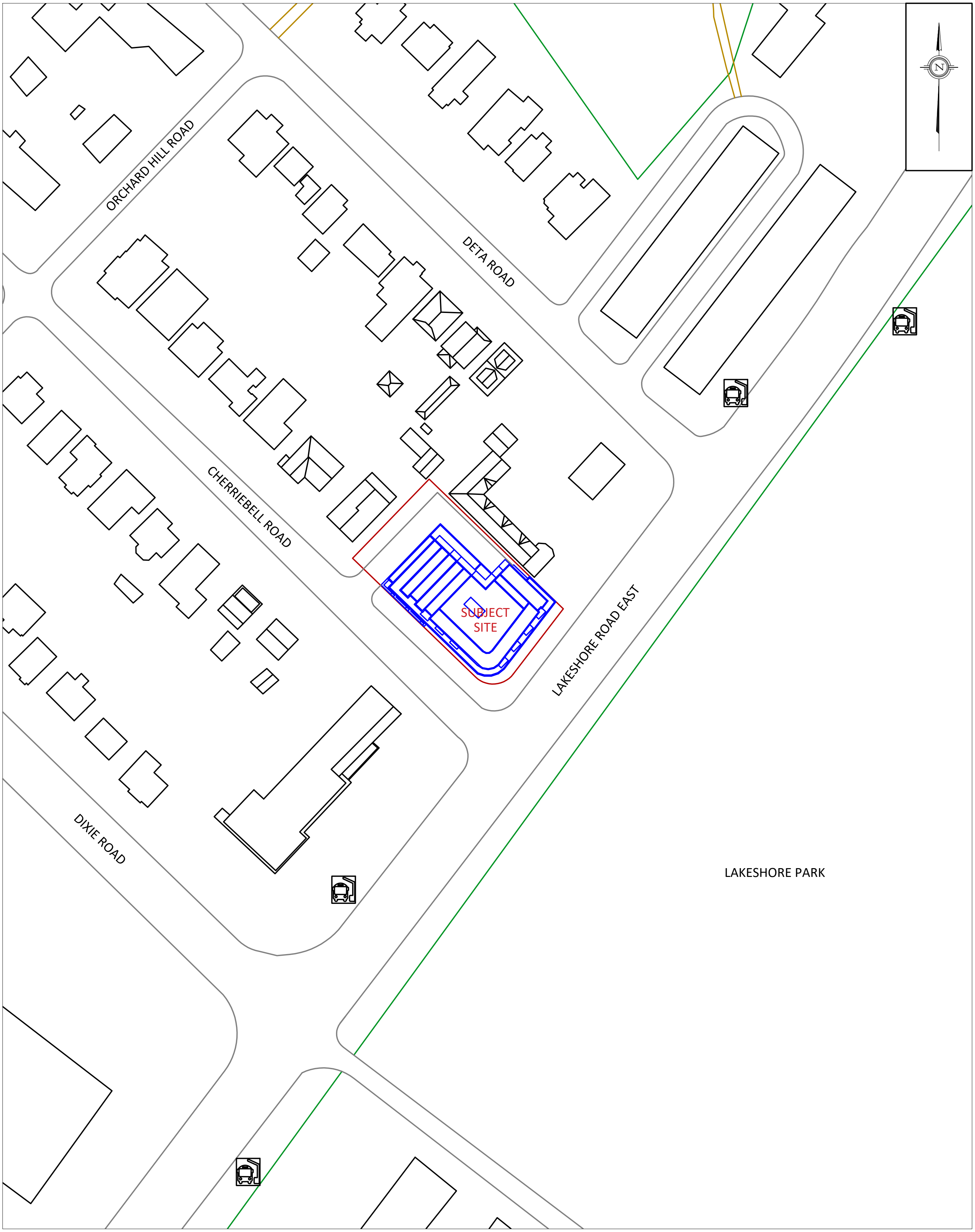
Sincerely,

Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
S. R. HALL
100197168
Mar 31, 2022
PROVINCE OF ONTARIO

Daniel Davalos, MESc.
Junior Wind Scientist

Steven Hall, M.A.Sc., P.Eng.
Senior Wind Engineer



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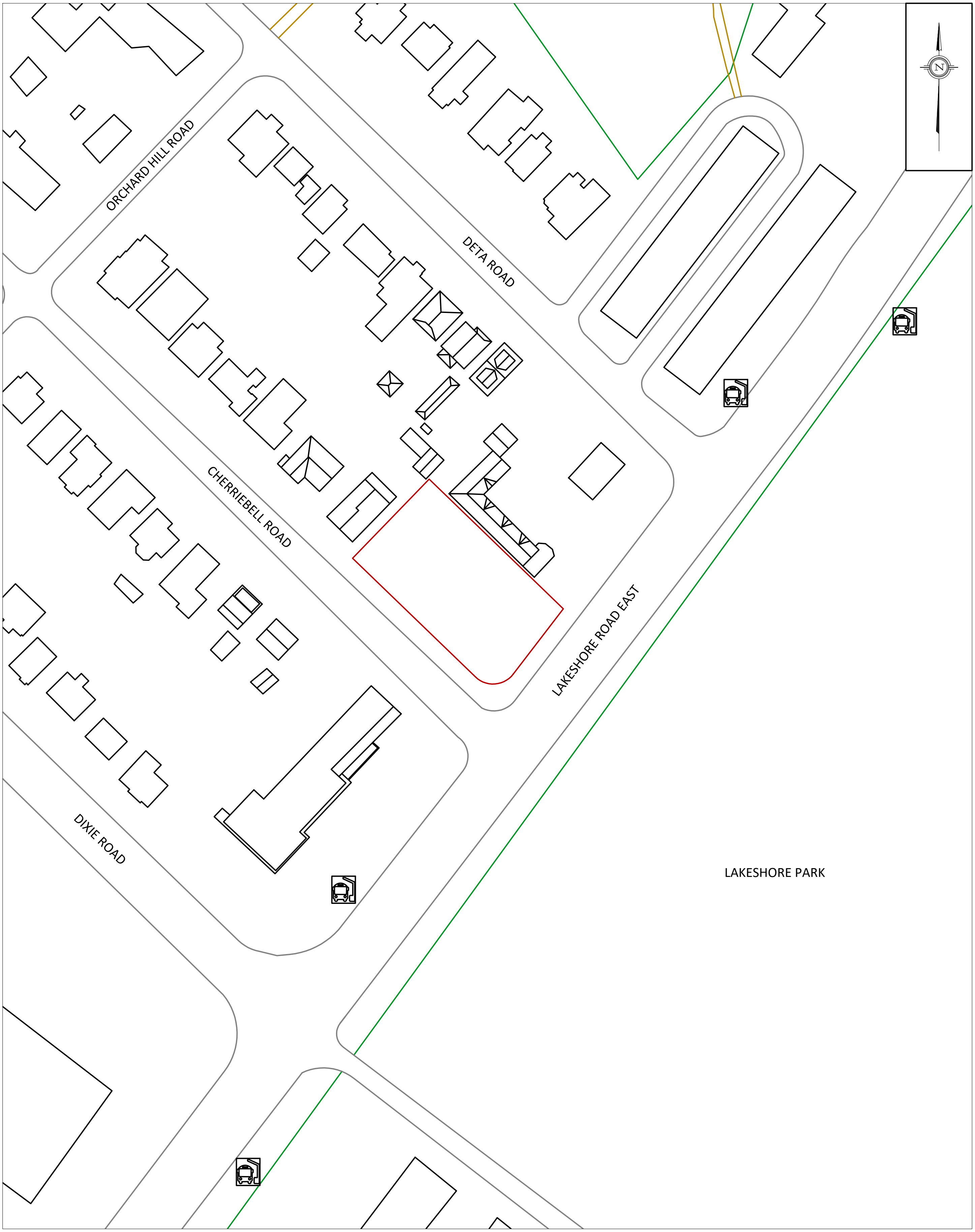
613 836 0934 • GRADIENTWIND.COM

