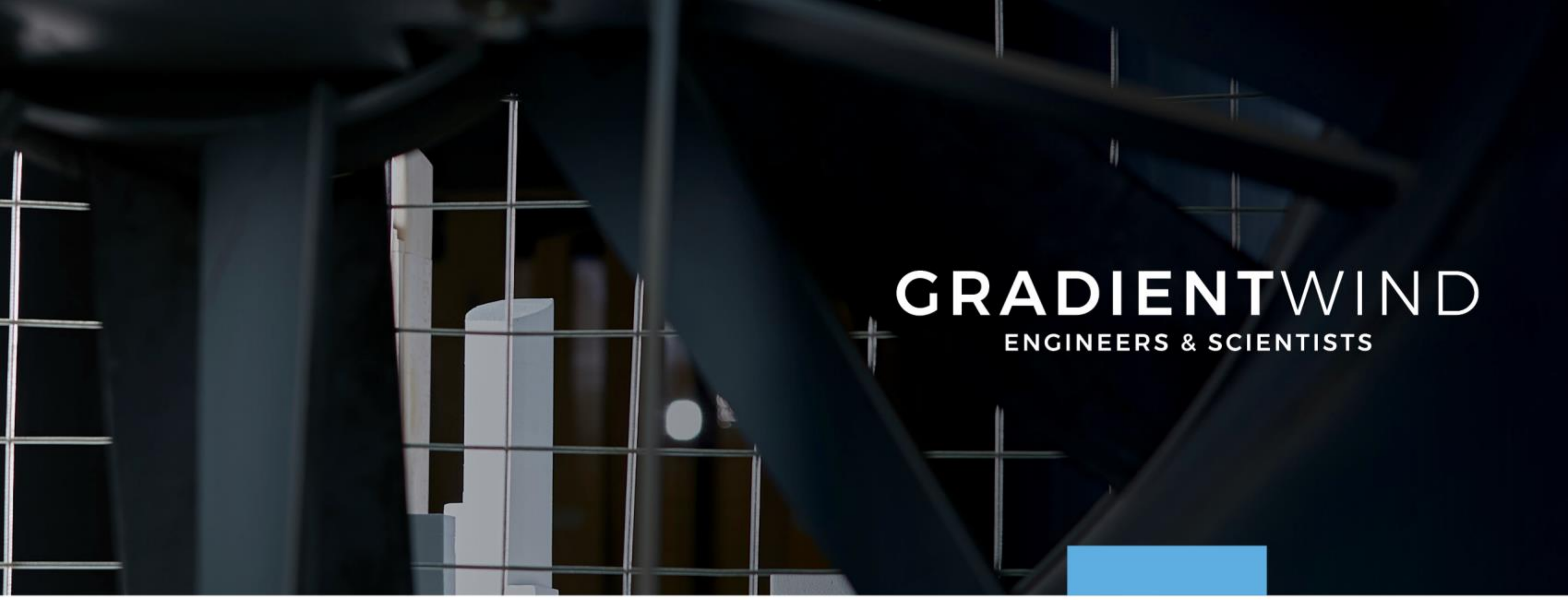
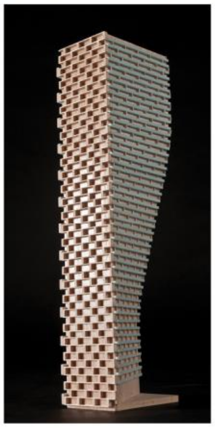
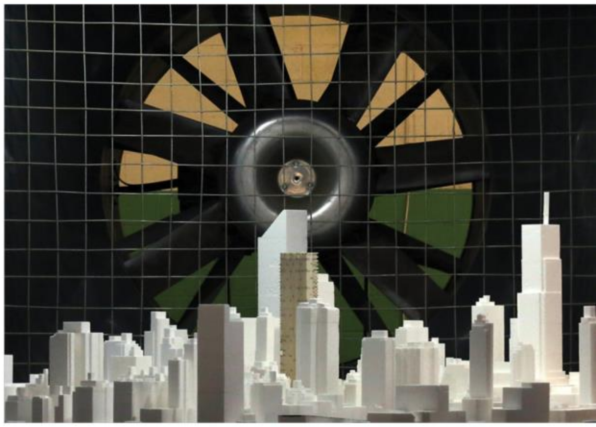


PEDESTRIAN LEVEL WIND STUDY

420 Lakeshore Road East
Mississauga, Ontario

REPORT: GW20-104-WTPLW





June 11, 2020

PREPARED FOR
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PREPARED BY
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EXECUTIVE SUMMARY

This report describes a comparative pedestrian level wind study undertaken to assess wind conditions for a proposed residential development located at 420 Lakeshore Road East in Mississauga, Ontario. Two configurations were studied: (i) existing conditions, including all approved, surrounding developments and without the proposed development, and (ii) future conditions with the proposed development in place. The study involves wind tunnel measurements of pedestrian wind speeds using a physical scale model, combined with meteorological data integration, to assess pedestrian comfort at key areas within and surrounding the study site. Grade-level areas investigated include sidewalks, laneways, parking areas, landscaped spaces, outdoor amenity areas, and building access points. The results and recommendations derived from these considerations are summarized in the following paragraphs and detailed in the subsequent report.

Our work is based on industry standard wind tunnel testing and data analysis procedures, architectural drawings provided by Turner Fleischer Architects Inc. in May 2020, surrounding street layouts, as well as existing and approved future building massing information obtained from the City of Mississauga, and recent site imagery.

A complete summary of the predicted wind conditions is provided in Section 5.2 of this report and is also illustrated in Figures 2 through 5, as well as Tables A1-A2 and B1-B4 in the appendices. Based on the wind tunnel test results, meteorological data analysis, and experience with similar developments in Mississauga, we conclude that future wind conditions over most grade-level pedestrian wind-sensitive areas within and surrounding the study site will be acceptable for the intended uses on a seasonal basis. Exceptions include potential lobby entrances at the northeast corner of the building (project northeast) and sections of sidewalk at the intersection of Lakeshore Road East and Enola Avenue. Mitigation is recommended as described in Section 5.2.

A comparison of the existing versus future wind comfort surrounding the study site indicates that grade-level wind comfort will generally be unchanged or reduced following introduction of the study building, depending on the location. Specifically, portions of sidewalk in proximity to the roadway intersection will become windier and uncomfortable for walking during the colder months. Conditions can be made comfortable through incorporation of mitigation as recommended in Section 5.2.

Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no areas over the study site were found to experience conditions that could be considered unsafe.

TABLE OF CONTENTS

1. INTRODUCTION

This report describes a comparative pedestrian level wind study undertaken to assess wind conditions for a proposed residential development located at 420 Lakeshore Road East in Mississauga, Ontario. Two configurations were studied: (i) existing conditions, including all approved, surrounding developments and without the proposed development, and (ii) future conditions with the proposed development in place. The study was performed in accordance with industry standard wind tunnel testing techniques, architectural drawings provided by Turner Fleischer Architects Inc. in May 2020, surrounding street layouts and existing and approved future building massing information, as well as recent site imagery.

2. TERMS OF REFERENCE

The focus of this comparative pedestrian wind study is the proposed residential development located at 420 Lakeshore Road East in Mississauga, Ontario. The study site is situated at the southwest corner of the Lakeshore Road East and Enola Avenue intersection.

The proposed development is a 12-storey building with an 'L'-shaped planform. The ground floor comprises a live/work unit at the northwest corner (referring to project northwest), and a mix of lobby, indoor amenity space, and building support functions in the remaining space. A driveway from Enola Avenue intersects the building at grade, separating a semi-detached condo-house at the southeast corner from the remaining ground floor area and providing access to a circular drop-off area, loading area and ramp to underground parking at the south side of the building. A grade-level outdoor amenity area is provided near the southwest corner of the site. At Level 2, the floorplate extends at the southeast corner to overhang the driveway below, terminating north of a private terrace. Above Level 2, the floorplate sets back with increasing elevation from the southeast corner of the building to provide various private terraces. A mechanical penthouse completes the development.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within a 200-metre radius of the site) are characterized by low-rise buildings in addition to several medium-rise buildings along Lakeshore Road East and an existing parking lot directly southwest (compass southwest). The far-field surroundings (defined as the area beyond the near field and within a two-kilometer radius) are a continuation of the near-field with occasional clusters of medium-rise buildings to the northeast and northwest, while the open exposure of Lake Ontario begins approximately 400 metres southeast of the site.

Grade-level areas investigated include sidewalks, laneways, parking areas, landscaped spaces, outdoor amenity areas, and building access points. Figure 1 illustrates the study site and surrounding context, and Photographs 1 through 6 depict the wind tunnel 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 areas within and surrounding the development site; (ii) identify areas where wind conditions may interfere with the intended uses of outdoor spaces; (iii) recommend suitable mitigation measures, where required; and (iv) evaluate the influence of the proposed development and of surrounding approved future developments, on the existing wind conditions.

4. METHODOLOGY

The approach followed to quantify pedestrian wind conditions over the site is based on wind tunnel measurements of wind speeds at selected locations on a reduced-scale physical model, meteorological analysis of the Toronto area wind climate and synthesis of wind tunnel data with industry-accepted guidelines[1]. The following sections describe the analysis procedures, including a discussion of the pedestrian comfort and safety guidelines.

4.1 Wind Tunnel Context Modelling

A detailed PLW study is performed to determine the influence of local winds at the pedestrian level for a proposed development. The physical model of the proposed development and relevant surroundings, illustrated in Photographs 1 through 6 following the main text, was constructed at a scale of 1:400. The wind tunnel model includes all existing buildings and approved future developments within a full-scale diameter of approximately 840 metres. The general concept and approach to wind tunnel modelling is to provide building and topographic detail in the immediate vicinity of the study site on the surrounding

[1] Toronto Development Guide, Pedestrian Level Wind Study Terms of Reference, November 2010

model, and to rely on a length of wind tunnel upwind of the model to develop wind properties consistent with known turbulent intensity profiles that represent the surrounding terrain.

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

4.2 Wind Speed Measurements

The PLW study was performed by testing a total of 53 sensor locations at grade on the scale model in Gradient Wind's wind tunnel. Wind speed measurements were performed for each sensor for 36 wind directions at 10° intervals. Figure 1 illustrates a plan of the site and relevant surrounding context, while sensor locations used to investigate wind conditions are illustrated in Figures 2 through 5.

