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PEDESTRIAN LEVEL WIND STUDY

1056 and 1060 Brant Street
Burlington, Ontario

Report: 25-054-PLW







October 1, 2025

PREPARED FOR

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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study to satisfy Official Plan Amendment and Zoning By-Law Amendment submission requirements for the proposed residential development located at 1056 and 1060 Brant Street in Burlington, Ontario (hereinafter referred to as the "subject site" or "proposed development"). Our mandate within this study is to investigate wind conditions within and surrounding the subject site, and to identify areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where required.

The study involves simulation of wind speeds for sixteen (16) wind directions in a three-dimensional (3D) computer model using the computational fluid dynamics (CFD) technique, combined with meteorological data integration, to assess pedestrian wind conditions within and surrounding the subject site according to City of Burlington wind comfort and safety criteria. A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-4B, and is summarized as follows:

1) Most grade-level areas surrounding the subject site are predicted to experience conditions that are considered acceptable for their intended pedestrian uses throughout the year. Specifically, conditions over the nearby public sidewalks, transit stop, and neighbouring existing surface parking lots remain acceptable following the introduction of the proposed development. Conditions over the proposed surface parking, walkways, and in the vicinity of the building access points serving the proposed development are considered acceptable.

2) If windier areas within the proposed grade-level outdoor amenity serving the proposed development will include seating or lounging areas, comfort conditions at these areas may be improved by implementing targeted mitigation elements as described in Section 5.1.

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

Addendum: The PLW study was completed with the architectural drawings prepared by WZMH Architects in March 2025. Updated drawings were distributed to the consultant team in September 2025 with some minor changes to the proposed development. At the ground floor, the building has been extended along the west elevation, access to below grade parking is now provided by two central car elevators, and the grade-level outdoor amenity has been extended along the west elevation. Moreover, the building steps back along the west elevation at Level 11.

The noted changes are considered modest from a wind engineering perspective. The wind comfort conditions predicted for the March 2025 massing and the conclusions and recommendations detailed in the present study remain representative of the current site massing.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by 2735841 Ontario Inc. to undertake a pedestrian level wind (PLW) study to satisfy Official Plan Amendment and Zoning By-Law Amendment submission requirements for the proposed residential development located at 1056 and 1060 Brant Street in Burlington, Ontario (hereinafter referred to as the "subject site" or "proposed development"). Our mandate within this study is to investigate pedestrian wind conditions within and surrounding the subject site, and to identify areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where required.

The study is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, City of Burlington wind comfort and safety criteria, architectural drawings provided by WZMH Architects in March 2025, surrounding street layouts and existing and approved future building massing information obtained from the City of Burlington, and recent site imagery.

2. TERMS OF REFERENCE

The subject site is located at 1056 and 1060 Brant Street in Burlington, situated approximately 70 metres (m) west-northwest of the intersection of Brant Street and Leighland Road on a parcel of land bounded by Brant Street to the northeast, a low-rise residential dwelling to the southeast, Ryckman Common to the southwest, and a low-rise commercial building with a surface parking lot to the northwest. Throughout this report, Brant Street is referred to as project east. The proposed development comprises a near-rectangular 11-storey residential building, topped with a mechanical penthouse (MPH). An outdoor amenity is provided along the south side of the subject site at grade.

Above an underground parking level, the ground floor includes a main entrance at the northeast corner to a lobby and shared building support spaces, an indoor amenity at the southeast corner, and a loading space and surface parking to the west. Access to the underground parking level is provided by a ramp at the southwest corner via a drive aisle extending along the north and west sides of the subject site from Brant Street. Levels 2-11 are reserved for residential occupancy.

The building extends from the north and west elevations at Level 2 and building setbacks are located from the north, south, and west elevations at Level 5 and from the east elevation at Levels 7 and 11.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within a 200-m-radius of the subject site) are characterized by mostly green space from the northwest clockwise to the northeast, and low-rise buildings in the remaining directions. The far-field surroundings (defined as the area beyond the near field and within a two-kilometre (km) radius) include low-rise suburban massing in all directions with isolated clusters of mid- and high-rise buildings farther to the south.

Site plans for the proposed and existing massing scenarios are illustrated in Figure 1, while Figures 2A-2H illustrate the computational model used to conduct the study.

3. OBJECTIVES

The principal objectives of this study are to (i) determine pedestrian level wind conditions at key areas within and surrounding the subject site; (ii) identify areas where wind conditions may interfere with the intended uses of outdoor spaces; and (iii) recommend suitable mitigation measures, where required.

4. METHODOLOGY

The approach followed to quantify wind conditions over the site is based on CFD simulations of wind speeds across the subject site within a virtual environment, meteorological analysis of the Burlington area wind climate, and synthesis of computational data with City of Burlington wind criteria[1]. The following sections describe the analysis procedures, including a discussion of the noted pedestrian wind criteria.

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

4.1 Computer-Based Context Modelling

A computer based PLW study was performed to determine the influence of the wind environment on pedestrian comfort over the proposed development site. Pedestrian comfort predictions, based on the mechanical effects of wind, were determined by combining measured wind speed data from CFD simulations with statistical weather data obtained from John C. Munro Hamilton International Airport in Hamilton, Ontario. The general concept and approach to CFD modelling is to represent building and topographic details in the immediate vicinity of the subject site on the surrounding model, and to create suitable atmospheric wind profiles at the model boundary. The wind profiles are designed to have similar mean and turbulent wind properties consistent with actual site exposures.

An industry standard practice is to omit trees, vegetation, and other existing and proposed landscape elements from the model due to the difficulty of providing accurate seasonal representation of vegetation. The omission of trees and other landscaping elements produces stronger wind speed values.

4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the subject site for 16 wind directions. The CFD simulation model was centered on the proposed development, complete with surrounding massing within a radius of 480 m. The process was performed for two massing scenarios, as described in Section 2.

