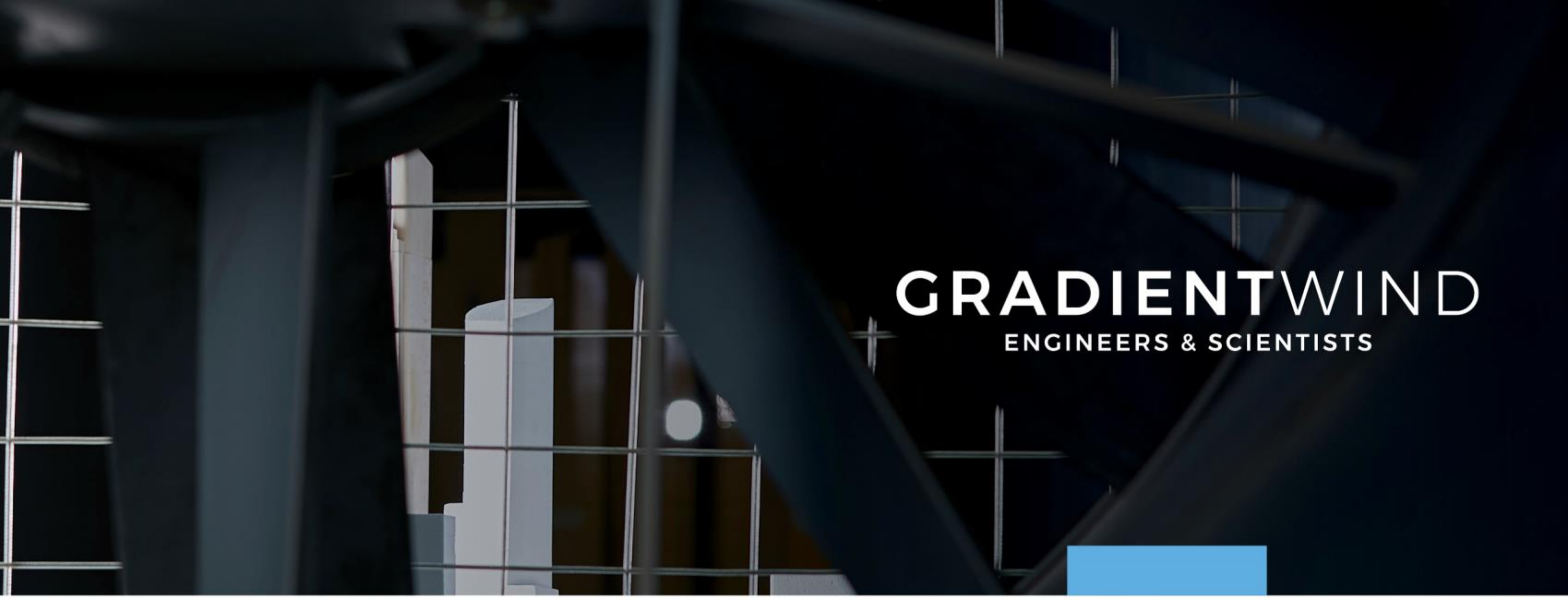
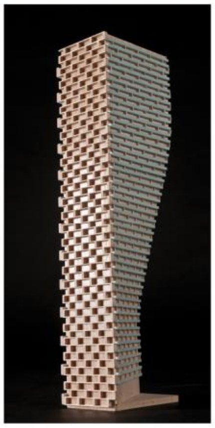
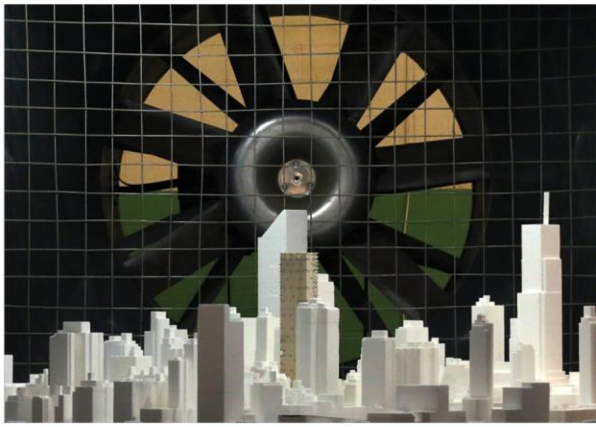


PEDESTRIAN LEVEL WIND STUDY

17 Jacobs Terrace
Barrie, Ontario

Report: 21-099-PLW-2023





October 18, 2023

PREPARED FOR
Tonlu Holdings Ltd.
401 Vaughan Valley Boulevard
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PREPARED BY
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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study to satisfy Site Plan Control application submission requirements for the proposed residential development located at 17 Jacobs Terrace in Barrie, Ontario (hereinafter referred to as the “subject site” or “propose 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.

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-9B, 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, wind conditions over the surrounding sidewalks, nearby existing parking lots, laneways, walkways, the entrance courtyard, and in the vicinity of building access points, are considered acceptable.

2) Regarding the Level 5 amenity terrace serving the proposed development, wind comfort conditions during the typical use period are predicted to be suitable for a mix of sitting and standing with conditions suitable for sitting to the north and west of the terrace, and conditions suitable for standing to the east and south.

    a. The areas that are predicted to be suitable for standing are also predicted to be suitable for sitting for at least 74% and 72% of the time to the north and south during the same period, respectively, where the target is 80% to achieve the sitting comfort class.

b. Notably, the landscape design incorporates seating areas along the west terrace elevation and to the north, where conditions are predicted to be suitable for sitting during the typical use period, which is considered acceptable. Pergolas with screening features that are situated to the west of the terrace are expected to improve wind conditions over seating areas located beneath the pergolas.

c. The landscape design incorporates a pet run and an activity/exercise lawn to the south and east of the terrace, respectively. The noted wind conditions over these areas are considered acceptable for the intended active-use programming.

d. Furthermore, landscaping elements, including raised planters throughout the terrace, that could not be implemented in the simulation model are expected to increase sitting percentages over the terrace beyond 72% of the time.

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

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Tonlu Holdings Ltd. to undertake a pedestrian level wind (PLW) study to satisfy Site Plan Control application submission requirements for the proposed residential development located at 17 Jacobs Terrace in Barrie, Ontario (hereinafter referred to as the "subject site" or "propose development"). A PLW study was conducted in September 2022 and revised in February 2023 for the previous design of the proposed development[1,2]. 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.

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 Architecture Unfolded in September 2023, surrounding street layouts and existing and approved future building massing information obtained from the City of Barrie, recent satellite imagery, and experience with numerous similar developments.

2. TERMS OF REFERENCE

The subject site is located at 17 Jacobs Terrace in Barrie, situated on a trapezoidal parcel of land bounded by Jacobs Terrace to the north, a proposed 17-storey residential development at 272 Innisfil Street to the east, and existing low-rise buildings to the south and west. Throughout this report, Jacobs Terrace is referred to as project north. The proposed development comprises two nominally rectangular residential buildings atop a shared trapezoidal 4-storey podium, with a 23-storey building to the east (Building 1) and a 19-storey building to the west (Building 2). The buildings share below-grade parking, and each building is topped off with a mechanical penthouse.

The ground floor includes main entrances at the northwest and northeast corners, a work space to the north, shared building support spaces and mechanical rooms along the east and west elevations, and indoor parking spaces throughout the remainder of the level. The indoor parking is accessed at the

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1 Gradient Wind Engineering Inc., '*17 Jacobs Terrace – Pedestrian Level Wind Study*', [Sept 15, 2022]
2 Gradient Wind Engineering Inc., '*17 Jacobs Terrace – Pedestrian Level Wind Study*', [Feb 27, 2023]

southeast corner via a laneway from Jacobs Terrace. Levels 2-4 include residential units to the north, east, and west, and parking spaces throughout the remainder of the levels. A private terrace is located near the northeast corner at Level 3. At Level 5, the building steps back from the podium, creating a 'U'-shaped planform with its long axis-oriented along Jacobs Terrace, accommodating a central landscaped amenity terrace and private terraces along the perimeters. Level 5 includes residential units and indoor amenities along the outer and inner perimeters of the level, respectively. Private terraces and green roofs are accommodated atop the north portion at the long axis of the 'U'-shaped planform at Levels 6-8 and by building setbacks to the north at Levels 6-10 and to the south at Levels 9-10.

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 massing in all directions. Notably, the Barrie-Collingwood railway extends from the west-southwest to the east-northeast to the immediate north of the subject site and continues into the far-field surroundings. In addition, a 17-storey residential building is approved at 272 Innisfil Street, to the immediate east of the subject site, and a development comprising four buildings rising to 20, 29, 35, and 37 storeys atop a shared 6-storey podium is proposed at 41 & 43 Essa Road and 259 & 273 Innisfil Street, located approximately 130 m to the east-northeast of the subject site. The far-field surroundings (defined as the area beyond the near field and within a 2-kilometre (km) radius) primarily comprise low-rise massing in all compass directions with isolated high-rise buildings to the north-northeast and the open exposure of Kempenfelt Bay from the north-northeast clockwise to the east. Notably, Lake Simcoe is situated approximately 730 m to the east-northeast.

Site plans for the proposed and existing massing scenarios are illustrated in Figures 1A and 1B, while Figures 2A-2H illustrate the computational models used to conduct the study. The existing massing scenario includes the existing massing and any future developments approved by the City of Barrie. The developments at 272 Innisfil Street and at 41 & 43 Essa Road and 259 & 273 Innisfil Street have been included in both the proposed and existing massing scenarios.

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 site is based on CFD simulations of wind speeds across the subject site within a virtual environment, meteorological analysis of the Barrie wind climate, and synthesis of computational data with industry-accepted guidelines. The following sections describe the analysis procedures, including a discussion of the comfort guidelines.

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. 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 Lake Simcoe Regional 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 planned landscape elements from the model due to the difficulty of providing accurate seasonal representation of vegetation. The omission of trees and other landscaping elements produces slightly stronger wind speeds.

4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the site for 12 wind directions. The CFD simulation model was centered on the study building, complete with surrounding massing within a radius of approximately 490 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 and the Level 5 common amenity terrace 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. 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.

