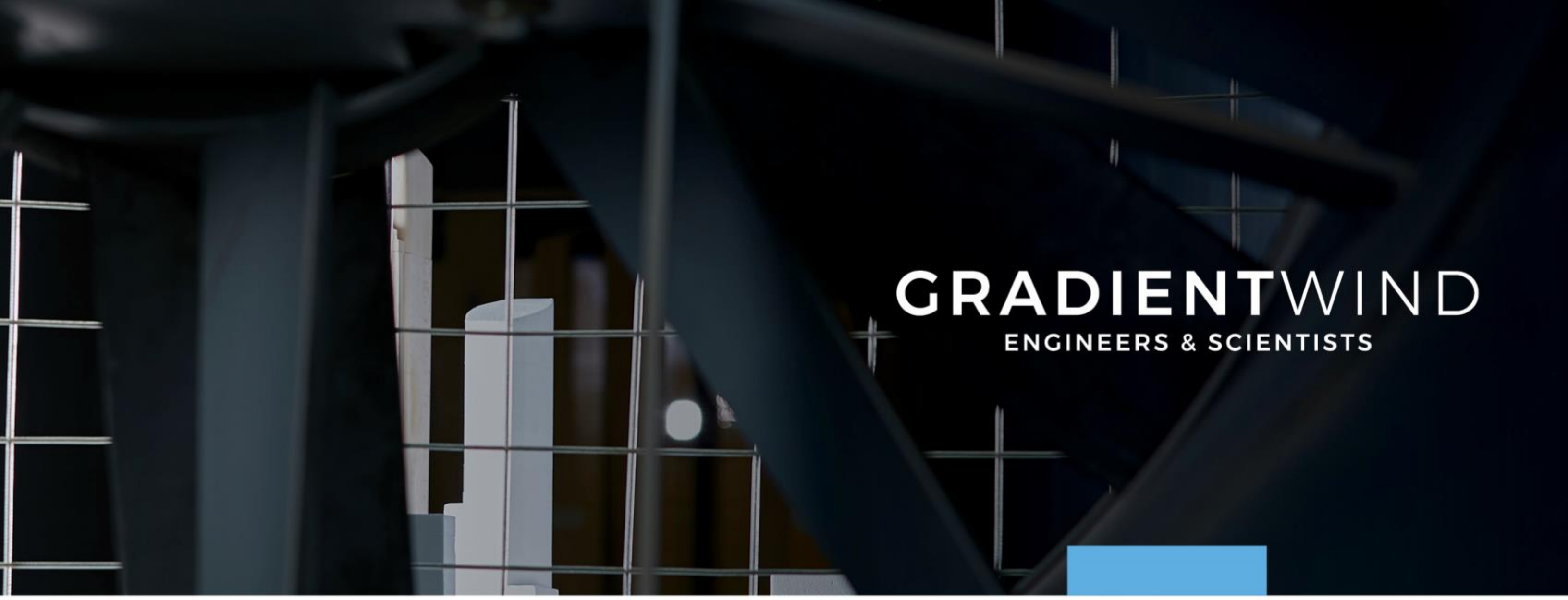
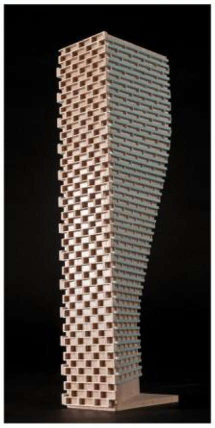
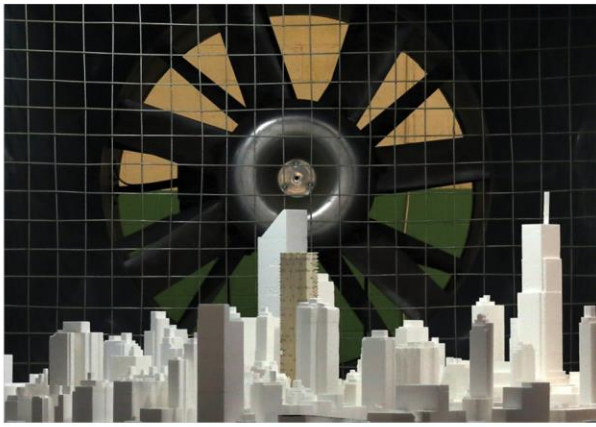


PEDESTRIAN LEVEL WIND STUDY

170 Slater Street
Ottawa, Ontario

REPORT: GW23-126-WTPLW





June 16, 2023

PREPARED FOR
GWL Realty Advisors
Suite 1000, 33 Yonge Street
Toronto, ON
M5E 1G4

PREPARED BY
Logan McFadden, B.Eng., Junior Wind Scientist
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Andrew Sliasas, M.A.Sc., P.Eng., Principal

EXECUTIVE SUMMARY

This report describes a pedestrian level wind study undertaken to assess wind conditions for a proposed mixed-use development located at 170 Slater Street in Ottawa, 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 areas investigated include sidewalks, laneways, parking areas, landscaped spaces, nearby patios and parkettes, and building access points. Wind comfort is also evaluated over the Level 2 and 8 outdoor amenity terraces. 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 NEUF Architect(e)s in May 2023, 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-4D Tables A1-A2 in Appendix A, and Tables B1-B2 in Appendix B. Based on wind tunnel test results, meteorological data analysis, and experience with similar developments in Ottawa, we conclude that wind conditions over all pedestrian sensitive grade-level locations within and surrounding the study site will be acceptable for the intended uses on a seasonal basis.

Wind conditions over the Level 2 and Level 8 outdoor amenity terraces will be comfortable for sitting or more sedentary activities throughout the year without the need for mitigation.

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.

GRADIENTWIND
ENGINEERS & SCIENTISTS

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by GWL Realty Advisors to undertake a pedestrian level wind study for a proposed mixed-use development located at 170 Slater Street in Ottawa, Ontario. The study was performed in accordance with industry standard wind tunnel testing techniques, architectural drawings provided by NEUF Architect(e)s in May 2023, 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 detailed pedestrian level wind study is 170 Slater Street, a mixed-use development located centrally on a city block bounded by Bank Street to the west, Slater Street to the north, O'Connor Street to the east, and Laurier Avenue West to the south.

The proposed development comprises of a 25-storey and a 26-storey residential tower oriented north-south, respectively, on a shared 7-storey podium. Two levels of below-grade parking are accessible via a covered driveway along the east elevation of the development. At grade, retail space and residential lobbies are located on the north and south sides, with an indoor amenity on the west side, and the remainder of the ground floor reserved for building support services. At Level 2, the podium sets back from the east and west facades, providing an outdoor amenity and private terraces. The building sets back again at Level 8 to the typical tower floorplates and providing an outdoor amenity on the between the towers. Above Level 8 the towers rise to their respective heights where they are each completed with mechanical penthouses.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within a 200-metre radius of the site) consist of a dense concentration of low-, mid- and high-rise buildings in all directions. The far-field surroundings (defined as the area beyond the near field and within a two-kilometer radius) are characterized primarily as an extension of the near-field surroundings within the downtown Ottawa core, followed by low-rise buildings in all directions. The Ottawa River flows southwest-northeast approximately 600 metres to the northwest of the site.

Grade-level areas investigated include sidewalks, laneways, parking areas, landscaped spaces, nearby patios and parkettes, and building access points. Wind comfort is also evaluated over the Level 2 and 8 outdoor amenity spaces. Figures 1A and 1B illustrates the *existing* and *proposed* study sites and surrounding context, respectively, 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; 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 Ottawa area wind climate and synthesis of wind tunnel data with City of Ottawa wind criteria [1]. The evaluation of snow drift accumulations involves the qualitative observation of local snow drift patterns, simulated in the wind tunnel, for statistically prominent wind and snowstorm directions. The following sections describe the individual analysis procedures.

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 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.

[1] City of Ottawa Terms of Reference – Wind Analysis (Undated)

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 on the scale model in Gradient Wind's wind tunnel. Of the 53 sensors, 44 were placed at grade level, with the remaining nine on the Level 2 and 8 amenity terraces. Wind speed measurements were performed for each of the 53 sensors for 36 wind directions at 10° intervals. Figures 1A and 1B illustrates the *existing* and *proposed* study sites and surrounding context, respectively, while sensor locations used to investigate wind conditions are illustrated in Figures 2A through 4D.

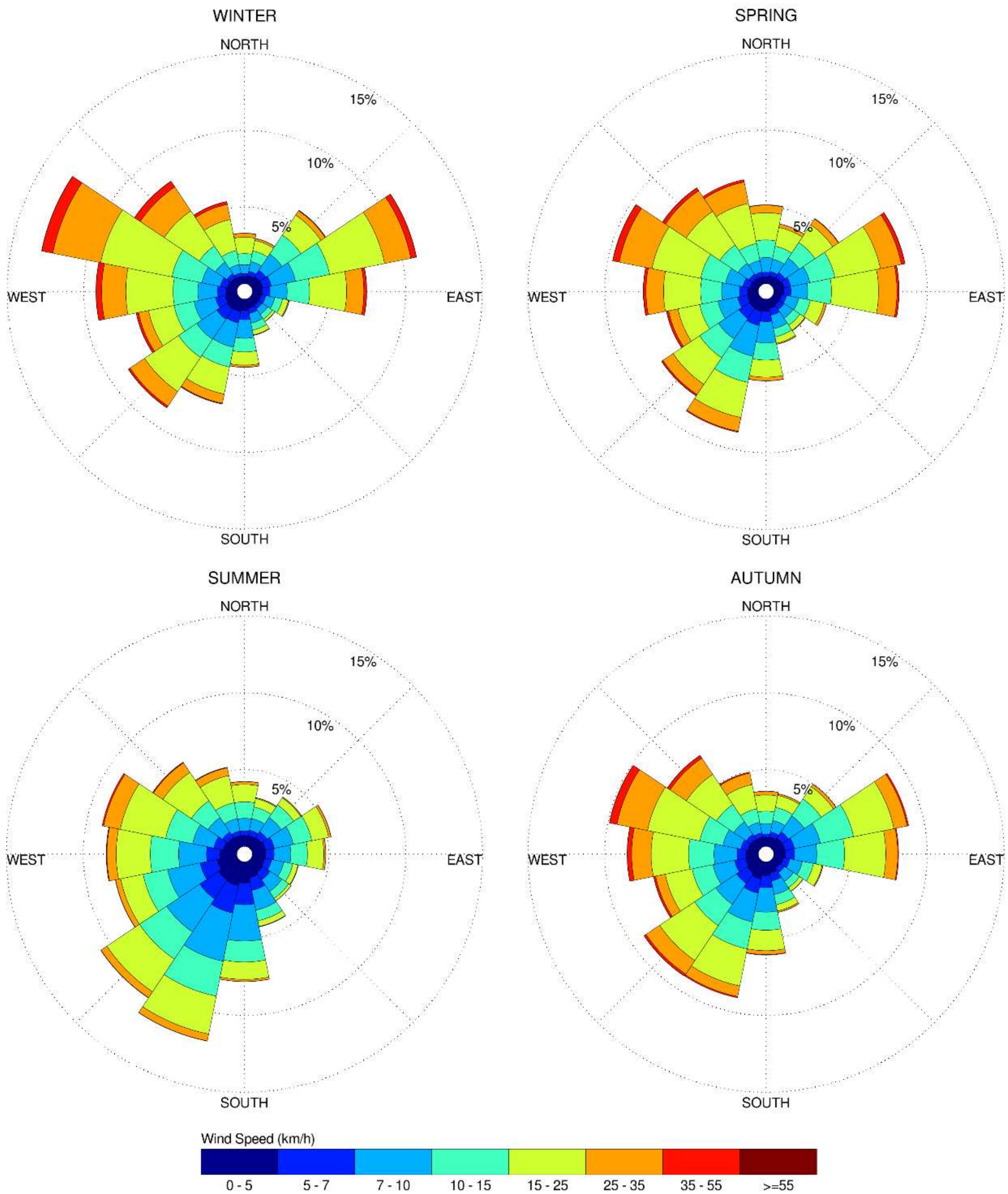
Mean and peak wind speed values for each location and wind direction were calculated from real-time pressure measurements, recorded at a sample rate of 500 samples per second, and taken over a 60-second time period. This period at model-scale corresponds approximately to one hour in full-scale, which 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 Ottawa was developed from approximately 40-years of hourly meteorological wind data recorded at Ottawa Macdonald-Cartier 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 Ottawa 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 Ottawa, the most common winds concerning pedestrian comfort occur for westerly wind directions, followed by those from the east. The directional preference and relative magnitude of wind speed changes somewhat from season to season. By convention in microclimate studies, wind direction refers to the wind origin (e.g., a north wind blows from north to south).

SEASONAL DISTRIBUTION OF WINDS FOR VARIOUS PROBABILITIES
OTTAWA MACDONALD-CARTIER INTERNATIONAL AIRPORT, OTTAWA, ONTARIO



NOTES:

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

4.4 Pedestrian Comfort and Safety Guidelines

Pedestrian comfort and safety guidelines are based on the mechanical effects of wind without consideration of other meteorological conditions (i.e. temperature, relative humidity). The comfort guidelines assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Four pedestrian comfort classes are based on 80% non-exceedance gust wind speed ranges, which include (i) Sitting; (ii) Standing; (iii) Strolling; (iv) Walking; and (v) Uncomfortable. More specifically, the comfort classes and associated gust wind speed ranges are summarized as follows, as dictated by the City of Ottawa wind criteria [2]:

(i) **Sitting:** Mean wind speeds less than or equal to 10 km/h.

(ii) **Standing:** Mean wind speeds less than or equal to 14 km/h.

(iii) **Strolling:** Mean wind speeds less than or equal to 17 km/h.

