THEAKSTON ENVIRONMENTAL

Consulting Engineers • Environmental Control Specialists

REPORT

PRELIMINARY PEDESTRIAN LEVEL WIND STUDY

91 Eglinton Ave, 131 Eglinton Ave, 5055 Hurontario Street

Mississauga, Ontario

91 Eglinton Limited Partnership

REPORT NO. 19501wind **May 30, 2019**

TABLE OF CONTENTS

1. CONCLUSIONS AND RECOMMENDATIONS

The Residential Development proposed by 91 Eglinton Limited Partnership for the property municipally known as 91 Eglinton Ave, 131 Eglinton Ave, and 5055 Hurontario Street, in the City of Mississauga, has been assessed for environmental standards with regard to pedestrian level wind relative to comfort and safety. The pedestrian level wind and gust velocities predicted for the locations tested are within the safety criteria and most are within the comfort criteria described within the following report.

The Development involves a proposal to construct 45, 40, 1, 33, 40, and 30 storey buildings denoted Tower A, Tower B, Building C, Tower D, Tower E, and Tower G, respectively, and 3 Townhouse Blocks denoted H1 through H3. The proposed towers include connective 2 storey podiums and/or stepped wings of various heights with outdoor Amenity spaces atop the podiums and at grade to the south of the Public Park. The proposed Development's residential entrances and vehicular drop-offs are accessed via Eglinton Avenue East and future extensions of Armdale Road and Thornwood Drive, as well as private driveways dissecting the Proposed Development site.

The Development is, for all intents and purposes, surrounded to prevailing windward directions by an urban/suburban mix of institutional, residential and commercial development, related open areas, and mature vegetation. These buildings and related open areas have a sympathetic relationship with the pending wind climate.

Urban development provides turbulence inducing surface roughness that can be wind friendly, while open settings afford wind the opportunity to accelerate as the wind's boundary layer profile thickens at the pedestrian level, owing to lack of surface roughness. High-rise buildings typically exacerbate wind conditions within their immediate vicinity, to varying degrees, by redirecting wind currents to the ground level and along streets and open areas. Transition zones from open to urban, and to a lesser degree suburban, settings may prove problematic, as winds exacerbated by the relatively more open settings are redirected to flow over, around, and between urban buildings.

These phenomena were observed at the site with prevailing winds that have opportunity to accelerate over the relatively open lands associated with Eglinton Avenue East, Hurontario Street, and green fields. This open setting, along with the rural, open setting of the site and relatively open lands accommodating large single storey retail buildings, and related parking, cumulatively account for the moderately windy conditions observed in the existing setting on and about the Development site. With inclusion of the proposed Development, winds that formerly flowed over the existing rural lands are redirected, tending to split with portions flowing over, around and down the proposed buildings' façades. At the pedestrian level, the winds redirect to travel horizontally along the buildings, around the corners and beyond, creating minor windswept areas and, on occasion, uncomfortable conditions at or near the buildings' corners and in the gaps between the buildings, and these conditions are primarily attributable to the setting, whereby the Proposed Development penetrates winds that formerly flowed over the existing lands.

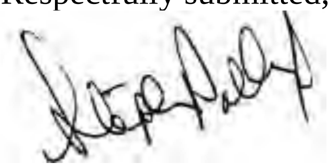
Winds emanating from remaining compass points are more effectively mitigated, though to varying degrees, by the local surrounds, and as such, upon impact with the proposed, tend to split, flowing over, and to a lesser extent around and down the buildings' faces. At the pedestrian level, the winds redirect to travel horizontally along the ground, around the corners and beyond, with less significant influence upon pedestrian comfort conditions.

These phenomena result in:

- localised improvements to wind conditions along **Eglinton Avenue East**, with several points realising windy conditions, on the occasion of high ambient winds, however, the area remains suitable for the intended purpose,
- localised windy conditions along the **future extensions of Armdale Road and Thornwood Drive** on occasion during the winter months. The ratings indicate seasonally appropriate conditions and will be suitable for the intended purpose,
- pedestrian comfort conditions in the **Public Park**, that are appropriate to the intended purpose,
- pedestrian comfort conditions at the **Main Entrances,** that are appropriate to the intended purpose,
- seasonally appropriate comfort conditions at the proposed **Amenity Spaces**, with incorporation of wind mitigation design features, as discussed in the following.

Comfort conditions expected at the proposed Development site are considered acceptable to the urban context. Where mitigation was recommended, it was achieved through: parapet walls, stepped façades, overhangs, canopies, balconies, porous fencing, screen walls landscaping, plantings, and others, that were incorporated into the proposed Development's massing and landscape design. The mitigation plan for the rooftop amenity spaces will be addressed at the Site Plan Approval stage. The ultimate plan will be developed in consultation, will respect wind conditions acting on the individual spaces, and incorporate mitigative design features that will result in comfort conditions appropriate to the areas' intended purpose.

Respectfully submitted,



Stephen Pollock, P. Eng. Paul Kankainen, M.A.Sc.

2. INTRODUCTION

Theakston Environmental Consulting Engineers, Fergus, Ontario, were retained by 91 Eglinton Limited Partnership to study the pedestrian level wind environment for their proposed Residential Development occupying a portion of a block of lands situated to the southeast of the future Armdale Road, northwest of Eglinton Avenue East, and northeast of Hurontario Street. The Development will be located in the City of Mississauga, with the site as depicted on the Aerial Photo in Figure 2a. The Development involves a proposal to construct 5 towers, 1 including a 2 storey connective podium, and 3 with stepped wings at various heights, a 1 storey building, and 3 townhouse blocks in the configuration shown in Figure 2b.

Mark Liddy, P. Eng., 91 Eglinton Limited Partnership, initiated the request, and Dialog Design provided drawings. The co-operation and interest of the Client and their sponsors in all aspects of this study is gratefully acknowledged.

The specific objective of the study is to determine areas of higher than normal wind velocities induced by the shape and orientation of the proposed buildings and surroundings. The wind velocities are rated in accordance with the safety and comfort of pedestrians, notably at entrances to the buildings, sidewalks, courtyards on the property, as well as other buildings in the immediate vicinity.

In order to obtain an objective analysis of the wind conditions for the property, the wind environment was tested in two configurations. The existing configuration included existing and proposed buildings in the surrounding area. The proposed configuration included the Development's subject buildings. Mitigation procedures were assessed during these tests to determine their impact on the various wind conditions.

The laboratory techniques used in this study are established procedures that have been developed specifically for analyses of this kind. The methodology, summarized herein, describes criteria used in the determination of pedestrian level wind conditions. The facilities used by Theakston are ideal for observance of the Development at various stages of testing, and the development of wind mitigation measures, if necessary.

3. OBJECTIVES OF THE STUDY

1. To quantitatively assess, by model analyses, the pedestrian level wind environment under existing conditions and future conditions with the Development in accordance with the City of Mississauga's Terms of Reference.

2. To assess mitigative solutions.

3. To publish a Consultant's report documenting the findings and recommendations.

4. METHOD OF STUDY

4.1 General

The Theakston Environmental wind engineering facility was developed for the study of, among other sciences, the pedestrian level wind environment occurring around buildings, with focus on the safety and comfort of pedestrians. To this end, physical scale models of proposed Development sites, and immediate surroundings, are built, instrumented and tested at the facility with resulting wind speeds measured for different wind directions at various locations likely to be frequented by pedestrians. This quantitative analysis provides predictions of wind speeds for various probabilities of occurrence and for various percentages of time that are ultimately weighted relative to a historical range of wind conditions, and provided to the client.

The techniques applied to wind and other studies carried out at the facility, utilise a boundary layer wind tunnel and/or water flume (Figure 1). The testing facility has been developed for these kinds of environmental studies, and has been adapted with equipment, testing procedures and protocols, in order to provide results comparable to full scale. The Boundary Layer Wind Tunnel lends itself well to the simultaneous acquisition of large data streams while the water flume is excellent for flow visualisation.

The purpose of this Pedestrian Level Wind Study is to evaluate the pedestrian level wind speeds for a full range of wind directions. To accomplish this, the wind's mean speed boundary layer profiles are simulated and applied to a site-specific model under test, instrumented with differential pressure probes at locations of interest. During testing, pressure readings are taken over a one-hour model scale period of time, at a full-scale height of approximately 1.8m and correlated to mean and gust wind speeds, expressed as ratios of the gradient wind speed.

The mean and gust wind speeds at the forty-four (44) points tested were subsequently combined with the design probability distribution of gradient wind speed and direction, (wind statistics) recorded at Airports in the vicinity, to provide predictions of the full-scale pedestrian level wind environment. Predictions of the full-scale pedestrian level wind environment are presented as the wind speed exceeded 20% of the time, based on annual, and wind for the seasons in Figures 6a – 6e. Criterion employed by Theakston Environmental was developed by others and us and published in the attached references. The methodology has been applied to over 800 projects on this continent and abroad.

4.2 Meteorological Data

The wind climate for the Mississauga region that was used in the analysis was based on historical records of wind speed and direction measured at Pearson International Airport for the period between 1980 and 2017. The meteorological data includes hourly wind records and annual extremes. The analysis of the hourly wind records provides information to develop the statistical climate model of wind speed and direction. From this model, predicted wind speeds regardless of wind direction for various return periods can be derived. The record of annual extremes was also used to predict wind speeds at various return periods. Based on the analysis of the hourly records, the predicted hourly-mean wind speed measured at 10*m* above grade, corrected for a standard open exposure definition, is 25*m/s* for a return period of 50 years.

4.3 Statistical Wind Climate Model

For the analysis of the data, the wind climate model is converted to a reference height of 500*m* using a standard open exposure wind profile. The mean-hourly wind speed at a 500*m* reference height used for this study is 45.6*m/s* for a return period of 50 years. The corresponding 1-year return period wind speed at the 500*m* height is 36*m/s*.

The design probability distribution of mean-hourly wind speed and wind direction at reference height is shown for Pearson International Airport in Figure 5. Both annual and seasonal distributions are shown. From this it is apparent that winds can occur from any direction, however, historical data indicates the directional characteristics of strong winds are north through west to southwest and said winds are most likely to occur during the winter, spring and fall seasons.

4.4 Wind Simulation

To simulate the correct macroclimate, the upstream flow passes over conditioning features placed upstream of the model, essentially strakes and an appropriately roughened surface, as required to simulate the full-scale mean speed boundary layer approach flow profiles occurring at the site.

4.5 Pedestrian Level Wind Velocity Study

A physical model of the proposed Development and pertinent surroundings, including existing buildings, roadways, pathways, terrain and other features, was constructed to a scale of 1:500. The model is based upon information gathered during a site visit to the proposed Development site, and surrounding area. Dialog Design provided architectural drawings. City of Mississauga aerial photographs were also used in development of the model to ensure the model reasonably represents conditions at the proposed Development. The model is constructed on a circular base so that, by rotation, any range of wind directions can be assessed. Structures and features that are deemed to have an impact on the wind flows are included upwind of the scale model.

In these studies, the effects of wind were analysed using omni-directional wind velocity probes that are placed on the model and located at the usual positions of pedestrian activity. The probes measure both mean and fluctuating wind speeds at a height of approximately 1.8m. During testing, the model sample period is selected to represent 1hr of sampling time at full scale. The velocities measured by the probes are recorded by a computerized data acquisition system and combined with historical meteorological data via a post-processing program.

4.6 Pedestrian Comfort Criteria

The assignment of pedestrian comfort takes into consideration pedestrian safety and comfort attributable to mean and gust wind speeds. Gusts have a significant bearing on safety, as they can affect a person's balance, while winds flowing at or near mean velocities have a greater influence upon comfort.

Figure 6 presents results for the mean wind speed that is exceeded 20% of the time. These speeds are directly related to the pedestrian comfort at a particular point. The overall comfort rating, for existing and proposed, are depicted in Figure 7. Table 1, below, summarizes the comfort criteria used in the presentation of the results depicted in Figures 6 and 7.

Table 1: Comfort Criteria

ACTIVITY	Gust Equivalent Mean Speed Exceeded 20% of the Time		Description
COMFORT	***km/h***	***m/s*** (used in Fig. 6)	
Sitting	0-10	0-2.8	Calm or light breezes desired for outdoor restaurants and seating areas where one can read a paper without having it blown away.
Standing	0-15	0-4.2	Gentle breezes suitable for main building entrances and bus stops.
Walking	0-20	0-5.6	Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering.
Uncomfortable	>20	>5.6	Strong winds of this magnitude are considered a nuisance for most activities, and wind mitigation is typically recommended.

The activities are described as suitable for Sitting, Standing, Walking, or Uncomfortable, depending on average wind speed exceeded 20% of the time. For a point to be rated as suitable for Sitting, for example, the wind conditions must not exceed 10*km/h* (2.8*m/s*), more than 20% of the time. Thus, in the plots (Figure 6), the upper limit of each bar ends within the range described by the comfort category. For sitting, the rating would include conditions ranging from calm up to wind speeds that would rustle tree leaves or wave flags slightly, as presented in the Beaufort Scale included in the Appendices. As the name infers, the category is recommended for outdoor space where people might sit for extended periods.

The Standing category is slightly more tolerant of wind, including wind speeds from calm up to 15*km/h* (4.2*m/s*). In this situation, the wind would rustle tree leaves and, on occasion, move smaller branches while flags flap. This category would be suitable for locations where people might sit for short periods or stand in relative comfort. The Walking category includes wind speeds from calm up to 20*km/h* (5.6*m/s*). These winds would set tree limbs in motion, lift leaves, litter and dust, and the locations are suitable for activity areas. The Uncomfortable category covers a broad range of wind conditions that are generally a nuisance for most activities, including wind speeds above 20*km/h* (15.6*m/s*).

In Figure 6, the probe locations are listed along the bottom of the chart; beneath the graphical representation of the Mean Wind Speed exceeded 20% of the time. Along the right edge of the plot the comfort categories are shown. The background of the plot is lightly shaded in colours corresponding to the categories shown in Table 1. Each category represents a 5*km/h* (or more) interval. The location is rated as suitable for Sitting, Standing, Walking, or Uncomfortable, if the bar extends into the corresponding interval.

The charts represent the average person's response to wind force annually and for four seasons. Effects such as wind chill and humidex (based on perception) are not considered. Also clothing is not considered, since clothing and perceived comfort varies greatly among the population. There are many variables that contribute to a person's perception of the wind environment beyond the seasonal variations presented. While people are generally more tolerant of wind during the summer months, than during the winter, due to the wind cooling effect, people become acclimatized to a particular wind environment. Persons dwelling near the shore of an ocean, large lake or open field are more tolerant of wind than someone residing in a sheltered wind environment.

4.7 Pedestrian Safety Criteria

Safety criteria are also included in the analysis to ensure that strong winds do not cause a loss of balance to individuals occupying the area. The safety criteria are based on wind speeds exceeded nine times per year as shown in Table 2.

Both the Comfort and Safety Criteria are based on those developed at the Allan G. Davenport Wind Engineering Group Boundary Layer Wind Tunnel Laboratory, located on the campus of The University of Western Ontario. The comfort criteria were subsequently revised for the Mississauga Urban Design Terms of Reference for Wind Comfort and Safety Studies, in consultation with RWDI and more closely respects the Lawson criteria.

Table 2: Safety Criteria

ACTIVITY	**Mean Wind Speed Exceeded 9 times per year**		**Description**
SAFETY	***km/h***	***m/s*** (used in Fig. 8)	
All-Weather	0-90	0-25	Acceptable gust speeds that will not adversely affect a pedestrian's balance and footing.
Exceeding All-Weather	>90	>25	Excessive gust speeds that can adversely affect a pedestrian's balance and footing. Wind mitigation is typically required.

4.8 Pedestrian Comfort Criteria – Seasonal Variation

The level of comfort perceived by an individual is highly dependent on seasonal variations of climate. Perceived comfort is also specific to each individual, and depends on the clothing choices. The comfort criterion that is being used averages the results across the general population to remove effects of individuals and clothing choices, however, seasonal effects are important. For instance, a terrace or outdoor amenity space may have limited use during the winter season, but require acceptable comfort during the summer.

The comfort of a site is based on the "annual" results of the study, Figures 6a and 7a and 7b. In cases where seasonal comfort is important, results have been included for the seasons; winter, spring, summer, and fall (see Figures 6b to 6e and Figures 7c to 7j).

When compared to the annual average wind speed, winter winds are about 12.5% higher and summer winds are about 16% lower.

5. RESULTS

5.1 Study Site and Test Conditions

Proposed Development

The Development occupies a portion of a block lands situated to the northeast of the intersection of Hurontario Street with Eglinton Avenue East in the City of Mississauga. The subject site was occupied by a one storey residential dwelling, and several farming related structures that are planned to be removed. The development is phased, however, the analysis is based upon the ultimate configuration. The first phase occupies the southeast portion of the Development site, along Eglinton Avenue East, and involves construction of Lot 1, which is comprised of 45 and 40 storey towers, denoted Towers A and B. The buildings step down from 8 storeys to a 2 storey connective podium with amenity space on the second level roof. A 33 storey tower, denoted Tower D, is proposed for Lot 2, proximate to the centre of the development site, with a multi-level wing including 5th Level Amenity space, extending towards the north along the future extensions of Armdale Road and Thornwood Drive. The west portion of the Development involves a 40 storey tower on Lot 3, denoted Tower E, with a 12 storey wing that extends to the northwest and steps down to 4 storeys and a 2 storey podium, the roof of which is assigned to Amenity space at the 3rd level. A 30 storey tower, denoted Tower G, is proposed for Lot 4 at the east corner of the Development. The tower has wings to the northeast along Eglington Avenue East and to the northwest along Thornwood Drive, the former 8 storeys and stepping down to 2 storeys with a 9th Level Amenity space, the latter extends along the future extension of Thornwood Drive and is 12 storeys in height. The building is penetrated adjacent to the tower with a 3 storey breezeway that accommodates a private driveway. Finally, a 1 storey building providing access to an underground Amenity space, denoted Building C, is located in the centre of the site, south of the Public Park space. The configuration of the proposed buildings and associated amenity spaces is shown in Figure 2b.

The Development, located in the City of Mississauga, is depicted in the Aerial Photo in Figure 2a. Note: Mississauga's street orientation is relative to the Lake Ontario Shoreline resulting in east/west orientated streets in the subject area being offset by approximately 50 degrees north.

Surrounding Area

The most noteworthy urban buildings in the immediate surroundings, by proximity, are the Pinnacle Development comprised of 8 buildings ranging in height from 30 to 50 storeys, occupying lands to the west of the intersection of Eglinton Avenue West and Hurontario Street. Earlier phases of the Pinnacle Development are complete, subsequent phases are under construction, approved, or seeking approval. To the west of the site the Hurontario Street & Nahani Way development site is proposed to include a 33 storey residential tower with 2 storey townhomes planned along the northeasterly side of the site, fronting the balance of Nahani Way and the future Belbin Street. To the southeast and east of the above-mentioned Pinnacle Development, also proposed along Hurontario Street, Summit Eglinton Inc. proposes to build Townhouses and Semi Detached Units on lands along the northwest and northeast extremities of the site, removed from Hurontario Street, with high-rise to the southeast and southwest with the latter fronting Hurontario Street. To the southeast of Eglinton Avenue West, and southwest of Hurontario Street lay several large residential buildings that are well spaced with parking, green space and Cooksville Creek related lands with townhomes and lower density residential farther to the southwest along Eglinton Avenue West.

Macroclimate

For the proposed Development, the upstream wind flow during testing was conditioned to simulate an atmospheric boundary layer passing over urban/suburban terrain. The terrain within the site's immediate vicinity was incorporated into the proximity model. Historical meteorological data recorded from the Toronto Pearson International Airport was used in this analysis. For studies in the City of Mississauga, the data is presented annually and for four seasons and the resulting wind roses are presented as mean velocity and percent frequency in Figure 5. The mean velocities presented in the wind roses are measured at an elevation of 10*m*. Thus, representative ground level velocities at a height of 2*m*, for an urban macroclimate, are 52% of the mean values indicated on the wind rose, (for suburban and rural macroclimates the values are 63% and 78% respectively). The macroclimate for this area is dependent upon wind direction and varies with direction between suburban and urban.

Winter (November 16 to March 31) has the highest mean velocities of the seasons with prevailing winds from the north and west, with significant components from north through west to southwest as indicated in Figure 5b. Summer (June 16 to September 15) has the lowest mean wind velocities of the seasons with prevailing winds from north through west to southerly as indicated in Figure 5d. Spring and Fall winds tend to be more moderate and emanate from the north through west to southwest. Reported pedestrian comfort ratings generally pertain to annual conditions, unless stated otherwise.

5.2 Pedestrian Level Wind Velocity Study

Pedestrian level wind velocity measurement probes were located on the site model. The instrumented areas include the street frontages adjacent to the proposed Development, placed at approximately 10m spacing, as well as other buildings and activity areas, and the test data was used to determine conditions related to comfort and safety. Figure 4 depicts probe locations at which pedestrian level wind velocity measurements were taken in the existing and proposed scenarios. For the existing setting, the subject building was removed and the "existing" site model retested.

Measurements of pedestrian level mean and gust wind speeds at the various locations shown were taken over a period of time equivalent to one hour of measurements at full-scale. The mean ground level wind velocity measured is presented as a ratio of gradient wind speed, in the plots of Figure B of the Appendices, for each point in the existing and proposed scenarios. These relative wind speeds are presented as polar plots in which the radial distance for a particular wind direction represents the wind speed at the location for that wind direction, expressed as a ratio of the corresponding wind speed at gradient height. They do not assist in assessing wind comfort conditions until the probability distribution gradient wind speed and direction is applied.

The design probability distribution gradient wind speed and direction, taken from historical meteorological data for the area (see Figure 5) was combined with pedestrian level mean and gust wind speeds measured at each point to provide predictions of the percentage of time a point will be comfortable for a given activity. These predictions of mean and maximum or "gust" wind speeds are provided on an annual and seasonal basis in Figures 6a-6e.

The ratings for a given location are conservative by design, and those ratings that are Uncomfortable, when close to a transition between Walking and Uncomfortable, will not pose a problem from a pedestrian comfort point of view. When the existing surroundings and proposed buildings' fine massing details and actual landscaping are taken into consideration, the results tend toward a more comfortable site than quantitative testing alone would indicate.

Venturi action, scour action, downwash and other factors, as discussed in the Appendix on wind flow phenomena, can be associated with large buildings, depending on their orientation and configuration. These serve to increase wind velocities. Open areas within a heavily developed area may also encounter high wind velocities. Consequently, wind force effects are common in heavily built-up areas. The Development site is open to an urban/suburban setting to prevailing and remaining compass points with winds flowing over and between buildings. As such, the surroundings can be expected to influence wind at the site to varying degrees. It should be noted that the probes are positioned at points typically subject to windy conditions in an urban environment in order to determine the worst-case scenario.

5.3 Review of Probe Results

The probe results, as follows, were clustered into groups comprised of Public Street Conditions, Public Park and Central Amenity Area Conditions, Pedestrian Entrance Conditions, and Rooftop Outdoor Amenity Areas. The measurement locations are depicted in Figure 4 and are listed in Figures 6a through 6e, annually and for the seasons, for the existing and proposed configurations. The results are also graphically depicted for the existing and proposed configurations in Figures 7a – 7j. The following discusses anticipated wind conditions and suitability for the points' intended use.

Public Street Conditions

Eglinton Avenue East

Probes 1 through 10, 18, 20 and 38 were located along the above-named street within the zone of influence of the proposed Development. Of these probe locations all indicate annual wind conditions that are suitable for standing in the existing setting. The relatively consistent ratings are partially attributed to westerly through northwesterly winds that approach from over the currently open development site, the lack of turbulence inducing roughness affording winds opportunity to approach the pedestrian level and smoothen. The predominately suburban setting to the east through north to near west of the site will introduce roughness to the wind's approach flow, moderating the winds upon approach. The ratings can also be partially attributed to winds approaching in approximate alignment with the street, the open approach of the street, related boulevards, and low-rise commercial buildings affording winds approaching from the southwesterly portion of the prevailing wind climate opportunity to approach the pedestrian level and similarly smoothen upon approach.

With inclusion of the proposed Development, probe locations 2, 3, 4, and 5 realised an improvement, however, only location 3 realised sufficient improvement to change annual comfort categories from standing to sitting. The improvements realised can be attributed to the proposed development presenting increased blockage to winds, resulting in the observed leeward effect, however, the realignment of winds associated with insertion of tall buildings into a suburban/urban setting invariably causes a realignment of winds that can result in localised windier conditions. Points 7, 18, and 20 realised increased wind effects sufficient to change annual comfort ratings from standing to walking, but the areas remain suitable for the intended purpose.

From the mean ground level wind velocity presented as a ratio of gradient wind speed, in the plots of Figure B in the Appendix, it is apparent that many of these points realise either no change or an improvement to the existing setting with inclusion of the Proposed Development for specific wind directions, however, there are directions from which the wind is exacerbated. Should that direction coincide with dominant wind directions, as indicated in Figure 5's wind roses, relatively more windy conditions can be expected. As such, the relatively more windy conditions predicted at the above named probe locations, situated at or near the corners of the Development, result from winds that formerly flowed over the open lands of the existing site being redirected to flow along the buildings, around the corners, and beyond, however, the areas remain suitable to the intended purpose year round.

The above-mentioned, considered in concert with massing features and landscaping that were too fine to be incorporated into the site and surroundings, and urban intensification will result in further improvement. During the winter months, occasionally windy conditions are predicted, however, acceptable pedestrian comfort conditions will prevail. All points are at least suitable for walking and activities requiring longer exposure times during the summer.

Townhouse Development to the Northeast

Probes 11 and 12 were placed along the Driveway serving a townhouse development to the northeast of the proposed Development. The area is effectively sheltered by the residential dwellings, and as such rated suitable for sitting in the existing setting on an annual basis. With inclusion of the Proposed Development there is a slight realignment of winds, however, point 11 is near the transition to standing and only a minor upset is required to effect the change of rating. The change to wind flow patterns with inclusion of the Proposed Development will be imperceptible.

Kencourt Drive

Probes 15 and 16 were placed along Kencourt Drive, to the northwest of the proposed Development, and were rated suitable for sitting in the existing setting on an annual basis. With inclusion of the proposed Development, the street realises a slight realignment of winds, and the change will not likely be perceptible, however, the annual rating at probe 15, which was also near the transition to standing, changed. The street remains suitable for the intended purpose.

