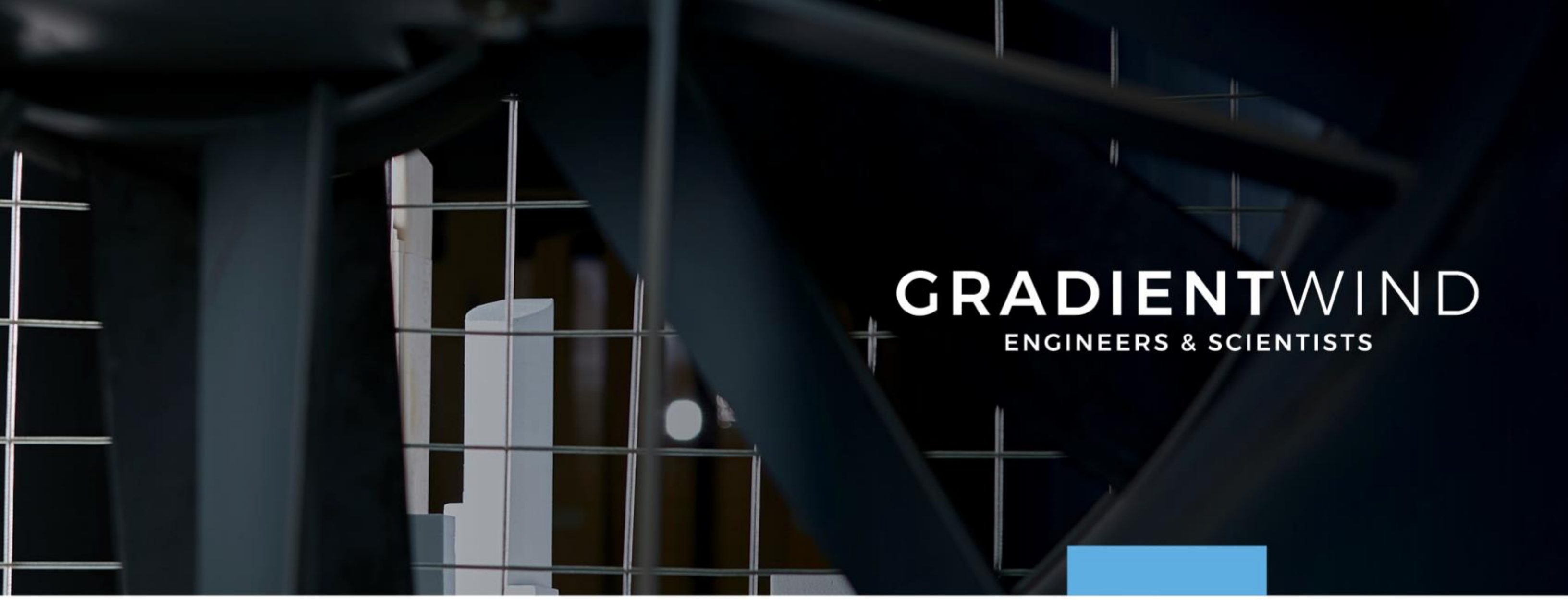
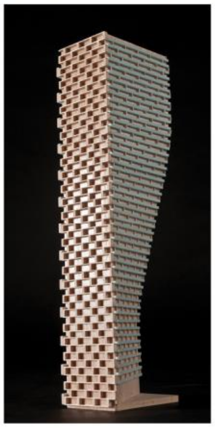
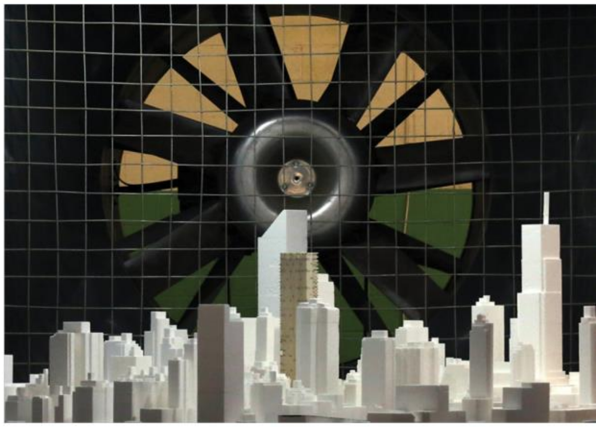


PEDESTRIAN LEVEL WIND STUDY

340-376R Dufferin Street
& 2 Melbourne Avenue
Toronto, Ontario

REPORT: GW22-016-WTPLW





June 16, 2022

PREPARED FOR
Hullmark
474 Wellington Street, Suite 200
Toronto, Ontario
M5V 1E3

PREPARED BY
Nick Petersen, P.Eng., Wind Engineer
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EXECUTIVE SUMMARY

This report describes a comparative pedestrian level wind study undertaken to assess wind conditions for a proposed mixed-use development, known as Hullmark's Radiator Site, located at 340-376R Dufferin Street & 2 Melbourne Avenue in Toronto, Ontario. Two configurations were studied: (i) existing conditions, including all approved, surrounding developments and without the proposed development, and (ii) future conditions with the proposed development in place. The study involves wind tunnel measurements of pedestrian wind speeds using a physical scale model, combined with meteorological data integration, to assess pedestrian comfort at key areas within and surrounding the study site. Grade-level areas investigated include sidewalks, laneways, walkways, parking areas, POPS, courtyards, transit stops, playgrounds, and building access points. Wind comfort is also evaluated over the various elevated 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 Sweeny&Co Architects in March 2022, surrounding street layouts, as well as existing and approved future building massing information obtained from the City of Toronto, and recent site imagery.

A complete summary of the predicted wind conditions is provided in Section 5.2 of this report and is also illustrated in Figures 2A through 4D, as well as Tables A1-A2 and B1-B3 in the appendices. Based on the wind tunnel test results, meteorological data analysis, and experience with similar developments in the Toronto area, we conclude that the future wind conditions over most grade-level pedestrian wind-sensitive areas within and surrounding the study site will be acceptable for the intended uses on a seasonal basis. Exceptions include the covered walkway separating Phases 1 and 2, as well as several internally facing commercial and lobby entrances, for which mitigation is recommended as detailed in Section 5.2.

The Level 3 amenity terrace will experience wind conditions comfortable for sitting or more sedentary activities during the summer months without the need for mitigation. The Level 5 and Level 11 amenity terraces variably exceed the sitting criterion and appropriate mitigatory measures are recommended in Section 5.2.

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

TABLE OF CONTENTS

1. INTRODUCTION

This report describes a comparative pedestrian level wind study undertaken to assess wind conditions for a proposed mixed-use development located at 340-376R Dufferin Street & 2 Melbourne Avenue in Toronto, Ontario. Two configurations were studied: (i) existing conditions, including all approved, surrounding developments and without the proposed development, and (ii) future conditions with the proposed development in place. The study was performed in accordance with industry standard wind tunnel testing techniques, architectural drawings provided by Sweeny&Co Architects in March 2022, surrounding street layouts and existing and approved future building massing information, as well as recent site imagery.

2. TERMS OF REFERENCE

The focus of this comparative pedestrian wind study is the proposed mixed-use development located at 340-376R Dufferin Street & 2 Melbourne Avenue in Toronto, Ontario. The study site is situated towards the southeast corner of a parcel of land bounded by Queen Street West to the north, Dufferin Street to the east, Melbourne Avenue to the south, and Gwynne Avenue to the west.

The study building comprises an approximately U-shaped planform open to the south, encompassing a central courtyard and POPS area. Phase 1 consists of a 6-story building in the northwest, a 25-storey (North Tower) to the northeast, and a 21-storey (South Tower) to the southeast. Phase 2 adds an 11-storey building directly south of South Tower. All buildings are connected with podia of varying heights. At grade, the development comprises primarily of commercial and lobby space with primary building access points fronting Dufferin Street, Melbourne Avenue, and the internal courtyard. A loading zone and ramp to two levels of shared below-grade parking are accessed via Milky Way to the north. Covered walkways at grade separate the 6-storey from North Tower north-south, and the 11-storey from South Tower east-west. Level 2 supports indoor amenity space and is otherwise open to below. At Level 3, both walkways are covered, connecting all buildings with a single floorplate and comprises primarily of residential occupancy with indoor and outdoor amenity space at the northeast corner. At Level 5, the floorplate steps back between the north and south towers accommodating an outdoor amenity terrace. At Level 7 the 6-storey building completes by stepping back towards the North Tower, the floorplate of which steps back again from the west elevation at Level 9 to create the typical North Tower floorplan. The west elevation of the 11-storey south building steps back at Levels 9 and 11, accommodating private and amenity terraces, respectively. At Level 12 the 11-storey completes with a mechanical penthouse, stepping back from the south to the typical South Tower floorplan. The north and south towers rise to their respective heights, where each is completed with a mechanical penthouse.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within a 200-metre (m) radius of the site) are characterized by a mix of low- and mid-rise buildings in all directions, with the CP rail line running from the southeast to the northwest approximately 50 m to the northeast the subject site. The far-field surroundings (defined as the area beyond the near field and within a 2-kilometre (km) radius) are characterized by high-rise buildings to the southeast, bisected by the CP rail line, and mostly low- and mid-rise buildings in all remaining directions. Lake Ontario lies approximately 1.3 km to the south.

Grade-level areas investigated include sidewalks, laneways, walkways, parking areas, POPS, courtyards, transit stops, playgrounds, and building access points. Wind comfort is also evaluated over the various elevated outdoor amenity terraces. 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; (iii) recommend suitable mitigation measures, where required; and (iv) evaluate the influence of the proposed development on the existing wind conditions.

4. METHODOLOGY

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

4.1 Wind Tunnel Context Modelling

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

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

4.2 Wind Speed Measurements

The PLW study was performed by testing a total of 88 sensor locations on the scale model in Gradient Wind's wind tunnel. Of these 88 sensors, 80 were located at grade and the remaining 8 sensors were located over the various elevated amenity terraces. Wind speed measurements were performed for each of the 88 sensors for 36 wind directions at 10° intervals. Figures 1A and 1B illustrate a plan of the existing and proposed site and relevant 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

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

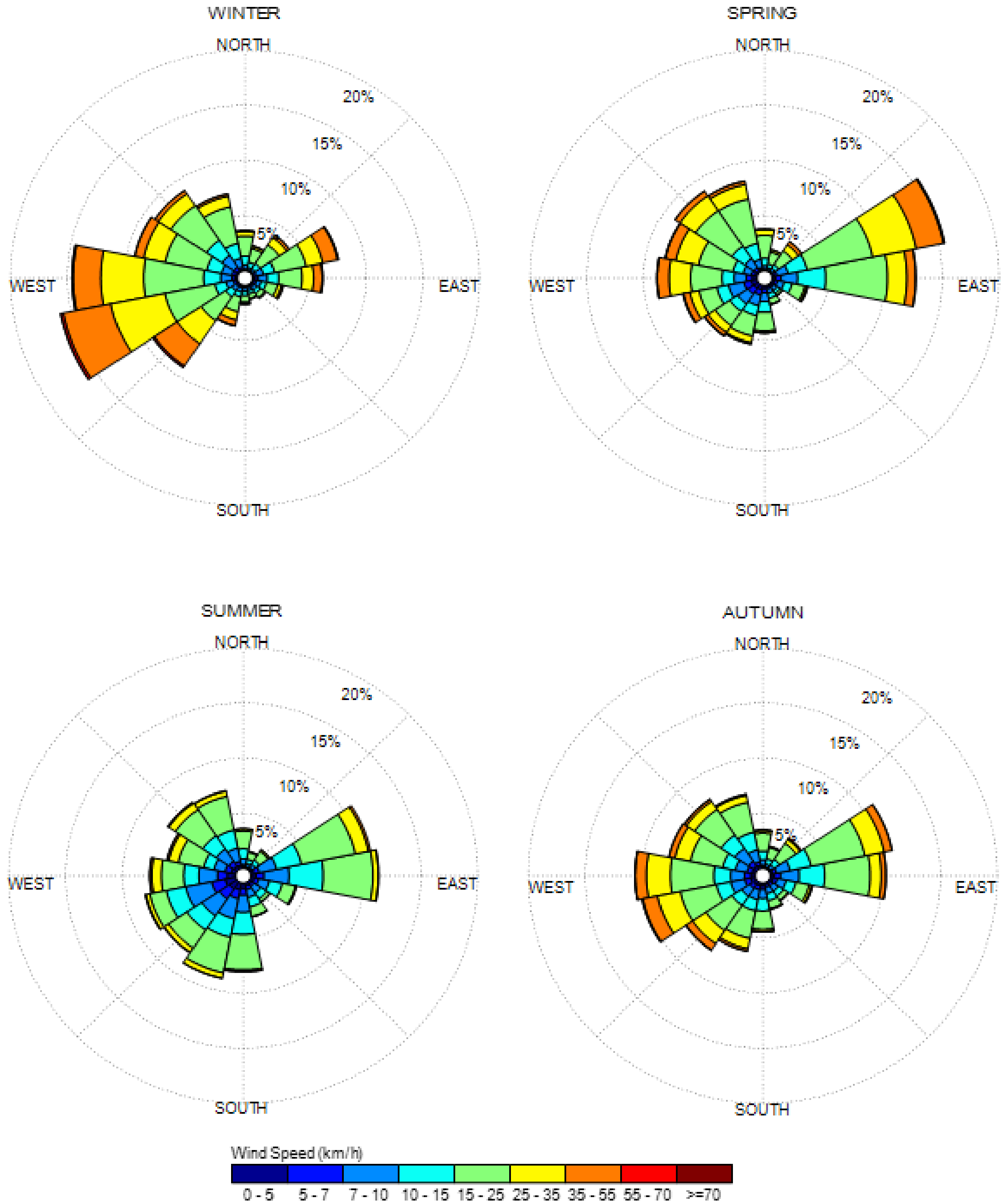
at grade were referenced to the wind speed measured near the ceiling of the wind tunnel to generate mean and peak wind speed ratios. Ceiling height in the wind tunnel represents the depth of the boundary layer of wind flowing over the earth's surface, referred to as the gradient height. Within this boundary layer, mean wind speed increases up to the gradient height and remains constant thereafter. Appendices C and D provide greater detail of the theory behind wind speed measurements. Wind tunnel measurements for this project, conducted in Gradient Wind's wind tunnel facility, meet or exceed guidelines found in the National Building Code of Canada 2015 and of 'Wind Tunnel Studies of Buildings and Structures', ASCE Manual 7 Reports on Engineering Practice No 67.