(iv) **Walking:** Mean wind speeds less than or equal to 20 km/h.

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

The pedestrian safety wind speed guideline is based on the approximate threshold that would cause a vulnerable member of the population to fall. A 0.1% exceedance gust wind speed of greater than 90 km/h is classified as dangerous.

Experience and research on people's perception of mechanical wind effects has shown that if the wind speed levels are exceeded for more than 20% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if wind speeds of 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 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.

[2] City of Ottawa Terms of Reference – Wind Analysis (Undated)

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. An overview of common pedestrian location types and their desired comfort classes is summarized on the following page.

DESIRED PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES

Location Types	Desired Comfort Classes
Primary Building Entrances	Standing
Secondary Building Access Points	Walking
Public Sidewalks	Strolling / Walking
Bicycle and Pedestrian Pathways	Walking
Outdoor Amenity Spaces	Sitting
Cafés / Patios / Benches / Gardens	Sitting
Plazas / Public Parks	Sitting / Standing / Strolling
Transit Stops	Standing
Garage / Service Entrances / Parking Lots	Walking
Vehicular Drop-Off Zones	Walking
Laneways / Loading Zones	Walking

5. RESULTS AND DISCUSSION

Tables A1 through A2 in Appendix A provide a summary of seasonal comfort predictions for each sensor location under the *existing* massing scenario. Similarly, Tables B1 through B2 in Appendix B provide the seasonal comfort predictions for under the *proposed* massing scenario. The tables indicate the 80% non-exceedance GEM wind speeds and corresponding comfort classifications as defined in Section 4.4. In other words, a wind speed threshold of 19.1 for the summer season indicates that 80% of the measured data falls at or below 19.1 km/h during the summer months and conditions are therefore suitable for walking, as the 80% threshold value falls within the exceedance range of 17-20 km/h for walking. 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, strolling, walking, etc.).

The most significant findings of the PLW study are summarized in Sections 5.1 and 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 4D. Conditions suitable for sitting are represented by the colour blue, while standing is represented by green, and walking by yellow.

5.1 Pedestrian Comfort Suitability – *Existing Scenario*

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 and illustrated in Figures 2A through 2D, this section summarizes the significant findings of the PLW study with respect to the *existing scenario*, as follows:

1. All public sidewalks, walkways, and surface parking within and surrounding the proposed development currently experience wind conditions suitable for standing or better during each seasonal period.

2. The nearby parkette northwest of the site (Sensors 22 and 23) currently experiences sitting conditions during each seasonal period.

3. The nearby patios southeast (Sensor 8) and north of the site (Sensor 15) currently experience sitting conditions throughout the year.

4. 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.

5.2 Pedestrian Comfort Suitability – *Proposed Scenario*

Based on the analysis of the measured data, consideration of local climate data, and the suitability descriptors provided in Tables B1-B2 in Appendix B and illustrated in Figures 3A through 4D, this section summarizes the significant findings of the PLW study with respect to the *proposed scenario*, as follows:

1. All public sidewalks, walkways, and surface parking within and surrounding the proposed development will experience wind conditions suitable for standing or better during each seasonal period, which is acceptable for the intended uses of the spaces.
2. All primary and secondary access points (including stairwell exits, and vehicle access points) will be suitable for sitting or better throughout each seasonal period, which is appropriate.
3. The grade-level exterior amenity along the west elevation of the building (Sensors 43 and 44) will be comfortable for sitting during each seasonal period, without the need for mitigation.
4. The nearby parkette northwest of the site (Sensors 22 and 23) will continue to experience conditions comfortable for sitting during each seasonal period.
5. The nearby patios southeast (Sensor 8) and north of the site (Sensor 15) will continue to experience sitting conditions throughout the year.
6. The Level 2 and 8 outdoor amenity terraces (Sensors 45-49, and 50-53, respectively) will be suitable for sitting or more sedentary activities throughout the year, which is appropriate.
7. 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.

6. CONCLUSIONS AND RECOMMENDATIONS

This report summarizes the methodology, results, and recommendations related to a pedestrian level wind study for the proposed mixed-use development located at 170 Slater Street in Ottawa, 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 2A-4D, Tables A1-A2 in Appendix A, and Tables B1-B2 in Appendix B. Based on wind tunnel test results, meteorological data analysis, and experience with similar developments in Ottawa we conclude that wind conditions over all pedestrian sensitive grade-level locations within and surrounding the study site will be acceptable for the intended uses on a seasonal basis.

Wind conditions over the Level 2 and Level 8 outdoor amenity terraces will be comfortable for sitting or more sedentary activities throughout the year without the need for mitigation.

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.

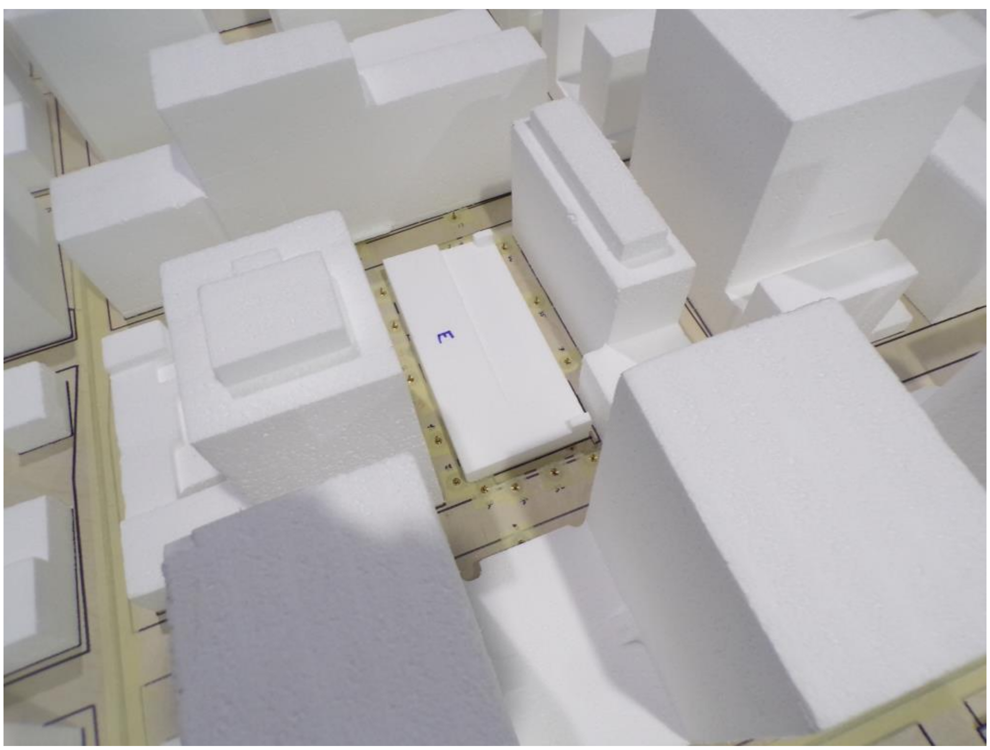
Logan McFadden, B.Eng.,
Junior Wind Scientist

Angelina Gomes, B.Eng., EIT
Junior Wind Scientist

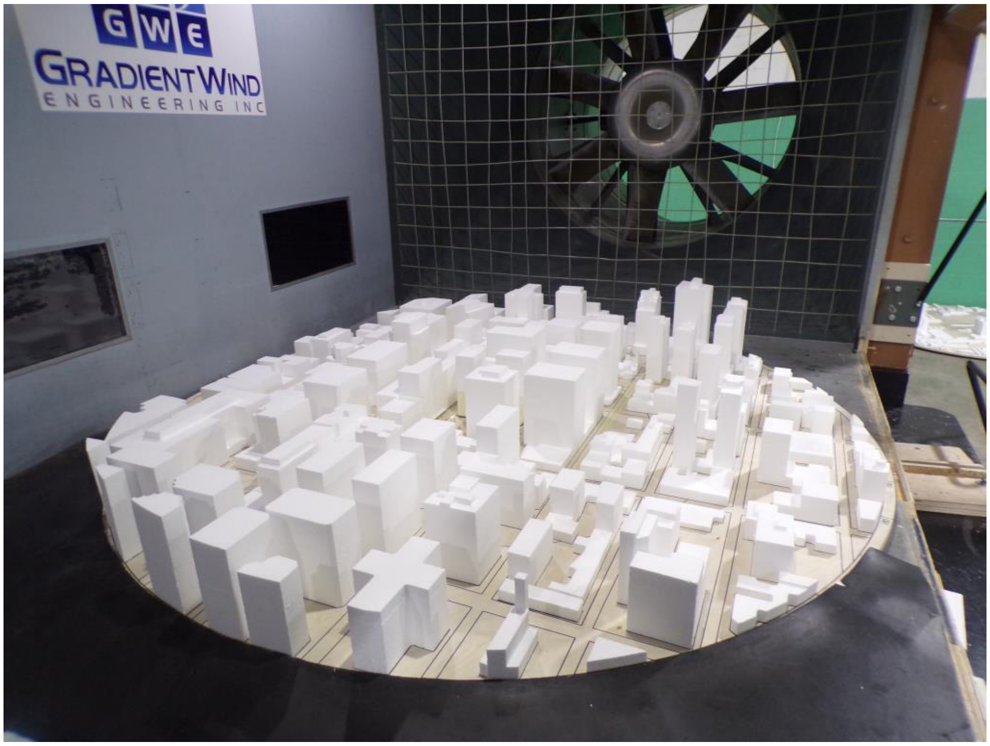
Andrew Sliasas, M.A.Sc., P.Eng
Principal

GW23-126-WTPLW

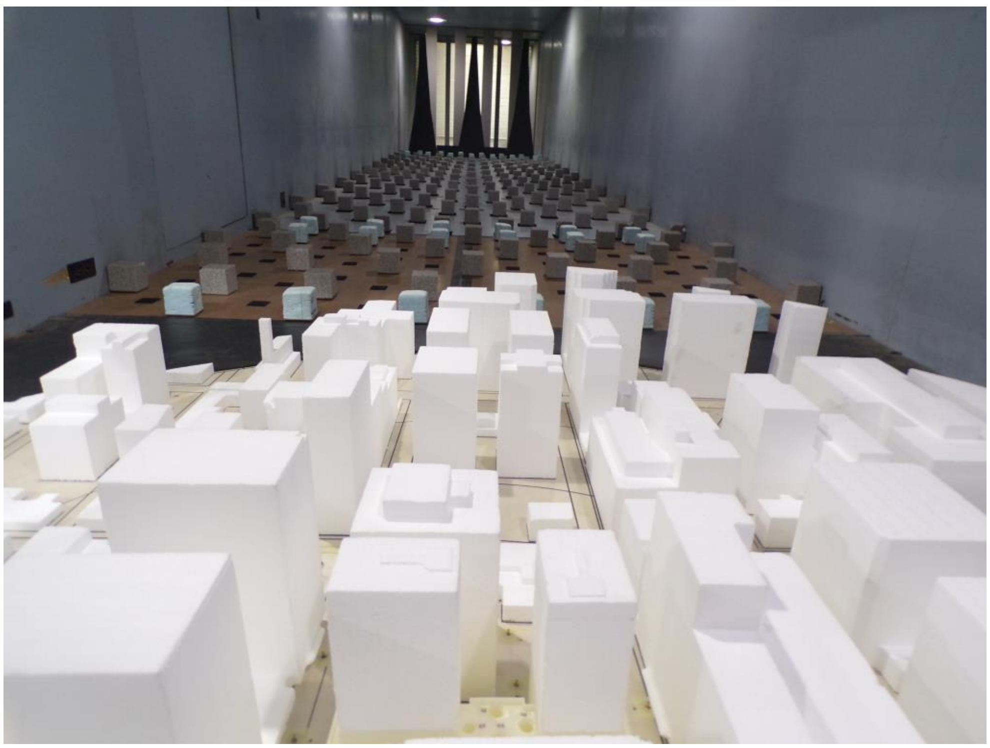
PHOTOGRAPH 1: CLOSE-UP VIEW OF EXISTING STUDY MODEL LOOKING SOUTH