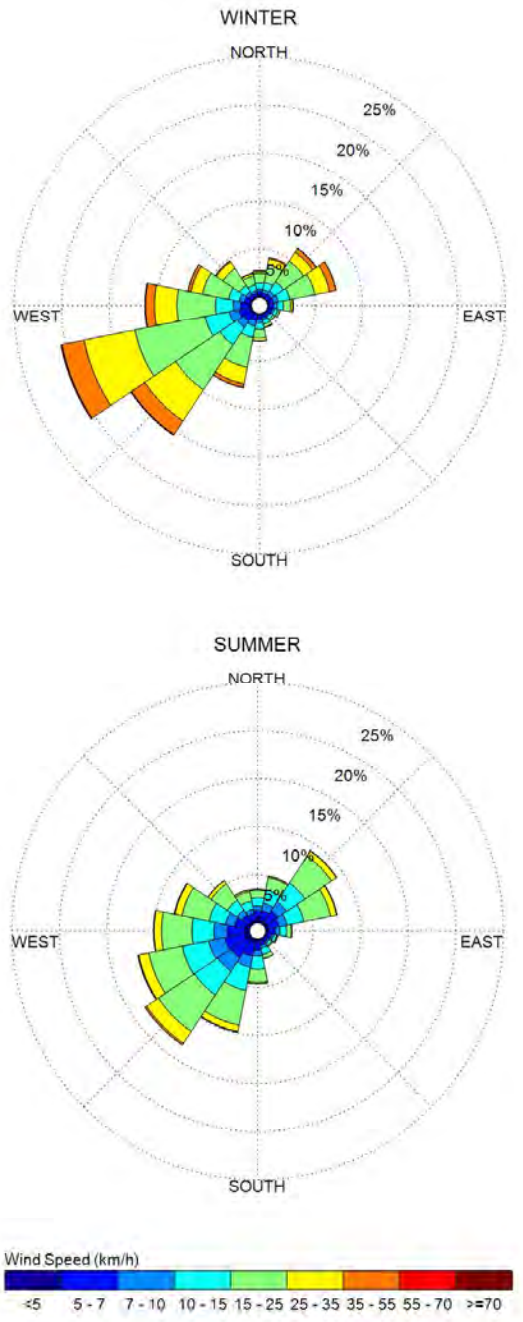
Mean and peak wind speed data obtained over the subject site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade were referenced to the wind speed at gradient height to generate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

4.3 Historical Wind Speed and Direction Data

A statistical model for winds in Hamilton, representative of Burlington, was developed from approximately 50 years of hourly meteorological wind data recorded at John C. Munro Hamilton International Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were analyzed during the appropriate hours of pedestrian usage (that is, between 06:00 and 23:00) and divided into two distinct seasons, as stipulated in the wind criteria. Specifically, the summer season is defined as May through October, while the winter season is defined as November through April, inclusive.

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

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



Notes:

1. Radial distances indicate percentage of time of wind events.
2. Wind speeds are mean hourly in km/h, measured at 10 m above the ground.

4.4 Pedestrian Wind Comfort and Safety Criteria – City of Burlington

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

PEDESTRIAN WIND COMFORT CLASS DEFINITIONS

Wind Comfort Class	GEM Speed (km/h)	Description
SITTING	≤ 10	GEM wind speeds no greater than 10 km/h occurring at least 80% of the time would be considered acceptable for sedentary activities, including sitting.
STANDING	≤ 14	GEM wind speeds no greater than 14 km/h occurring at least 80% of the time are acceptable for activities such as standing or more vigorous activities.
LEISURELY WALKING	≤ 17	GEM wind speeds no greater than 17 km/h occurring at least 80% of the time are acceptable for leisurely walking, strolling, or more vigorous activities.
FAST WALKING	≤ 20	GEM wind speeds no greater than 20 km/h occurring at least 80% of the time are acceptable for fast walking or more vigorous activities.
UNCOMFORTABLE	> 20	Uncomfortable conditions are characterized by predicted values that fall below the 80% target for walking. Brisk walking and exercise, such as jogging, would be acceptable for moderate excesses of this criterion.

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

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

Once the pedestrian wind speed predictions have been established throughout the subject site, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for discrete regions within and surrounding the subject site. This step involves comparing the predicted comfort classes to the target comfort classes, which are dictated by the location type for each region (that is, a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their typical windiest target comfort classes are summarized below. Depending on the programming of a space, the desired comfort class may differ from this table.

TARGET PEDESTRIAN WIND COMFORT CLASSES FOR VARIOUS LOCATION TYPES

Location Types	Target Comfort Classes
Primary Building Entrance	Standing
Secondary Building Access Point	Fast Walking
Public Sidewalk / Bicycle Path	Fast Walking
Café / Patio / Bench / Garden	Sitting / Standing
Transit/Bus Stop (Without Shelter)	Standing
Transit/Bus Stop (With Shelter)	Fast Walking
Public Park / Plaza / Amenity Space	Sitting / Standing
Garage / Service Entrance / Parking Lot	Fast 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. Conditions are presented as continuous contours of wind comfort within and surrounding the subject site and correspond to the various comfort classes noted in Section 4.4.

The details of these conditions are summarized in the following pages for each area of interest.

5.1 Wind Comfort Conditions

Sidewalks and Transit Stop along Brant Street: Following the introduction of the proposed development, wind conditions over the nearby public sidewalks along Brant Street are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for fast walking, or better, during the winter. Conditions in the vicinity of the nearby transit stop along Brant Street are predicted to be suitable for mostly standing, or better, throughout the year. The noted conditions are considered acceptable.

Under the existing massing, conditions over the noted sidewalks are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for leisurely walking, or better, during the winter, and conditions over the noted transit stop are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, during the winter. While the introduction of the proposed development produces somewhat windier conditions over Brant Street in comparison to existing conditions, wind comfort conditions with the proposed development are nevertheless considered acceptable for public sidewalks and the noted transit stop.

Ryckman Common: Wind conditions following the introduction of the proposed development along Ryckman Common are predicted to be suitable for leisurely walking, or better, during the summer. During the winter season, windier conditions are predicted over some areas near and within the subject site. The mostly suburban environs of the subject site and the limited built-up massing in the vicinity of the proposed development exposes the subject site to the prevailing winter winds from the southwest compass quadrant, which are the predominant winds during the winter season. The prevailing winds from the southwest are predicted to downwash over the western façade and northwest corner of the building towards grade-level and accelerate around the northwest corner of the building at grade-level between

the proposed development and the neighbouring low-rise commercial building to the north. Regions of conditions that may be considered occasionally uncomfortable for walking are predicted to the northeast over the proposed drive aisle, and to the west over Ryckman Common during the winter.

Specifically, over Ryckman Common, conditions during the winter season are predicted to be suitable for fast walking approximately 75% of the winter season, representing a 5% exceedance of the walking threshold. The uncomfortable wind conditions are located over the roadway surface; as such, the noted conditions with the proposed development over Ryckman Common may be considered satisfactory.

Conditions under the existing massing along Ryckman Common are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for fast walking, or better, during the winter. Prior to and following the introduction of the proposed development, conditions over the surface parking lot to the northwest of the subject site along Ryckman Common are predicted to be suitable for mostly leisurely walking, or, better, throughout the year. While the introduction of the proposed development produces windier conditions along Ryckman Common in comparison to existing conditions, wind comfort conditions with the proposed development over Ryckman Common are nevertheless considered satisfactory.

