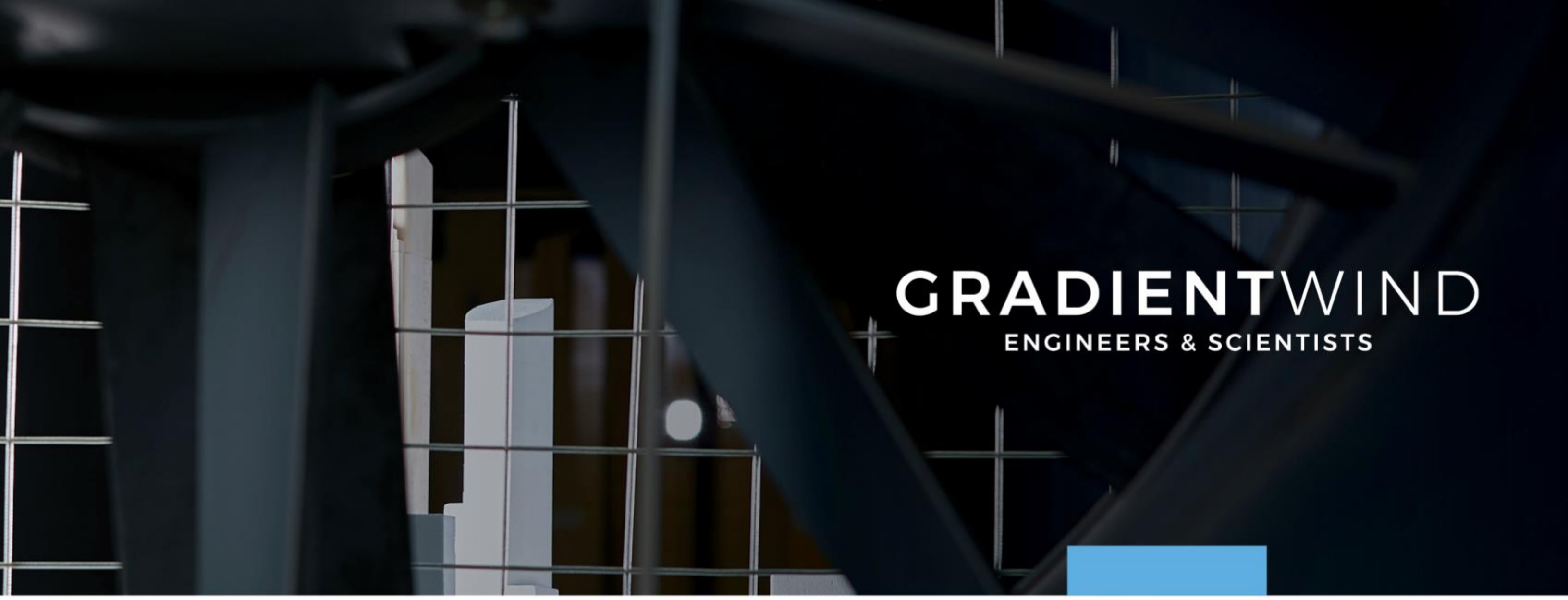
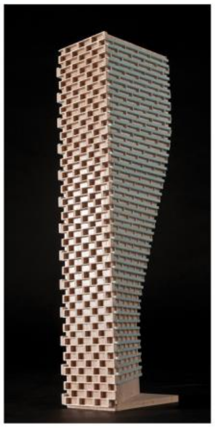
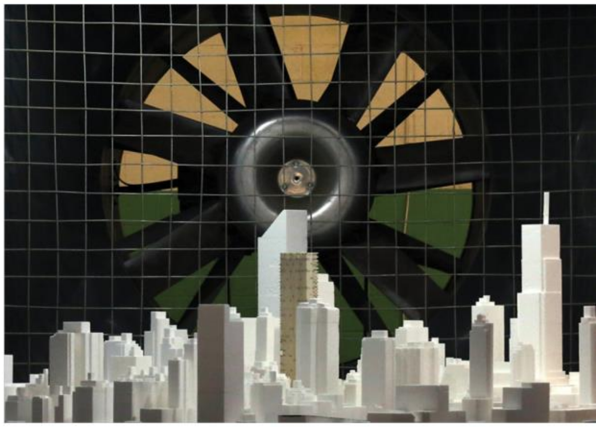


PEDESTRIAN LEVEL WIND STUDY

Building C
16 Elm Drive West
Mississauga, Ontario

REPORT: GW15-028-WTPLW 2019 Tower C





July 20, 2020

PREPARED FOR
Solmar (Edge3) Corp.
122 Romina Drive
Concord, ON L4K 4Z7
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PREPARED BY
Nick Petersen, B.Eng., EIT, Junior Wind Scientist
Andrew Sliasas, M.A.Sc., P.Eng., Principal

EXECUTIVE SUMMARY

This report describes a pedestrian level wind study undertaken for Building C of a planned mixed-use three-tower development located at the intersection of Elm Drive West and Hurontario Street in Mississauga, Ontario. 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 pedestrian areas investigated include nearby sidewalks and walkways, building access points, laneways, outdoor amenity areas, parks, transit stops, loading zones, and landscaped areas. Wind conditions were also measured over the Building C Levels 6 and 13 amenity terraces. The results and recommendations derived from these considerations are summarized in the following paragraphs and detailed in the subsequent report.

For a summary of the existing wind conditions over the site, as well as conditions for various interim phasing scenarios, refer to the following previously completed Gradient Wind reports: (i) GWE15-028-PLW Final R2, dated November 25, 2015, and (ii) Gradient Wind 15-028-PLW 2019, dated May 30, 2019.

Our work is based on industry standard wind tunnel testing and data analysis procedures, architectural drawings provided by r. Varacalli Architect Inc. in October 2019, surrounding street layouts and existing and approved future building massing information, as well as 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 2A – 5B, as well as Tables A1 - A3 in the appendices. Based on wind tunnel test results, meteorological data analysis, and experience with similar developments in Mississauga, we conclude that conditions over all pedestrian-sensitive areas within and surrounding the development site will be acceptable for the intended pedestrian uses on an annual and seasonal basis.

Regarding conditions over the Building C Levels 6 and 13 amenity terraces, appropriate wind mitigation, as detailed in Section 5.2, has been included in the design.

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 too windy for walking, or that could be considered unsafe.

TABLE OF CONTENTS

1. INTRODUCTION

This report describes a pedestrian level wind study undertaken to assess wind conditions for Building C of a proposed multi-tower development, referred to as Edge Towers, located at the intersection of Elm Drive West and Hurontario Street in Mississauga, Ontario. The study was performed in accordance with industry standard wind tunnel testing techniques, City of Mississauga wind criteria, architectural drawings provided by r. Varacalli Architect Inc. in October 2019 and updated in July 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 pedestrian wind study is Building C of the proposed three-building, mixed-use development located at the intersection of Elm Drive West and Hurontario Street in Mississauga, Ontario. The overall development site comprises the east portion of a parcel of land bounded by Hurontario Street to the East, Elm Drive West to the north, Kariya Drive to the west, and an access laneway to the south.

Upon completion, the proposed development will contain three tower phases in an east-west linear arrangement across the study site. Phase I, on the west portion of the development site, comprises a 35-storey plus mechanical penthouse tower (Building A) integral with a three-storey podium, rising to a total height of approximately 118 metres above local grade. Above four levels of below-grade parking, the ground floor will contain daycare/pre-school space, a lounge, a residential lobby, and building support functions. The second and third podium levels contain residential occupancy and various Building Amenities. The fourth level contains indoor amenity space, and an outdoor amenity terrace, as well as private terraces, on the podium roof where the floorplate steps back to the base of the tower. Above the fourth level, the fully-residential tower features multiple floorplate setbacks from the east elevation accommodating private terraces at Levels 25, 29, 35, and at the first mechanical level.

The Phase II tower (Building B) is situated immediately to the east of Phase I, and features a similar three-storey podium as Phase I. Above four levels of below-grade parking, the ground floor contains a residential lobby and Building Amenities. On the second and third levels, the floorplans comprise residential units with wraparound terraces along all elevations. On the fourth level, the podium steps back to the base of the Building to accommodate indoor and outdoor amenity space, as well as residential units with private terraces. Above the podium, the tower rises with uniform residential floorplates to Level 40, reaching a total height of approximately 134 metres above local grade.