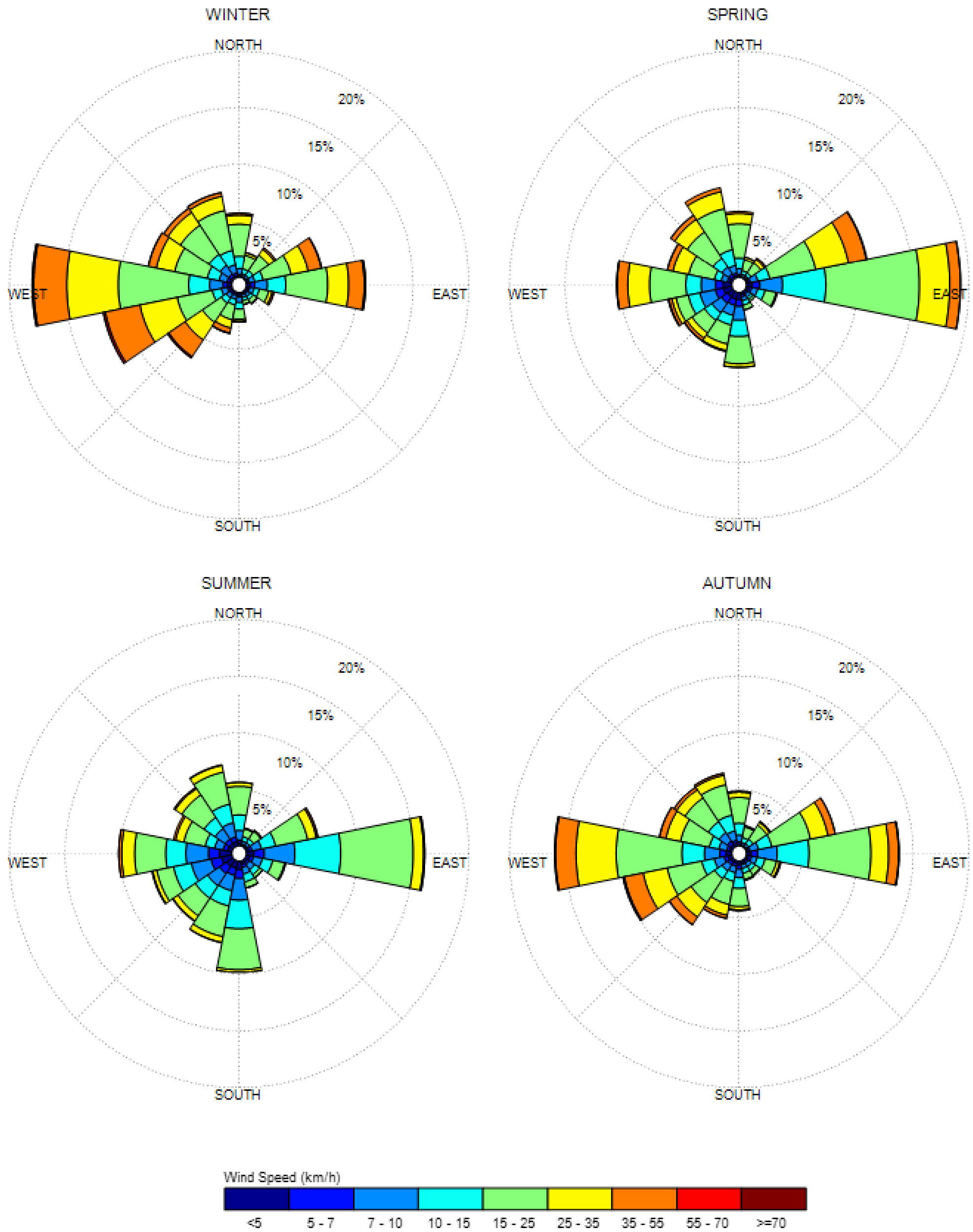
Mean and peak wind speed values for each location and wind direction were calculated from real-time pressure measurements, recorded at a sample rate of 500 samples per second, and taken over a 60-second time period. This period at model-scale corresponds approximately to one hour in full-scale, which matches the time frame of full-scale meteorological observations. Measured mean and gust wind speeds at grade were referenced to the wind speed measured near the ceiling of the wind tunnel to generate mean and peak wind speed ratios. Ceiling height in the wind tunnel represents the depth of the boundary layer of wind flowing over the earth's surface, referred to as the gradient height. Within this boundary layer, mean wind speed increases up to the gradient height and remains constant thereafter. Appendices C and D provide greater detail of the theory behind wind speed measurements. Wind tunnel measurements for this project, conducted in Gradient Wind's wind tunnel facility, meet or exceed guidelines found in the National Building Code of Canada 2010 and of 'Wind Tunnel Studies of Buildings and Structures', ASCE Manual 7 Reports on Engineering Practice No 67.

4.3 Meteorological Data Analysis

A statistical model for winds in Mississauga was developed from approximately 35-years of hourly meteorological wind data recorded at Toronto Island Billy Bishop Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were analyzed for each month of the year in order to determine the statistically prominent wind directions and corresponding speeds, and to characterize similarities between monthly weather patterns. Based on this portion of the 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.

The statistical model of the Mississauga area wind climate, which indicates the directional character of local winds on a seasonal basis, is illustrated on the following page. The plots illustrate seasonal distribution of measured wind speeds and directions in kilometers per hour (km/h). Probabilities of occurrence of different wind speeds are represented as stacked polar bars in sixteen azimuth divisions. The radial direction represents the percentage of time for various wind speed ranges per wind direction during the measurement period. The preferred wind speeds and directions can be identified by the longer length of the bars. For Mississauga (south of the Queen Elizabeth Way, or QEW), the most common winds concerning pedestrian comfort occur from the west, followed by those from the east. The directional preference and relative magnitude of the wind speed varies somewhat from season to season. Also, by convection in microclimate studies, wind direction refers to the wind origin (e.g., a north wind blows from north to south).

SEASONAL DISTRIBUTION OF WIND
TORONTO ISLAND BILLY BISHOP AIRPORT



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 wind comfort and safety criteria are based on the mechanical effects of wind without consideration of other meteorological conditions (i.e., temperature, relative humidity). The criteria assume pedestrians are appropriately dressed for a specified outdoor activity during any given season. Since both mean and gust wind speeds affect pedestrian comfort, their combined effect is defined in the City of Mississauga Urban Design Terms of Reference. More specifically, the criteria are defined as a Gust Equivalent Mean (GEM) wind speed, which is the greater of the mean wind speed or the gust wind speed divided by 1.85. The wind speed ranges are selected based on 'The Beaufort Scale' (presented on the following page), which describes the effects of forces produced by varying wind speed levels on objects.

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

(i) **Sitting** – GEM wind speeds below 10 km/h occurring more than 80% of the time would be considered acceptable for sedentary activities, including sitting.

(ii) **Standing** – GEM wind speeds below 15 km/h (i.e., 10-15 km/h) occurring more than 80% of the time are acceptable for activities such as standing, strolling or more vigorous activities.

(iii) **Walking** – GEM wind speeds below 20 km/h (i.e., 15-20 km/h) occurring more than 80% of the time are acceptable for walking or more vigorous activities.

(iv) **Uncomfortable** – Uncomfortable conditions are characterized by predicted values that fall below the 80% criterion for walking. Brisk walking and exercise, such as jogging, would be acceptable for moderate excesses of this criterion.

Dangerous – Wind speeds greater than 90 km/h, occurring more than 0.1% of the time on an annual basis, are classified as dangerous. From calculations of stability, it can be shown that gust wind speeds of 90 km/h would be the approximate threshold wind speed that would cause a vulnerable member of the population to fall.

THE BEAUFORT SCALE

NUMBER	DESCRIPTION	WIND SPEED (KM/H)	DESCRIPTION
2	Light Breeze	4-8	Wind felt on faces
3	Gentle Breeze	8-15	Leaves and small twigs in constant motion; Wind extends light flags
4	Moderate Breeze	15-22	Wind raises dust and loose paper; Small branches are moved
5	Fresh Breeze	22-30	Small trees in leaf begin to sway
6	Strong Breeze	30-40	Large branches in motion; Whistling heard in electrical wires; Umbrellas used with difficulty
7	Moderate Gale	40-50	Whole trees in motion; Inconvenient walking against wind
8	Gale	50-60	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 80% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if GEM wind speeds of 10 km/h were exceeded for more than 20% of the time, most pedestrians would judge that location to be too windy for sitting or more sedentary activities. Similarly, if GEM wind speeds of 20 km/h were exceeded for more than 20% of the time, walking or less vigorous activities would be considered uncomfortable. As most of 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 at tested locations, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for their associated spaces. This step involves comparing the predicted comfort class to the desired comfort class, which is dictated by the location type represented by the sensor (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	Walking
Public Sidewalks / Pedestrian Walkways	Walking
Outdoor Amenity Spaces	Sitting / Standing
Cafés / Patios / Benches / Gardens	Sitting / Standing
Plazas	Standing / Walking
Transit Stops	Standing
Public Parks	Sitting / Walking
Garage / Service Entrances	Walking
Vehicular Drop-Off Zones	Walking
Laneways / Loading Zones	Walking

Following the comparison, the location is assigned a descriptor that indicates the suitability of the location for its intended use. The suitability descriptors are summarized as follows:

- **Acceptable**: The predicted wind conditions are suitable for the intended uses of the associated outdoor spaces without the need for mitigation.
- **Acceptable with Mitigation**: The predicted wind conditions are not acceptable for the intended use of a space; however, following the implementation of typical mitigation measures, the wind conditions are expected to satisfy the required comfort guidelines.
- **Mitigation Testing Recommended**: The effectiveness of typical mitigation measures is uncertain, and additional wind tunnel testing is recommended to explore other options and to ensure compliance with the comfort guidelines.
- **Incompatible**: The predicted wind conditions will interfere with the comfortable and/or safe use of a space and cannot be feasibly mitigated to acceptable levels.

5. RESULTS AND DISCUSSION

5.1 Pedestrian Comfort Suitability – Future Conditions

Tables A1 through A2 in Appendix A provide a summary of seasonal comfort predictions for each sensor location under the future massing scenario considering the study building and all approved surrounding developments. The tables indicate the 80% non-exceedance gust wind speeds and corresponding comfort classifications as defined in Section 4.4. In other words, a gust wind speed threshold of 12.1 for the summer season indicates that 80% of the measured data falls at or below 12.1 km/h during the summer months and conditions are therefore suitable for standing, as the 80% threshold value falls within the exceedance range of 10-15 km/h for standing. The tables include the predicted threshold values for each sensor location during each season, accompanied by the corresponding predicted comfort class (i.e. sitting, standing, walking, etc.).

The most significant findings of the PLW are summarized in the Section 5.2. To assist with understanding and interpretation, predicted conditions for the proposed development are also illustrated in colour-coded format in Figures 2 through 5. Conditions suitable for sitting are represented by the colour green, while standing is represented by yellow, and walking by blue. Conditions uncomfortable for walking are represented by magenta. Measured mean and gust velocity ratios, which constitutes the raw data upon which the results are based, will be made available upon request.

5.2 Summary of Findings – Future Conditions

Based on the analysis of the measured data, consideration of local climate data, and the suitability descriptors provided in Tables A1-A2 in Appendix A, this section summarizes the most significant findings of the PLW study with respect to future conditions, as follows:

1. Overall, public sidewalks within and surrounding the development will experience wind conditions suitable for a mix of sitting and standing during the summer, transitioning to become largely suitable for walking or better for the remainder of the year. Exceptions include portions of sidewalk at the south corners of the Lakeshore Road East and Enola Avenue intersection (Sensors 20 and 31), which will transition to conditions uncomfortable for walking during the winter. To improve wind speeds to walking conditions, it is recommended to install clusters of wind barriers near these sidewalk locations. Barriers may take the form of high-solidity wind

screens, clusters of dense coniferous plantings, or a combination thereof, and should rise at least 2.0 metres at the time of installation.

2. Most building entrances will be suitable for sitting or standing throughout the year. An exception includes potential lobby entrances near the northeast corner of the building facing the intersection of Lakeshore Road East and Enola Avenue (project northeast, Sensors 30-32), which will transition to walking conditions during the spring and autumn and will include conditions uncomfortable walking during the winter. The mitigation described for Item 1 above will serve to improve wind speeds at this location at no additional effort. However, to ensure conditions at the doorway achieve the desired standing classification throughout the year, it is further recommended that any entrances at this location be either recessed into the building façade, flanked by vertical wind barriers, or relocated at least five metres away from the angled wall.

3. All laneways and most parking lot areas within and surrounding the development will achieve the desired walking classification, or better, throughout the year. An exception is a portion of the existing parking lot south of the study site (Sensor 42), which will transition to conditions uncomfortable for walking during the winter. It is noteworthy that wind speeds will only marginally exceed the walking comfort threshold and are considered safe (refer to Tables A1-A2 under 'Pedestrian Safety'). The noted conditions are therefore considered acceptable.

4. The nearby transit stop (Sensor 2) will be comfortable for standing throughout the year, which is acceptable.

5. Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no areas over the study site were found to experience wind conditions that are considered unsafe.

5.3 Pedestrian Comfort Suitability – Existing Versus Future Conditions

To evaluate the influence of the study building on existing wind conditions at and near the study site, an additional pedestrian level wind test was performed for the existing site massing without the study building present. A comparison of wind comfort results for the existing and future configurations is provided in Tables B1 to B4 in Appendix B, which provide a summary of the comparative wind comfort predictions based on summer and winter wind statistics. The future and existing massing scenarios are shown in Photographs 1 through 6 following the main text.

Pedestrian wind comfort resulting from the construction of the study building and future surrounding developments may be described as being *unchanged*, *improved*, or *reduced* as compared to the existing conditions. These designations are not strictly determined by the predicted percentage values, rather by the change to the predicted comfort class.

A review of Tables B1 to B4 indicates that wind comfort at grade-level areas will largely remain unchanged or be reduced upon the introduction of the proposed study building. In particular, portions of sidewalk at the south corners of the intersection of Lakeshore Road East and Enola Avenue (Sensors 20 and 31) and a portion of the parking lot southwest of the study site (Sensor 42) will transition to conditions uncomfortable for walking during the winter. Mitigation is recommended for these sidewalk areas as described in Section 5.2. Although the windy parking lot area marginally exceeds walking conditions, the annual safety criteria is achieved and conditions at this location are considered acceptable.