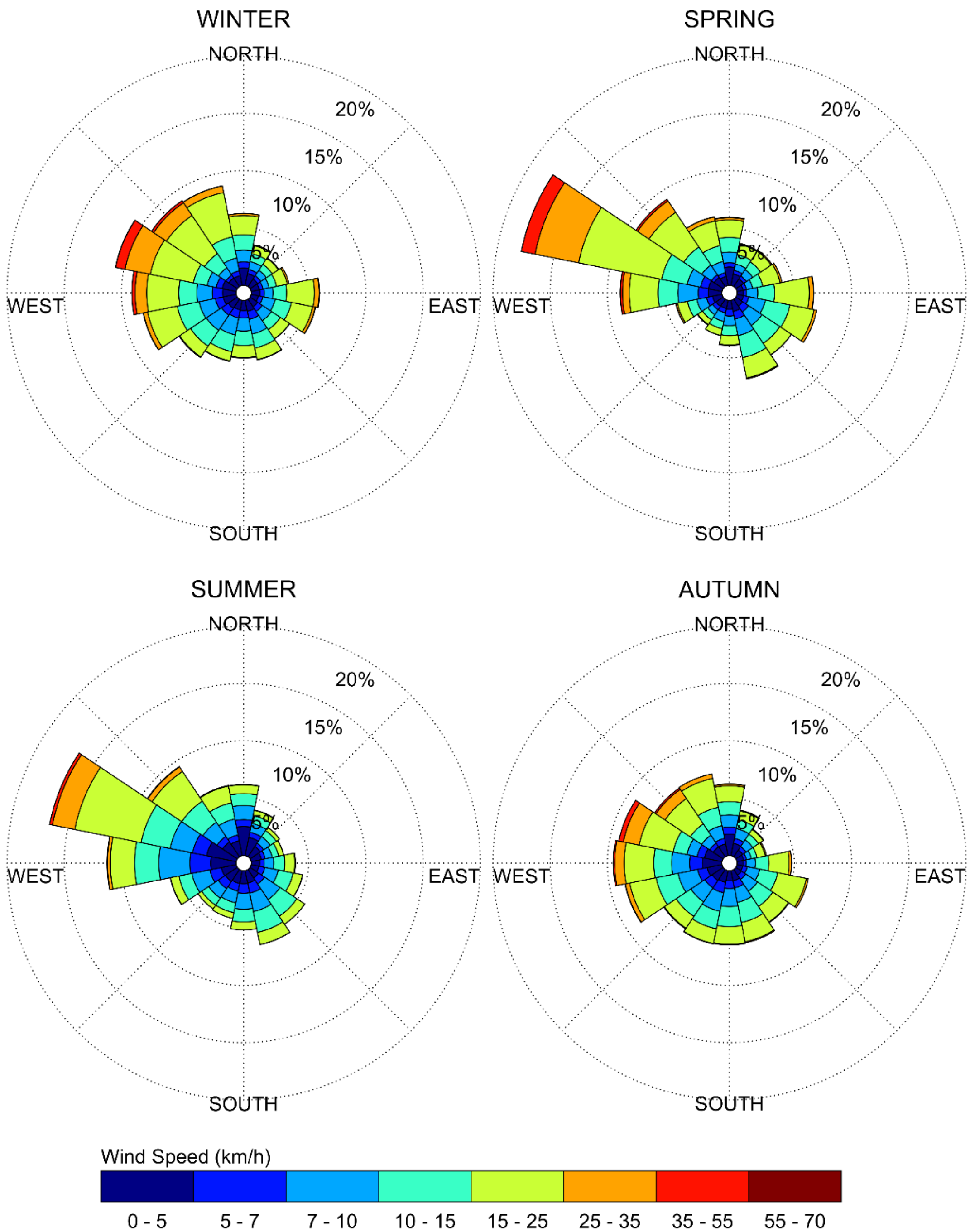
4.3 Meteorological Data Analysis

A statistical model for winds in Barrie was developed from approximately 18 years of hourly meteorological wind data recorded at Lake Simcoe Regional Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were analyzed for each month of the year to determine the statistically prominent wind directions and corresponding speeds, and to characterize similarities between monthly weather patterns. Based on this portion of analysis, the four seasons are represented by grouping data from consecutive months based on similarity of weather patterns, and not according to the traditional calendar method; spring is defined as April-May, summer as June-September, autumn as October-November, and winter as December-March.

The statistical model of the Barrie 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 km/h. Probabilities of occurrence of different wind speeds are represented as stacked polar bars in twelve 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 Barrie, the most common winds concerning pedestrian comfort occur from the west clockwise to the north. 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.

Additionally, a second model was developed from approximately twenty years of similar data recorded at the Centre for Atmospheric Research Experiments in Egbert, which lies to the southwest of Barrie, whereas the Lake Simcoe Airport lies to the northeast of Barrie. The results of the second model exhibited generally lower wind speeds since the Lake Simcoe Airport is more exposed to prominent winds from Georgian Bay. Since the Lake Simcoe Airport data produce more conservative results, the results of the second model are not presented in this report.

SEASONAL DISTRIBUTION OF WIND
LAKE SIMCOE REGIONAL AIRPORT, ORO-MEDONTE, 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

Pedestrian comfort and safety guidelines are based on the mechanical effects of wind without consideration of other meteorological conditions (that is, temperature, relative humidity). The comfort guidelines assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Five pedestrian comfort classes are based on 20% non-exceedance gust wind speed ranges, which include (1) Sitting; (2) Standing; (3) Strolling; (4) Walking; and (5) Uncomfortable. The gust speeds, and equivalent mean speeds, are selected based on the Beaufort scale, which describes the effects of forces produced by varying wind speed levels on objects. 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 the colour magenta. Specifically, the comfort classes, associated wind speed ranges, and limiting criteria are summarized as follows:

PEDESTRIAN WIND COMFORT CLASS DEFINITIONS

Wind Comfort Class	Mean Speed (km/h)	Description
SITTING	≤ 10	Mean wind speeds no greater than 10 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 16 km/h.
STANDING	≤ 14	Mean wind speeds no greater than 14 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 22 km/h.
STROLLING	≤ 17	Mean wind speeds no greater than 17 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 27 km/h.
WALKING	≤ 20	Mean wind speeds no greater than 20 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 32 km/h.
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, the pedestrian safety wind speed criterion is based on the approximate threshold that would cause a vulnerable member of the population to fall. A 0.1% exceedance gust wind speed of 90 km/h is classified as dangerous. 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. Notably, pedestrians tend to be more sensitive to wind gusts than to steady winds for lower wind speed ranges. For strong winds approaching dangerous levels, this effect is less important because the mean wind can also create problems for pedestrians.

Experience and research on people's perception of mechanical wind effects has shown that if the wind speed levels are exceeded for more than 20% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if a mean wind speed of 10 km/h (equivalent gust wind speed of approximately 16 km/h) were exceeded for more than 20% of the time most pedestrians would judge that location to be too windy for sitting. Similarly, if mean wind speed of 20 km/h (equivalent gust wind speed of approximately 32 km/h) at a location were exceeded for more than 20% of the time, walking or less vigorous activities would be considered uncomfortable. As these criteria are based on subjective reactions of a population to wind forces, their application is partly based on experience and judgment.

Once the pedestrian wind speed predictions have been established throughout the 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 on the following page. Depending on the programming of a space, the desired comfort class may differ from this table.

TARGET PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES

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

5. RESULTS AND DISCUSSION

The following discussion of the predicted pedestrian wind conditions for the subject site is accompanied by Figures 3A-6B, illustrating wind conditions at grade level for the proposed and existing massing scenarios, and by Figures 8A-8D, illustrating wind conditions over the common amenity terrace serving the proposed development at Level 5. 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 are also reported for the typical use period, which is defined as May to October, inclusive. Figures 7 and 9A illustrate wind comfort conditions at grade level and over the Level 5 common amenity terrace serving the proposed development, respectively, consistent with the comfort classes in Section 4.4, while Figure 9B illustrates contours indicating the percentage of time conditions within the noted terrace are predicted to be suitable for sitting during the same period. The details of these conditions are summarized in the following sections for each area of interest.

5.1 Wind Comfort Conditions – Grade Level

Sidewalks along Jacobs Terrace: Prior to the introduction of the proposed development, wind comfort conditions over the nearby public sidewalks along Jacobs Terrace are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing throughout the remainder of the year. The noted conditions remain unchanged following the introduction of the proposed development. The noted wind conditions with the proposed development are considered acceptable.

Existing Parking Lots to the East and West of the Subject Site: Following the introduction of the proposed development, wind conditions over the neighbouring existing parking lot to the east of the subject site are predicted to be suitable for sitting during the summer, autumn, and winter, becoming suitable for a mix of sitting and standing during the spring. Conditions over the neighbouring existing parking lot to the west of the subject site are predicted to be suitable for a mix of sitting and standing throughout the year. The noted conditions are considered acceptable.

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

South Elevation of the Subject Site: Following the introduction of the proposed development, wind conditions along the south elevation of the subject site are predicted to be suitable for mostly sitting throughout the year. The noted conditions are considered acceptable.

Conditions over the noted area with the existing massing are predicted to be suitable for sitting during the summer and autumn, becoming suitable for a mix of sitting and standing during the winter and spring. Notably, the introduction of the proposed development is predicted to improve comfort levels along the south elevation of the subject site, in comparison to existing conditions, and wind conditions with the proposed development are considered acceptable.

Entrance Courtyard Northeast of the Subject Site: Wind conditions during the typical use period within the entrance courtyard situated to the northeast of the subject site are predicted to be suitable for mostly sitting with an isolated region suitable for standing to the southeast, as illustrated in Figure 7. The noted conditions are considered acceptable.

Laneway and Walkways Within the Subject Site: Wind conditions over the laneway along the east elevation and the walkways along the north, east, and west elevations of the subject site are predicted to be suitable for standing, or better, throughout the year, with isolated regions suitable for strolling during the spring. The noted conditions are considered acceptable.

Building Access Points: Wind conditions in the vicinity of the building access points along the north elevation of the proposed development are predicted to be suitable for sitting throughout the year, while conditions in the vicinity of the remaining building access points serving the proposed development are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. The noted conditions are considered acceptable.

5.2 Wind Comfort Conditions – Level 5 Common Amenity Terrace

Wind comfort conditions during the typical use period within the common amenity terrace serving the proposed development at Level 5 are predicted to be suitable for a mix of sitting and standing during the typical use period, as illustrated in Figure 9A. Specifically, conditions are predicted to be suitable for sitting to the north and west of the terrace, while standing conditions are predicted to the east and south. During the same period, the areas that are predicted to be suitable for standing are also predicted to be suitable for sitting for at least 74% and 72% of the time to the north and south, respectively, where the target is 80% to achieve the sitting comfort class.

Notably, the landscape design for the Leve 5 amenity terrace incorporates seating areas along the west terrace elevation and to the north, where conditions are predicted to be suitable for sitting during the typical use period, which is considered acceptable. The landscape design also includes pergolas with integrated screening features to the west of the terrace, which are expected to improve wind conditions over seating areas located beneath the pergolas.

Additionally, the landscape design incorporates activity/exercise active use areas and a pet run to the east and south, respectively. The noted wind conditions over these areas are considered acceptable for the active-use programming.

Furthermore, landscaping elements that could not be implemented in the simulation model (that is, dense plantings and trees), as described in Section 4.1, are expected to increase sitting percentages beyond 72% of the time.

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-9B. Based on computer simulations using the CFD technique, meteorological data analysis of the Barrie wind climate, industry standard wind comfort and safety guidelines, 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, wind conditions over the surrounding sidewalks, nearby existing parking lots, laneways, walkways, the entrance courtyard, and in the vicinity of building access points, are considered acceptable.

2) Regarding the Level 5 amenity terrace serving the proposed development, wind comfort conditions during the typical use period are predicted to be suitable for a mix of sitting and standing with conditions suitable for sitting to the north and west of the terrace, and conditions suitable for standing to the east and south.

    a. The areas that are predicted to be suitable for standing are also predicted to be suitable for sitting for at least 74% and 72% of the time to the north and south during the same period, respectively, where the target is 80% to achieve the sitting comfort class.

    b. Notably, the landscape design incorporates seating areas along the west terrace elevation and to the north, where conditions are predicted to be suitable for sitting during the typical use period, which is considered acceptable. Pergolas with screening features that are situated to the west of the terrace are expected to improve wind conditions over seating areas located beneath the pergolas.

    c. The landscape design incorporates a pet run and an activity/exercise lawn to the south and east of the terrace, respectively. The noted wind conditions over these areas are considered acceptable for the intended active-use programming.

d. Furthermore, landscaping elements, including raised planters throughout the terrace, that could not be implemented in the simulation model are expected to increase sitting percentages over the terrace beyond 72% of the time.