Phase III (Building C) is located at the east side of the development site, and contains a 50-storey plus mechanical penthouse tower rising from the north side of a 12-storey stepped podium achieving a total height of approximately 176 metres above local grade. At grade, the podium is bisected in the east-west direction by a driveway and walkway. North of the driveway the podium features the main lobby and various building support functions, and south of the driveway the building is primarily occupied by loading and storage spaces. Retail units and an outdoor amenity area occupy the east elevation fronting Hurontario Street. Levels 2 to 5 comprise internal parking at the southwest corner and residential units elsewhere. At Level 6 the podium steps back from the west elevation accommodating indoor and outdoor amenity space, as well as additional residential units along the east elevation. Above Level 6 the podium rises with a uniform floorplate to Level 13 where the podium steps back from the south elevation to the base of the tower, accommodating additional outdoor and indoor amenity space. The remaining floors of the tower above Level 13 comprise residential occupancy up to a mechanical penthouse.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within a 200-metre (m) radius from the subject site) are characterized by a moderately dense concentration of high-rise buildings in all directions. Near-field buildings include two 29-storey buildings at 33 Elm Dr. West to the north of the site, a 23-storey Building At 55 Elm Dr. West to the northwest, and a 31-, 32-, and 33-storey Building At 3525 Kariya Dr., 3515 Kariya Dr., and 3504 Hurontario Street, respectively, to the southeast. Beyond the near-field, the surroundings are generally characterized as a low-rise suburban exposure with clusters of high-rise developments in the north and west quadrants.

Grade-level areas investigated include sidewalks and walkways, building access points, laneways, outdoor amenity areas, parks, transit stops, loading zones, and landscaped areas. Wind conditions were also measured over the Building C Levels 6 and 13 amenity terraces. Figure 1 illustrates the study site and surrounding context, and Photographs 1 through 4 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; and (iii) recommend suitable mitigation measures, where required.

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 Mississauga 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 4 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 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.

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

4.2 Wind Speed Measurements

The PLW study was performed by testing a total of 89 sensor locations on the scale model in Gradient Wind's wind tunnel. Of the 89 sensors, 81 were placed at grade level, with the remaining eight on the Level 6 and 13 amenity terraces. Wind speed measurements were performed for each of the sensors 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 2A through 5B.

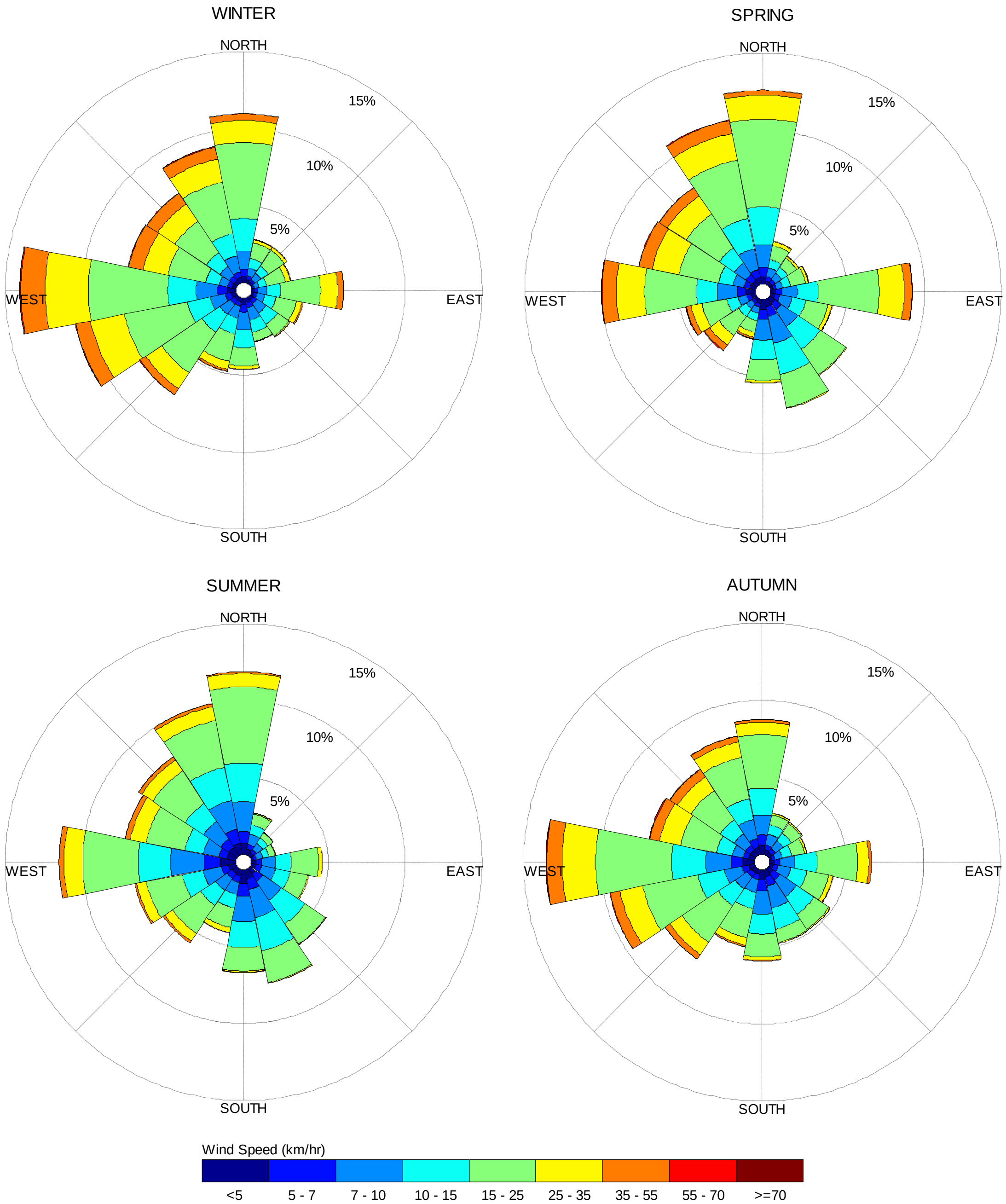
Mean and peak wind speed values for each location and wind direction were calculated from real-time pressure measurements, recorded at a sample rate of 500 samples per second, and taken over a 60-second time period. This period at model-scale corresponds approximately to one hour in full-scale, which 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 B and C 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 2015 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 Toronto, representative of the Mississauga area, was developed from approximately 40-years of hourly meteorological wind data recorded at Pearson International Airport, and obtained from the local branch of Atmospheric Environment Services of Environment 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 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, the most common winds concerning pedestrian comfort occur from the southwest clockwise to the north, as well as those from the east. 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 WINDS FOR VARIOUS PROBABILITIES
PEARSON INTERNATIONAL AIRPORT, MISSISSAUGA, 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. 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[1]. 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 at a location 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 across the study site, 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. 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

Tables A1 through A3 in Appendix A provide a summary of seasonal comfort predictions for each sensor location under the full site build out massing scenario. 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.). Sensor locations with a predicted comfort class that is windier than the desired comfort class for that location type are highlighted in red.

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 2A through 5B. Conditions suitable for sitting are represented by the colour green, while standing is represented by yellow, and walking by blue. 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

Based on the analysis of the measured data, consideration of local climate data, and the suitability descriptors provided in Tables A1-A3 in Appendix A, this section summarizes the most significant findings of the PLW study, as follows:

1. All surrounding public sidewalks along Elm Drive West and Hurontario Street, as well as all walkways and laneways within the development site, will experience wind conditions suitable for standing or better during the summer months, and for walking or better throughout the remaining seasonal periods, which is acceptable for the intended uses of the spaces.
2. All primary retail entrances along the east elevation of Building C (Sensors 72 – 75) will be calm and comfortable for standing or better on a seasonal basis, which is acceptable.

3. The main lobby entrance on the west elevation of Building C (Sensor 67) will experience wind conditions suitable for walking during the spring, autumn and winter months. To ensure safe door operability and door hardware longevity, the entrance has been recessed behind the main building façade.

4. All secondary building access points will be comfortable for walking or better on a seasonal basis, which is considered appropriate.

5. Wind conditions at the loading area along the south elevation of Building C (Sensors 78 and 79) and nearby transit stops (Sensors 8, 17, and 22) will generally be comfortable for standing or better throughout the year, which is considered appropriate.

6. The various grade-level outdoor amenity areas situated along the southeast side of the study site (Sensors 42 – 51) will experience wind conditions suitable for standing or better during the summer and for walking or better throughout the rest of the year. For all designated seating areas within these amenity spaces, targeted wind barriers measuring at least 1.8-metres-tall to the north and west of such areas, will improve pedestrian comfort.

   Under the tested building configuration, the outdoor amenity space at the east side of the Building C podium (Sensor 64) experienced windy conditions suitable for standing or walking throughout year, resulting from salient northerly winds channeling through the corridor. To reduce wind flows through the space, vertical wind screening measuring 2.4 metres above the walking surface has been included at the west side of the amenity space.

7. The proposed park space to the southwest of the development (Sensors 25 – 29), will generally experience wind conditions suitable for sitting during the summer months, becoming generally comfortable for standing throughout the remaining seasonal periods, with the standing criterion being marginally exceeded along the southeast side of the park (Sensor 27) during the winter months. The noted conditions are considered acceptable.

8. The proposed outdoor daycare space along the south elevation of Building A (Sensor 41) is well-sheltered by the included wind screen and will be calm and suitable for sitting or more sedentary activities throughout the spring, summer, and autumn, which is appropriate.