Neighbouring Existing Surface Parking Lots to the North and East of Subject Site: Prior to and following the introduction of the proposed development, wind conditions over the existing surface parking lot to the east of the subject site across Brant Street are predicted to be suitable for a mix of mostly sitting and standing throughout the year. The noted conditions are considered acceptable.

Under the existing massing, conditions over the existing surface parking lot to the immediate north of the subject site are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for a mix of standing and leisurely walking during the winter. Following the introduction of the proposed development, conditions over the noted parking lot to the north are predicted to be suitable for standing, or better, during the summer, becoming suitable for a mix of standing and leisurely walking during the winter, with isolated regions suitable for fast walking. The noted conditions are considered acceptable.

Surface Parking and Walkways within the Subject Site: Conditions over the visitor surface parking to the west are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for mostly standing during the winter. Conditions over the walkways within the subject site are predicted to be suitable for fast walking, or better, throughout the year. The noted conditions are considered acceptable.

Proposed Drive Aisle: Wind conditions over the proposed drive aisle along the north and west sides of the subject site are predicted to be suitable for leisurely walking, or better, during the summer, becoming suitable for a mix of mostly standing, leisurely walking, and fast walking during the winter. Within the above-noted uncomfortable region at the northeast corner of the proposed development, conditions are predicted to be suitable for walking at least 78% of the winter, representing a 2% exceedance of the walking criterion. Of importance, the predicted windier region of uncomfortable wind conditions is isolated to over the drive aisle and is not located over pedestrian areas. Given the marginal exceedance and the limited area of uncomfortable conditions, which are predicted during the winter season and in an area designated for vehicular use where pedestrians are not expected to linger, the noted conditions may be considered satisfactory.

Outdoor Amenity: Wind comfort conditions during the summer over the outdoor amenity located along the south elevation of the subject site are predicted to be suitable for sitting close to the building façade and suitable for standing to the south of the area.

Comfort conditions at sensitive-use areas within the outdoor amenity may be improved by implementing landscaping elements such as tall wind screens and coniferous plantings in dense arrangements that are targeted adjacent to designated seating areas farther from the building façade, in combination with strategically placed seating with high benches, and other forms of local wind mitigation. The extent of the mitigation measures is dependent on the programming of the outdoor amenity.

Building Access Points: Owing to the protection of the building façade, wind conditions in the vicinity of the primary and secondary building access points serving the proposed development are predicted to be suitable for standing, or better, throughout the year. The noted conditions are considered acceptable.

5.2 Wind 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.

5.3 Applicability of Results

Pedestrian wind comfort and safety have been quantified for the specific configuration of existing and foreseeable construction around the subject site. Future changes (that is, construction or demolition) of these surroundings may cause changes to the wind effects in two ways, namely: (i) changes beyond the immediate vicinity of the subject site would alter the wind profile approaching the subject site; and (ii) development in proximity to the subject site would cause changes to local flow patterns.

6. SUMMARY AND RECOMMENDATIONS

A complete summary of the predicted wind conditions is provided in Section 5 of this report and illustrated in Figures 3A-4B. Based on computer simulations using the CFD technique, meteorological data analysis, and experience with numerous similar developments, the study concludes the following:

1) Most grade-level areas surrounding the subject site are predicted to experience conditions that are considered acceptable for their intended pedestrian uses throughout the year. Specifically, conditions over the nearby public sidewalks, transit stop, and neighbouring existing surface parking lots remain acceptable following the introduction of the proposed development. Conditions over the proposed surface parking, walkways, and in the vicinity of the building access points serving the proposed development are considered acceptable.

2) If windier areas within the proposed grade-level outdoor amenity serving the proposed development will include seating or lounging areas, comfort conditions at these areas may be improved by implementing targeted mitigation elements as described in Section 5.1.

