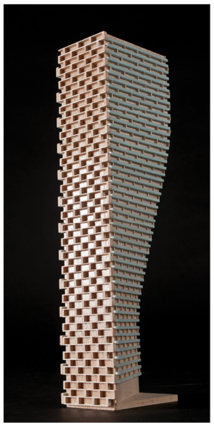
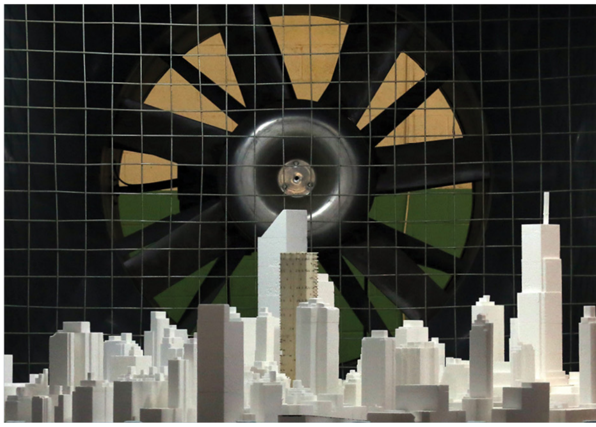
GRADIENTWIND
ENGINEERS & SCIENTISTS

PEDESTRIAN LEVEL WIND STUDY

12563 & 12599 Highway 50
Bolton, Ontario

Report: 20-248-PLW R1





March 5, 2021

PREPARED FOR
12599 Hwy 50 Ltd.
91 Parr Boulevard
Bolton, ON L7E 4E3

PREPARED BY
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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study to satisfy the requirements for a joint Official Plan Amendment (OPA) and Zoning By-law Amendment (ZBA) submission for the proposed multi-building development located at 12563 & 12599 Highway 50 in Bolton, Ontario (hereinafter referred to as "subject site"). Our mandate within this study is to investigate pedestrian wind comfort and safety within and surrounding the subject site, and to identify any areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where necessary.

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

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

1) Conditions within and surrounding the subject site at grade level along sidewalks and walkways are predicted to be mostly acceptable for their intended uses throughout the year.

    a. Three regions within the subject site are expected to be uncomfortable for walking during the winter season: (i) an area between Buildings B3 and B4; (ii) an area between Buildings B1 and B2; and (iii) an area between Buildings B1 and B5. Region (i) includes an amenity area and is discussed below. Region (ii) is not expected to be a major pedestrian thoroughfare or amenity area, so the noted conditions may be acceptable. For region (iii), which includes sidewalks along the road that is proposed to run through the subject site, conditions could be improved by setting the tall building component in Building B1 back from the edge of the podium on the northeast and southeast sides would be expected to reduce wind speeds at grade. Incorporating tall wind barriers, such as wind screens or public art installations, within the landscaped areas between Buildings B1 and B5 would also be expected to improve wind comfort within this region.

2) Four grade-level amenity areas are planned throughout the subject site.

    a. The predicted conditions within the amenity area to the north of Building B5 are likely acceptable. If calmer conditions are required, we recommend installing 1.6-m-tall wind barriers along the perimeter of the terrace.

    b. The amenity area at the northeast of Building B4 is predicted to be windy along the north façade of the building, and calm along the eastern façade. We recommend locating the area fully on the east side of the building, where conditions are calm. If this is not possible, mitigation will be required to provide conditions suitable for sitting on the north side of the building at least 80% of the time during the typical use period.

    c. The amenity areas between Buildings B3 and B4 and between Buildings B4 and B5 are expected to be windy throughout the year. We recommend that these amenity areas be relocated to regions that are predicted to experience calmer wind conditions during the typical use period of late spring to early autumn. This relocation, and any required mitigation, should be developed for the Site Plan Control application, which will require a detailed PLW study via wind tunnel testing of a physical scale model of the subject site within its surroundings.

3) The location and design of elevated amenity terraces had not been fully defined prior to commencing wind simulations, so wind conditions on terraces are not formally reported for this study. However, Section 5 provides some general guidance regarding which roof surfaces are expected to be calmest during the typical use period; it will be easiest to mitigate wind conditions to acceptable levels on these roofs. Mitigation may include tall wind screens along the perimeter of the amenity terraces, wind barriers inboard of the perimeter, and canopies on the towers to protect the areas from downwash winds. Dense landscaping elements may also be required.

4) In general, the predicted wind conditions, as well as mitigation, should be confirmed for the Site Plan Control application, which will require a detailed PLW study via wind tunnel testing of a physical scale model of the subject site within its surroundings.

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

6) 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.

TABLE OF CONTENTS

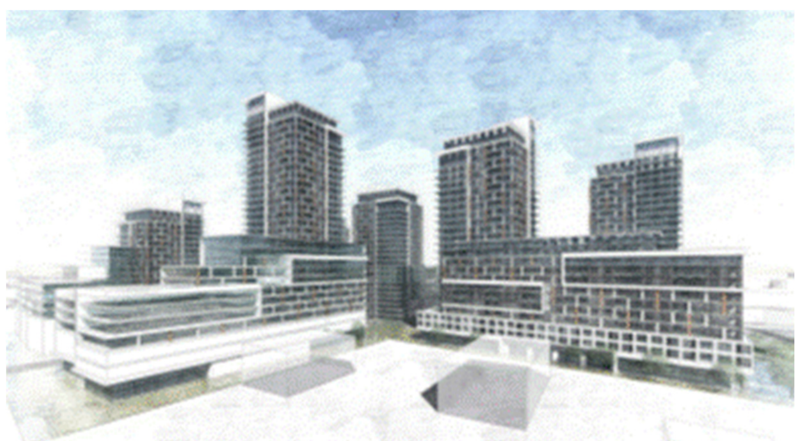
1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by 12599 Hwy 50 Ltd. to undertake a pedestrian level wind (PLW) study to satisfy the requirements for a joint Official Plan Amendment (OPA) and Zoning By-law Amendment (ZBA) submission for the proposed multi-building development located at 12563 & 12599 Highway 50 in Bolton, Ontario (hereinafter referred to as "subject site"). Our mandate within this study is to investigate pedestrian wind comfort and safety within and surrounding the subject site, and to identify any areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where necessary.

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

2. TERMS OF REFERENCE

The subject site is located at 12563 & 12599 Highway 50 in Bolton, Ontario, on a parcel of land bordered by Highway 50 to the southwest, McEwan Drive East to the northwest and northeast, Commercial Road to the east, and Industrial Road to the southeast.



Rendering of Planned Development, South Perspective (Courtesy of SRN Architects Inc.)