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

Sincerely,

Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
J. D. FERRARO
100158495
Oct 18, 2023
PROVINCE OF ONTARIO

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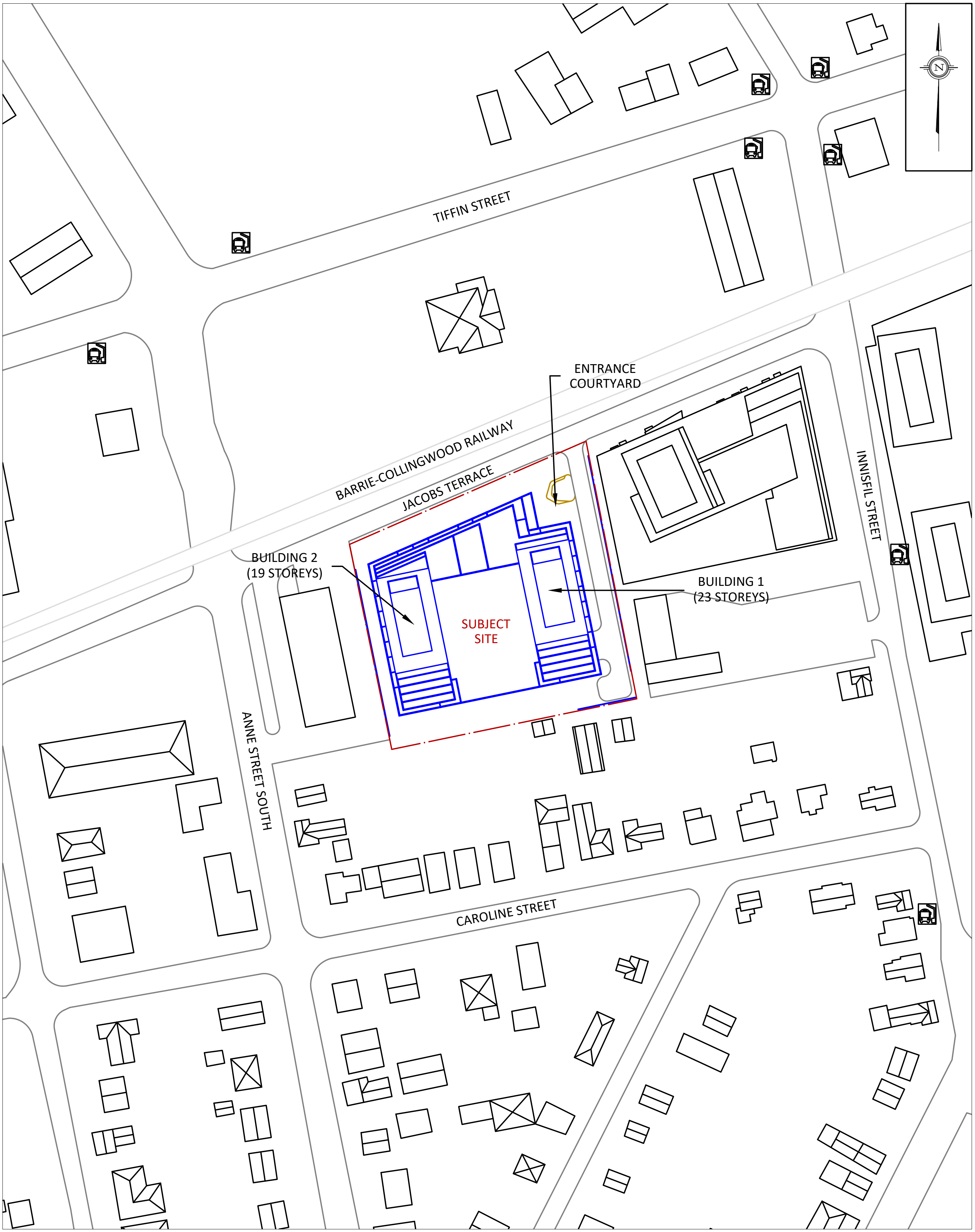
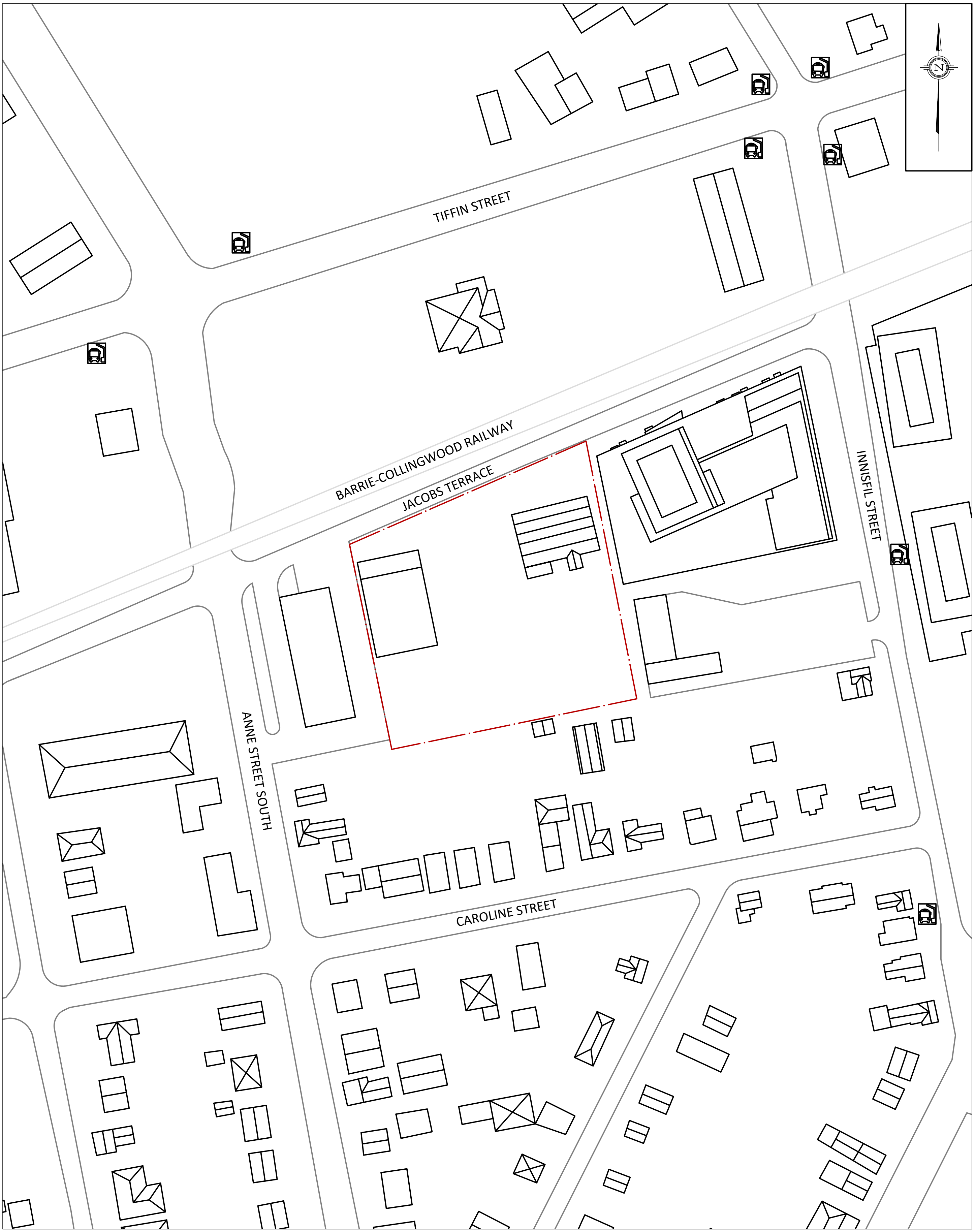


GRADIENTWIND
ENGINEERS & SCIENTISTS

127 WALGREEN ROAD, OTTAWA, ON
613 836 0934 • GRADIENTWIND.COM

PROJECT		DESCRIPTION
17 JACOBS TERRACE, BARRIE PEDESTRIAN LEVEL WIND STUDY		FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
SCALE 1:2000	DRAWING NO. 21-099-PLW-2023-1A	
DATE OCTOBER 10, 2023	DRAWN BY S.K.	



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PROJECT	17 JACOBS TERRACE, BARRIE PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:2000	DRAWING NO.	21-099-PLW-2023-1B
DATE	OCTOBER 10, 2023	DRAWN BY	S.K.