9. Under the tested configuration, the Level 6 amenity terrace along the west elevation of Building C (Sensors 82 – 86) was found to be suitable for standing during the three warmer seasons. To

ensure wind conditions comfortable for sitting or more sedentary activities are experienced throughout the typical use period of late spring to early autumn, the terrace perimeter guards have been raised to 2.0 metres above the walking surface along the north and west elevations. As well, 3.0-metre-deep canopy has been added along the west elevation of the tower to deflect downwash flows.

10. As tested, the Level 13 terrace space (Sensors 87 – 89) was found to be comfortable for sitting during the summer months and for standing or better throughout the spring and autumn, with marginally windier conditions occurring towards the centre of the terrace. To improve wind comfort, 2.0-metre-tall vertical wind barriers have been installed along the east and west perimeters of the terrace.

11. 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 uncomfortable for walking or unsafe.

6. CONCLUSIONS AND RECOMMENDATIONS

This report summarizes the methodology, results, and recommendations related to a pedestrian level wind study for Building C of a planned mixed-use three-tower development located at the intersection of Elm Drive West and Hurontario Street in Mississauga, Ontario. The study was performed in accordance with industry standard wind tunnel testing and data analysis procedures.

For a summary of the existing wind conditions over the site, as well as conditions for various interim phasing scenarios, refer to the following previously completed Gradient Wind reports: (i) GWE15-028-PLW Final R2, dated November 25, 2015, and (ii) Gradient Wind 15-028-PLW 2019, dated May 30, 2019.

A complete summary of the predicted wind conditions is provided in Section 5.2 of this report, and is also illustrated in Figures 2A – 5B, as well as Tables A1 - A3 in the appendices. Based on wind tunnel test results, meteorological data analysis, and experience with similar developments in Mississauga, we conclude that conditions over all pedestrian-sensitive areas within and surrounding the development site will be acceptable for the intended pedestrian uses on an annual and seasonal basis.

Regarding conditions over the Building C Levels 6 and 13 amenity terraces, appropriate wind mitigation, as detailed in Section 5.2, has been included in the design.

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 too windy for walking, or 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.

Nick Petersen, B.Eng., EIT,
Junior Wind Scientist

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

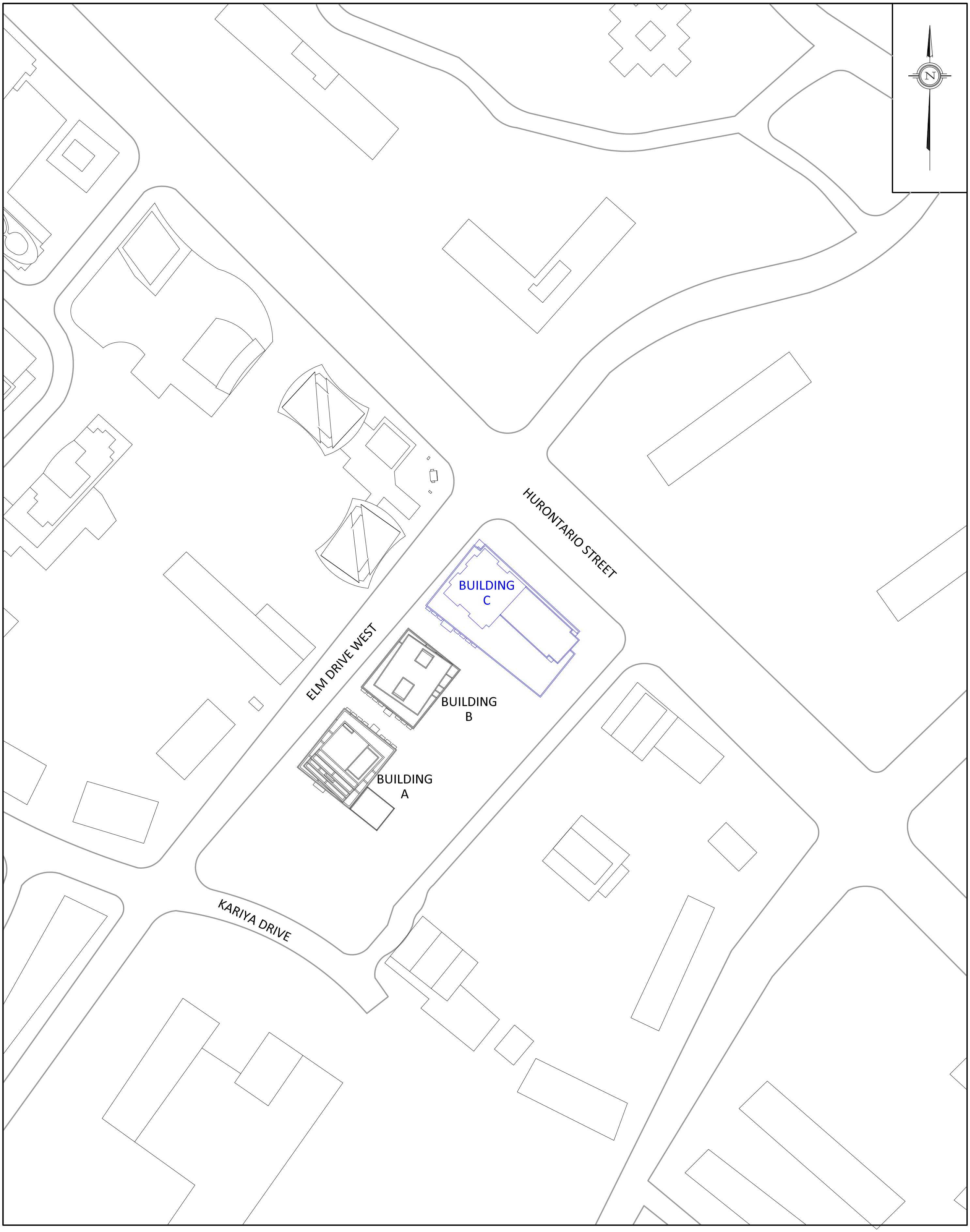
GW15-028-WTPLW 2019 Tower C

PHOTOGRAPH 1: STUDY MODEL INSIDE THE GWE WIND TUNNEL LOOKING DOWNWIND

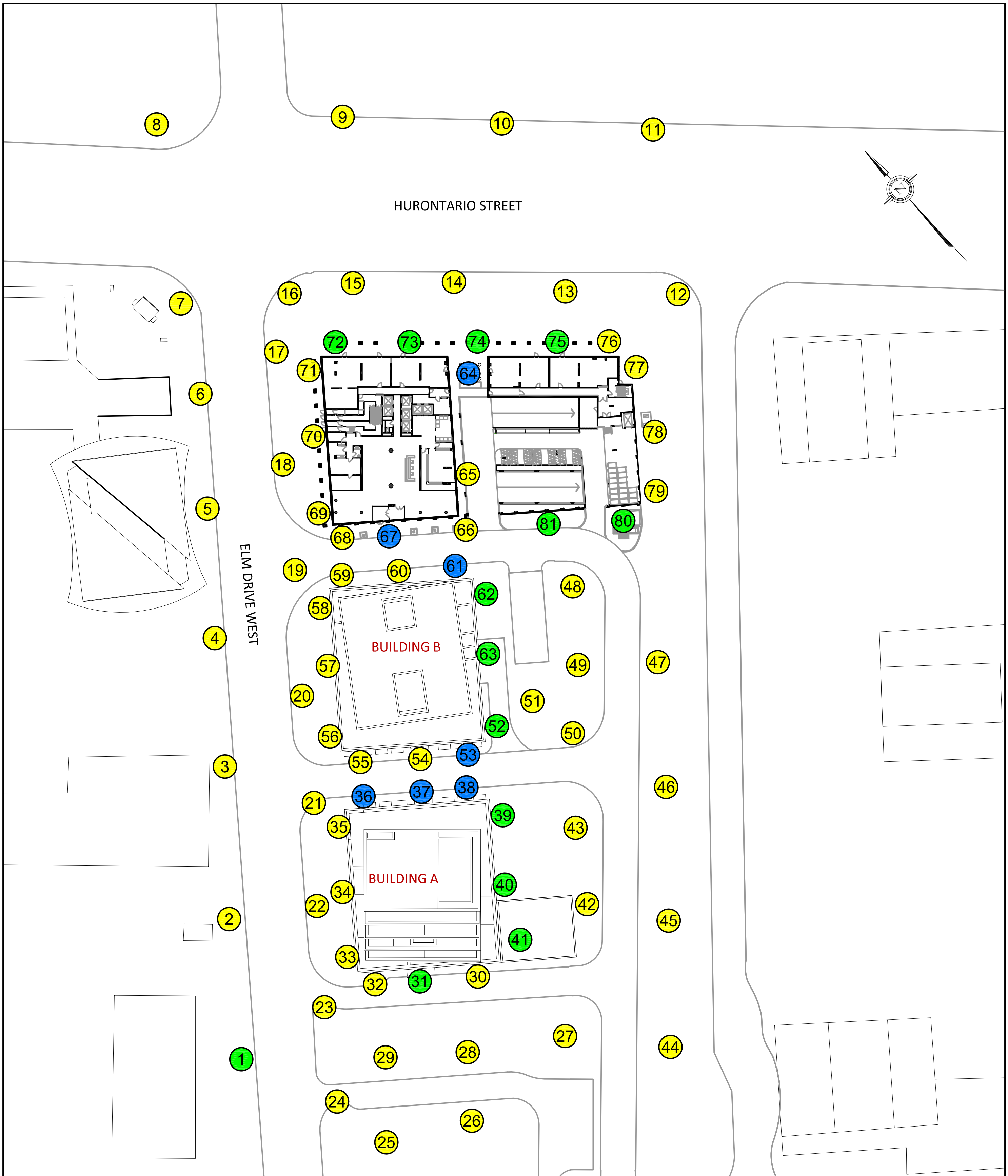
PHOTOGRAPH 2: STUDY MODEL INSIDE THE GWE WIND TUNNEL LOOKING UPWIND