The multi-building development comprises five buildings ranging in height between 18 and 32 storeys and stepped podia up to 12 storeys. Building B1, at the southwest of the site, includes a 32-storey tower with a 7/9/12-storey stepped podium extending to the south and west of the tower. Building B2, at the south of the site, includes a 26-storey tower at the north of the building with a 9/12-storey stepped podium to the south. Building B3, at the east of the site, includes a 24-storey tower at the south of the building with a 9/12 storey stepped podium to the north. Building B4, at the north end of the site, includes two towers, of 20 and 23 storeys, which share a 12-storey podium. Finally, Building B5, at the west end of the site, includes an 18-storey tower with a 5/7/9/12-storey stepped podium extending to the west and south.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within a 200-metre (m) radius of the site) are characterized by low-rise commercial buildings in all directions. The far-field surroundings (defined as the area beyond the near field and within a 2-kilometre (km) radius) represent a continuation of the near-field from the south clockwise to the north and are characterized by farms and parkland to the east.

Key areas under consideration include surrounding sidewalks, building access points, and outdoor amenity spaces. Figure 1 illustrates the subject site and surrounding context, while Figures 2A-2D illustrate the computational model used to conduct the study.

3. OBJECTIVES

The principal objectives of this study are to: (i) determine pedestrian level wind 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 Site within a virtual environment, meteorological analysis of the Greater Toronto Area (GTA) 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 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 Lester B. Pearson International Airport.

The general concept and approach to CFD modelling is to represent building and topographic details in the immediate vicinity of the study site on the surrounding model, and to create suitable atmospheric wind profiles at the model boundary. The wind profiles are designed to have similar mean and turbulent wind properties consistent with actual site exposures.

An industry standard practice is to omit trees, vegetation, and other existing and planned landscape elements from the model due to the difficulty of providing accurate seasonal representation of vegetation. The omission of trees and other landscaping elements produces slightly more conservative (i.e., windier) wind speed values.

4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the site for 12 wind directions. The CFD simulation model was centered on the study building, complete with surrounding massing within a diameter of approximately 1000 m.

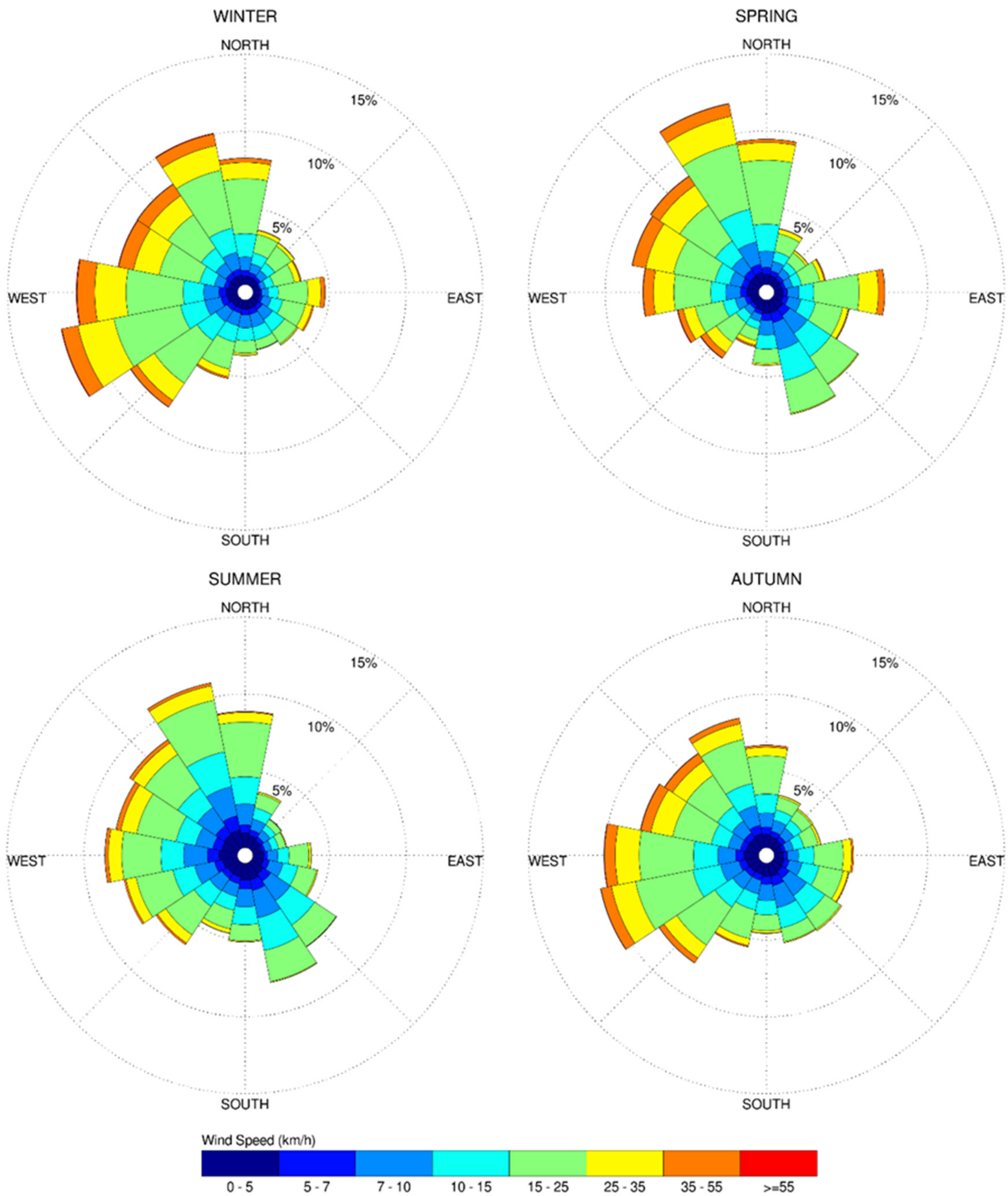
Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds on a continuous measurement plane 1.5 m above local grade were referenced to the wind speed at gradient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

4.3 Meteorological Data Analysis

A statistical model for winds in and around Toronto, representative of Bolton, was developed from approximately 40 years of hourly wind data recorded at Lester B. Pearson International 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.

The statistical model of the Toronto 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 sixteen azimuth divisions. The radial direction shows the frequency distribution of wind speeds for each wind direction during the measurement period. The preferred wind speeds and directions can be identified by the longer length of the bars. For Toronto, representative of Bolton, the most common winds concerning pedestrian comfort occur from the southwest clockwise to the north, as well as those from the east and southeast. The directional preference and relative magnitude of the wind speed varies somewhat from season to season, with the summer months displaying the calmest winds relative to the remaining seasonal periods.