PHOTOGRAPH 2: CLOSE-UP VIEW OF EXISTING STUDY MODEL LOOKING NORTH



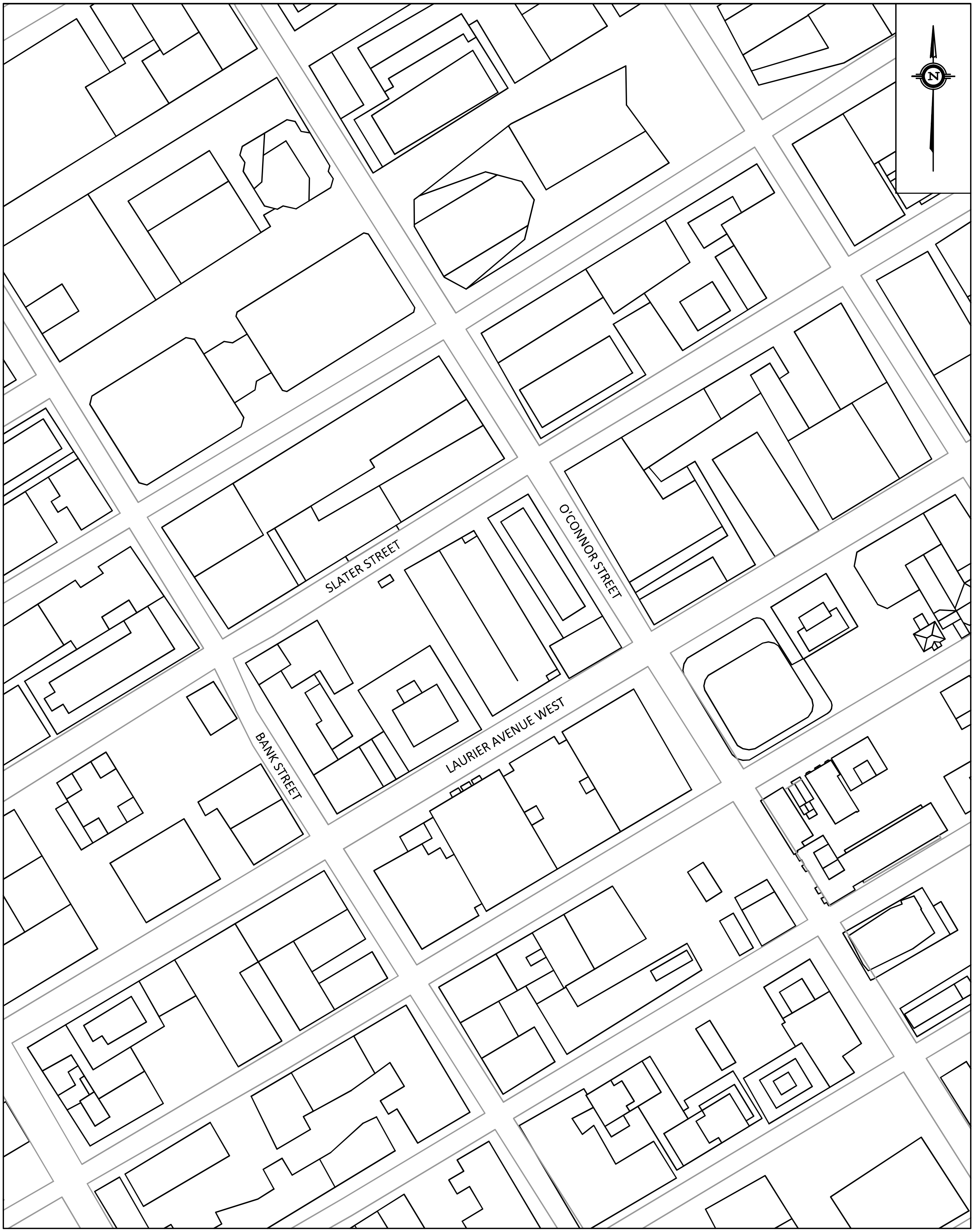
PHOTOGRAPH 3: STUDY MODEL INSIDE THE GWE WIND TUNNEL LOOKING DOWNWIND



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

PHOTOGRAPH 5: CLOSE-UP VIEW OF PROPOSED STUDY MODEL LOOKING NORTHWEST

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



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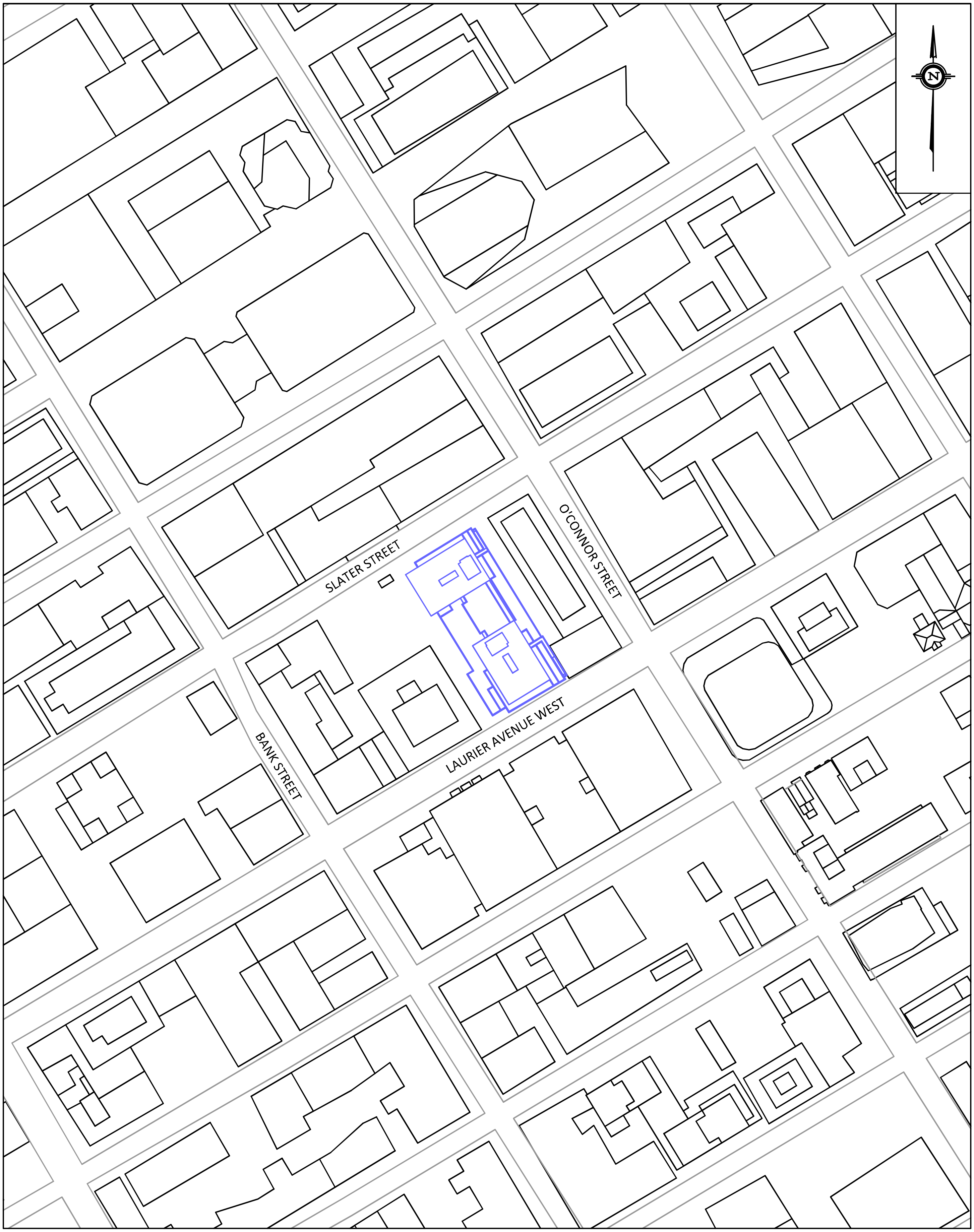
PROJECT	170 SLATER STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:2500 (APPROX.)
DRAWING NO.	GW23-126-PLW-1A
DATE	JUNE 16, 2023
DRAWN BY	K.A.
DESCRIPTION	FIGURE 1A: EXISTING SITE PLAN AND SURROUNDING CONTEXT



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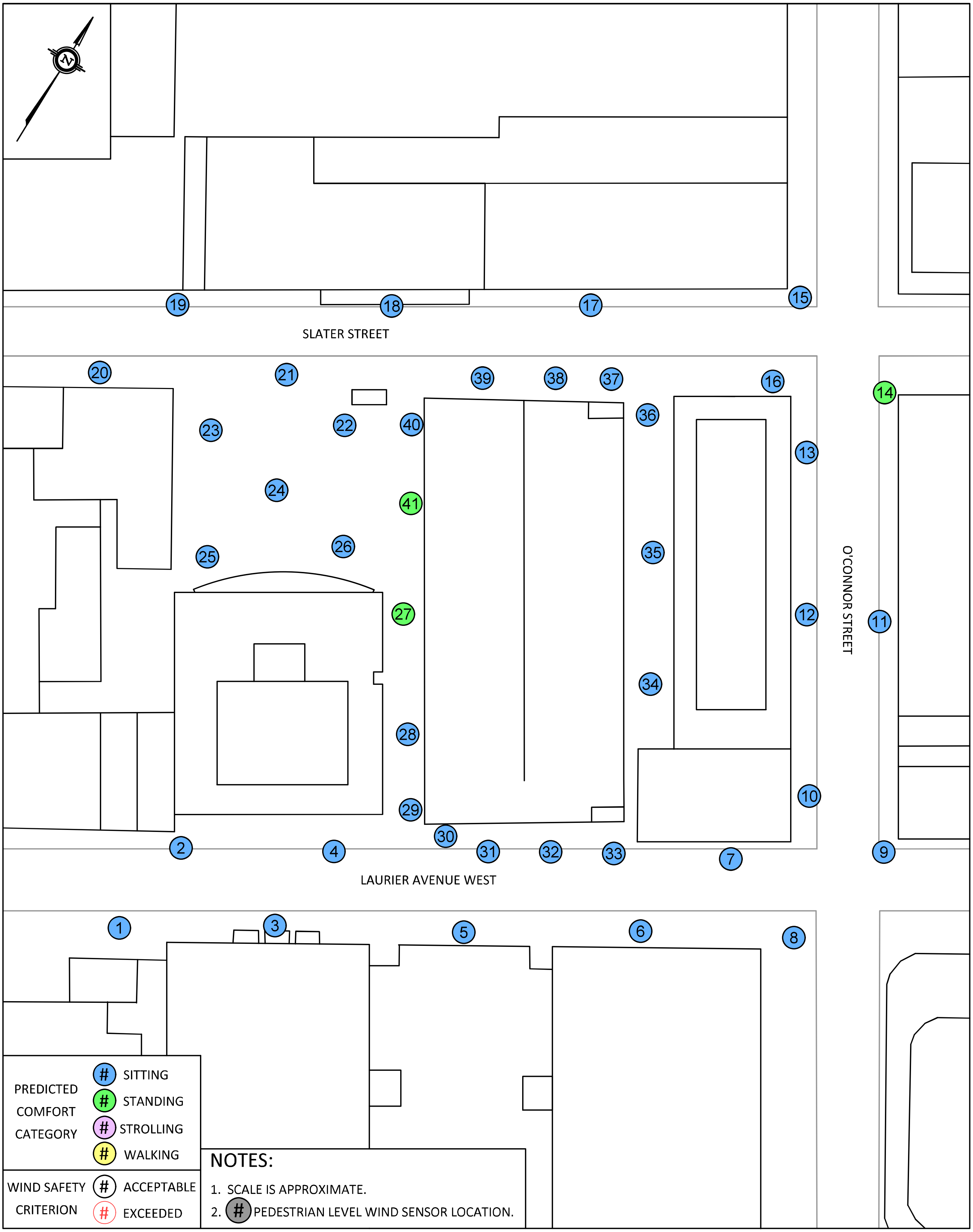
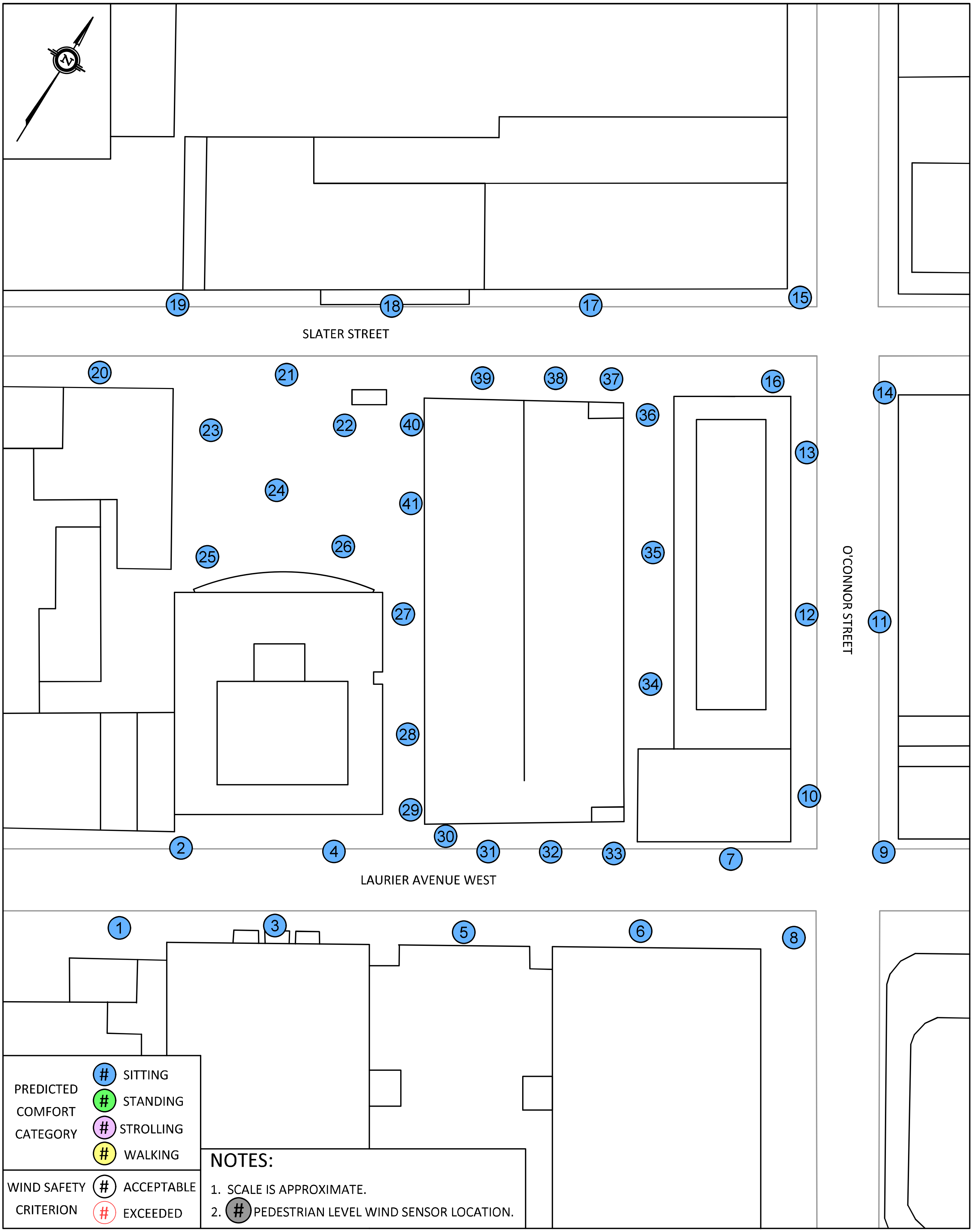
PROJECT	170 SLATER STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION
SCALE	1:2500 (APPROX.)	DRAWING NO. GW23-126-PLW-1B	FIGURE 1B: FUTURE SITE PLAN AND SURROUNDING CONTEXT
DATE	JUNE 16, 2023	DRAWN BY K.A.	