Future Thornwood Drive Extension

Probes 13, 14, 20, 21, 29, 30, 38, and 41 were located along Thornwood Drive and the future extension of the same name. In the existing setting said points display an annual rating as suitable for standing, with the exception of point 13, situated adjacent to the townhomes along the street to the north, which was rated as suitable for sitting. The comfortable conditions at probe 13, adjacent to the townhouses, is attributed to the homes deflecting much of the prevailing wind climate to flow up and over the street at the selected test location. The relatively windier conditions realised on the Proposed Development site can be attributed to the more open setting allowing the wind's boundary layer profile to thicken and approach the ground.

With inclusion of the Proposed Development a realignment of winds will occur, resulting in windier conditions being realised at most of the points, with winds emanating from specific directions, and more comfortable conditions with winds from others. However, the net result of the altered wind flow patterns only changes the annual comfort ratings for points 20 and 21, that are along the future Thornwood Drive extension, adjacent to Tower B's corners, and these changed from standing to walking annually. Note: the prevailing wind conditions in the existing open setting are for the most part very near the transition from standing to walking and as such only a minor upset is required to change the comfort category.

During the winter months there is a greater propensity for stronger winds from specific directions, and should these directions coincide with an area sensitive to wind from a particular direction, windier, less comfortable conditions will prevail. As a result, in addition to points 20 and 21, points 38 and 41, situated at the corners of Building G, also become suitable for walking. Urban intensification of lands to the west can reasonably be expected to moderate westerly winds upon approach, likely resulting in more comfortable conditions,

Future Armdale Road Extension

Probes 17, 27, 34 and 35 were placed along the future extension of Armdale Road, in addition to the above discussed probes 14, 16, 30, and 41, that were placed at the intersections with Kencourt Drive and Thornwood Drive Extension. Probes 17, 27, 34 and 35 realised conditions in the existing setting that are suitable for standing on an annual basis. With inclusion of the Proposed Development points 17 and 27 realised an improvement to wind conditions, however, this is insufficient to change the annual comfort ratings. Conversely, an increase in windiness was realised at points 34 and 35 that was sufficient to change the comfort rating at point 35 to walking annually and in the winter both points 34 and 35 become suitable for walking during the winter.

Mitigation of downwash conditions is well understood and was applied through design whereby canopies, balconies and overhangs, porous fencing, as well as other design features, were employed, as discussed in the Conclusions and Recommendations Section of this report. These, considered in concert with massing features that were too fine to be incorporated into the surroundings, as well as urban intensification of the street, indicate that the future Armdale Road extension will remain suitable for its intended purpose, within acceptable pedestrian comfort criteria for the winter months, and suitable for activities requiring longer exposure times during the summer and shoulder seasons.

Private Driveway Conditions

Probe 32, among others discussed in preceding and following sections, was placed along the sidewalk adjacent to the Private Driveway proximate to the south corner of the Development Tower E and probes 42 and 43 respectively on and near the sidewalks adjacent to the driveway serving the Townhouse Blocks and Tower G. The analysis indicates conditions that are suitable for standing annually, in the proposed setting, with exception; probe 43 is suitable for walking. During the winter, summer and shoulder seasons probe 32 retains a rating as suitable for standing, probe 42 is similar, but improved to sitting during the summer and probe 43 is suitable for walking annually and throughout the seasons. As such the areas remain appropriate to their intended purpose.

Public Park and Central Amenity Area Conditions

Probes 24 through 26 were placed in the above-mentioned areas. The analysis indicates conditions that are respectively suitable for standing annually, in the existing setting. With inclusion of the Proposed Development probe locations 25 and 26 realised a slight, likely imperceptible, improvement. During the summer months, points 25 and 26 are suitable for sitting and point 24 suitable for standing, but at the transition to sitting. During the shoulder seasons the ratings vary with point 25 suitable for sitting and points 24 and 26 suitable for standing, but again at the transition to sitting. The results as tested included hard landscape design features that were sufficiently large to incorporate into the model under test. The represented comfort conditions can reasonably be expected to improve to levels suitable to the respective areas' intended purpose through incorporation of an appropriate Public Park and Central Amenity Area landscape plan that will be addressed at the Site Plan Approval stage.

Probe 43 was situated in the small amenity area to the north of Tower G and is suitable for walking annually and throughout the seasons. As such the area is not likely appropriate to the intended purpose and windscreens, raised planters, recessed seating, and/or other forms of mitigation will be required to bring pedestrian comfort conditions to within expectations. Mitigation plans will be addressed at the Site Plan Approval stage.

Pedestrian Entrance Conditions

Probes 19 and 22 were placed along the sidewalks leading to the residential lobby entrances to Lot 1's Tower A and Tower B, respectively fronting Eglinton Avenue East and the Private Driveway. With inclusion of the proposed Development point 19 realised improved annual comfort conditions that were sufficient to change the ratings from suitable for standing in the existing to sitting in the proposed. Point 22 realised a decrease in windiness as well, however, this was insufficient to change its annual rating from standing. During the winter and fall the points are suitable for sitting and standing respectively, and as such, will be appropriate to the area's intended purpose.

Probes 28 and 29, placed adjacent to the residential lobby entrances of Lot 2's Tower D, were rated as annually suitable for standing in the existing setting. With inclusion of the proposed Development, wind is deflected over, and/or around the building podium resulting in the entrances being in the building's aerodynamic shade regions, for most wind directions and as such will realise improved comfort conditions, suitable for sitting and standing respectively, through the seasons, with exception; location 29 was predicted suitable for sitting during the summer.

Probes 33 and 36 were similarly placed proximate to the residential lobby entrances to Lot 3's Tower E. In the existing setting the probe locations were rated as suitable for standing annually. With inclusion of the proposed Development, both points realised an improvement to wind conditions that was sufficient to change comfort ratings at the entrances to sitting annually and through the seasons.

Probes 39 and 40, placed at the principal entrances to Lot 4's 30 storey tower which are situated in the 3 storey high breezeway between the tower and 12 storey wing to the north. These were annually rated as suitable for standing in the existing setting. With inclusion of the proposed Development, portions of the wind climate that formerly flowed over the open area were obstructed, causing the point to improve comfort ratings with winds from specific directions, however, northerly through easterly, and to a lesser degree, southerly winds will be deflected to flow through the breezeway resulting in a net increase in windiness. As a result the entrances will realise wind conditions that are suitable for standing annually and throughout the seasons. On the occasion of high ambient northeasterly winds windy conditions will be realised in the breezeway, however, as indicated in Figure 5's wind roses, winds seldom come from this direction.

With consideration of the Development's and neighbouring buildings' fine design features, and landscaping, and incorporation of entrance vestibules, the entrances will be comfortable and suitable to the intended purpose.

Wind conditions comfortable for standing are preferable at building entrances, while conditions suitable for walking are suitable for sidewalks. Conditions at the proposed main residential entrances and related walkways are considered comfortable and suitable to the intended purpose. Consideration of existing and proposed surface roughness features too fine to incorporate into the massing model will further improve the comfort ratings.

Rooftop Outdoor Amenity Areas

Outdoor amenity areas are proposed situated atop the podiums and/or between the towers at probe locations 23, 31, 37 and 44, as indicated in Figures 2b and 4. The spaces will be susceptible to winds from specific directions being deflected to flow down, around and where applicable, through the gap between the towers, resulting in windy, though not inordinate wind conditions. Probes 31 and 44, situated on the podium amenity spaces for Tower D and Tower G, respectively, are predicted suitable for sitting and standing during the summer months respectively, however, probe 44 is near the transition to sitting, and as such these locations are expected to realise seasonally appropriate conditions much of the time.

Probe location 23, situated on podium amenity space between Tower A and Tower B will realise uncomfortable conditions during the winter and spring, walking conditions during the summer and fall. Uncomfortable wind conditions are a reasonable expectation for narrow gaps between towers, and as such, the rooftop amenity areas will not realise pedestrian comfort conditions that are appropriate for the intended purpose without implementation of effective wind mitigation plans. The wind mitigation plans will be examined further at the Site Plan Approval stage.

Probe location 37, situated on the podium amenity space of Tower E will realise conditions suitable for standing during the summer and walking during the spring and fall. Windy conditions are also a reasonable expectation for areas exposed to prevailing winds that are deflected to flow along the subject building and over the rooftop amenity area. The area will realise pedestrian comfort conditions that are appropriate for the intended purpose with implementation of an effective wind mitigation plan at the Site Plan Approval stage.

The analysis was conducted without the subject and neighbouring buildings' fine design features or existing and proposed hard and soft landscape features in place. As such, we reasonably expect prevailing pedestrian comfort conditions will be better than those predicted. A mitigation plan is required for the amenity spaces, if activities requiring longer exposure times are desired. This might be accomplished with a landscaping plan for the rooftop amenity spaces that includes appropriately engineered windscreens, railings, trellises, coarse vegetation, recessed seating, and others, which considered cumulatively, will further improve wind conditions in the residential amenity areas, making them suitable to the intended purpose.

The mitigation plan for the rooftop amenity spaces will be implemented at the Site Plan Approval stage. The ultimate plan will be developed in consultation, will respect wind conditions acting on the individual spaces, and incorporate mitigative design features that will result in comfort conditions appropriate to the areas' intended purpose.

Summary

The observed wind velocity and flow patterns at the Development are largely influenced by approach wind characteristics that are dictated by the urban/suburban mix of residential and commercial development, related open areas, and mature vegetation mitigating the wind, to different degrees, on approach. Historical weather data indicates that strong winds of a mean wind speed greater than 30 km/h occur approximately 13 percent of the time during the winter months and 4 percent of the time during the summer. Once the subject site is developed, ground level winds at several locations will improve, with occasional localized areas of higher pedestrian level winds. The relationship between surface roughness and wind is discussed in the Appendix and shown graphically in Figure A of the same section.

Consideration of existing and proposed building features too fine to incorporate into the massing model, along with recommended mitigation through the implementation of the landscape plan addressed at the Site Plan Approval stage, will improve the predicted comfort ratings beyond those reported herein, resulting in conditions suitable for the intended use.

As such, the site is predicted comfortable under normal wind conditions annually; however, under high ambient winter wind conditions with winds emanating from specific directions several localized areas may be windy from time to time, but the area remains within safety criteria and appropriate to the intended purpose. The consideration of proposed surface roughness will result in conditions more comfortable than those reported herein.

The mitigation plan for the rooftop amenity spaces will be examined at the Site Plan Approval stage. The ultimate plan will be developed in consultation, will respect wind conditions acting on the individual spaces, and incorporate mitigative design features that will result in comfort conditions appropriate to the areas' intended purpose.

As described in Table 2 and depicted in Figures 8 and 9, all locations tested are within safety criteria and are rated as All-Weather Areas.

6. FIGURES:

Figure 1: Laboratory Testing Facility

Figure 2a: Site Aerial Photo

X:\Drawings\1179-001\2019 05 May\PJR Figures_May 28 19.dwg

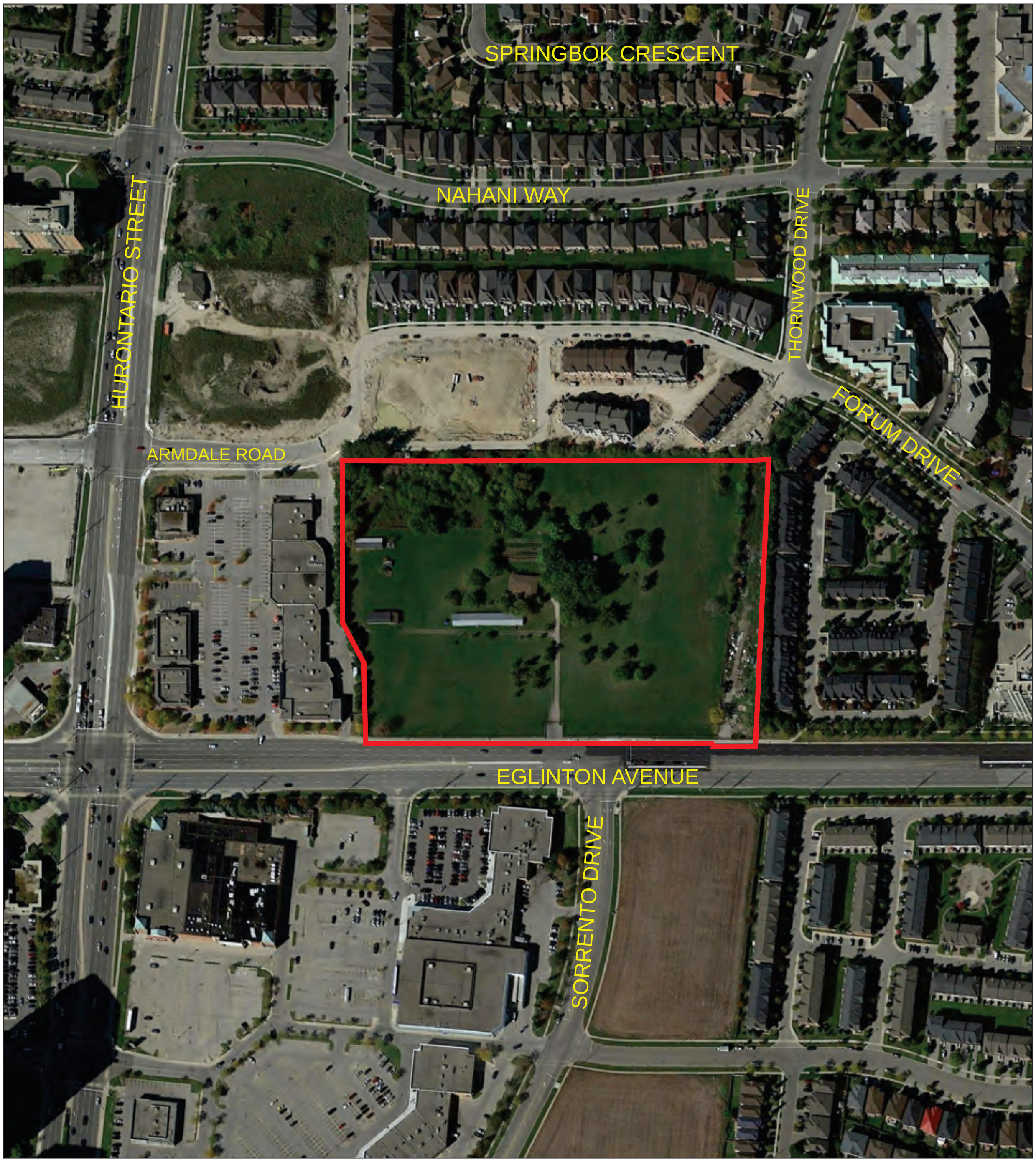


FIGURE 1

AERIAL CONTEXT PLAN

91 EGLINTON AVENUE &
5055 HURONTARIO STREET, ON

Subject Property

Scale NTS
May 28, 2019

GSAI
Glen Schnarr & Associates Inc.

Figure 2b: Site Plan

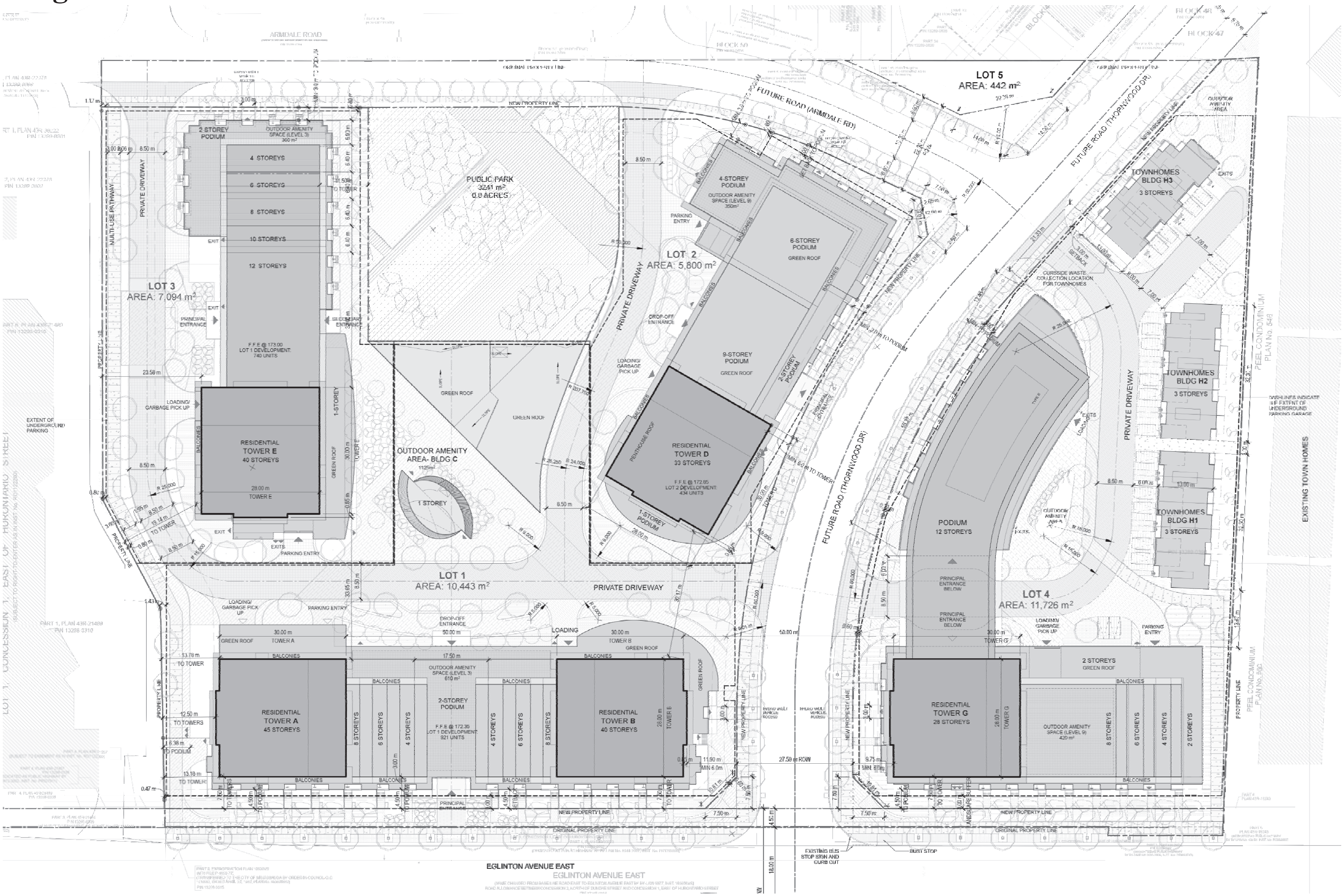
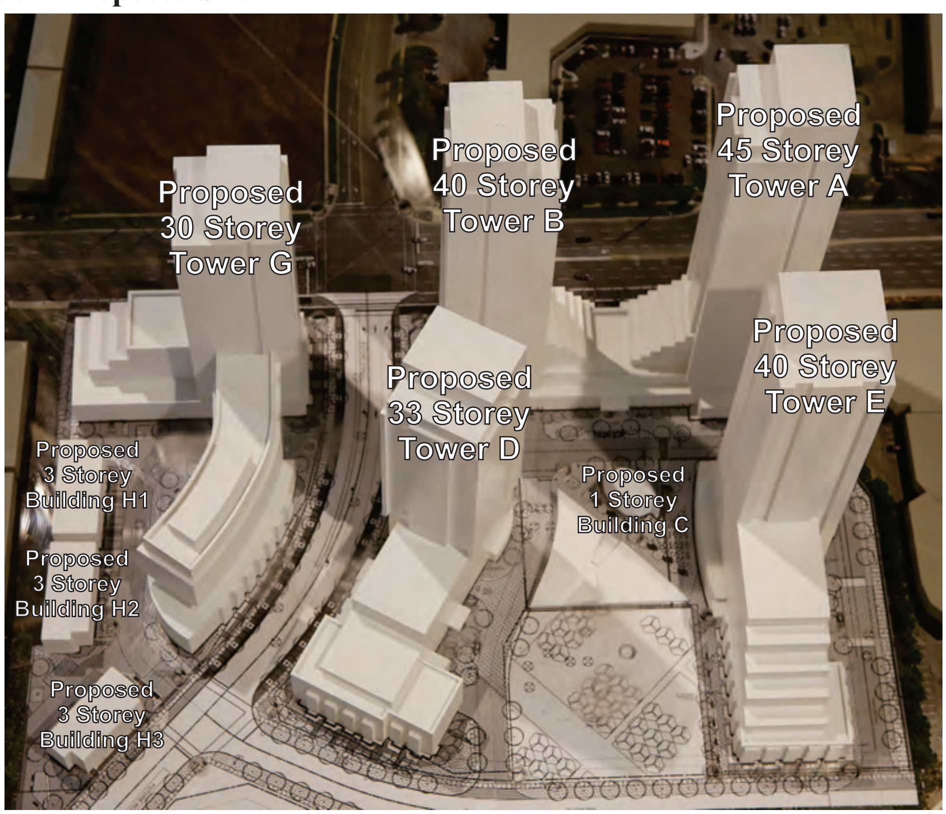


Figure 3: 1:500 Scale model of test site

a) Overall view of model - Proposed Site



b) Close-up view of model - Proposed Site

Figure 4: Location plan for pedestrian level wind velocity measurements.

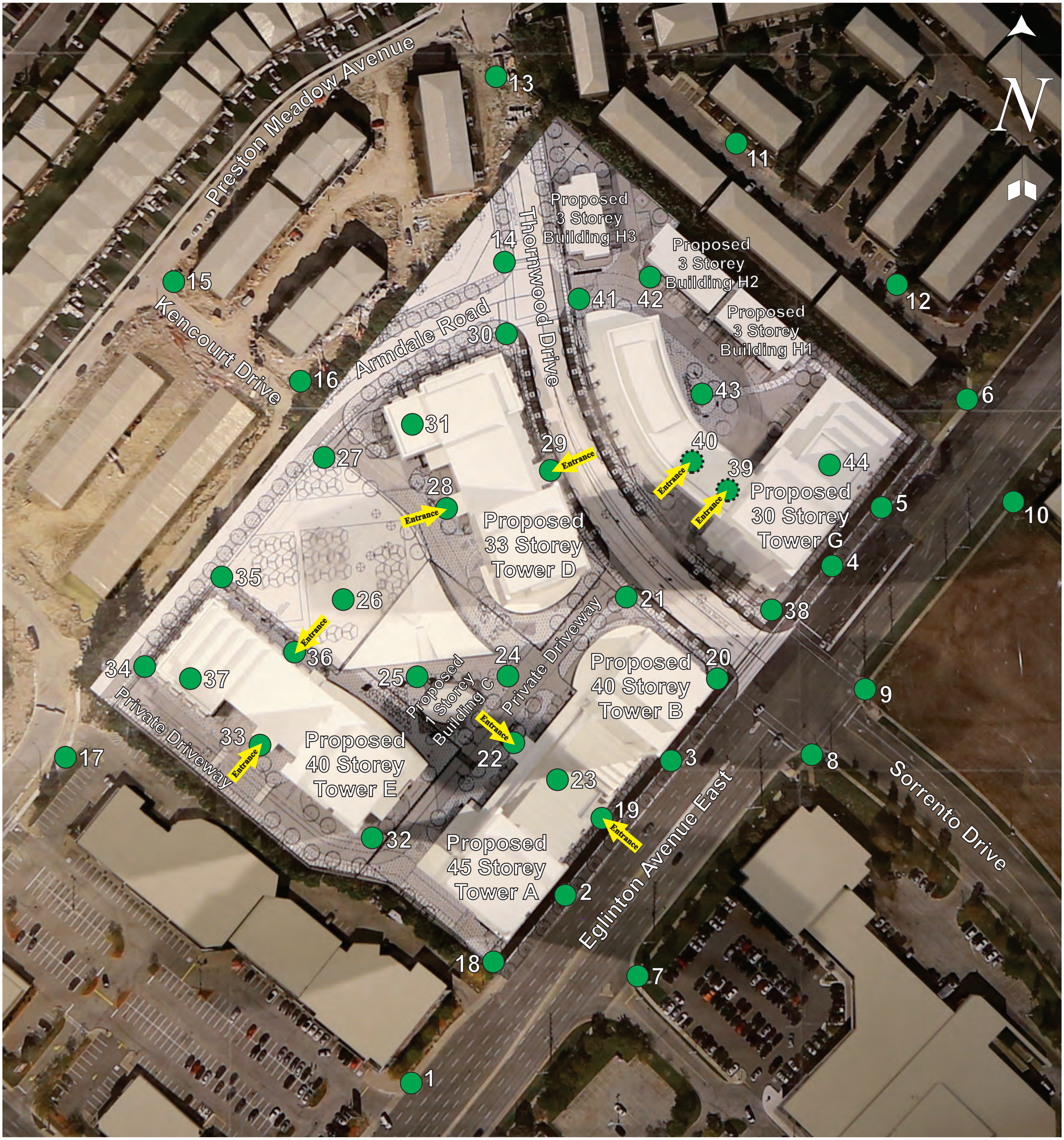
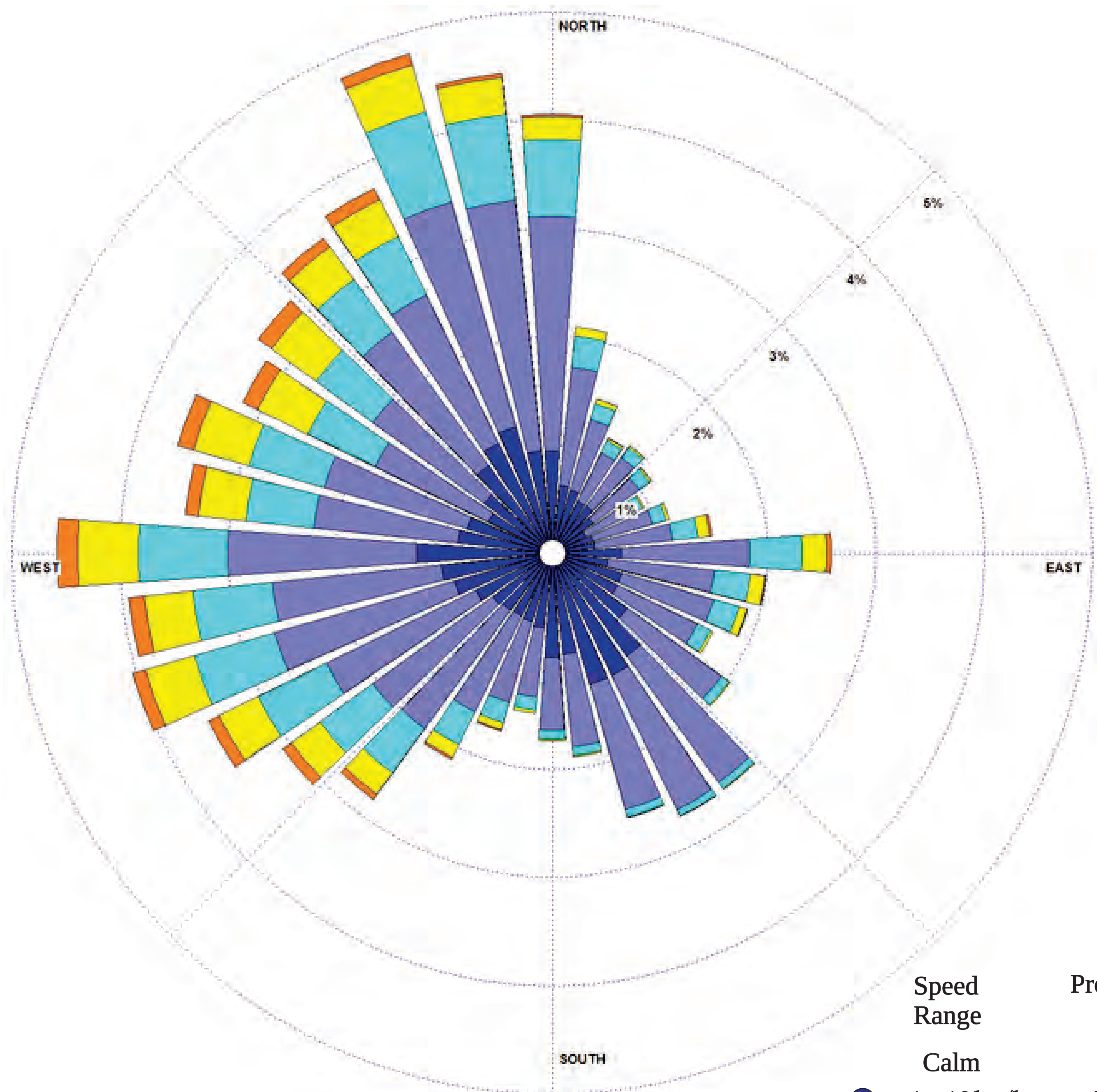


Figure 5a: Annual Wind Rose - Pearson International Airport.