DESCRIPTION

FIGURE 1B:
EXISTING SITE PLAN AND SURROUNDING CONTEXT

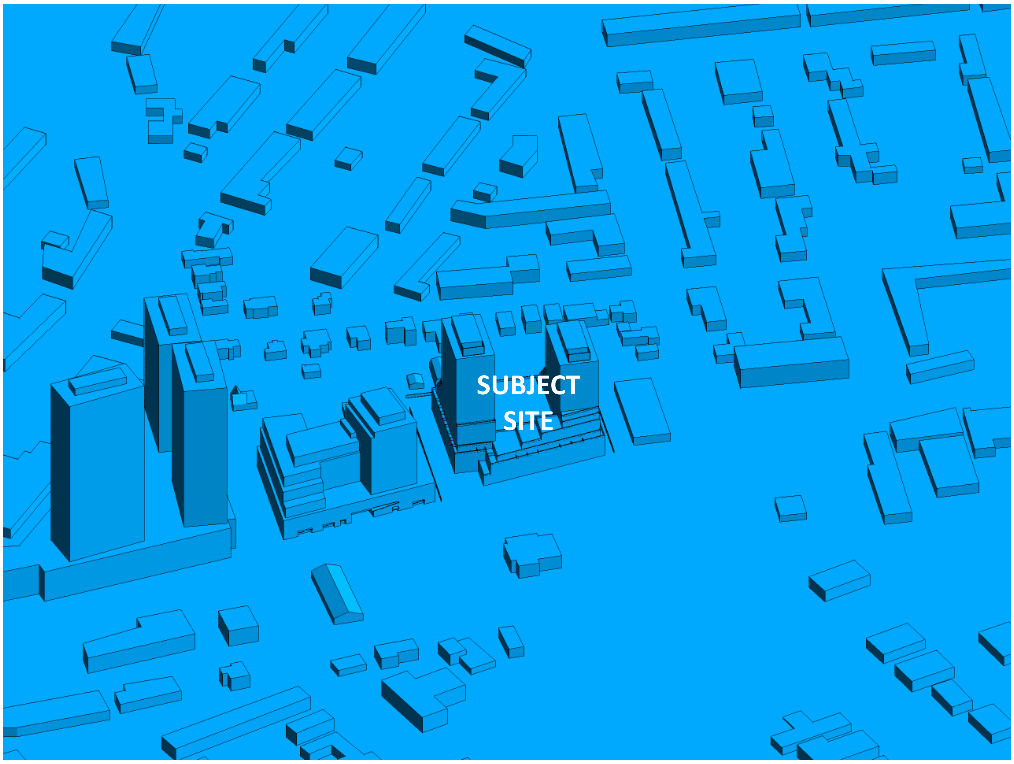

FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTH PERSPECTIVE

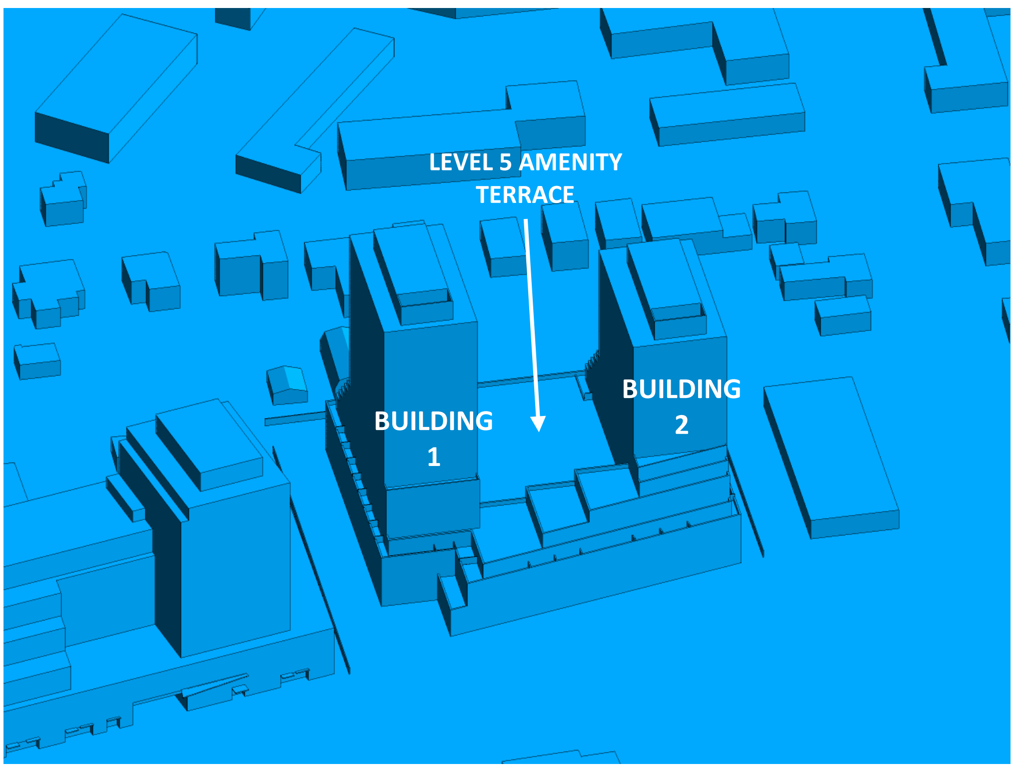

FIGURE 2B: CLOSE-UP OF FIGURE 2A

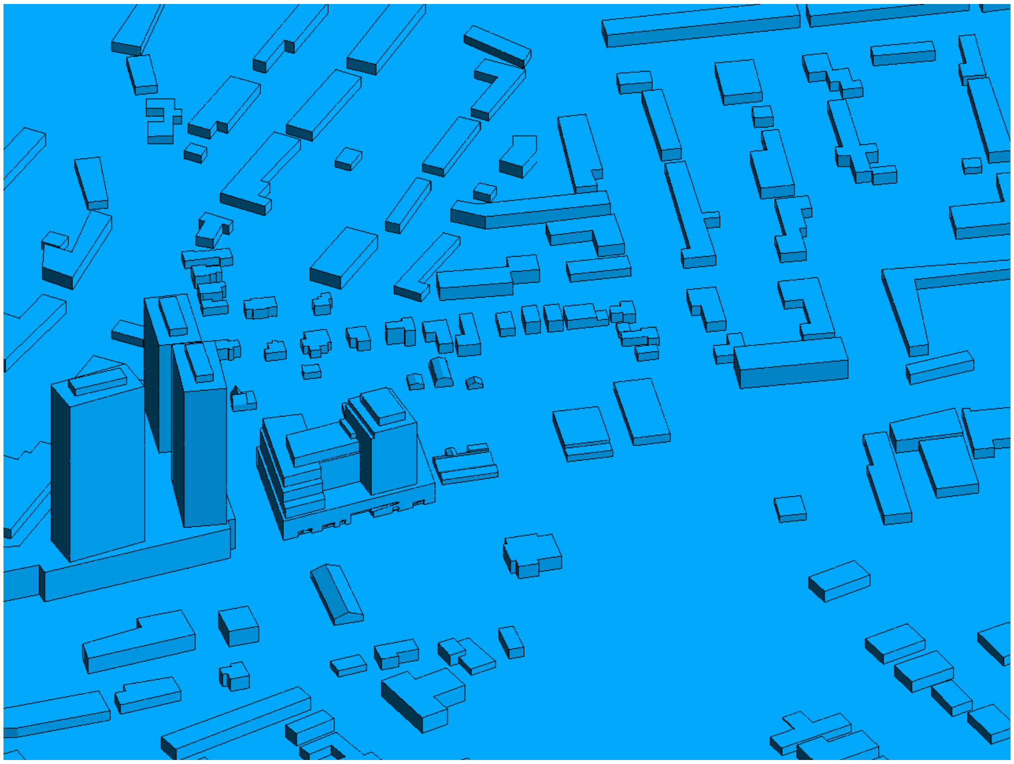

FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, NORTH PERSPECTIVE

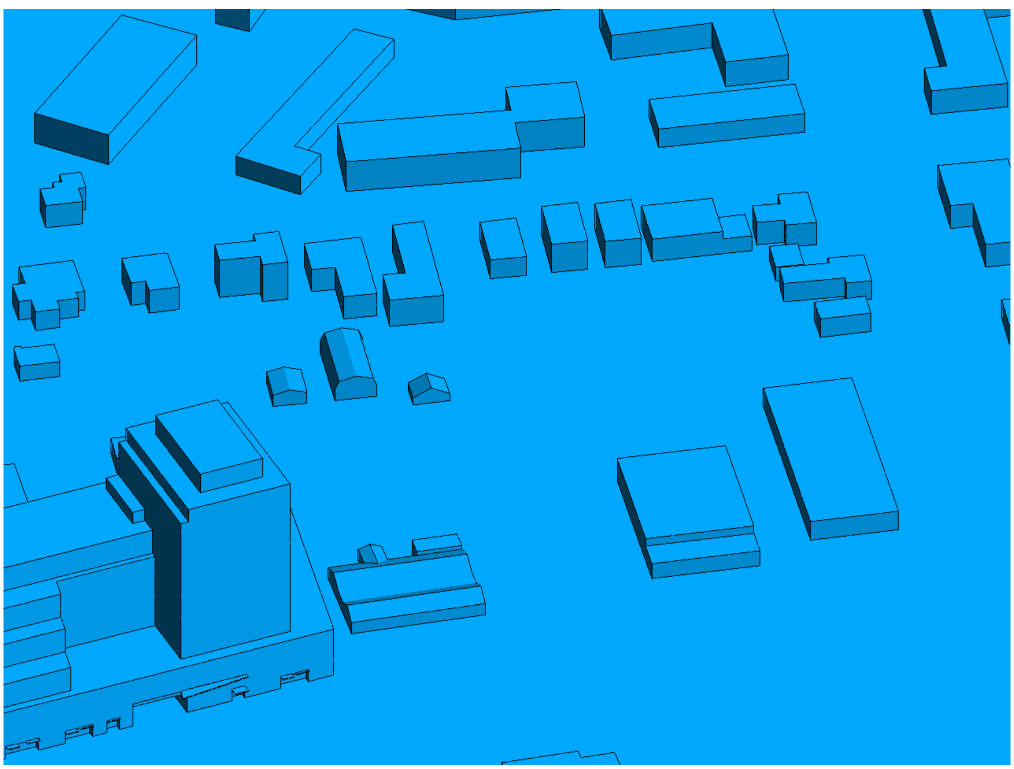

FIGURE 2D: CLOSE-UP OF FIGURE 2C

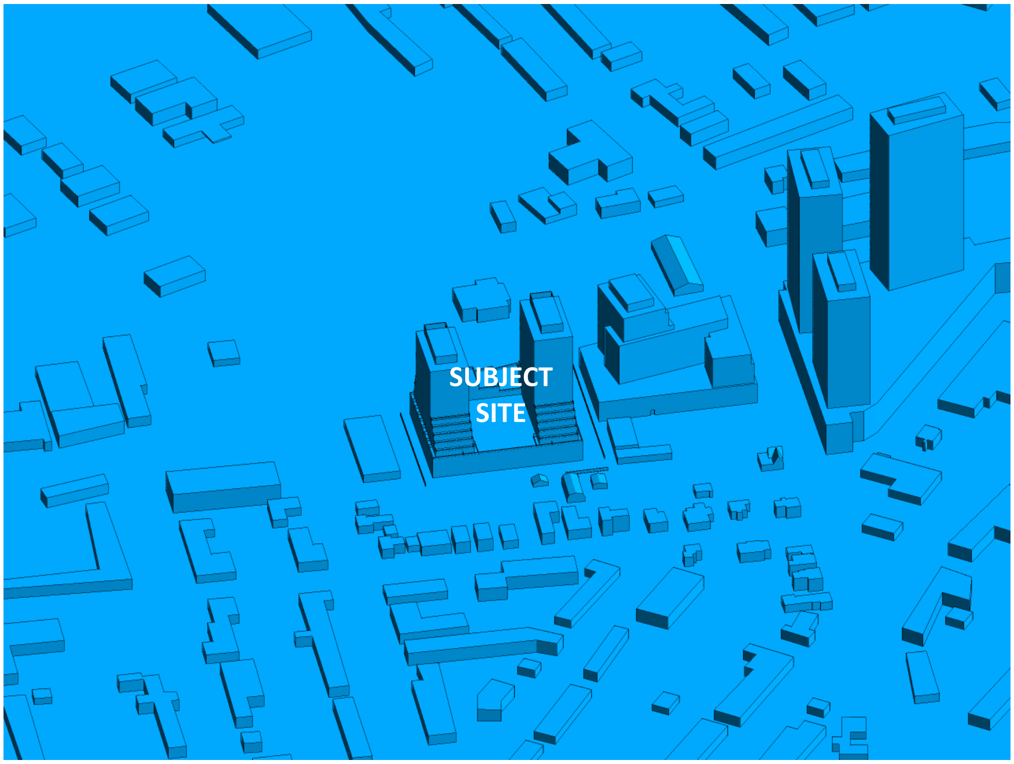

FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTH PERSPECTIVE

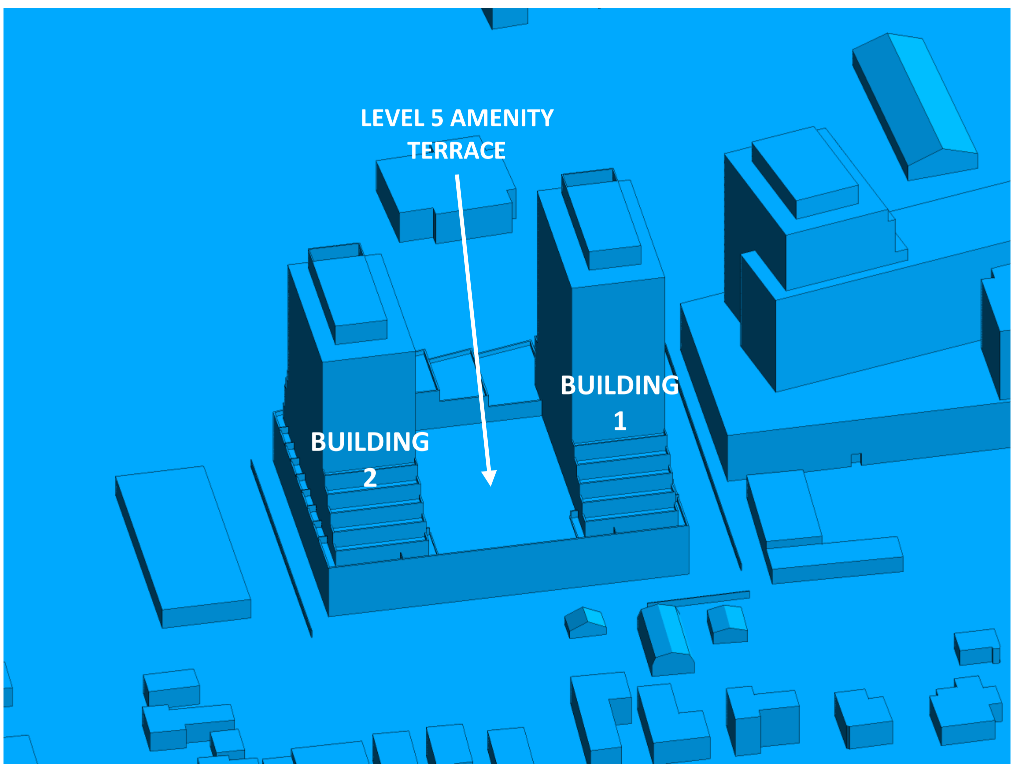