PHOTOGRAPH 3: CLOSE-UP VIEW OF STUDY MODEL LOOKING EAST

PHOTOGRAPH 4: CLOSE-UP VIEW OF STUDY MODEL LOOKING NORTH



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD , OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT: TOWER C - ELM & HURONTARIO, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT
	SCALE: 1:2500 (APPROX.)	DRAWING NO.: GWE15-028-PLW-1	
	DATE: OCTOBER 25, 2019	DRAWN BY: C.E.	



PREDICTED COMFORT CLASSES

- # SITTING
- # STANDING
- # WALKING

NOTES:

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

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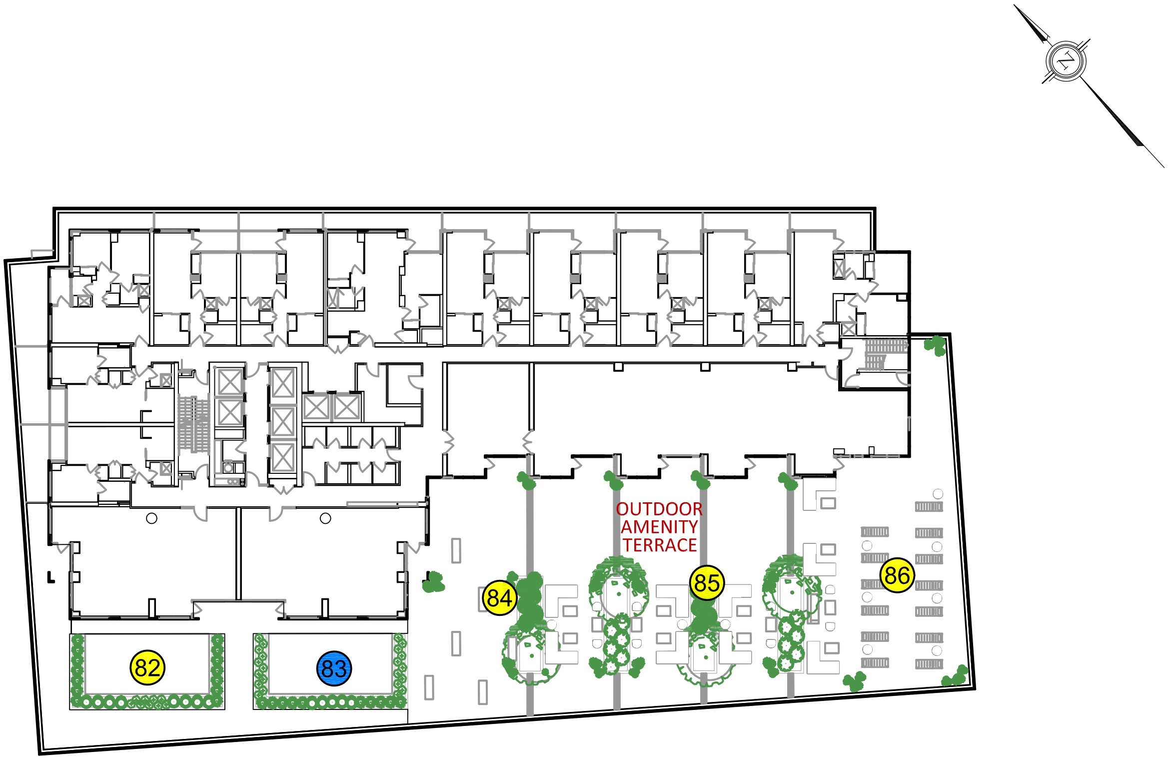
PROJECT	TOWER C - ELM & HURONTARIO, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:1200 (APPROX.)	DRAWING NO.	GWE15-028-PLW-2A
DATE	OCTOBER 25, 2019	DRAWN BY	C.E.

DESCRIPTION

FIGURE 2A: SPRING
GROUND FLOOR PLAN
PEDESTRIAN COMFORT PREDICTIONS



6th FLOOR PLAN

13th FLOOR PLAN

PREDICTED COMFORT CLASSES	
# (green)	SITTING
# (yellow)	STANDING
# (blue)	WALKING

NOTES:

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

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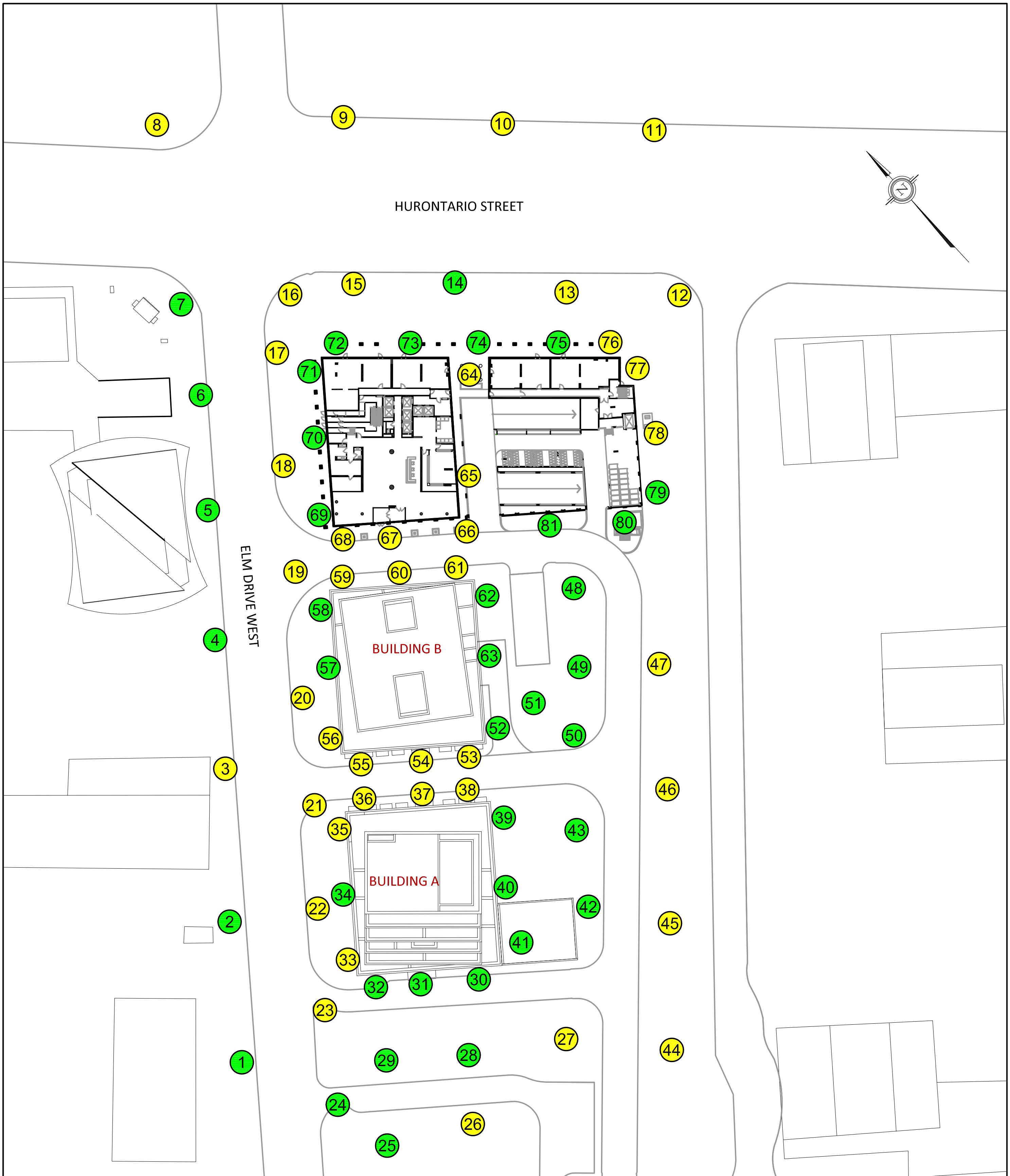
PROJECT	TOWER C - ELM & HURONTARIO, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:600 (APPROX.)	DRAWING NO.	GWE15-028-PLW-2B
DATE	OCTOBER 25, 2019	DRAWN BY	C.E.