4.3 Meteorological Data Analysis – Billy Bishop Toronto City Airport

A statistical model for winds in Toronto was developed from over 50 years of hourly meteorological wind data recorded at Billy Bishop Toronto City Airport. 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 Toronto area wind climate, which indicates the directional character of local winds on a seasonal basis, is illustrated on the following page. The plots illustrate seasonal distribution of measured wind speeds and directions in km/h. Probabilities of occurrence of different wind speeds are represented as stacked polar bars in sixteen azimuth divisions. The radial direction 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 Billy Bishop Toronto City Airport, the most common winds concerning pedestrian comfort occur from the southwest clockwise to the north, as well as those from the east-northeast. 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
BILLY BISHOP TORONTO CITY AIRPORT, TORONTO, 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 Guest Equivalent Mean (GEM) wind speed ranges, which include (i) Sitting; (ii) Standing; (iii) Walking; and (iv) Uncomfortable. More specifically, the comfort classes and associated GEM wind speed ranges are summarized as follows:

(i) **Sitting** – A wind speed below 10 km/h (i.e. 0 – 10 km/h) would be considered acceptable for sedentary activities, including sitting.

(ii) **Standing** – A wind speed below 15 km/h (i.e. 10 km/h – 15 km/h) is acceptable for activities such as standing or leisurely strolling.

(iii) **Walking** – A wind speed below 20 km/h (i.e. 15 km/h – 20 km/h) is acceptable for walking or more vigorous activities.

(iv) **Uncomfortable** – A wind speed over 20 km/h is classified as uncomfortable from a pedestrian comfort standpoint. Brisk walking and exercise, such as jogging, would be acceptable for moderate excesses of this 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.

Once the pedestrian wind speed predictions have been established at tested locations, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for their associated spaces. This step involves comparing the predicted comfort class to the desired comfort class, which is dictated by the location type represented by the sensor (i.e. a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their desired comfort classes are summarized below.

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

5. RESULTS AND DISCUSSION

Tables A1 and A2 in Appendix A provide a summary of seasonal comfort predictions for each sensor location under the *existing* massing scenario. Similarly, Tables B1 through B3 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 15-20 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, 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, walking by yellow, and uncomfortable by orange. For locations where the wind safety criterion is exceeded, the sensor is highlighted in red.

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, laneways, and parking areas within and surrounding the study site currently experience wind conditions suitable for walking or better during each seasonal period.
2. The existing playground on the south side of Melbourne Avenue (Sensor 12) will be suitable for sitting on a seasonal basis, which is ideal.
3. Most nearby existing transit stops will be comfortable for standing or better on a seasonal basis, with the exception of the stop at the southwest corner of the intersection of Dufferin Street and Queens Street West (Sensor 29), which is comfortable for walking during the winter months.
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. Most public sidewalks, walkways, laneways, and parking areas within and surrounding the proposed development will experience wind conditions suitable for walking or better on a seasonal basis, which is appropriate for the intended uses of the spaces. An exception is the east-

west covered walkway separating the Phase 1 and Phase 2 developments (Sensor 56-58), which variably exceeds the walking criterion during the winter months. To achieve acceptable conditions within the corridor on a seasonal basis it is recommended to instal vertical wind barriers, comprising high-solidity windscreens, dense coniferous plantings in raised planters, or a combination thereof, in a staggered arrangement at the west side of the corridor to buffer salient westerly winds. The exact configuration can be coordinated with the design team as the landscaping plan progresses.

2. Most primary and secondary building access points throughout the development will be comfortable for standing or better and walking or better, respectively, throughout each seasonal period, which is acceptable. To ensure the Phase 1 internal courtyard facing Flex/Studio lobby entrance (Sensor 67) and Flex/Commercial entrance (Sensor 54) will be suitable for standing or better throughout the year it is recommended to either recess the entrances within the building façade, or flank the entrances with vertical wind barriers and provide a canopy overhead. A similar approach may be applied to the windy Phase 2 north elevation Flex/Commercial entrance (Sensor 56), however a more practical approach may be to limit entrances to the east and west elevations (Sensors 80 and 73, respectively) where conditions are calmer.

3. The existing playground on the south side of Melbourne Avenue (Sensor 12) will be suitable for sitting on a seasonal basis, which is ideal.

4. Regarding nearby transit stops, the two stops to the southeast of the site at the intersection of Dufferin Street and Melbourne Avenue (Sensors 16 & 78) will be comfortable for standing or better throughout the year, which is acceptable. The two stops to the northeast at the intersection of Dufferin Street and Queen Street West (Sensors 28 & 29) will exceed the standing criterion on a limited basis, however these locations are already equipped with transit shelters, which is considered appropriate mitigation.

5. The internal courtyard and POPS area (Sensors 51-55 & 69-77) will generally be suitable for sitting during the summer, standing or better throughout the spring and autumn, and walking or better during the winter. The noted conditions are considered acceptable.

6. The Level 3 amenity terrace at the east side of the building (Sensors 83 & 84) will be comfortable for sitting or more sedentary activities throughout the spring, summer, and autumn months, without the need for mitigation.

7. Without mitigation, the Level 5 amenity terrace (Sensors 85-88) will be comfortable for standing during the summer and autumn, becoming suitable for walking or better throughout the remaining seasonal periods. To ensure conditions suitable for sitting or more sedentary activities during the summer months, it is recommended to raise the west terrace perimeter guard to 2.4 metres above the walking surface and to extend a canopy or pergola structure at least 2.0 metres from the North Tower's south façade and South Tower' north facade.

8. The Level 11 amenity terrace (Sensors 81 & 82) will be comfortable for standing during the spring and summer, and walking or uncomfortable throughout the rest of the year. To achieve conditions suitable for sitting or more sedentary activities throughout the warmer months, it is recommended to raise the full perimeter guard to 2.0-metres-tall.

9. 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 340-376R Dufferin Street & 2 Melbourne Avenue in Toronto, 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 of this report and is also illustrated in Figures 2A through 4D, as well as Tables A1-A2 and B1-B3 in the appendices. Based on the wind tunnel test results, meteorological data analysis, and experience with similar developments in the Toronto area, we conclude that the future wind conditions over most grade-level pedestrian wind-sensitive areas within and surrounding the study site will be acceptable for the intended uses on a seasonal basis. Exceptions include the covered walkway separating Phases 1 and 2, as well as several internally facing commercial and lobby entrances, for which mitigation is recommended as detailed in Section 5.2.

The Level 3 amenity terrace will experience wind conditions comfortable for sitting or more sedentary activities during the summer months without the need for mitigation. The Level 5 and Level 11 amenity terraces variably exceed the sitting criterion and appropriate mitigatory measures are recommended in Section 5.2.

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

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

Sincerely,

Gradient Wind Engineering Inc.

Nick Petersen, P.Eng.,
Wind Engineer

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

GW22-016-WTPLW

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

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

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 <u>STUDY MODEL</u> LOOKING NORTHWEST

PHOTOGRAPH 6: CLOSE-UP VIEW OF <u>STUDY MODEL</u> LOOKING NORTHEAST

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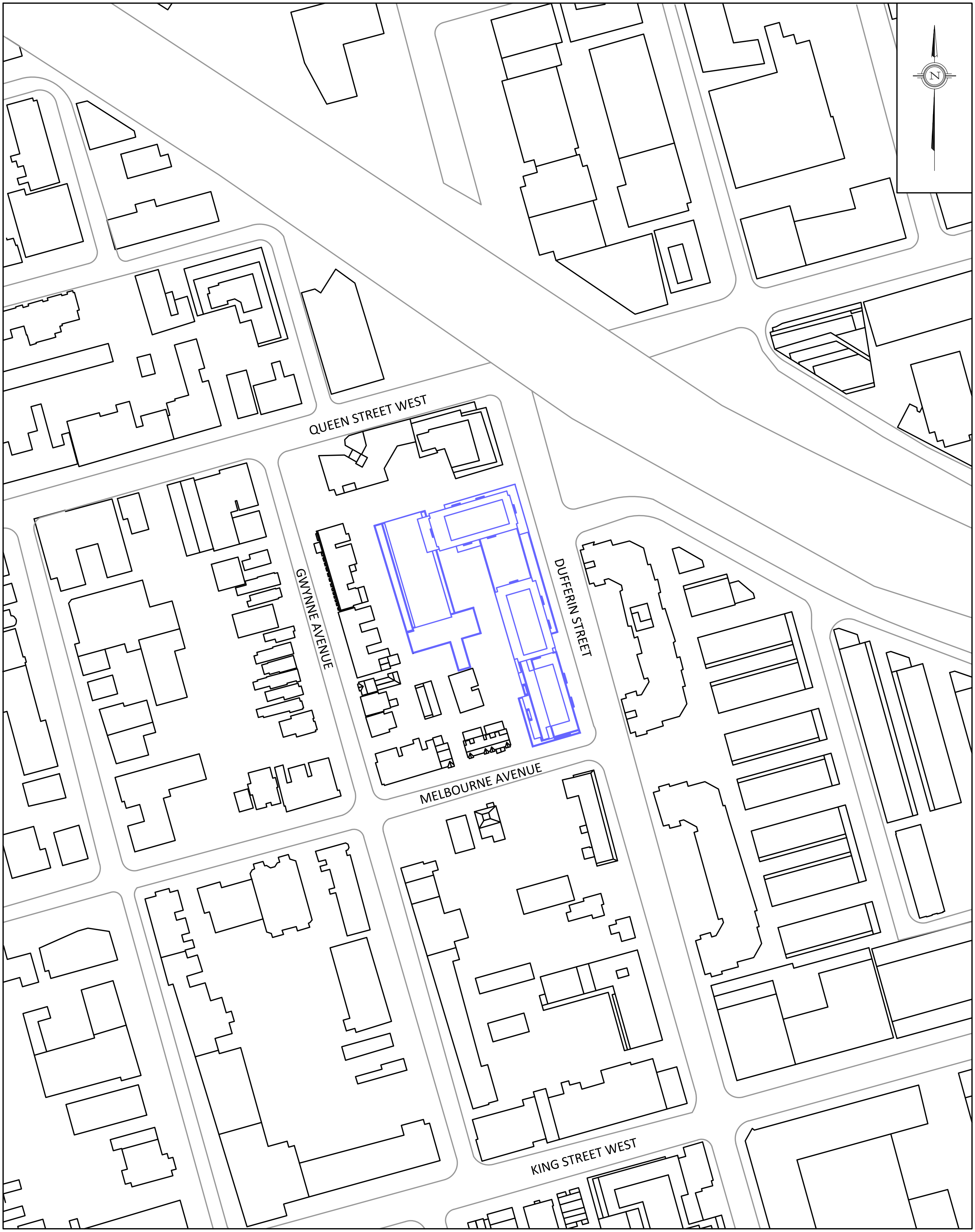
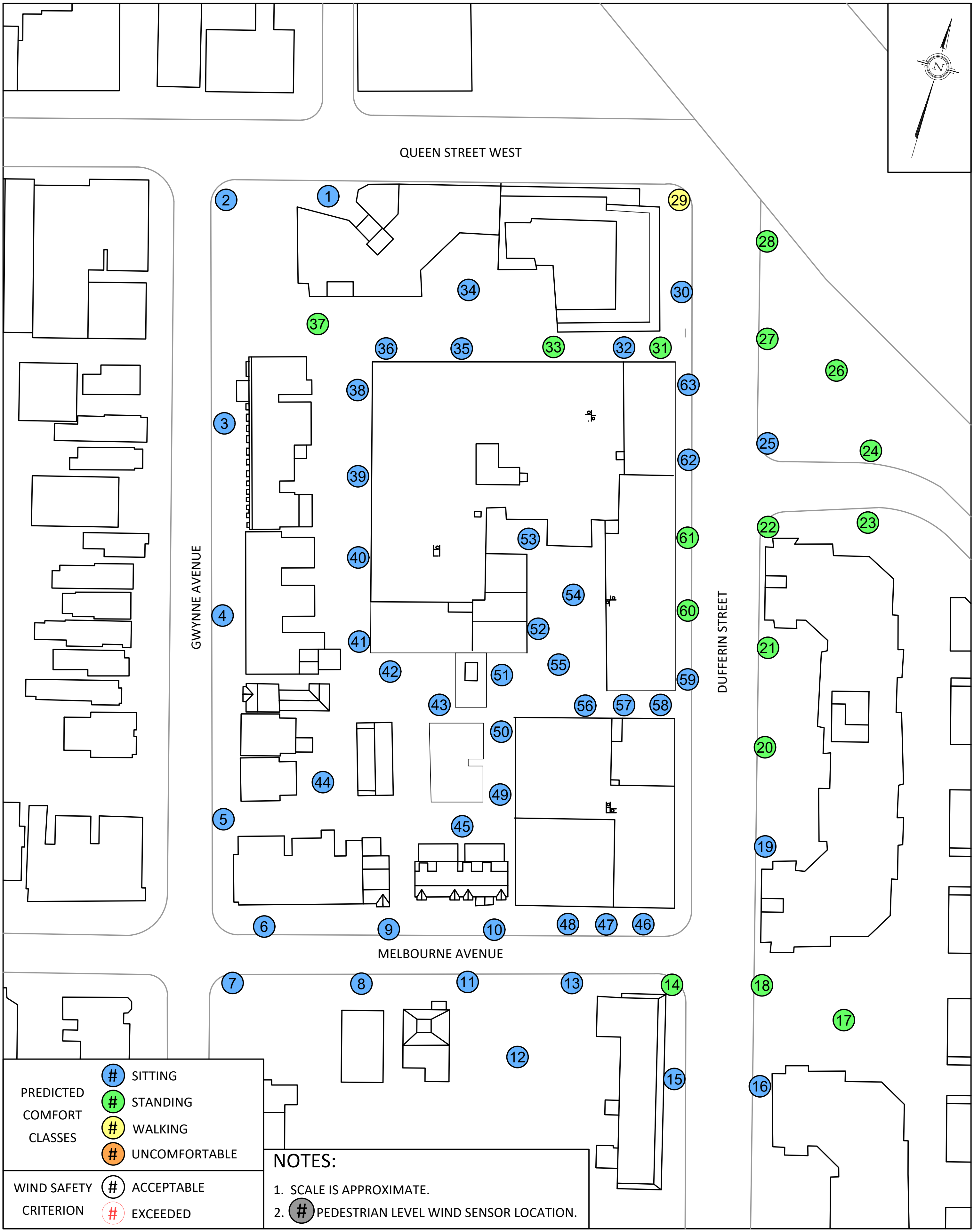
PROJECT		DESCRIPTION
340-376R DUFFERIN STREET,TORONTO PEDESTRIAN LEVEL WIND STUDY		FIGURE 1A: SITE PLAN AND SURROUNDING CONTEXT EXISTING SCENARIO
SCALE: 1:2500 (APPROX.)	DRAWING NO.: GW22-016-PLW-1A	
DATE: JUNE 17, 2022	DRAWN BY: K.A.	