6. CONCLUSIONS AND RECOMMENDATIONS

This report summarizes the methodology, results, and recommendations related to a pedestrian level wind study for the proposed residential development located at 420 Lakeshore Road East in Mississauga, Ontario. The study was performed in accordance with industry standard wind tunnel testing and data analysis procedures.

A complete summary of the predicted wind conditions is provided in Section 5.2 of this report and is also illustrated in Figures 2 through 5, as well as Tables A1-A2 and B1-B4 in the appendices. Based on the wind tunnel test results, meteorological data analysis, and experience with similar developments in Mississauga, we conclude that future wind conditions over most grade-level pedestrian wind-sensitive areas within and surrounding the study site will be acceptable for the intended uses on a seasonal basis. Exceptions include potential lobby entrances at the northeast corner of the building (project northeast) and sections of sidewalk at the intersection of Lakeshore Road East and Enola Avenue. Mitigation is recommended as described in Section 5.2.

A comparison of the existing versus future wind comfort surrounding the study site indicates that grade-level wind comfort will generally be unchanged or reduced following introduction of the study building, depending on the location. Specifically, portions of sidewalk in proximity to the roadway intersection will become windier and uncomfortable for walking during the colder months. Conditions can be made comfortable through incorporation of mitigation as recommended in Section 5.2.

Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no areas over the study site were found to experience conditions that could be considered unsafe.

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

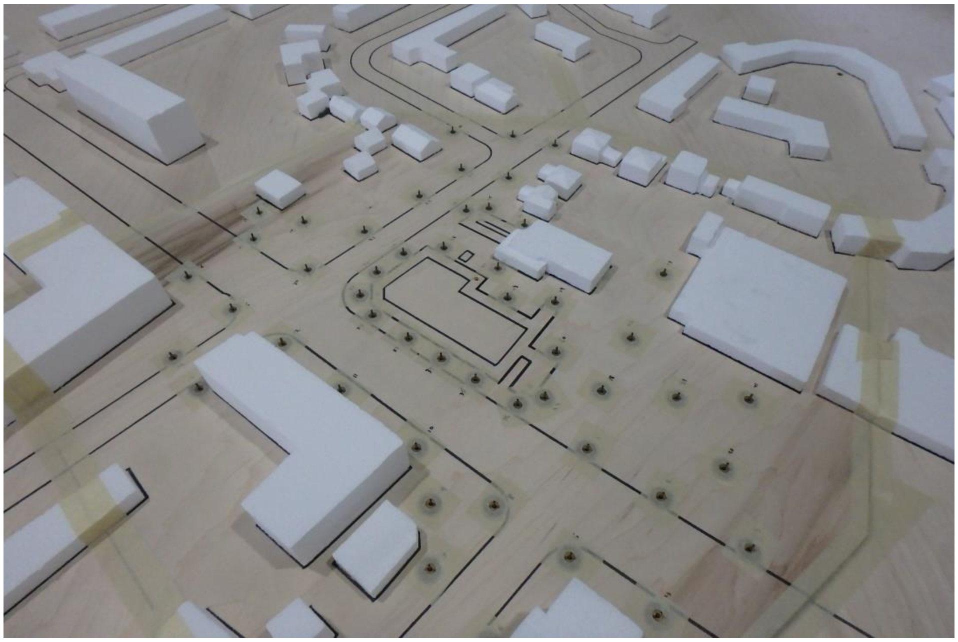
Sincerely,

Gradient Wind Engineering Inc.

Angelina Gomes, B.Eng.,
Junior Wind Scientist

Andrew Sliasas, M.A.Sc., P.Eng.,
Principal

GW20-104-WTPLW



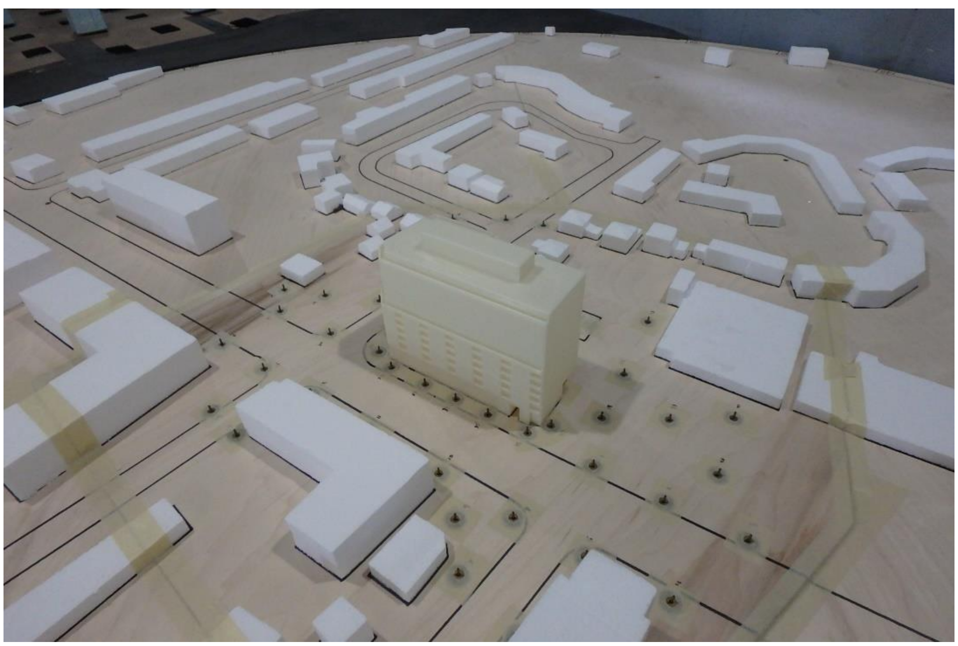
PHOTOGRAPH 1: CLOSE-UP VIEW OF EXISTING CONTEXT MODEL LOOKING EAST

PHOTOGRAPH 2: CLOSE-UP VIEW OF EXISTING CONTEXT MODEL LOOKING WEST

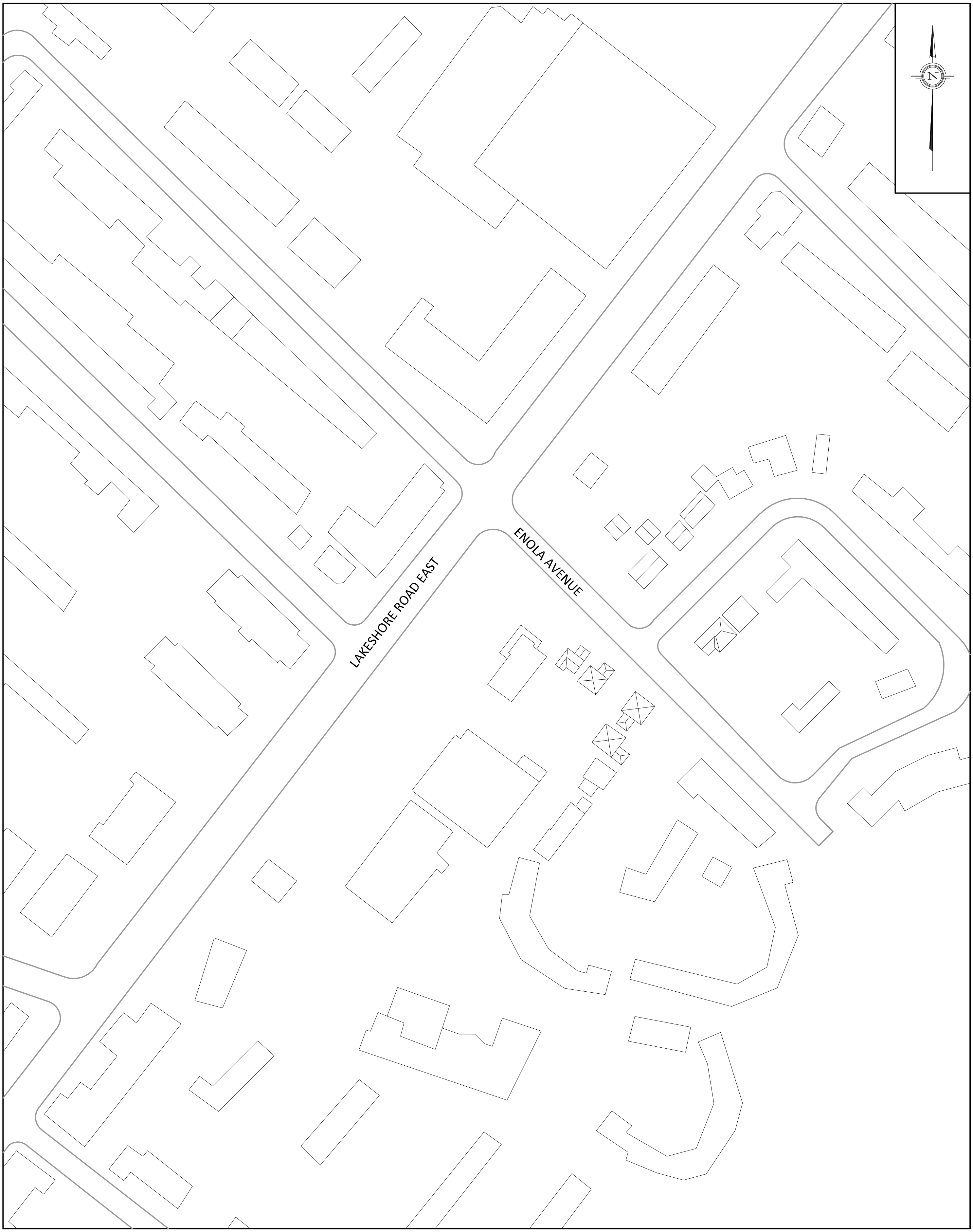
PHOTOGRAPH 3: STUDY MODEL INSIDE THE GWE WIND TUNNEL LOOKING DOWNWIND

PHOTOGRAPH 4: STUDY MODEL INSIDE THE GWE WIND TUNNEL LOOKING UPWIND

PHOTOGRAPH 5: CLOSE-UP VIEW OF STUDY MODEL LOOKING NORTH



PHOTOGRAPH 6: CLOSE-UP VIEW OF STUDY MODEL LOOKING EAST



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PROJECT: 420 LAKESHORE ROAD EAST, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 1A: EXISTING CONDITIONS SITE PLAN AND SURROUNDING CONTEXT
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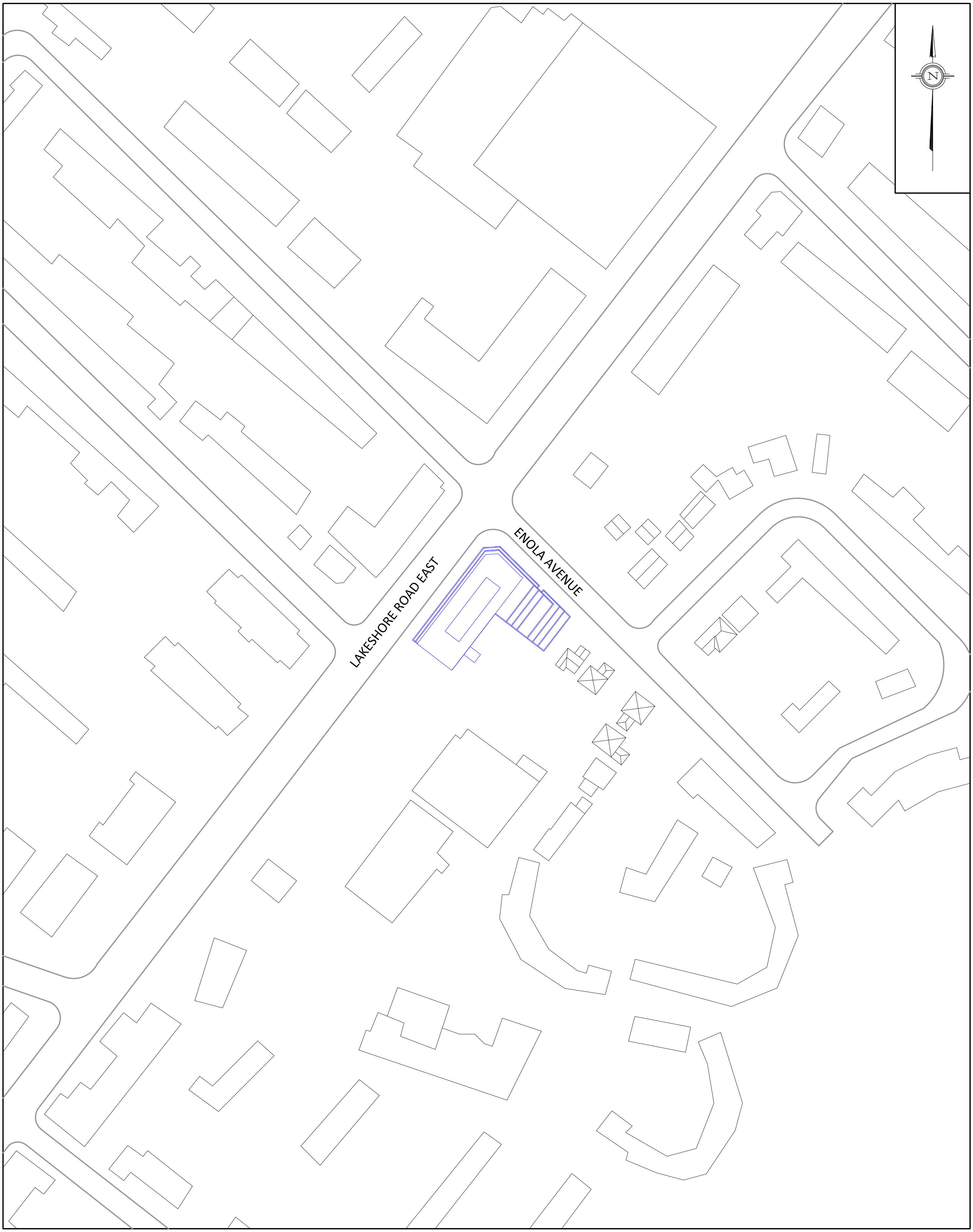
DATE: JUNE 11, 2020	DRAWN BY: A.G.	