PROJECT: 1407 LAKESHORE ROAD EAST, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
SCALE: 1:1500	DRAWING NO.: 21-431-PLW-1A	
DATE: JANUARY 12, 2022	DRAWN BY: S.K.	



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PROJECT	1407 LAKESHORE ROAD EAST, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:1500	DRAWING NO.	21-431-PLW-1B
DATE	JANUARY 12, 2022	DRAWN BY	S.K.

DESCRIPTION

FIGURE 1B:
EXISTING SITE PLAN AND SURROUNDING CONTEXT

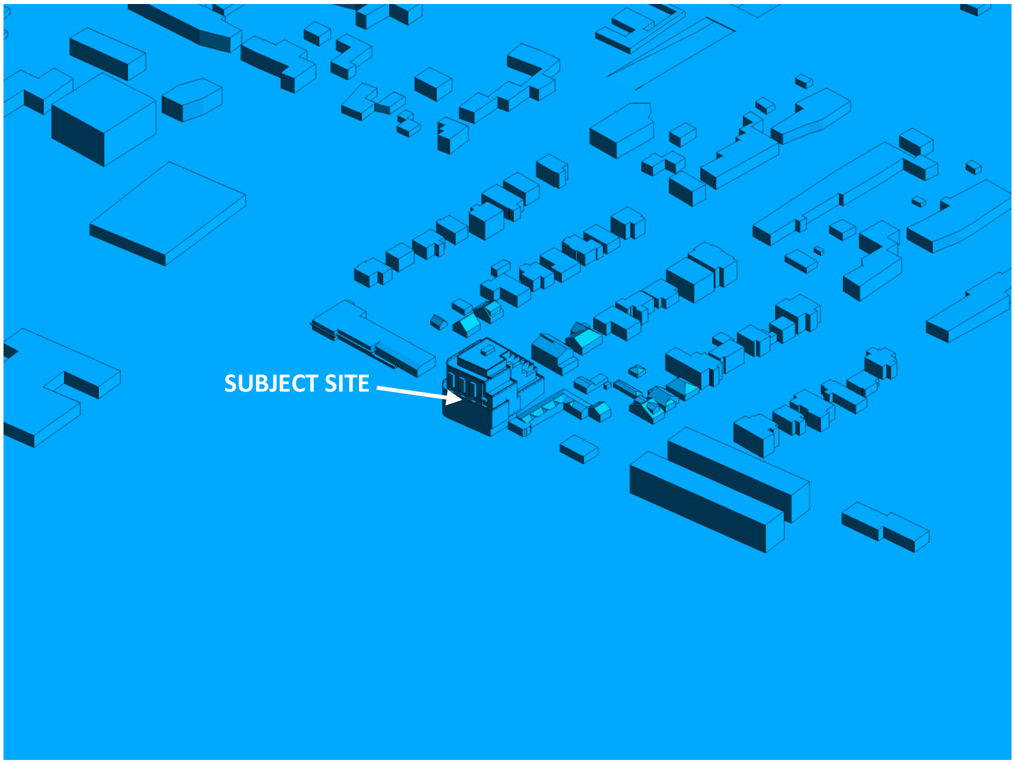


FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, EAST PERSPECTIVE

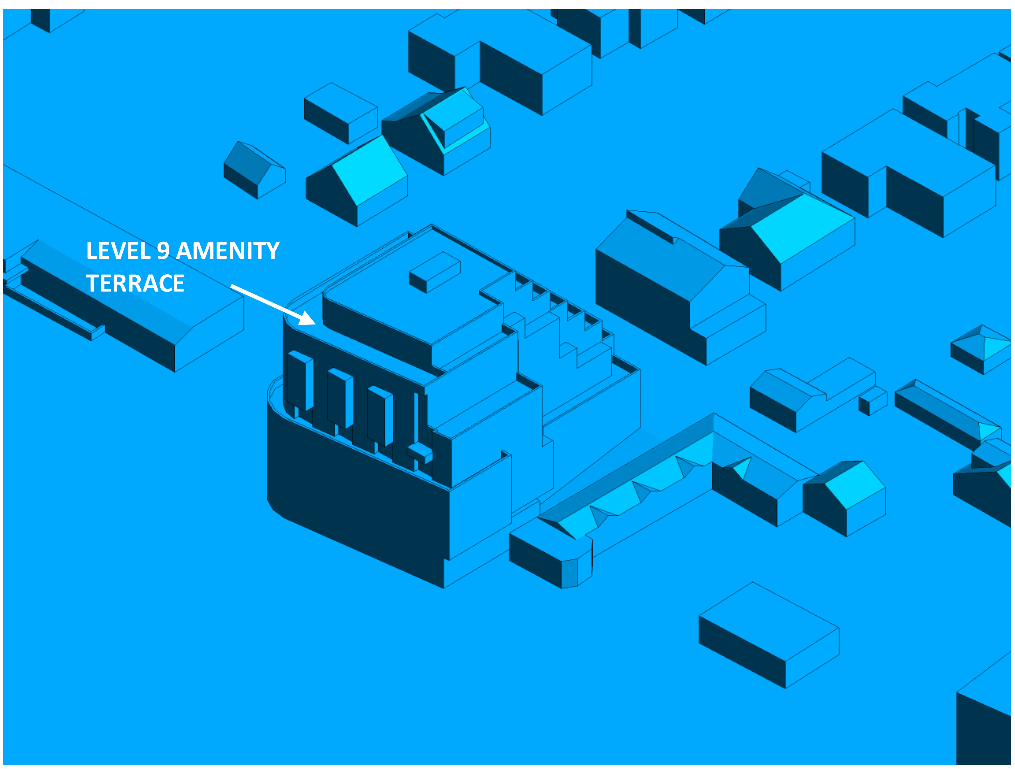


FIGURE 2B: CLOSE-UP VIEW OF FIGURE 2A

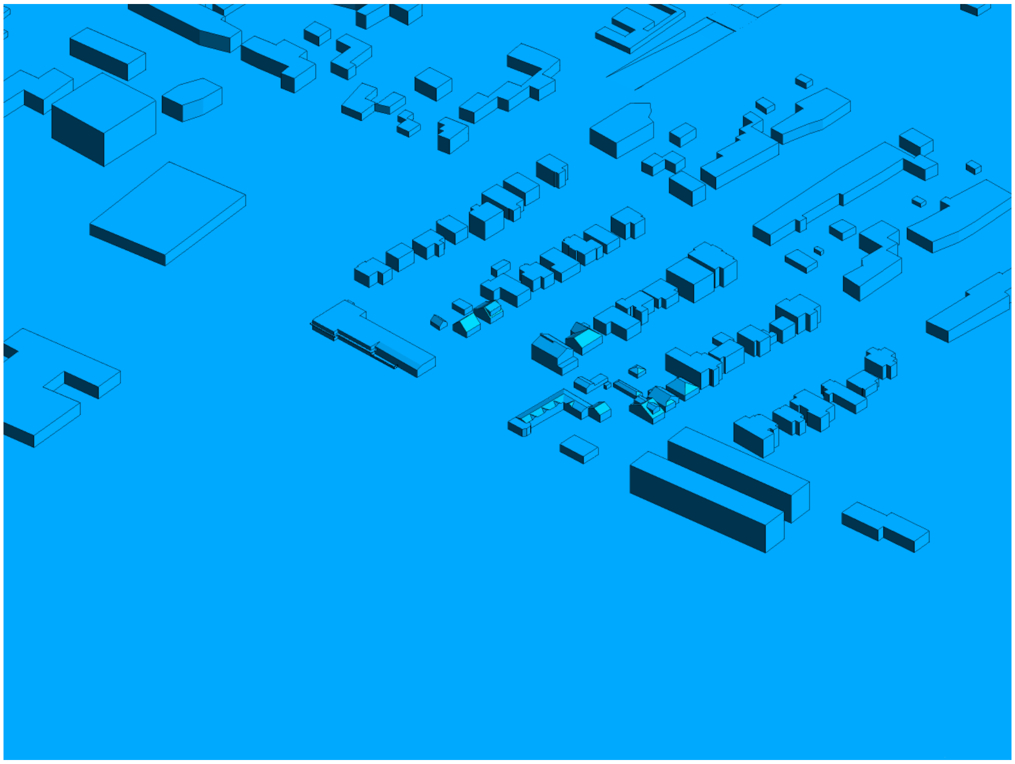


FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, EAST PERSPECTIVE