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD, OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT 340-376R DUFFERIN STREET,TORONTO PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION FIGURE 1B: SITE PLAN AND SURROUNDING CONTEXT FUTURE SCENARIO
	SCALE 1:2500 (APPROX.)	DRAWING NO. GW22-016-PLW-1B	
	DATE JUNE 17, 2022	DRAWN BY K.A.	



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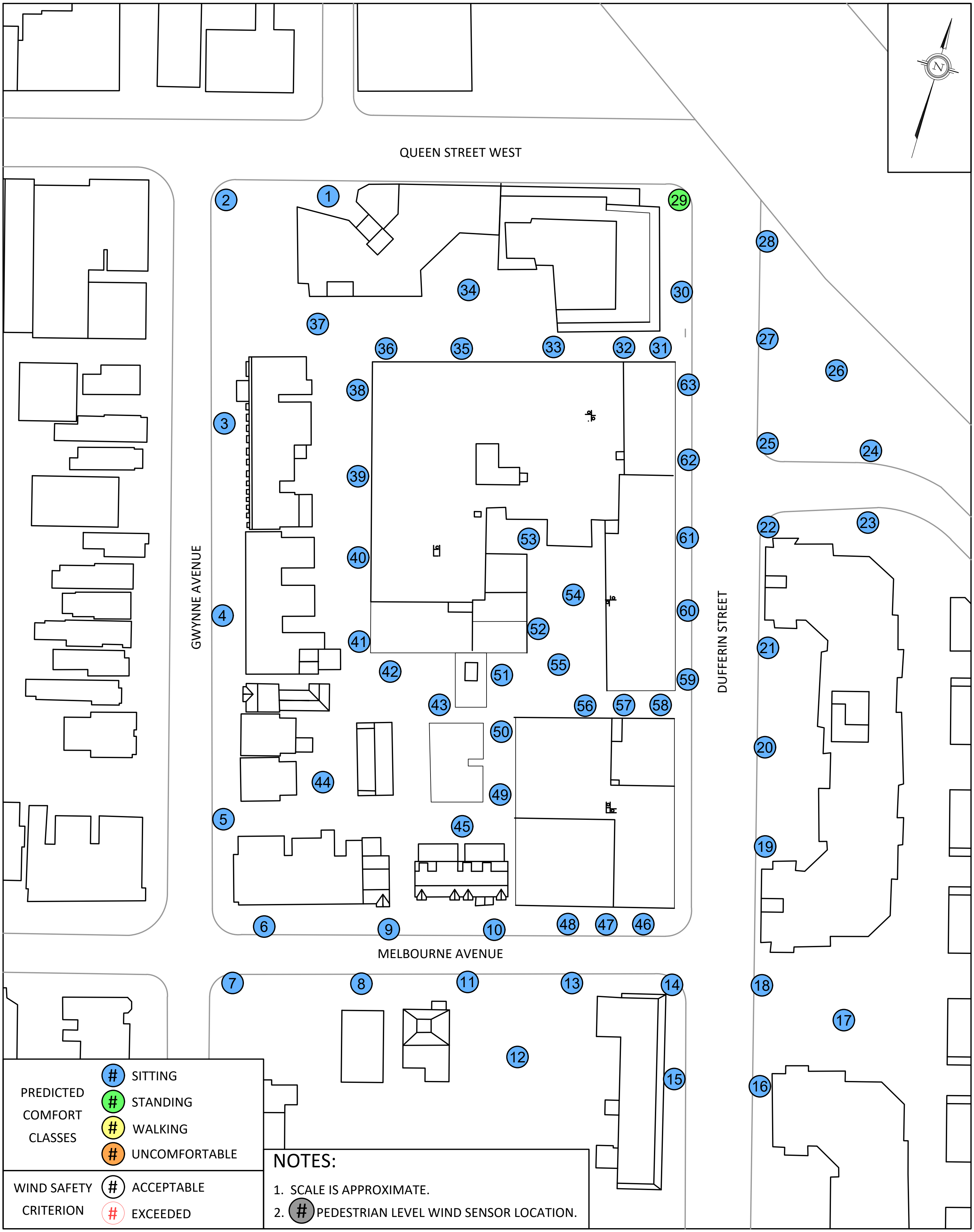
PROJECT: 340-376R DUFFERIN STREET, TORONTO PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 2A: SPRING EXISTING GROUND LEVEL PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:1200 (APPROX.)	DRAWING NO.: GW22-016-PLW-2A	
DATE: JUNE 17, 2022	DRAWN BY: K.A.	



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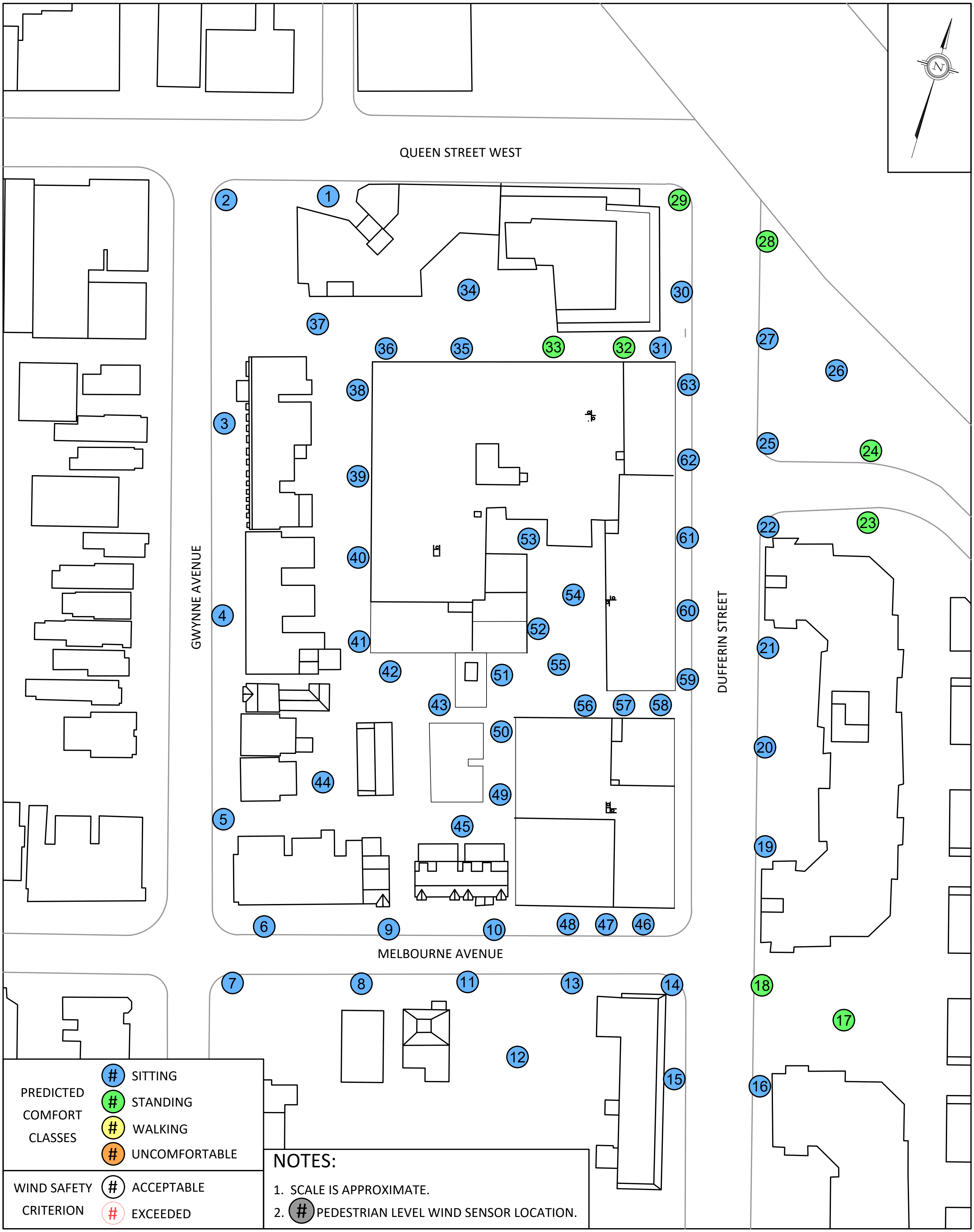
PROJECT	340-376R DUFFERIN STREET,TORONTO PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1200 (APPROX.)
DRAWING NO.	GW22-016-PLW-2B
DATE	JUNE 17, 2022
DRAWN BY	K.A.
DESCRIPTION	FIGURE 2B: SUMMER EXISTING GROUND LEVEL PEDESTRIAN COMFORT PREDICTIONS



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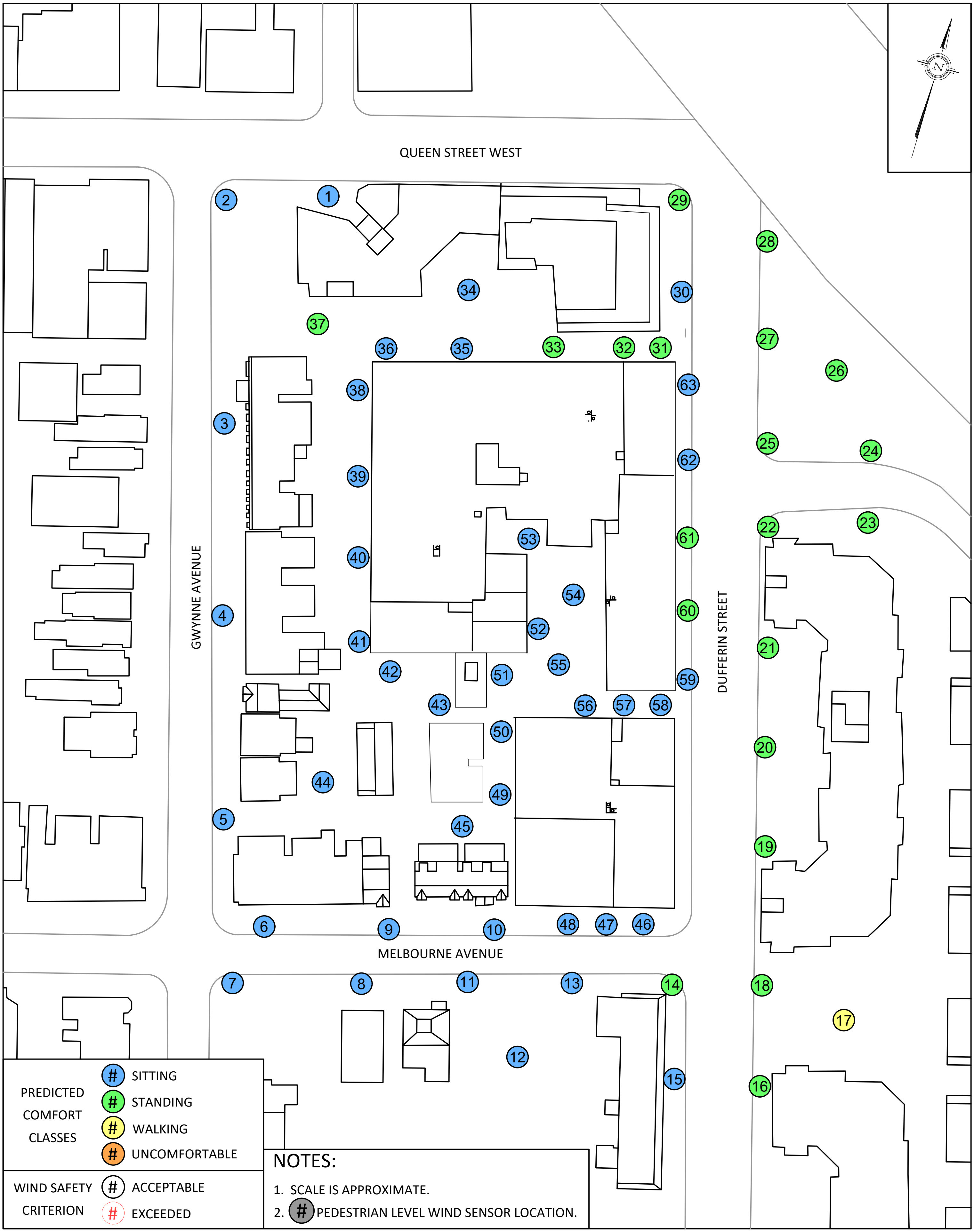
PROJECT: 340-376R DUFFERIN STREET, TORONTO PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 2C: AUTUMN EXISTING GROUND LEVEL PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:1200 (APPROX.)	DRAWING NO.: GW22-016-PLW-2C	
DATE: JUNE 17, 2022	DRAWN BY: K.A.	