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



Notes:

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

4.4 Pedestrian Comfort and Safety Guidelines

Pedestrian 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. Four pedestrian comfort classes are based on 20% non-exceedance gust wind speed ranges, which include (i) Sitting; (ii) Standing; (iii) Walking; and (iv) Uncomfortable. More specifically, the comfort classes and associated gust wind speed ranges are summarized as follows:

(i) **Sitting** – A gust wind speed no greater than 16 km/h is considered acceptable for sedentary activities, including sitting.

(ii) **Standing** – A gust wind speed greater than 16 km/h but no greater than 22 km/h is considered acceptable for activities such as standing or leisurely strolling.

(iii) **Walking** – A gust wind speed greater than 22 km/h but no greater than 30 km/h is considered acceptable for walking or more vigorous activities.

(iv) **Uncomfortable** – A gust wind speed greater than 30 km/h is classified as uncomfortable from a pedestrian comfort standpoint. Brisk walking and exercise, such as jogging, would be acceptable for moderate excesses of this comfort class.

The pedestrian safety wind speed guideline 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 greater than 90 km/h is classified as dangerous. The wind speeds associated with the above categories are gust wind speeds. The gust speeds, and equivalent mean speeds, 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. Gust speeds are included because 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.

THE BEAUFORT SCALE

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

Experience and research on people's perception of mechanical wind effects has shown that if the wind speed levels are exceeded for more than 20% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if wind speeds of 16 km/h were exceeded for more than 20% of the time most pedestrians would judge that location to be too windy for sitting or more sedentary activities. Similarly, if 30 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 site, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for discrete regions within and surrounding the subject site. This step involves comparing the predicted comfort classes to the desired comfort classes, which are dictated by the location type for each region (i.e., a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their desired comfort classes are summarized on the following page.

DESIRED PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES

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

5. RESULTS AND DISCUSSION

The following discussion of the predicted pedestrian wind conditions for the subject site is accompanied by Figures 3A-3D (following the main text), which illustrate seasonal wind conditions at grade level for the proposed massing scenario. The wind conditions are presented as continuous contours of wind comfort within and surrounding the subject site.

The colour contours indicate predicted regions of the various comfort classes noted in Section 4.4. Wind conditions suitable for sitting are represented by the colour green, standing by yellow, and walking by blue. Uncomfortable conditions are represented by magenta. The predicted pedestrian wind conditions are summarized on the following pages for each area of interest.

5.1 Wind Comfort Conditions

Sidewalk along Highway 50 and Industrial Road: Conditions over the sidewalks surrounding the subject site are predicted to be suitable for a mix of sitting and standing during the summer season, a mix of standing and walking during the spring and autumn seasons, becoming mostly suitable for walking during the winter season. These conditions are considered acceptable according to the comfort guidelines in Section 4.4.

Sidewalks and Walkways throughout Subject Site: The sidewalks and walkways within the subject site are predicted to be mostly suitable for standing during the summer season, although certain areas near the buildings are predicted to be suitable for sitting, and discrete areas between some of the buildings are predicted to be suitable for walking. During the spring and autumn seasons, conditions are predicted to be suitable for walking, or better, in most areas.

During the winter season, discrete areas are predicted to develop conditions that exceed the recommended wind speed that is considered comfortable for walking more than 20% of the time. Conditions are expected to be uncomfortable within three regions: (i) between Buildings B3 and B4; (ii) between Buildings B1 and B2; and (iii) between Buildings B1 and B5.

(i) The windy conditions between Buildings B3 and B4 are caused by channelling of prominent southwesterly winds between the 9- and 12-storey podia of the two buildings. Should the amenity area within this region be relocated, as we recommend on Page 11, Paragraph 3, the area would not be expected to be a major pedestrian thoroughfare. The conditions may therefore be considered acceptable.

(ii) The windy conditions between Buildings B1 and B2 are caused by channelling of prominent southeasterly and northeasterly winds between the 28- and 32-storey towers of Buildings B1 and B2, respectively. This area does not appear to be a major pedestrian thoroughfare or amenity area; the conditions may be considered acceptable.

(iii) The windy conditions within the area between Buildings B1 and B5 are caused by channelling and downwash of southwesterly and northerly winds. During the winter season, uncomfortable conditions are predicted over the sidewalk along the road that is proposed to pass through the subject site. Setting the tall building component in Building B1 back from the edge of the podium on the northeast and southeast sides would be expected to reduce wind speeds at grade. Incorporating tall wind barriers, such as wind screens or public art installations, within the landscaped areas between Buildings B1 and B5 would also be expected to improve wind comfort within this region.

Wind conditions, inclusive of any mitigation, should be confirmed for the Site Plan Control application, which will require a detailed PLW study via wind tunnel testing of a physical scale model of the subject site within its surroundings.

Building Entrances: Conditions along most building façades at grade are predicted to be suitable for standing, or better, throughout the year, which is considered acceptable for primary or secondary entrances. We recommend primary entrances be located: (i) away from building corners, where windy conditions are common due to acceleration of winds and vortices; and (ii) not along the façade at the northwest end of the southwest façade of Building B3, where walking conditions are expected to develop during the winter season.

Outdoor Grade-Level Amenity Areas: Four amenity areas are planned at grade throughout the site.

(i) The amenity area on the north side of Building B5 is predicted to be suitable for sitting during the summer season, becoming suitable for standing during the three colder seasons. These conditions may be considered acceptable. If calmer conditions are required, we recommend introducing 1.6-m-tall wind barriers along the perimeter of the amenity area.

(ii) The amenity area between Buildings B4 and B5 is predicted to be suitable for walking, or better, throughout the year. Significant mitigation measures would be required to provide conditions suitable for sitting at least 80% of the time during the typical use period of late spring to early autumn. We recommend that the amenity area be relocated to a region that is predicted to experience calmer wind conditions. This relocation, and any required mitigation, should be developed for the Site Plan Control application, which will require a detailed PLW study via wind tunnel testing of a physical scale model of the subject site within its surroundings.

(iii) The amenity area at the northeast corner of Building B4 is predicted to be suitable for a mix of sitting and standing during the summer season, becoming suitable for walking, or better, during the three colder seasons. The windier conditions are predicted to occur along the north side of the building, while the portion of the area on the east side of the building is predicted to be mostly suitable for sitting throughout the year.

a. If possible, we recommend that this amenity area be located fully along the eastern side of the building, where conditions are predicted to be calm during the typical use period. Mitigation would be required to provide conditions suitable for sitting on the north side of the building at least 80% of the time during the typical use period. Mitigation could include tall wind barriers along the west and north perimeters of the area and inboard of the perimeter to protect designated seating areas.