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

Sincerely,

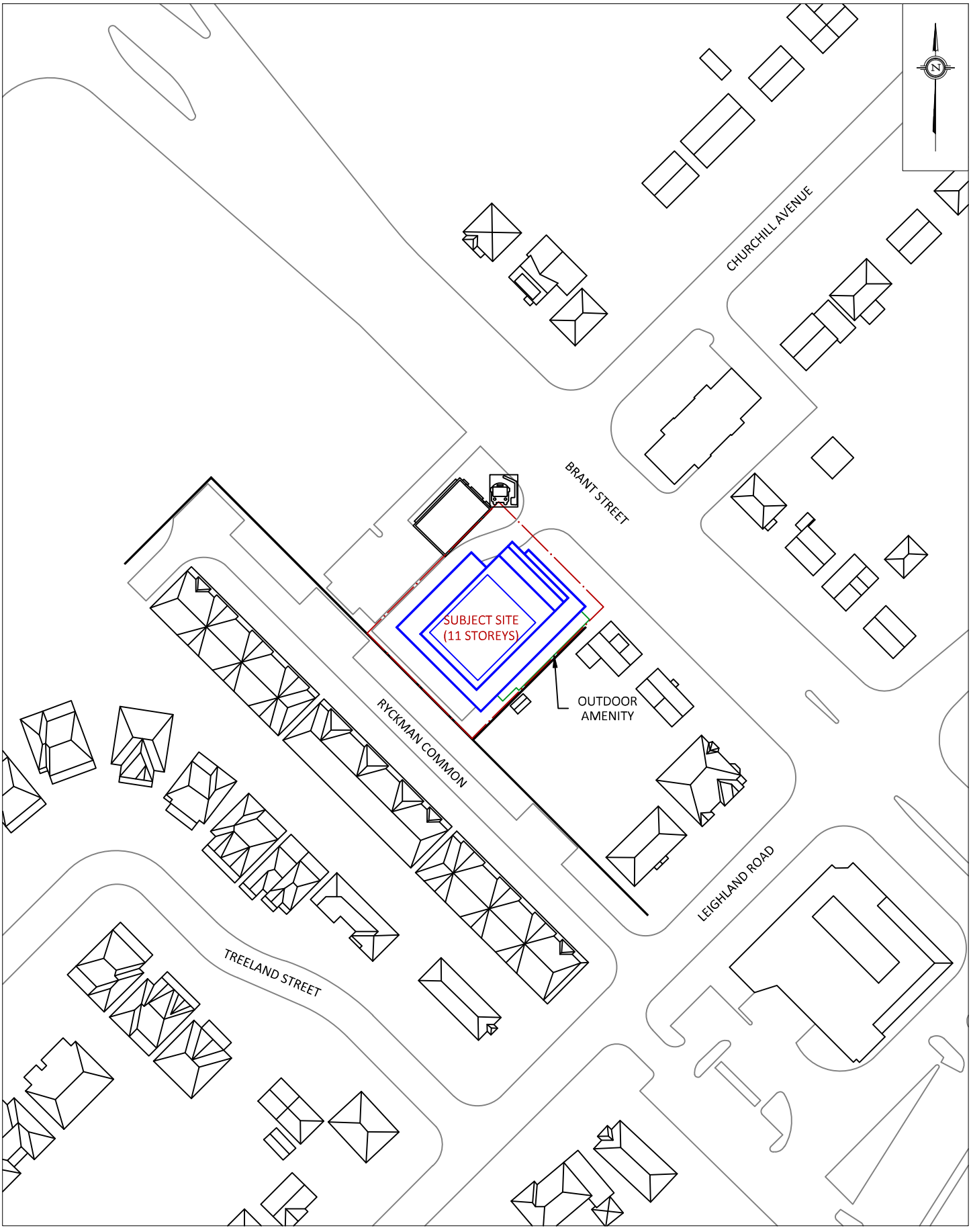
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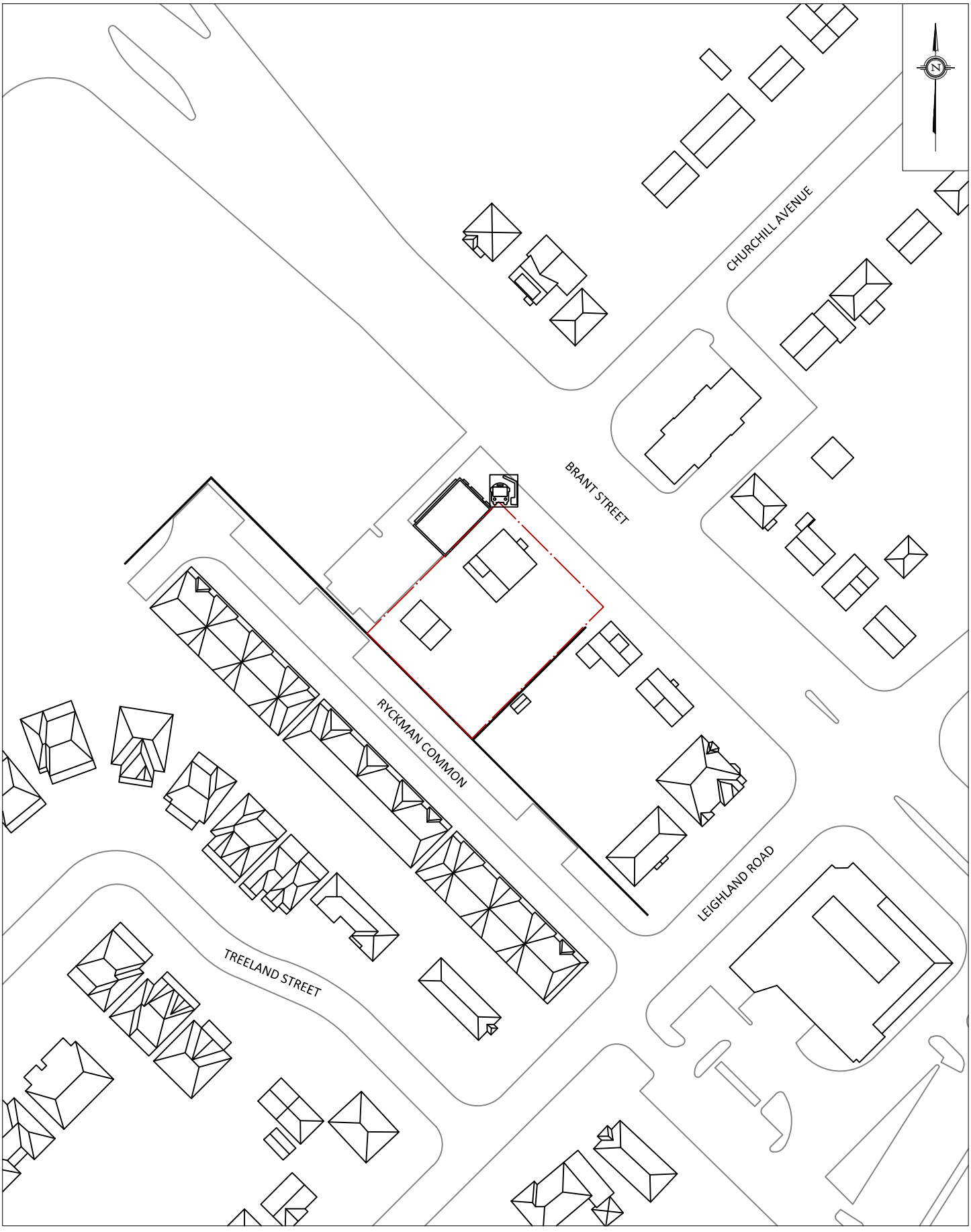
Sunny Kang, B.A.S.
Project Coordinator



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PROJECT	1056 AND 1060 BRANT STREET, BURLINGTON PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION
SCALE	1:1250	DRAWING NO. 25-054-PLW-1A	FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
DATE	APRIL 11, 2025	DRAWN BY S.K.	



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PROJECT	1056 AND 1060 BRANT STREET, BURLINGTON PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1250
DRAWING NO.	25-054-PLW-1B
DATE	APRIL 11, 2025
DRAWN BY	S.K.