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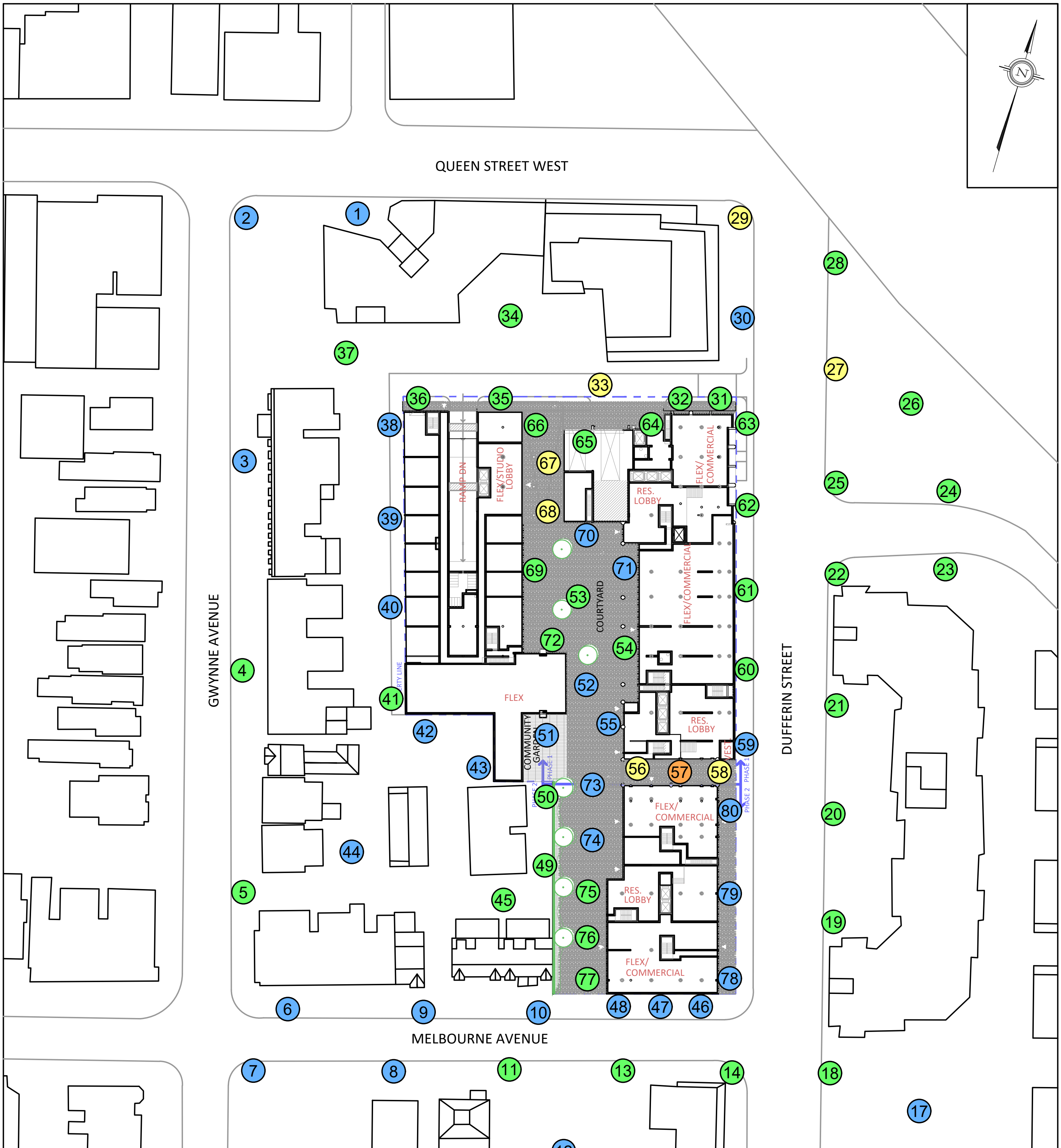
PROJECT: 340-376R DUFFERIN STREET, TORONTO PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 2D: WINTER EXISTING GROUND LEVEL PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:1200 (APPROX.)	DRAWING NO.: GW22-016-PLW-2D	
DATE: JUNE 17, 2022	DRAWN BY: K.A.	



PREDICTED COMFORT CLASSES
- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

WIND SAFETY CRITERION
- # ACCEPTABLE
- # EXCEEDED

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

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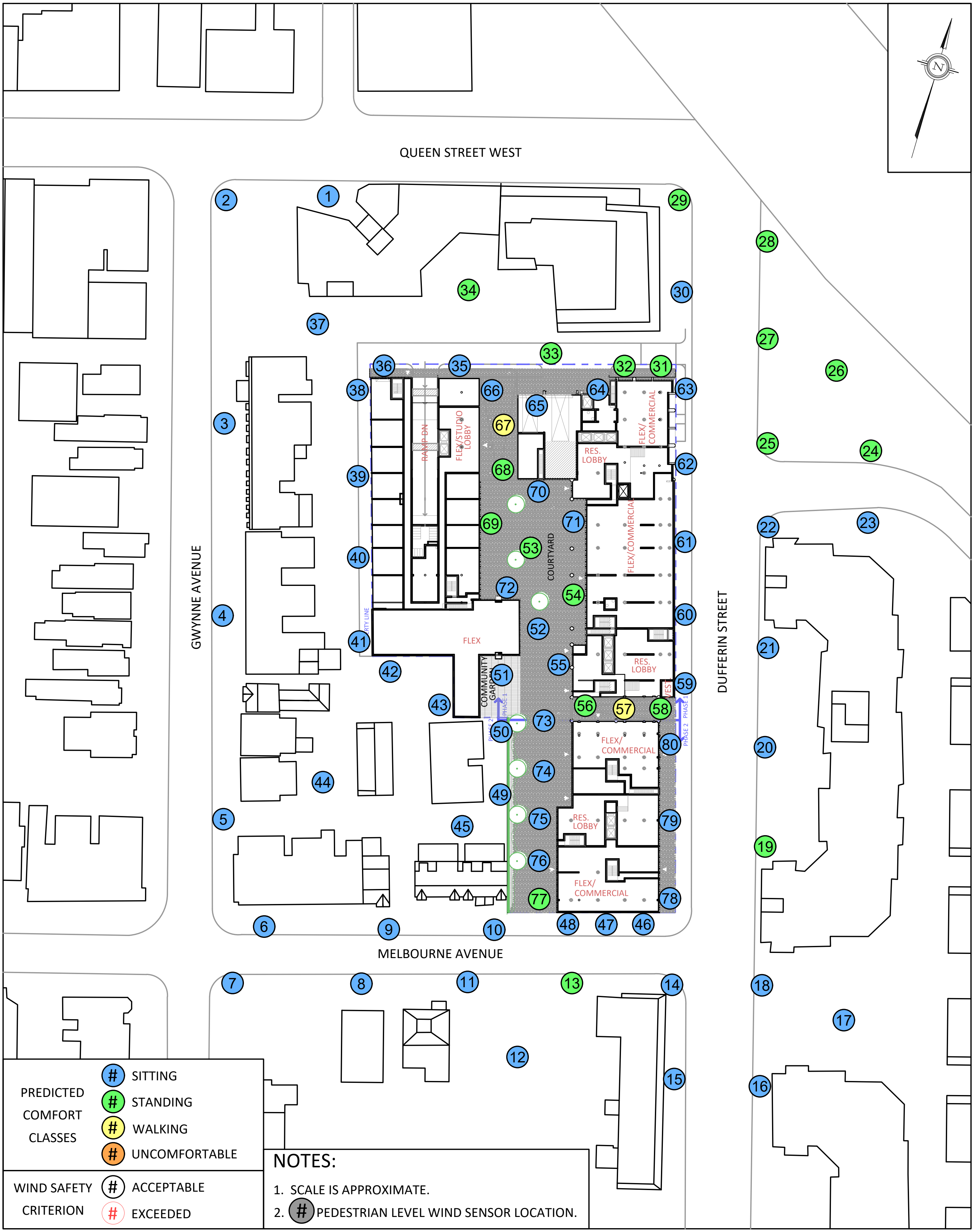
PROJECT	340-376R DUFFERIN STREET,TORONTO PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1200 (APPROX.)
DRAWING NO.	GW22-016-PLW-3A
DATE	JUNE 17, 2022
DRAWN BY	K.A.
DESCRIPTION	FIGURE 3A: SPRING GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CLASSES

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

WIND SAFETY CRITERION

- # ACCEPTABLE
- # EXCEEDED

NOTES:

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

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PROJECT: 340-376R DUFFERIN STREET,TORONTO
PEDESTRIAN LEVEL WIND STUDY

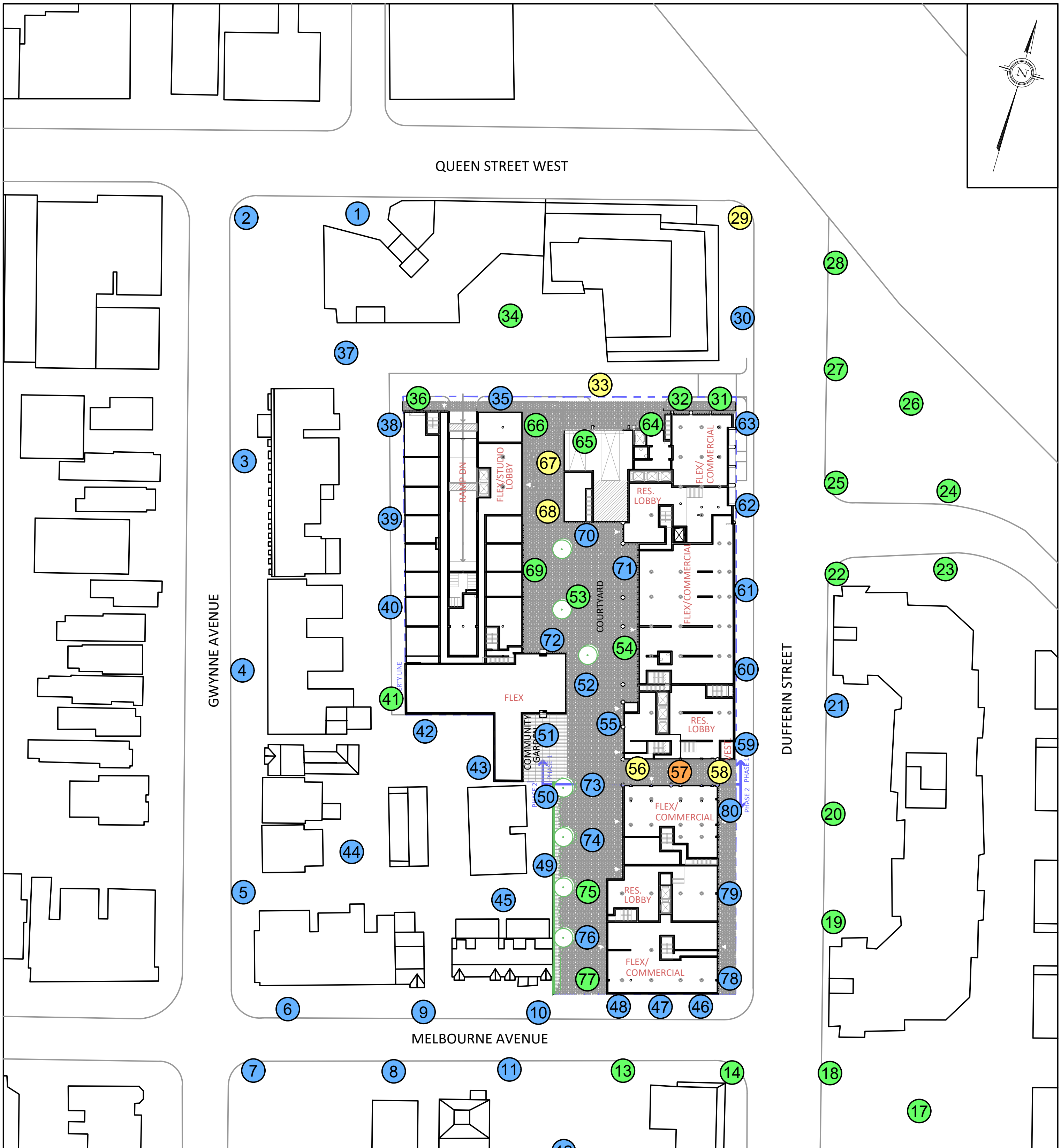
SCALE: 1:1200 (APPROX.)