NOTES:

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

GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD, OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT: 170 SLATER STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 2A: SPRING EXISTING GRADE LEVEL PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS
	SCALE: 1:1000 (APPROX.)	DRAWING NO.: GW23-126-PLW-2A	
	DATE: JUNE 16, 2023	DRAWN BY: K.A.	



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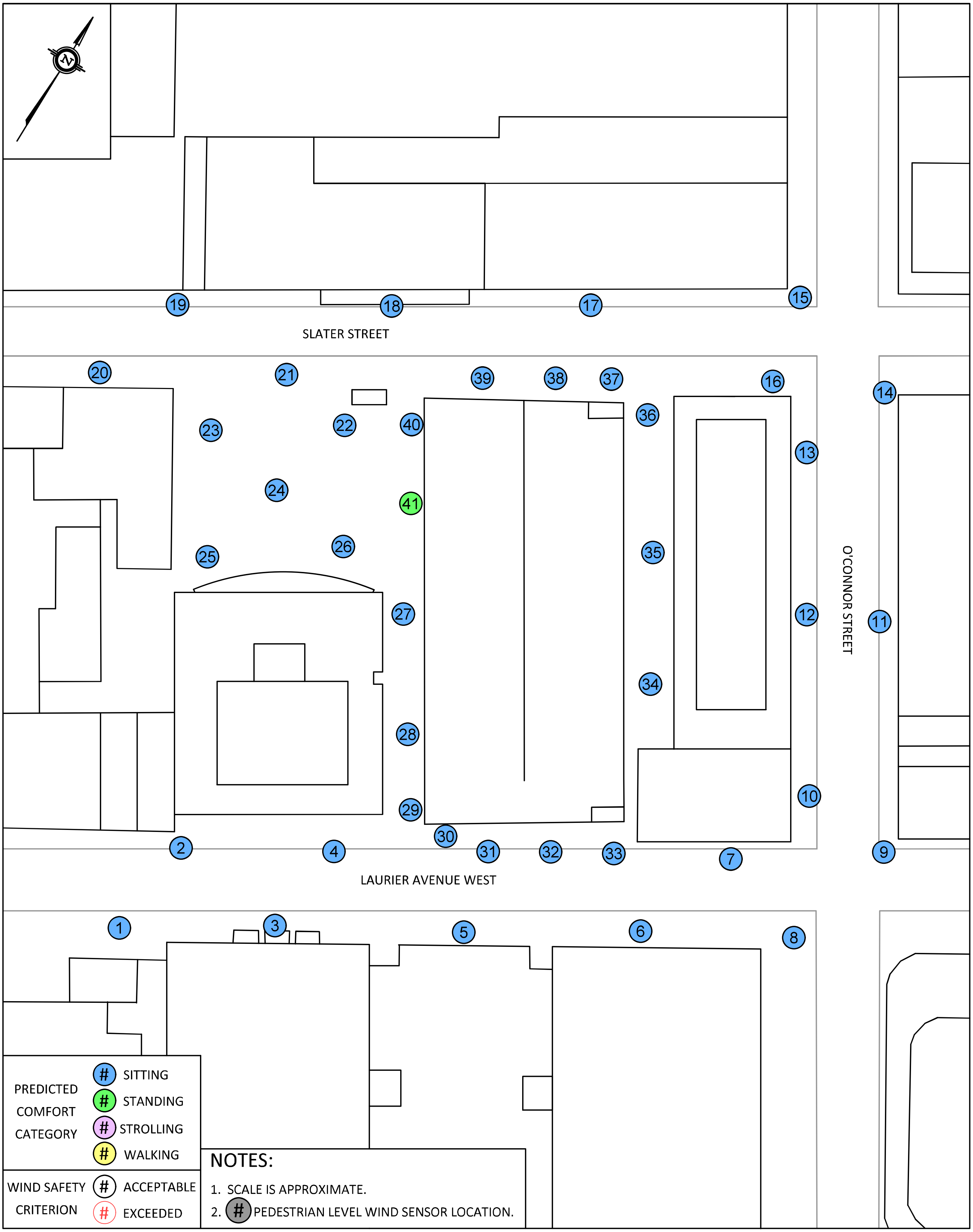
PROJECT: 170 SLATER STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 2B: SUMMER EXISTING GRADE LEVEL PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:1000 (APPROX.)	DRAWING NO.: GW23-126-PLW-2B	
DATE: JUNE 16, 2023	DRAWN BY: K.A.	



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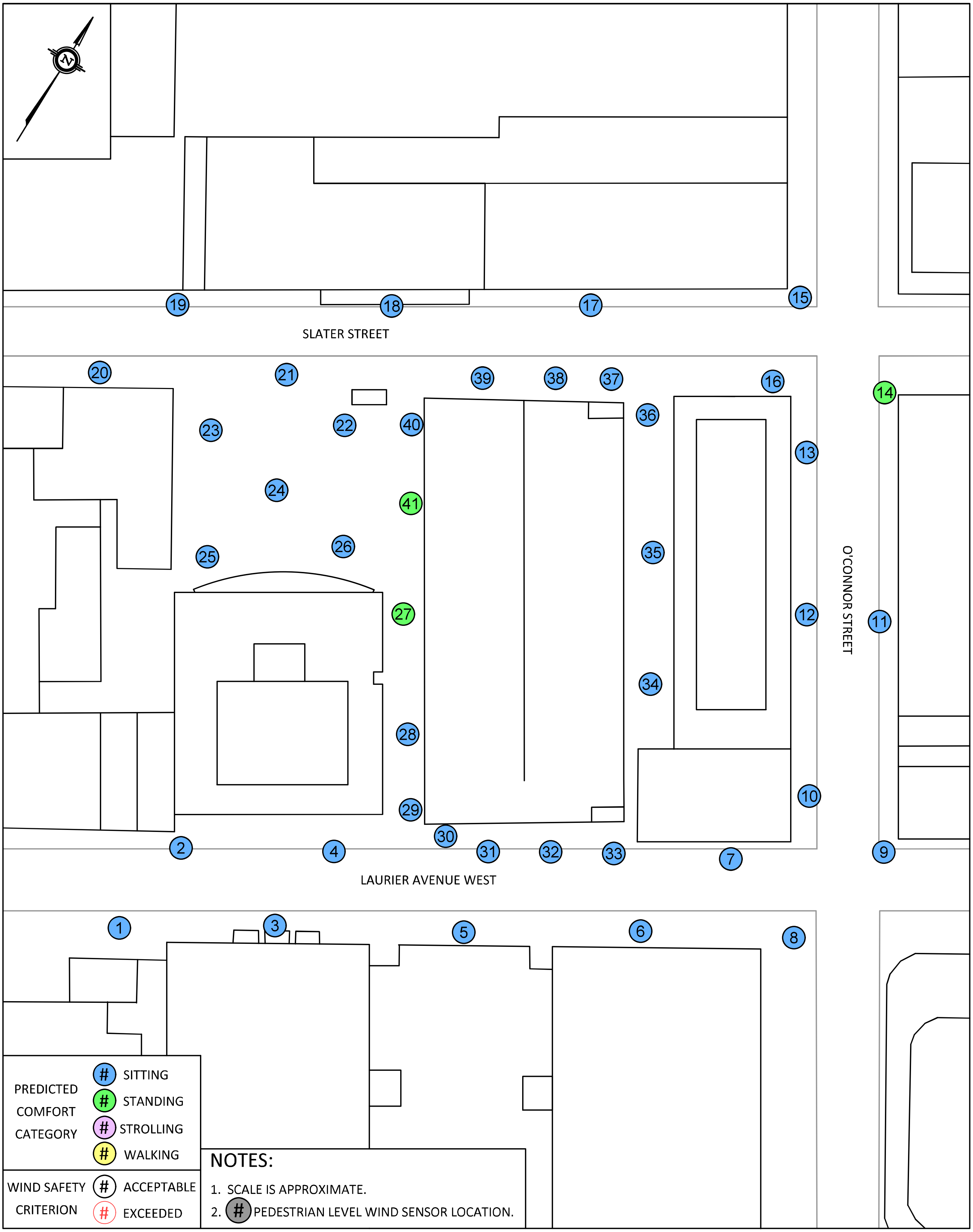
PROJECT: 170 SLATER STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 2C: AUTUMN EXISTING GRADE LEVEL PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:1000 (APPROX.)	DRAWING NO.: GW23-126-PLW-2C	
DATE: JUNE 16, 2023	DRAWN BY: K.A.	



NOTES:

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

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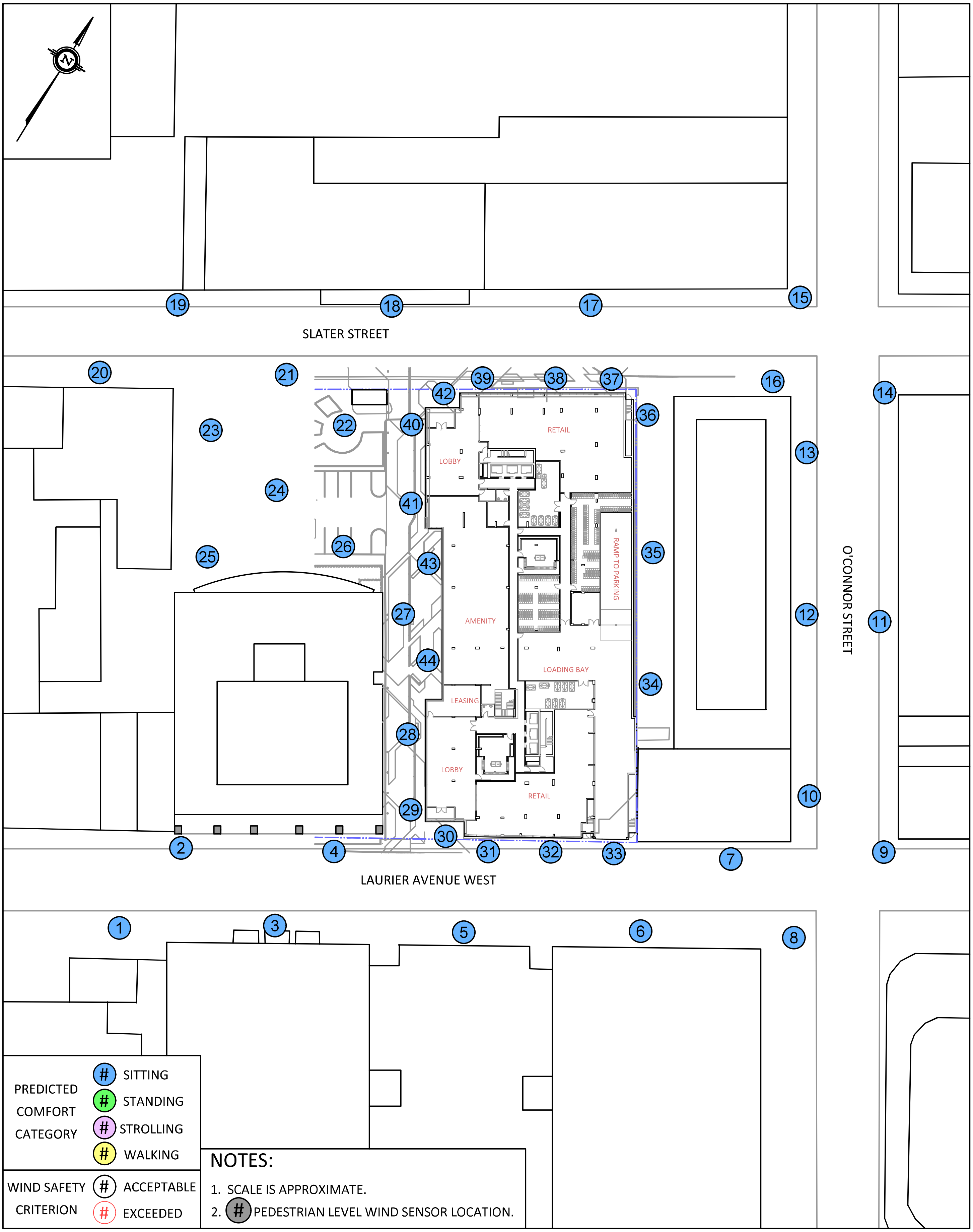
SCALE	1:1000 (APPROX.)
DRAWING NO.	GW23-126-PLW-2D
DATE	JUNE 16, 2023
DRAWN BY	K.A.
DESCRIPTION	FIGURE 2D: WINTER EXISTING GRADE LEVEL PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS



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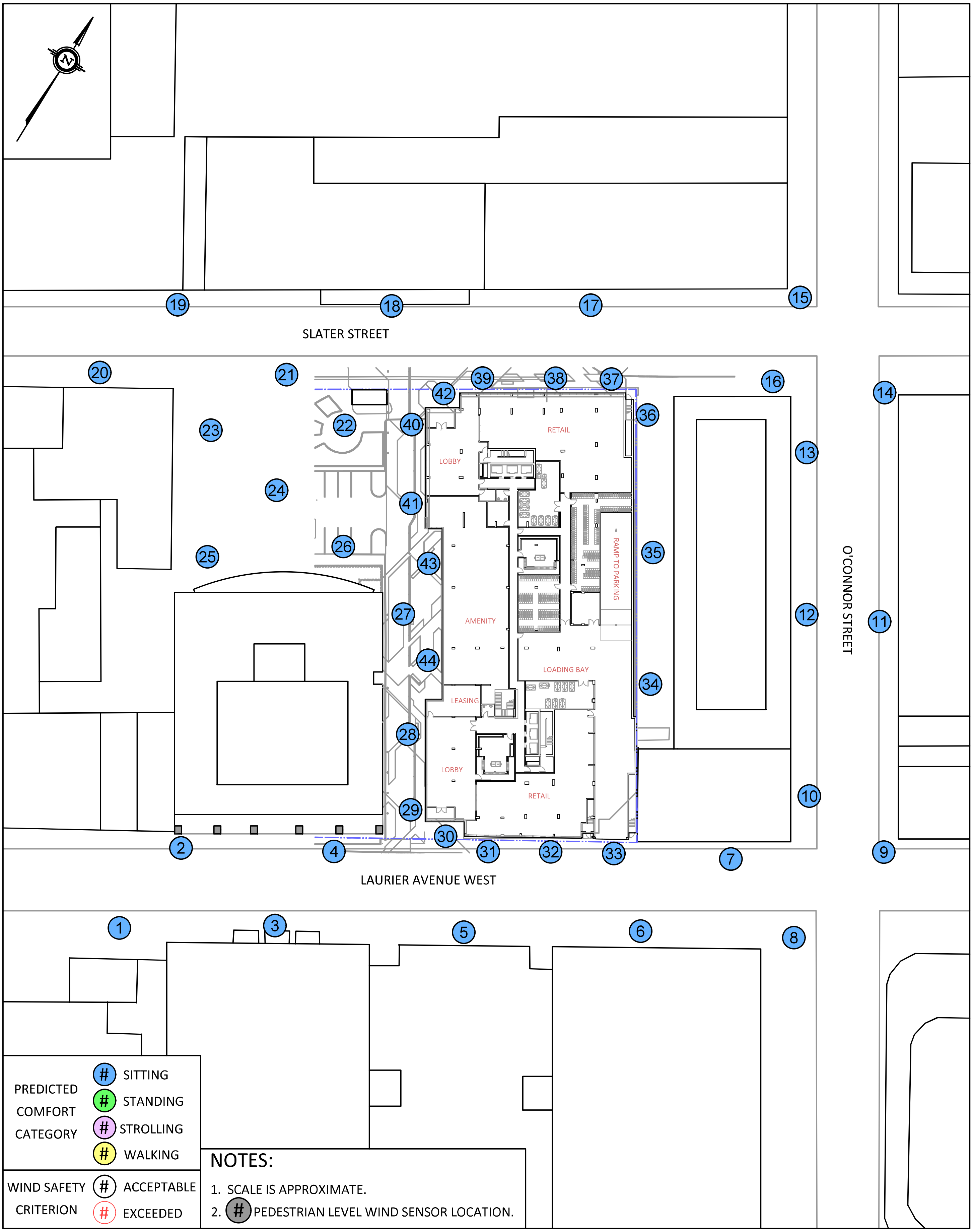
PROJECT: 170 SLATER STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 3A: SPRING FUTURE GRADE LEVEL PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:1000 (APPROX.)	DRAWING NO.: GW23-126-PLW-3A	
DATE: JUNE 16, 2023	DRAWN BY: K.A.	



PREDICTED COMFORT CATEGORY: # SITTING; # STANDING; # STROLLING; # WALKING

WIND SAFETY CRITERION: # ACCEPTABLE; # EXCEEDED

NOTES:

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

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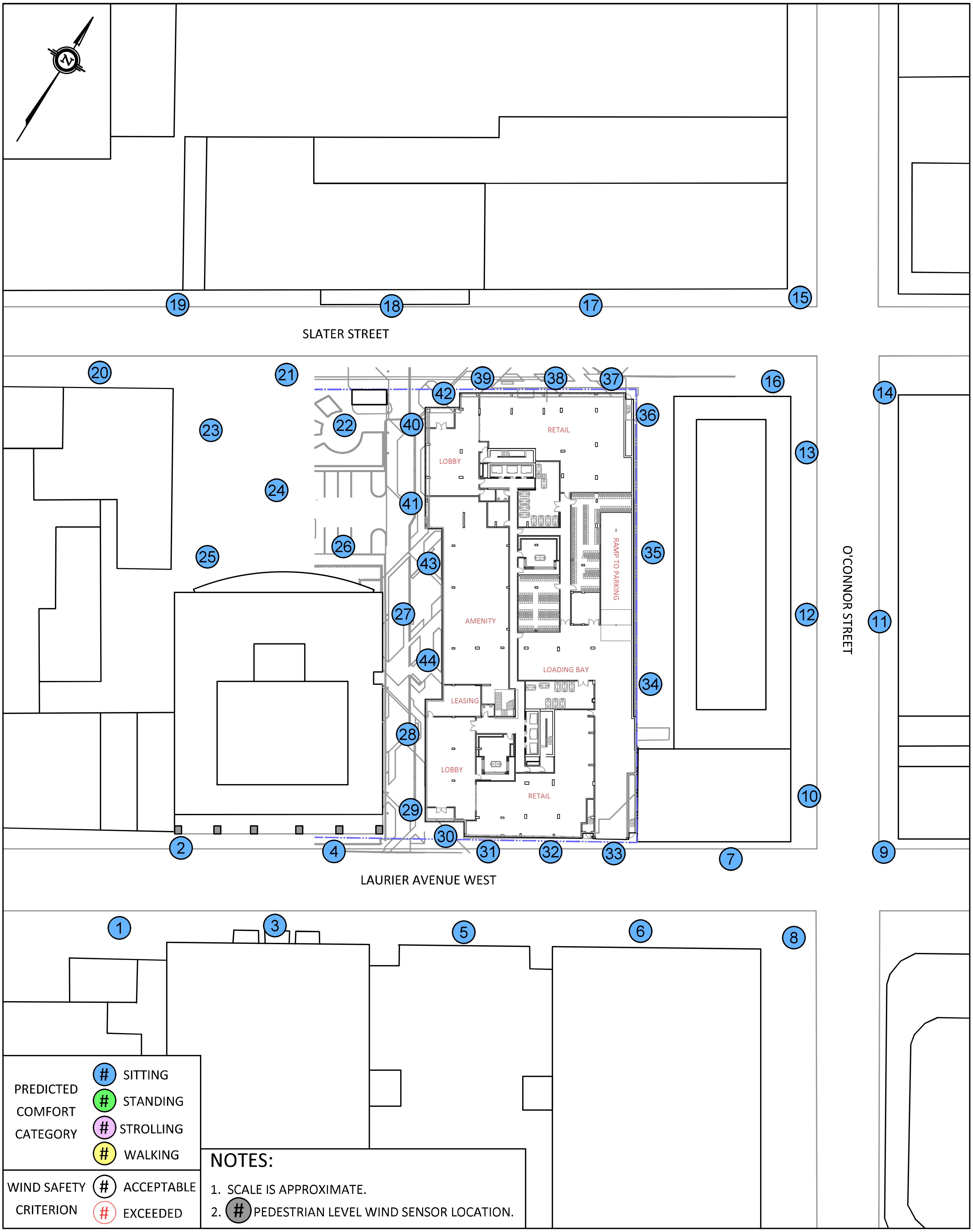
PROJECT	170 SLATER STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1000 (APPROX.)
DRAWING NO.	GW23-126-PLW-3B
DATE	JUNE 16, 2023
DRAWN BY	K.A.
DESCRIPTION	FIGURE 3B: SUMMER FUTURE GRADE LEVEL PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS



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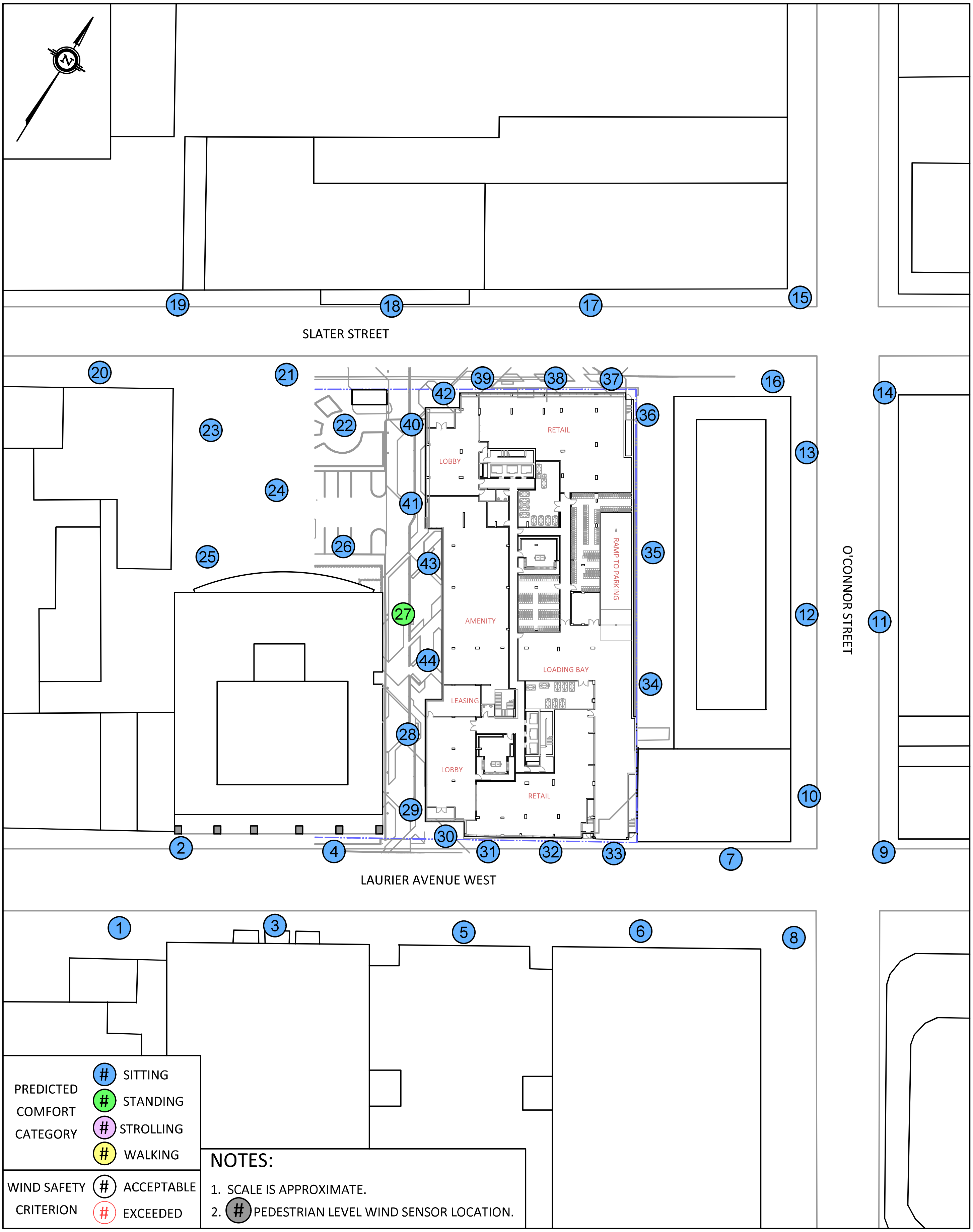
PROJECT	170 SLATER STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1000 (APPROX.)
DRAWING NO.	GW23-126-PLW-3C
DATE	JUNE 16, 2023
DRAWN BY	K.A.
DESCRIPTION	FIGURE 3C: AUTUMN FUTURE GRADE LEVEL PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS



NOTES:

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

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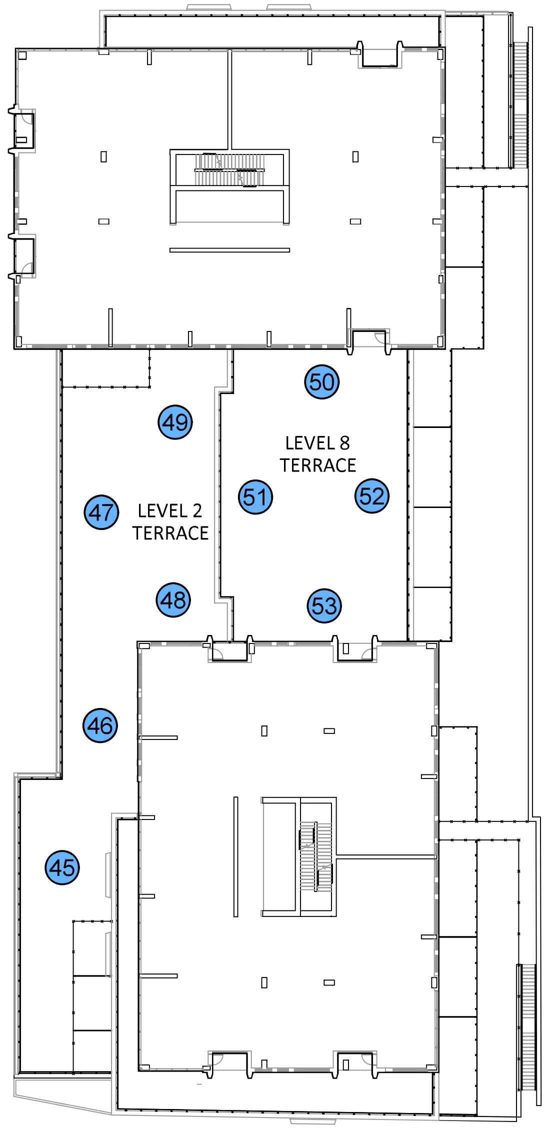
PROJECT	170 SLATER STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:1000 (APPROX.)	DRAWING NO.	GW23-126-PLW-3D
DATE	JUNE 16, 2023	DRAWN BY	K.A.