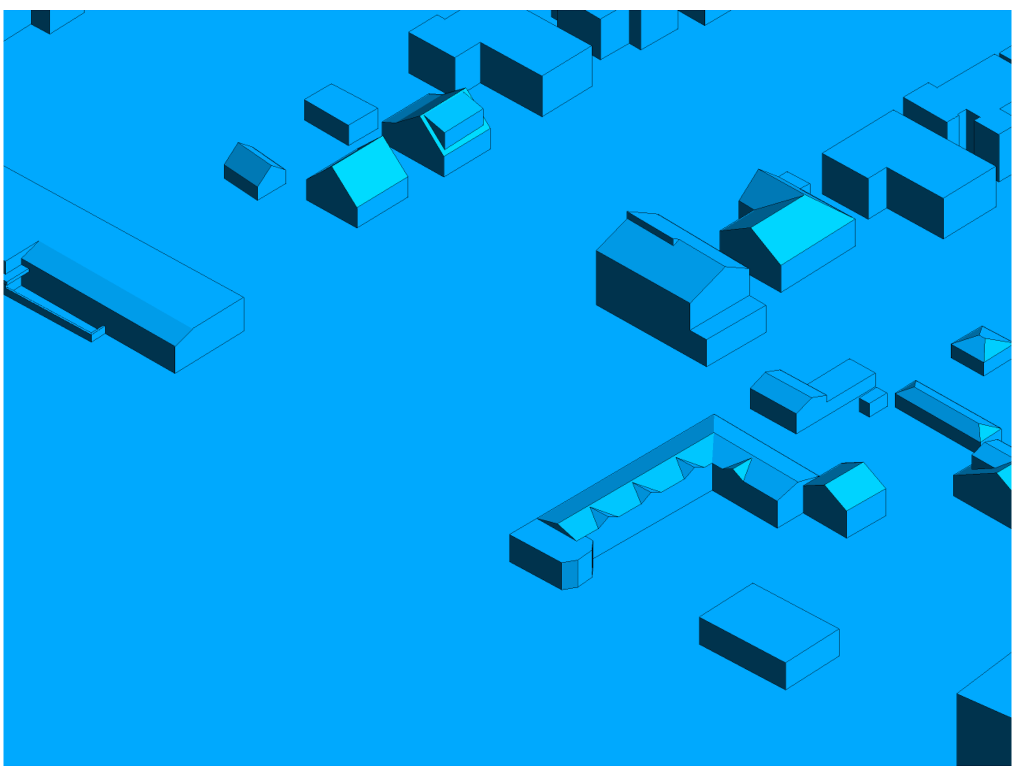


FIGURE 2D: CLOSE-UP VIEW OF FIGURE 2C

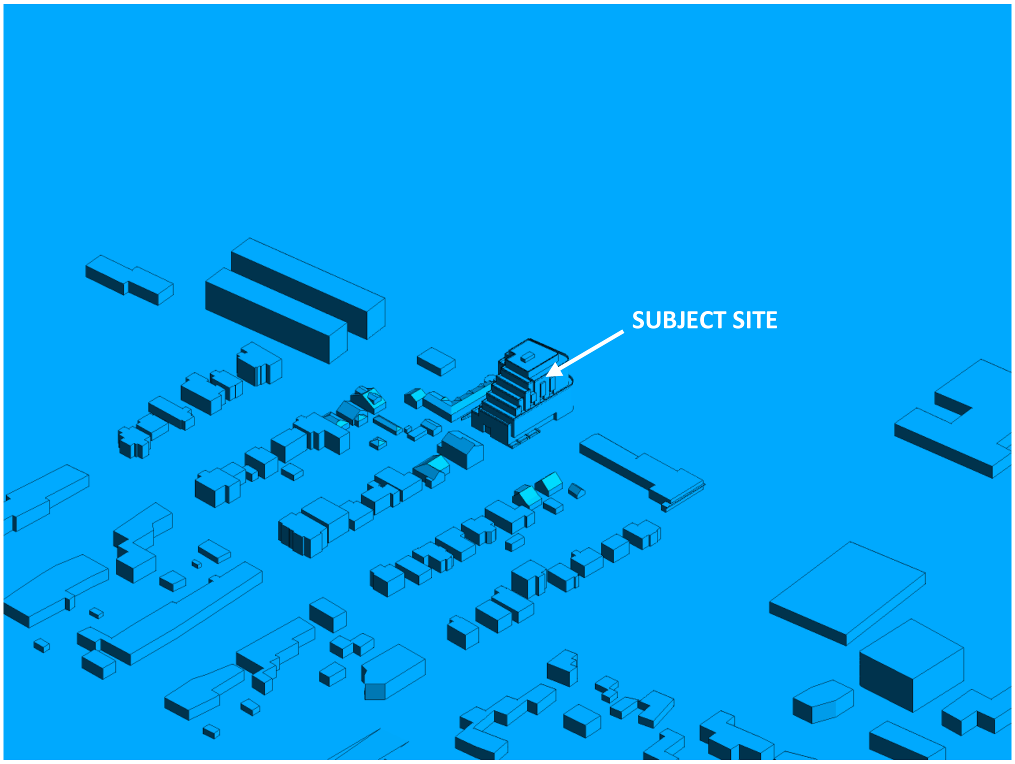


FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, WEST PERSPECTIVE

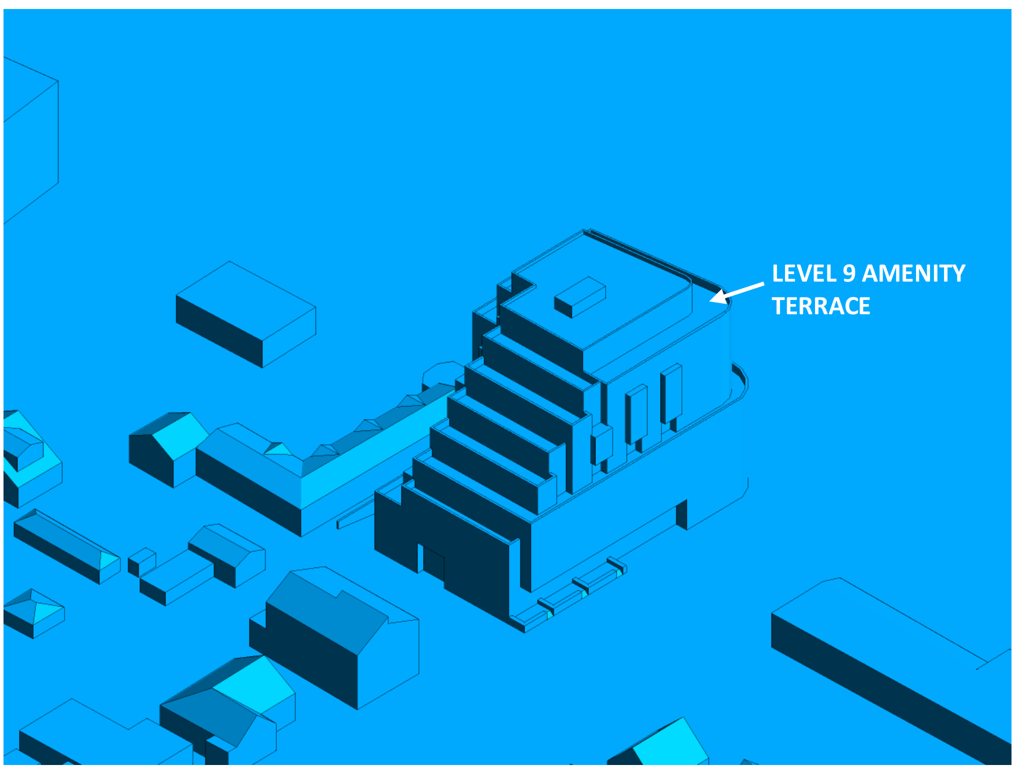


FIGURE 2F: CLOSE-UP VIEW OF FIGURE 2E

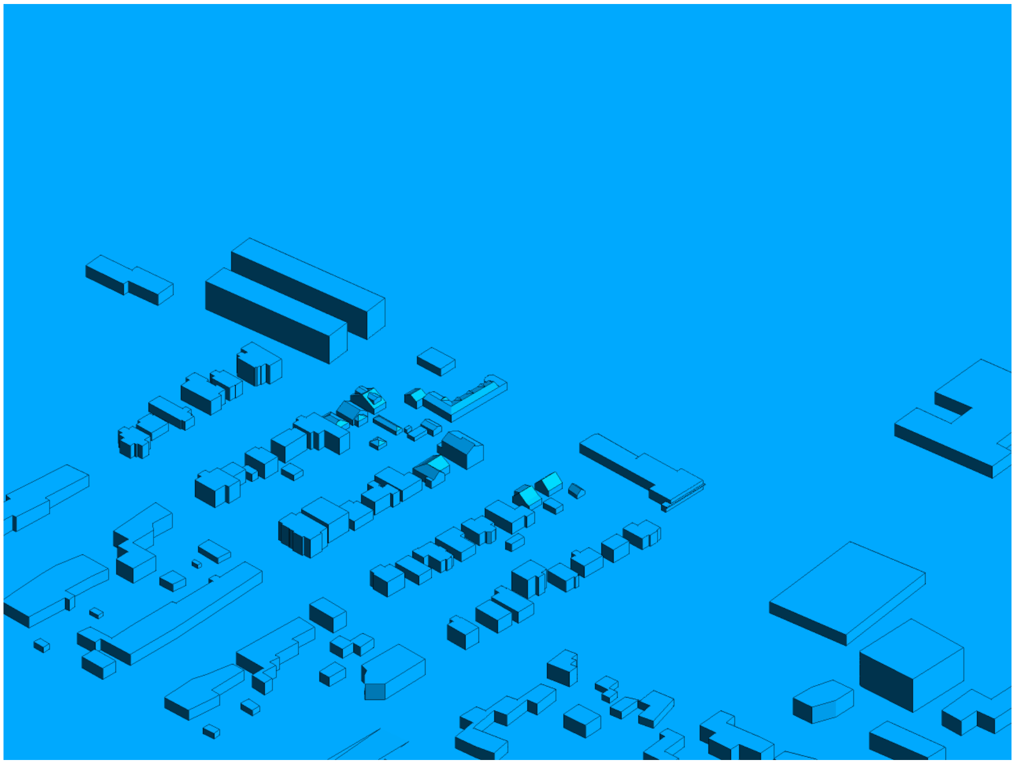


FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, WEST PERSPECTIVE

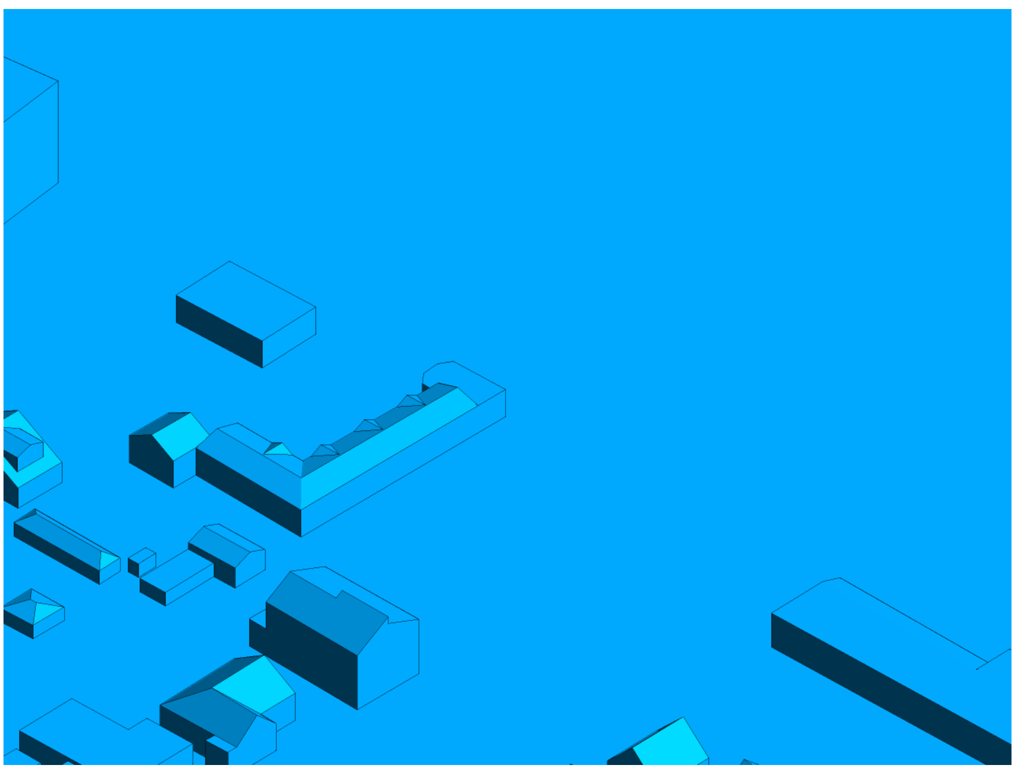


FIGURE 2H: CLOSE-UP VIEW OF FIGURE 2G

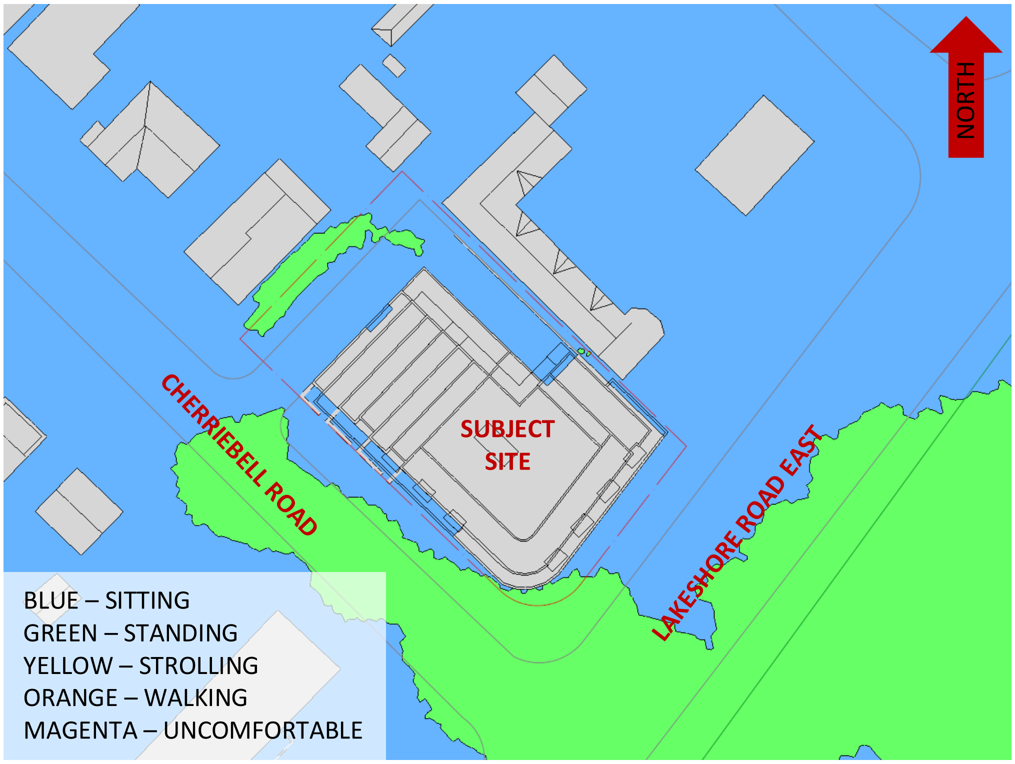


FIGURE 3A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

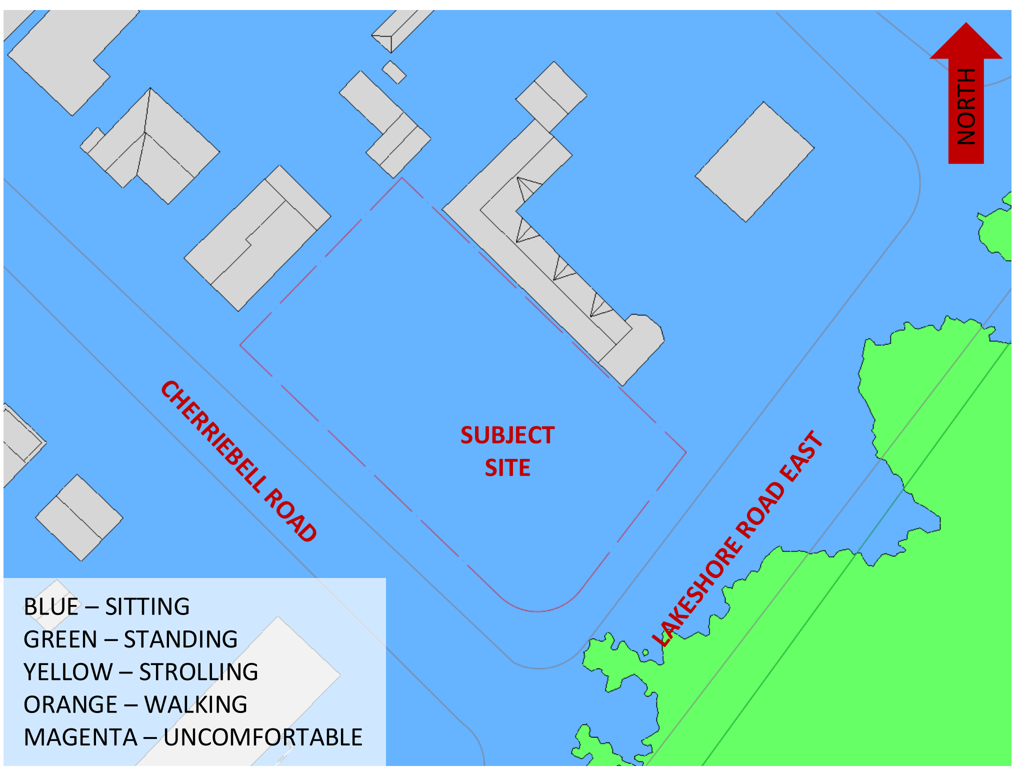


FIGURE 3B: SUMMER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