DRAWING NO. GW22-016-PLW-3B

DATE: JUNE 17, 2022

DRAWN BY: K.A.

DESCRIPTION: FIGURE 3B: SUMMER
GROUND FLOOR PLAN
PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CLASSES

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

WIND SAFETY CRITERION

- # ACCEPTABLE
- # EXCEEDED

NOTES:

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

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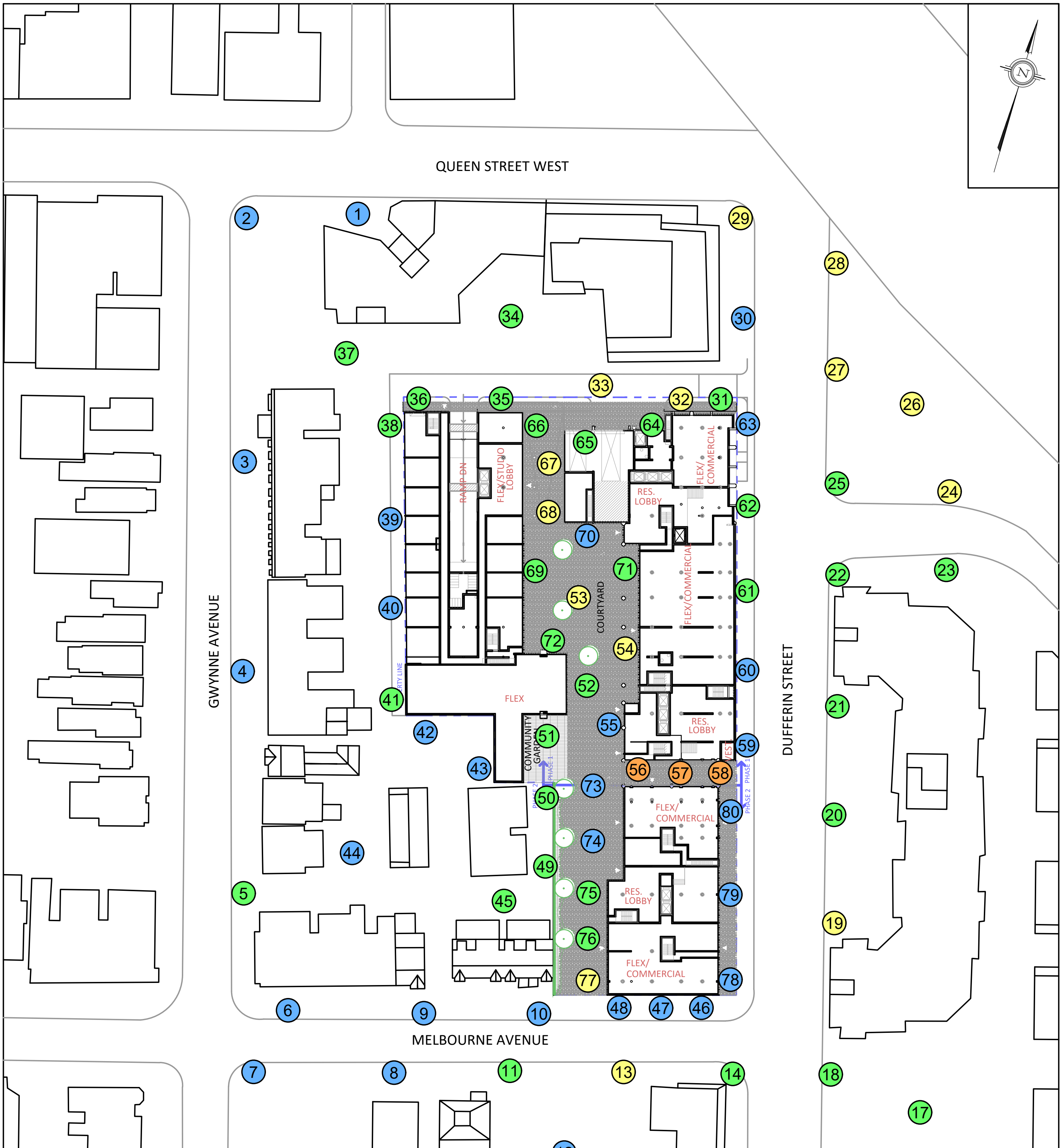
PROJECT	340-376R DUFFERIN STREET,TORONTO PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION
SCALE	1:1200 (APPROX.)	DRAWING NO. GW22-016-PLW-3C	FIGURE 3C: AUTUMN GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS
DATE	JUNE 17, 2022	DRAWN BY K.A.	



PREDICTED COMFORT CLASSES

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

WIND SAFETY CRITERION

- # ACCEPTABLE
- # EXCEEDED

NOTES:

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

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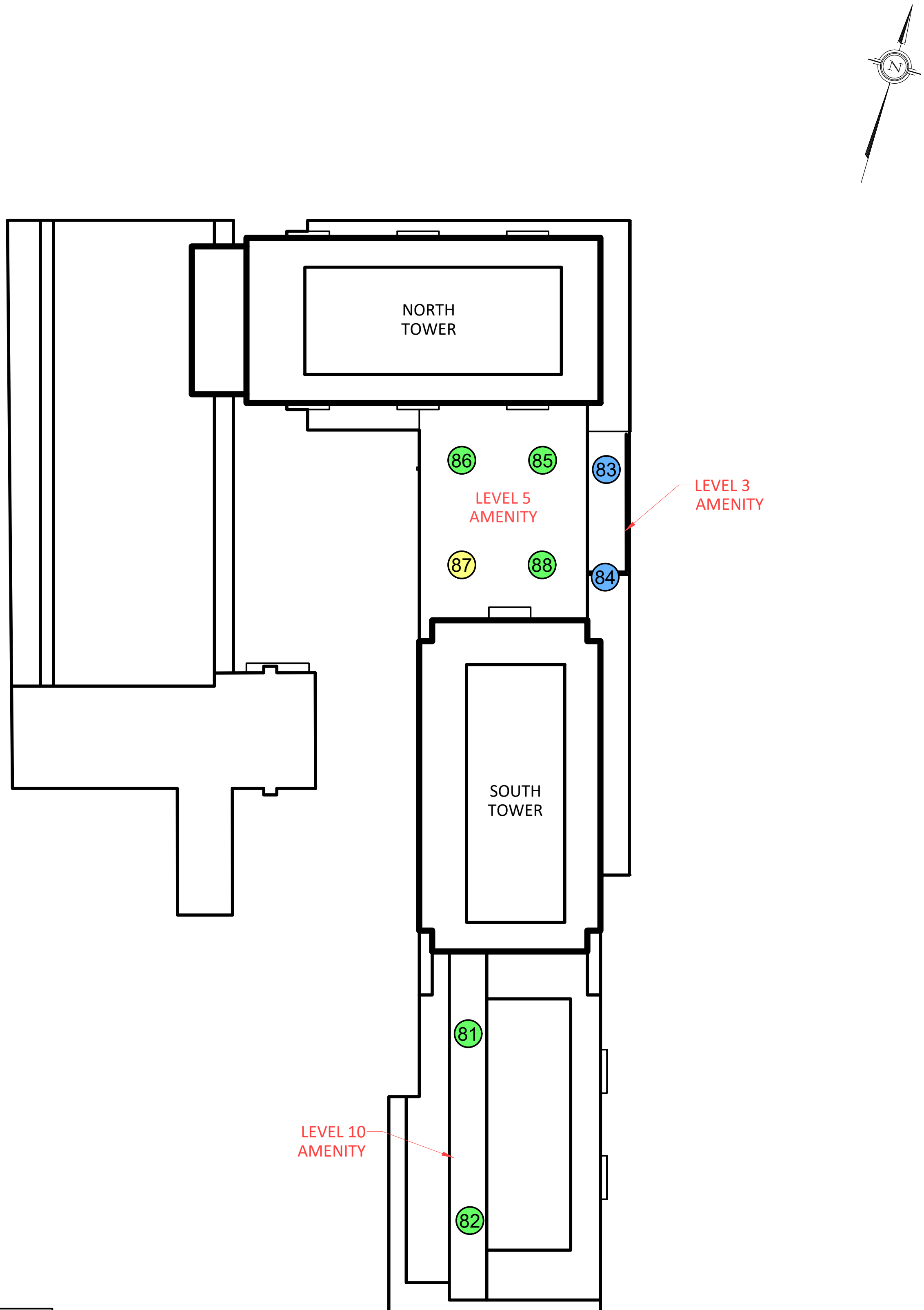
PROJECT: 340-376R DUFFERIN STREET,TORONTO PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 3D: WINTER GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:1200 (APPROX.)	DRAWING NO.: GW22-016-PLW-3D	
DATE: JUNE 17, 2022	DRAWN BY: K.A.	



PREDICTED COMFORT CLASSES
- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

WIND SAFETY CRITERION
- # ACCEPTABLE
- # EXCEEDED

NOTES:

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

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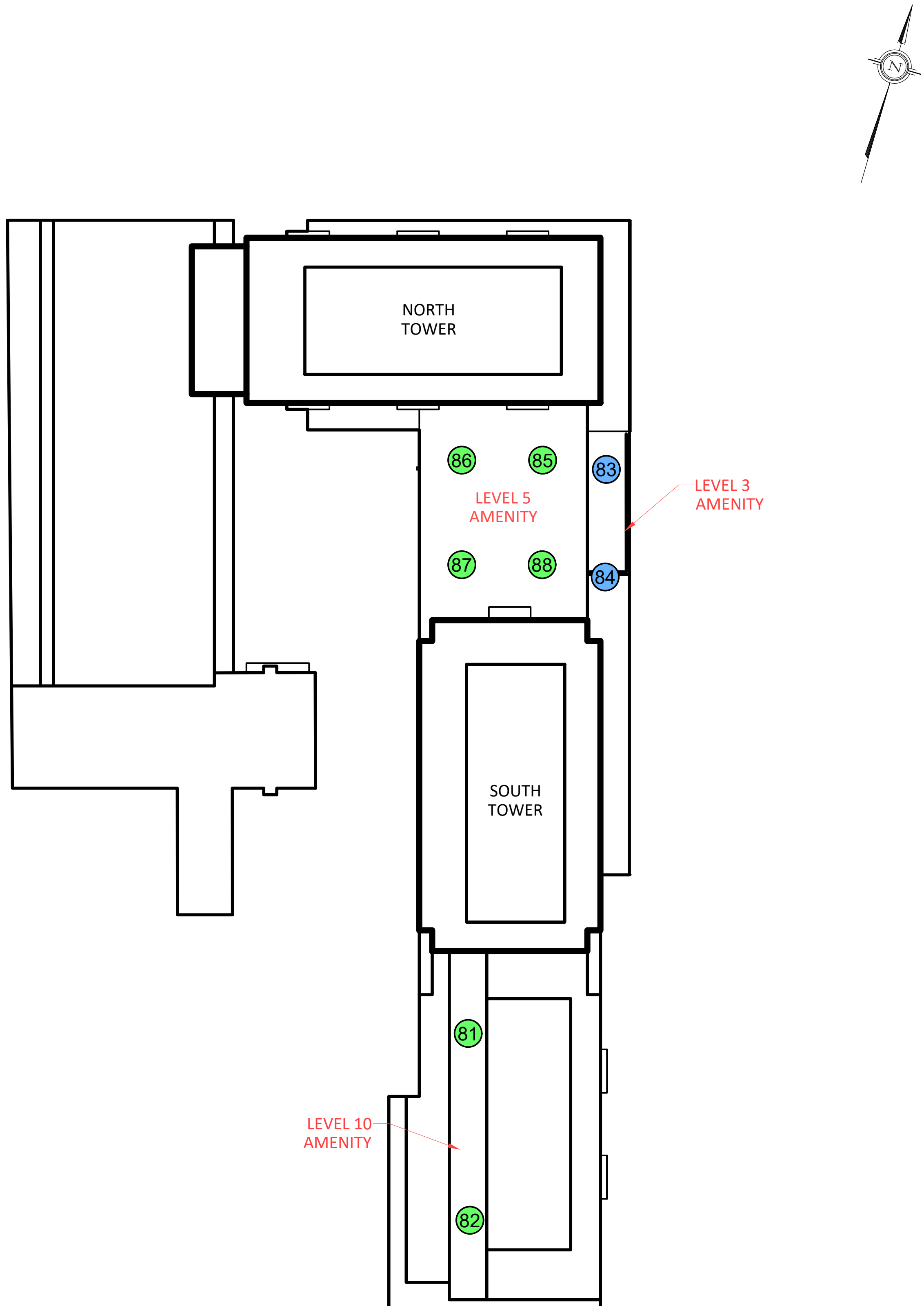
PROJECT	340-376R DUFFERIN STREET,TORONTO PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:750 (APPROX.)	DRAWING NO.	GW22-016-PLW-4A
DATE	JUNE 17, 2022	DRAWN BY	K.A.