FIGURE 2F: CLOSE-UP OF FIGURE 2E

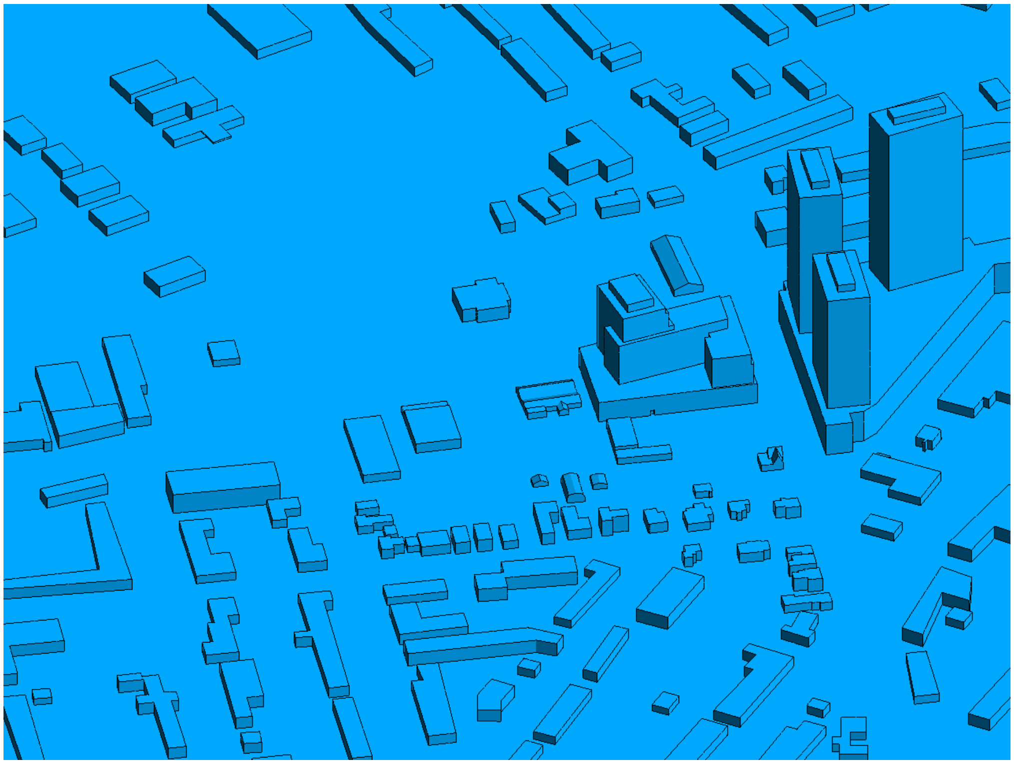

FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTH PERSPECTIVE

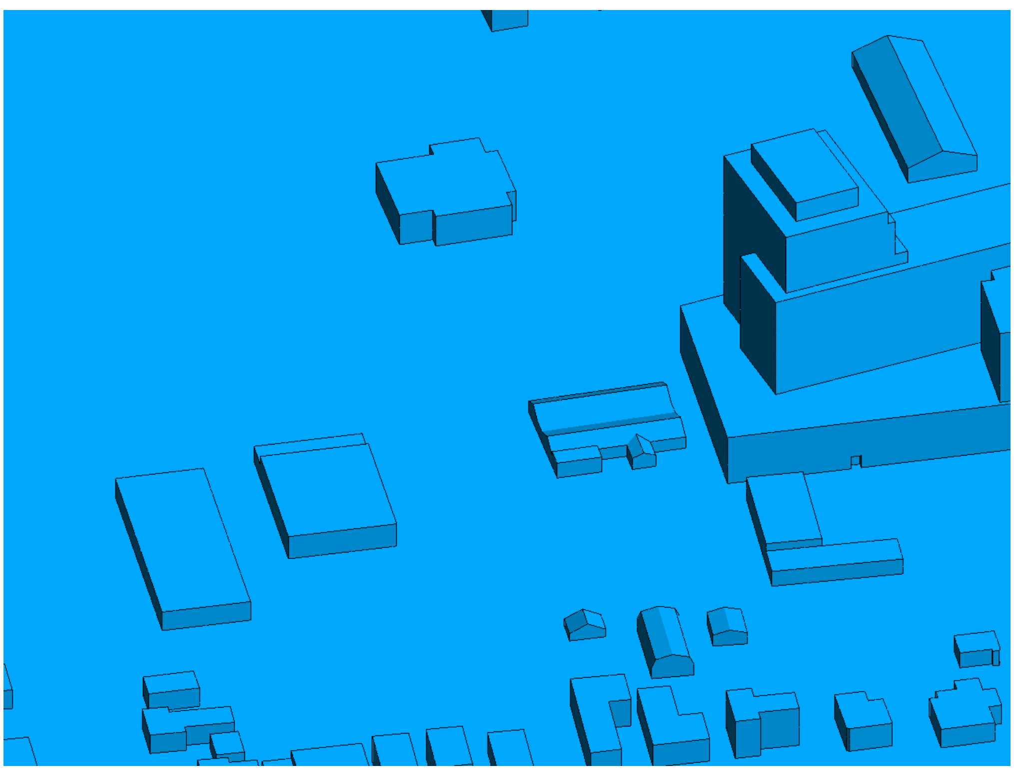

FIGURE 2H: CLOSE-UP OF FIGURE 2G

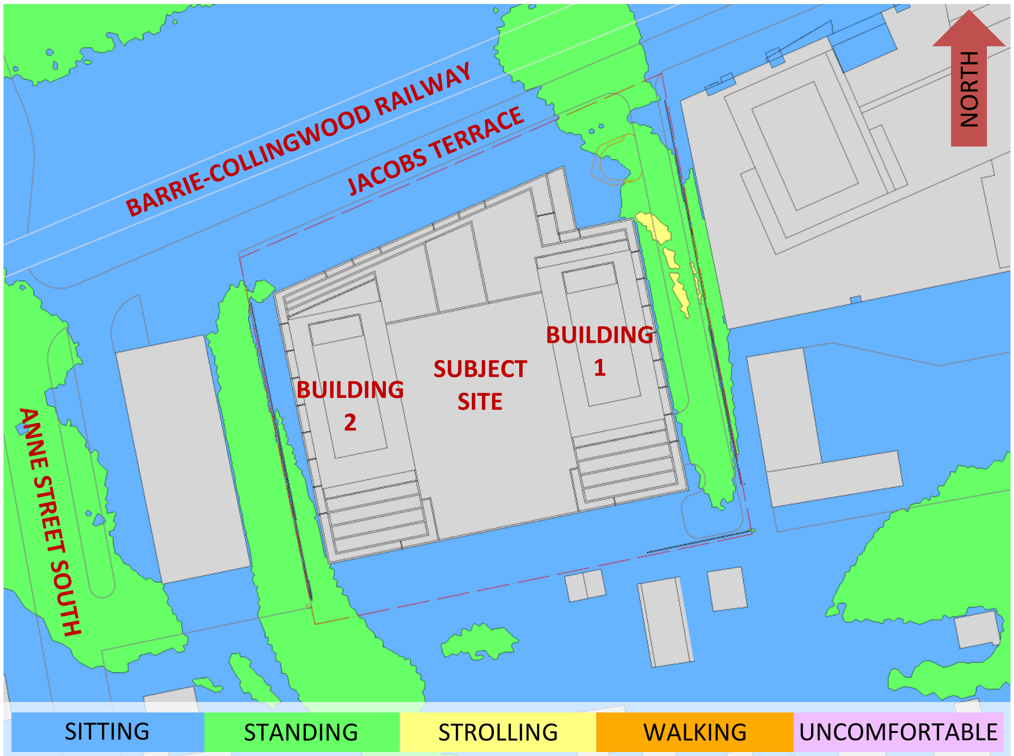

FIGURE 3A: SPRING – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

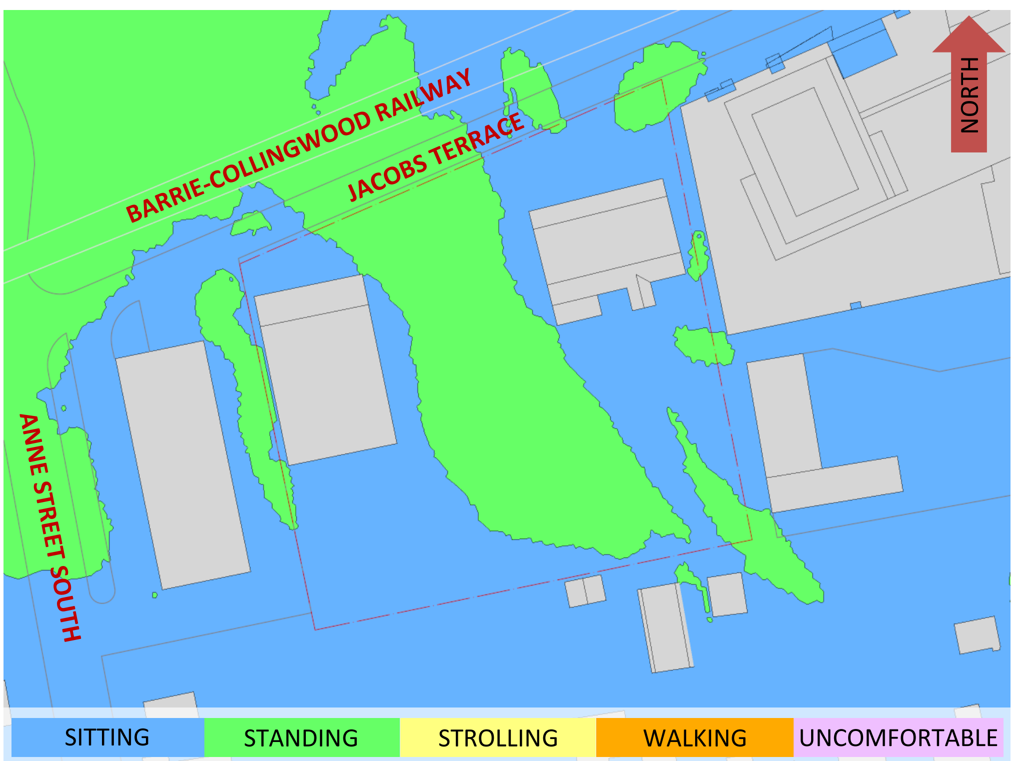

FIGURE 3B: SPRING – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

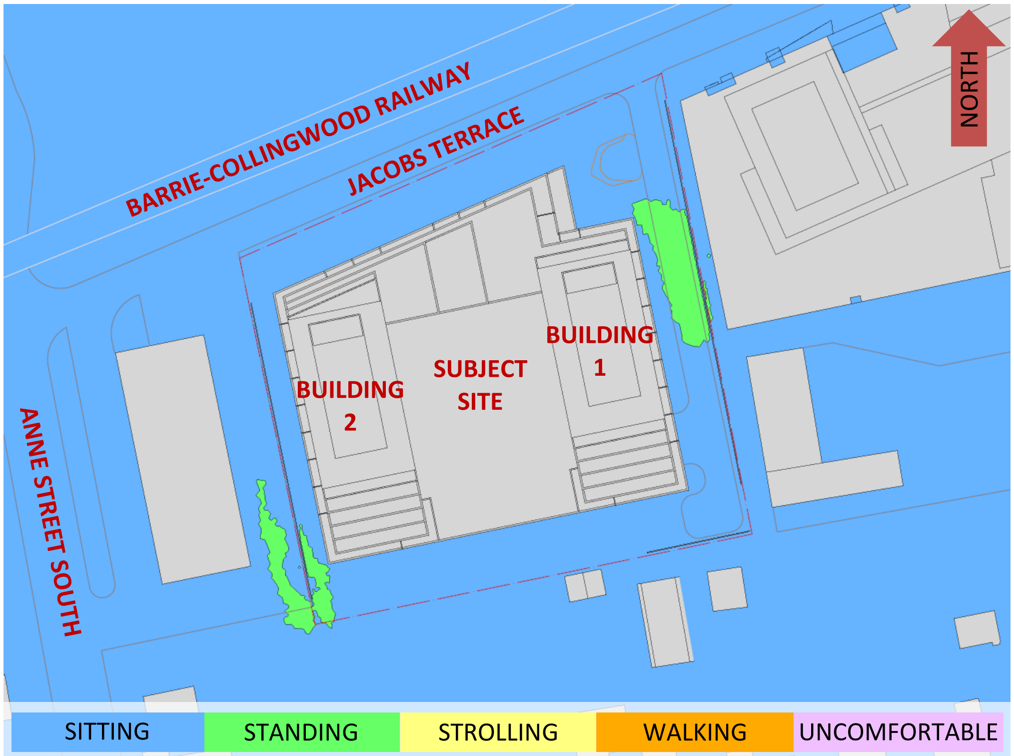

FIGURE 4A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

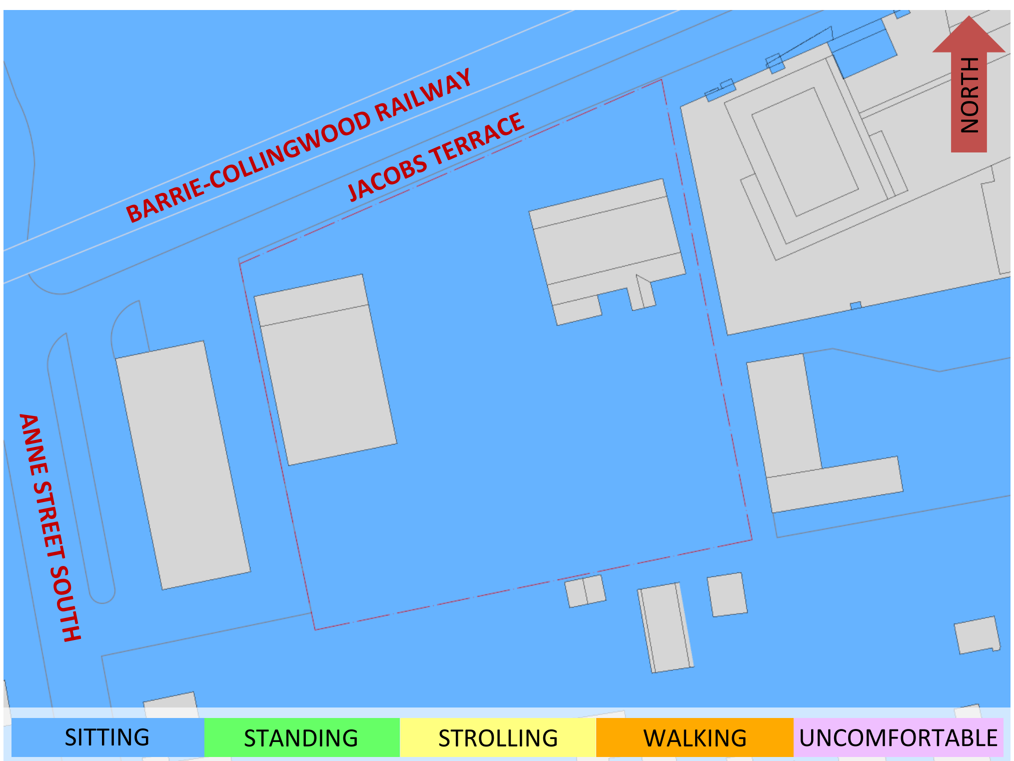