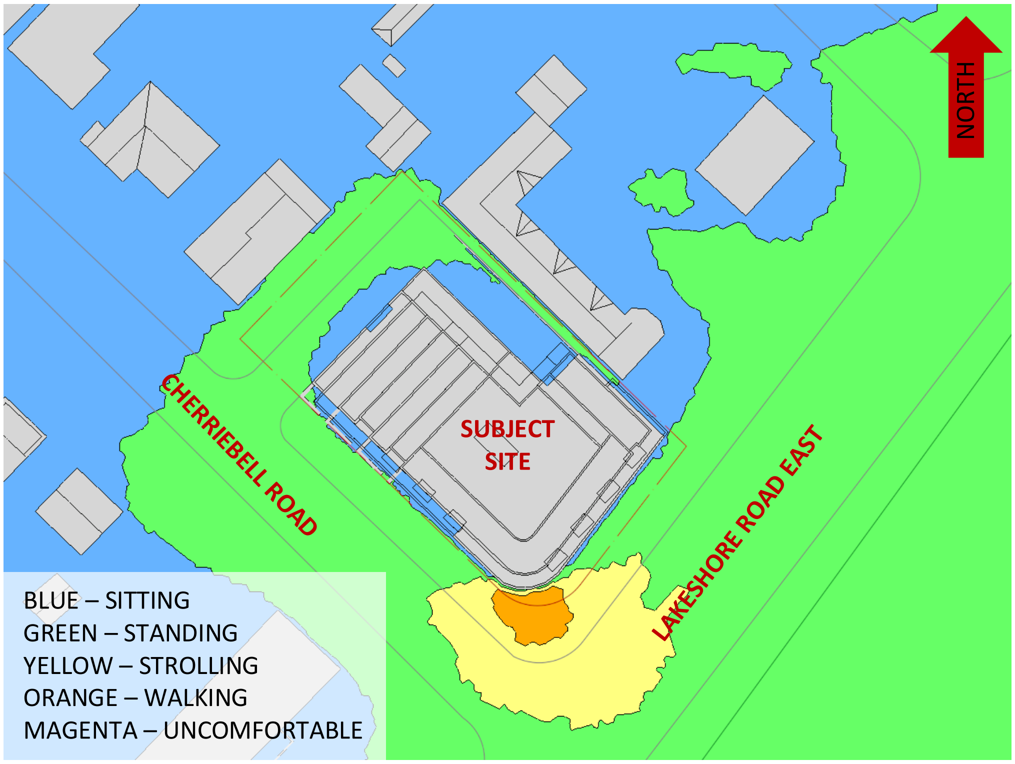


FIGURE 4A: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

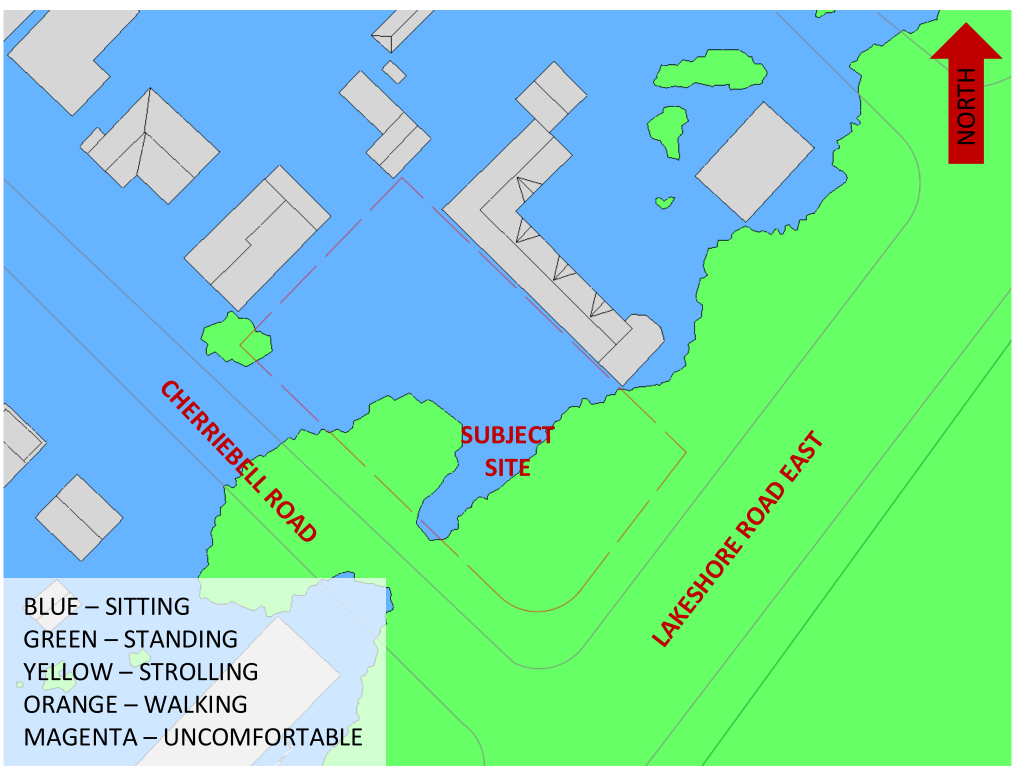


FIGURE 4B: WINTER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

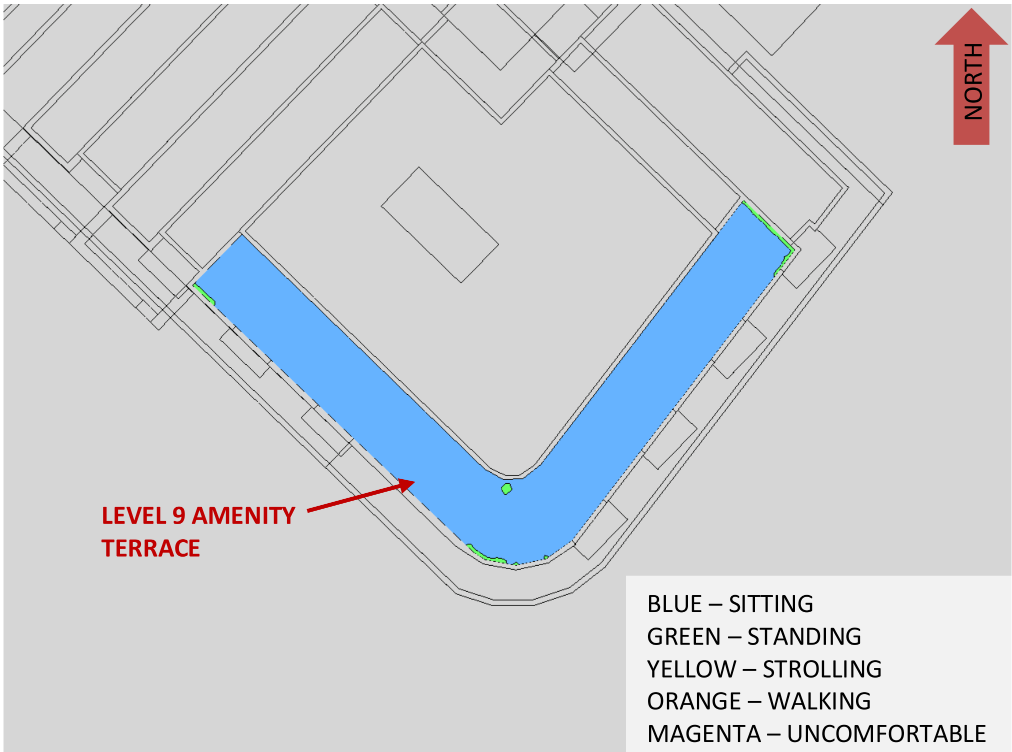


FIGURE 5A: SUMMER – WIND COMFORT, LEVEL 9 AMENITY TERRACE

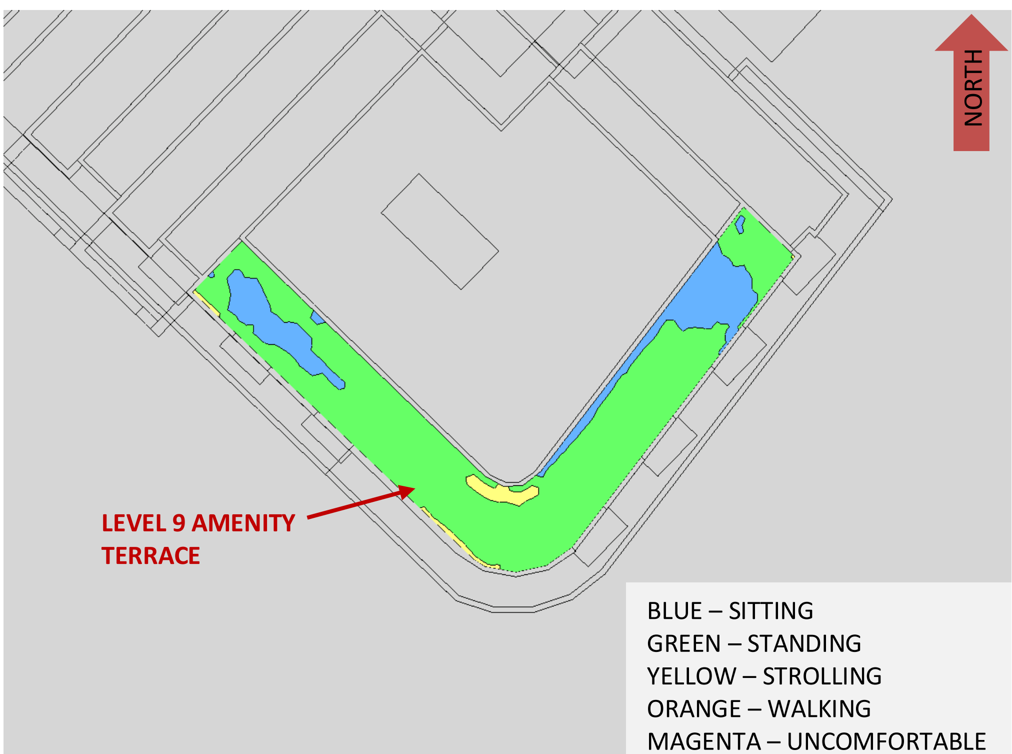