DESCRIPTION

FIGURE 4A: SPRING
OUTDOOR AMENITY TERRACES
PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CLASSES
- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

WIND SAFETY CRITERION
- # ACCEPTABLE
- # EXCEEDED

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

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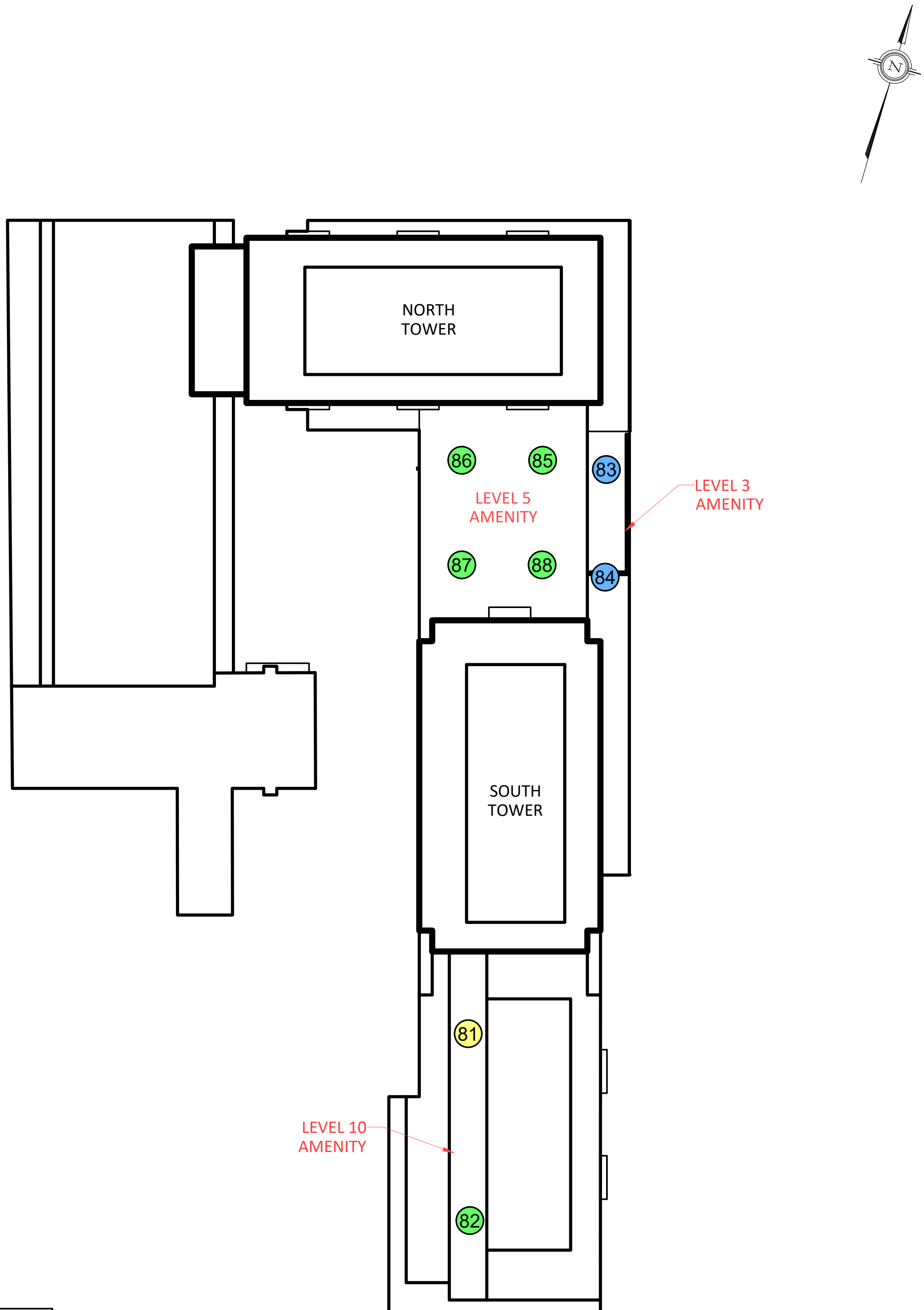
PROJECT	340-376R DUFFERIN STREET,TORONTO PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:750 (APPROX.)	DRAWING NO.	GW22-016-PLW-4B
DATE	JUNE 17, 2022	DRAWN BY	K.A.

DESCRIPTION

FIGURE 4B: SUMMER
OUTDOOR AMENITY TERRACES
PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CLASSES
- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

WIND SAFETY CRITERION
- # ACCEPTABLE
- # EXCEEDED

NOTES:

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

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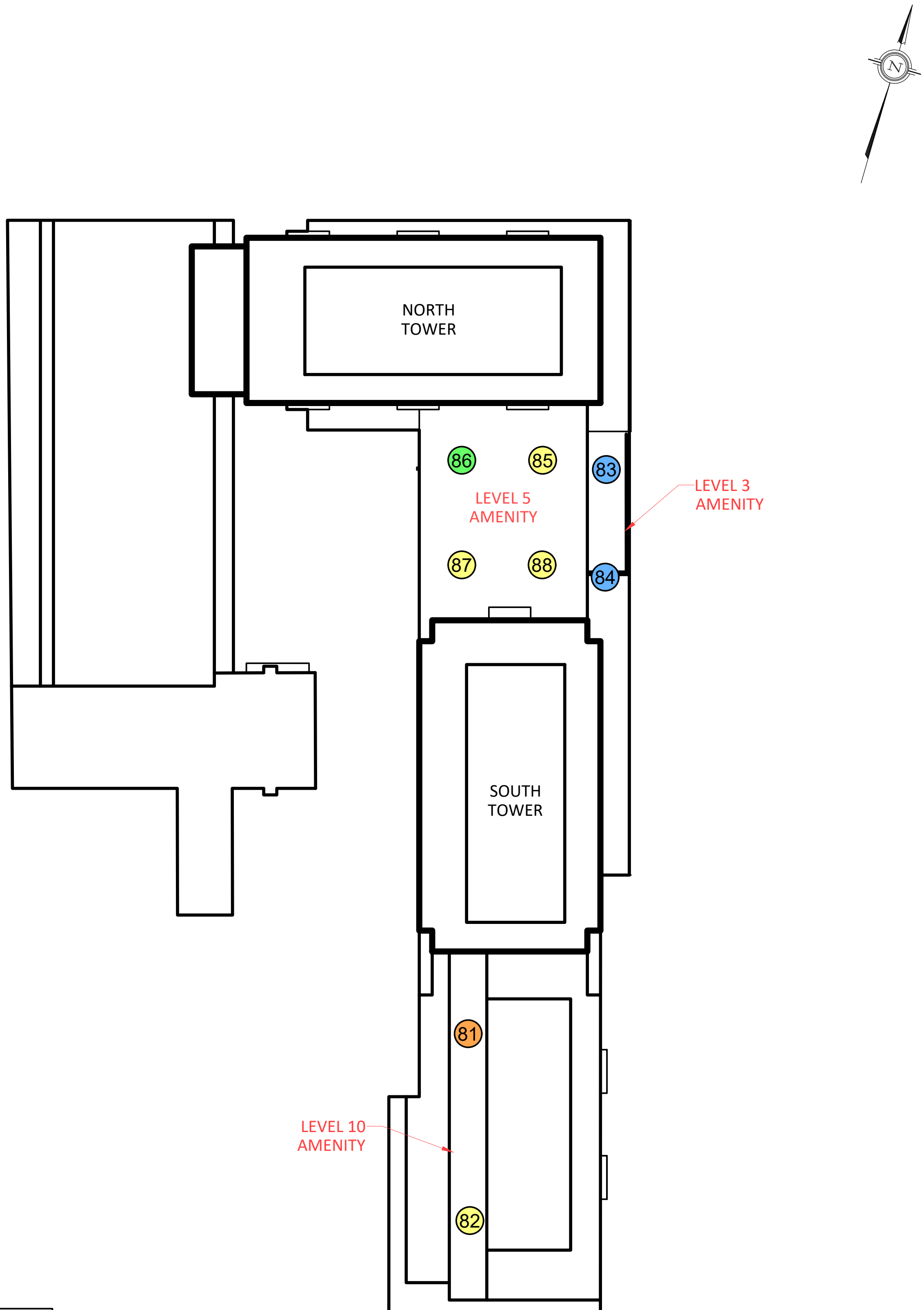
PROJECT	340-376R DUFFERIN STREET,TORONTO PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:750 (APPROX.)	DRAWING NO.	GW22-016-PLW-4C
DATE	JUNE 17, 2022	DRAWN BY	K.A.

DESCRIPTION

FIGURE 4C: AUTUMN
OUTDOOR AMENITY TERRACES
PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CLASSES
- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

WIND SAFETY CRITERION
- # ACCEPTABLE
- # EXCEEDED

NOTES:

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

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PROJECT: 340-376R DUFFERIN STREET,TORONTO PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 4D: WINTER OUTDOOR AMENITY TERRACES PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:750 (APPROX.)	DRAWING NO. GW22-016-PLW-4D	
DATE: JUNE 17, 2022	DRAWN BY: K.A.	

APPENDIX A

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

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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

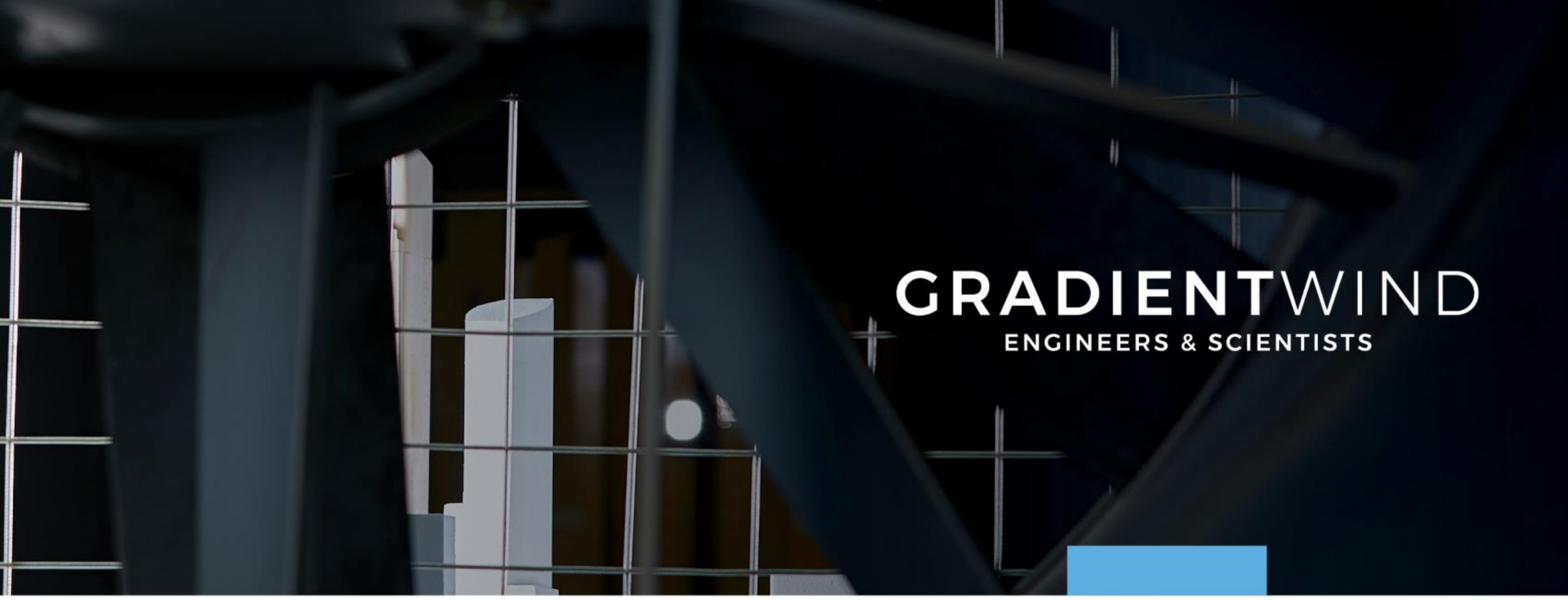
TABLE A1: SUMMARY OF PEDESTRIAN COMFORT (EXISTING SCENARIO)