DESCRIPTION

FIGURE 2B: SPRING
LEVEL 6 & 13 AMENITY
PEDESTRIAN COMFORT PREDICTIONS



NOTES:

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

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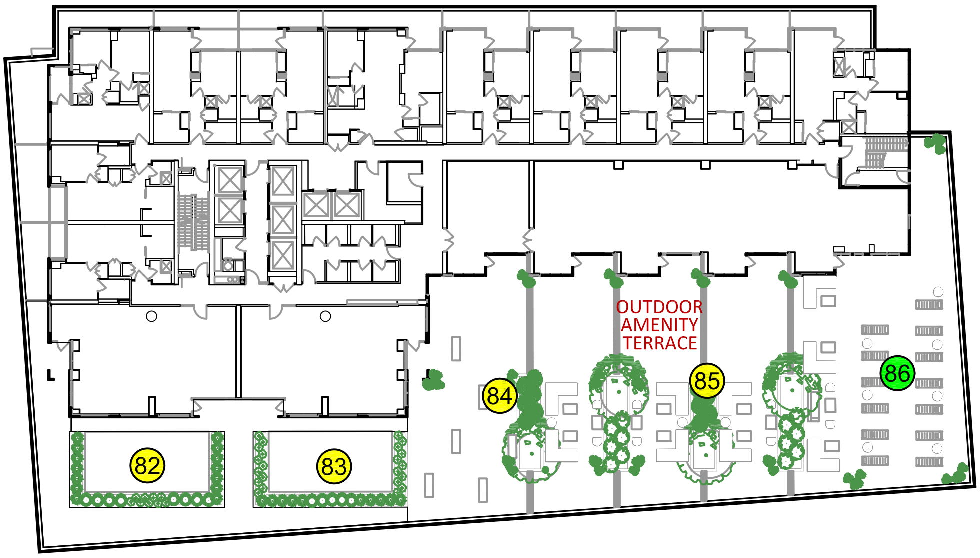
PROJECT: TOWER C - ELM & HURONTARIO, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 3A: SUMMER GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:1200 (APPROX.)	DRAWING NO.: GWE15-028-PLW-3A	
DATE: OCTOBER 25, 2019	DRAWN BY: C.E.	



6th FLOOR PLAN

13th FLOOR PLAN

PREDICTED COMFORT CLASSES	
#	SITTING
#	STANDING
#	WALKING

NOTES:

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

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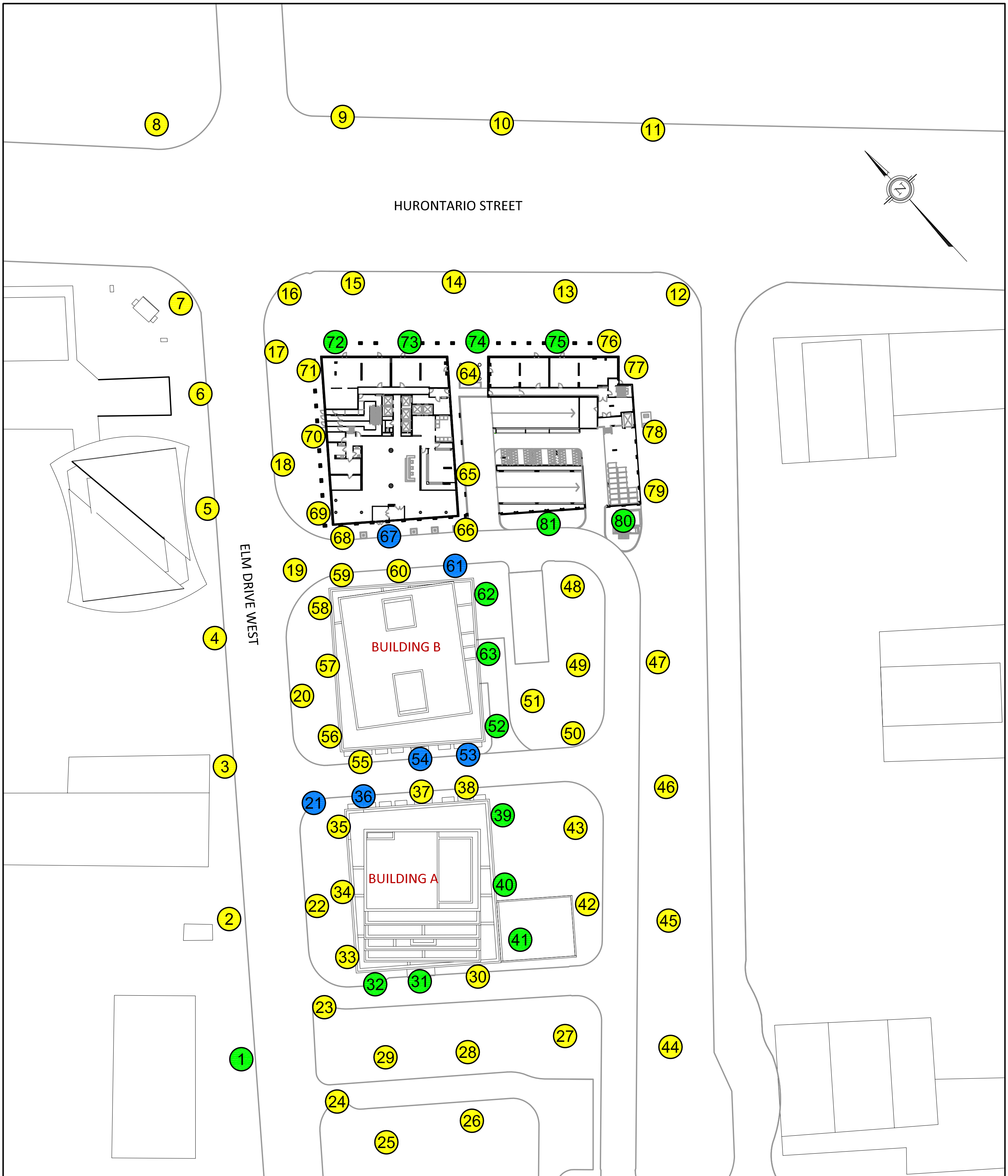
613 836 0934 • GRADIENTWIND.COM

PROJECT	TOWER C - ELM & HURONTARIO, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:600 (APPROX.)
DRAWING NO.	GWE15-028-PLW-3B
DATE	OCTOBER 25, 2019
DRAWN BY	C.E.
DESCRIPTION	FIGURE 3B: SUMMER LEVEL 6 & 13 AMENITY PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CLASSES	
(#) green	SITTING
(#) yellow	STANDING
(#) blue	WALKING

NOTES:

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

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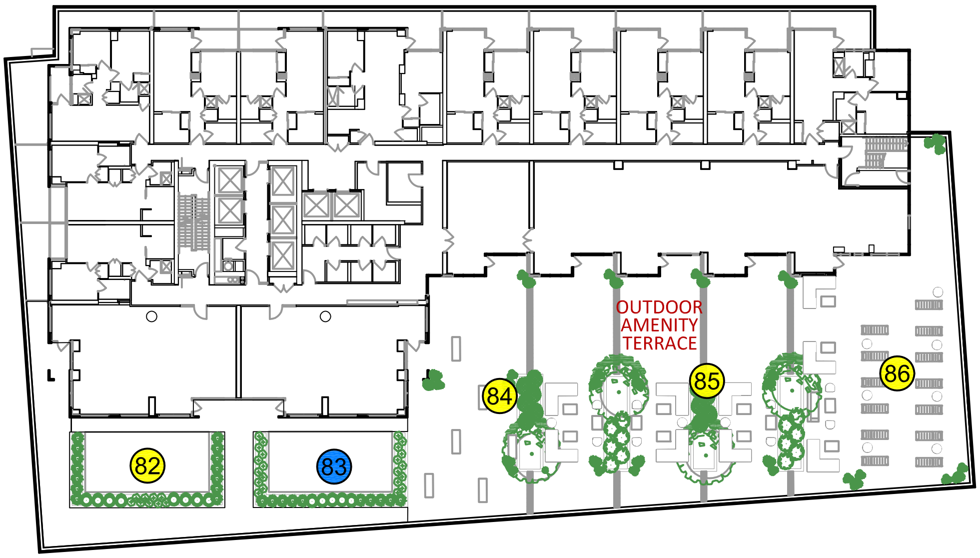
PROJECT	TOWER C - ELM & HURONTARIO, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:1200 (APPROX.)	DRAWING NO.	GWE15-028-PLW-4A
DATE	OCTOBER 25, 2019	DRAWN BY	C.E.