DESCRIPTION

FIGURE 3D: WINTER
FUTURE GRADE LEVEL PLW SENSOR LAYOUT
PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CATEGORY	#	SITTING
	#	STANDING
	#	STROLLING
	#	WALKING
WIND SAFETY CRITERION	#	ACCEPTABLE
	#	EXCEEDED

NOTES:

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

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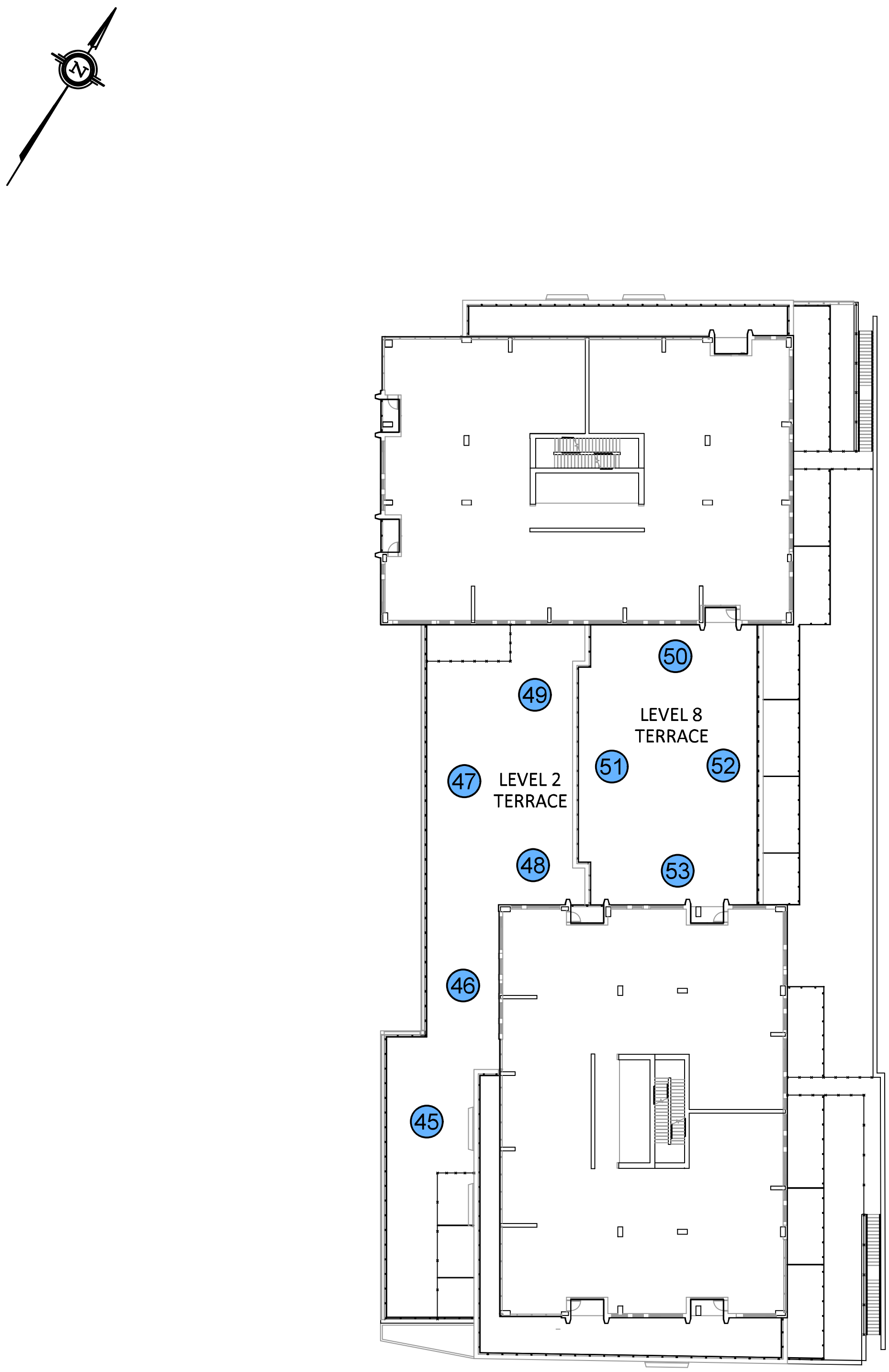
PROJECT	170 SLATER STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:600 (APPROX.)	DRAWING NO.	GW23-126-PLW-4A
DATE	JUNE 16, 2023	DRAWN BY	K.A.

DESCRIPTION

FIGURE 4A: SPRING
FUTURE TERRACE PLW SENSOR LAYOUT
PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CATEGORY	#	SITTING
	#	STANDING
	#	STROLLING
	#	WALKING
WIND SAFETY CRITERION	#	ACCEPTABLE
	#	EXCEEDED

NOTES:

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

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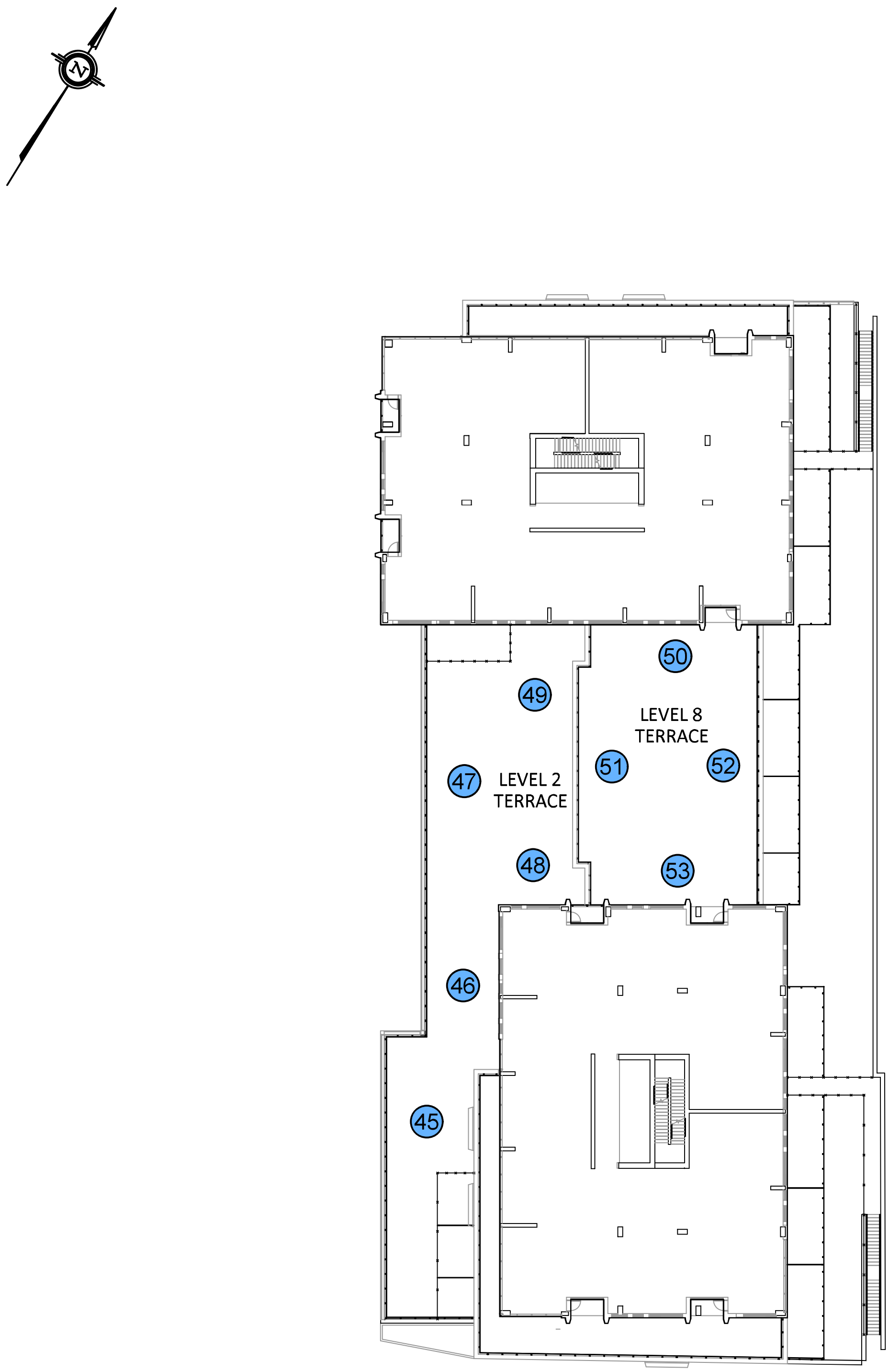
SCALE	1:600 (APPROX.)	DRAWING NO. GW23-126-PLW-4B
DATE	JUNE 16, 2023	DRAWN BY K.A.

DESCRIPTION

FIGURE 4B: SUMMER
FUTURE TERRACE PLW SENSOR LAYOUT
PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CATEGORY	#	SITTING
	#	STANDING
	#	STROLLING
	#	WALKING
WIND SAFETY CRITERION	#	ACCEPTABLE
	#	EXCEEDED

NOTES:

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

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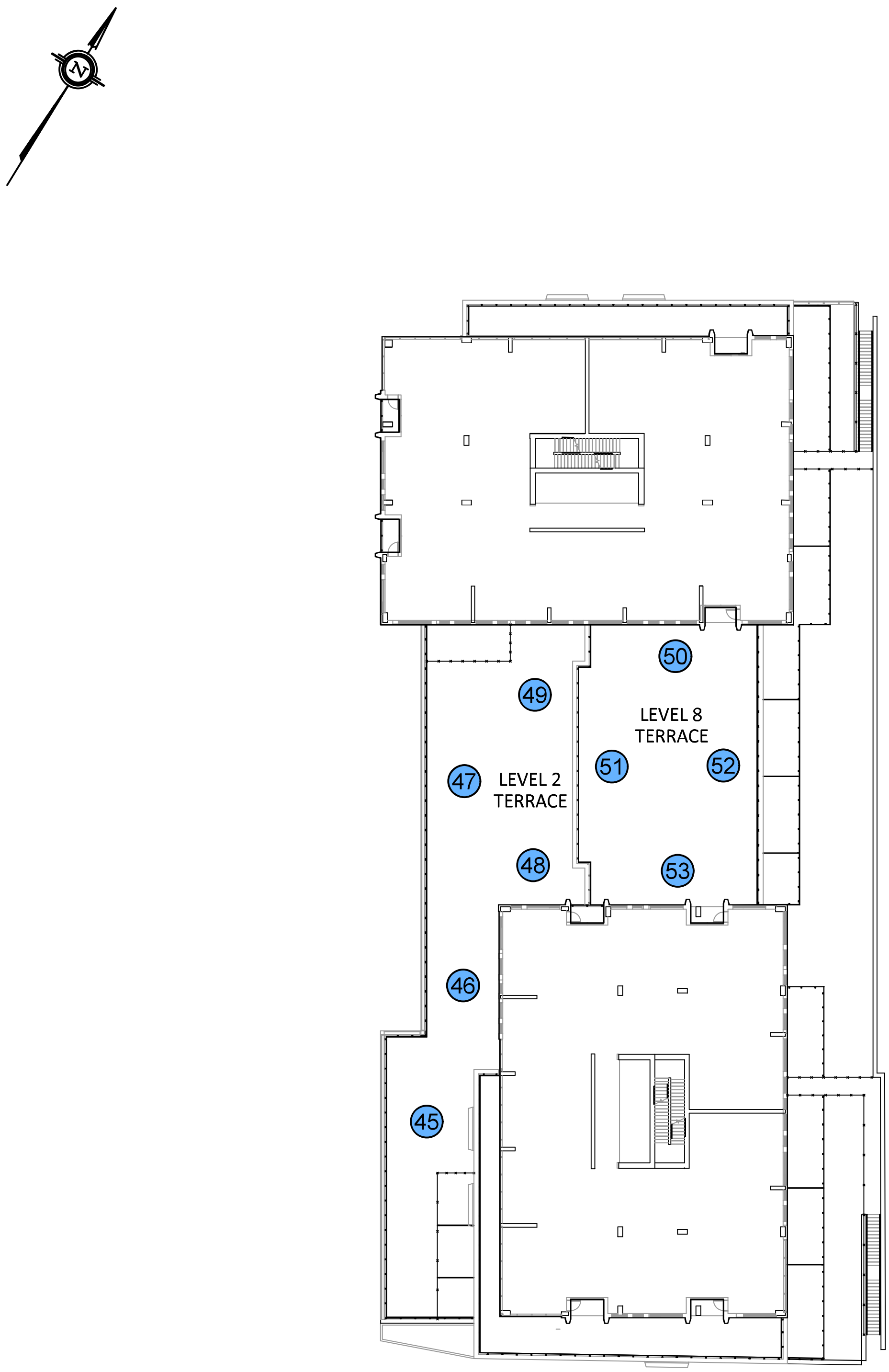
PROJECT	170 SLATER STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:600 (APPROX.)	DRAWING NO.	GW23-126-PLW-4C
DATE	JUNE 16, 2023	DRAWN BY	K.A.