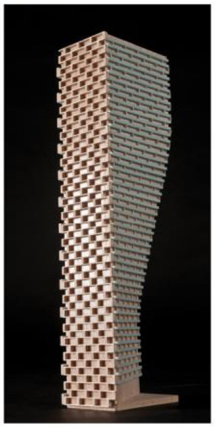
Sensor	Pedestrian Comfort								Pedestrian Safety	
	Spring		Summer		Autumn		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
1	9.5	Sitting	7.7	Sitting	8.2	Sitting	9.7	Sitting	36.9	9.1
2	8.7	Sitting	7.0	Sitting	7.5	Sitting	8.7	Sitting	34.4	8.5
3	7.6	Sitting	6.2	Sitting	6.8	Sitting	7.9	Sitting	30.5	7.1
4	8.9	Sitting	7.2	Sitting	8.0	Sitting	9.6	Sitting	38.6	8.2
5	9.8	Sitting	7.7	Sitting	8.4	Sitting	10.0	Sitting	38.7	9.0
6	8.8	Sitting	6.9	Sitting	8.0	Sitting	9.5	Sitting	36.9	8.5
7	9.0	Sitting	7.1	Sitting	7.8	Sitting	9.6	Sitting	41.1	8.4
8	7.9	Sitting	6.1	Sitting	6.8	Sitting	8.2	Sitting	37.9	7.4
9	8.8	Sitting	7.1	Sitting	8.0	Sitting	9.7	Sitting	36.3	8.6
10	7.0	Sitting	5.7	Sitting	6.4	Sitting	7.7	Sitting	30.3	6.7
11	8.0	Sitting	6.1	Sitting	6.9	Sitting	8.3	Sitting	34.4	7.9
12	8.1	Sitting	6.5	Sitting	7.1	Sitting	8.3	Sitting	32.3	7.6
13	8.2	Sitting	6.5	Sitting	7.3	Sitting	8.7	Sitting	34.1	7.5
14	10.2	Standing	7.9	Sitting	8.7	Sitting	10.1	Standing	39.2	9.7
15	8.1	Sitting	6.9	Sitting	7.8	Sitting	9.4	Sitting	40.5	7.8
16	8.6	Sitting	7.2	Sitting	8.5	Sitting	10.4	Standing	46.3	8.1
17	11.8	Standing	9.9	Sitting	12.7	Standing	17.0	Walking	66.1	11.3
18	12.0	Standing	9.6	Sitting	11.3	Standing	13.9	Standing	52.5	11.0
19	9.6	Sitting	7.9	Sitting	8.9	Sitting	10.5	Standing	44.0	8.9
20	10.3	Standing	8.3	Sitting	9.2	Sitting	11.2	Standing	44.4	9.7
21	10.1	Standing	8.3	Sitting	9.2	Sitting	11.1	Standing	45.3	9.5
22	11.2	Standing	9.0	Sitting	10.0	Sitting	12.3	Standing	48.6	10.3
23	11.9	Standing	9.0	Sitting	10.6	Standing	13.6	Standing	53.3	11.2
24	12.6	Standing	9.9	Sitting	10.9	Standing	13.4	Standing	47.0	11.8
25	9.4	Sitting	7.6	Sitting	8.5	Sitting	10.1	Standing	40.7	8.6
26	10.8	Standing	8.3	Sitting	9.1	Sitting	10.7	Standing	46.6	9.8
27	11.6	Standing	9.0	Sitting	9.4	Sitting	11.0	Standing	48.1	10.6
28	12.7	Standing	9.8	Sitting	10.3	Standing	12.1	Standing	51.9	11.9
29	15.9	Walking	11.8	Standing	12.7	Standing	14.8	Standing	55.2	14.3
30	9.6	Sitting	7.4	Sitting	7.7	Sitting	8.9	Sitting	42.0	9.0
31	10.4	Standing	8.4	Sitting	9.1	Sitting	10.4	Standing	37.9	10.3
32	12.6	Standing	10.0	Sitting	11.1	Standing	13.0	Standing	45.7	12.6
33	11.5	Standing	9.0	Sitting	10.6	Standing	12.9	Standing	48.4	11.1
34	8.9	Sitting	7.2	Sitting	8.2	Sitting	9.9	Sitting	40.2	8.2
35	8.5	Sitting	6.7	Sitting	7.3	Sitting	8.5	Sitting	36.4	8.1

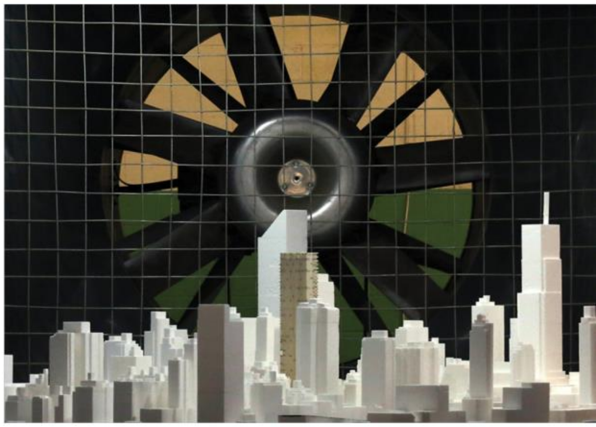
Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE A2: SUMMARY OF PEDESTRIAN COMFORT (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	7.4	Sitting	5.8	Sitting	6.3	Sitting	7.5	Sitting	30.3	Safe
37	11.5	Standing	9.1	Sitting	9.8	Sitting	11.9	Standing	45.0	Safe
38	6.7	Sitting	5.4	Sitting	5.9	Sitting	7.2	Sitting	28.7	Safe
39	8.0	Sitting	6.4	Sitting	7.2	Sitting	8.9	Sitting	37.4	Safe
40	8.2	Sitting	6.6	Sitting	7.5	Sitting	9.1	Sitting	39.2	Safe
41	9.2	Sitting	7.2	Sitting	7.7	Sitting	9.3	Sitting	39.0	Safe
42	6.5	Sitting	5.4	Sitting	6.1	Sitting	7.2	Sitting	30.4	Safe
43	6.9	Sitting	5.6	Sitting	6.1	Sitting	7.4	Sitting	28.5	Safe
44	7.6	Sitting	6.0	Sitting	6.7	Sitting	8.1	Sitting	31.9	Safe
45	7.2	Sitting	5.7	Sitting	6.2	Sitting	7.4	Sitting	28.1	Safe
46	7.7	Sitting	6.3	Sitting	6.9	Sitting	8.1	Sitting	30.6	Safe
47	8.1	Sitting	6.5	Sitting	7.3	Sitting	8.6	Sitting	31.3	Safe
48	7.0	Sitting	5.8	Sitting	6.4	Sitting	7.5	Sitting	27.5	Safe
49	6.4	Sitting	5.0	Sitting	5.6	Sitting	6.6	Sitting	24.7	Safe
50	6.7	Sitting	5.3	Sitting	5.9	Sitting	7.0	Sitting	25.8	Safe
51	6.0	Sitting	4.8	Sitting	5.2	Sitting	6.1	Sitting	21.6	Safe
52	8.6	Sitting	6.6	Sitting	7.1	Sitting	8.3	Sitting	36.1	Safe
53	9.0	Sitting	7.3	Sitting	8.2	Sitting	9.6	Sitting	32.6	Safe
54	7.4	Sitting	6.0	Sitting	6.9	Sitting	8.2	Sitting	32.3	Safe
55	9.3	Sitting	7.2	Sitting	7.9	Sitting	9.4	Sitting	35.8	Safe
56	7.4	Sitting	6.0	Sitting	6.5	Sitting	7.7	Sitting	31.2	Safe
57	8.4	Sitting	6.7	Sitting	7.2	Sitting	8.5	Sitting	36.4	Safe
58	7.1	Sitting	5.7	Sitting	6.2	Sitting	7.1	Sitting	27.9	Safe
59	8.4	Sitting	6.6	Sitting	7.2	Sitting	8.4	Sitting	32.9	Safe
60	10.9	Standing	8.6	Sitting	9.6	Sitting	11.4	Standing	40.9	Safe
61	10.5	Standing	8.5	Sitting	9.6	Sitting	11.5	Standing	41.6	Safe
62	8.0	Sitting	6.4	Sitting	7.1	Sitting	8.4	Sitting	31.5	Safe
63	7.7	Sitting	5.8	Sitting	6.3	Sitting	7.5	Sitting	33.2	Safe







APPENDIX B

PEDESTRIAN COMFORT SUITABILITY, TABLES B1-B3
(PROPOSED SCENARIO)

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

TABLE B1: 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	9.0	Sitting	7.2	Sitting	7.9	Sitting	9.5	Sitting	36.2	Safe
2	9.7	Sitting	7.8	Sitting	8.6	Sitting	10.0	Sitting	37.6	Safe
3	9.9	Sitting	7.9	Sitting	8.7	Sitting	10.0	Sitting	37.0	Safe
4	10.6	Standing	8.1	Sitting	8.8	Sitting	10.5	Sitting	40.5	Safe
5	10.8	Standing	8.1	Sitting	8.7	Sitting	10.2	Standing	39.3	Safe
6	9.1	Sitting	7.2	Sitting	7.9	Sitting	9.3	Sitting	34.3	Safe
7	8.3	Sitting	6.5	Sitting	7.2	Sitting	8.9	Sitting	40.8	Safe
8	9.3	Sitting	7.1	Sitting	7.9	Sitting	9.5	Sitting	41.1	Safe
9	9.5	Sitting	7.5	Sitting	8.2	Sitting	9.5	Sitting	33.9	Safe
10	9.4	Sitting	7.3	Sitting	8.1	Sitting	9.6	Sitting	35.6	Safe
11	10.2	Standing	7.9	Sitting	9.0	Sitting	10.8	Standing	39.9	Safe
12	9.2	Sitting	7.1	Sitting	7.9	Sitting	9.6	Sitting	48.2	Safe
13	13.5	Standing	10.8	Standing	12.6	Standing	15.8	Walking	59.6	Safe
14	12.9	Standing	9.9	Sitting	11.7	Standing	14.7	Standing	65.8	Safe
15	10.5	Standing	8.9	Sitting	10.6	Standing	13.4	Standing	54.1	Safe
16	9.7	Sitting	7.9	Sitting	9.5	Sitting	11.9	Standing	51.8	Safe
17	10.0	Sitting	8.5	Sitting	10.5	Standing	14.6	Standing	66.7	Safe
18	11.0	Standing	9.0	Sitting	10.6	Standing	13.4	Standing	54.0	Safe
19	13.7	Standing	11.5	Standing	14.2	Standing	17.9	Walking	67.9	Safe
20	12.5	Standing	9.7	Sitting	11.4	Standing	13.3	Standing	50.6	Safe
21	10.8	Standing	8.6	Sitting	9.9	Sitting	11.7	Standing	49.0	Safe
22	12.8	Standing	10.0	Sitting	10.9	Standing	12.7	Standing	55.0	Safe
23	12.2	Standing	9.5	Sitting	10.5	Standing	12.9	Standing	56.7	Safe
24	14.3	Standing	11.2	Standing	12.6	Standing	15.4	Walking	57.5	Safe
25	14.0	Standing	10.7	Standing	11.9	Standing	14.4	Standing	61.0	Safe
26	14.6	Standing	11.7	Standing	12.8	Standing	15.8	Walking	56.0	Safe
27	15.1	Walking	11.8	Standing	12.8	Standing	15.4	Walking	58.1	Safe
28	14.5	Standing	11.7	Standing	13.1	Standing	16.0	Walking	54.5	Safe
29	16.9	Walking	13.3	Standing	15.2	Walking	18.4	Walking	59.8	Safe
30	9.3	Sitting	7.4	Sitting	7.9	Sitting	8.8	Sitting	35.5	Safe
31	14.4	Standing	10.5	Standing	11.5	Standing	13.8	Standing	53.4	Safe
32	14.3	Standing	11.0	Standing	13.5	Standing	17.0	Walking	61.0	Safe
33	15.1	Walking	12.4	Standing	15.1	Walking	19.0	Walking	68.2	Safe
34	12.3	Standing	10.2	Standing	10.9	Standing	13.2	Standing	49.6	Safe
35	10.3	Standing	8.1	Sitting	9.1	Sitting	10.3	Standing	42.0	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

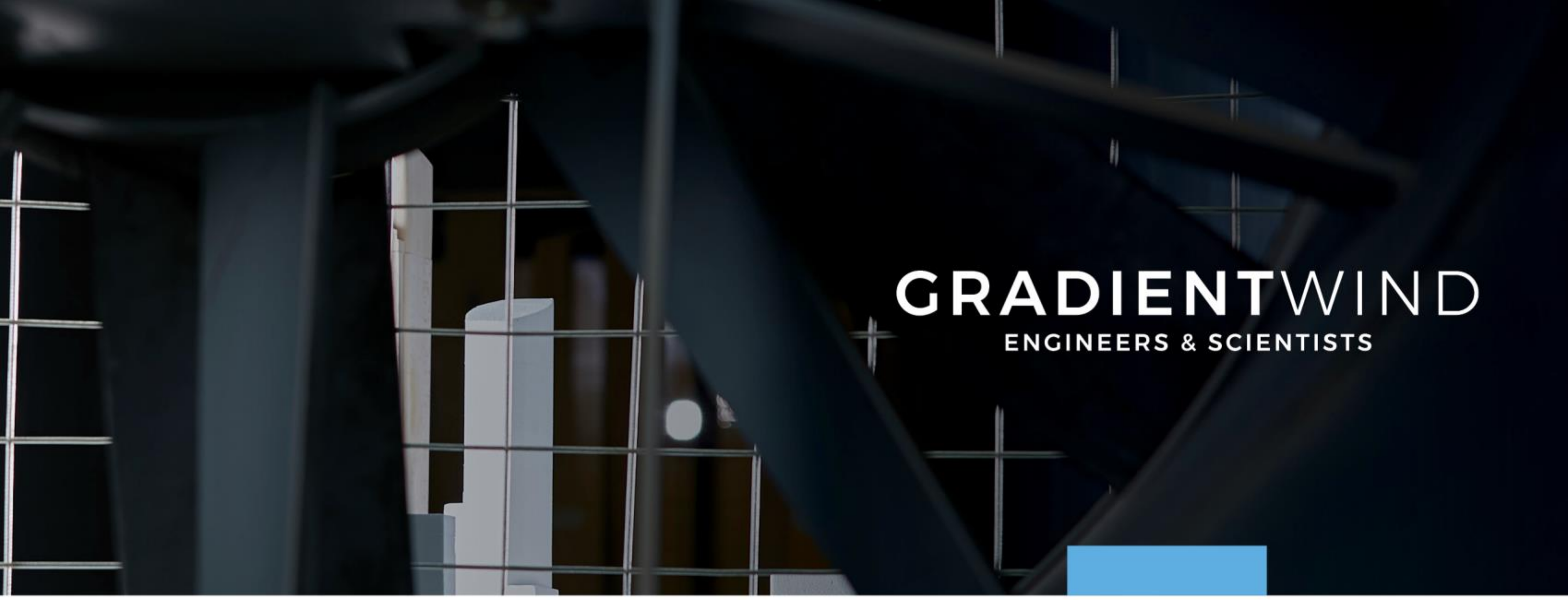
TABLE B2: SUMMARY OF PEDESTRIAN COMFORT (PROPOSED SCENARIO)