DESCRIPTION

FIGURE 4A: AUTUMN
GROUND FLOOR PLAN
PEDESTRIAN COMFORT PREDICTIONS



6th FLOOR PLAN

13th FLOOR PLAN

PREDICTED COMFORT CLASSES	
#	SITTING
#	STANDING
#	WALKING

NOTES:

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

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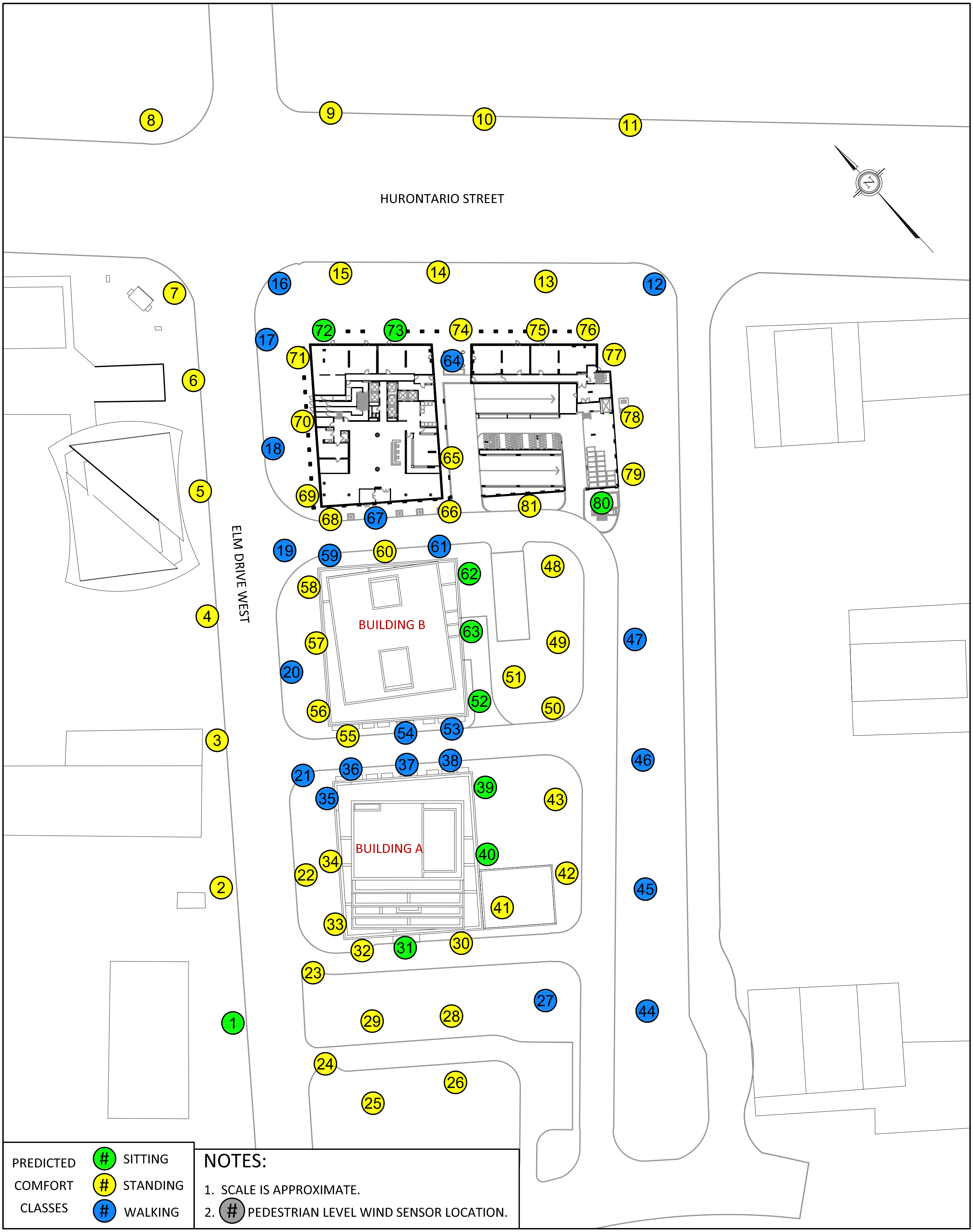
PROJECT	TOWER C - ELM & HURONTARIO, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:600 (APPROX.)	DRAWING NO.	GWE15-028-PLW-4B
DATE	OCTOBER 25, 2019	DRAWN BY	C.E.

DESCRIPTION

FIGURE 4B: AUTUMN
LEVEL 6 & 13 AMENITY
PEDESTRIAN COMFORT PREDICTIONS



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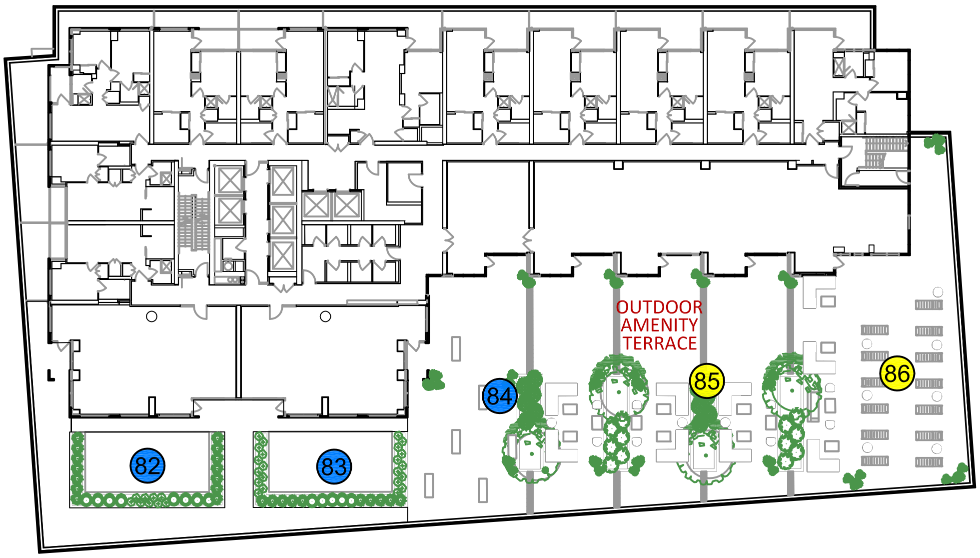
SCALE	1:1200 (APPROX.)
DRAWING NO.	GWE15-028-PLW-5A
DATE	OCTOBER 25, 2019
DRAWN BY	C.E.
DESCRIPTION	FIGURE 5A: WINTER GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS



6th FLOOR PLAN

13th FLOOR PLAN

PREDICTED COMFORT CLASSES	
# (green)	SITTING
# (yellow)	STANDING
# (blue)	WALKING

NOTES:

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

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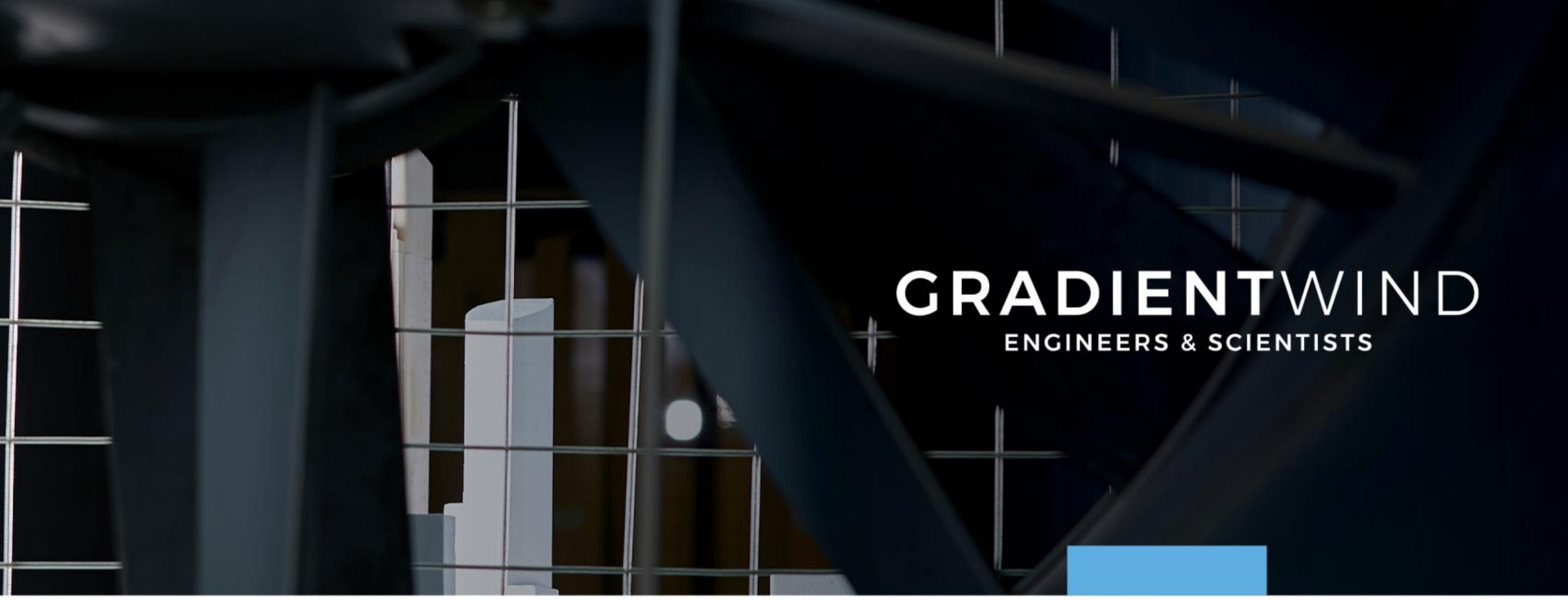
SCALE	1:600 (APPROX.)	DRAWING NO.	GWE15-028-PLW-5B
DATE	OCTOBER 25, 2019	DRAWN BY	C.E.