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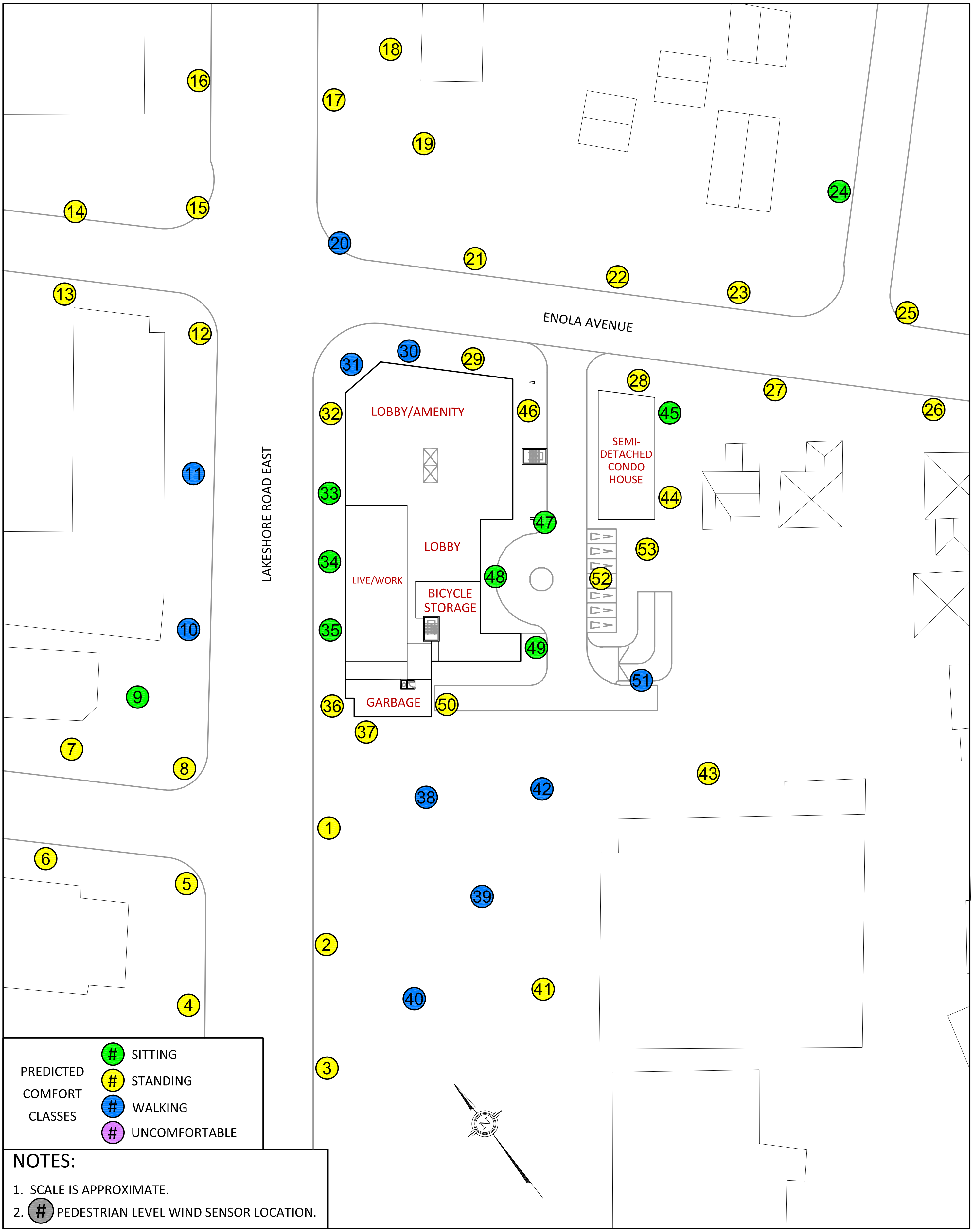
PROJECT	420 LAKESHORE ROAD EAST, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:2500 (APPROX.)	DRAWING NO.	GWE20-104-PLW-1B
DATE	JUNE 11, 2020	DRAWN BY	A.G.

DESCRIPTION

FIGURE 1B: FUTURE PROPOSED SCENARIO
SITE PLAN AND SURROUNDING CONTEXT



NOTES:

1. SCALE IS APPROXIMATE.
2. # PEDESTRIAN LEVEL WIND SENSOR LOCATION.

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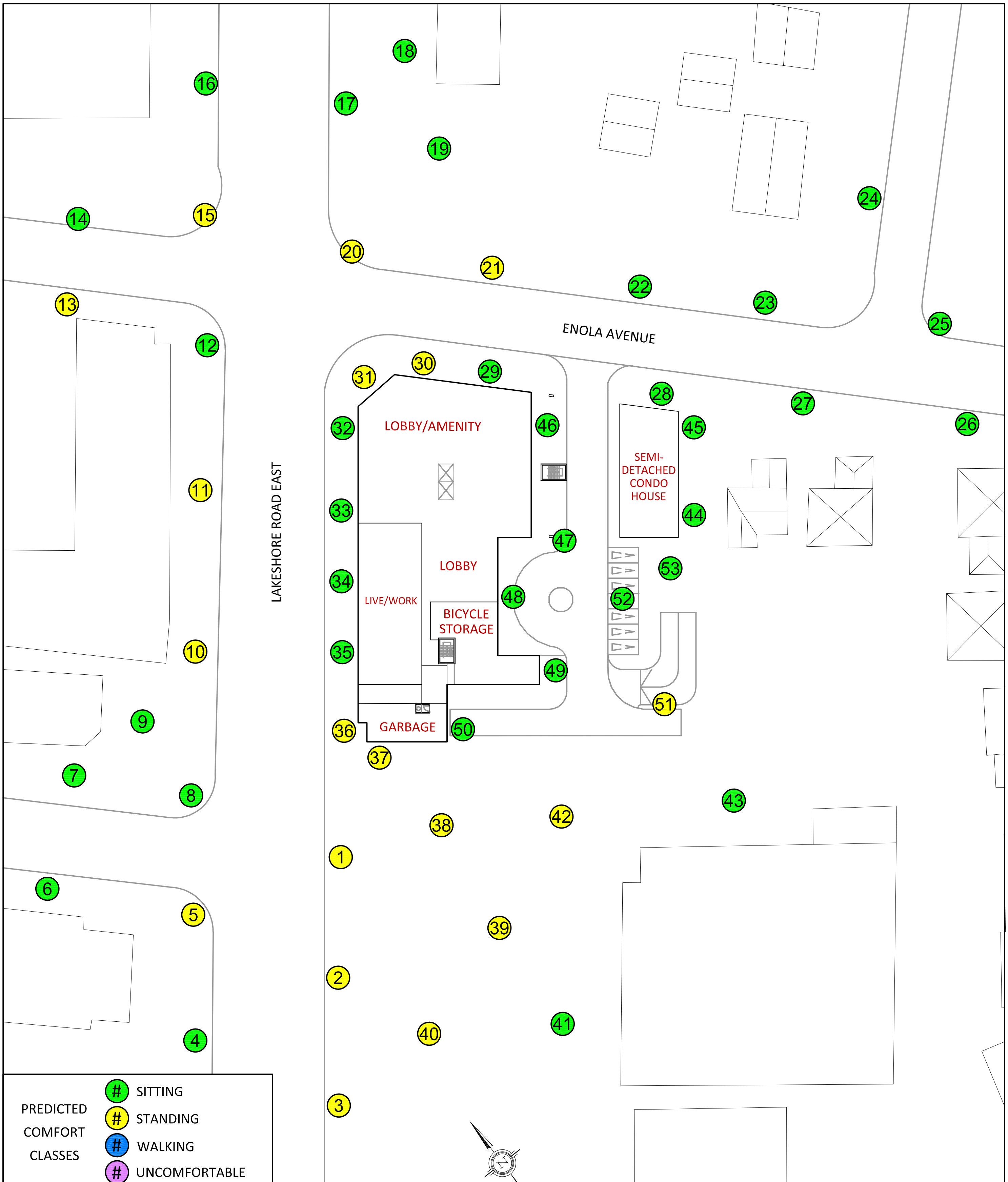
PROJECT	420 LAKESHORE ROAD EAST, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:900 (APPROX.)	DRAWING NO.	GWE20-104-PLW-2
DATE	JUNE 11, 2020	DRAWN BY	A.G.

DESCRIPTION

FIGURE 2: SPRING
GROUND FLOOR PLAN
PEDESTRIAN COMFORT PREDICTIONS



NOTES:

1. SCALE IS APPROXIMATE.
2. # PEDESTRIAN LEVEL WIND SENSOR LOCATION.

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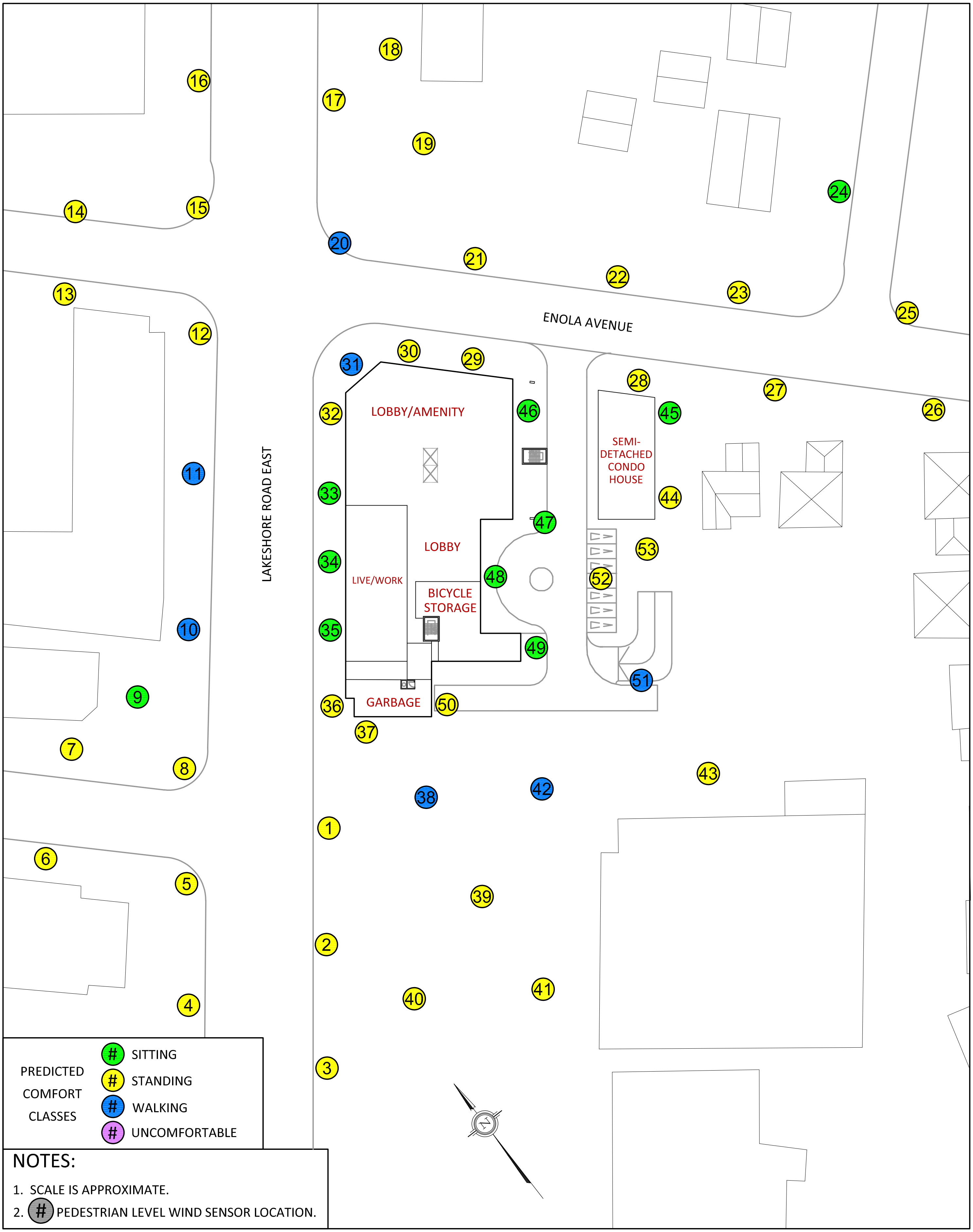
PROJECT	420 LAKESHORE ROAD EAST, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:900 (APPROX.)	DRAWING NO.	GWE20-104-PLW-3
DATE	JUNE 11, 2020	DRAWN BY	A.G.

DESCRIPTION

FIGURE 3: SUMMER
GROUND FLOOR PLAN
PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CLASSES

- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

NOTES:

1. SCALE IS APPROXIMATE.
2. # PEDESTRIAN LEVEL WIND SENSOR LOCATION.

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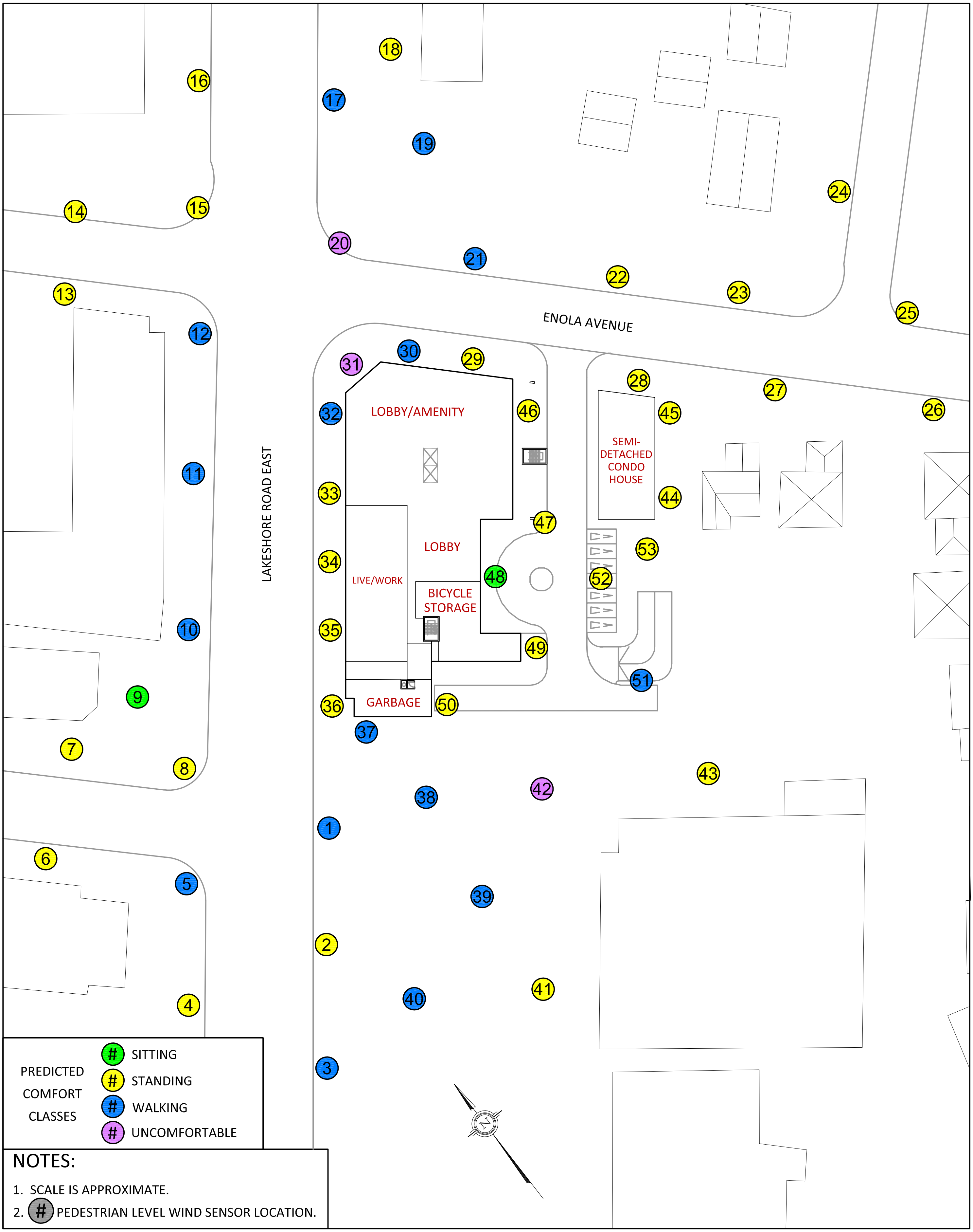
PROJECT: 420 LAKESHORE ROAD EAST, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 4: AUTUMN GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:900 (APPROX.)	DRAWING NO.: GWE20-104-PLW-4	
DATE: JUNE 11, 2020	DRAWN BY: A.G.	



NOTES:

1. SCALE IS APPROXIMATE.
2. # PEDESTRIAN LEVEL WIND SENSOR LOCATION.

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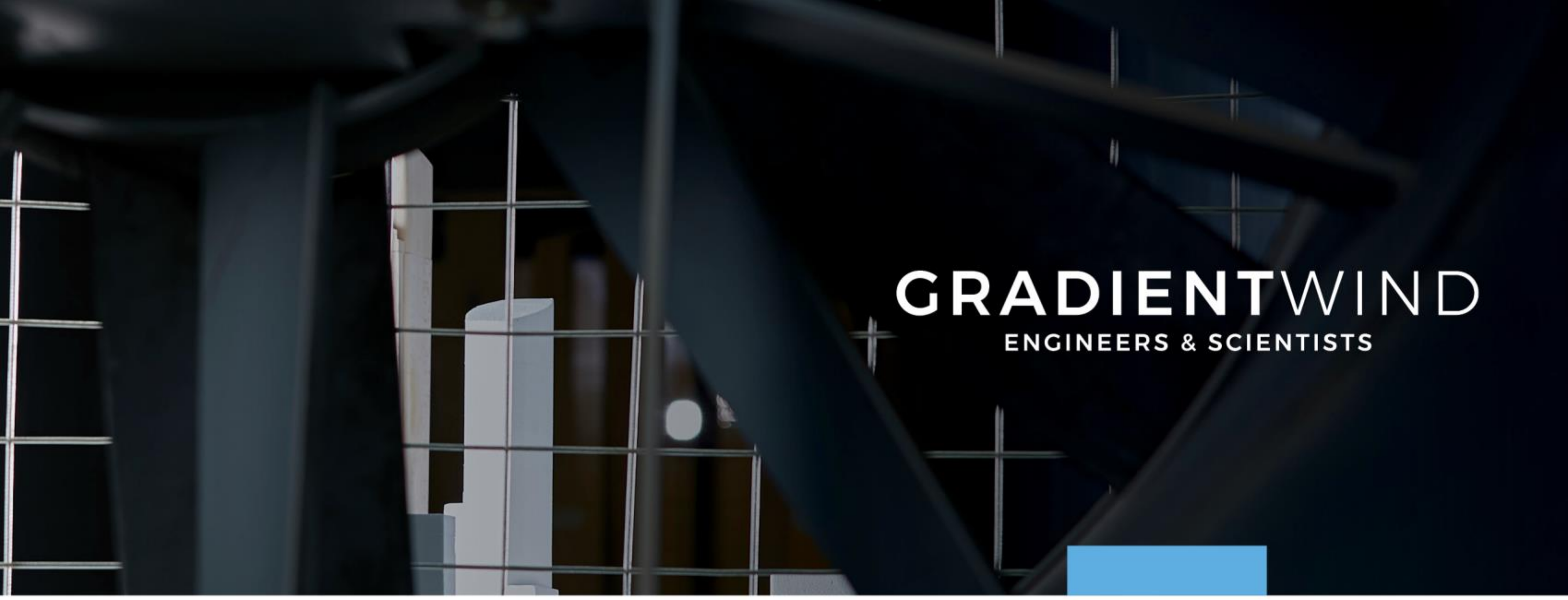
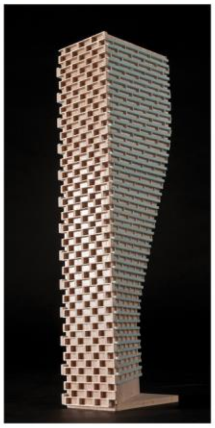
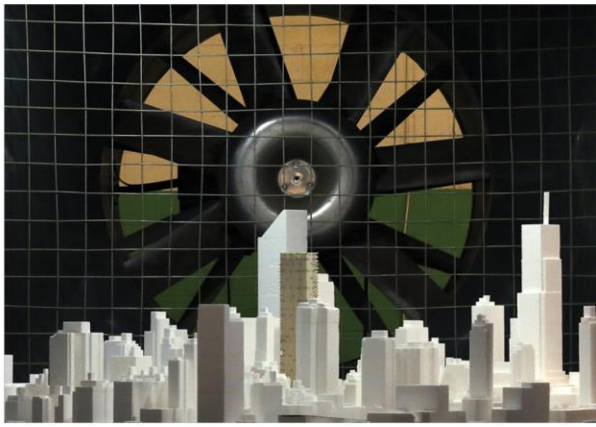
PROJECT	420 LAKESHORE ROAD EAST, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:900 (APPROX.)	DRAWING NO.	GWE20-104-PLW-5
DATE	JUNE 11, 2020	DRAWN BY	A.G.