DESCRIPTION

FIGURE 1B:
EXISTING SITE PLAN AND SURROUNDING CONTEXT

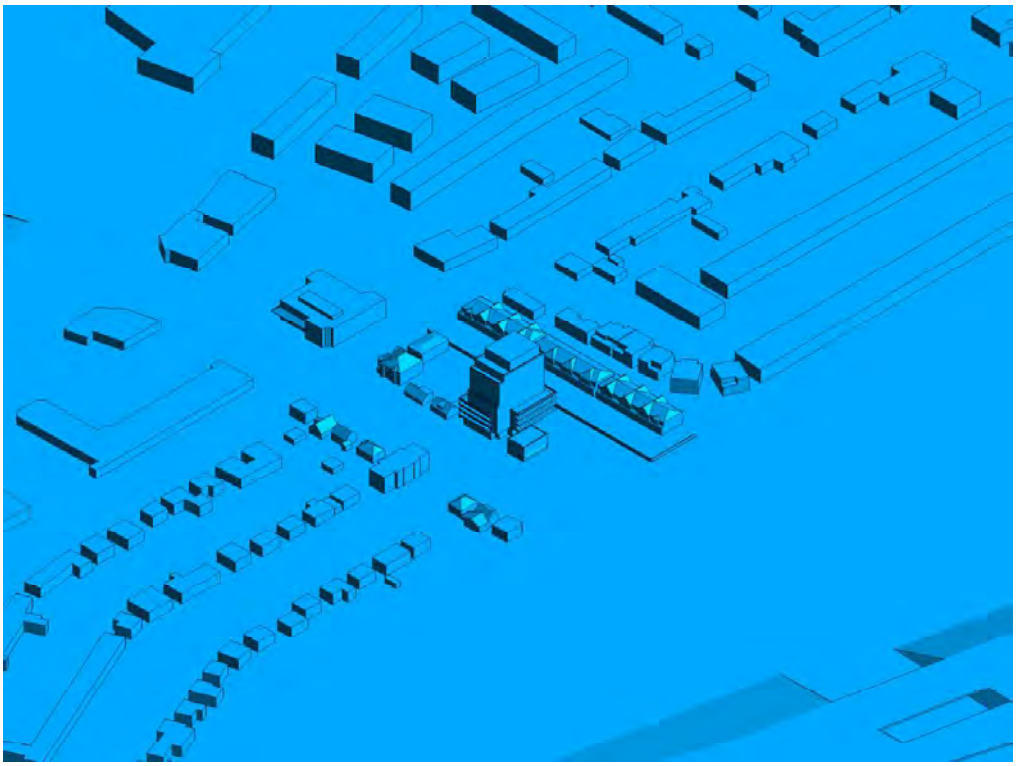


FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTH PERSPECTIVE

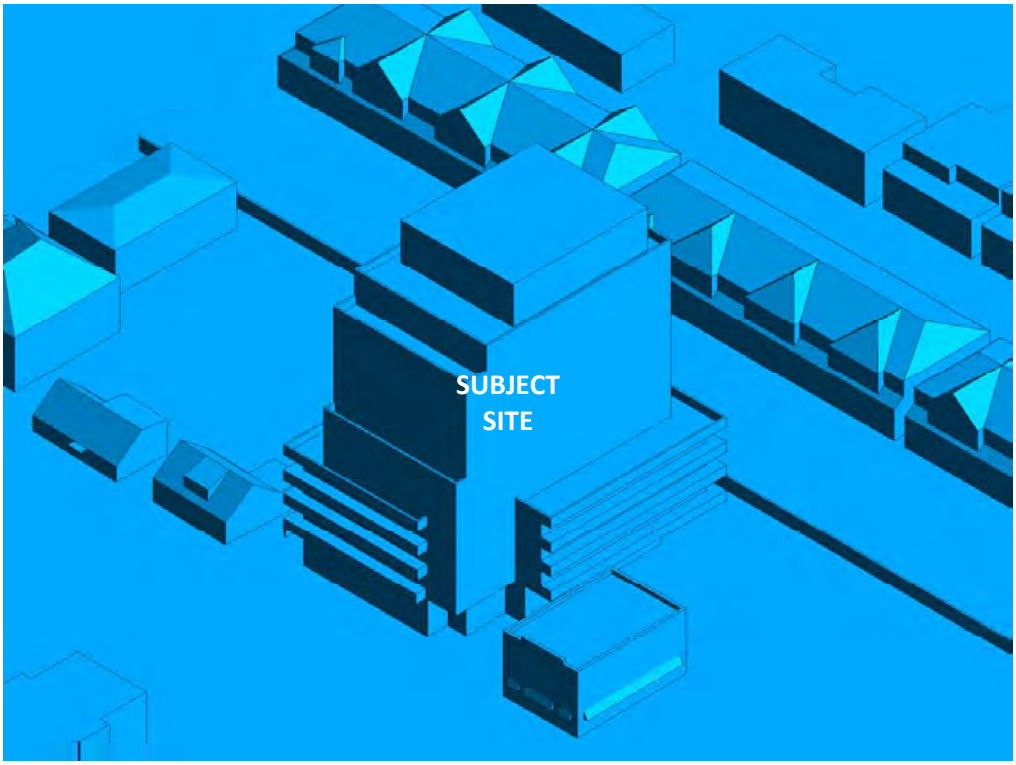


FIGURE 2B: CLOSE-UP VIEW OF FIGURE 2A

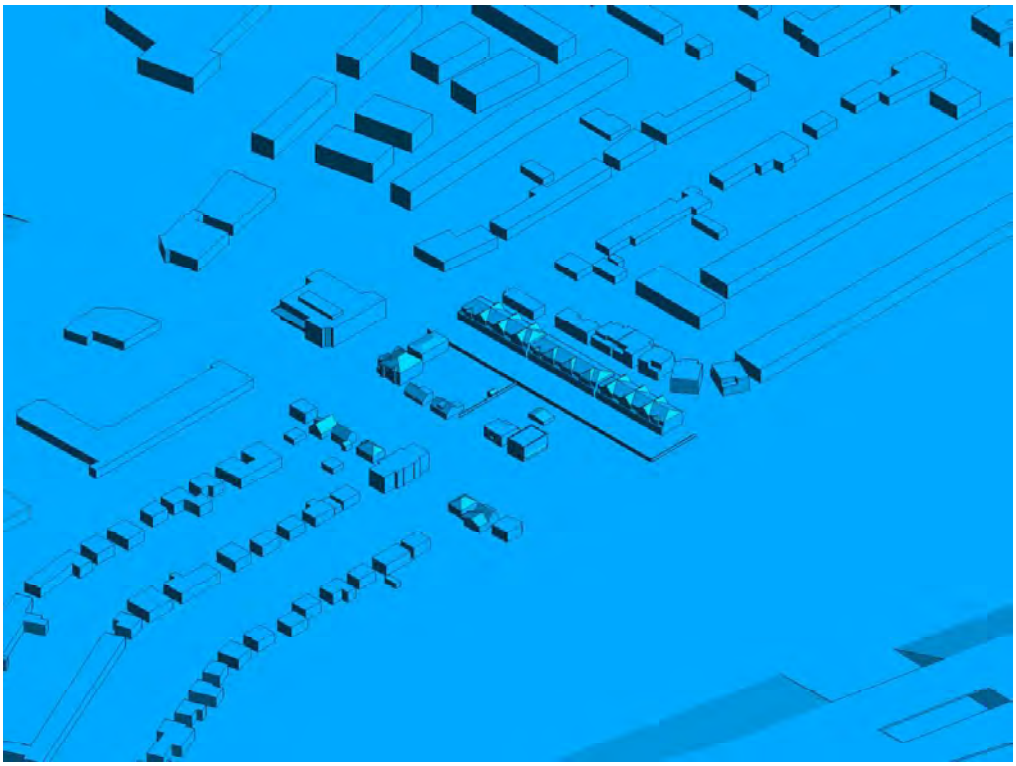


FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, NORTH PERSPECTIVE

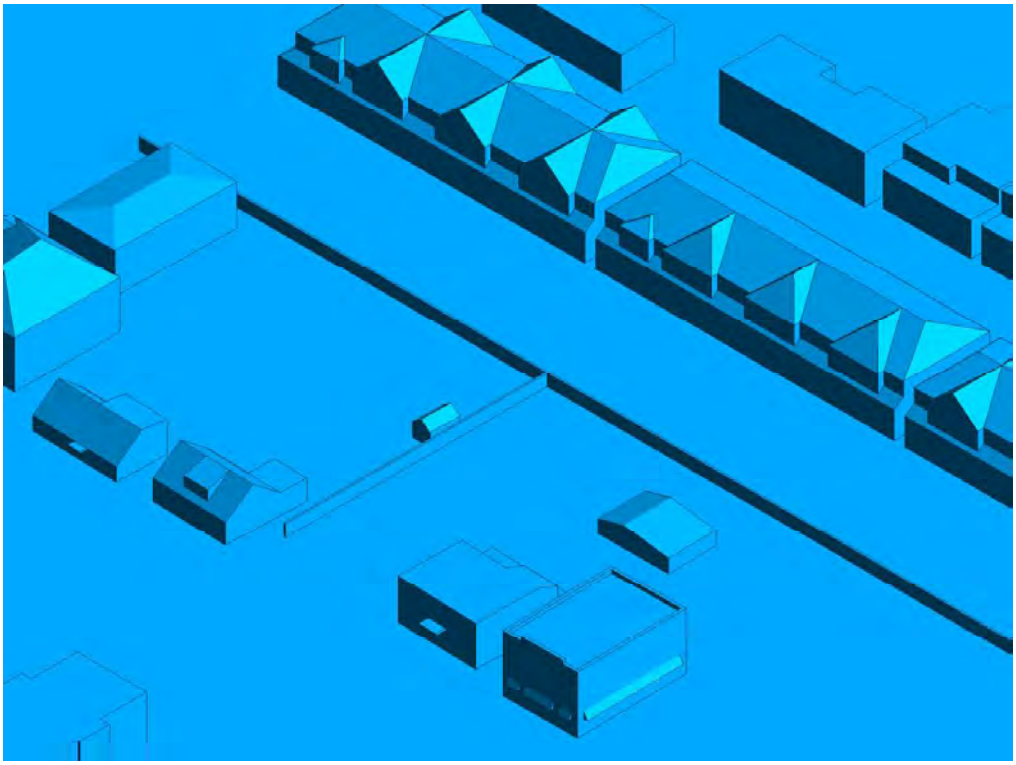


FIGURE 2D: CLOSE-UP VIEW OF FIGURE 2C

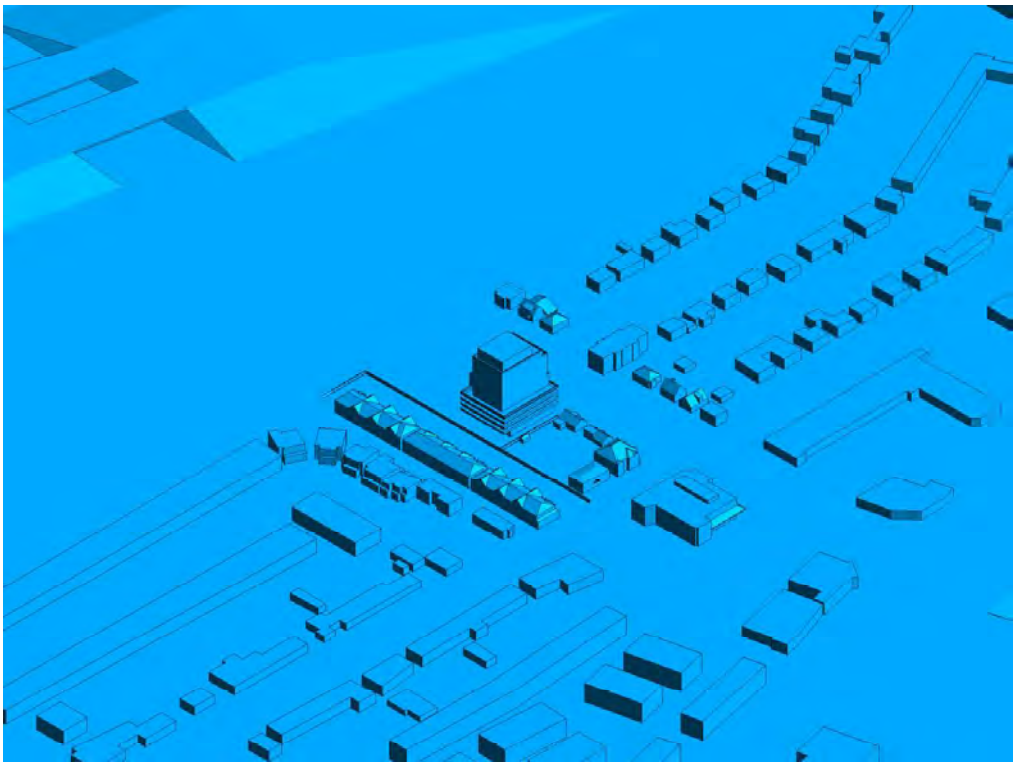


FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTH PERSPECTIVE

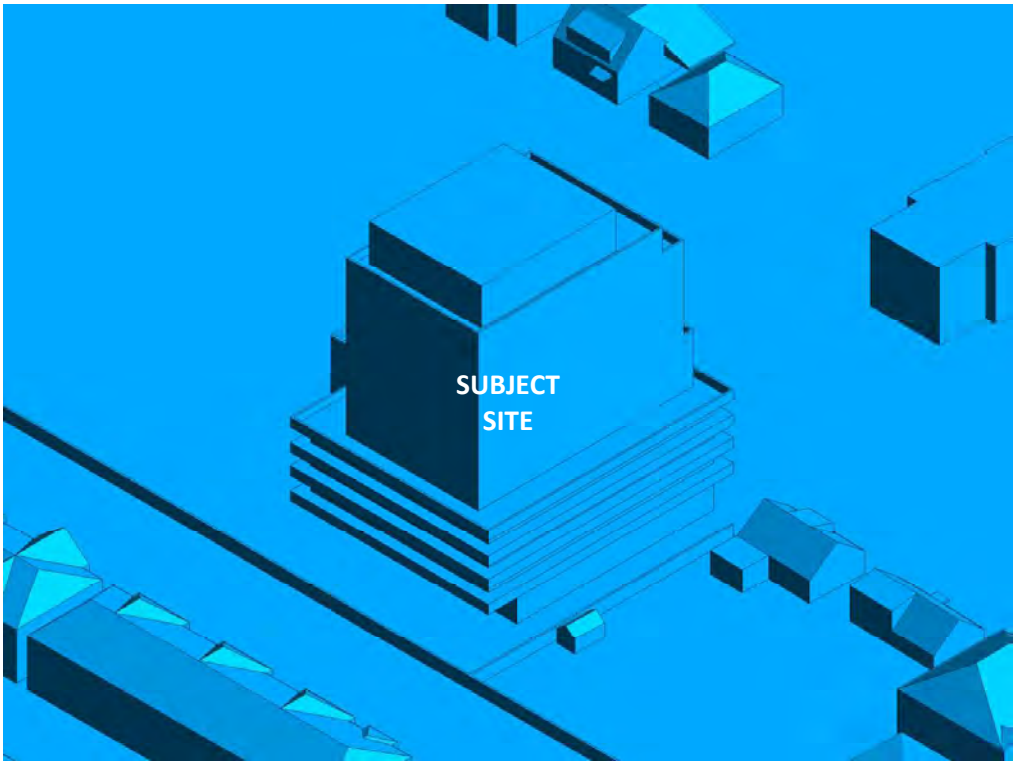


FIGURE 2F: CLOSE-UP VIEW OF FIGURE 2E