DESCRIPTION

FIGURE 5B: WINTER
LEVEL 6 & 13 AMENITY
PEDESTRIAN COMFORT PREDICTIONS



APPENDIX A

PEDESTRIAN COMFORT SUITABILITY, TABLES A1-A3

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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

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	9.8	Sitting	7.8	Sitting	8.7	Sitting	9.9	Sitting	40.9	Safe
2	12.0	Standing	9.6	Sitting	11.4	Standing	12.9	Standing	51.4	Safe
3	12.1	Standing	10.1	Standing	11.2	Standing	12.7	Standing	49.2	Safe
4	11.7	Standing	9.3	Sitting	11.2	Standing	12.5	Standing	53.8	Safe
5	11.8	Standing	9.7	Sitting	11.0	Standing	12.5	Standing	49.8	Safe
6	11.2	Standing	9.3	Sitting	10.5	Standing	11.7	Standing	43.8	Safe
7	11.6	Standing	9.5	Sitting	10.8	Standing	12.1	Standing	47.3	Safe
8	13.9	Standing	11.0	Standing	11.9	Standing	13.3	Standing	57.7	Safe
9	13.5	Standing	11.2	Standing	12.3	Standing	13.9	Standing	50.3	Safe
10	14.2	Standing	11.8	Standing	12.7	Standing	14.2	Standing	51.9	Safe
11	12.3	Standing	10.4	Standing	11.5	Standing	12.9	Standing	49.1	Safe
12	12.7	Standing	10.7	Standing	13.1	Standing	15.0	Walking	61.9	Safe
13	12.6	Standing	10.6	Standing	11.4	Standing	12.8	Standing	51.7	Safe
14	12.1	Standing	9.7	Sitting	11.2	Standing	12.7	Standing	51.2	Safe
15	13.3	Standing	10.6	Standing	12.8	Standing	14.7	Standing	55.4	Safe
16	13.5	Standing	10.8	Standing	13.3	Standing	15.2	Walking	54.2	Safe
17	14.1	Standing	11.0	Standing	13.6	Standing	15.9	Walking	57.2	Safe
18	14.6	Standing	12.3	Standing	14.3	Standing	16.4	Walking	59.0	Safe
19	14.2	Standing	11.8	Standing	14.2	Standing	16.2	Walking	58.9	Safe
20	13.5	Standing	11.2	Standing	12.9	Standing	15.0	Walking	59.7	Safe
21	15.0	Standing	12.3	Standing	15.0	Walking	17.4	Walking	63.7	Safe
22	13.7	Standing	10.7	Standing	12.5	Standing	14.3	Standing	54.4	Safe
23	12.4	Standing	10.2	Standing	10.9	Standing	12.3	Standing	46.0	Safe
24	12.1	Standing	9.7	Sitting	10.6	Standing	11.8	Standing	48.6	Safe
25	12.5	Standing	9.9	Sitting	11.2	Standing	12.8	Standing	47.6	Safe
26	13.9	Standing	10.6	Standing	12.5	Standing	14.3	Standing	54.9	Safe
27	14.8	Standing	11.7	Standing	14.7	Standing	16.7	Walking	56.3	Safe
28	13.0	Standing	10.0	Sitting	11.8	Standing	13.4	Standing	53.3	Safe
29	12.1	Standing	9.6	Sitting	10.7	Standing	11.9	Standing	47.9	Safe
30	10.5	Standing	9.0	Sitting	10.9	Standing	12.6	Standing	52.2	Safe
31	8.6	Sitting	7.1	Sitting	8.1	Sitting	9.1	Sitting	39.2	Safe
32	10.8	Standing	8.6	Sitting	9.7	Sitting	10.8	Standing	61.1	Safe
33	12.8	Standing	10.1	Standing	11.5	Standing	13.1	Standing	51.2	Safe
34	12.2	Standing	9.7	Sitting	11.2	Standing	12.9	Standing	47.7	Safe
35	12.4	Standing	10.5	Standing	13.3	Standing	15.5	Walking	61.9	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