FIGURE 4B: SUMMER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

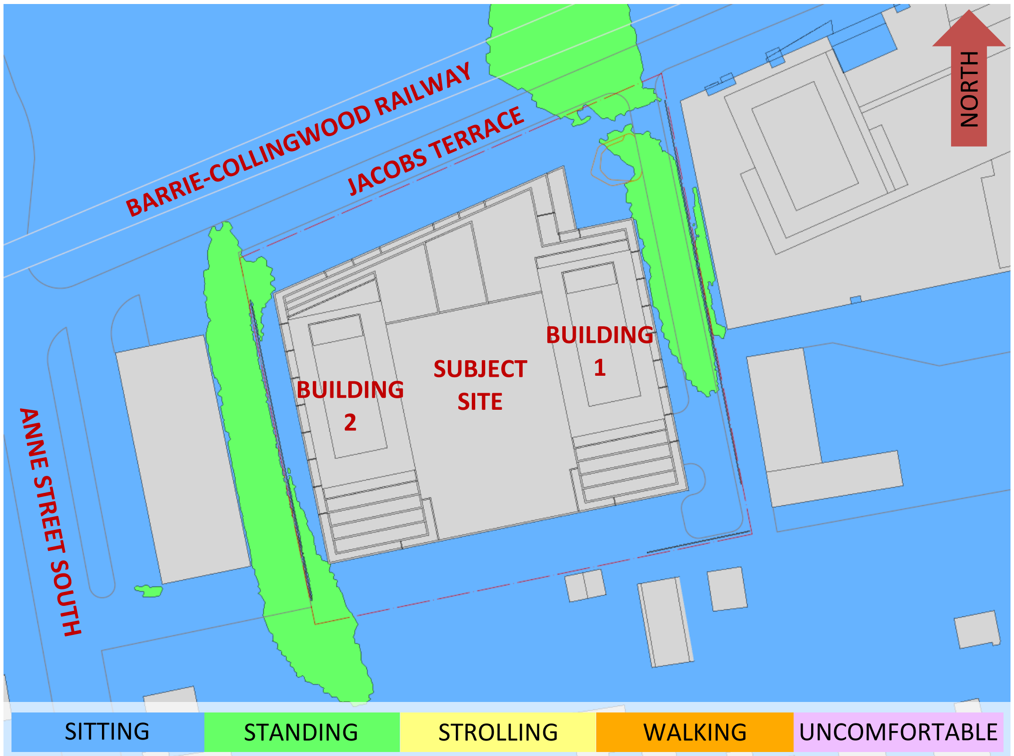

FIGURE 5A: AUTUMN – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

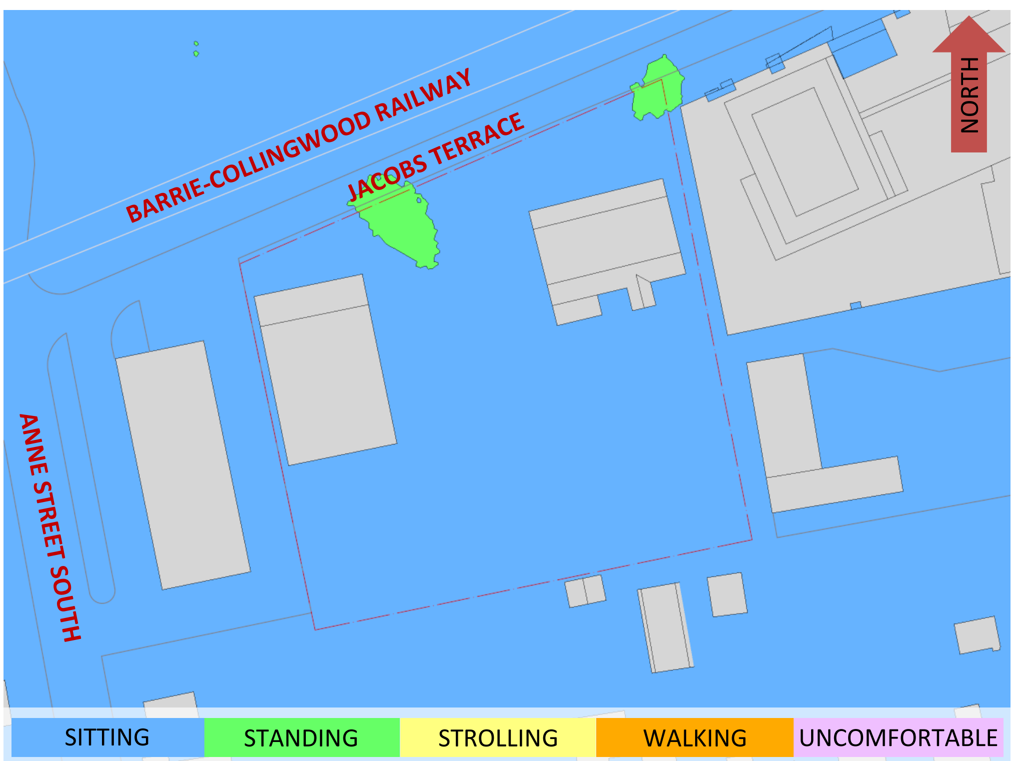

FIGURE 5B: AUTUMN – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

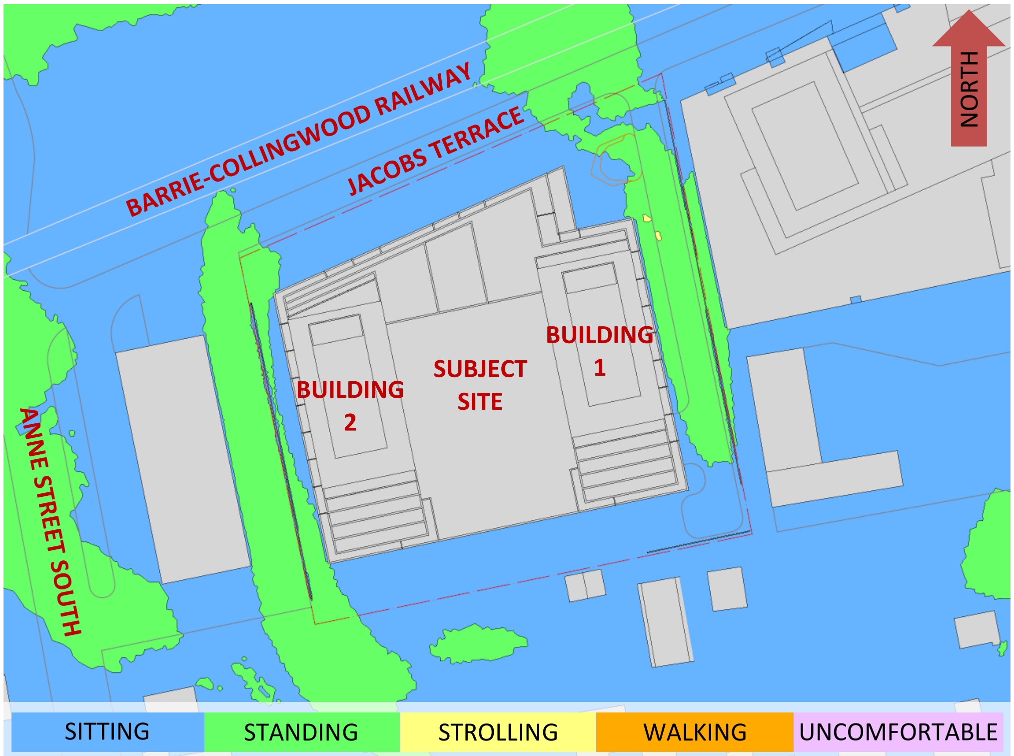

FIGURE 6A: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

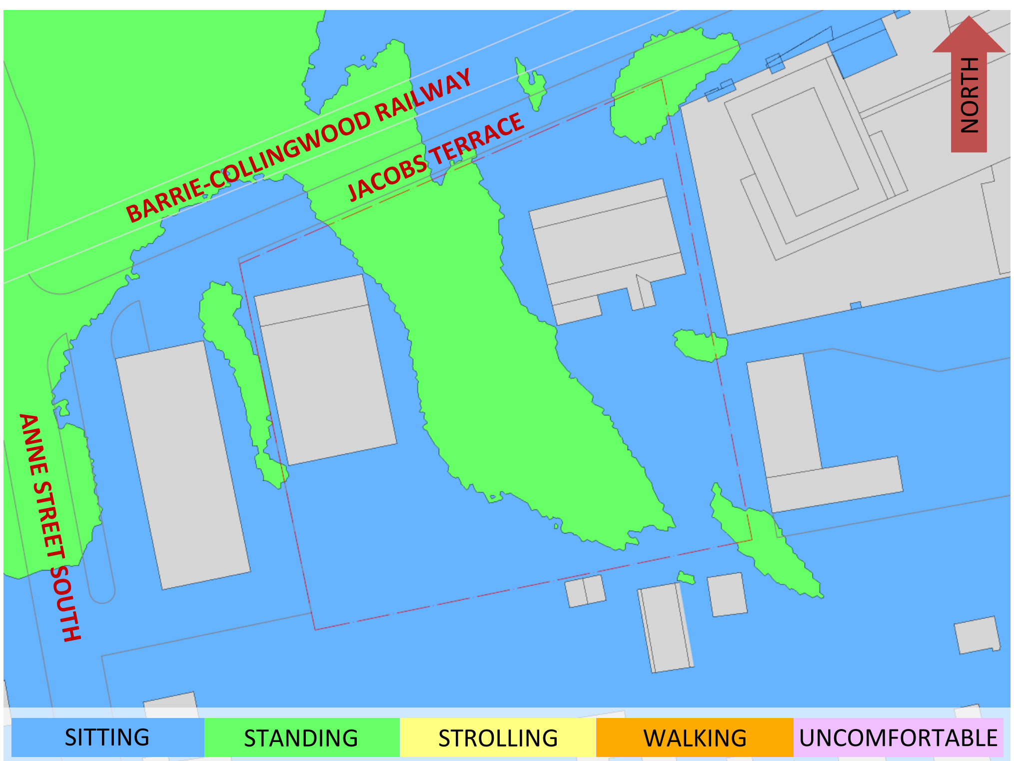

FIGURE 6B: WINTER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

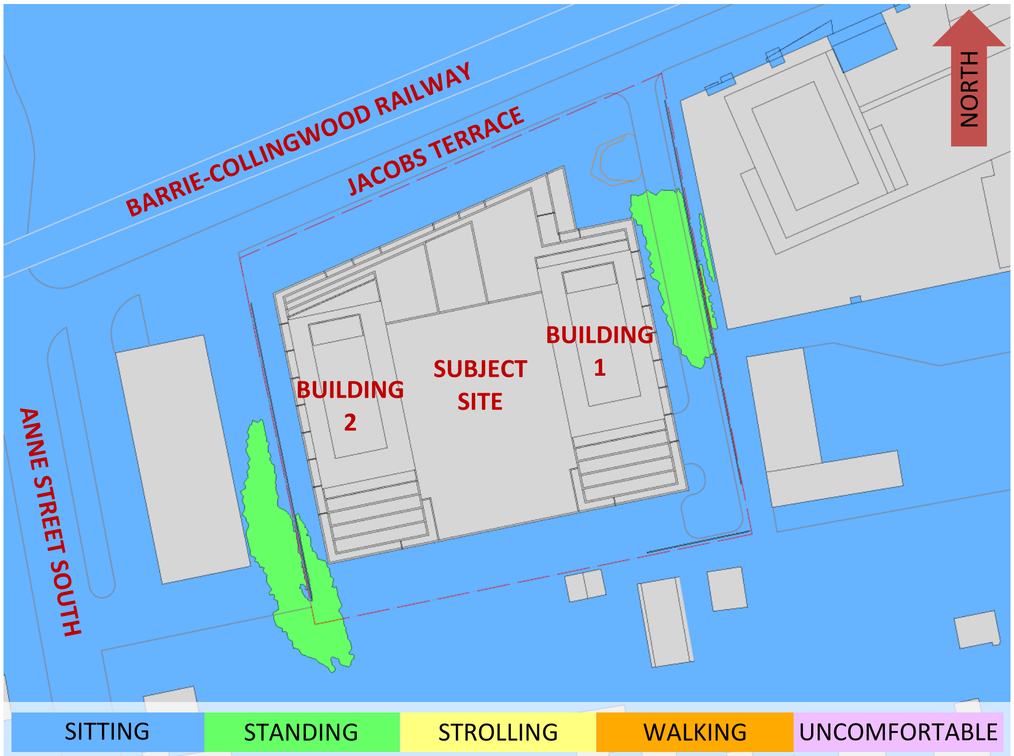

FIGURE 7: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