DESCRIPTION

FIGURE 5: WINTER
GROUND FLOOR PLAN
PEDESTRIAN COMFORT PREDICTIONS







APPENDIX A

PEDESTRIAN COMFORT SUITABILITY, TABLES A1-A2 (FUTURE CONDITIONS)

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Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

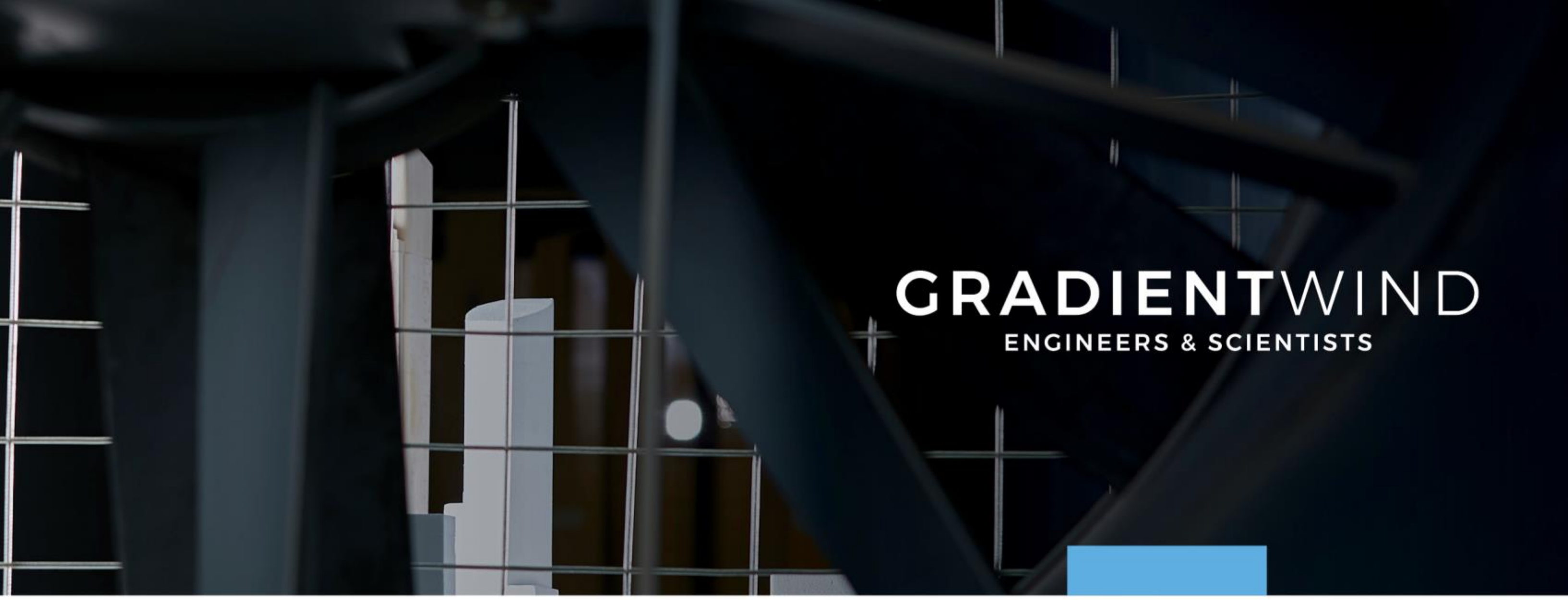
TABLE A1: SUMMARY OF PEDESTRIAN COMFORT (FUTURE CONDITIONS)

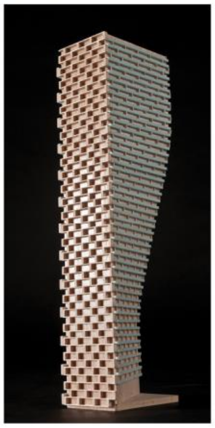
Sensor	Pedestrian Comfort								Pedestrian Safety	
	Spring		Summer		Autumn		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
1	14.5	Standing	11.3	Standing	14.7	Standing	17.0	Walking	57.1	Safe
2	14.3	Standing	10.9	Standing	12.9	Standing	14.2	Standing	55.4	Safe
3	14.9	Standing	11.2	Standing	14.2	Standing	16.1	Walking	52.9	Safe
4	10.4	Standing	8.1	Sitting	10.2	Standing	11.5	Standing	46.3	Safe
5	14.3	Standing	11.2	Standing	13.5	Standing	15.2	Walking	52.4	Safe
6	10.7	Standing	8.1	Sitting	10.4	Standing	11.9	Standing	47.1	Safe
7	10.5	Standing	8.5	Sitting	10.6	Standing	11.9	Standing	43.2	Safe
8	11.2	Standing	9.2	Sitting	11.1	Standing	12.5	Standing	42.6	Safe
9	8.0	Sitting	6.4	Sitting	8.2	Sitting	9.5	Sitting	33.9	Safe
10	17.7	Walking	13.5	Standing	16.5	Walking	18.1	Walking	67.9	Safe
11	18.2	Walking	14.1	Standing	17.4	Walking	18.9	Walking	71.1	Safe
12	13.0	Standing	9.9	Sitting	13.9	Standing	16.6	Walking	51.5	Safe
13	14.1	Standing	10.3	Standing	12.7	Standing	14.0	Standing	56.6	Safe
14	11.6	Standing	8.7	Sitting	11.4	Standing	12.6	Standing	51.1	Safe
15	13.6	Standing	10.0	Standing	13.0	Standing	14.8	Standing	50.0	Safe
16	10.6	Standing	8.0	Sitting	11.2	Standing	13.0	Standing	54.8	Safe
17	12.1	Standing	9.1	Sitting	13.7	Standing	16.4	Walking	52.9	Safe
18	10.7	Standing	8.2	Sitting	12.0	Standing	14.6	Standing	51.9	Safe
19	11.7	Standing	9.3	Sitting	14.0	Standing	17.0	Walking	59.5	Safe
20	16.4	Walking	12.0	Standing	17.8	Walking	21.2	Uncomfortable	66.3	Safe
21	14.1	Standing	10.7	Standing	14.6	Standing	16.9	Walking	64.0	Safe
22	12.2	Standing	9.6	Sitting	12.3	Standing	14.3	Standing	56.1	Safe
23	11.7	Standing	8.8	Sitting	11.2	Standing	12.9	Standing	51.1	Safe
24	9.4	Sitting	7.6	Sitting	9.3	Sitting	10.6	Standing	37.8	Safe
25	10.1	Standing	8.1	Sitting	10.5	Standing	12.1	Standing	42.1	Safe
26	11.2	Standing	8.3	Sitting	10.5	Standing	11.9	Standing	41.8	Safe
27	11.8	Standing	8.3	Sitting	10.8	Standing	12.8	Standing	49.0	Safe
28	11.7	Standing	8.5	Sitting	11.4	Standing	13.2	Standing	51.0	Safe
29	12.5	Standing	9.0	Sitting	11.6	Standing	13.3	Standing	57.8	Safe
30	15.8	Walking	11.2	Standing	13.9	Standing	15.6	Walking	67.0	Safe
31	19.0	Walking	13.0	Standing	19.6	Walking	22.7	Uncomfortable	73.5	Safe
32	12.1	Standing	8.8	Sitting	14.7	Standing	17.7	Walking	60.5	Safe
33	9.0	Sitting	7.0	Sitting	9.6	Sitting	11.1	Standing	37.8	Safe
34	9.3	Sitting	7.2	Sitting	9.4	Sitting	10.8	Standing	37.5	Safe
35	9.3	Sitting	7.2	Sitting	9.2	Sitting	10.5	Standing	38.7	Safe

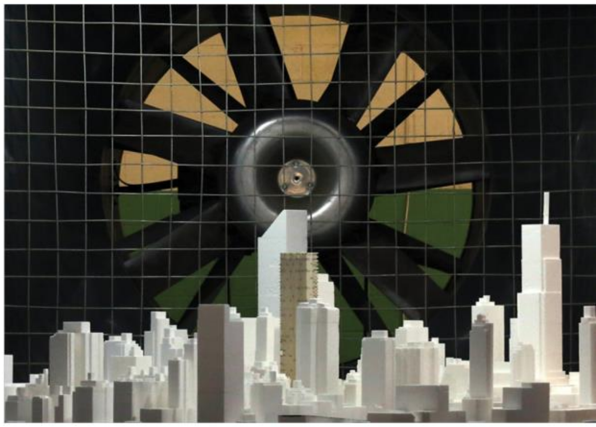
Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE A2: SUMMARY OF PEDESTRIAN COMFORT (FUTURE CONDITONS)

Sensor	Pedestrian Comfort								Pedestrian Safety	
	Spring		Summer		Autumn		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
36	12.7	Standing	11.1	Standing	12.5	Standing	13.8	Standing	56.2	Safe
37	13.1	Standing	10.3	Standing	14.4	Standing	17.1	Walking	71.3	Safe
38	15.6	Walking	11.6	Standing	15.2	Walking	17.3	Walking	60.4	Safe
39	15.3	Walking	10.9	Standing	13.7	Standing	15.3	Walking	55.3	Safe
40	15.6	Walking	11.3	Standing	14.2	Standing	16.3	Walking	54.9	Safe
41	11.1	Standing	8.7	Sitting	12.1	Standing	14.5	Standing	46.2	Safe
42	17.6	Walking	12.6	Standing	17.6	Walking	20.2	Uncomfortable	62.8	Safe
43	11.8	Standing	8.6	Sitting	11.2	Standing	12.9	Standing	44.8	Safe
44	12.2	Standing	9.4	Sitting	12.5	Standing	14.8	Standing	51.0	Safe
45	9.4	Sitting	7.7	Sitting	10.0	Sitting	11.5	Standing	38.8	Safe
46	10.3	Standing	7.3	Sitting	9.5	Sitting	10.6	Standing	46.7	Safe
47	8.1	Sitting	6.7	Sitting	8.6	Sitting	10.1	Standing	38.9	Safe
48	6.9	Sitting	5.6	Sitting	7.7	Sitting	9.1	Sitting	41.7	Safe
49	8.6	Sitting	6.7	Sitting	9.6	Sitting	11.5	Standing	52.8	Safe
50	10.2	Standing	8.3	Sitting	11.0	Standing	12.7	Standing	57.8	Safe
51	15.2	Walking	10.9	Standing	16.6	Walking	19.4	Walking	62.6	Safe
52	10.1	Standing	8.3	Sitting	11.4	Standing	13.6	Standing	57.1	Safe
53	11.1	Standing	8.9	Sitting	11.7	Standing	13.2	Standing	44.2	Safe







APPENDIX B

PEDESTRIAN COMFORT SUITABILITY, TABLES B1-B4
(EXISTING VS FUTURE CONDITIONS)

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Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE B1: COMPARATIVE SUMMARY OF PEDESTRIAN COMFORT

Sensor	Massing Scenario	Summer Pedestrian Comfort			Winter Pedestrian Comfort		
		Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing	Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing
1	Existing	10.0	Sitting	-	13.9	Standing	-
	Future	11.3	Standing	Reduced	17.0	Walking	Reduced
2	Existing	9.5	Sitting	-	12.5	Standing	-
	Future	10.9	Standing	Reduced	14.2	Standing	Unchanged
3	Existing	10.6	Standing	-	16.0	Walking	-
	Future	11.2	Standing	Reduced	16.1	Walking	Unchanged
4	Existing	8.8	Sitting	-	12.8	Standing	-
	Future	8.1	Sitting	Unchanged	11.5	Standing	Unchanged
5	Existing	10.1	Standing	-	14.2	Standing	-
	Future	11.2	Standing	Unchanged	15.2	Walking	Reduced
6	Existing	10.0	Sitting	-	14.4	Standing	-
	Future	8.1	Sitting	Unchanged	11.9	Standing	Unchanged
7	Existing	9.9	Sitting	-	14.8	Standing	-
	Future	8.5	Sitting	Unchanged	11.9	Standing	Unchanged
8	Existing	9.7	Sitting	-	14.6	Standing	-
	Future	9.2	Sitting	Unchanged	12.5	Standing	Unchanged
9	Existing	7.4	Sitting	-	10.4	Standing	-
	Future	6.4	Sitting	Unchanged	9.5	Sitting	Improved
10	Existing	9.8	Sitting	-	15.9	Walking	-
	Future	13.5	Standing	Reduced	18.1	Walking	Unchanged
11	Existing	7.8	Sitting	-	11.9	Standing	-
	Future	14.1	Standing	Reduced	18.9	Walking	Reduced
12	Existing	8.1	Sitting	-	12.0	Standing	-
	Future	9.9	Sitting	Unchanged	16.6	Walking	Reduced
13	Existing	9.6	Sitting	-	14.5	Standing	-
	Future	10.3	Standing	Reduced	14.0	Standing	Unchanged
14	Existing	8.7	Sitting	-	13.4	Standing	-
	Future	8.7	Sitting	Unchanged	12.6	Standing	Unchanged
15	Existing	10.3	Standing	-	15.8	Walking	-
	Future	10.0	Standing	Unchanged	14.8	Standing	Improved