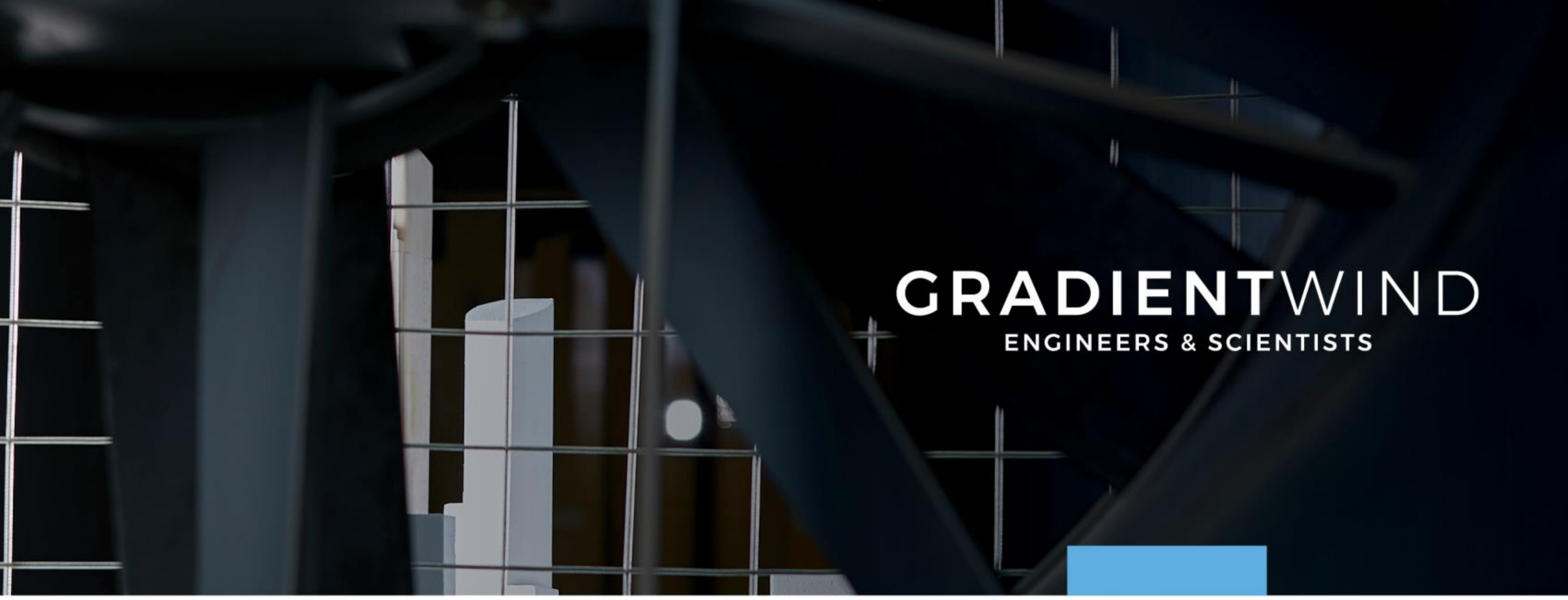
TABLE A2: SUMMARY OF PEDESTRIAN COMFORT

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	15.6	Walking	12.4	Standing	15.2	Walking	17.8	Walking	66.5	Safe
37	17.0	Walking	12.9	Standing	14.5	Standing	16.7	Walking	59.9	Safe
38	15.8	Walking	12.7	Standing	14.2	Standing	16.0	Walking	56.4	Safe
39	8.3	Sitting	6.9	Sitting	8.1	Sitting	9.2	Sitting	37.3	Safe
40	8.0	Sitting	6.5	Sitting	7.9	Sitting	8.9	Sitting	33.7	Safe
41	9.1	Sitting	7.4	Sitting	8.9	Sitting	10.0	Standing	40.5	Safe
42	11.4	Standing	9.3	Sitting	11.9	Standing	13.6	Standing	57.0	Safe
43	10.8	Standing	8.7	Sitting	10.7	Standing	12.3	Standing	48.3	Safe
44	14.4	Standing	11.3	Standing	13.7	Standing	15.5	Walking	60.6	Safe
45	13.3	Standing	11.2	Standing	14.9	Standing	17.5	Walking	65.4	Safe
46	12.8	Standing	10.7	Standing	13.3	Standing	15.2	Walking	60.2	Safe
47	13.0	Standing	10.6	Standing	13.3	Standing	15.4	Walking	61.8	Safe
48	11.1	Standing	8.9	Sitting	10.5	Standing	12.2	Standing	49.8	Safe
49	11.4	Standing	9.3	Sitting	11.5	Standing	13.2	Standing	57.5	Safe
50	11.9	Standing	9.6	Sitting	12.0	Standing	13.7	Standing	56.5	Safe
51	10.7	Standing	8.6	Sitting	10.3	Standing	12.1	Standing	54.6	Safe
52	8.7	Sitting	6.9	Sitting	8.0	Sitting	9.0	Sitting	37.3	Safe
53	16.1	Walking	13.4	Standing	16.1	Walking	18.2	Walking	65.0	Safe
54	14.7	Standing	13.3	Standing	16.9	Walking	19.4	Walking	80.7	Safe
55	13.1	Standing	11.2	Standing	13.3	Standing	14.9	Standing	54.0	Safe
56	12.7	Standing	10.6	Standing	12.1	Standing	14.2	Standing	56.4	Safe
57	10.8	Standing	8.8	Sitting	10.8	Standing	12.5	Standing	53.3	Safe
58	12.2	Standing	9.7	Sitting	12.4	Standing	14.6	Standing	63.6	Safe
59	14.9	Standing	12.1	Standing	14.5	Standing	17.0	Walking	63.1	Safe
60	13.9	Standing	11.4	Standing	12.6	Standing	14.5	Standing	57.3	Safe
61	17.0	Walking	14.3	Standing	15.7	Walking	17.0	Walking	59.5	Safe
62	8.2	Sitting	6.9	Sitting	7.9	Sitting	8.9	Sitting	38.1	Safe
63	8.4	Sitting	6.8	Sitting	8.0	Sitting	9.3	Sitting	36.5	Safe
64	15.5	Walking	12.5	Standing	13.1	Standing	15.1	Walking	60.3	Safe
65	12.7	Standing	10.5	Standing	11.0	Standing	12.6	Standing	45.8	Safe
66	13.0	Standing	11.2	Standing	13.3	Standing	14.7	Standing	58.2	Safe
67	16.5	Walking	14.7	Standing	17.3	Walking	19.2	Walking	73.2	Safe
68	13.4	Standing	11.5	Standing	13.2	Standing	14.5	Standing	52.6	Safe
69	11.7	Standing	9.5	Sitting	11.1	Standing	13.1	Standing	53.2	Safe
70	10.6	Standing	8.6	Sitting	10.7	Standing	12.7	Standing	52.1	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 A3: SUMMARY OF PEDESTRIAN COMFORT

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
71	10.9	Standing	9.0	Sitting	11.1	Standing	12.9	Standing	54.3	Safe
72	9.9	Sitting	7.4	Sitting	8.7	Sitting	9.9	Sitting	44.8	Safe
73	9.1	Sitting	7.3	Sitting	8.3	Sitting	9.6	Sitting	45.5	Safe
74	10.0	Sitting	8.4	Sitting	9.4	Sitting	10.5	Standing	42.6	Safe
75	9.5	Sitting	7.7	Sitting	8.6	Sitting	10.1	Standing	45.0	Safe
76	12.9	Standing	10.7	Standing	11.0	Standing	12.4	Standing	49.2	Safe
77	14.2	Standing	12.0	Standing	12.8	Standing	14.4	Standing	55.4	Safe
78	12.1	Standing	10.3	Standing	12.1	Standing	13.5	Standing	54.6	Safe
79	11.6	Standing	9.7	Sitting	12.4	Standing	14.1	Standing	60.2	Safe
80	8.4	Sitting	7.2	Sitting	8.5	Sitting	9.6	Sitting	46.0	Safe
81	9.2	Sitting	7.6	Sitting	9.5	Sitting	11.0	Standing	51.4	Safe
82	14.4	Standing	12.4	Standing	13.5	Standing	15.3	Walking	73.1	Safe
83	17.4	Walking	14.8	Standing	17.1	Walking	19.5	Walking	74.1	Safe
84	13.6	Standing	11.6	Standing	14.1	Standing	15.8	Walking	74.5	Safe
85	12.4	Standing	10.7	Standing	12.8	Standing	14.4	Standing	61.1	Safe
86	11.3	Standing	9.4	Sitting	11.5	Standing	13.1	Standing	56.7	Safe
87	10.1	Standing	8.2	Sitting	9.3	Sitting	10.7	Standing	45.2	Safe
88	14.9	Standing	11.8	Standing	13.1	Standing	15.3	Walking	71.1	Safe
89	11.9	Standing	9.7	Sitting	10.9	Standing	12.4	Standing	53.5	Safe



APPENDIX B

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; U = mean wind speed, U_g = gradient wind speed, Z = height above ground, 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 B2 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.

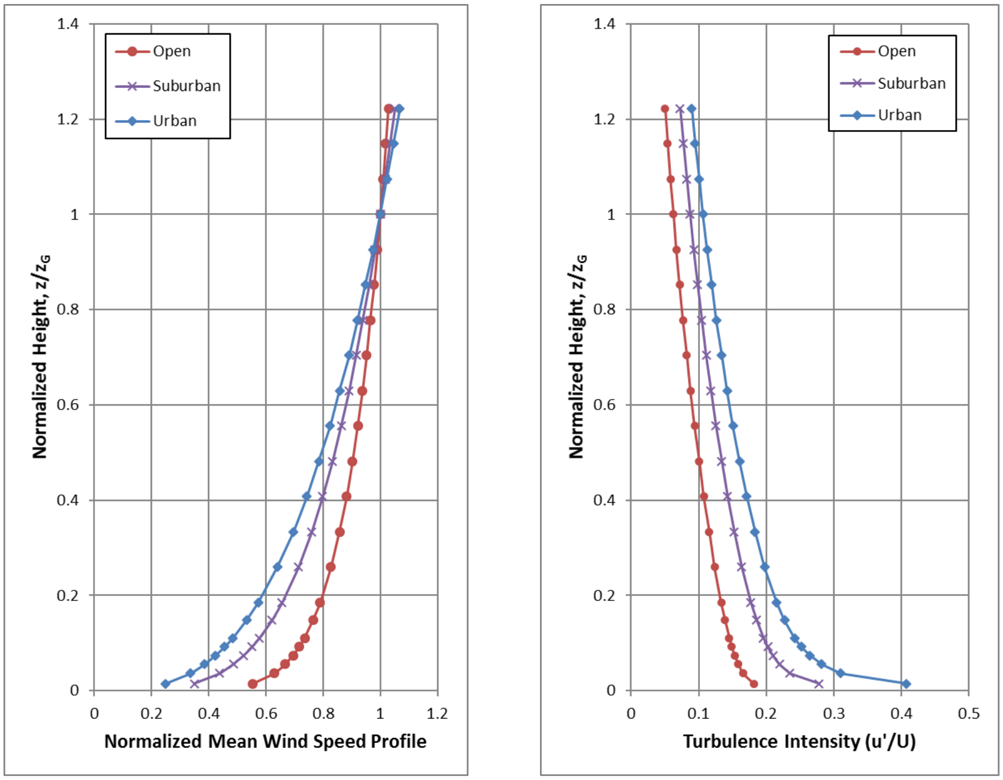

FIGURE B1 (LEFT): MEAN WIND SPEED PROFILES;
FIGURE B2 (RIGHT): TURBULENCE INTENSITY PROFILES

REFERENCES

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APPENDIX C

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 B1. 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 C_θ and K_θ 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.

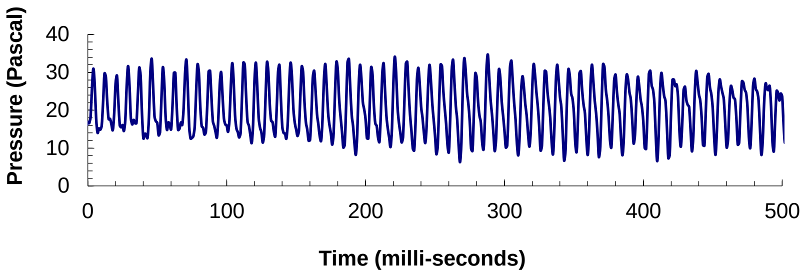

FIGURE C1: TIME VERSUS VELOCITY TRACE FOR A TYPICAL WIND SENSOR

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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.