Historical Directional Distribution of Winds (@ 10*m* height)
(1980 - 2017)



Speed Range	Probability (%)
Calm	6%
1 - 10*km/h*	29%
11 - 20*km/h*	42%
21 - 30*km/h*	14%
31 - 40*km/h*	7%
> 40*km/h*	2%

Figure 5b: Winter Wind Rose - Pearson International Airport.

Historical Directional Distribution of Winds (@ 10*m* height)
November 16 through March 31 (1980 - 2017)

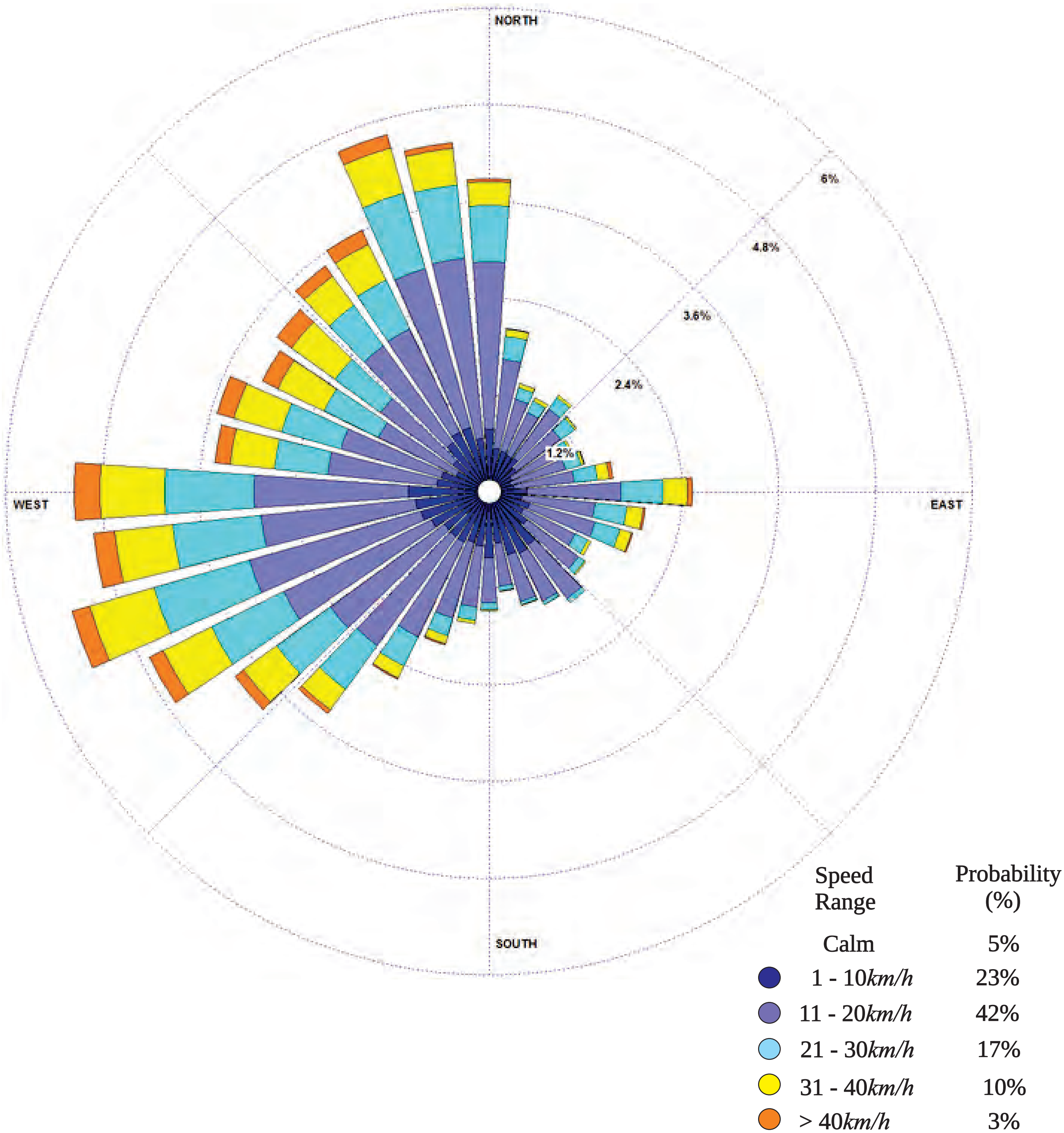
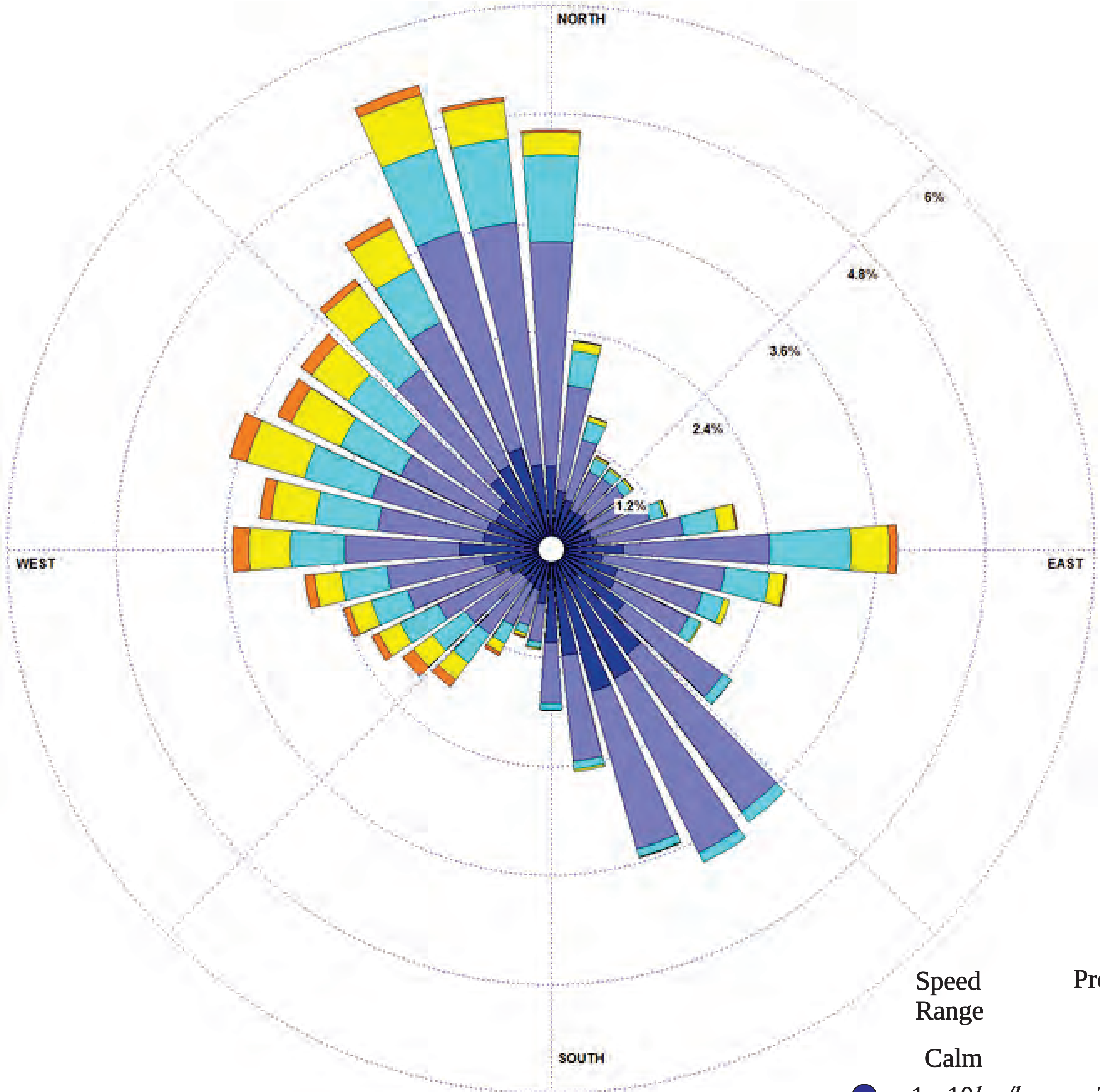


Figure 5c: Spring Wind Rose - Pearson International Airport.

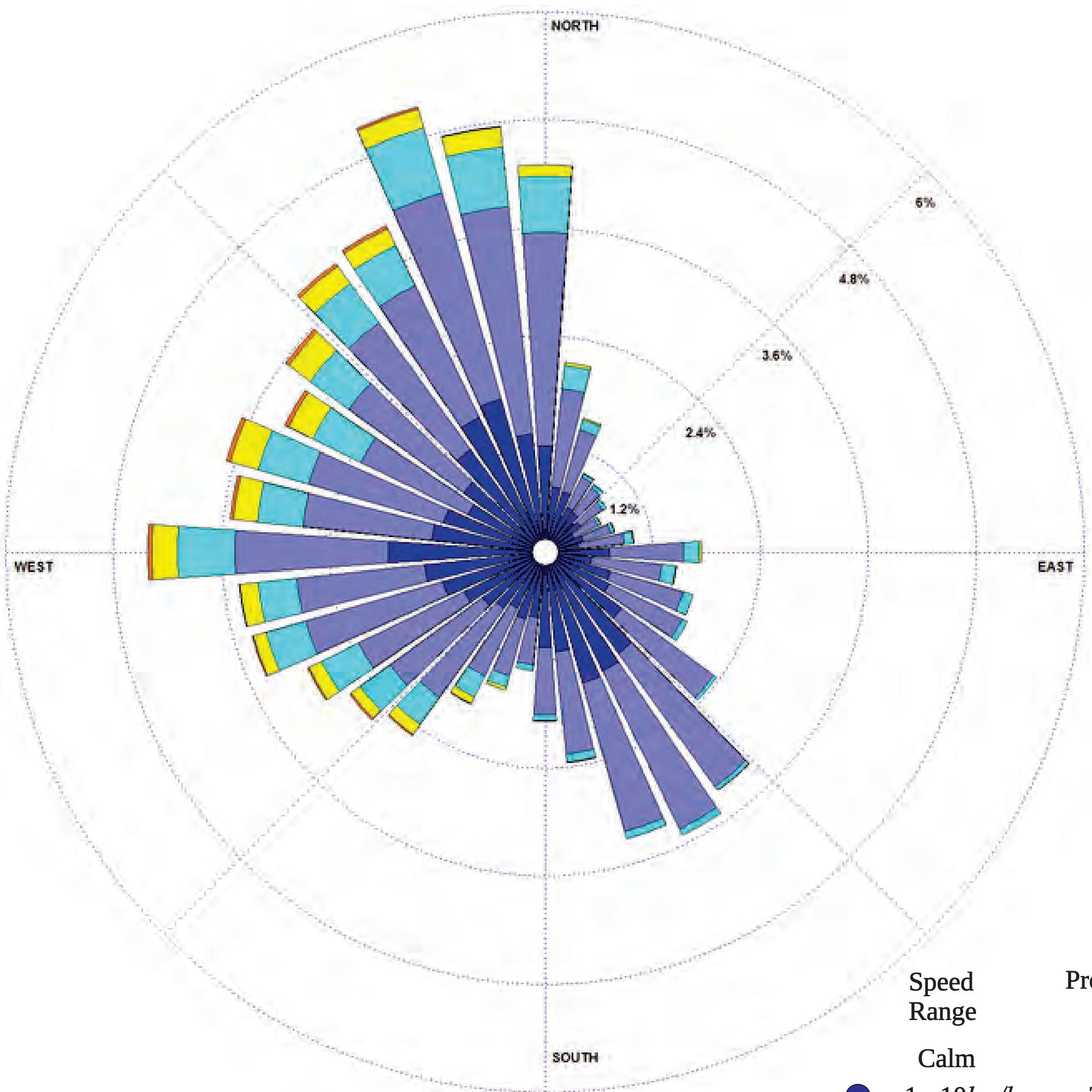
Historical Directional Distribution of Winds (@ 10*m* height)
April 1 through June 15 (1980 - 2017)



Speed Range	Probability (%)
Calm	6%
1 - 10*km/h*	28%
11 - 20*km/h*	42%
21 - 30*km/h*	14%
31 - 40*km/h*	8%
> 40*km/h*	2%

Figure 5d: Summer Wind Rose - Pearson International Airport.

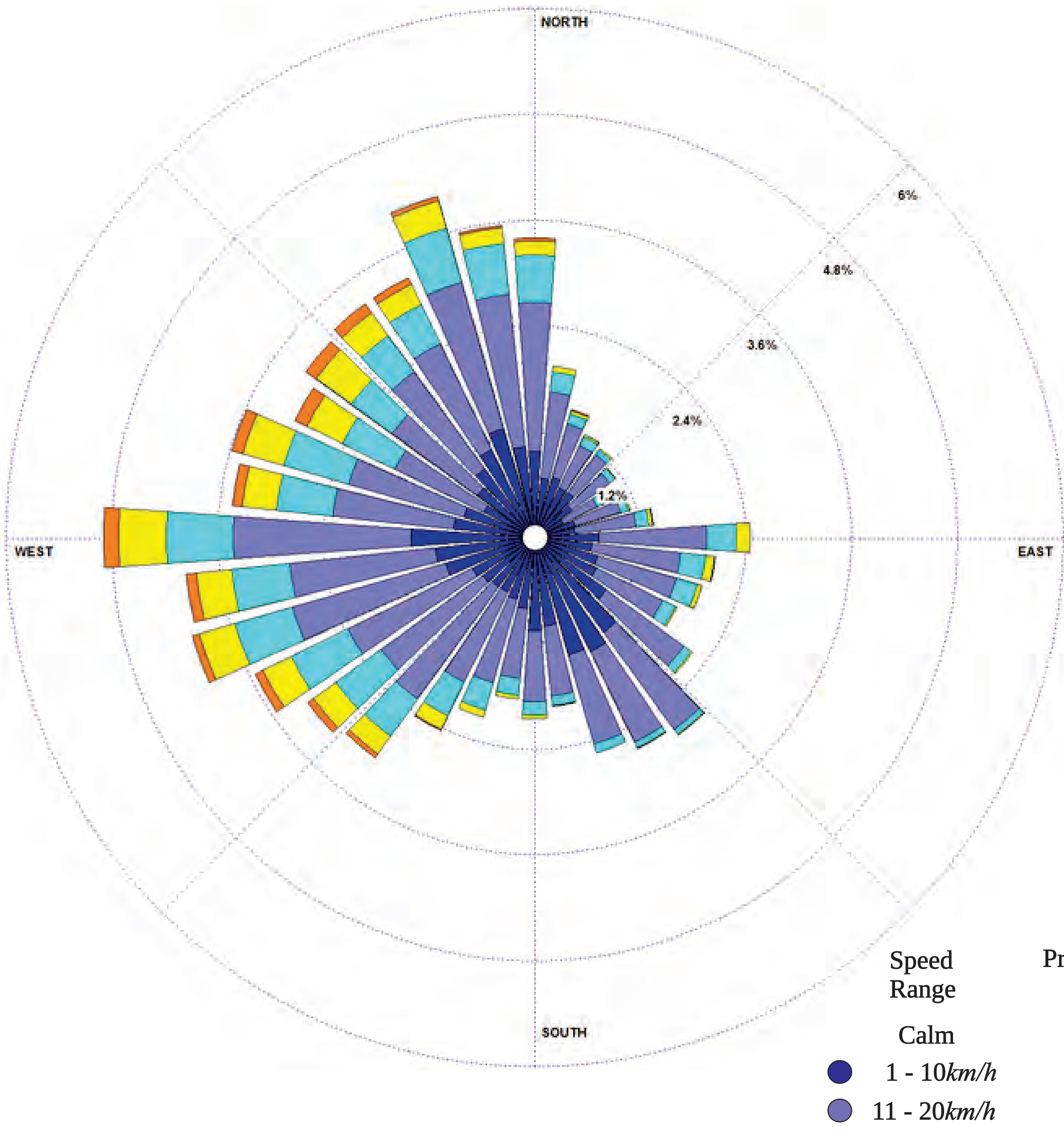
Historical Directional Distribution of Winds (@ 10*m* height)
June 16 through September 15 (1980 - 2017)



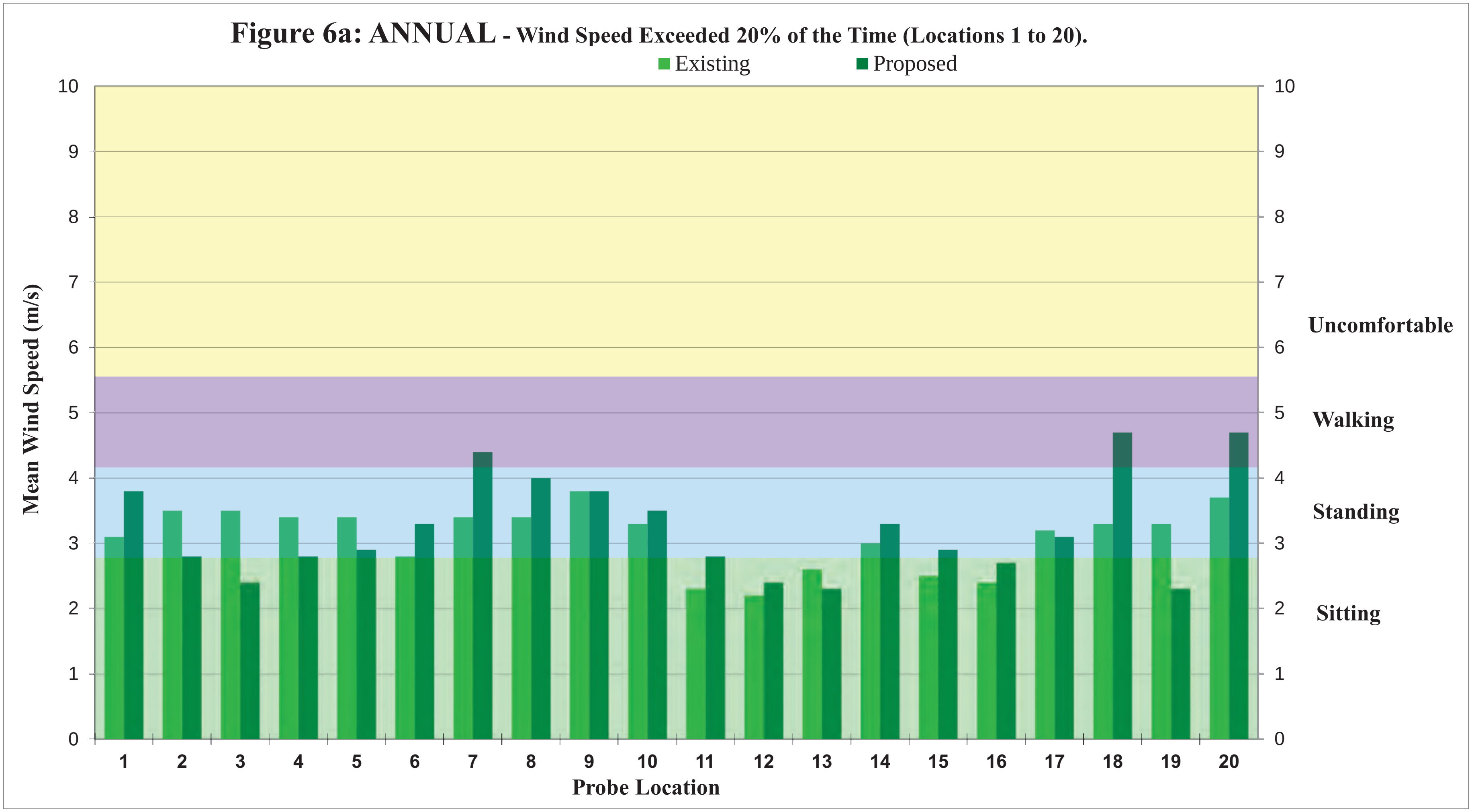
Speed Range	Probability (%)
Calm	7%
1 - 10*km/h*	36%
11 - 20*km/h*	43%
21 - 30*km/h*	10%
31 - 40*km/h*	4%
> 40*km/h*	<1%

Figure 5e: Fall Wind Rose - Pearson International Airport.

Historical Directional Distribution of Winds (@ 10*m* height)
September 16 through November 15 (1980 - 2017)



Speed Range	Probability (%)
Calm	7%
1 - 10*km/h*	31%
11 - 20*km/h*	41%
21 - 30*km/h*	13%
31 - 40*km/h*	6%
> 40*km/h*	2%



Theakston Environmental

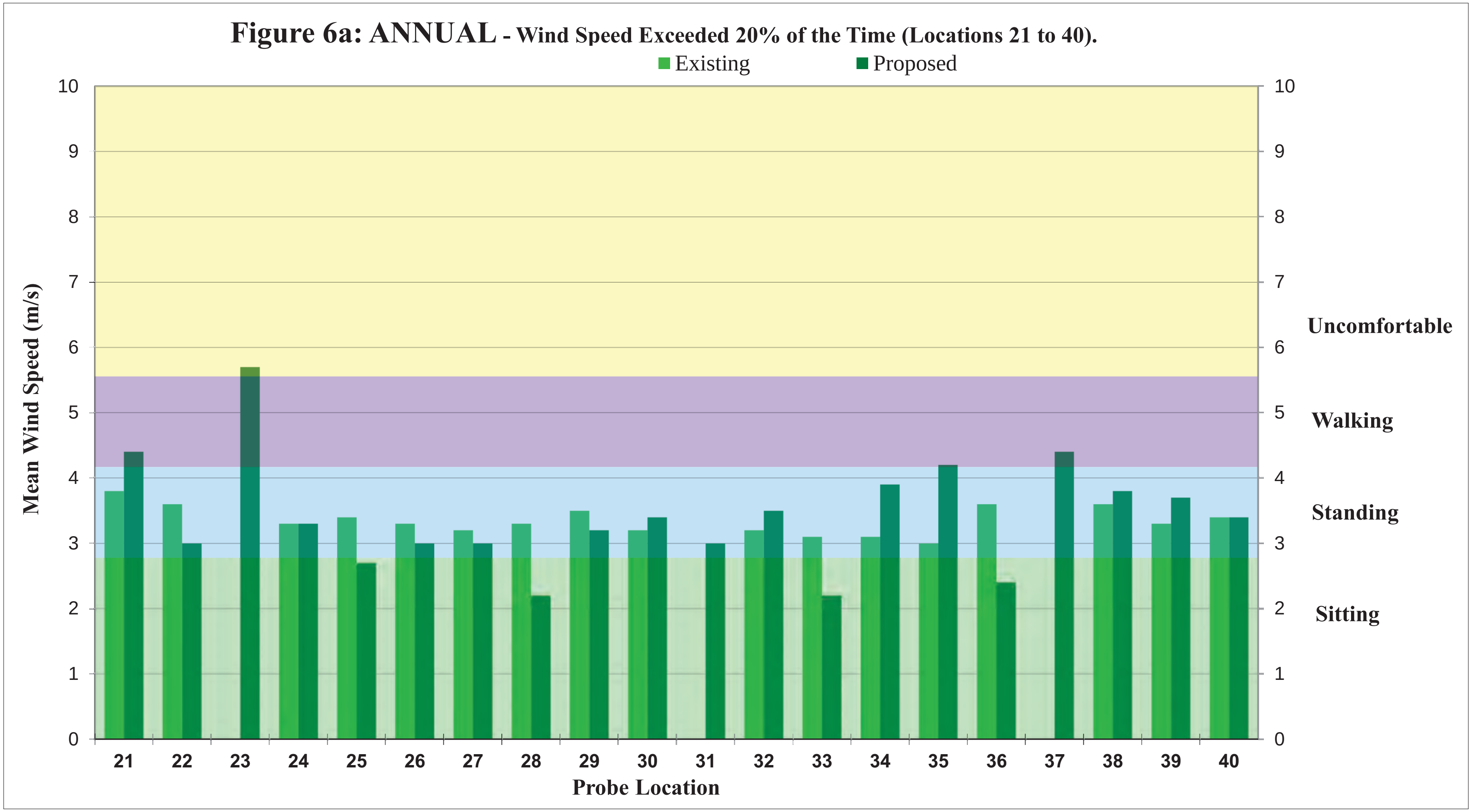
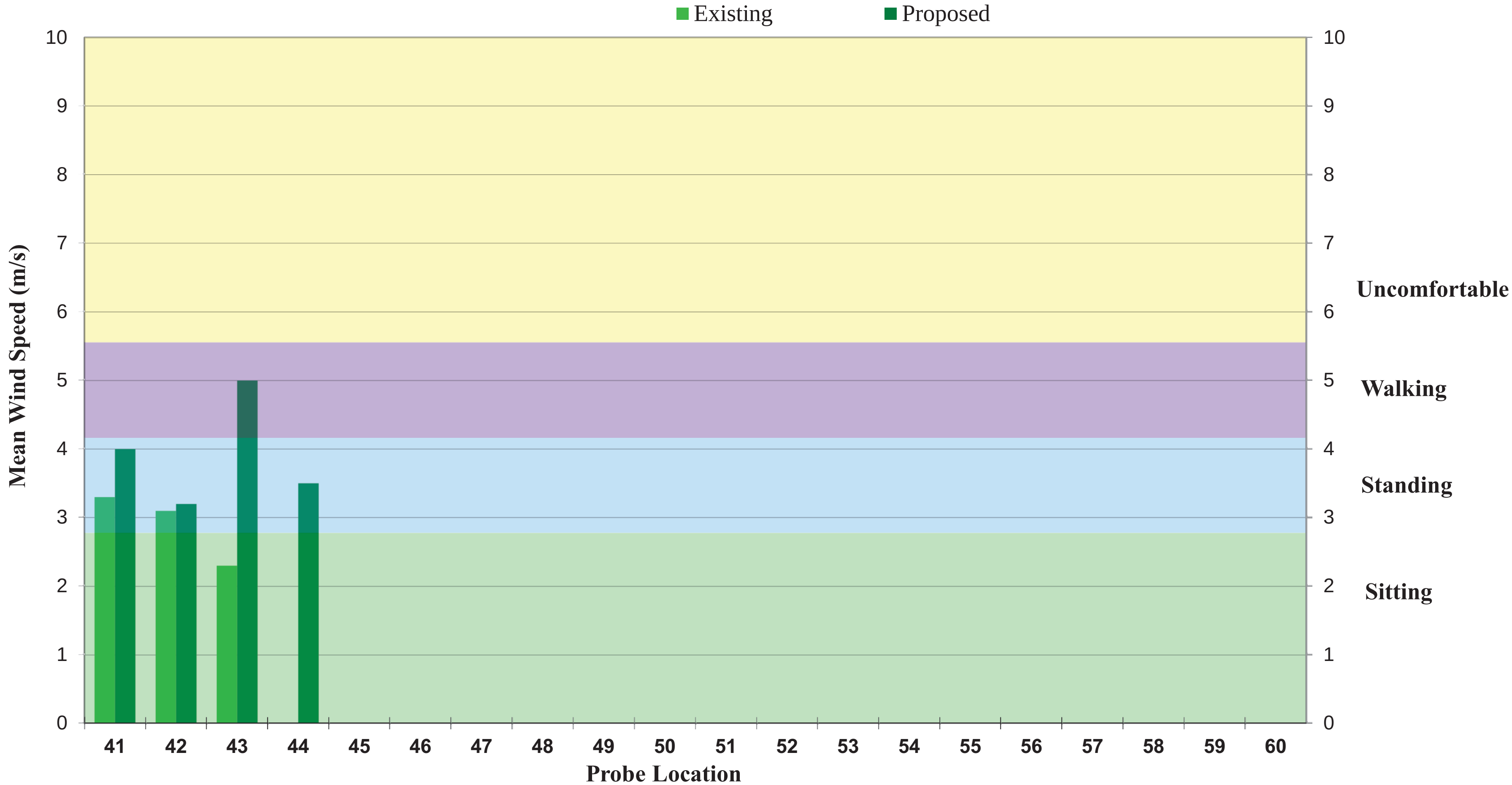


Figure 6a: ANNUAL - Wind Speed Exceeded 20% of the Time (Locations 21 to 40).
Existing
Proposed
Mean Wind Speed (m/s)
Probe Location
Uncomfortable
Walking
Standing
Sitting
0
1
2
3
4
5
6
7
8
9
10
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

Figure 6a: ANNUAL - Wind Speed Exceeded 20% of the Time (Locations 41 to 44).