DESCRIPTION

FIGURE 4C: AUTUMN
FUTURE TERRACE PLW SENSOR LAYOUT
PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CATEGORY	
#	SITTING
#	STANDING
#	STROLLING
#	WALKING

WIND SAFETY CRITERION	
#	ACCEPTABLE
#	EXCEEDED

NOTES:

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

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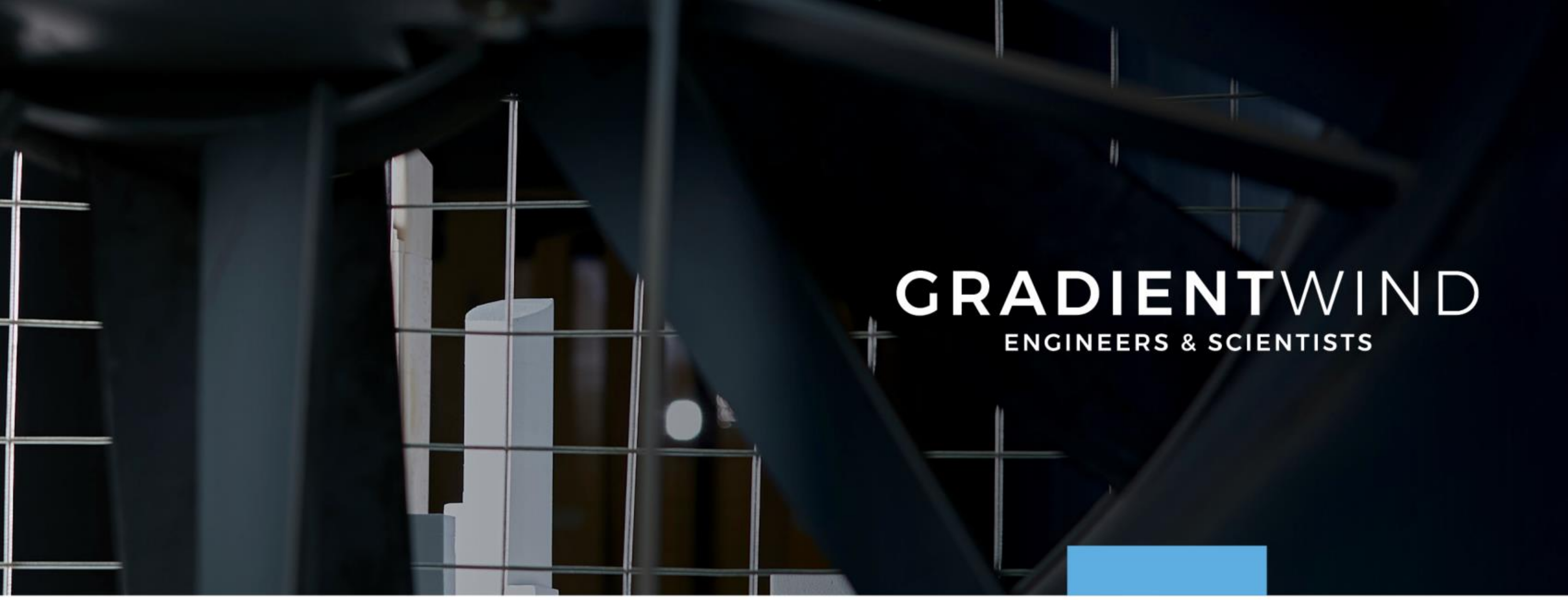
PROJECT	170 SLATER STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:600 (APPROX.)
DRAWING NO.	GW23-126-PLW-4D
DATE	JUNE 16, 2023
DRAWN BY	K.A.
DESCRIPTION	FIGURE 4D: WINTER FUTURE TERRACE PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS



APPENDIX A

PEDESTRIAN COMFORT SUITABILITY, TABLES A1-A2
(EXISTING SCENARIO)

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-14 km/h = Standing, 14-17 km/h = Strolling, 17-20 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 (EXISTING SCENARIO)

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	9.3	Sitting	7.2	Sitting	8.2	Sitting	9.5	Sitting	39.4	Safe
2	8.3	Sitting	6.5	Sitting	7.5	Sitting	8.3	Sitting	32.8	Safe
3	8.6	Sitting	7.0	Sitting	7.9	Sitting	8.9	Sitting	39.1	Safe
4	9.3	Sitting	7.9	Sitting	8.8	Sitting	9.3	Sitting	42.1	Safe
5	7.7	Sitting	6.1	Sitting	7.0	Sitting	7.7	Sitting	30.8	Safe
6	7.7	Sitting	6.5	Sitting	7.1	Sitting	7.7	Sitting	33.8	Safe
7	8.9	Sitting	6.8	Sitting	7.9	Sitting	8.8	Sitting	35.4	Safe
8	8.7	Sitting	6.6	Sitting	7.5	Sitting	9.1	Sitting	39.2	Safe
9	9.1	Sitting	7.1	Sitting	8.4	Sitting	10.0	Sitting	41.8	Safe
10	7.6	Sitting	5.7	Sitting	6.7	Sitting	7.9	Sitting	34.0	Safe
11	6.9	Sitting	5.3	Sitting	6.1	Sitting	7.1	Sitting	29.7	Safe
12	8.5	Sitting	6.1	Sitting	7.2	Sitting	8.2	Sitting	29.9	Safe
13	9.1	Sitting	6.5	Sitting	7.6	Sitting	8.7	Sitting	33.9	Safe
14	10.4	Standing	7.7	Sitting	8.8	Sitting	10.3	Standing	39.3	Safe
15	8.5	Sitting	6.5	Sitting	7.4	Sitting	8.3	Sitting	33.0	Safe
16	6.8	Sitting	5.1	Sitting	5.9	Sitting	6.5	Sitting	25.6	Safe
17	6.5	Sitting	5.1	Sitting	5.9	Sitting	6.5	Sitting	24.6	Safe
18	7.1	Sitting	5.8	Sitting	6.7	Sitting	7.1	Sitting	30.6	Safe
19	6.9	Sitting	5.1	Sitting	6.0	Sitting	7.0	Sitting	25.5	Safe
20	9.4	Sitting	7.0	Sitting	8.1	Sitting	9.4	Sitting	39.3	Safe
21	8.9	Sitting	6.8	Sitting	7.9	Sitting	9.2	Sitting	36.3	Safe
22	8.5	Sitting	6.4	Sitting	7.5	Sitting	9.0	Sitting	37.8	Safe
23	8.5	Sitting	6.4	Sitting	7.5	Sitting	9.1	Sitting	40.9	Safe
24	9.2	Sitting	6.7	Sitting	7.9	Sitting	9.8	Sitting	44.1	Safe
25	6.8	Sitting	5.4	Sitting	6.2	Sitting	7.1	Sitting	28.9	Safe
26	7.3	Sitting	5.4	Sitting	6.3	Sitting	7.9	Sitting	37.2	Safe
27	10.7	Standing	7.8	Sitting	9.1	Sitting	12.1	Standing	56.9	Safe
28	7.4	Sitting	5.4	Sitting	6.4	Sitting	8.1	Sitting	42.2	Safe
29	7.0	Sitting	5.4	Sitting	6.2	Sitting	7.1	Sitting	38.9	Safe
30	7.9	Sitting	6.5	Sitting	7.3	Sitting	8.0	Sitting	35.1	Safe
31	8.5	Sitting	7.1	Sitting	7.9	Sitting	8.6	Sitting	40.4	Safe
32	8.9	Sitting	7.3	Sitting	8.2	Sitting	8.9	Sitting	39.9	Safe
33	9.4	Sitting	7.5	Sitting	8.8	Sitting	9.3	Sitting	38.9	Safe
34	6.6	Sitting	5.2	Sitting	5.9	Sitting	7.0	Sitting	29.2	Safe
35	6.6	Sitting	5.0	Sitting	5.8	Sitting	7.2	Sitting	35.8	Safe

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-14 km/h = Standing, 14-17 km/h = Strolling, 17-20 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 (EXISTING SCENARIO)

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	8.2	Sitting	6.1	Sitting	7.1	Sitting	9.2	Sitting	43.0	Safe
37	6.5	Sitting	4.9	Sitting	5.6	Sitting	6.2	Sitting	24.3	Safe
38	6.6	Sitting	5.1	Sitting	5.8	Sitting	6.5	Sitting	22.9	Safe
39	6.3	Sitting	4.9	Sitting	5.5	Sitting	6.2	Sitting	22.3	Safe
40	8.6	Sitting	6.2	Sitting	7.3	Sitting	9.4	Sitting	44.4	Safe
41	12.2	Standing	8.9	Sitting	10.6	Standing	12.5	Standing	44.4	Safe

APPENDIX B

PEDESTRIAN COMFORT SUITABILITY, TABLES B1-B2
(PROPOSED SCENARIO)

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Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-14 km/h = Standing, 14-17 km/h = Strolling, 17-20 km/h =- Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

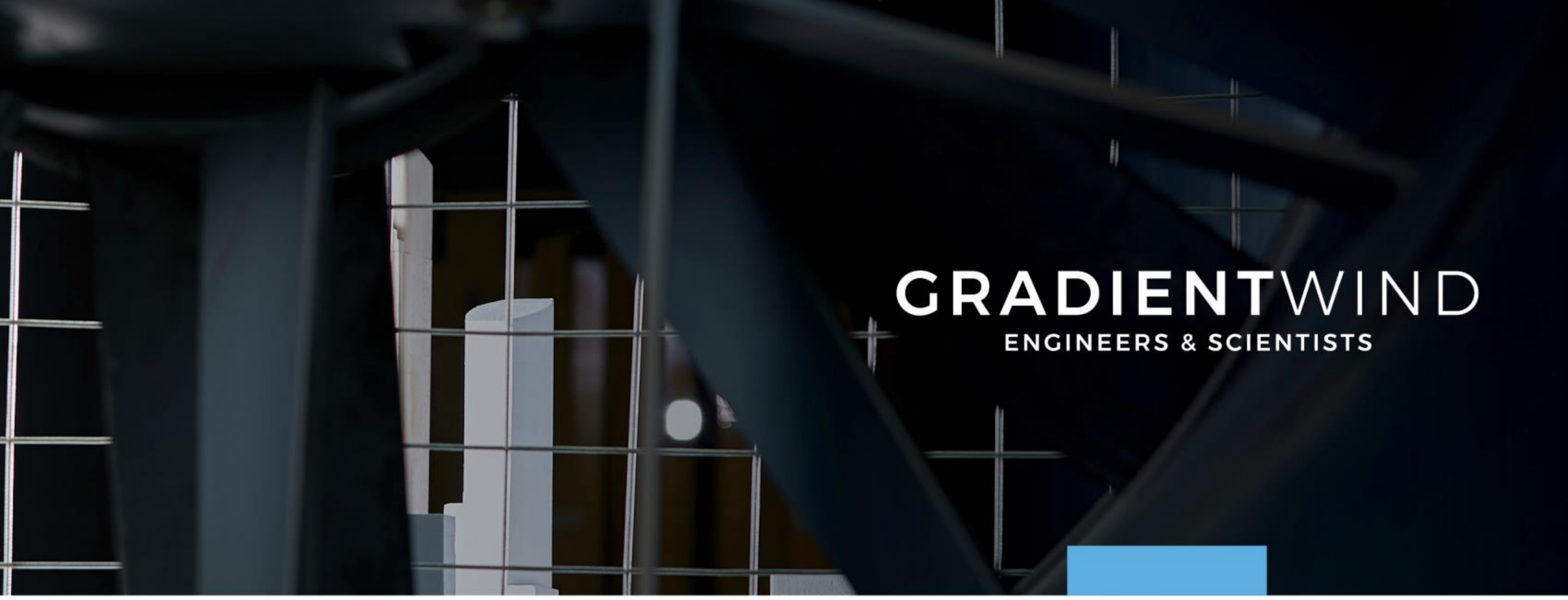
TABLE B1: SUMMARY OF PEDESTRIAN COMFORT (PROPOSED SCENARIO)