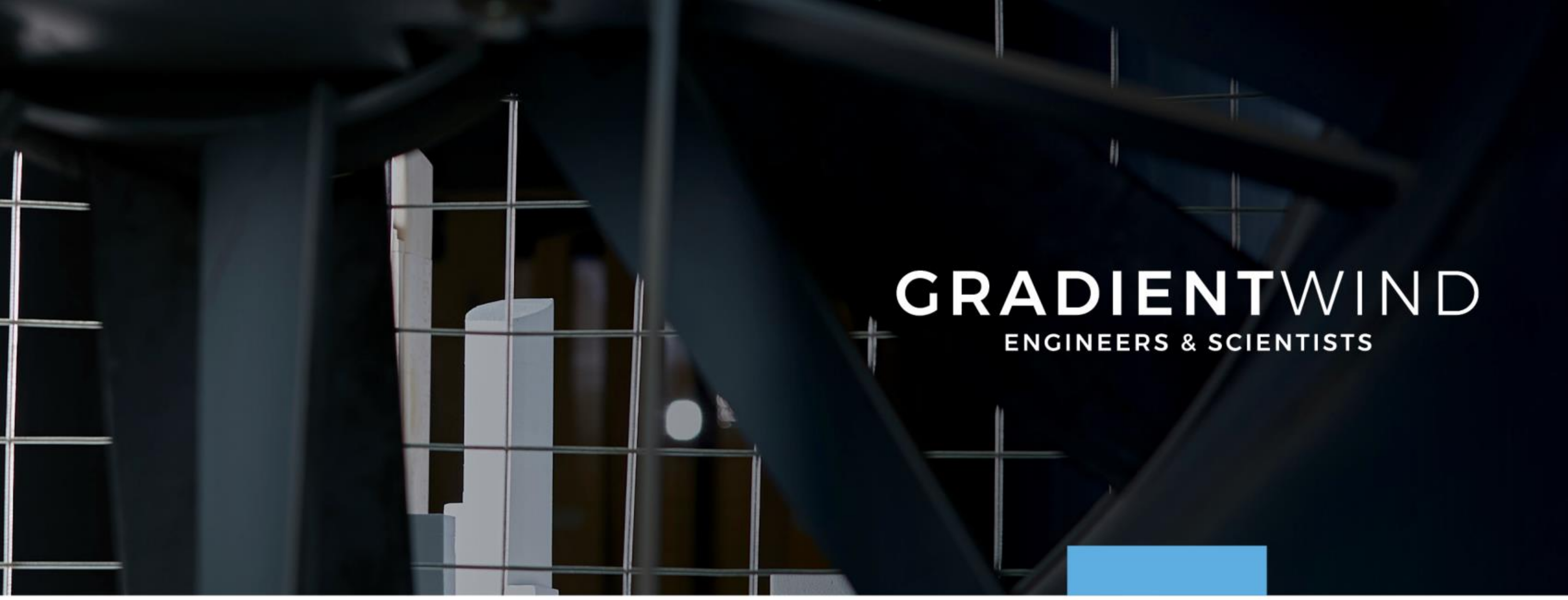


FIGURE 5B: WINTER – WIND COMFORT, LEVEL 9 AMENITY TERRACE



APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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

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

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

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

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

Wind Direction (Degrees True)	Alpha Value (α)
0	0.24
40	0.24
97	0.14
136	0.16
170	0.18
210	0.18
237	0.23
258	0.24
278	0.24
300	0.22
322	0.22
341	0.22

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

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

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