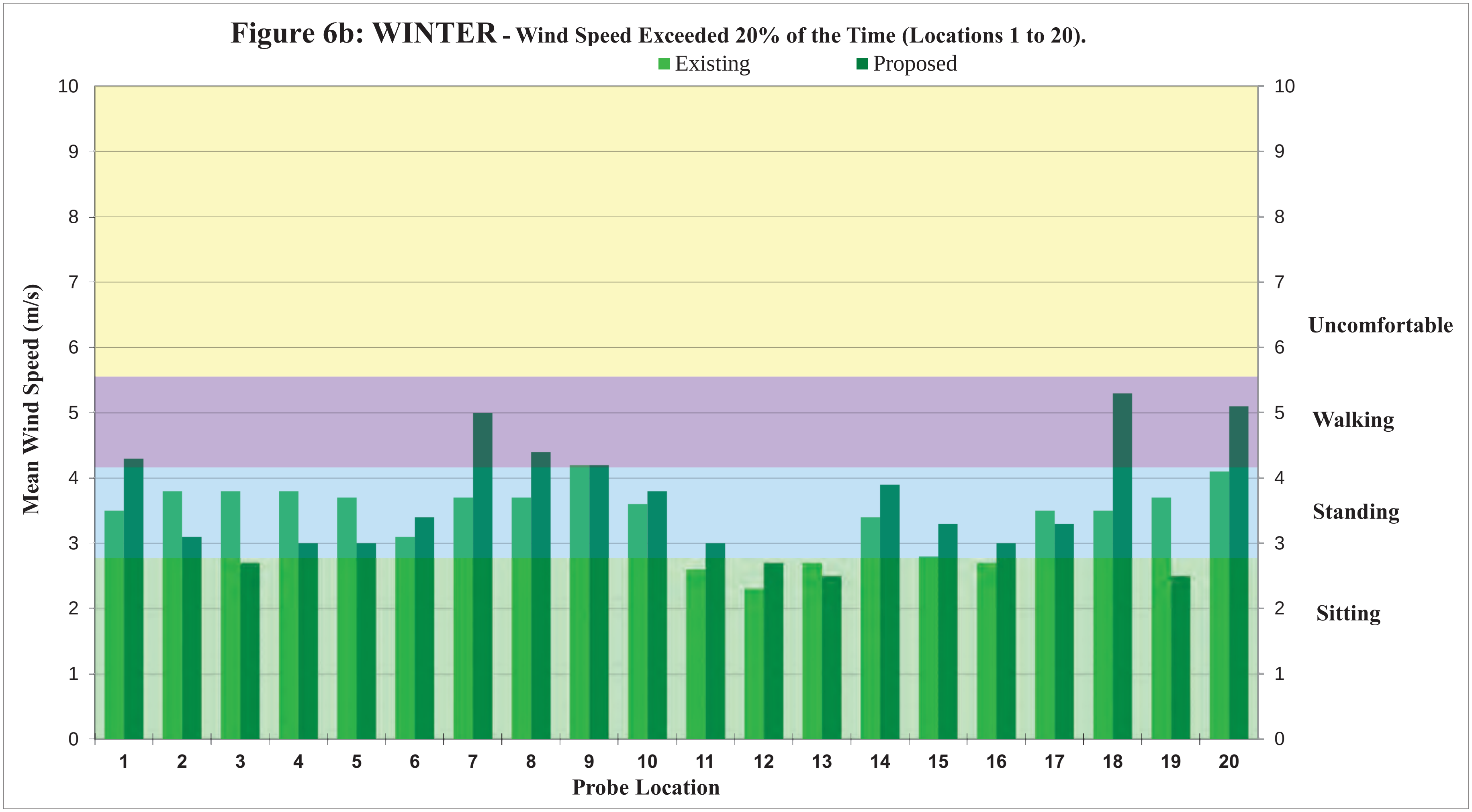
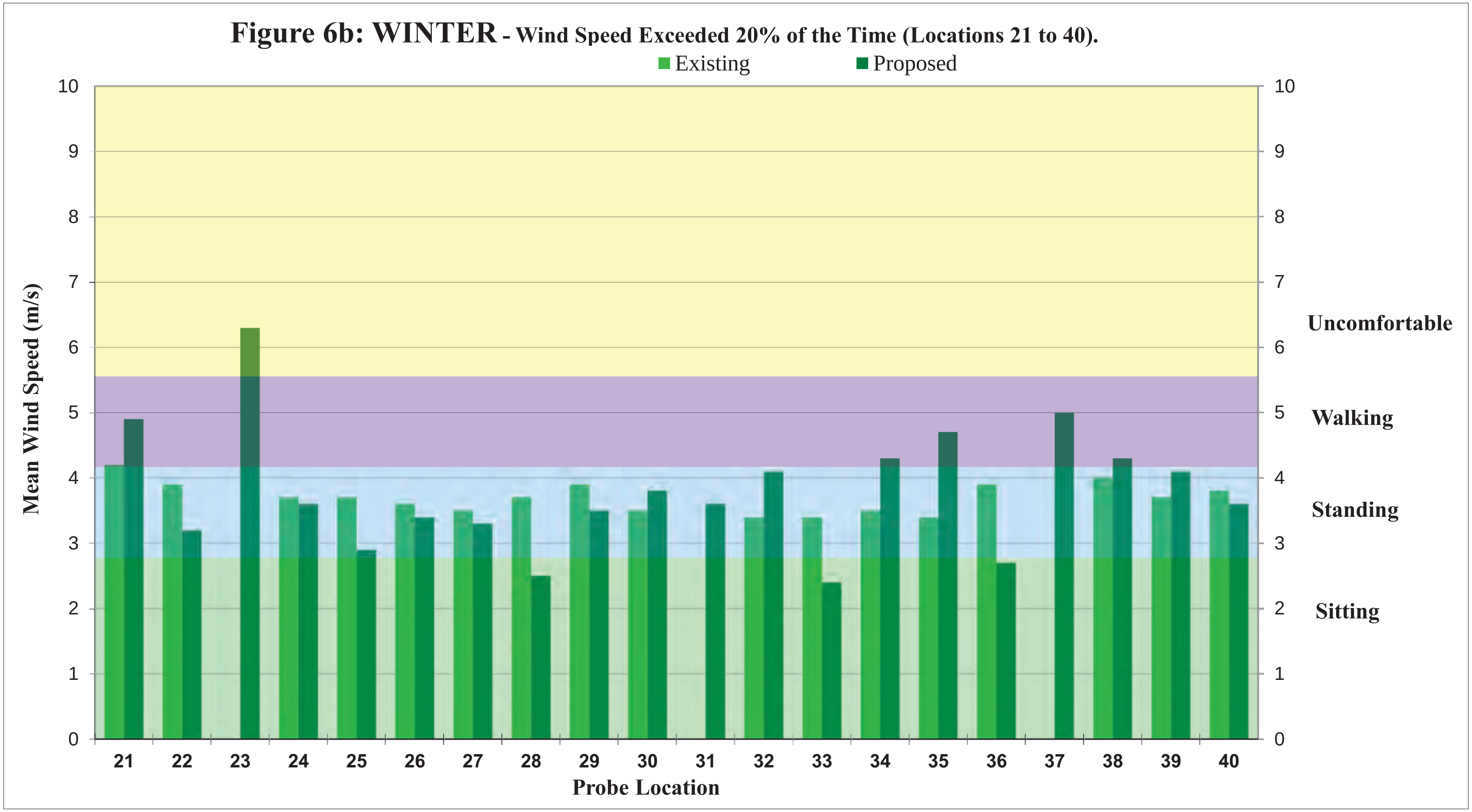


Figure 6b: WINTER - Wind Speed Exceeded 20% of the Time (Locations 1 to 20).
Existing
Proposed
Mean Wind Speed (m/s)
0
1
2
3
4
5
6
7
8
9
10
Uncomfortable
Walking
Standing
Sitting
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Probe Location



Theakston
Environmental

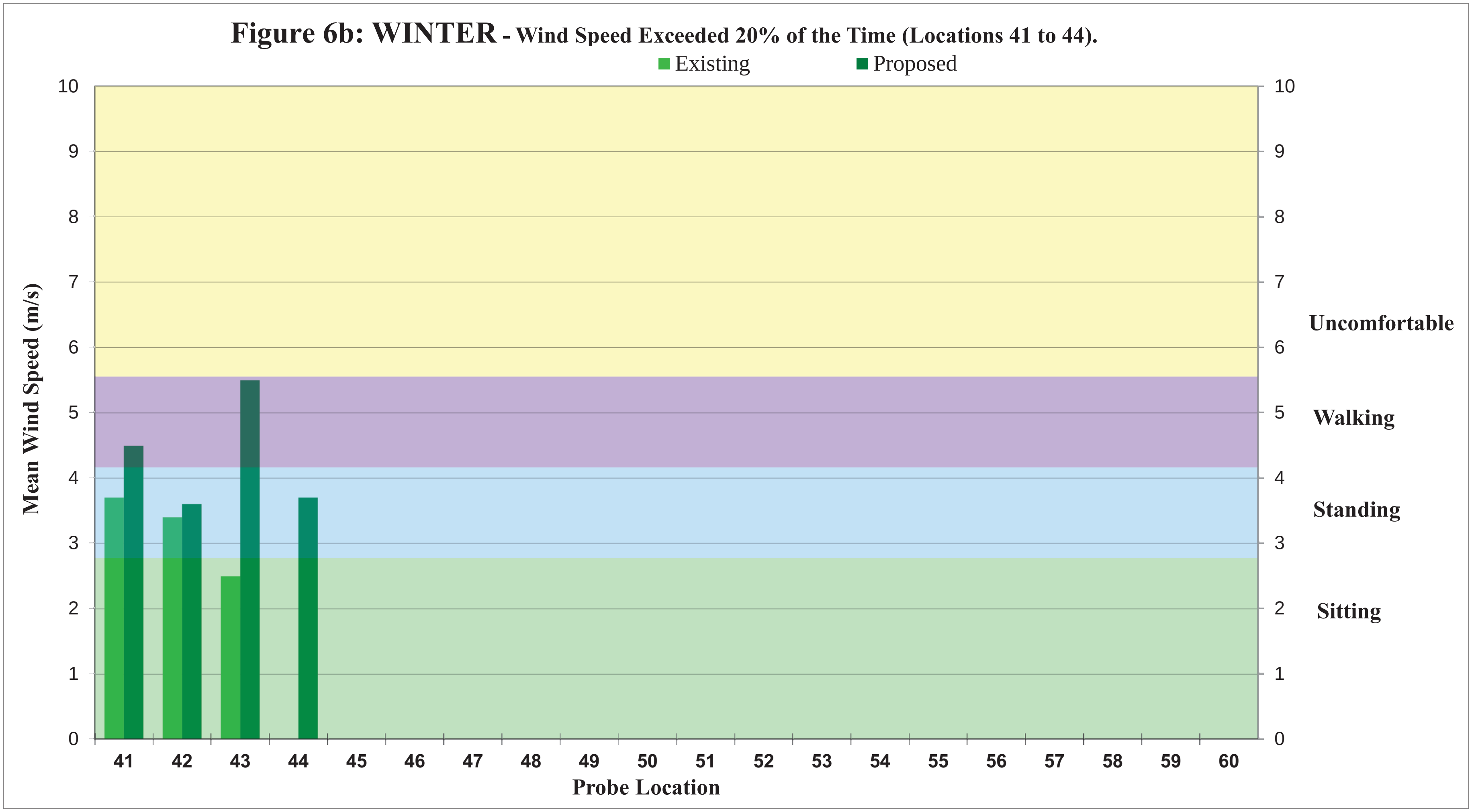
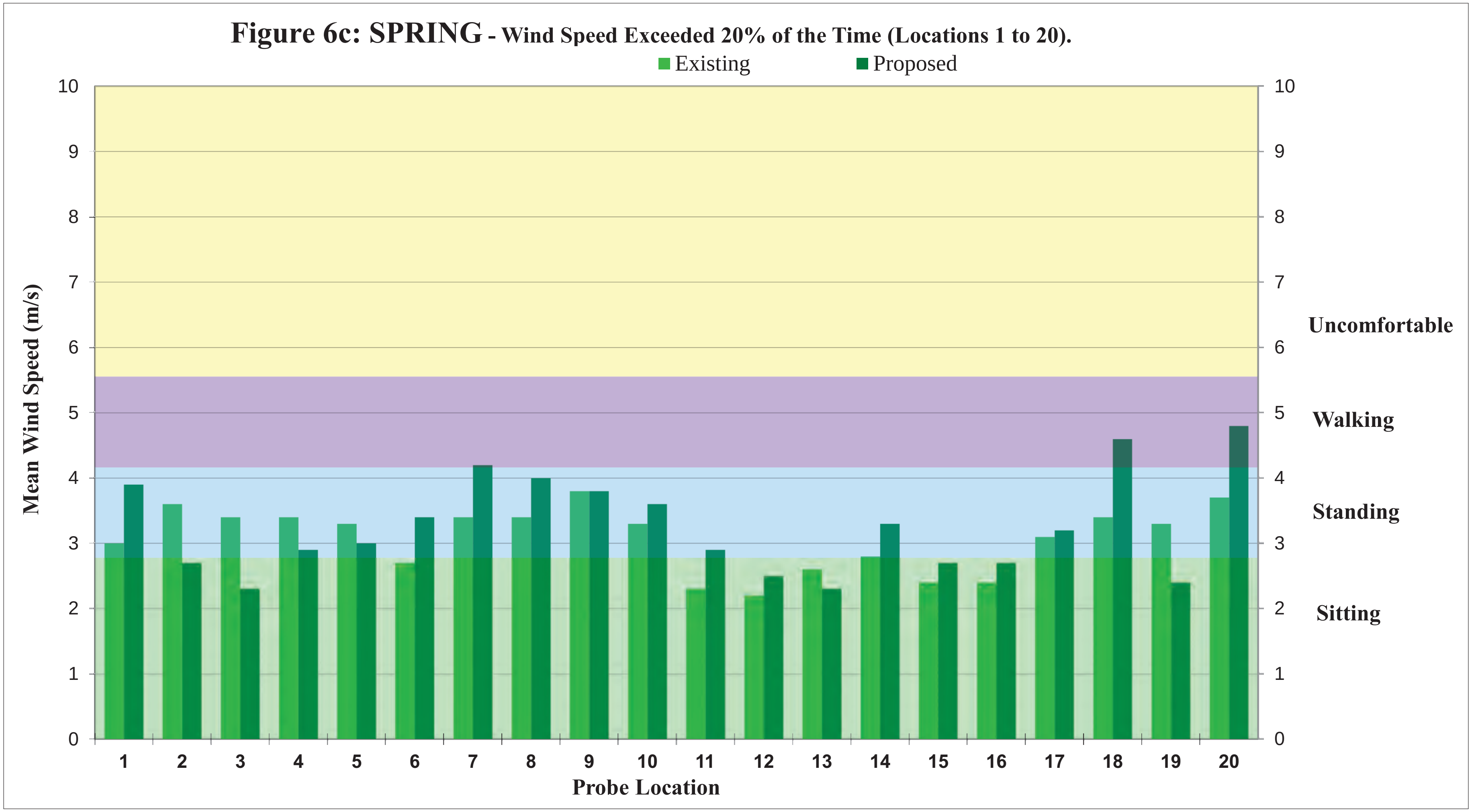


Figure 6b: WINTER - Wind Speed Exceeded 20% of the Time (Locations 41 to 44).
Existing
Proposed
Mean Wind Speed (m/s)
Probe Location
Uncomfortable
Walking
Standing
Sitting
0
1
2
3
4
5
6
7
8
9
10
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Theakston Environmental

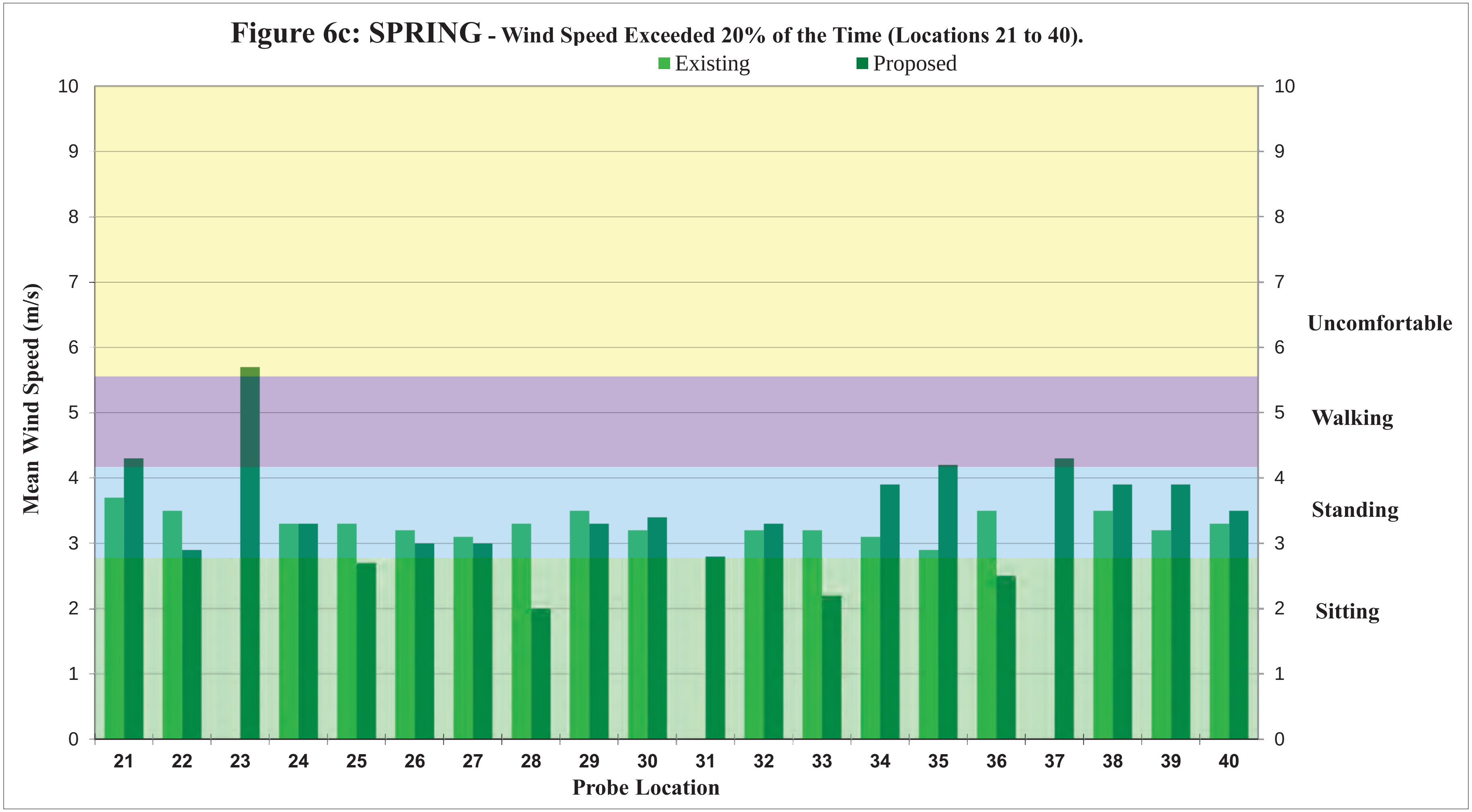


Figure 6c: SPRING - Wind Speed Exceeded 20% of the Time (Locations 21 to 40).
Existing
Proposed
Mean Wind Speed (m/s)
0
1
2
3
4
5
6
7
8
9
10
Uncomfortable
Walking
Standing
Sitting
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
Probe Location