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE B2: COMPARATIVE SUMMARY OF PEDESTRIAN COMFORT

Sensor	Massing Scenario	Summer Pedestrian Comfort			Winter Pedestrian Comfort		
		Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing	Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing
16	Existing	8.4	Sitting	-	12.0	Standing	-
	Future	8.0	Sitting	Unchanged	13.0	Standing	Unchanged
17	Existing	9.2	Sitting	-	14.5	Standing	-
	Future	9.1	Sitting	Unchanged	16.4	Walking	Reduced
18	Existing	8.8	Sitting	-	13.5	Standing	-
	Future	8.2	Sitting	Unchanged	14.6	Standing	Unchanged
19	Existing	8.1	Sitting	-	12.4	Standing	-
	Future	9.3	Sitting	Unchanged	17.0	Walking	Reduced
20	Existing	9.4	Sitting	-	13.5	Standing	-
	Future	12.0	Standing	Reduced	21.2	Uncomfortable	Reduced
21	Existing	9.2	Sitting	-	13.8	Standing	-
	Future	10.7	Standing	Reduced	16.9	Walking	Reduced
22	Existing	8.0	Sitting	-	12.6	Standing	-
	Future	9.6	Sitting	Unchanged	14.3	Standing	Unchanged
23	Existing	9.0	Sitting	-	14.3	Standing	-
	Future	8.8	Sitting	Unchanged	12.9	Standing	Unchanged
24	Existing	8.2	Sitting	-	12.6	Standing	-
	Future	7.6	Sitting	Unchanged	10.6	Standing	Unchanged
25	Existing	8.2	Sitting	-	13.1	Standing	-
	Future	8.1	Sitting	Unchanged	12.1	Standing	Unchanged
26	Existing	9.4	Sitting	-	13.2	Standing	-
	Future	8.3	Sitting	Unchanged	11.9	Standing	Unchanged
27	Existing	8.7	Sitting	-	12.7	Standing	-
	Future	8.3	Sitting	Unchanged	12.8	Standing	Unchanged
28	Existing	9.2	Sitting	-	13.3	Standing	-
	Future	8.5	Sitting	Unchanged	13.2	Standing	Unchanged
29	Existing	9.2	Sitting	-	14.3	Standing	-
	Future	9.0	Sitting	Unchanged	13.3	Standing	Unchanged
30	Existing	9.6	Sitting	-	14.4	Standing	-
	Future	11.2	Standing	Reduced	15.6	Walking	Reduced

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

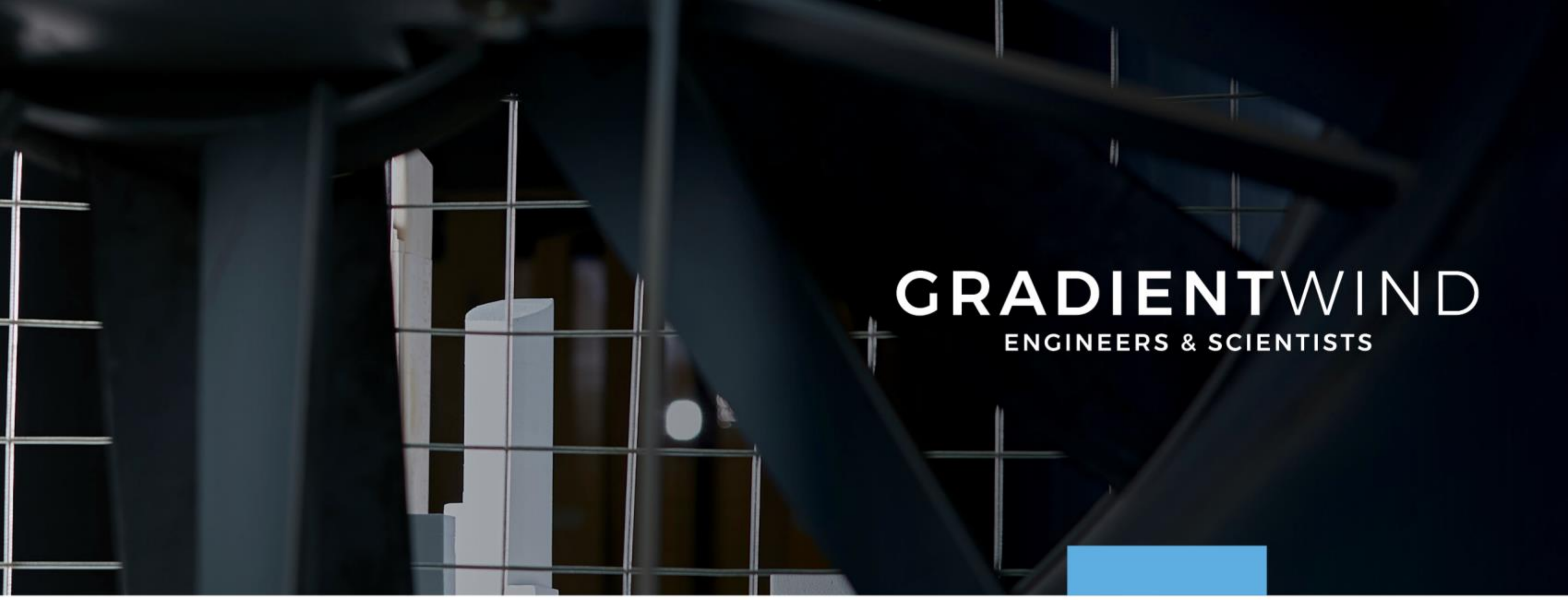
TABLE B3: COMPARATIVE SUMMARY OF PEDESTRIAN COMFORT

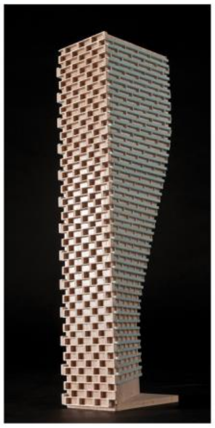
Sensor	Massing Scenario	Summer Pedestrian Comfort			Winter Pedestrian Comfort		
		Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing	Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing
31	Existing	8.8	Sitting	-	13.0	Standing	-
	Future	13.0	Standing	Reduced	22.7	Uncomfortable	Reduced
32	Existing	8.8	Sitting	-	13.3	Standing	-
	Future	8.8	Sitting	Unchanged	17.7	Walking	Reduced
33	Existing	9.1	Sitting	-	13.3	Standing	-
	Future	7.0	Sitting	Unchanged	11.1	Standing	Unchanged
34	Existing	9.1	Sitting	-	13.2	Standing	-
	Future	7.2	Sitting	Unchanged	10.8	Standing	Unchanged
35	Existing	8.8	Sitting	-	12.7	Standing	-
	Future	7.2	Sitting	Unchanged	10.5	Standing	Unchanged
36	Existing	8.8	Sitting	-	12.5	Standing	-
	Future	11.1	Standing	Reduced	13.8	Standing	Unchanged
37	Existing	9.2	Sitting	-	12.8	Standing	-
	Future	10.3	Standing	Reduced	17.1	Walking	Reduced
38	Existing	9.0	Sitting	-	12.2	Standing	-
	Future	11.6	Standing	Reduced	17.3	Walking	Reduced
39	Existing	8.7	Sitting	-	11.7	Standing	-
	Future	10.9	Standing	Reduced	15.3	Walking	Reduced
40	Existing	9.7	Sitting	-	14.4	Standing	-
	Future	11.3	Standing	Reduced	16.3	Walking	Reduced
41	Existing	9.0	Sitting	-	13.9	Standing	-
	Future	8.7	Sitting	Unchanged	14.5	Standing	Unchanged
42	Existing	8.8	Sitting	-	13.0	Standing	-
	Future	12.6	Standing	Reduced	20.2	Uncomfortable	Reduced
43	Existing	7.4	Sitting	-	10.8	Standing	-
	Future	8.6	Sitting	Unchanged	12.9	Standing	Unchanged
44	Existing	8.5	Sitting	-	11.4	Standing	-
	Future	9.4	Sitting	Unchanged	14.8	Standing	Unchanged
45	Existing	9.8	Sitting	-	14.0	Standing	-
	Future	7.7	Sitting	Unchanged	11.5	Standing	Unchanged

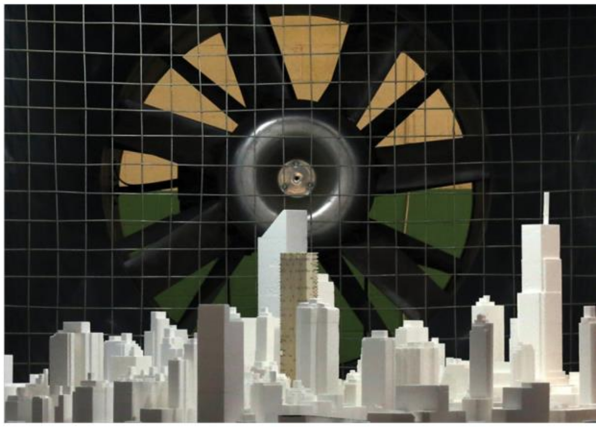
Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE B4: COMPARATIVE SUMMARY OF PEDESTRIAN COMFORT

Sensor	Massing Scenario	Summer Pedestrian Comfort			Winter Pedestrian Comfort		
		Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing	Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing
46	Existing	9.5	Sitting	-	15.1	Walking	-
	Future	7.3	Sitting	Unchanged	10.6	Standing	Improved
47	Existing	7.7	Sitting	-	11.9	Standing	-
	Future	6.7	Sitting	Unchanged	10.1	Standing	Unchanged
48	Existing	7.9	Sitting	-	11.6	Standing	-
	Future	5.6	Sitting	Unchanged	9.1	Sitting	Improved
49	Existing	7.9	Sitting	-	10.9	Standing	-
	Future	6.7	Sitting	Unchanged	11.5	Standing	Unchanged
50	Existing	8.9	Sitting	-	12.4	Standing	-
	Future	8.3	Sitting	Unchanged	12.7	Standing	Unchanged







APPENDIX C

WIND TUNNEL SIMULATION OF THE NATURAL WIND

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WIND TUNNEL SIMULATION OF THE NATURAL WIND

Wind flowing over the surface of the earth develops a boundary layer due to the drag produced by surface features such as vegetation and man-made structures. Within this boundary layer, the mean wind speed varies from zero at the surface to the gradient wind speed at the top of the layer. The height of the top of the boundary layer is referred to as the gradient height, above which the velocity remains more-or-less constant for a given synoptic weather system. The mean wind speed is taken to be the average value over one hour. Superimposed on the mean wind speed are fluctuating (or turbulent) components in the longitudinal (i.e. along wind), vertical and lateral directions. Although turbulence varies according to the roughness of the surface, the turbulence level generally increases from nearly zero (smooth flow) at gradient height to maximum values near the ground. While for a calm ocean the maximum could be 20%, the maximum for a very rough surface such as the center of a city could be 100%, or equal to the local mean wind speed. The height of the boundary layer varies in time and over different terrain roughness within the range of 400 metres (m) to 600 m.

Simulating real wind behaviour in a wind tunnel requires simulating the variation of mean wind speed with height, simulating the turbulence intensity, and matching the typical length scales of turbulence. It is the ratio between wind tunnel turbulence length scales and turbulence scales in the atmosphere that determines the geometric scales that models can assume in a wind tunnel. Hence, when a 1:200 scale model is quoted, this implies that the turbulence scales in the wind tunnel and the atmosphere have the same ratios. Some flexibility in this requirement has been shown to produce reasonable wind tunnel predictions compared to full scale. In model scale the mean and turbulence characteristics of the wind are obtained with the use of spires at one end of the tunnel and roughness elements along the floor of the tunnel. The fan is located at the model end and wind is pulled over the spires, roughness elements and model. It has been found that, to a good approximation, the mean wind profile can be represented by a power law relation, shown below, giving height above ground versus wind speed.

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

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.

Figure B1 on the following page plots three velocity profiles for open country, and suburban and urban exposures.

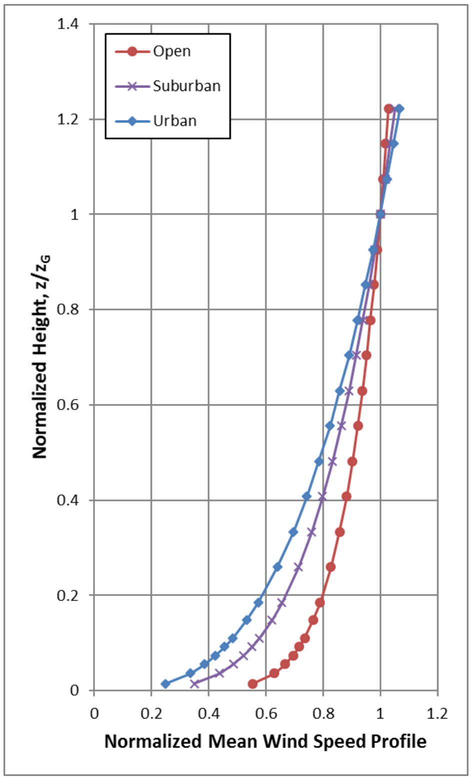
The exponent α varies according to the type of upwind terrain; α ranges from 0.14 for open country to 0.33 for an urban exposure. Figure C2 illustrates the theoretical variation of turbulence for open country, suburban and urban exposures.