(iv) The amenity area between Buildings B3 and B4 is predicted to be suitable for a mix of standing and walking during the summer seasons and mostly suitable for walking during the spring and autumn seasons. Conditions are predicted to be uncomfortable for walking during the winter season. Significant mitigation measures would be required to provide conditions suitable for sitting at least 80% of the time during the typical use period. We recommend that the amenity area be relocated to a region that is predicted to experience calmer wind conditions. This relocation, and any required mitigation, should be developed for the Site Plan Control application, which will require a detailed PLW study via wind tunnel testing of a physical scale model of the subject site within its surroundings.

Elevated Amenity Terraces: Since the location and design of elevated amenity terraces had not been fully defined prior to commencing wind simulations for this study, wind comfort conditions for the terraces have not been formally investigated in the current study. Nevertheless, we can provide some general comments based on the CFD simulations and the exposure and orientation of the subject site to statistically prominent winds.

The podia roofs of the proposed buildings are, in general, taller than the buildings in the surrounding area, and will thus be exposed to strong direct winds. In addition, downwash from the towers can be expected to create windy conditions over the roofs. Should amenity terraces be planned for the podia roofs of the proposed development, significant mitigation is expected to be required to achieve conditions suitable for sitting during the typical use period. Mitigation would include tall wind screens along the perimeter of the amenity terraces, wind barriers inboard of the perimeter, and canopies on the towers to protect the areas from downwash winds. Dense landscaping elements may also be required.

We expect wind mitigation efforts will be more successful on some roofs than on others. Conditions on the following roofs are expected to require less extensive mitigation than other roofs within the site:

(i) Podium roofs serving Building B2 at Levels 10 and 13. The significant upwind massing provided by Buildings B4, B5, and B1 for prominent northwesterly winds is expected to reduce wind speeds over the noted roofs.

(ii) Podium roofs serving Building B5 at Levels 6 and 8. The roof areas will be protected from prominent northwesterly winds by the taller massing of Building B5, and from easterly winds by the massing of Building B1.

(iii) Podium roof serving Building B1 at Level 10. The roof area will be protected from northeasterly winds. The small size of the terrace will also facilitate wind mitigation.

(iv) Podium roof serving Building B4, to the northeast and southeast of the southeast tower. While most of the terrace is expected to be windy, conditions at the southeast end of the building are expected to be reasonably calm, owing to the protection from southwest winds provided by the southeast tower, and the protection from northwest winds provided by the northwest tower.

Wind conditions over the elevated amenity terraces, and any mitigation, should be confirmed for the Site Plan Control application, which will require a detailed PLW study via wind tunnel testing of a physical scale model of the subject site within its surroundings.

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 surrounding the subject site at grade level were found 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 study site. Future changes (i.e., construction or demolition) of these surroundings may cause changes to the wind effects in two ways, namely: (i) changes beyond the immediate vicinity of the site would alter the wind profile approaching the site; and (ii) development in proximity to the site would cause changes to local flow patterns. In general, development in urban centers creates reduction in the mean wind speeds and localized increases in the gustiness of the wind.

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

6. SUMMARY AND RECOMMENDATIONS

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

1) Conditions within and surrounding the subject site at grade level along sidewalks and walkways are predicted to be mostly acceptable for their intended uses throughout the year.

    a. Three regions within the subject site are expected to be uncomfortable for walking during the winter season: (i) an area between Buildings B3 and B4; (ii) an area between Buildings B1 and B2; and (iii) an area between Buildings B1 and B5. Region (i) includes an amenity area and is discussed below. Region (ii) is not expected to be a major pedestrian thoroughfare or amenity area, so the noted conditions may be acceptable. For region (iii), which includes sidewalks along the road that is proposed to run through the subject site, conditions could be improved by setting the tall building component in Building B1 back from the edge of the podium on the northeast and southeast sides would be expected to reduce wind speeds at grade. Incorporating tall wind barriers, such as wind screens or public art installations, within the landscaped areas between Buildings B1 and B5 would also be expected to improve wind comfort within this region.

2) Four grade-level amenity areas are planned throughout the subject site.

   a. The predicted conditions within the amenity area to the north of Building B5 are likely acceptable. If calmer conditions are required, we recommend installing 1.6-m-tall wind barriers along the perimeter of the terrace.

   b. The amenity area at the northeast of Building B4 is predicted to be windy along the north façade of the building, and calm along the eastern façade. We recommend locating the area fully on the east side of the building, where conditions are calm. If this is not possible, mitigation will be required to provide conditions suitable for sitting on the north side of the building at least 80% of the time during the typical use period.

   c. The amenity areas between Buildings B3 and B4 and between Buildings B4 and B5 are expected to be windy throughout the year. We recommend that these amenity areas be relocated to regions that are predicted to experience calmer wind conditions during the typical use period of late spring to early autumn. This relocation, and any required mitigation, should be developed for the Site Plan Control application, which will require a detailed PLW study via wind tunnel testing of a physical scale model of the subject site within its surroundings.

3) The location and design of elevated amenity terraces had not been fully defined prior to commencing wind simulations, so wind conditions on terraces are not formally reported for this study. However, Section 5 provides some general guidance regarding which roof surfaces are expected to be calmest during the typical use period; it will be easiest to mitigate wind conditions to acceptable levels on these roofs. Mitigation may include tall wind screens along the perimeter of the amenity terraces, wind barriers inboard of the perimeter, and canopies on the towers to protect the areas from downwash winds. Dense landscaping elements may also be required.

4) In general, the predicted wind conditions, as well as mitigation, should be confirmed for the Site Plan Control application, which will require a detailed PLW study via wind tunnel testing of a physical scale model of the subject site within its surroundings.

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

6) 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.