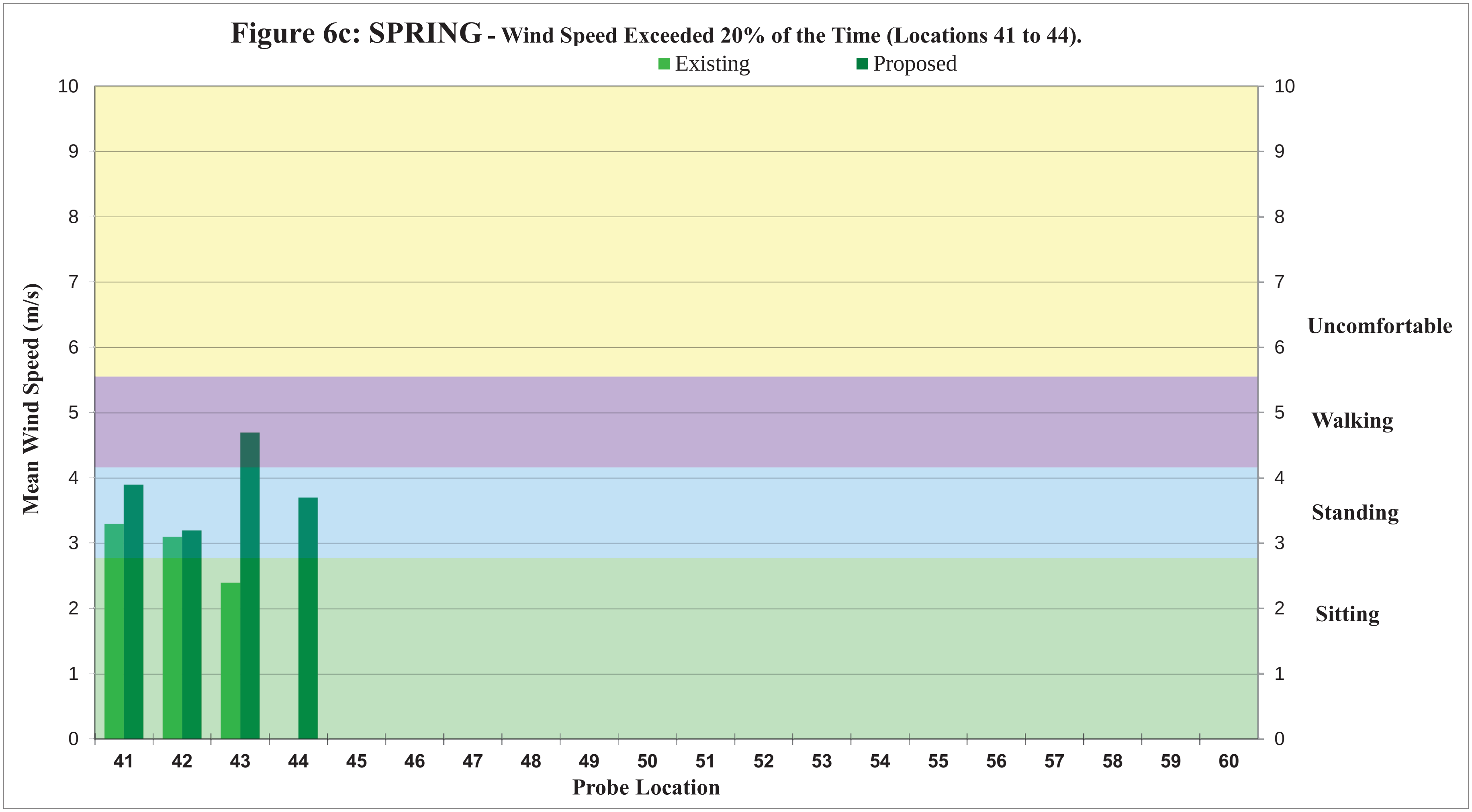
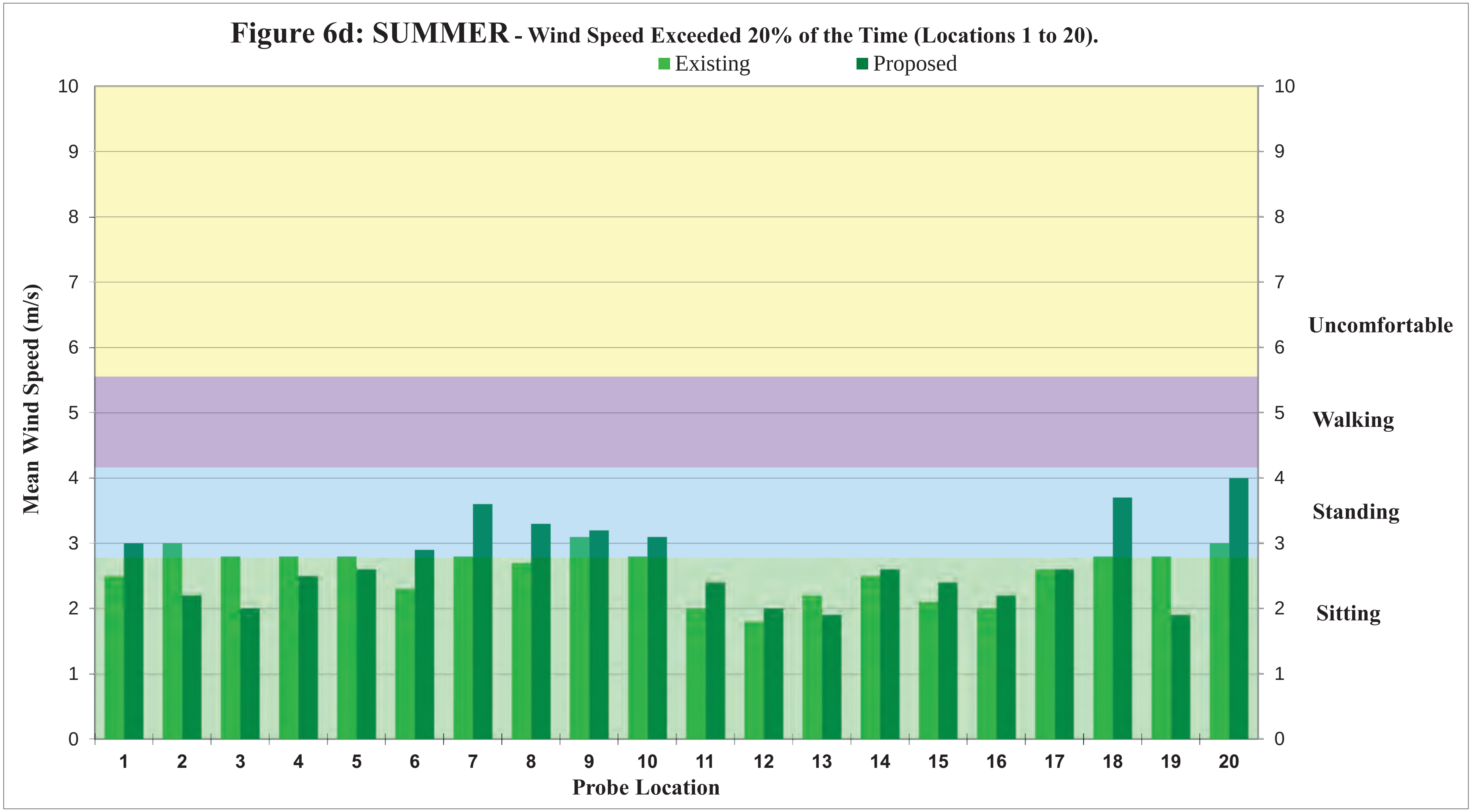
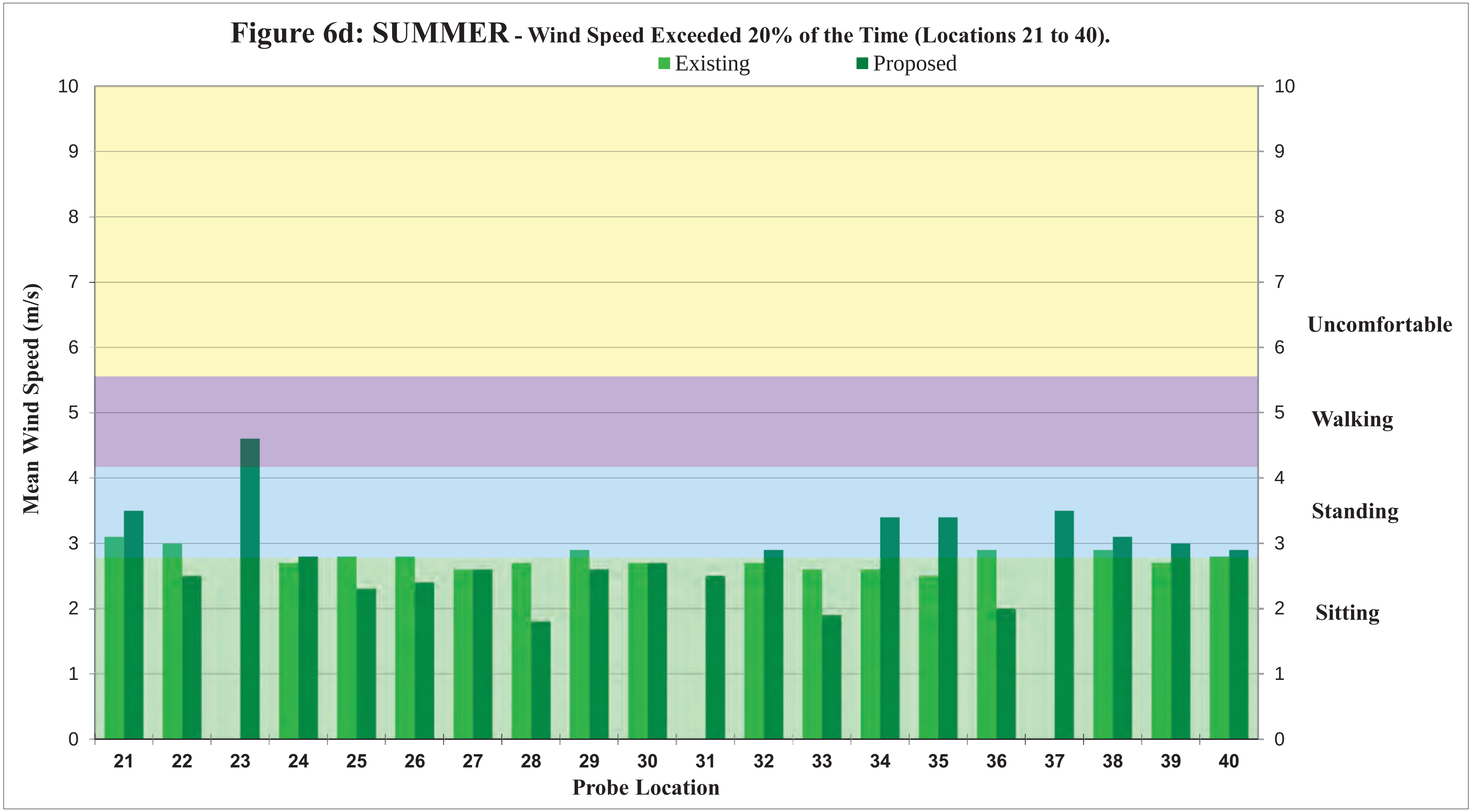


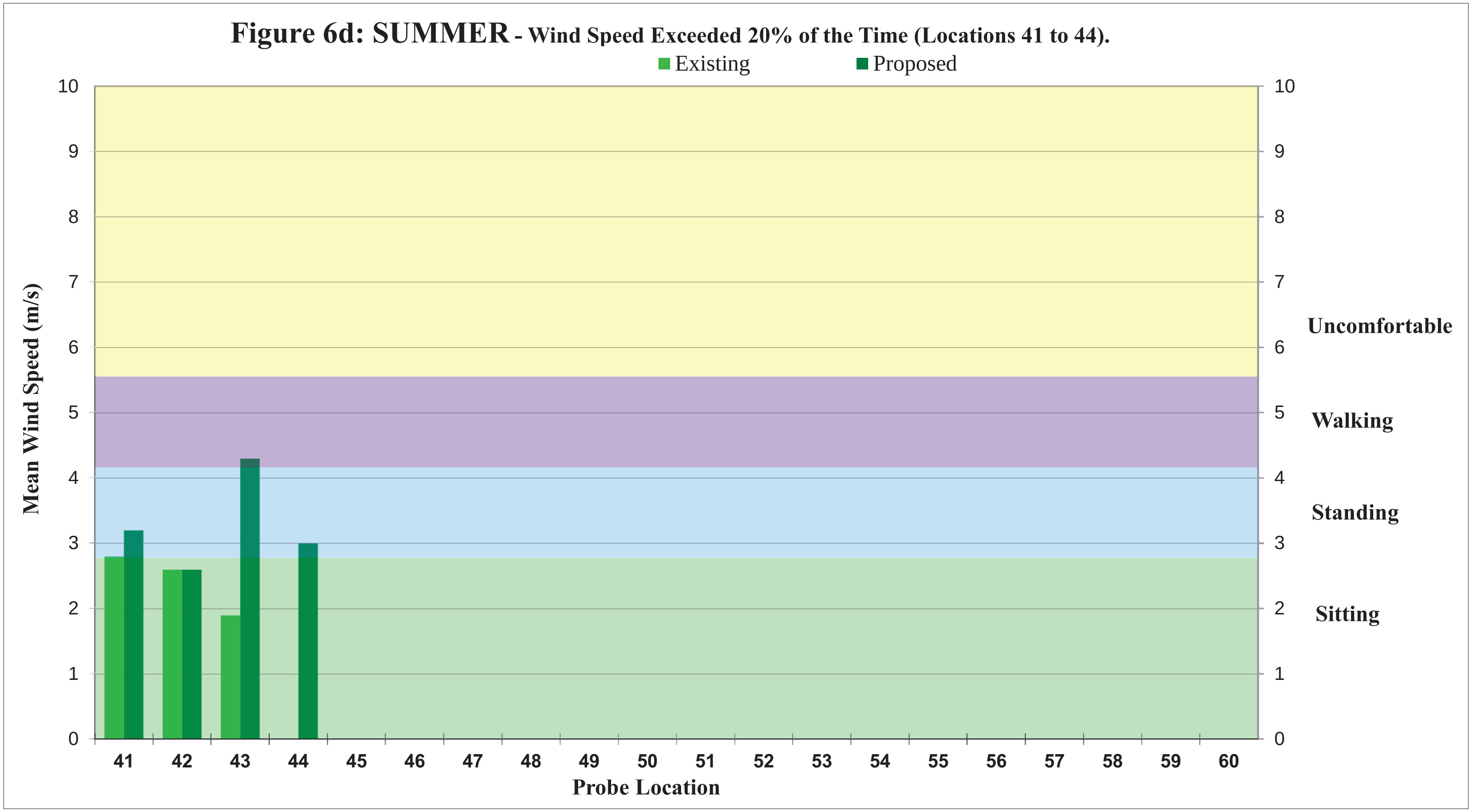
Figure 6c: SPRING - Wind Speed Exceeded 20% of the Time (Locations 41 to 44).
Existing
Proposed
Mean Wind Speed (m/s)
0
1
2
3
4
5
6
7
8
9
10
Uncomfortable
Walking
Standing
Sitting
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
Probe Location



Theakston
Environmental



Theakston Environmental



Theakston
Environmental

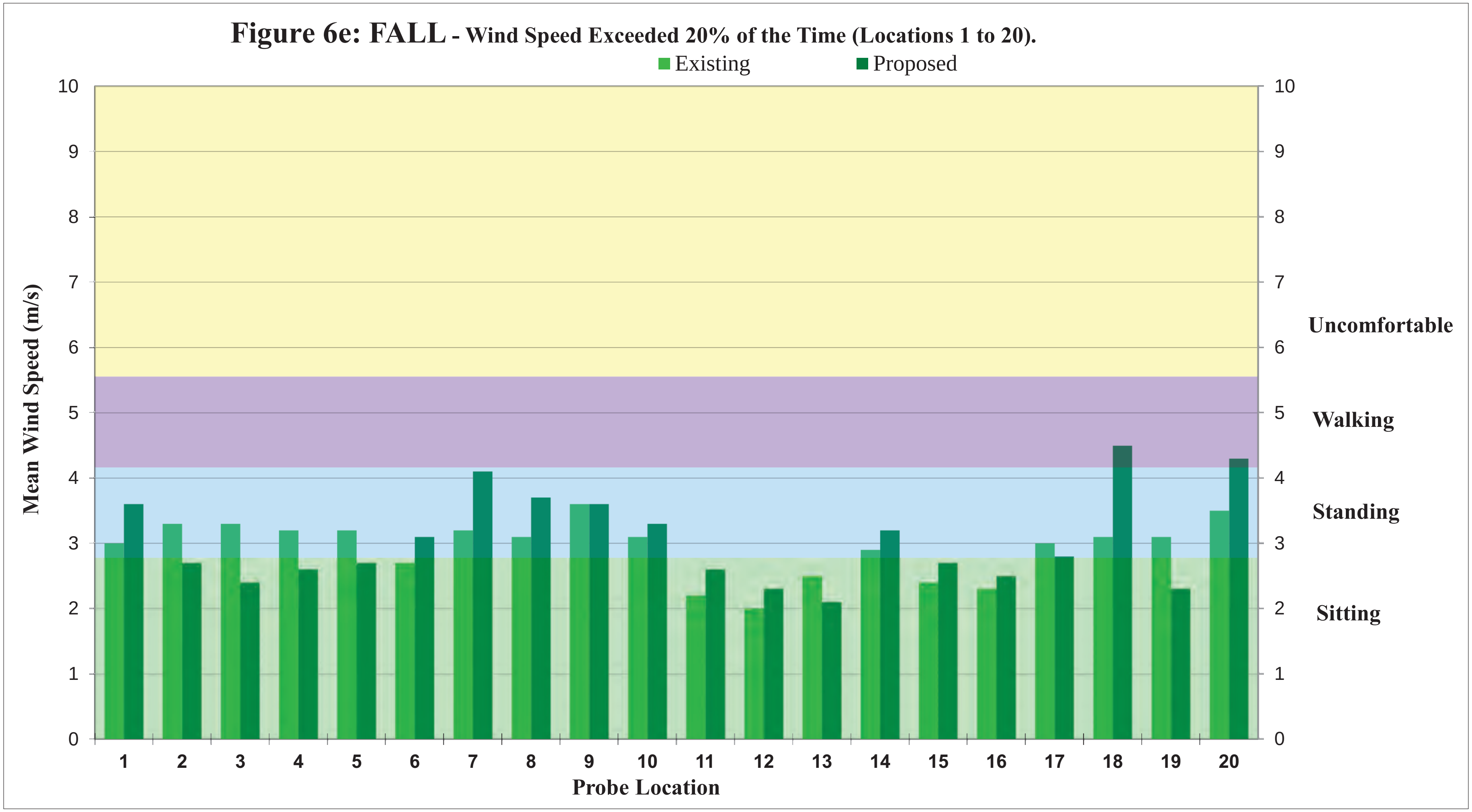


Figure 6e: FALL - Wind Speed Exceeded 20% of the Time (Locations 1 to 20).
Existing
Proposed
Mean Wind Speed (m/s)
Probe Location
Uncomfortable
Walking
Standing
Sitting
0
1
2
3
4
5
6
7
8
9
10
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

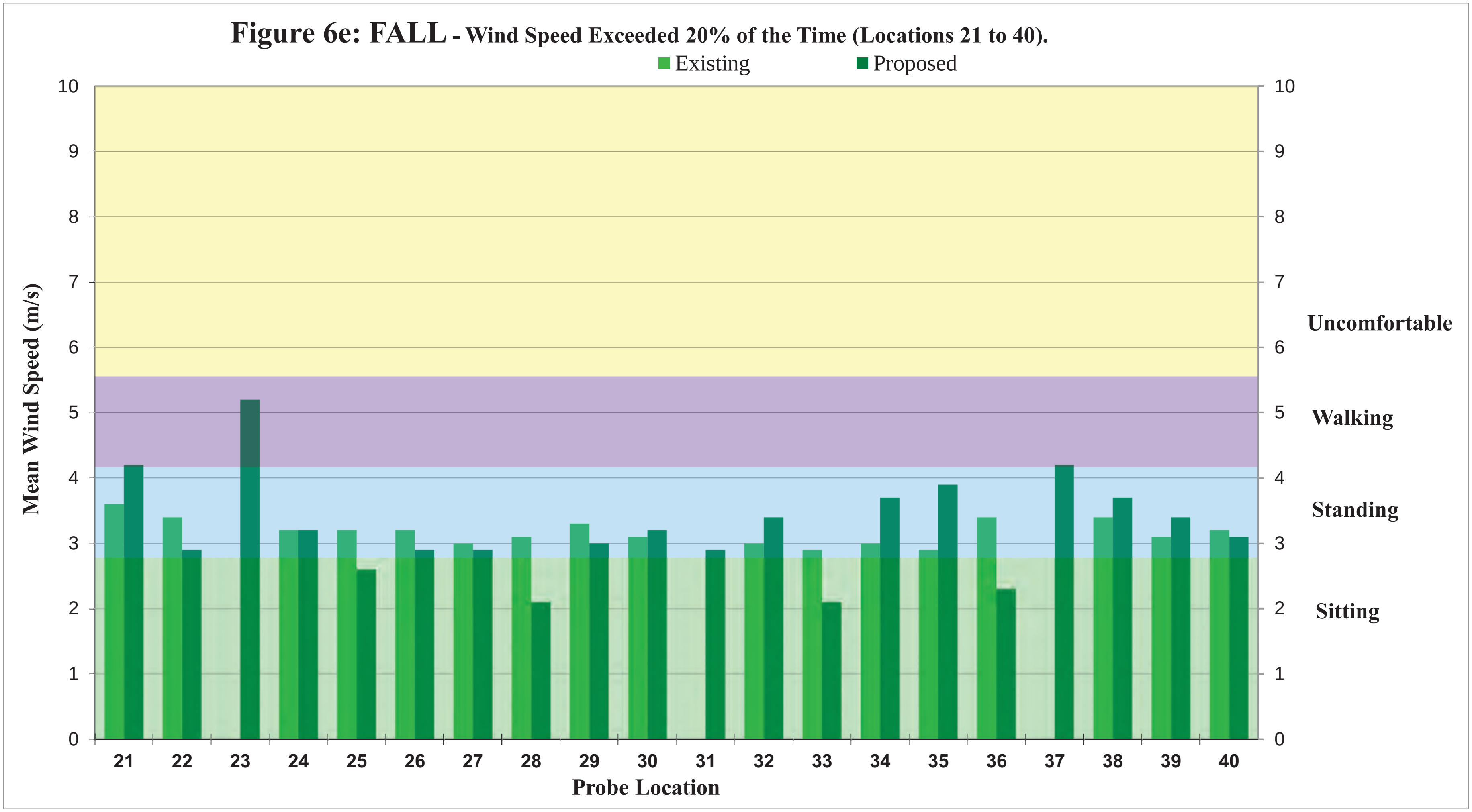
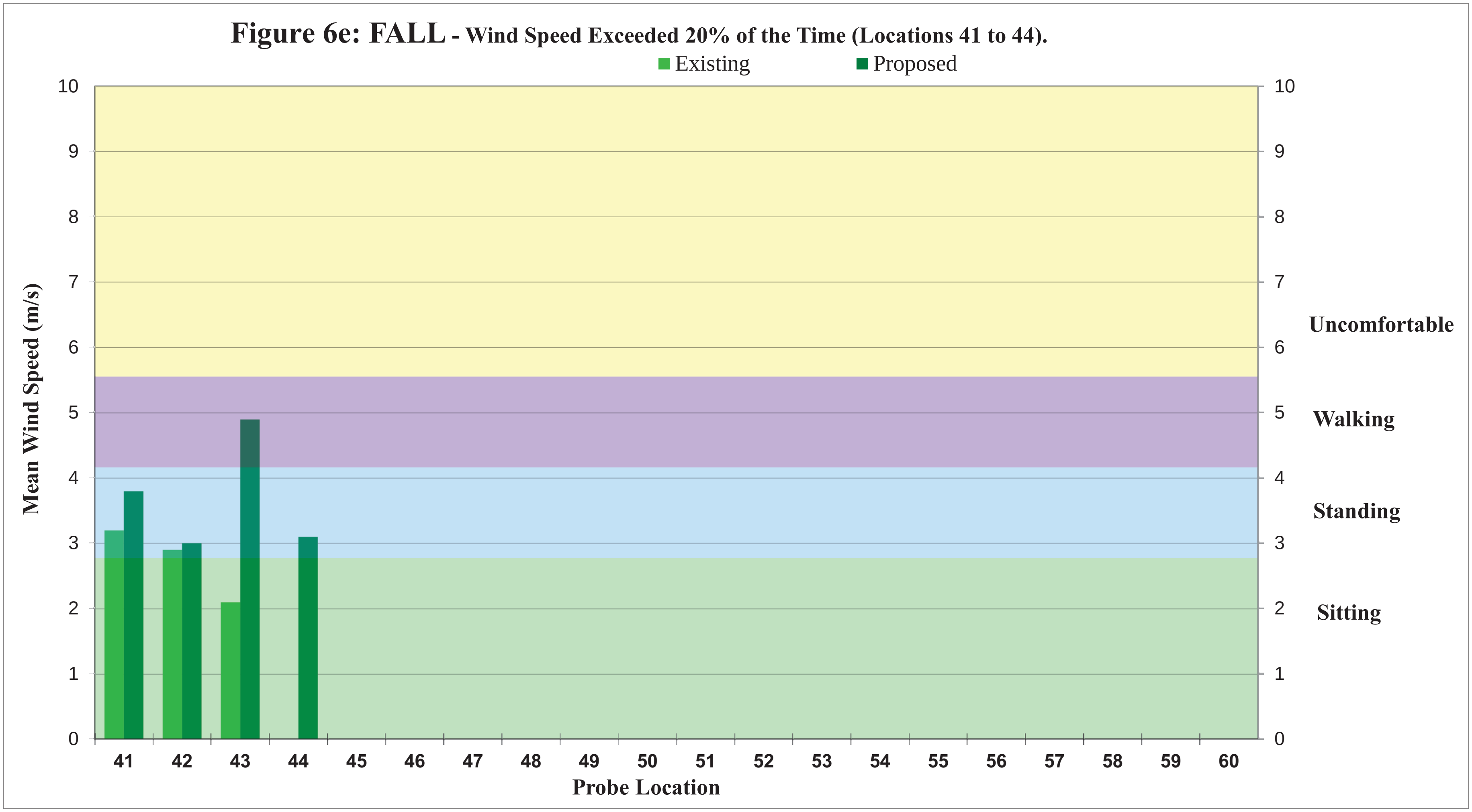


Figure 6e: FALL - Wind Speed Exceeded 20% of the Time (Locations 21 to 40).
Existing
Proposed
Mean Wind Speed (m/s)
Probe Location
Uncomfortable
Walking
Standing
Sitting
0
1
2
3
4
5
6
7
8
9
10
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

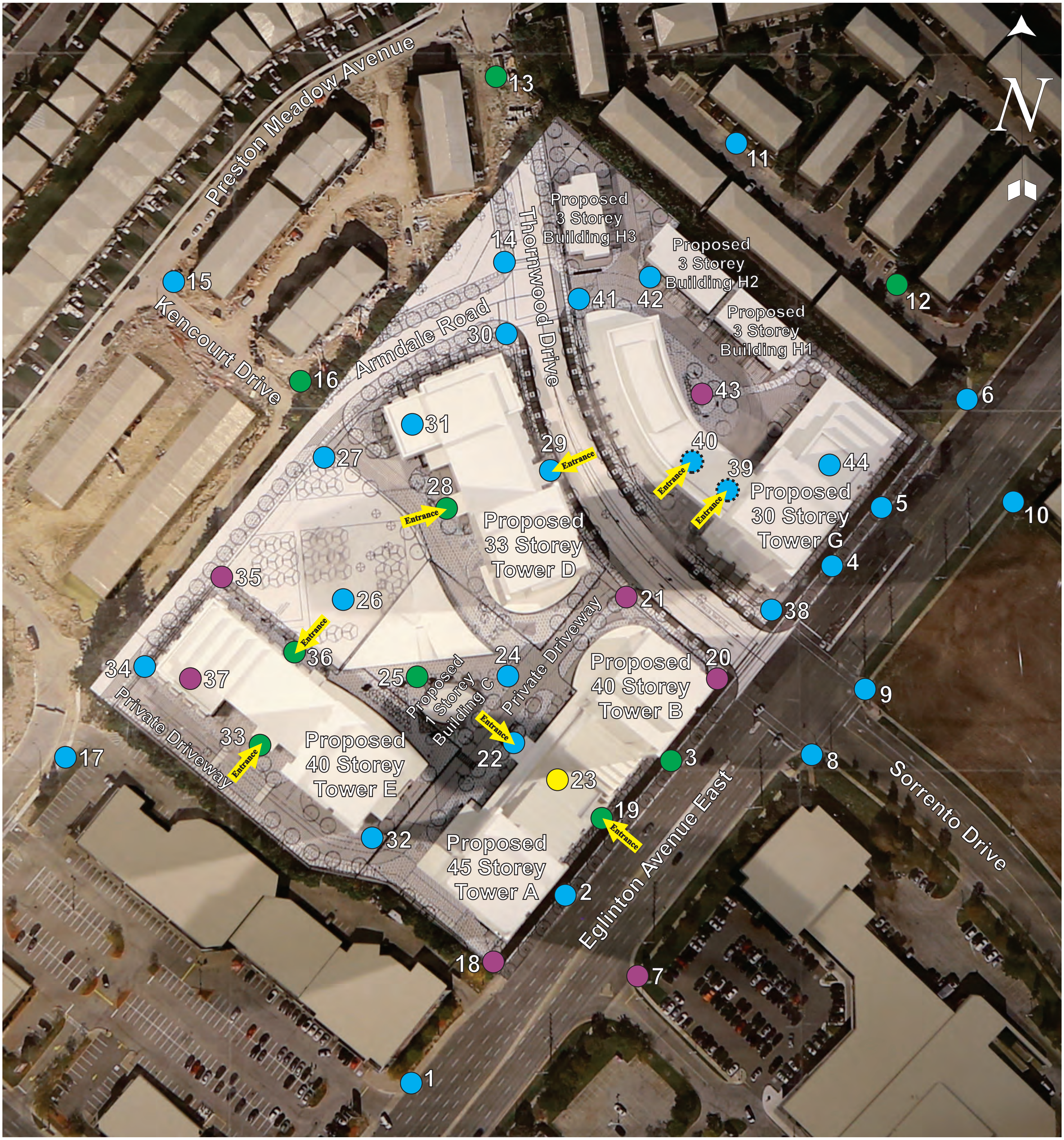


Theakston
Environmental

Figure 7a: Pedestrian level wind velocity comfort categories.