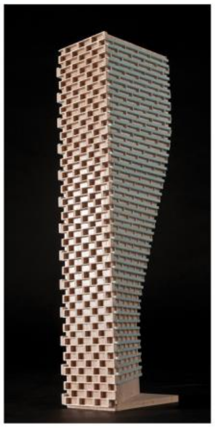
Sensor	Pedestrian Comfort								Pedestrian Safety	
	Spring		Summer		Autumn		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
1	8.5	Sitting	6.6	Sitting	7.6	Sitting	8.7	Sitting	37.1	Safe
2	8.7	Sitting	6.7	Sitting	7.9	Sitting	8.7	Sitting	33.5	Safe
3	8.8	Sitting	7.1	Sitting	8.1	Sitting	9.2	Sitting	37.8	Safe
4	9.0	Sitting	7.6	Sitting	8.6	Sitting	9.1	Sitting	40.9	Safe
5	8.1	Sitting	6.4	Sitting	7.3	Sitting	8.0	Sitting	30.8	Safe
6	8.4	Sitting	7.0	Sitting	7.7	Sitting	8.4	Sitting	34.8	Safe
7	8.4	Sitting	6.7	Sitting	7.7	Sitting	8.4	Sitting	37.3	Safe
8	9.1	Sitting	7.0	Sitting	8.1	Sitting	9.4	Sitting	40.5	Safe
9	8.9	Sitting	7.0	Sitting	8.0	Sitting	9.8	Sitting	42.9	Safe
10	6.9	Sitting	5.1	Sitting	6.0	Sitting	7.1	Sitting	33.2	Safe
11	6.7	Sitting	5.1	Sitting	6.0	Sitting	6.8	Sitting	27.2	Safe
12	8.3	Sitting	5.8	Sitting	6.9	Sitting	7.9	Sitting	29.1	Safe
13	8.2	Sitting	5.7	Sitting	6.7	Sitting	7.7	Sitting	32.0	Safe
14	9.3	Sitting	6.8	Sitting	7.8	Sitting	9.1	Sitting	37.9	Safe
15	8.1	Sitting	6.1	Sitting	7.0	Sitting	8.0	Sitting	31.3	Safe
16	6.7	Sitting	5.1	Sitting	5.8	Sitting	6.4	Sitting	24.5	Safe
17	7.6	Sitting	6.1	Sitting	6.9	Sitting	7.7	Sitting	28.6	Safe
18	7.9	Sitting	6.5	Sitting	7.3	Sitting	7.8	Sitting	33.0	Safe
19	6.7	Sitting	5.0	Sitting	5.8	Sitting	6.9	Sitting	26.7	Safe
20	6.8	Sitting	5.3	Sitting	6.0	Sitting	6.8	Sitting	29.4	Safe
21	7.7	Sitting	6.1	Sitting	6.9	Sitting	7.8	Sitting	30.0	Safe
22	7.4	Sitting	5.8	Sitting	6.7	Sitting	7.7	Sitting	32.7	Safe
23	7.6	Sitting	5.9	Sitting	6.8	Sitting	7.8	Sitting	32.2	Safe
24	8.0	Sitting	6.2	Sitting	7.1	Sitting	8.6	Sitting	41.2	Safe
25	6.5	Sitting	5.2	Sitting	5.9	Sitting	6.7	Sitting	26.5	Safe
26	6.7	Sitting	5.1	Sitting	5.9	Sitting	7.1	Sitting	30.8	Safe
27	8.9	Sitting	6.7	Sitting	7.8	Sitting	10.1	Standing	48.3	Safe
28	8.1	Sitting	5.9	Sitting	7.1	Sitting	8.4	Sitting	35.8	Safe
29	7.7	Sitting	6.1	Sitting	7.0	Sitting	7.7	Sitting	39.1	Safe
30	7.2	Sitting	5.7	Sitting	6.5	Sitting	7.2	Sitting	29.2	Safe
31	8.8	Sitting	7.1	Sitting	8.1	Sitting	9.0	Sitting	36.7	Safe
32	8.7	Sitting	7.0	Sitting	8.0	Sitting	8.7	Sitting	36.0	Safe
33	9.2	Sitting	7.3	Sitting	8.5	Sitting	8.9	Sitting	37.7	Safe
34	5.9	Sitting	4.4	Sitting	5.1	Sitting	6.0	Sitting	22.3	Safe
35	5.9	Sitting	4.4	Sitting	5.2	Sitting	5.9	Sitting	22.1	Safe

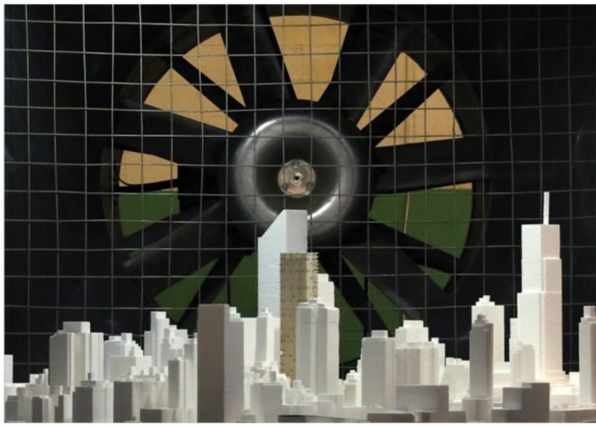
Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-14 km/h = Standing, 14-17 km/h = Strolling, 17-20 km/h =- Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE B2: SUMMARY OF PEDESTRIAN COMFORT (PROPOSED SCENARIO)

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	7.1	Sitting	5.2	Sitting	6.1	Sitting	7.2	Sitting	30.6	Safe
37	7.9	Sitting	5.9	Sitting	6.9	Sitting	7.6	Sitting	29.9	Safe
38	7.3	Sitting	5.8	Sitting	6.6	Sitting	7.2	Sitting	25.7	Safe
39	7.5	Sitting	6.1	Sitting	6.8	Sitting	7.3	Sitting	27.2	Safe
40	7.3	Sitting	5.5	Sitting	6.3	Sitting	7.8	Sitting	36.0	Safe
41	8.3	Sitting	6.0	Sitting	7.2	Sitting	8.6	Sitting	36.0	Safe
42	6.4	Sitting	5.1	Sitting	5.7	Sitting	6.4	Sitting	23.9	Safe
43	7.5	Sitting	5.5	Sitting	6.5	Sitting	7.8	Sitting	32.3	Safe
44	7.9	Sitting	6.1	Sitting	7.0	Sitting	8.6	Sitting	40.9	Safe
45	7.7	Sitting	6.1	Sitting	7.0	Sitting	8.1	Sitting	36.3	Safe
46	7.7	Sitting	5.9	Sitting	6.8	Sitting	8.2	Sitting	39.0	Safe
47	7.0	Sitting	5.3	Sitting	6.2	Sitting	7.4	Sitting	33.6	Safe
48	5.9	Sitting	4.6	Sitting	5.3	Sitting	6.0	Sitting	23.5	Safe
49	5.9	Sitting	4.5	Sitting	5.2	Sitting	5.9	Sitting	23.7	Safe
50	7.0	Sitting	5.1	Sitting	6.1	Sitting	7.0	Sitting	27.3	Safe
51	8.1	Sitting	5.7	Sitting	6.8	Sitting	8.1	Sitting	34.1	Safe
52	8.4	Sitting	5.9	Sitting	7.0	Sitting	8.5	Sitting	35.9	Safe
53	6.8	Sitting	4.9	Sitting	5.8	Sitting	7.1	Sitting	31.1	Safe







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.

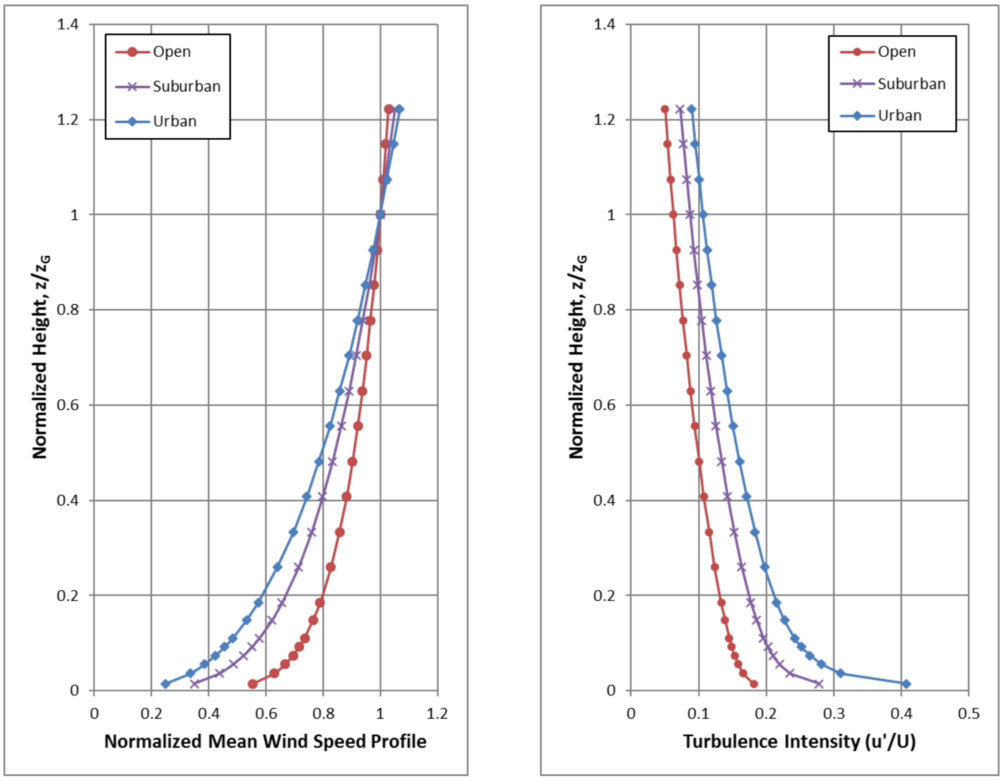

FIGURE C1 (LEFT): MEAN WIND SPEED PROFILES;
FIGURE C2 (RIGHT): TURBULENCE INTENSITY PROFILES

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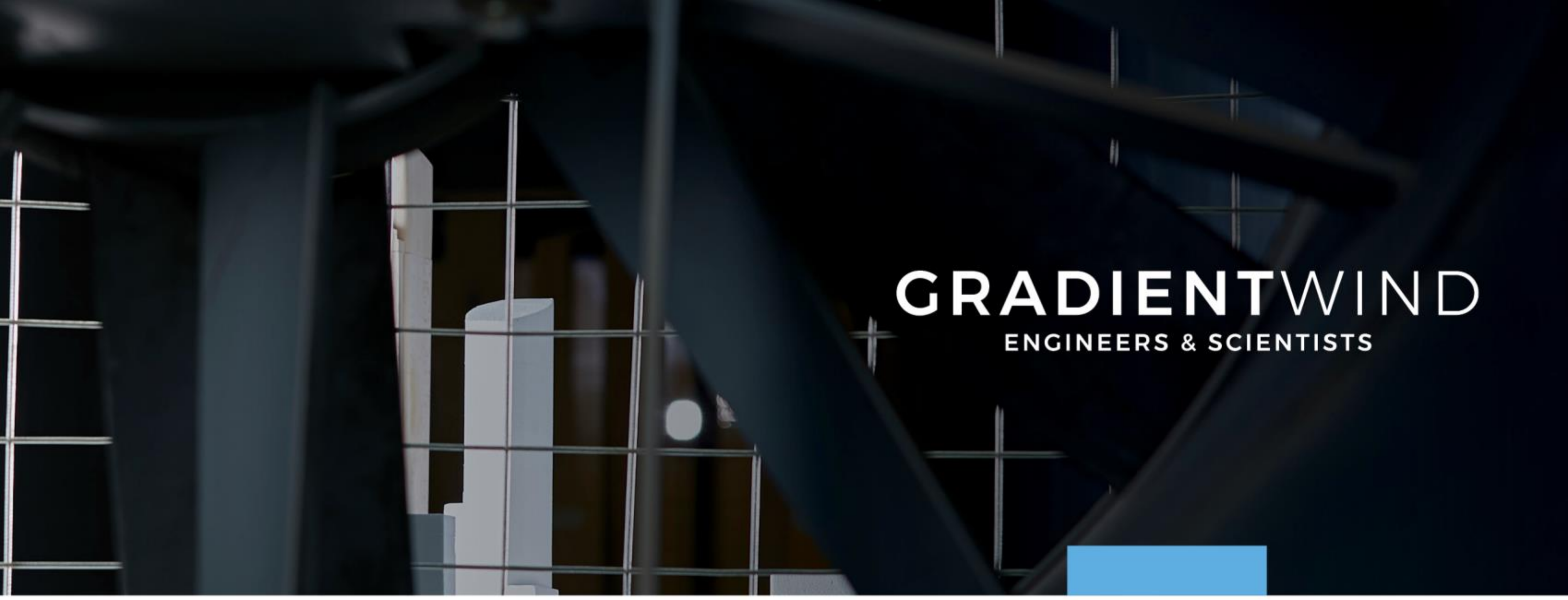
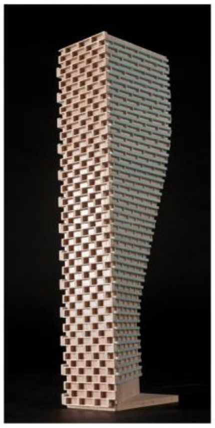
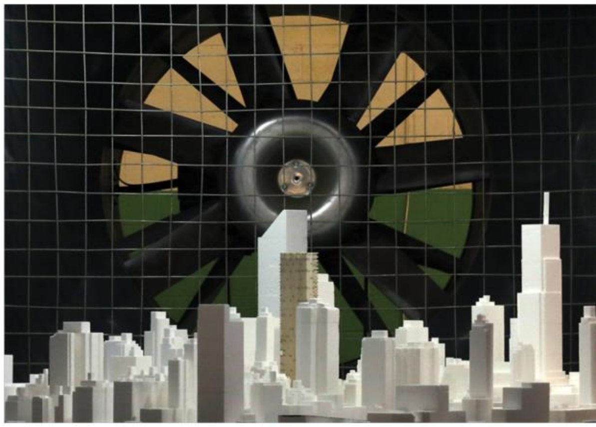
3. ESDU, 'Characteristics of Atmospheric Turbulence Near the Ground', 74030

4. Bradley, E.F., Coppin, P.A., Katen, P.C., '*Turbulent Wind Structure Above Very Rugged Terrain*', 9th Australian Fluid Mechanics Conference, Auckland, Dec. 1966







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:

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

$$P_N(>20) = \Sigma_\theta P\{>20/(U_N/U_g)\}$$

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.

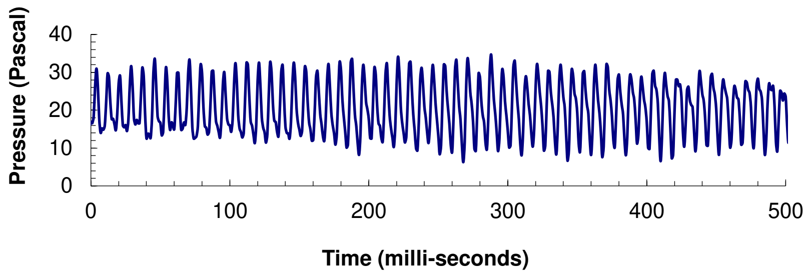

FIGURE D1: TIME VERSUS VELOCITY TRACE FOR A TYPICAL WIND SENSOR

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