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

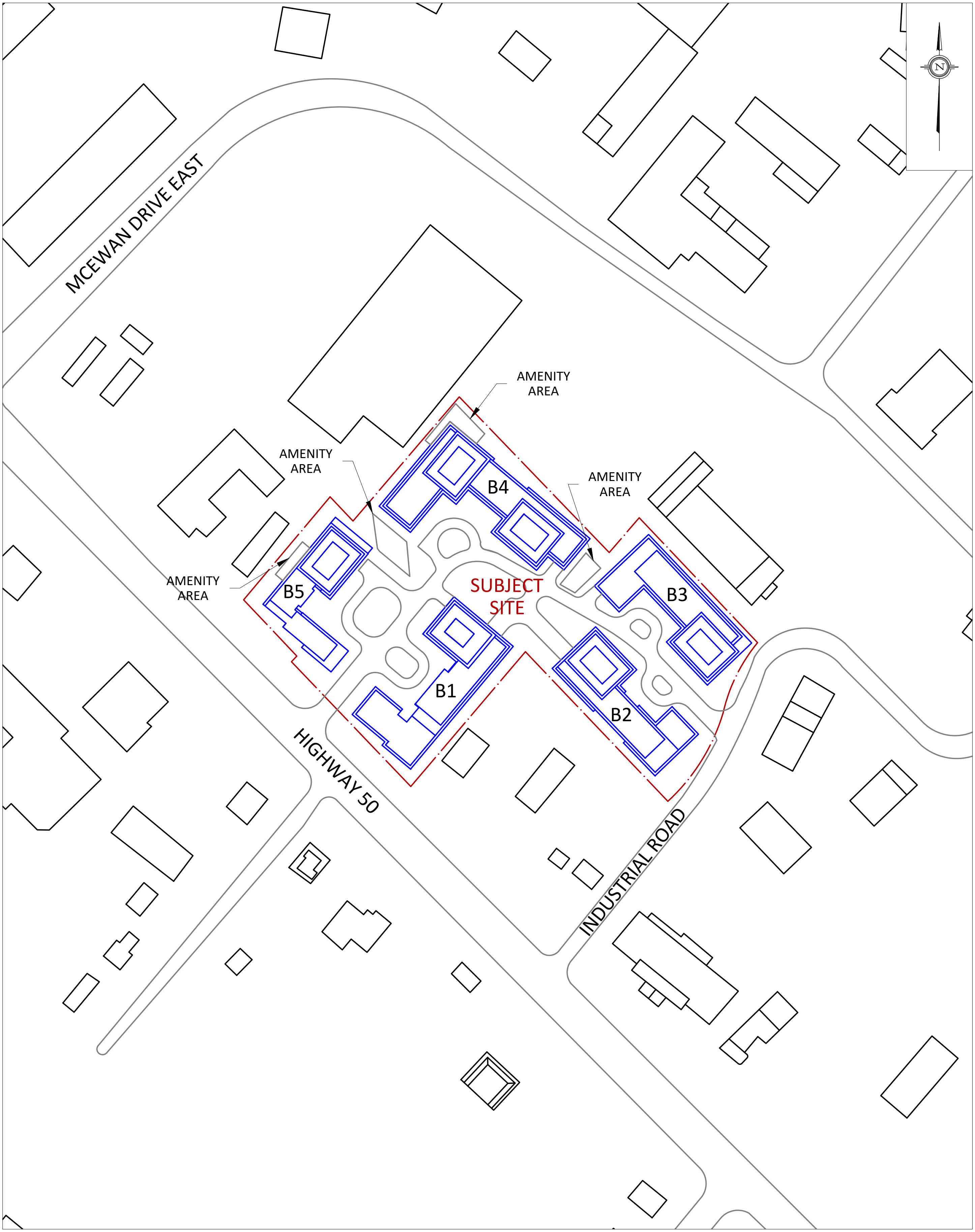
Sincerely,

Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
J. D. FERRARO
100158495
Mar 5, 2021
PROVINCE OF ONTARIO

Sacha Ruzzante, MASc
Junior Wind Scientist

Justin Ferraro, P.Eng.
Principal



GRADIENTWIND
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613 836 0934 • GRADIENTWIND.COM

PROJECT		DESCRIPTION
12563 & 12599 HIGHWAY 50, BOLTON PEDESTRIAN LEVEL WIND STUDY		FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT
SCALE 1:3000	DRAWING NO. 20-248-PLW-1	
DATE MARCH 4, 2021	DRAWN BY O.R.	