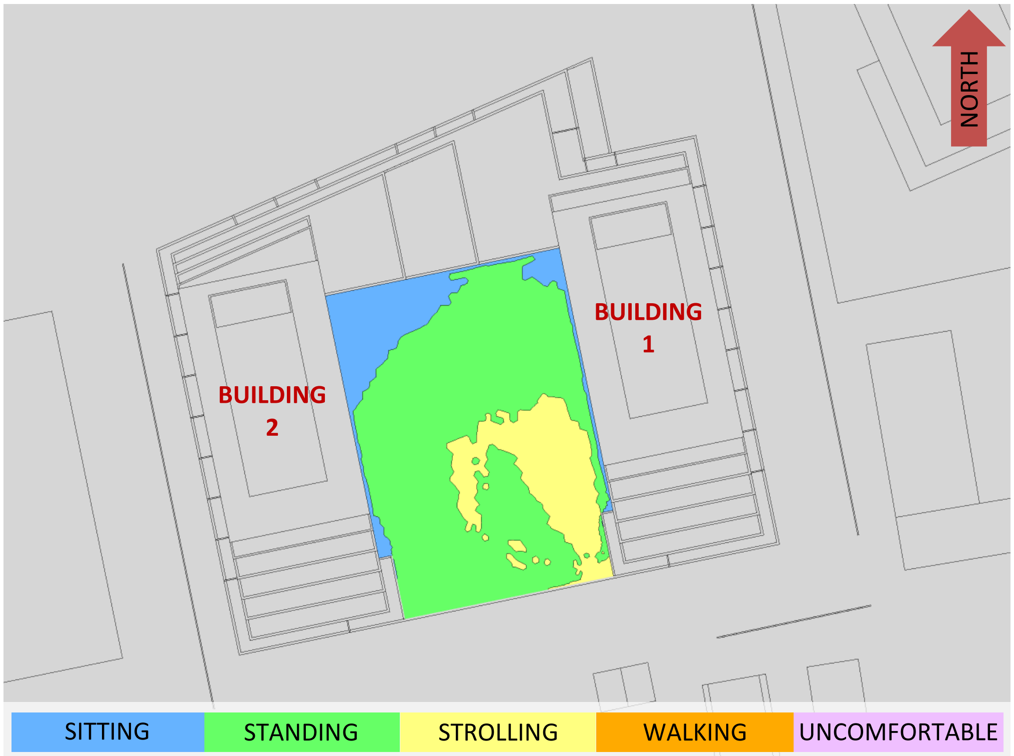

FIGURE 8A: SPRING – WIND COMFORT, LEVEL 5 AMENITY TERRACE

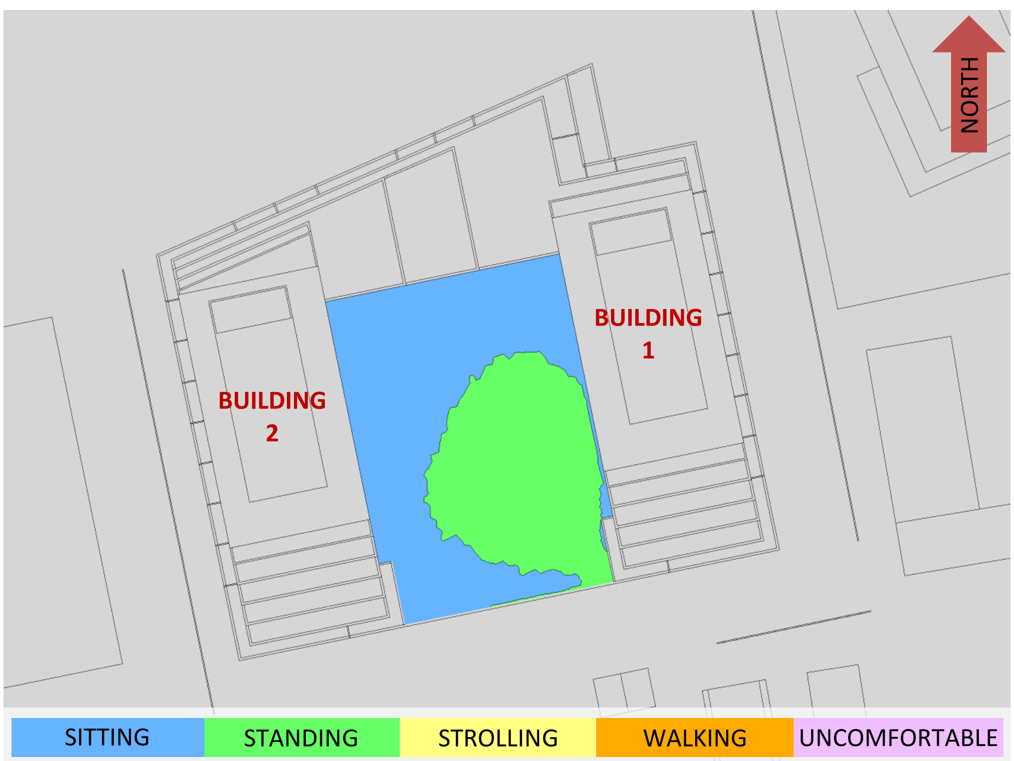

FIGURE 8B: SUMMER – WIND COMFORT, LEVEL 5 AMENITY TERRACE

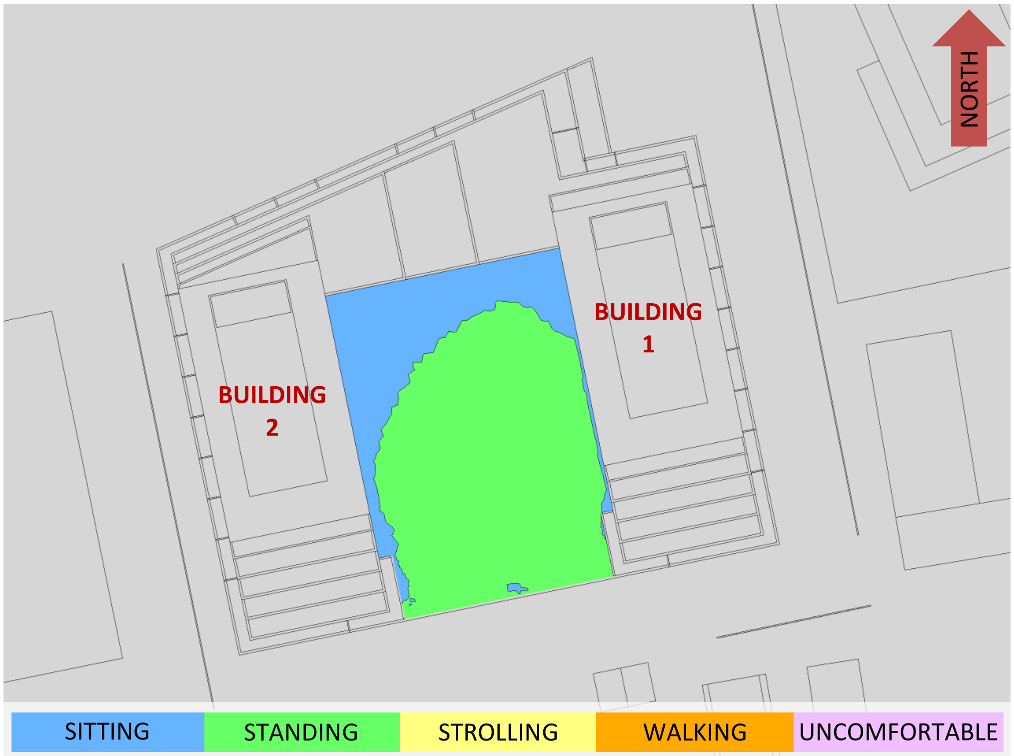

FIGURE 8C: AUTUMN – WIND COMFORT, LEVEL 5 AMENITY TERRACE

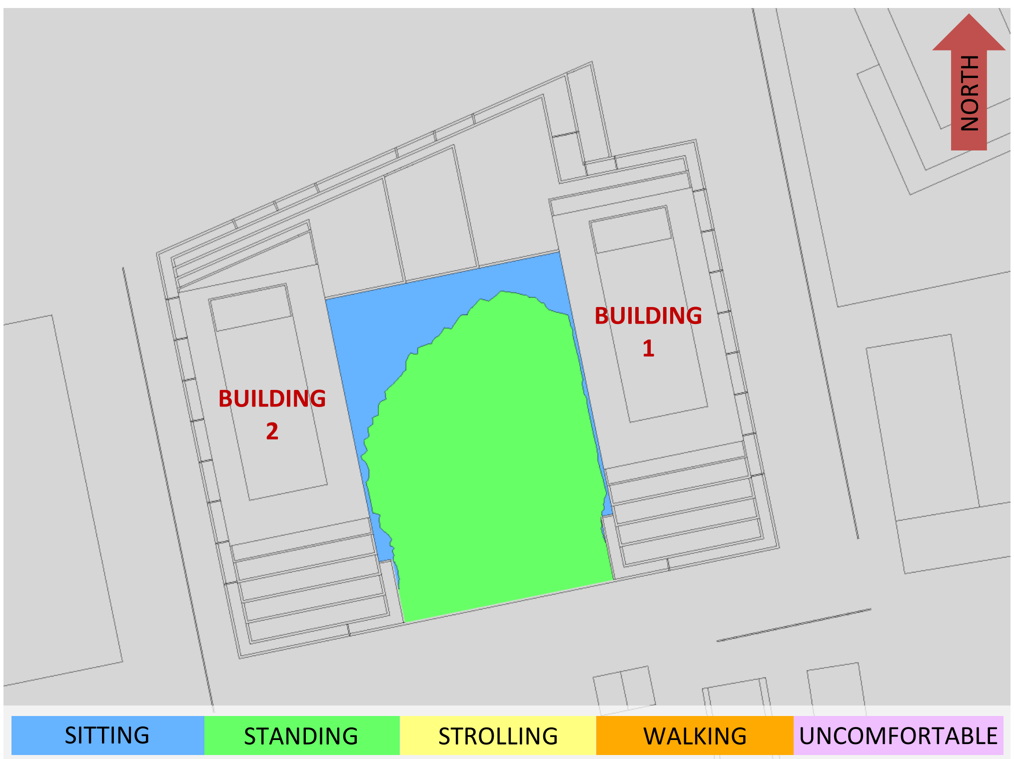

FIGURE 8D: WINTER – WIND COMFORT, LEVEL 5 AMENITY TERRACE

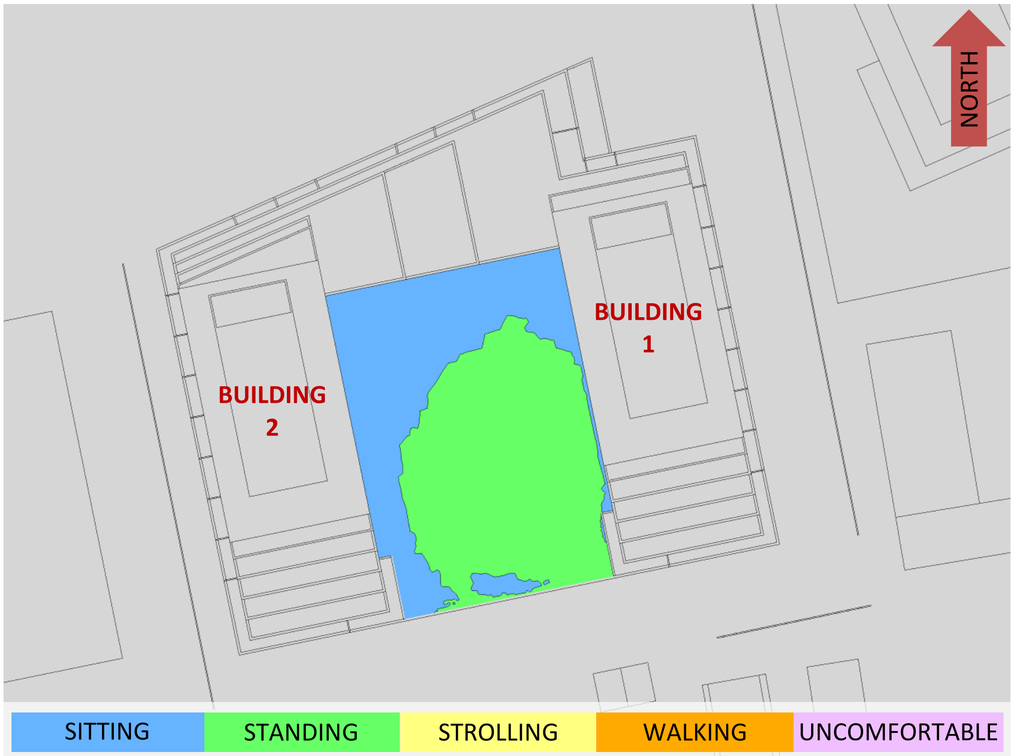

FIGURE 9A: TYPICAL USE PERIOD – WIND COMFORT, LEVEL 5 AMENITY TERRACE

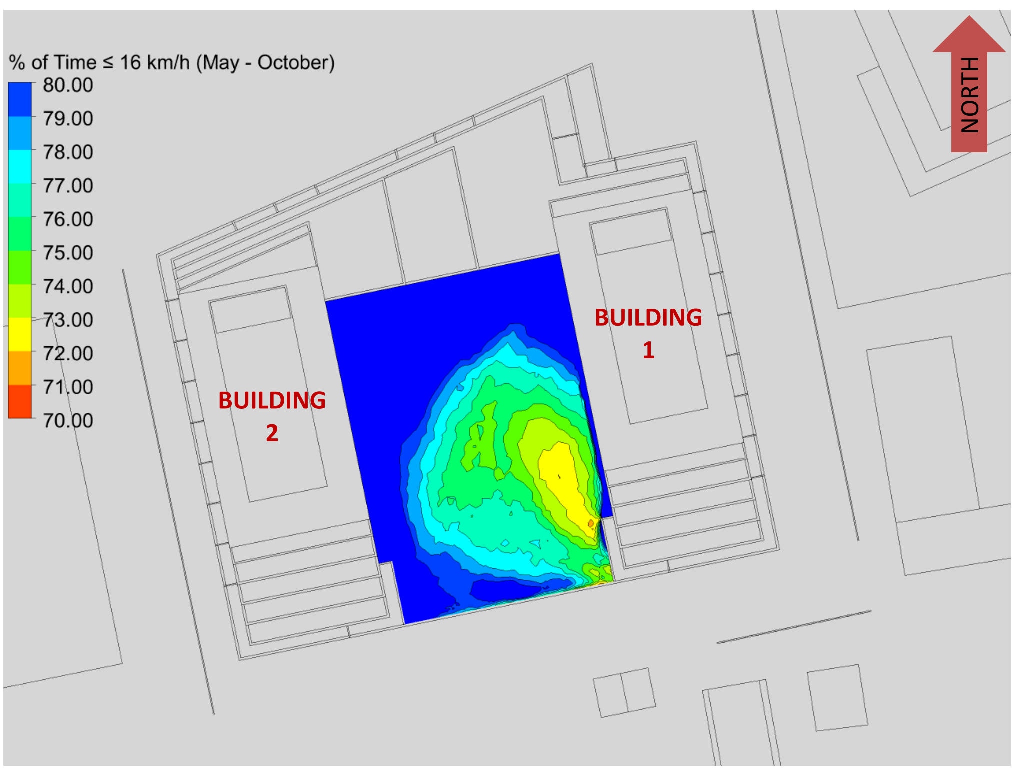

FIGURE 9B: PERCENTAGE OF TIME SUITABLE FOR SITTING IN FIGURE 9A

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

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

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

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

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

Wind Direction (Degrees True)	Alpha Value (α)
0	0.23
49	0.20
98	0.22
132	0.23
164	0.23
200	0.23
237	0.22
263	0.22
280	0.23
295	0.23
310	0.23
331	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, $\boldsymbol{L_t}$ = 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 Engineering Symposium, IWES 2003*, Taiwan, 2003.