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	11.3	Standing	9.1	Sitting	10.1	Standing	12.2	Standing	55.6	Safe
37	10.1	Standing	8.0	Sitting	8.7	Sitting	10.1	Standing	42.7	Safe
38	8.7	Sitting	7.8	Sitting	8.7	Sitting	10.1	Standing	48.9	Safe
39	8.7	Sitting	7.1	Sitting	7.8	Sitting	9.0	Sitting	34.0	Safe
40	9.8	Sitting	7.9	Sitting	8.4	Sitting	9.8	Sitting	38.2	Safe
41	12.8	Standing	9.8	Sitting	10.4	Standing	12.4	Standing	48.0	Safe
42	7.1	Sitting	5.7	Sitting	6.2	Sitting	7.0	Sitting	30.7	Safe
43	7.8	Sitting	6.2	Sitting	6.6	Sitting	7.9	Sitting	31.5	Safe
44	8.3	Sitting	6.6	Sitting	7.3	Sitting	8.7	Sitting	34.1	Safe
45	10.8	Standing	8.2	Sitting	9.7	Sitting	11.9	Standing	49.1	Safe
46	8.2	Sitting	6.6	Sitting	8.0	Sitting	10.0	Sitting	43.7	Safe
47	7.8	Sitting	6.3	Sitting	7.4	Sitting	9.0	Sitting	38.6	Safe
48	7.9	Sitting	6.2	Sitting	7.4	Sitting	8.5	Sitting	36.8	Safe
49	10.2	Standing	8.0	Sitting	9.3	Sitting	12.1	Standing	51.7	Safe
50	10.5	Standing	8.3	Sitting	9.6	Sitting	12.2	Standing	49.2	Safe
51	9.3	Sitting	7.3	Sitting	8.5	Sitting	11.0	Standing	50.4	Safe
52	9.8	Sitting	8.0	Sitting	9.0	Sitting	11.2	Standing	47.5	Safe
53	14.5	Standing	11.6	Standing	13.6	Standing	17.5	Walking	69.6	Safe
54	12.8	Standing	10.3	Standing	12.1	Standing	15.9	Walking	67.1	Safe
55	8.2	Sitting	6.5	Sitting	7.2	Sitting	8.6	Sitting	35.4	Safe
56	19.5	Walking	14.7	Standing	18.3	Walking	22.5	Uncomfortable	74.7	Safe
57	21.1	Uncomfortable	16.8	Walking	20.9	Uncomfortable	26.1	Uncomfortable	86.8	Safe
58	15.6	Walking	12.6	Standing	15.9	Walking	20.8	Uncomfortable	72.3	Safe
59	9.4	Sitting	7.2	Sitting	7.7	Sitting	8.9	Sitting	38.6	Safe
60	10.8	Standing	8.2	Sitting	8.8	Sitting	9.9	Sitting	43.2	Safe
61	11.1	Standing	8.4	Sitting	9.0	Sitting	10.1	Standing	49.4	Safe
62	11.1	Standing	9.0	Sitting	9.5	Sitting	10.4	Standing	55.9	Safe
63	10.1	Standing	8.1	Sitting	8.6	Sitting	9.1	Sitting	45.2	Safe
64	12.4	Standing	9.6	Sitting	10.3	Standing	12.4	Standing	46.2	Safe
65	13.3	Standing	9.9	Sitting	10.3	Standing	12.3	Standing	47.8	Safe
66	11.4	Standing	9.7	Sitting	10.8	Standing	12.8	Standing	50.8	Safe
67	19.7	Walking	15.5	Walking	15.9	Walking	18.5	Walking	73.9	Safe
68	17.0	Walking	14.1	Standing	15.5	Walking	18.7	Walking	66.6	Safe
69	14.9	Standing	11.3	Standing	11.8	Standing	14.7	Standing	63.0	Safe
70	8.7	Sitting	6.7	Sitting	7.8	Sitting	9.6	Sitting	40.6	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 B3: 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
71	9.7	Sitting	7.7	Sitting	8.8	Sitting	11.3	Standing	54.6	Safe
72	11.5	Standing	8.8	Sitting	9.5	Sitting	11.9	Standing	51.0	Safe
73	9.0	Sitting	6.8	Sitting	7.8	Sitting	9.3	Sitting	36.3	Safe
74	9.4	Sitting	7.0	Sitting	7.8	Sitting	9.2	Sitting	36.6	Safe
75	12.3	Standing	9.4	Sitting	10.8	Standing	13.4	Standing	63.0	Safe
76	10.9	Standing	8.6	Sitting	9.9	Sitting	12.6	Standing	58.5	Safe
77	14.4	Standing	11.1	Standing	13.5	Standing	17.9	Walking	71.4	Safe
78	9.5	Sitting	7.0	Sitting	7.6	Sitting	8.8	Sitting	37.9	Safe
79	8.9	Sitting	6.8	Sitting	7.6	Sitting	8.7	Sitting	33.7	Safe
80	7.9	Sitting	6.1	Sitting	6.8	Sitting	7.7	Sitting	30.5	Safe
81	14.4	Standing	12.0	Standing	15.2	Walking	20.6	Uncomfortable	79.0	Safe
82	14.6	Standing	12.3	Standing	15.0	Walking	19.8	Walking	77.6	Safe
83	7.7	Sitting	6.4	Sitting	7.0	Sitting	7.7	Sitting	30.4	Safe
84	9.9	Sitting	7.7	Sitting	8.5	Sitting	9.7	Sitting	38.0	Safe
85	12.4	Standing	10.5	Standing	12.8	Standing	16.3	Walking	63.1	Safe
86	13.2	Standing	10.5	Standing	11.7	Standing	13.9	Standing	52.5	Safe
87	16.4	Walking	12.7	Standing	14.5	Standing	17.7	Walking	61.6	Safe
88	14.9	Standing	11.8	Standing	13.8	Standing	16.9	Walking	61.3	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.

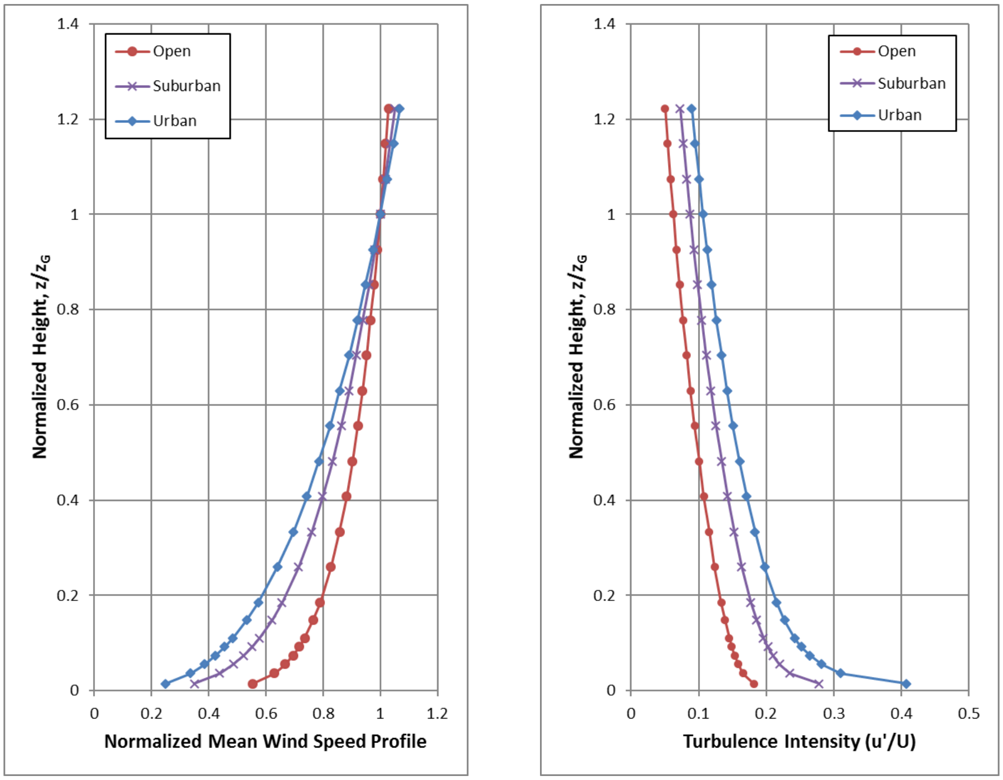

FIGURE C1 (LEFT): MEAN WIND SPEED PROFILES;
FIGURE C2 (RIGHT): TURBULENCE INTENSITY PROFILES

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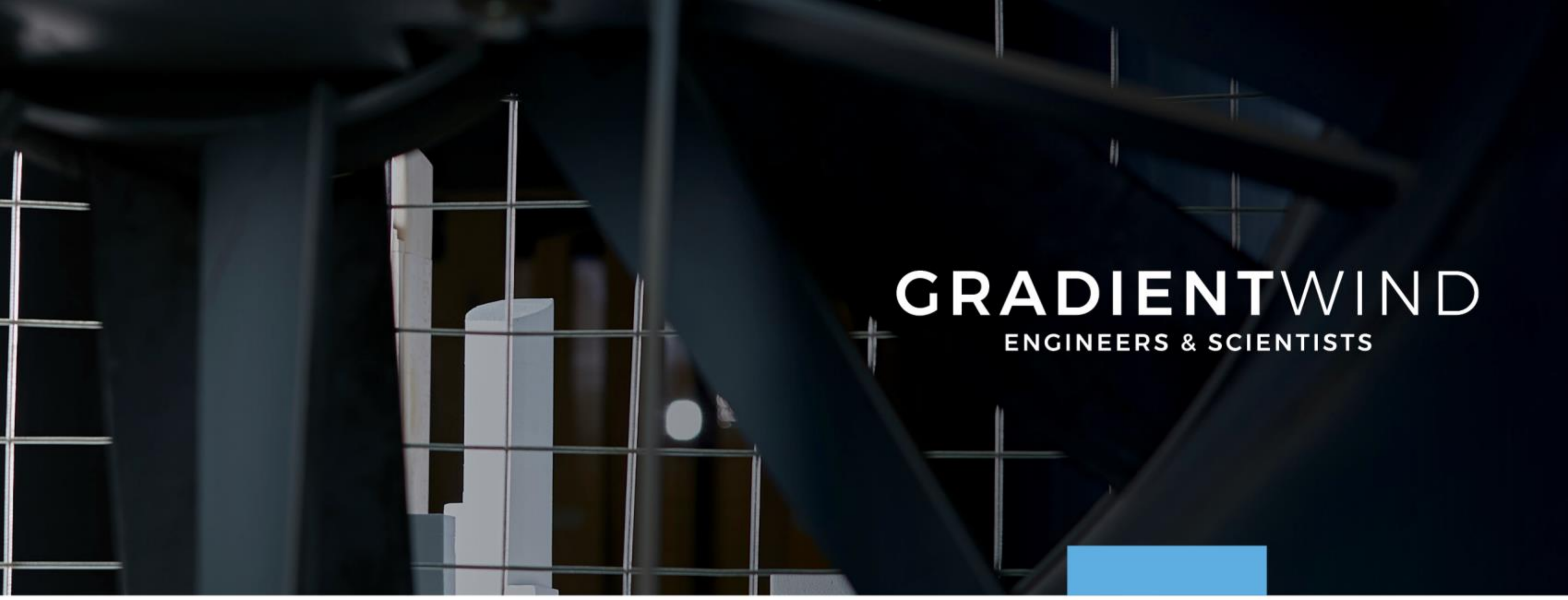

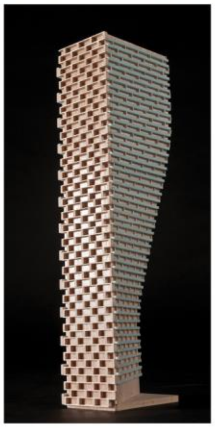

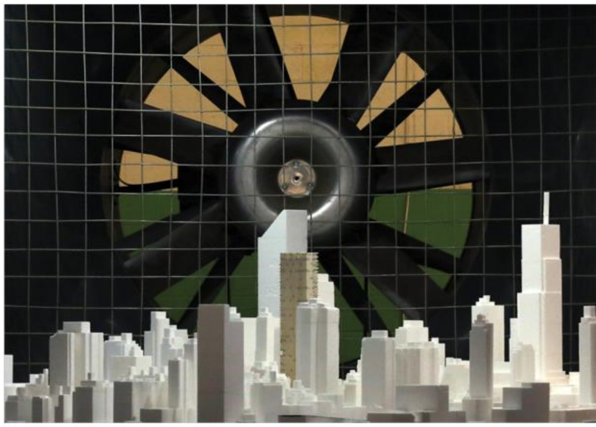

APPENDIX D

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:

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

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

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.

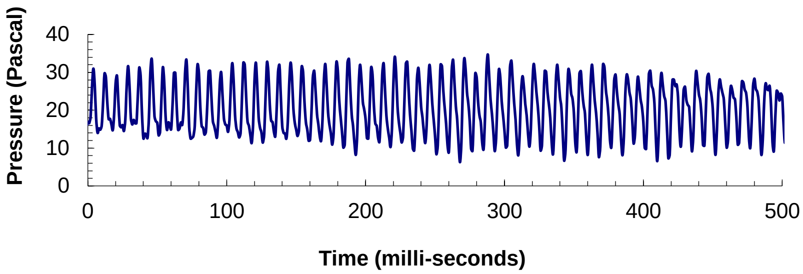

FIGURE D1: TIME VERSUS VELOCITY TRACE FOR A TYPICAL WIND SENSOR

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