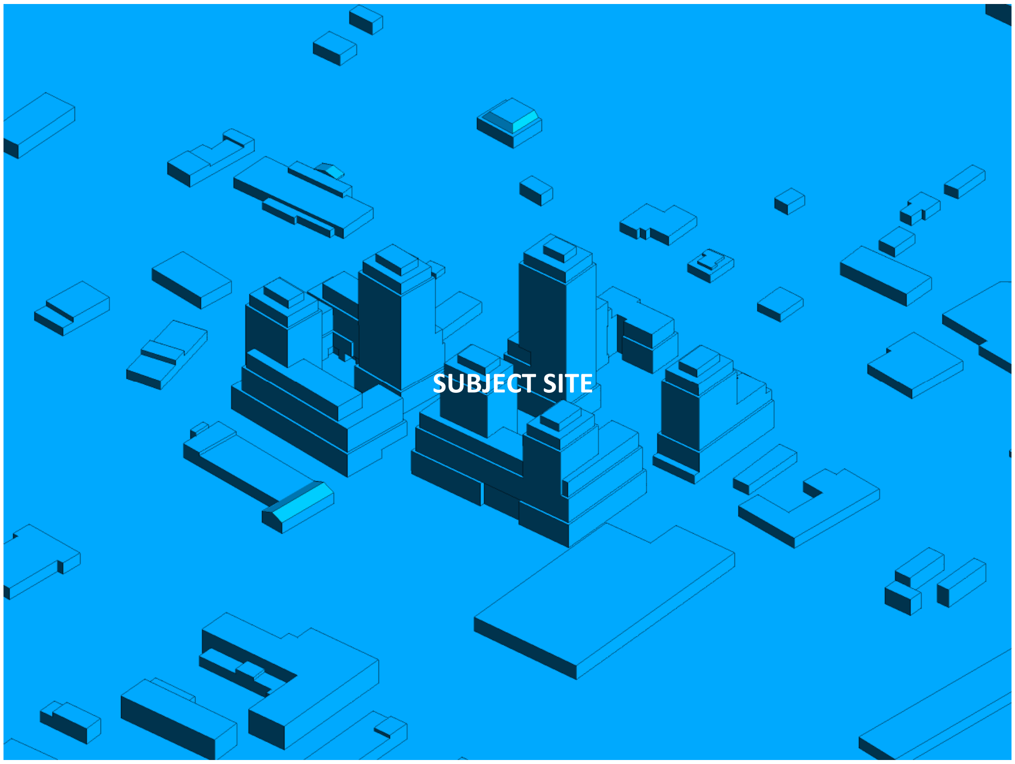


FIGURE 2A: COMPUTATIONAL MODEL, NORTH PERSPECTIVE

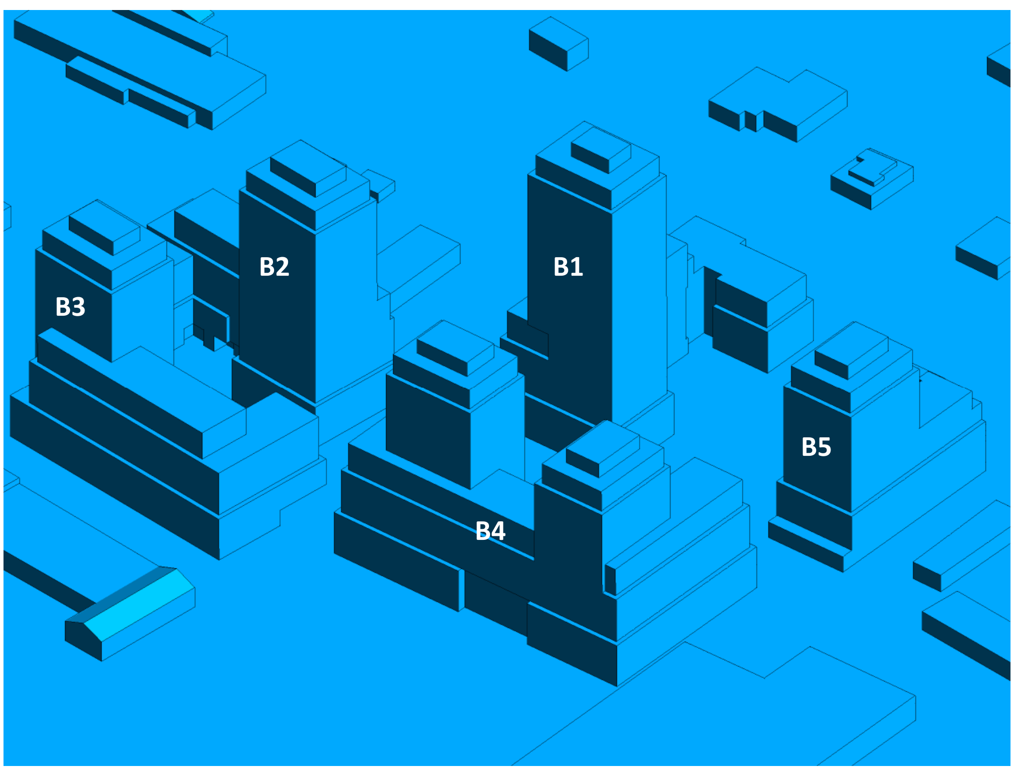


FIGURE 2B: CLOSE UP OF FIGURE 2A

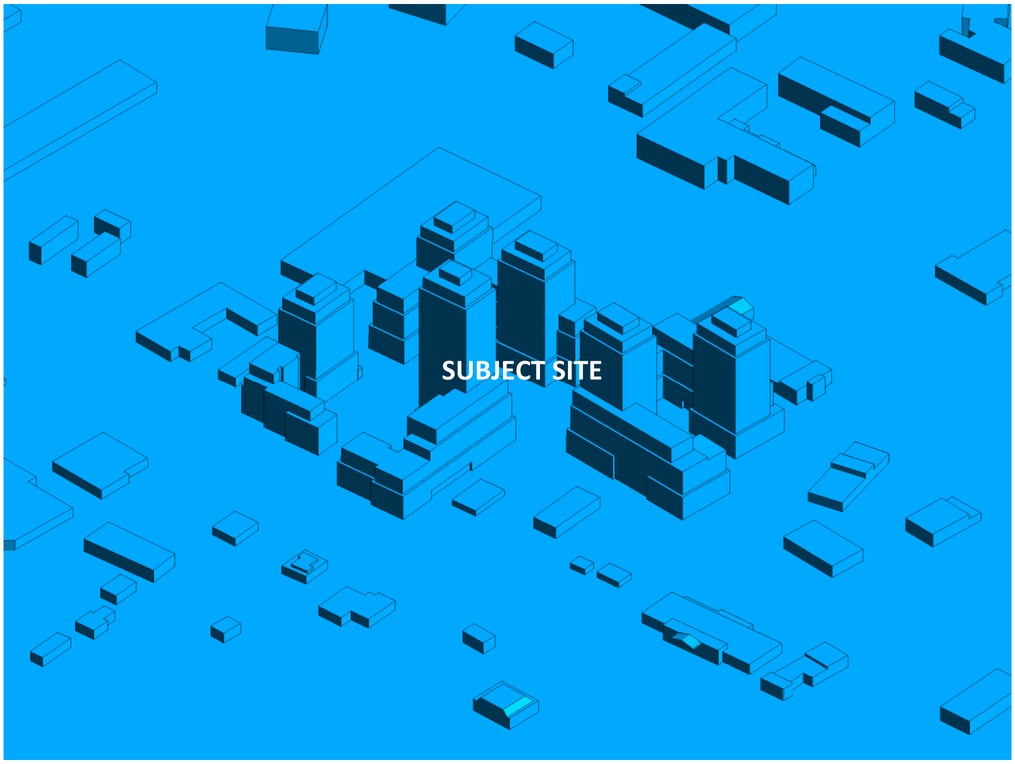


FIGURE 2C: COMPUTATIONAL MODEL, SOUTH PERSPECTIVE

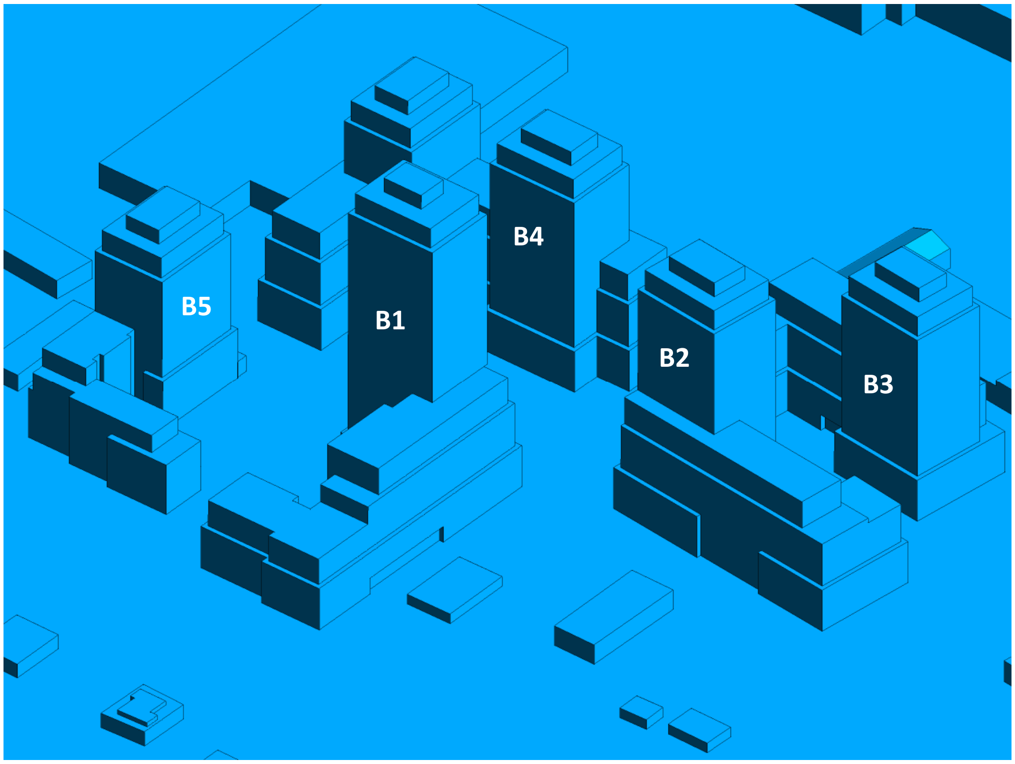


FIGURE 2D: CLOSE UP OF FIGURE 2C

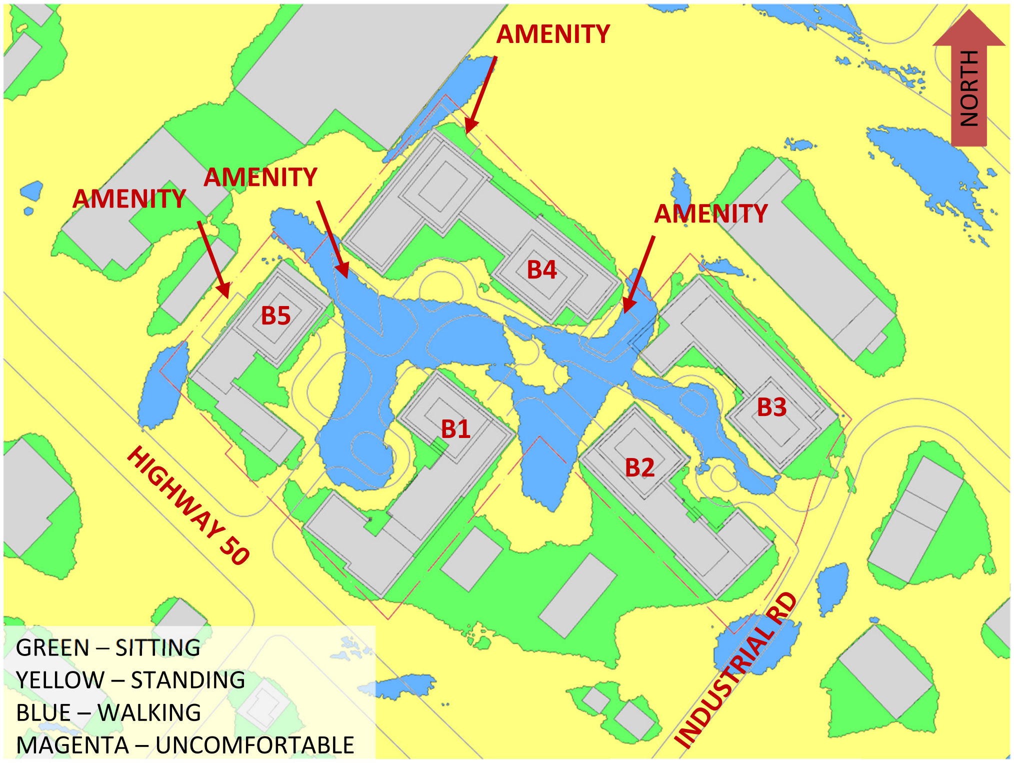


FIGURE 3A: SPRING – WIND COMFORT CONDITIONS, GRADE LEVEL

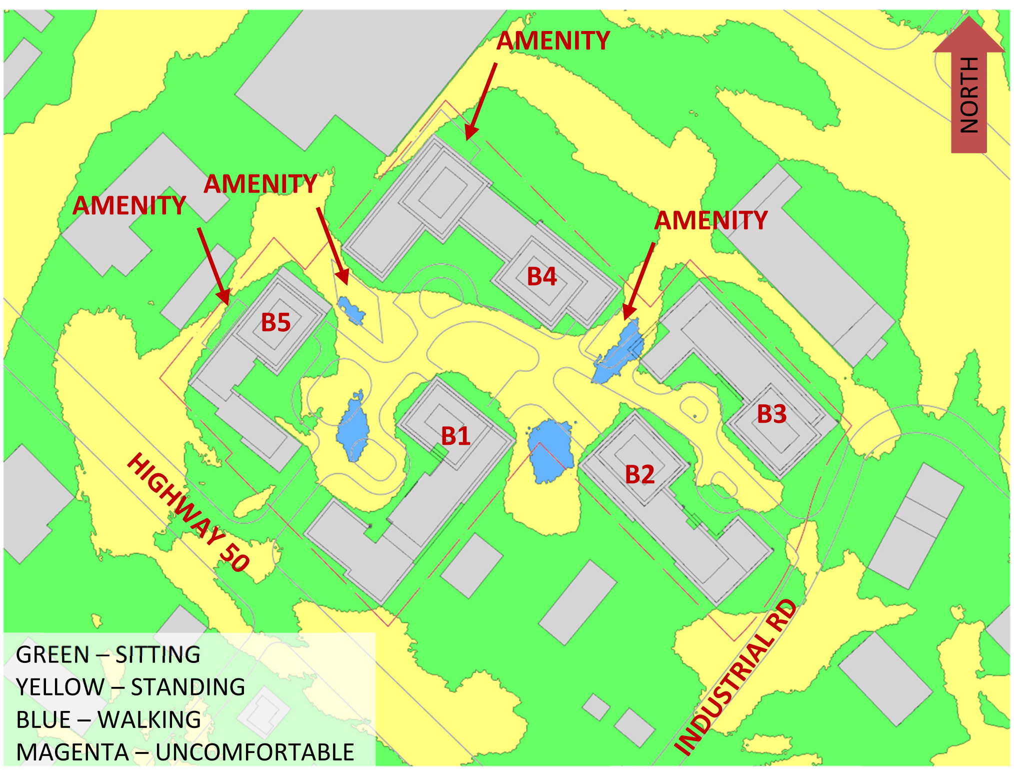


FIGURE 3B: SUMMER – WIND COMFORT CONDITIONS, GRADE LEVEL

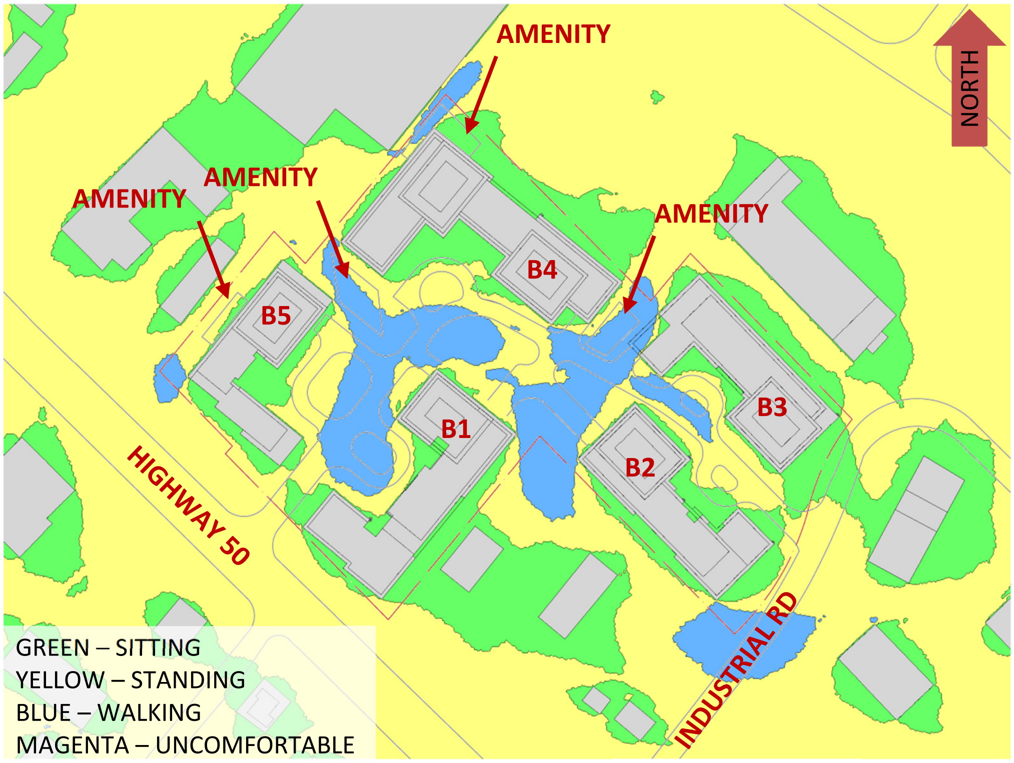