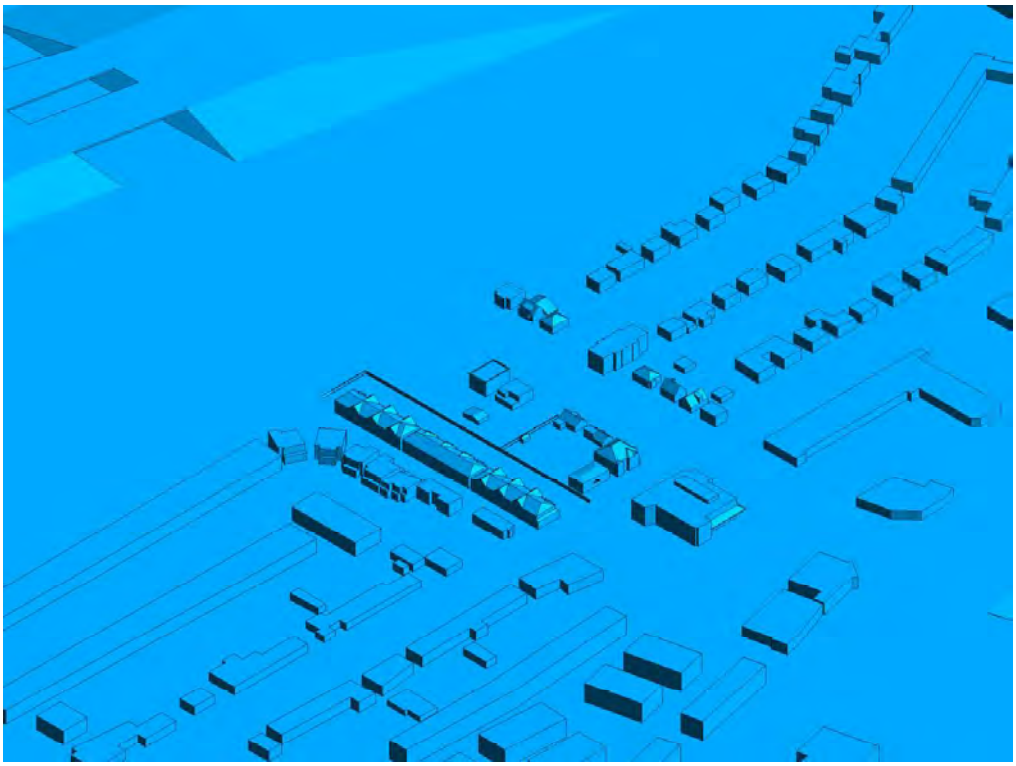


FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTH PERSPECTIVE

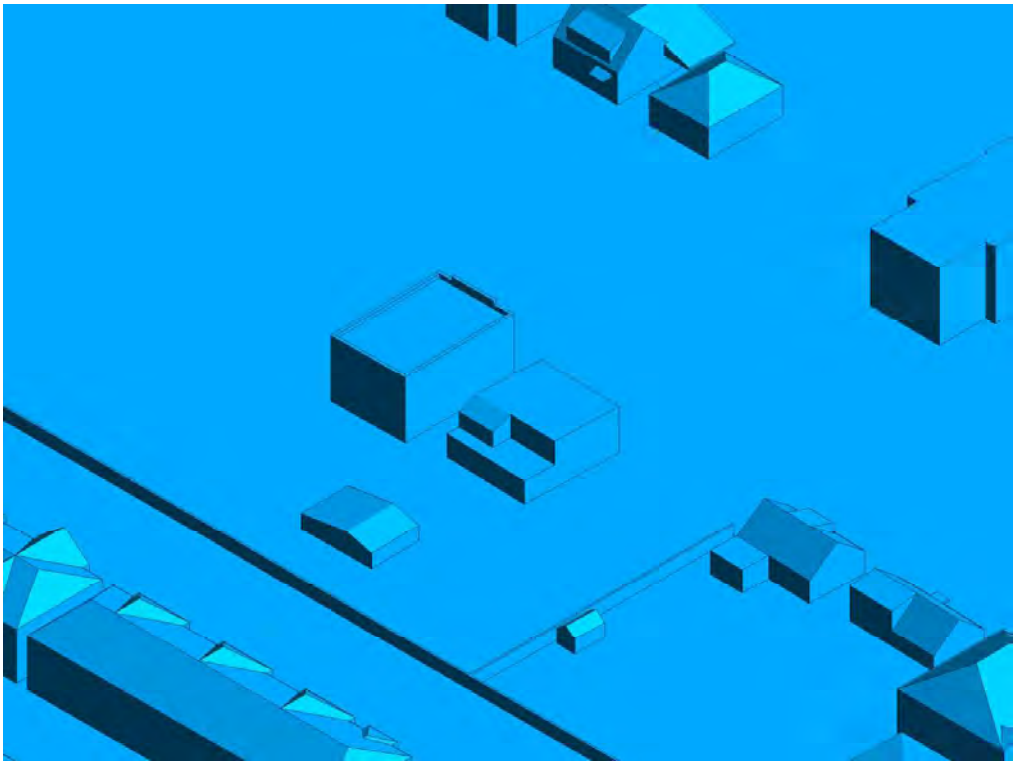


FIGURE 2H: CLOSE-UP VIEW OF FIGURE 2G

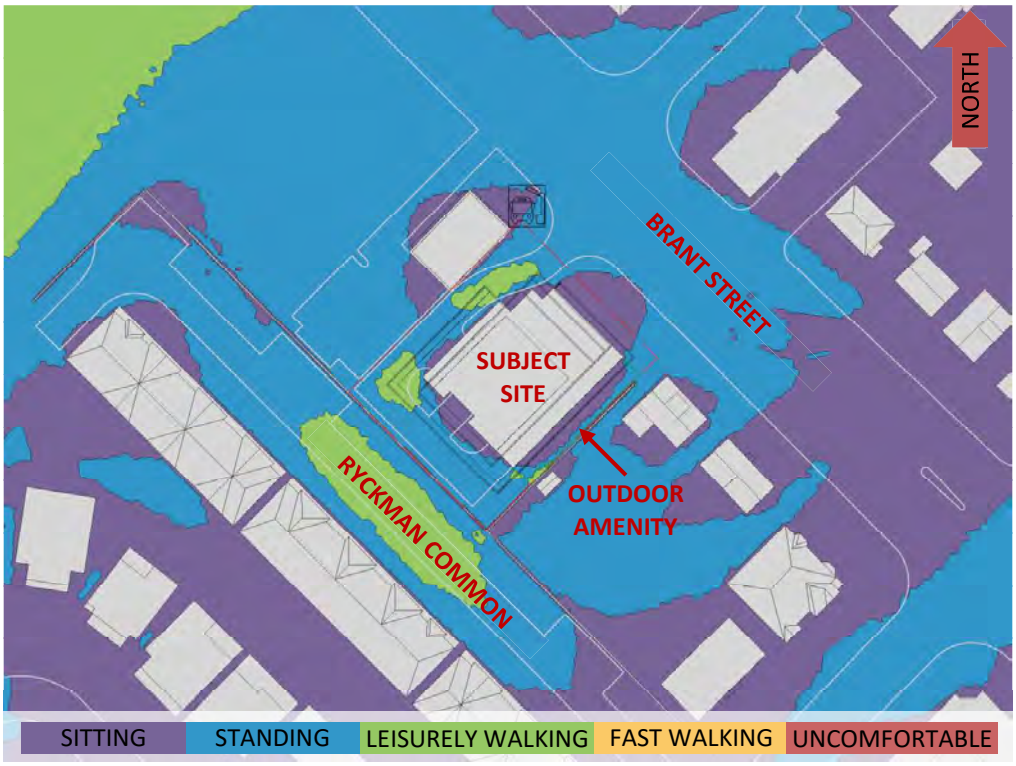


FIGURE 3A: SUMMER – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL



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

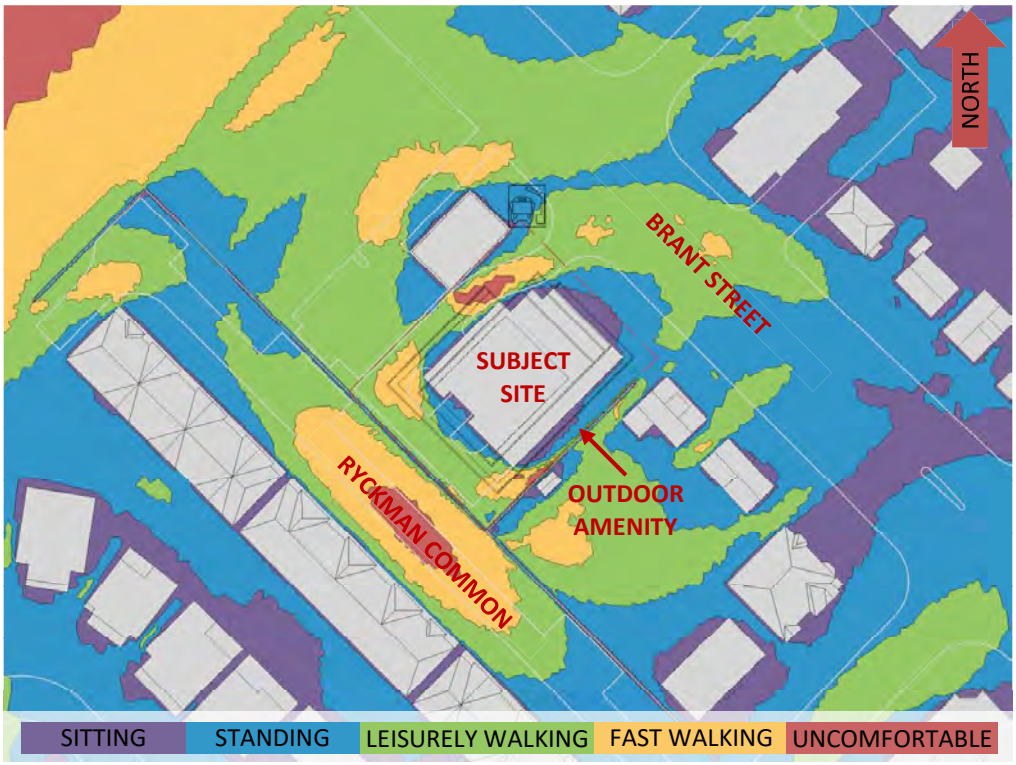


FIGURE 4A: WINTER – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL



FIGURE 4B: WINTER – EXISTING MASSING – WIND COMFORT, 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].

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

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

For the model, U_g is set to 6.5 metres per second (m/s), which approximately corresponds to the 50% mean wind speed for Burlington based on historical climate data and statistical analyses. When the results are normalized by this velocity, they are relatively insensitive to the selection of gradient wind speed.

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

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

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

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

Wind Direction (Degrees True)	Alpha Value (α)
0	0.23
22.5	0.23
45	0.23
67.5	0.23
90	0.24
112.5	0.23
135	0.23
157.5	0.23
180	0.23
202.5	0.25
225	0.22
247.5	0.21
270	0.22
292.5	0.23
315	0.23
337.5	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].

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

$$L_t(Z) = \begin{cases} 100\ \text{m}\sqrt{\frac{Z}{30}}, & Z > 30\ \text{m} \\ 100\ \text{m}, & Z \leq 30\ \text{m} \end{cases} \qquad \text{Equation (3)}$$

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

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

REFERENCES

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

[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.