Theakston Environmental

Figure 7b: Pedestrian level wind velocity comfort categories.



Comfort Categories - Annual - Proposed

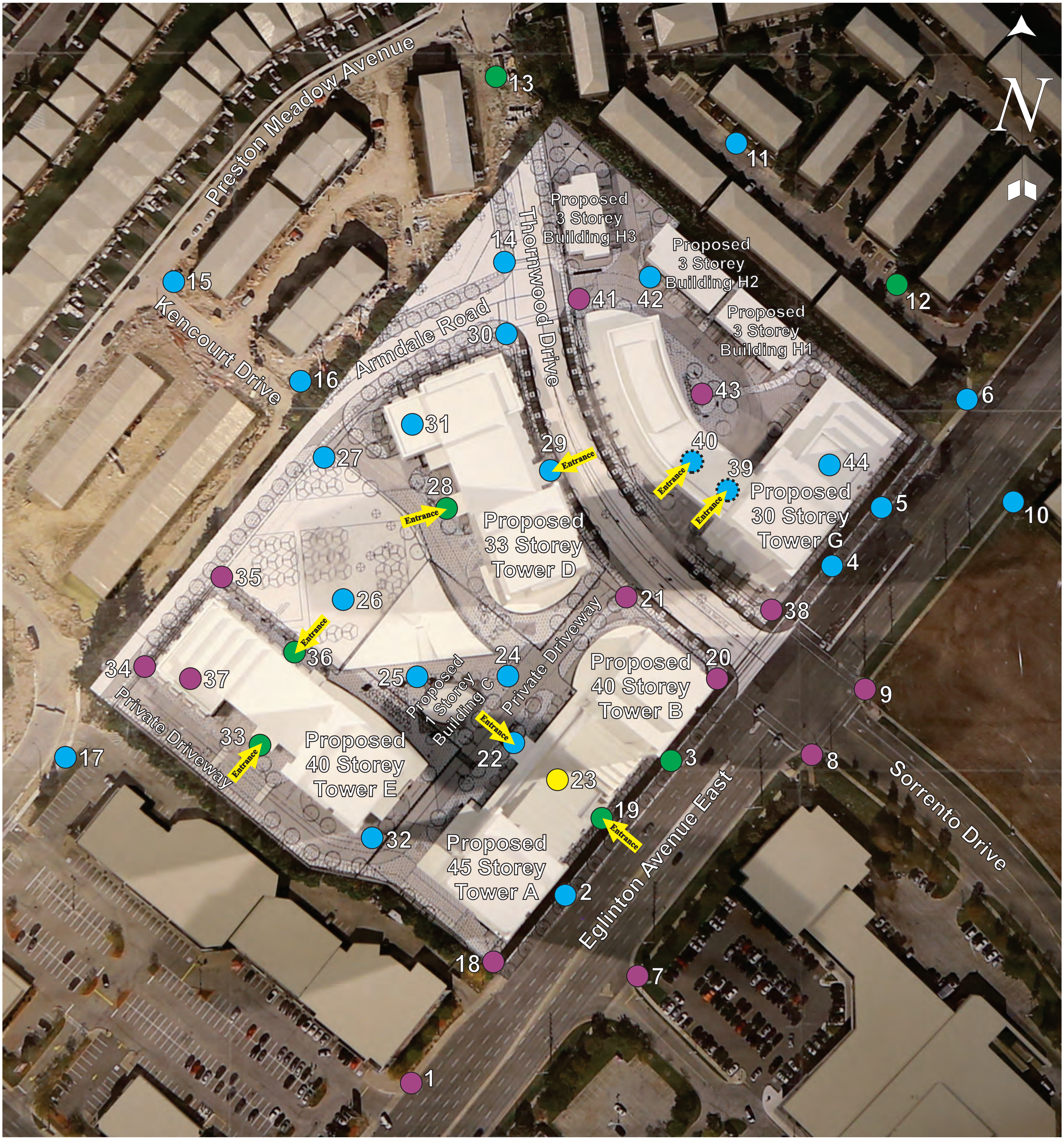
Sitting Standing Walking Uncomfortable

Figure 7c: Pedestrian level wind velocity comfort categories.

Comfort Categories - Winter - Existing

Sitting · Standing · Walking · Uncomfortable

Figure 7d: Pedestrian level wind velocity comfort categories.



Comfort Categories - Winter - Proposed

Sitting Standing Walking Uncomfortable

Theakston
Environmental

Figure 7e: Pedestrian level wind velocity comfort categories.

Comfort Categories - Spring - Existing

Sitting Standing Walking Uncomfortable

Theakston
Environmental

Figure 7f: Pedestrian level wind velocity comfort categories.

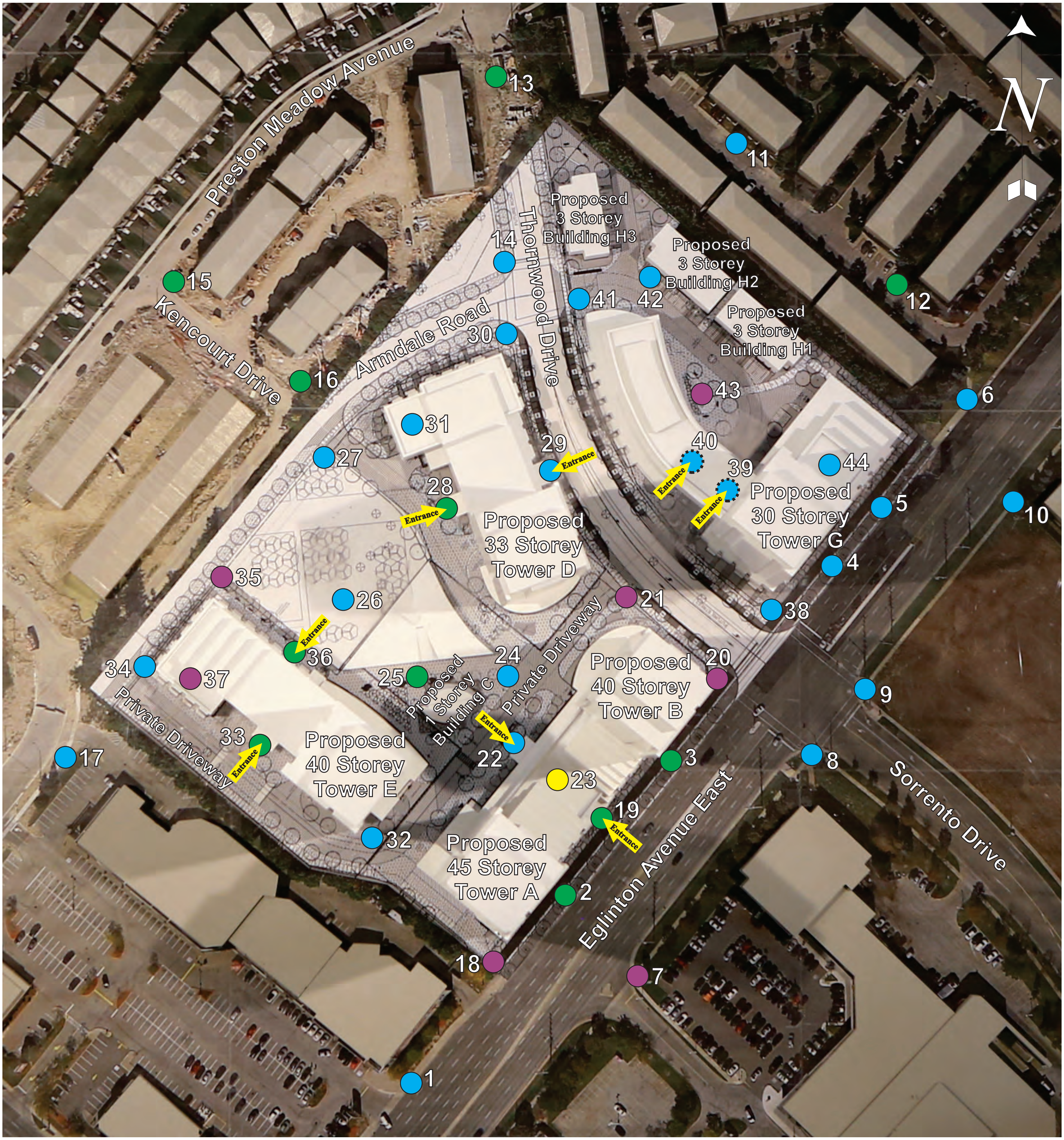


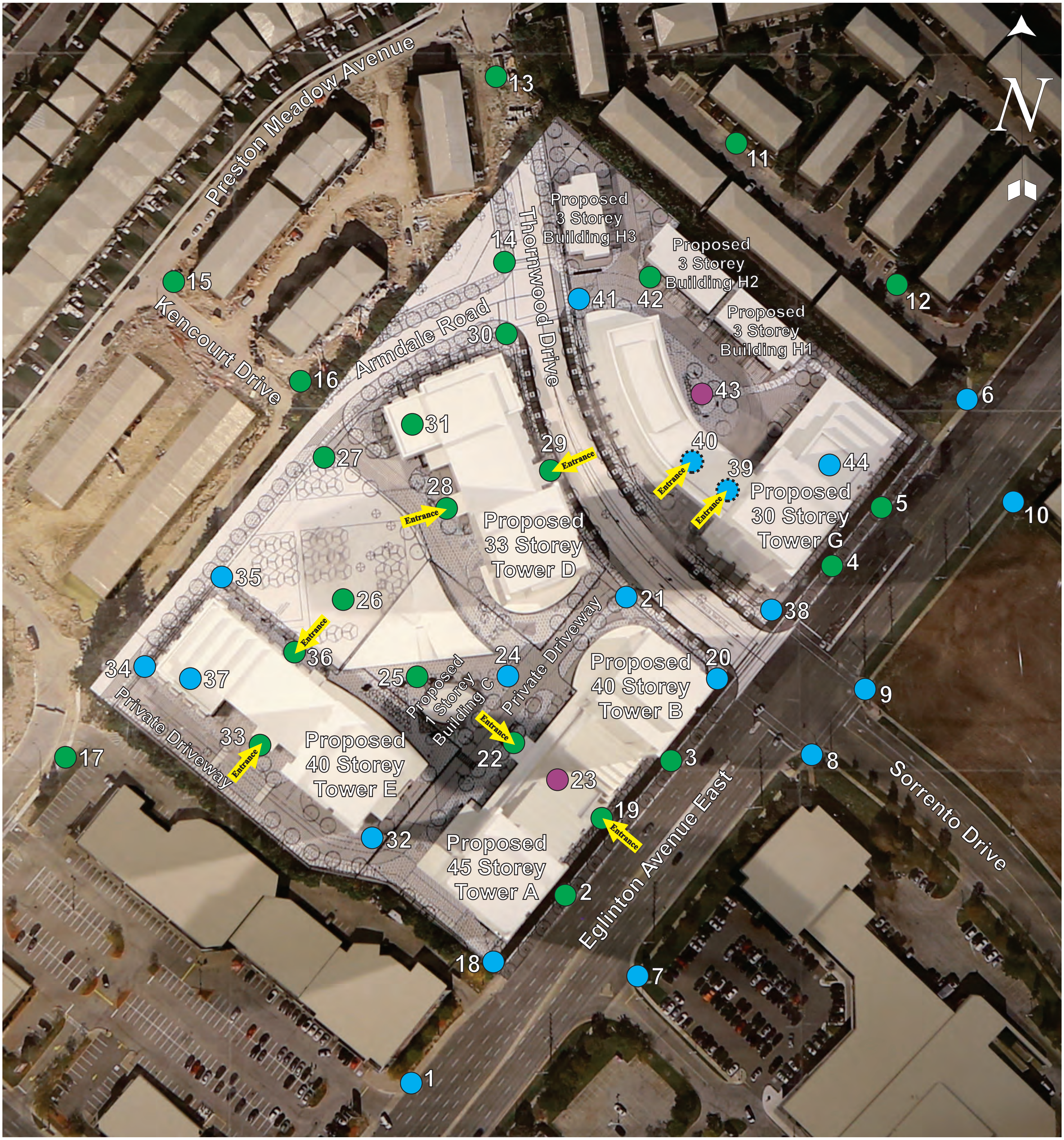
Figure 7g: Pedestrian level wind velocity comfort categories.

Comfort Categories - Summer - Existing

Sitting Standing Walking Uncomfortable

Theakston
Environmental

Figure 7h: Pedestrian level wind velocity comfort categories.



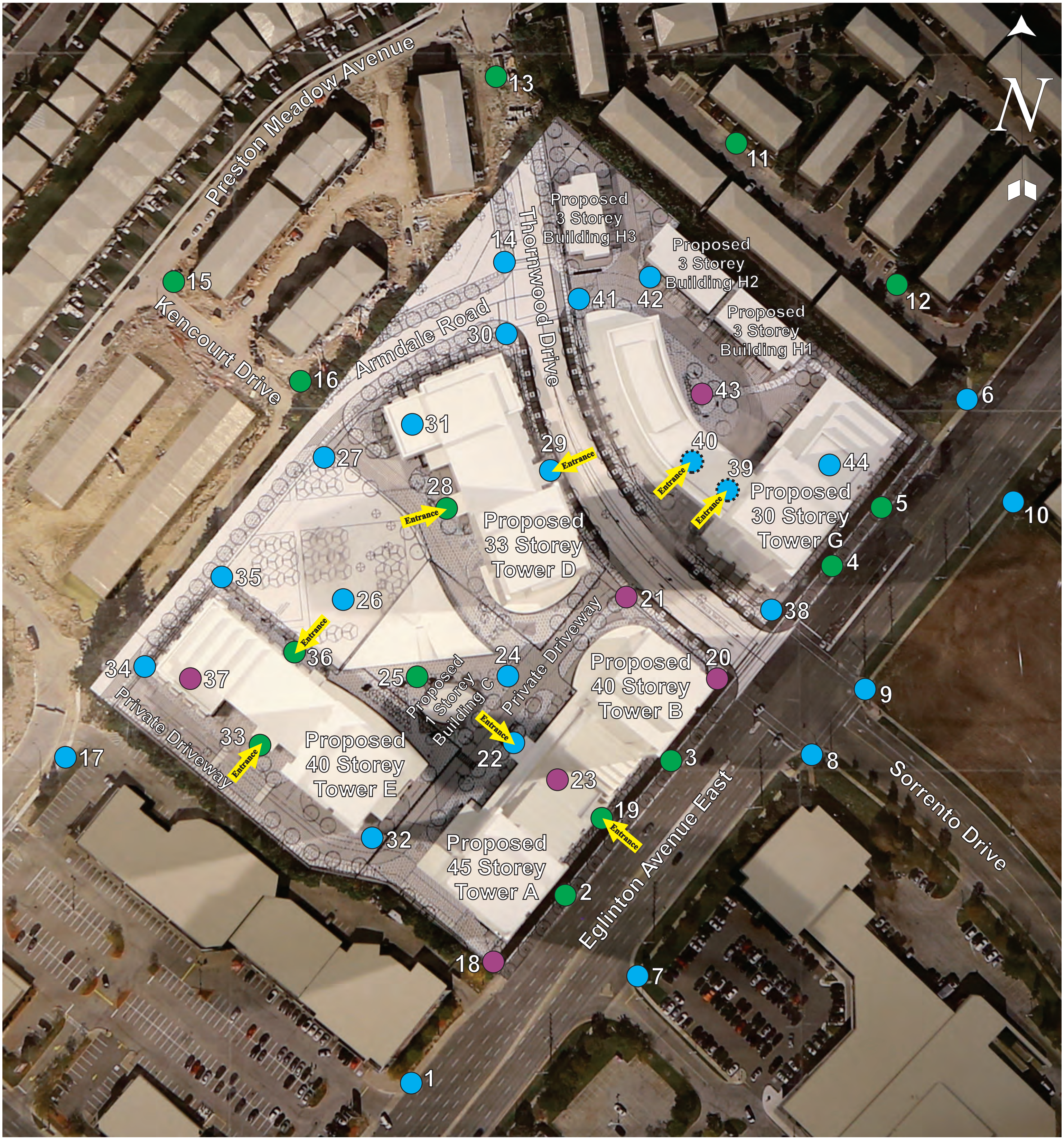
Comfort Categories - Summer - Proposed

Sitting Standing Walking Uncomfortable

Figure 7i: Pedestrian level wind velocity comfort categories.

Theakston Environmental

Figure 7j: Pedestrian level wind velocity comfort categories.



Comfort Categories - Fall - Proposed

Sitting Standing Walking Uncomfortable

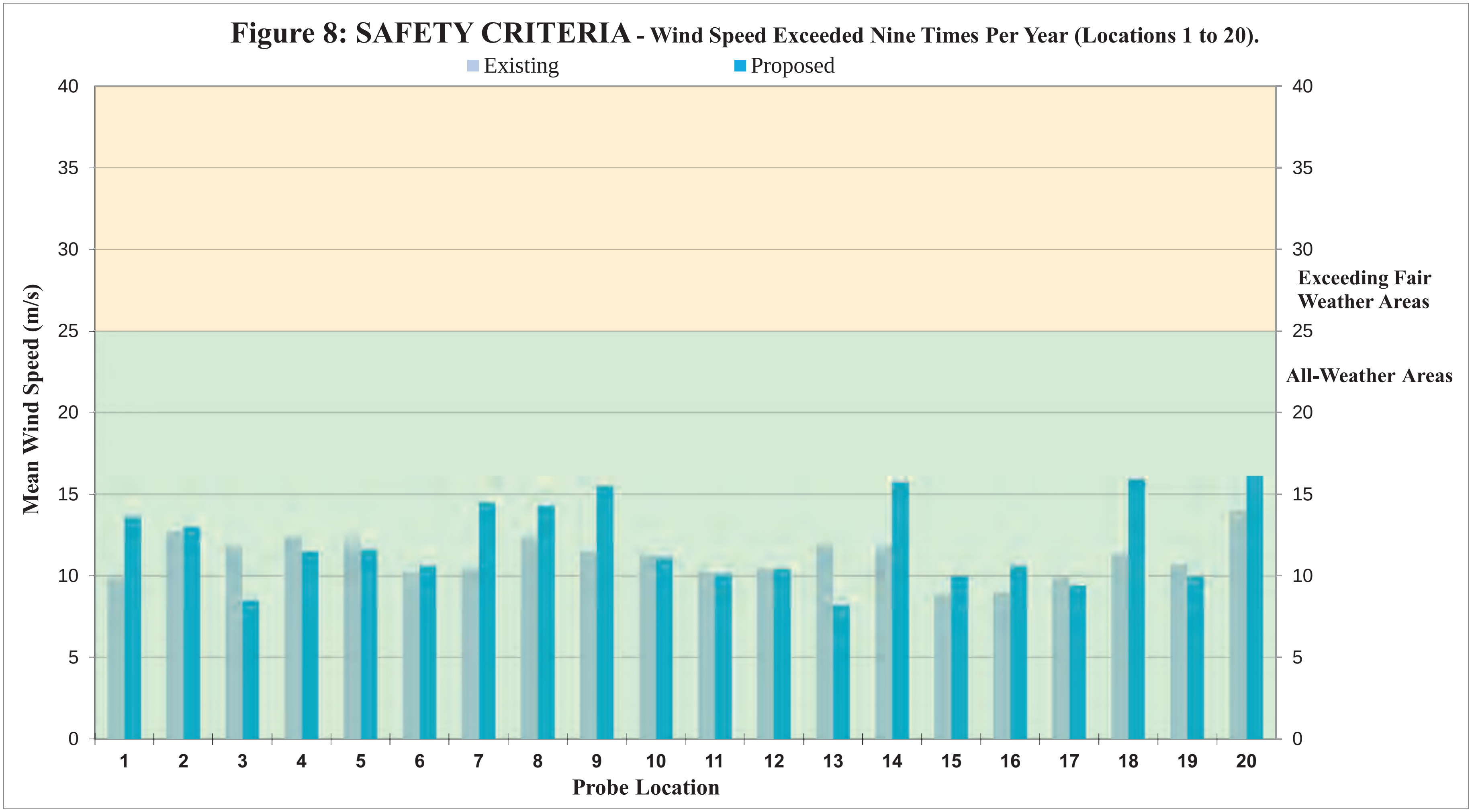


Figure 8: SAFETY CRITERIA - Wind Speed Exceeded Nine Times Per Year (Locations 1 to 20).
Existing
Proposed
40
35
30
25
20
15
10
5
0
Mean Wind Speed (m/s)
Exceeding Fair Weather Areas
All-Weather Areas
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Probe Location

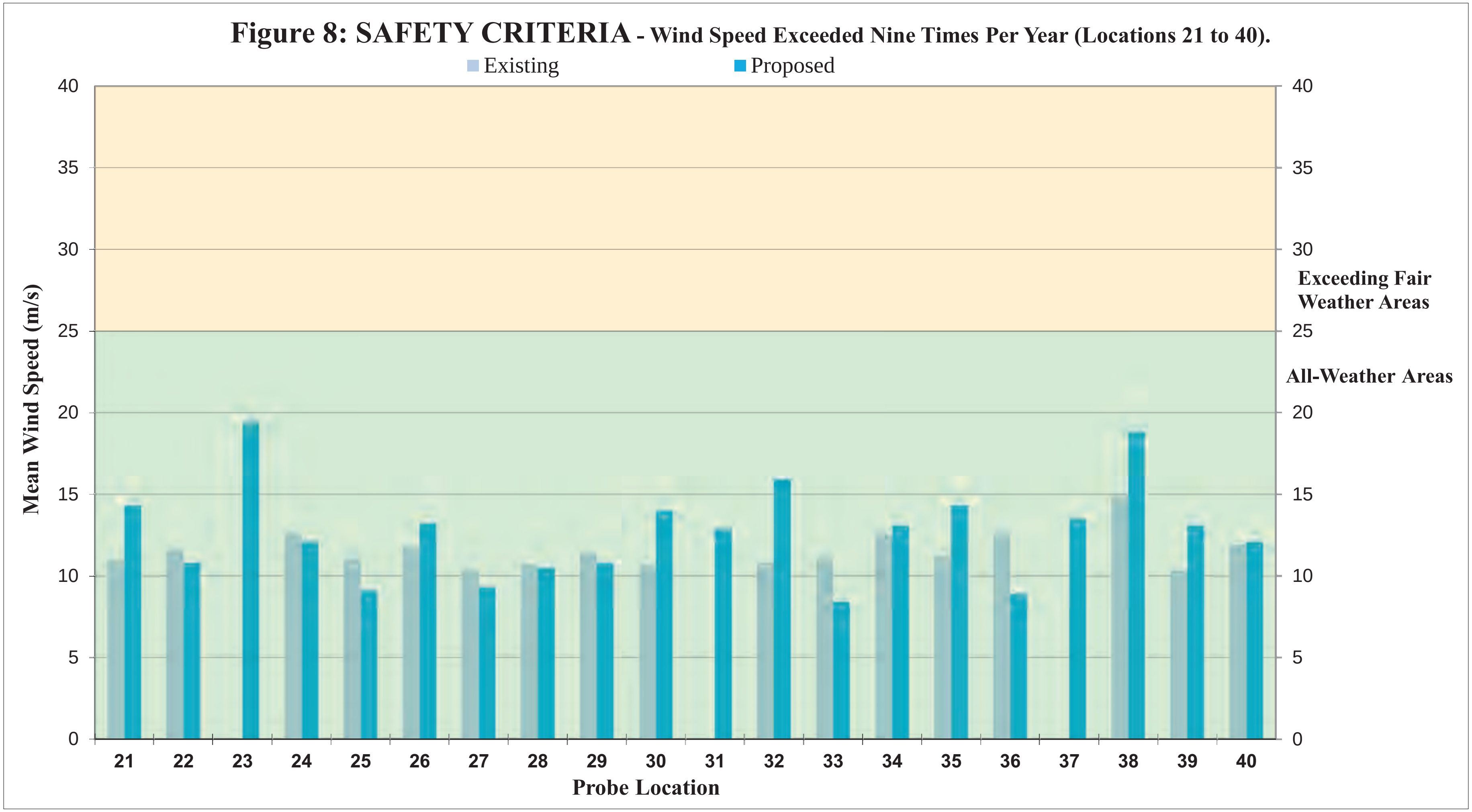


Figure 8: SAFETY CRITERIA - Wind Speed Exceeded Nine Times Per Year (Locations 21 to 40).
Existing
Proposed
Mean Wind Speed (m/s)
Probe Location
Exceeding Fair Weather Areas
All-Weather Areas
0
5
10
15
20
25
30
35
40
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