FIGURE 3C: AUTUMN – WIND COMFORT CONDITIONS, GRADE LEVEL

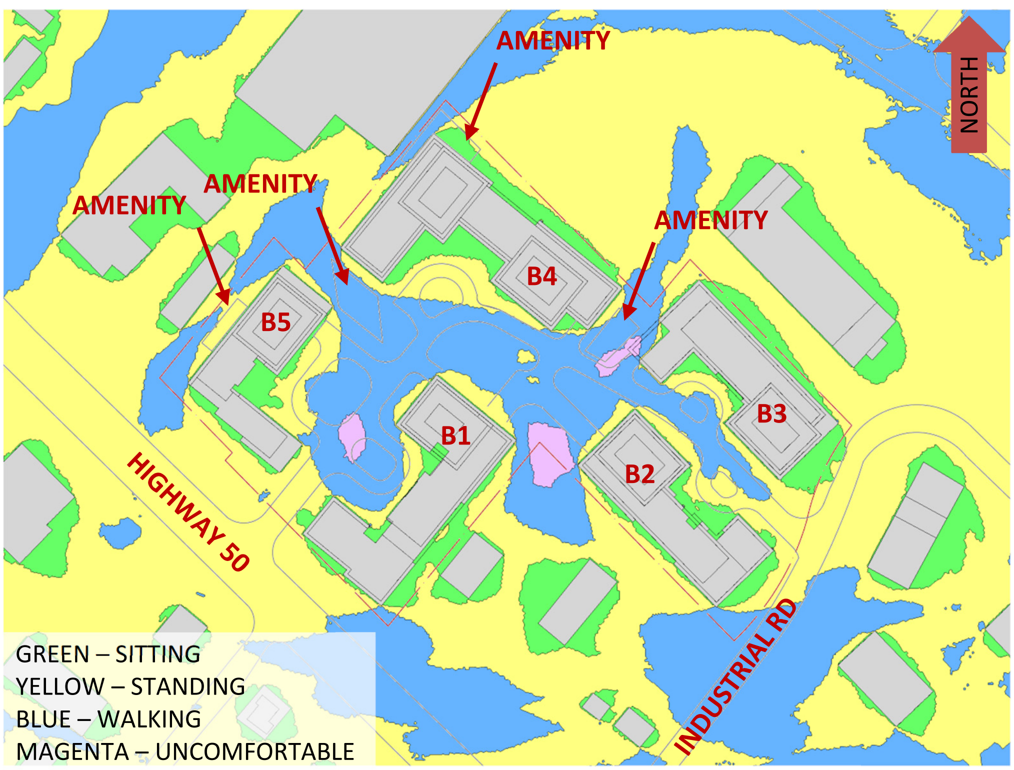
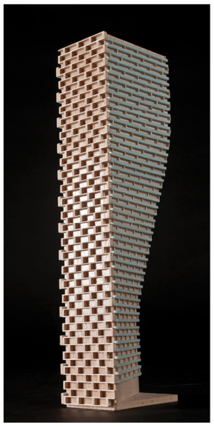
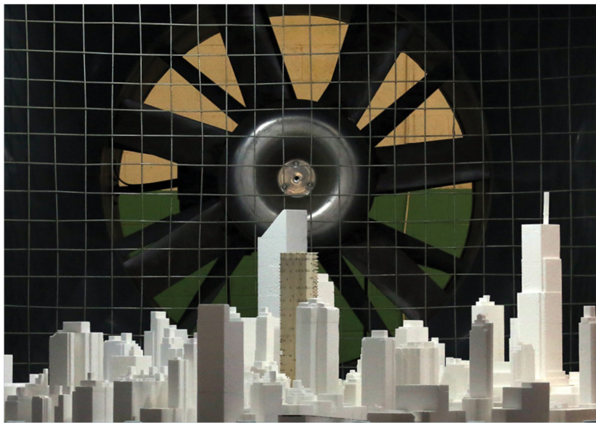


FIGURE 3D: WINTER – WIND COMFORT CONDITIONS, GRADE LEVEL





APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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

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

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

For the model, U_g is set to 6.5 metres per second (m/s), which approximately corresponds to the 50% mean wind speed for 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	0.20
40	0.20
97	0.19
136	0.21
170	0.21
210	0.21
237	0.21
258	0.21
278	0.22
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, I = turbulence intensity, L_t = turbulence length scale, Z = height above ground, and α is the power law exponent used for the velocity profile in Equation (1).

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

REFERENCES

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

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

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