The integral length scale of turbulence can be thought of as an average size of gust in the atmosphere. Although it varies with height and ground roughness, it has been found to generally be in the range of 100 m to 200 m in the upper half of the boundary layer. Thus, for a 1:300 scale, the model value should be between 1/3 and 2/3 of a metre. Integral length scales are derived from power spectra, which describe the energy content of wind as a function of frequency. There are several ways of determining integral length scales of turbulence. One way is by comparison of a measured power spectrum in model scale to a non-dimensional theoretical spectrum such as the Davenport spectrum of longitudinal turbulence. Using the Davenport spectrum, which agrees well with full-scale spectra, one can estimate the integral scale by plotting the theoretical spectrum with varying L until it matches as closely as possible the measured spectrum:

$$f \times S(f) = \frac{\dfrac{4(Lf)^2}{U_{10}{}^2}}{\left[1 + \dfrac{4(Lf)^2}{U_{10}{}^2}\right]^{\frac{4}{3}}}$$

Where, f is frequency, S(f) is the spectrum value at frequency f, U10 is the wind speed 10 m above ground level, and L is the characteristic length of turbulence.

Once the wind simulation is correct, the model, constructed to a suitable scale, is installed at the center of the working section of the wind tunnel. Different wind directions are represented by rotating the model to align with the wind tunnel center-line axis.



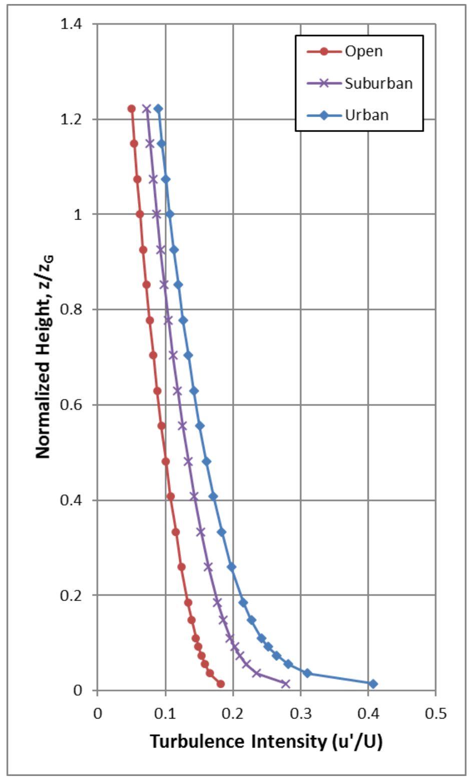


FIGURE C1 (LEFT): MEAN WIND SPEED PROFILES;
FIGURE C2 (RIGHT): TURBULENCE INTENSITY PROFILES

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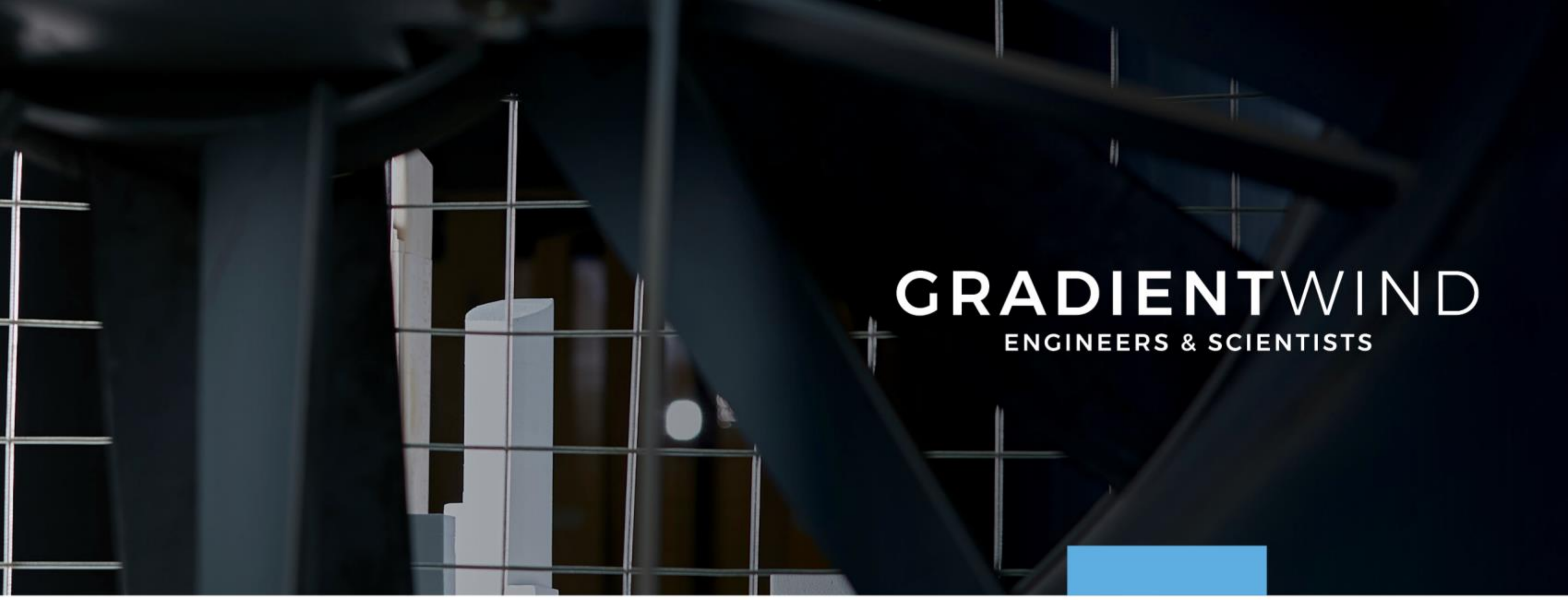

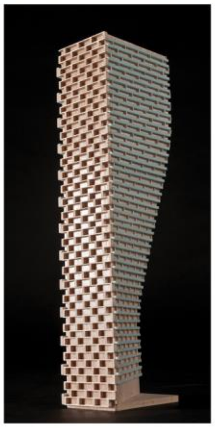

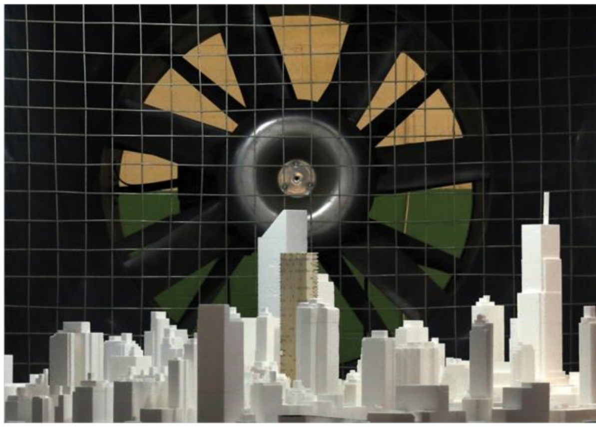

APPENDIX D

PEDESTRIAN LEVEL WIND MEASUREMENT METHODOLOGY

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PEDESTRIAN LEVEL WIND MEASUREMENT METHODOLOGY

Pedestrian level wind studies are performed in a wind tunnel on a physical model of the study buildings at a suitable scale. Instantaneous wind speed measurements are recorded at a model height corresponding to 1.5 m full scale using either a hot wire anemometer or a pressure-based transducer. Measurements are performed at any number of locations on the model and usually for 36 wind directions. For each wind direction, the roughness of the upwind terrain is matched in the wind tunnel to generate the correct mean and turbulent wind profiles approaching the model.

The hot wire anemometer is an instrument consisting of a thin metallic wire conducting an electric current. It is an omni-directional device equally sensitive to wind approaching from any direction in the horizontal plane. By compensating for the cooling effect of wind flowing over the wire, the associated electronics produce an analog voltage signal that can be calibrated against velocity of the air stream. For all measurements, the wire is oriented vertically so as to be sensitive to wind approaching from all directions in a horizontal plane.

The pressure sensor is a small cylindrical device that measures instantaneous pressure differences over a small area. The sensor is connected via tubing to a transducer that translates the pressure to a voltage signal that is recorded by computer. With appropriately designed tubing, the sensor is sensitive to a suitable range of fluctuating velocities.

For a given wind direction and location on the model, a time history of the wind speed is recorded for a period of time equal to one hour in full-scale. The analog signal produced by the hot wire or pressure sensor is digitized at a rate of 400 samples per second. A sample recording for several seconds is illustrated in Figure D1. This data is analyzed to extract the mean, root-mean-square (rms) and the peak of the signal. The peak value, or gust wind speed, is formed by averaging a number of peaks obtained from sub-intervals of the sampling period. The mean and gust speeds are then normalized by the wind tunnel gradient wind speed, which is the speed at the top of the model boundary layer, to obtain mean and gust ratios. At each location, the measurements are repeated for 36 wind directions to produce normalized polar plots, which will be provided upon request.

In order to determine the duration of various wind speeds at full scale for a given measurement location the gust ratios are combined with a statistical (mathematical) model of the wind climate for the project site. This mathematical model is based on hourly wind data obtained from one or more meteorological stations (usually airports) close to the project location. The probability model used to represent the data is the Weibull distribution expressed as:

$$P\left(>U_g\right) = A_\theta \bullet \exp\left[\left(-\frac{U_g}{C\theta}\right)^{K\theta}\right]$$

Where,

P (> U_g) is the probability, fraction of time, that the gradient wind speed ***U_g*** is exceeded; ***θ*** is the wind direction measured clockwise from true north, ***A***, ***C***, ***K*** are the Weibull coefficients, (Units: A - dimensionless, C - wind speed units [km/h] for instance, K - dimensionless). A_θ is the fraction of time wind blows from a 10° sector centered on ***θ***.

Analysis of the hourly wind data recorded for a length of time, on the order of 10 to 30 years, yields the A_θ, C_θ and K_θ values. The probability of exceeding a chosen wind speed level, say 20 km/h, at sensor *N* is given by the following expression:

$$P_N(>20) = \Sigma_\theta P\left[\frac{(>20)}{\left(\frac{U_N}{U_g}\right)}\right]$$

$$P_N\,(>20) \quad = \quad \Sigma_\theta P\,\{>20/(U_N/Ug)\}$$

Where, U_N/U_g is the gust velocity ratios, where the summation is taken over all 36 wind directions at 10° intervals.

If there are significant seasonal variations in the weather data, as determined by inspection of the $\boldsymbol{C_\theta}$ and $\boldsymbol{K_\theta}$ values, then the analysis is performed separately for two or more times corresponding to the groupings of seasonal wind data. Wind speed levels of interest for predicting pedestrian comfort are based on the comfort guidelines chosen to represent various pedestrian activity levels as discussed in the main text.

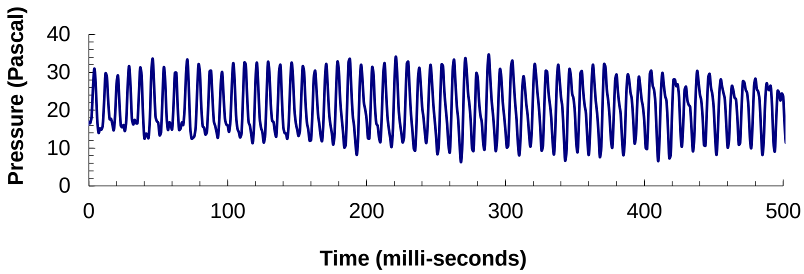

FIGURE D1: TIME VERSUS VELOCITY TRACE FOR A TYPICAL WIND SENSOR

REFERENCES

1. Davenport, A.G., '*The Dependence of Wind Loading on Meteorological Parameters*', Proc. of Int. Res. Seminar, Wind Effects on Buildings & Structures, NRC, Ottawa, 1967, University of Toronto Press.

2. Wu, S., Bose, N., 'An *Extended Power Law Model for the Calibration of Hot-wire/Hot-film Constant Temperature Probes*', Int. J. of Heat Mass Transfer, Vol.17, No.3, pp.437-442, Pergamon Press.