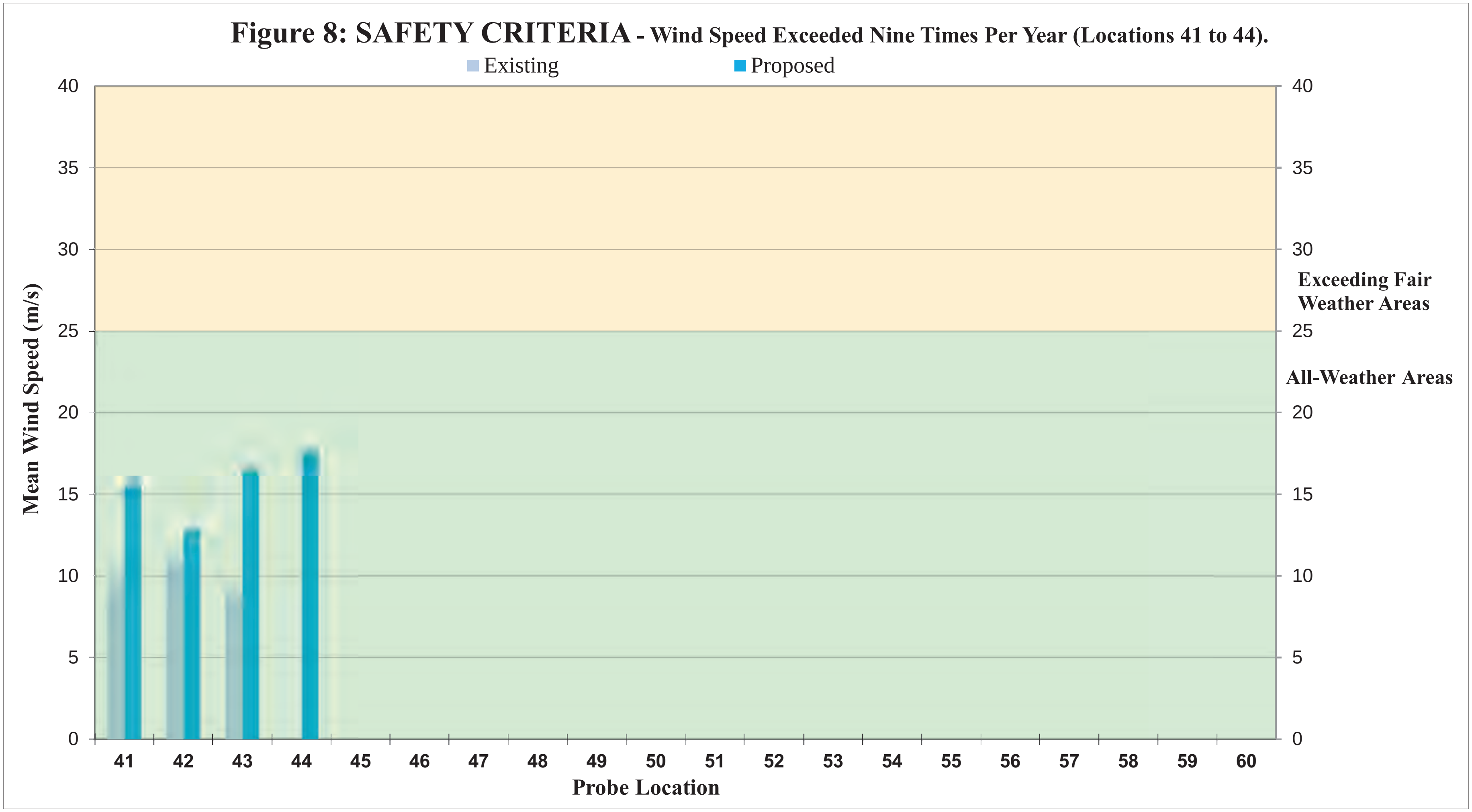


Figure 8: SAFETY CRITERIA - Wind Speed Exceeded Nine Times Per Year (Locations 41 to 44).
Existing
Proposed
Mean Wind Speed (m/s)
40
35
30
25
20
15
10
5
0
Exceeding Fair Weather Areas
All-Weather Areas
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
Probe Location

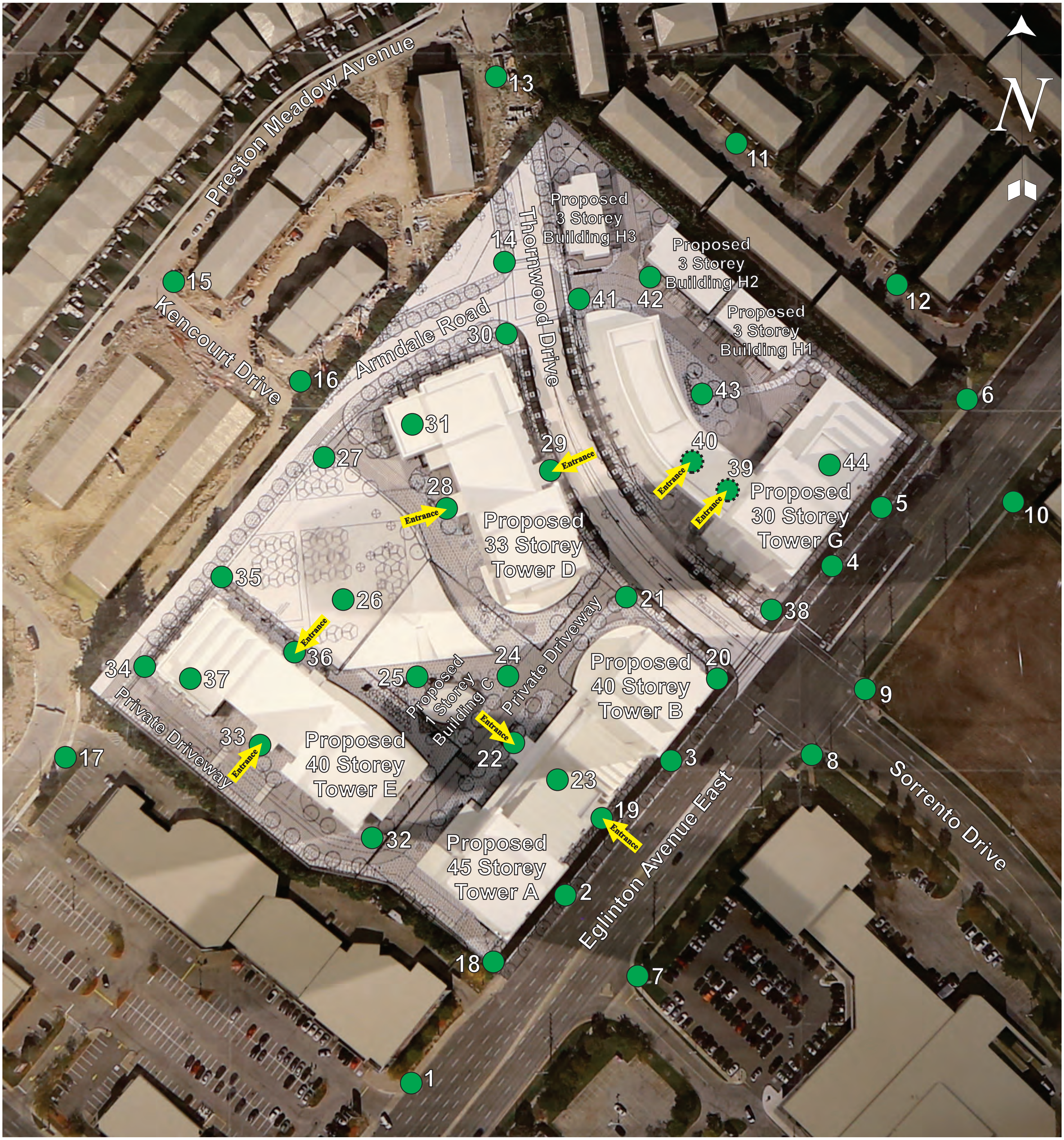
Figure 9a: Pedestrian level wind velocity safety criteria.

Safety Criteria - Existing

All-Weather Areas
Exceeding Fair-Weather Areas

Theakston
Environmental

Figure 9b: Pedestrian level wind velocity safety criteria.



Safety Criteria - Proposed

● All-Weather Areas ● Exceeding Fair-Weather Areas

Theakston Environmental

7. APPENDIX

BACKGROUND AND THEORY OF WIND MOVEMENT

During the course of a modular analysis of an existing or proposed site, pertinent wind directions must be analysed with regard to the macroclimate and microclimate. In order for the results of the study to be valid, the effects of both climates must be modelled in test procedures.

Macroclimate

Wind velocity, frequency and directions are used in tests with models to establish part of the macroclimate. These variables are determined from meteorological data collected at the closest weather monitoring station. This information is used in the analysis of the site to establish upstream (approach) wind and weather conditions.

When evaluating approach wind velocities and characteristic profiles in the field it is necessary to evaluate certain boundary conditions. At the earth's surface, "no slip" conditions require the wind speed to be zero. At an altitude of approximately one kilometre above the earth's surface, the motion of the wind is governed by pressure distributions associated with large-scale weather systems. Consequently, these winds, known as "geostrophic" or "freestream" winds, are independent of the surface topography. In model simulation, as in the field, the area of concern is the boundary layer between the earth's surface and the geostrophic winds. The term boundary layer is used to describe the velocity profile of wind currents as they increase from zero to the geostrophic velocity.

The approach boundary layer profile is affected by specific surface topography upstream of the test site. Over relatively rough terrain (urban) the boundary layer is thicker and the wind speed increases rather slowly with height. The opposite is true over open terrain (rural). The following power law equation is used to represent the mean velocity profile for any given topographic condition:

$$\frac{U}{U_F} = \left(\frac{z}{z_F}\right)^a$$

where U = wind velocity (m/s) at height z (m)
a = power law exponent
and subscript $_F$ refers to freestream conditions

Typical values for a and z_F are summarized below:

Terrain	a	z_F (m)
Rural	0.14 - 0.17	260 - 300
Suburban	0.20 - 0.28	300 - 420
Urban	0.28 - 0.40	420 - 550

Wind data is recorded at meteorological stations at a height z_{ref}, usually equal to about 10m above grade. This historical mean wind velocity and frequency data is often presented in the form of a wind rose. The mean wind velocity at z_{ref}, along with the appropriate constants based on terrain type, are used to determine the value for U_F, completing the definition of the boundary layer profile specific to the site. The following Figure shows representations of the boundary layer profile for each of the above terrain conditions:

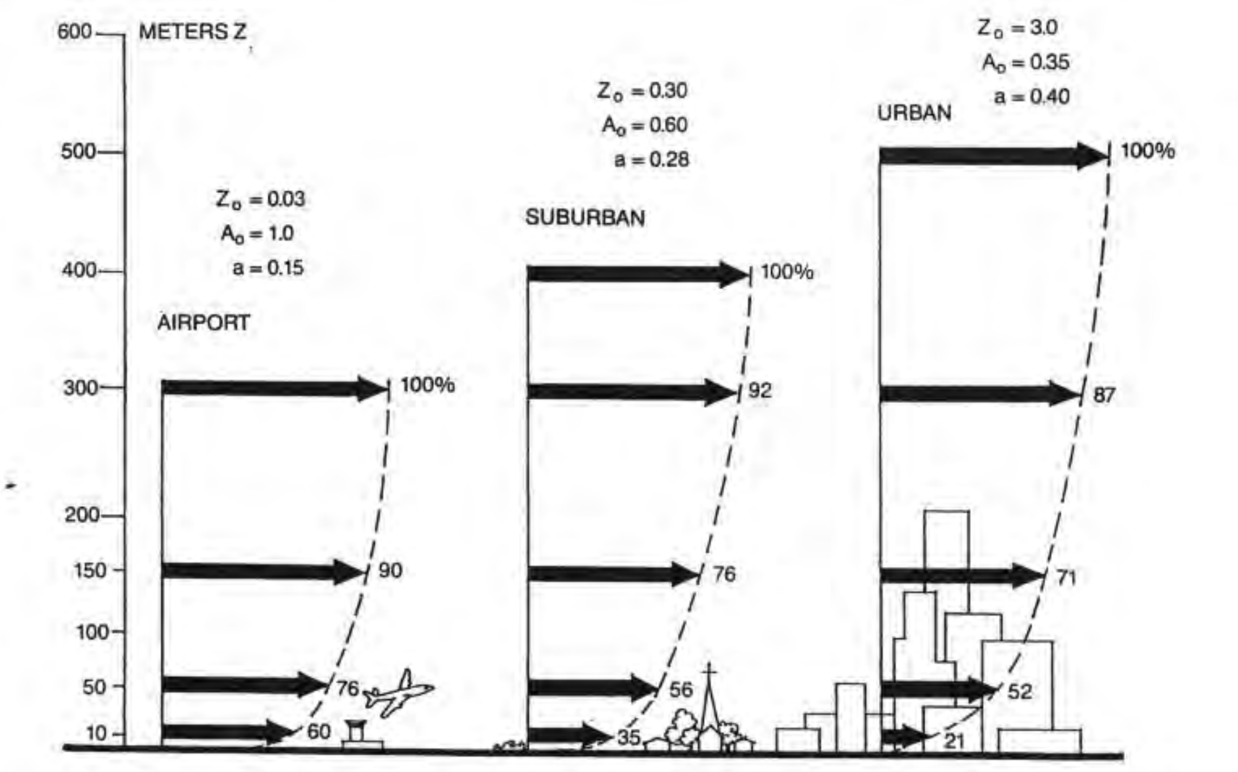


Figure A: Mean wind speed profiles for various terrain (from ASHRAE 1989).

For the above velocity profiles, ground level velocities at a height of $z = 2m$, for an urban macroclimate are approximately 52% of the mean values recorded at the meteorological station at a height equal to $z_{ref} = 10m$. For suburban and rural conditions, the values are 63% and 78% respectively. Thus, for a given wind speed at z_{ref} open terrain or fields (rural) will experience significantly higher ground level wind velocities than suburban or urban areas.

When a boundary layer wind flows over one terrain onto another, the boundary layer profile shape rapidly changes to that dictated by the new terrain. If the preceding wind flow is over rough suburban terrain and an open area is encountered a rapid increase in ground level winds will be realized. A similar effect will occur when large low-density residential areas are demolished to accommodate high-rise developments. The transitional open area will experience significantly higher pedestrian level winds than the previous suburban setting. Once the high-rise development is established, ground level winds will moderate with localized areas of higher pedestrian level winds likely to occur. Pedestrian level wind velocities respond to orientation and shape of the development and if the site is not appropriately engineered or mitigated, pedestrian level wind may be problematic.

Microclimate

The specific wind conditions related to the study site are known as the microclimate, which are dictated mainly by the following factors:

- The orientation and conformation of buildings within the vicinity of the site.
- The surrounding contours and pertinent landscape features.

The microclimate establishes the effect that surrounding buildings or landscape features have on the subject building and the effect the subject building has on the surrounds. For the majority of urban test sites the proper microclimate can be established by modelling an area of 300*m* in radius around the subject building. If extremely tall buildings are present then the study area must be larger, and if the building elevations are on the order of a few floors, smaller areas will suffice to establish the required microclimate.

General Wind Flow Phenomena

Wind flow across undulating terrain contains parallel streamlines with the lowest streamline adjacent to the surface. These conditions continue until the streamlines approach vertical objects. When this occurs there is a general movement of the streamlines upward ("Wind Velocity Gradient") and as they reach the top of the objects turbulence is generated on the lee side. This is one of the reasons for unexpected high wind velocities as this turbulent action moves to the base of the objects on the lee side.

Other fluid action occurs through narrow gaps between buildings (Venturi Action) and at sharp edges of a building or other vertical objects (Scour Action). These conditions are predictable at selected locations but do not conform to a set direction of wind as described by a macroclimate condition. In fact, the orientation and conformation of buildings, streets and landscaping establish a microclimate.

Because of the "Wind Velocity Gradient" phenomena, there is a "downwash" of wind at the face of buildings and this effect is felt at the pedestrian level. It may be experienced as high gusty winds or drifting snow. These effects can be obviated by windbreak devices on the windward side or by canopies over windows and doors on the lee side of the building.

The intersection of two streets or pedestrian walkways have funnelling effects of wind currents from any one of the four directions and is particularly severe at corners if the buildings project to the street line or are close to walkways.

Some high-rise buildings have gust effects as the wind velocities are generated suddenly due to the orientation and conformation of the site. Since wind velocities are the result of energy induced wind currents the solution to most problems is to reduce the wind energy at selected locations by carefully designed windbreak devices, often landscaping, to blend with the surrounds.

The Beaufort Scale is often used as a numerical relationship to wind speed based upon an observation of the effects of wind. Rear-Admiral Sir Francis Beaufort, commander of the Royal Navy, developed the wind force scale in 1805, and by 1838 the Beaufort wind force scale was made mandatory for log entries in ships of the Royal Navy. The original scale was an association of integers from 0 to 12, with a description of the effect of wind on the behaviour of a full-rigged man-of-war. The lower Beaufort numbers described wind in terms of ship speed, mid-range numbers were related to her sail carrying ability and upper numbers were in terms of survival. The Beaufort Scale was adopted in 1874 by the International Meteorological Committee for international use in weather telegraphy and, with the advent of anemometers, the scale was eventually adopted for meteorological purposes. Eventually, a uniform set of equivalents that non-mariners could relate to was developed, and by 1955, wind velocities in knots had replaced Beaufort numbers on weather maps. While the Beaufort Scale lost ground to technology, there remains the need to relate wind speed to observable wind effects and the Beaufort Scale remains a useful tool.

The Beaufort Scale

Beaufort Number	Description	Wind Speed			Observations
		mph	km/h	Knots	
0	Calm	0	0	0	Tree leaves don't move; smoke rises vertically; sea is calm, mirror like.
1	Light Air	1-3	1-5	1-3	Tree leaves don't move; smoke drifts slowly; direction of wind shown by smoke, not by vane; sea is lightly rippled.
2	Slight Breeze	4-7	6-11	4-6	Tree leaves rustle; flags wave slightly; vanes show wind direction; small wavelets or scale waves.
3	Gentle Breeze	8-12	12-19	7-10	Leaves and twigs in constant motion; small flags extended; long unbreaking waves.
4	Moderate Breeze	13-18	20-29	11-16	Small branches move; flags flap; waves with whitecaps.
5	Fresh Breeze	19-24	30-38	17-21	Small trees sway; flags flap and ripple; moderate waves with many whitecaps.
6	Strong Breeze	25-31	39-50	22-27	Large branches sway; umbrellas used with difficulty; flags beat and pop; larger waves with regular whitecaps.
7	Moderate Gale	32-38	51-61	28-33	Sea heaps up, white foam streaks; whole trees sway; difficult to walk; large waves.
8	Fresh Gale	39-46	62-74	34-40	Twigs break off trees; moderately high sea with blowing foam.
9	Strong Gale	47-54	75-86	41-47	Branches break off trees; tiles blown from roofs; high crested waves.
10	Whole Gale	55-63	87-101	48-55	Some trees blown down; damage to buildings; high churning white seas and exceptionally high waves hiding ships from view.
11	Storm	64-74	102-120	56-63	Widespread damage to trees and buildings; mountainous waves. Sea covered in white foam.
12	Hurricane	75+	120+	64+	Severe and extensive damage.

Wind speeds indicated above are at a reference height of 10 metres, as are the wind speeds indicated on the Figure 6 wind roses. The mean wind speeds at pedestrian level would be approximately 80% of these values. The relationship between wind speed and height relative to terrain is discussed in the appendices.

The table below correlates the Beaufort Scale with the average pedestrian comfort response as listed in Figure 7a – 7d, of the report, which provide an indication of the safety and comfort of pedestrians. The scale reflected on the figures takes into consideration the area around the subject building and in the immediate vicinity of the subject building, as affected by the wind patterns induced by the location, orientation and configuration of the proposed structure. At each point, as the wind velocity increases, the comfort level decreases. Also, at lower temperatures, relative comfort level might be expected to be reduced by one Beaufort number for every 20 degrees Celsius reduction in temperature, however, this is not applied to the wind driven results provided.

		Relative Comfort		
Activity	Areas Applicable	Perceptible	Tolerable	Uncomfortable
Occasional Use	Sidewalks	6	7	8
Walking	Sidewalks, Parking Lots	5	6	7
Strolling	Parks, Entrances	4	5	6
Standing, Sitting, Short exp.	Parks, Plaza areas	3	4	5
Standing, Sitting, Long exp.	Outdoor Restaurants	2	3	4
Representative criteria for acceptability			< 1 occn./week	< 1 occn./month

Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

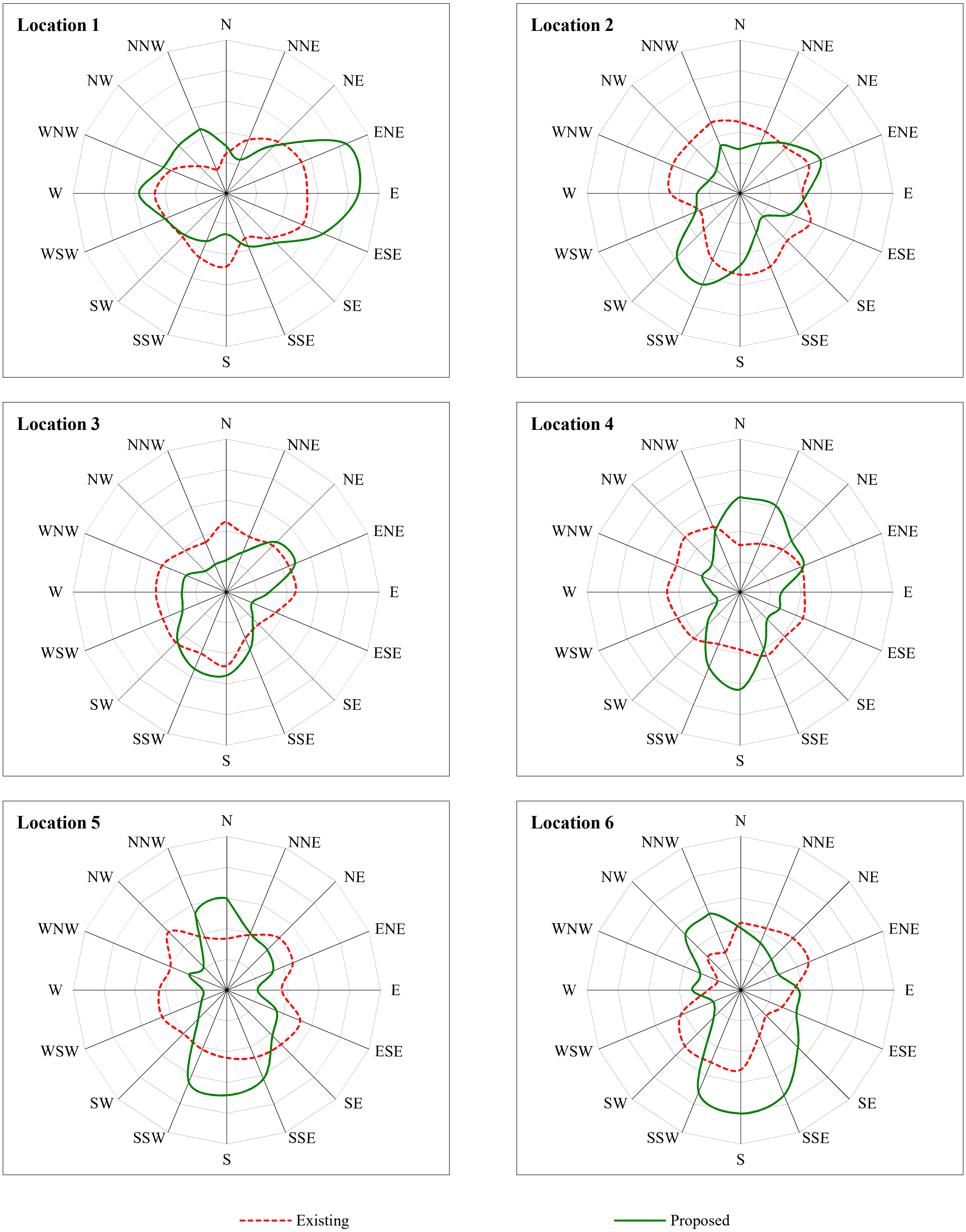


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

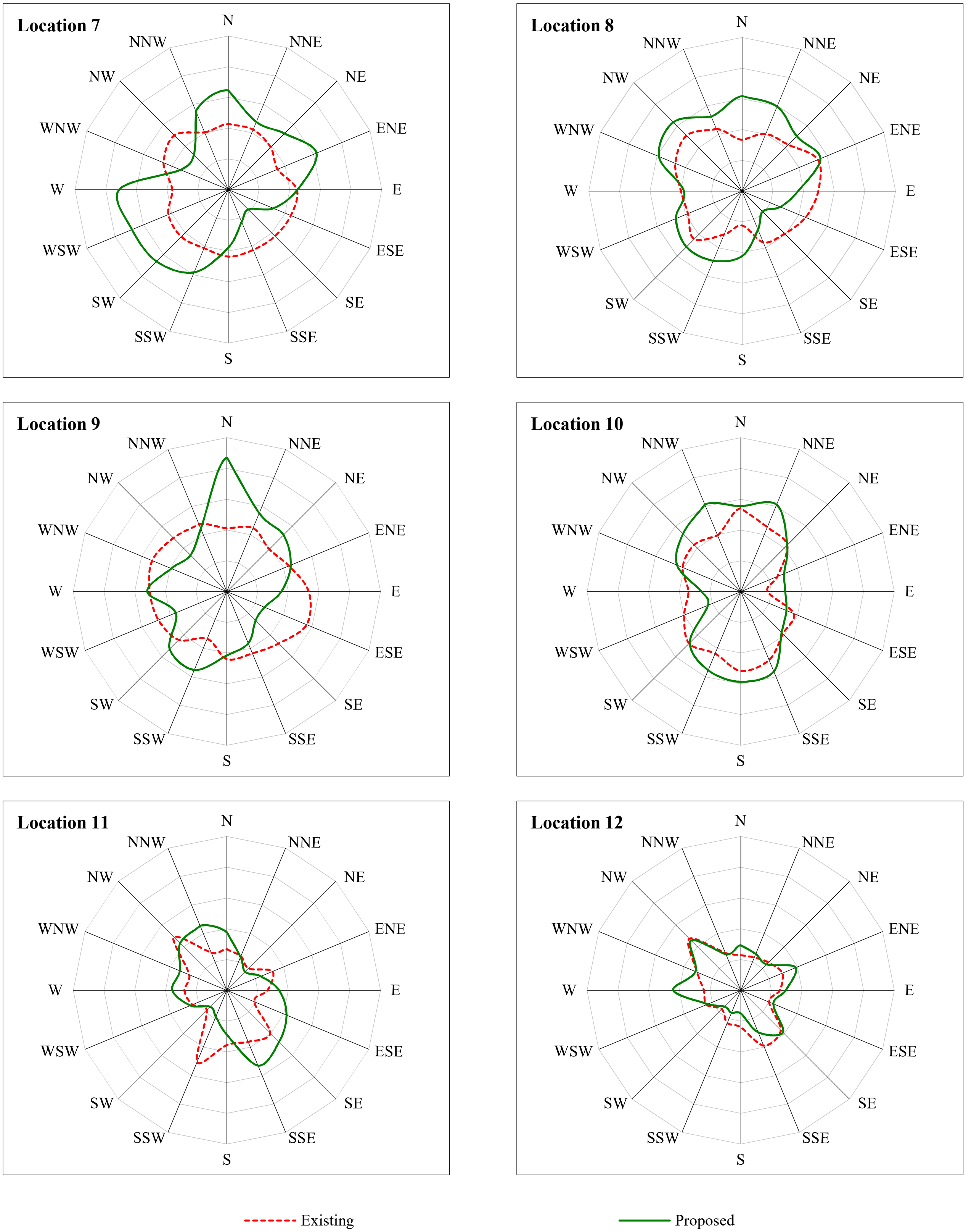


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

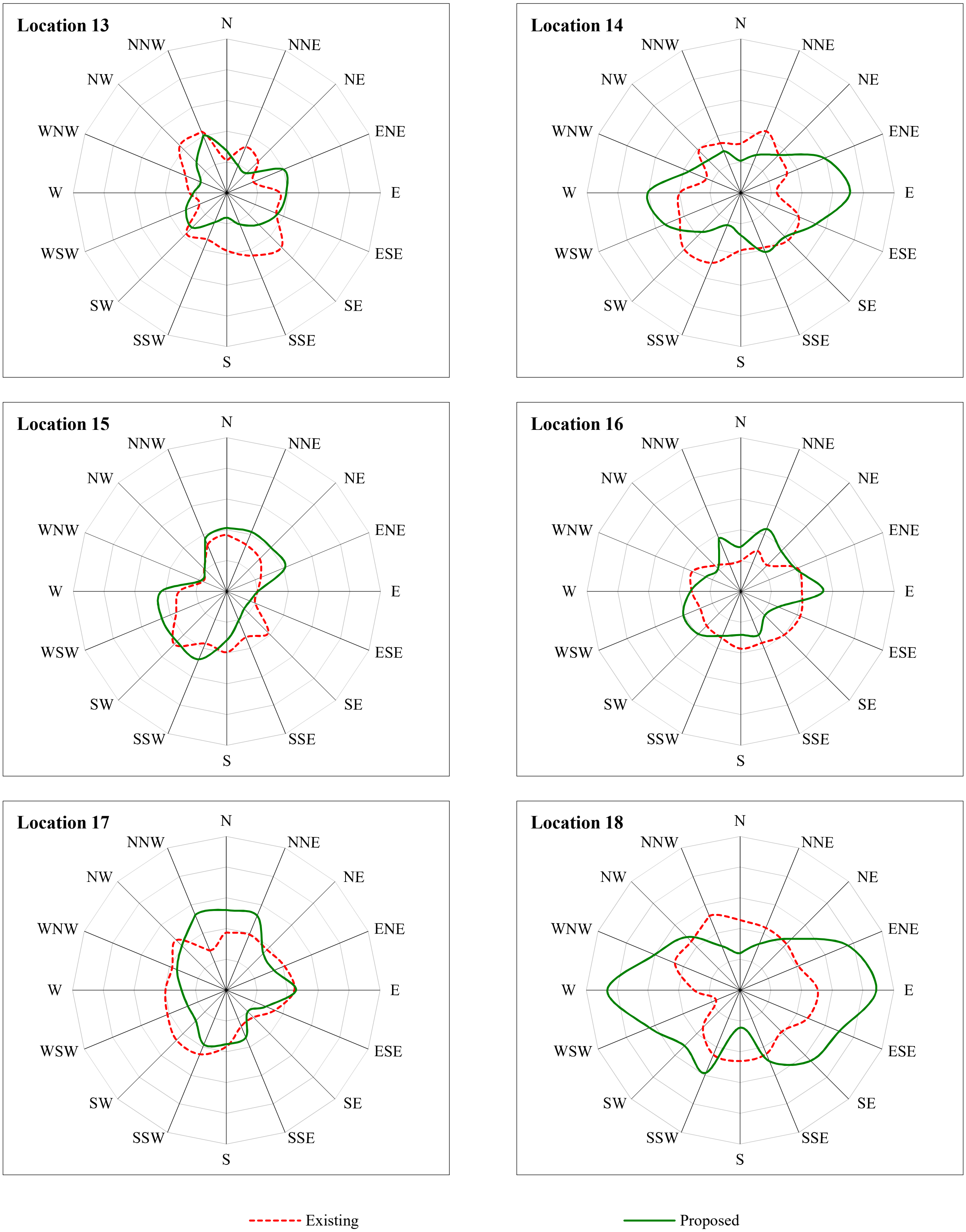


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

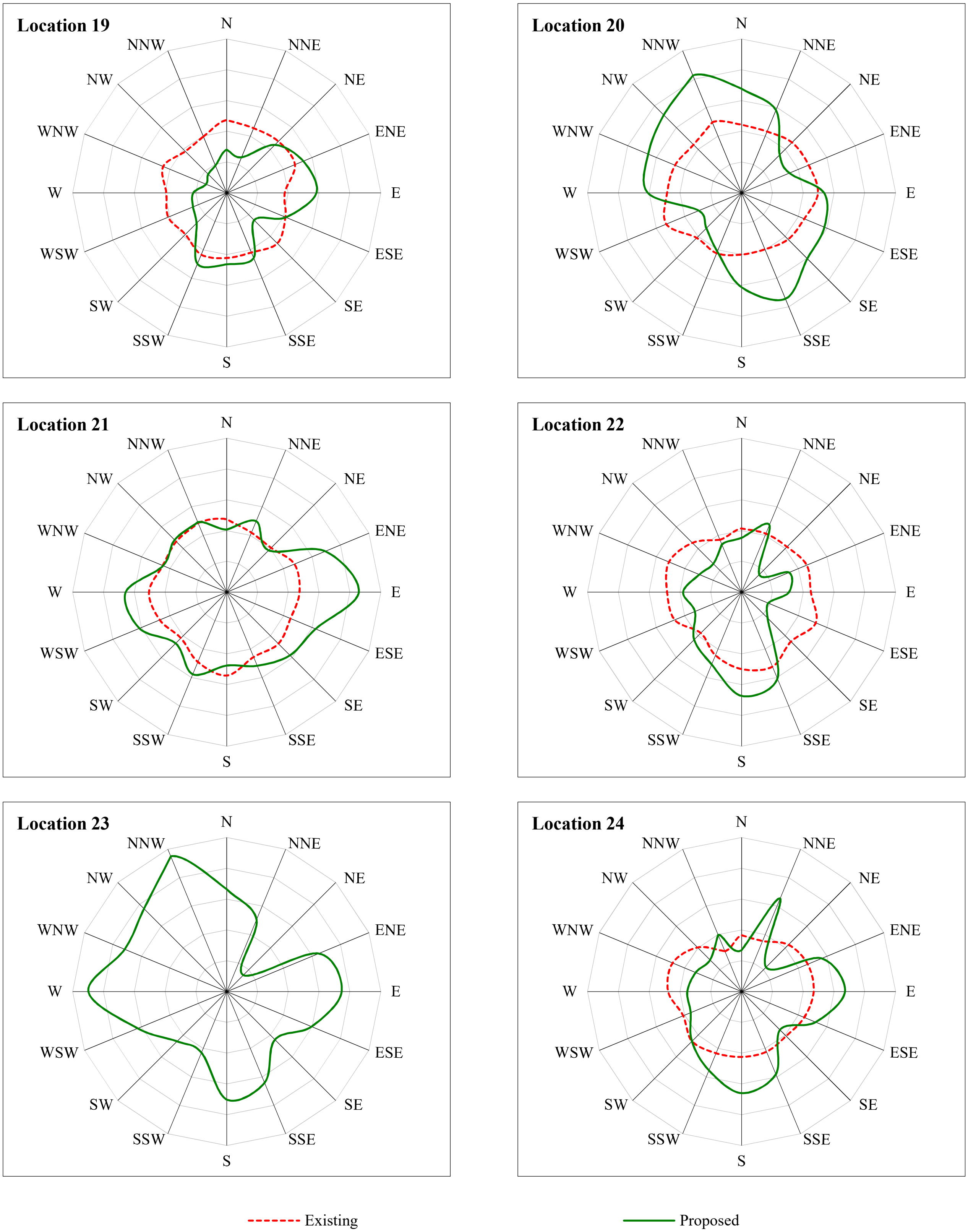


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

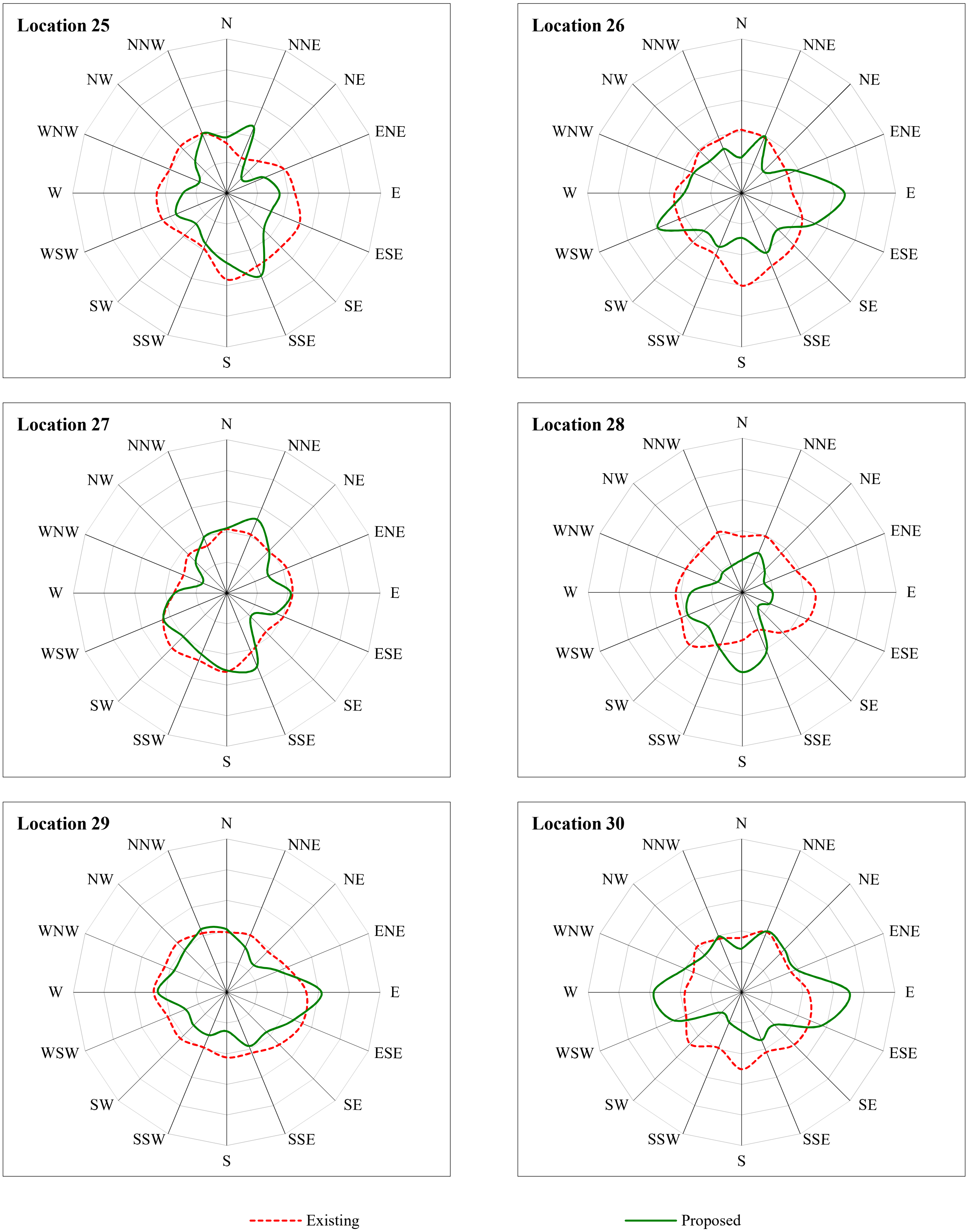


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

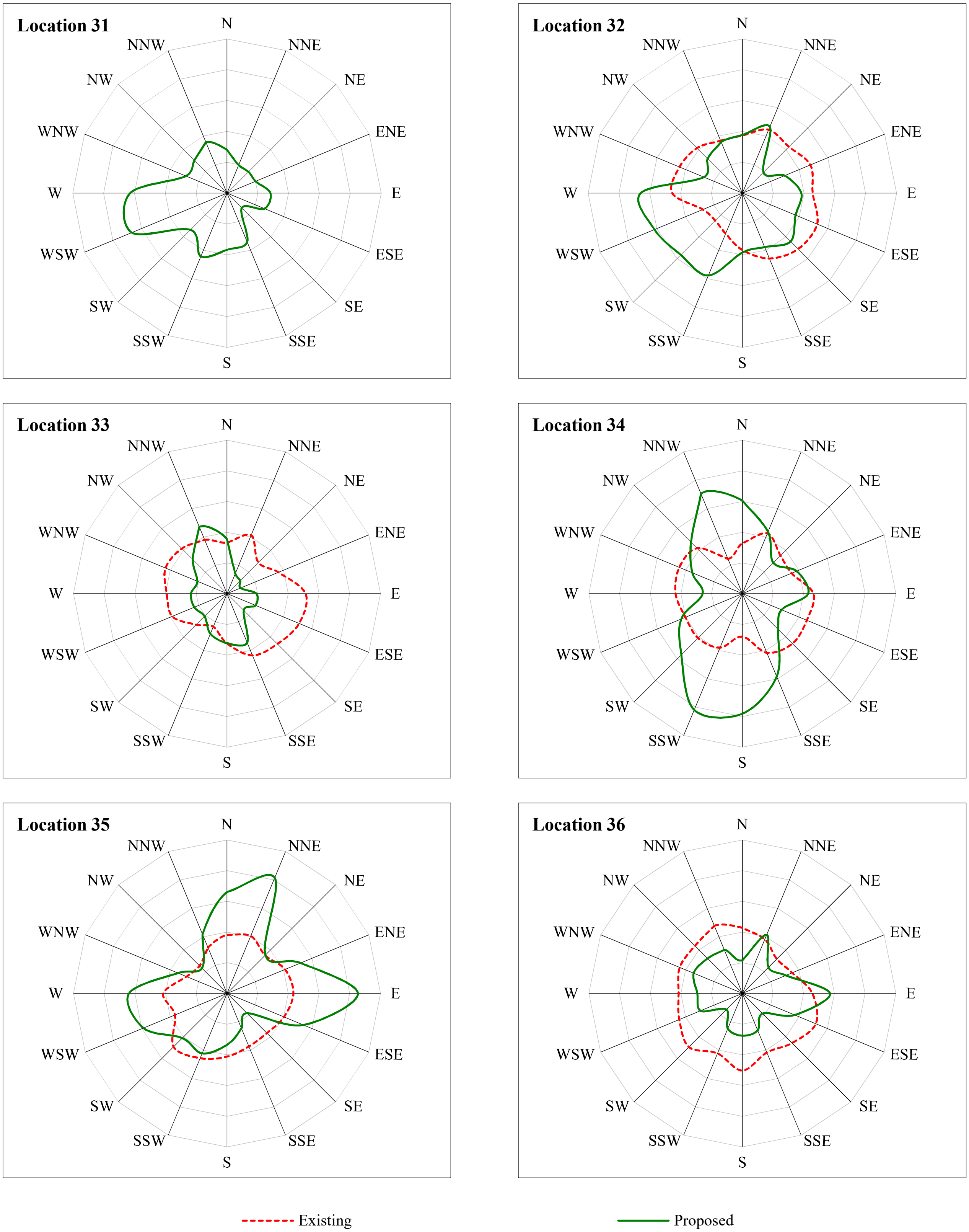


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

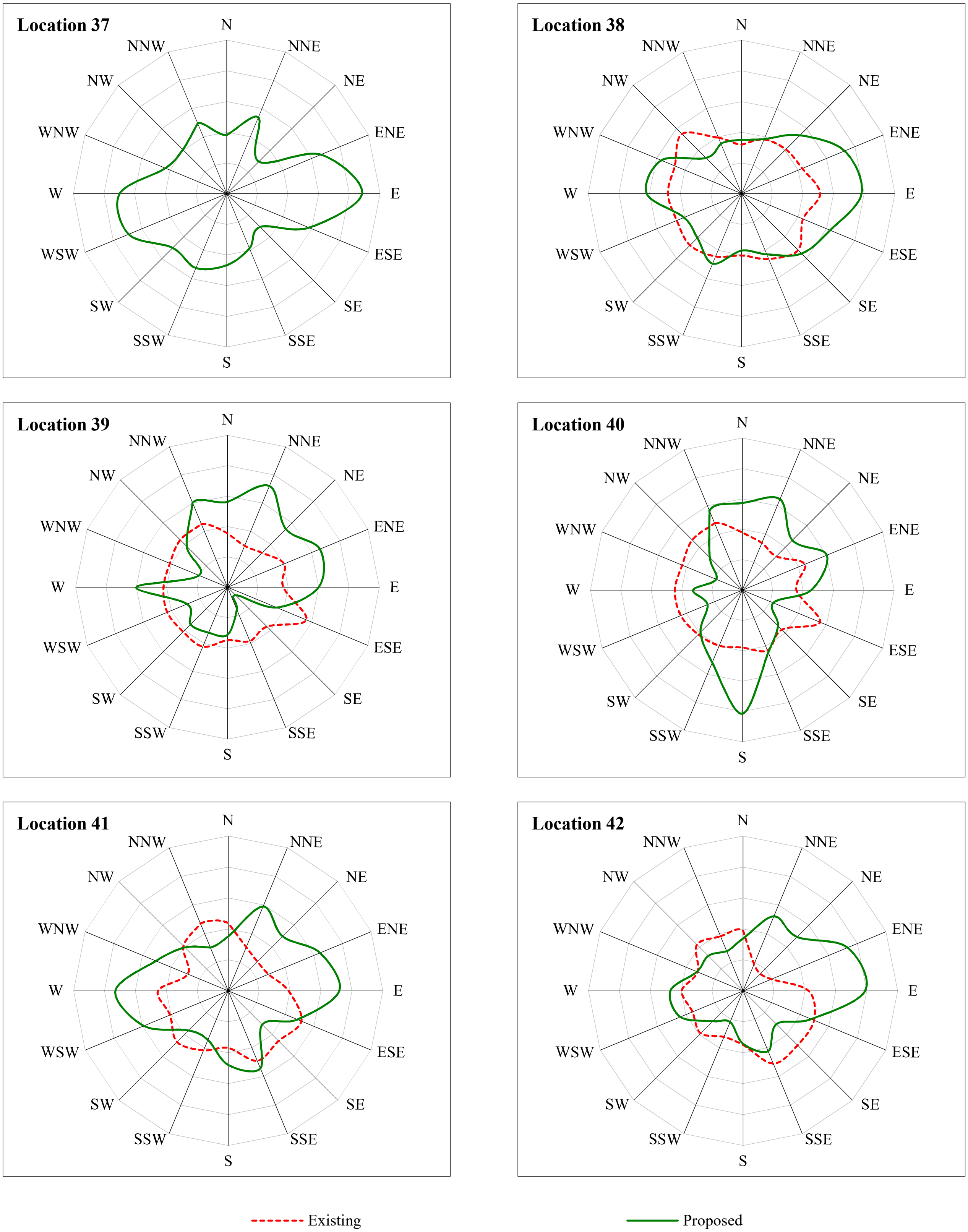
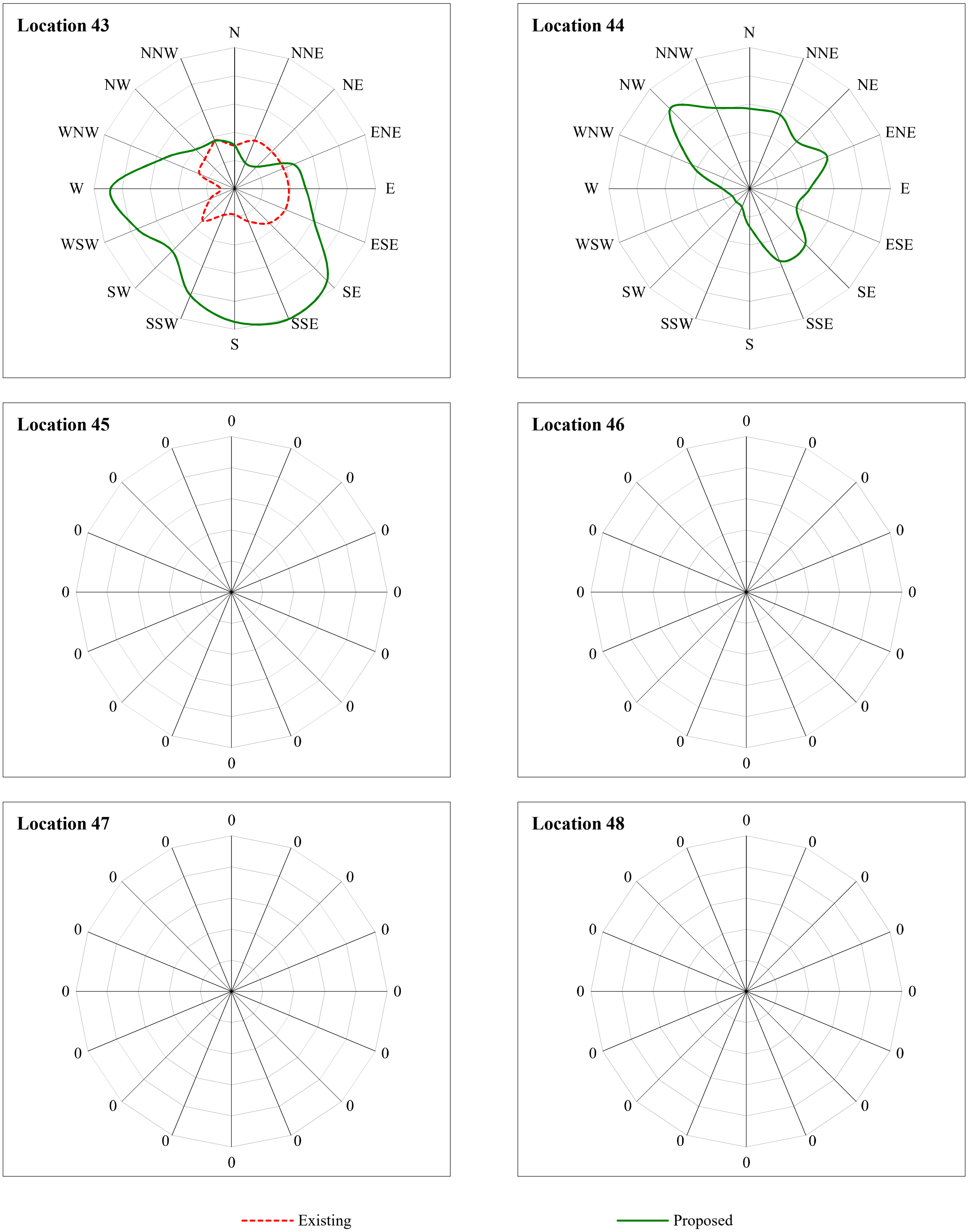


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.



8. REFERENCES

Canadian Climate Program. Canadian Climate Normals, 1961-1990. Documentation for Diskette-Based Version 2.0E (in English) Copyright 1993 by Environment Canada.

Cermak, J.E., "Applications of Fluid Mechanics to Wind Engineering A Freeman Scholar Lecture." Journal of Fluids Engineering, (March 1975), 9-38.

Davenport, A.G."The Dependence of Wind Loads on Meteorological Parameters." International Seminar on Wind Effects on Buildings and Structures, Ottawa, 1967.

-----"An Approach to Human Comfort Criteria for Environmental Wind Conditions." Colloquium on Building Climatology, Stockholm, Sweden, September, 1972.

-----"The Relationship of Wind Structure to Wind Loading." Symposium on Wind Effects on Buildings and Structures, Teddington, 1973.

-----and N. Isyumov. "The Application of the Boundary Layer Wind Tunnel to the Prediction of Wind Loading." Proceedings of International Seminar on Wind Effects on Buildings and Structures, Ottawa, 1967.

-----and N. Isyumov. "The Application of the Boundary Layer Wind Tunnel to the Prediction of Wind Loading." International Research Seminar on Wind Effects on Buildings and Structures, Toronto: University of Toronto Press, 1968.

-----and T. Tschanz. "The Response of Tall Buildings to Wind: Effect of Wind Direction and the Direction Measurement of Force." Proceedings of the Fourth U.S.National Conference on Wind Engineering Research, Seattle, Washington, July 1981.

-----Isyumov, N. "Studies of the Pedestrian Level Wind Environment at the Boundary Layer Wind Tunnel Laboratory University of Western Ontario." Journal of Industrial Aerodynamics, (1978), 187-200.

-----and A.G.Davenport. "The Ground Level Wind Environment in Built-up Areas." Proceedings of the Fourth International Conference on Wind Effects on Buildings and Structures, London, England: Cambridge University Press, 1977, 403-422

-----M.Mikitiuk, C.Harding and A.G.Davenport. "A Study of Pedestrian Level Wind Speeds at the Toronto City Hall, Toronto,Ontario." London, Ontario: The University of Western Ontario, Paper No.BLWT-SS17-1985, August 1985.

Milles, Irwin and John E. Freund. Probability and Statistics Engineers, Toronto: Prentice-Hall Canada Ltd., 1965.

National Building Code of Canada, Ottawa: National Research Council of Canada, 1990.

Simiu, Emil, Wind Induced Discomfort In and Around Buildings. New York: John Wiley & Sons, 1978.

Surry, David, Robert B.Kitchen and Alan Davenport, "Design Effectiveness of Wind Tunnel Studies for Buildings of Intermediate Height." Canadian Journal of Civil Engineering 1977, 96-116.

Theakston, F.H., "Windbreaks and Snow Barriers." Morgantown, West Virginia, ASAE Paper No. NA-62-3d, August 1962.

------"Advances in the Use of Models to Predict Behaviour of Snow and Wind", Saskatoon, Saskatchewan: CSAE, June 1967.

Gagge, A.P., Fobelets, A.P., Berglund, L.G., "A Standard Predictive Index of Human Response to the Environment", ASHRAE Transactions, Vol. 92, p709-731, 1986.

Gagge, A.P., Nishi, Y., Nevins, R.G., "The Role of Clothing in Meeting FEA Energy Conservation Guidelines", ASHRAE Transactions, Vol. 82, p234-247, 1976.

Gagge, A.P., Stolwijk, J.A., Nishi, Y., "An Effective Temperature Scale Based on a Simple Model of Human Physiological Regulatory Response", ASHRAE Transactions, Vol. 77, p247-262, 1971.

Berglund, L.G., Cunningham, D.J., "Parameters of Human Discomfort in Warm Environments", ASHRAE Transactions, Vol. 92, p732-746, 1986.

ASHRAE, "Physiological Principles, Comfort, and Health", ASHRAE Handbook - 1981 Fundamentals, Chapter 8, Atlanta, American Society of Heating, Refrigeration and Air-Conditioning Engineers Inc., 1981,

ASHRAE, "Airflow Around Buildings", ASHRAE Handbook - 1989 Fundamentals, Chapter 14, Atlanta, American Society of Heating, Refrigeration and Air-Conditioning Engineers Inc., 1989,