THEAKSTON ENVIRONMENTAL

Consulting Engineers • Environmental Control Specialists

REPORT

CFD PEDESTRIAN LEVEL WIND STUDY

51 – 57 Tannery Street & 208 Emby Drive

Mississauga, Ontario

Montcrest Asset Management

REPORT NO. 23032wind **June 24, 2024**

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1. EXECUTIVE SUMMARY

The Development proposed by Montcrest Asset Management for their property municipally known as 51-57 Tannery Street & 208 Emby Drive, in the City of Mississauga, has been assessed for environmental standards with regard to pedestrian level wind velocities relative to comfort and safety. Based upon our analysis, wind conditions on and around the proposed Development site are considered suitable for sitting or standing year-round, in the existing setting.

The proposed Development involves construction of a 14 storey "L" shaped residential building, with a 12 storey "L" shaped wing extending to the west. The Development site is, for all intents and purposes, surrounded by an open/suburban mix of low through mid-rise residential and commercial buildings, mature vegetation, and open spaces. The proposed Development will have a sympathetic relationship with the pending wind climate. Urban development provides turbulence inducing surface roughness that can be wind friendly, while open, and to a lesser degree, suburban 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. Transition zones from open and/or suburban to urban settings can prove problematic, as winds exacerbated by relatively more open settings are redirected to flow over, around, down, and between buildings.

The proposed Development redirects winds that formerly flowed over the site, the increased blockage relative to the existing setting causing wind to redirect to flow over the building without consequence, and/or, depending upon the angle of incidence, around, or down the façades towards the pedestrian level, as downwash. The Development features stepped conditions that intercept downwash, deflecting a portion of said flows around the building at elevations above the pedestrian level.

Based upon this analysis, wind conditions on and around the proposed Development are predicted to, in many cases, remain suitable for sitting or standing throughout the year and similar to the existing setting. Localised areas proximate to the proposed Development's corners will realise windier conditions, rated for walking from time to time through the winter months, but generally remain suitable for the intended use throughout the year. Consideration of fine design and landscape features will result in more comfortable conditions than reported.

If activity areas are proposed on site, a mitigation plan may be required to improve pedestrian comfort conditions in said areas. A mitigation plan may include berms, fencing/porous wind screens, coniferous trees, raised planters, trellises, and/or others situated throughout the space.

The proposed Development is predicted to realise wind conditions acceptable to a typical open/suburban context, based on this preliminary Computational Fluid Dynamics analysis.

The proposed berm along the northern site boundary was not included in the assessment. In our experience, topographical features are not included in preliminary qualitative assessments. The proposed berm, and associated plantings, are expected to improve conditions in the immediate surrounds, and as such the results of our report are expected to be conservative.

Subsequent to testing, the massing of the proposed Development was revised whereby a 7 storey step was added between the 14 and 12 storey massings. The 7 storey step will theoretically intercept portions of downwash from the building above, moderating winds at the pedestrian level, however the changes are expected to be minor.

As such, the results and conclusions of the report remain valid. Further testing of the final massing, as well as significant topographical features, will occur at the Site Plan stage.

Respectfully submitted,

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PROVINCE OF ONTARIO

2. INTRODUCTION

Theakston Environmental was retained by Montcrest Asset Management to study the pedestrian level wind environment for the proposed Development at 51-57 Tannery Street & 208 Emby Drive, in the City of Mississauga, as shown in Figure 1. The Development involves a proposal to construct a 14 storey "L" shaped residential building, with a 12 storey "L" shaped wing extending to the west, in the configuration shown in Figure 2. SRM Architects provided architectural 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 Development 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 in the immediate vicinity.

To obtain an objective analysis of the wind conditions for the property, the wind environment was tested in two configurations. The existing configuration included the current site with the existing buildings as well as neighbouring proposed developments in the surrounding area. The proposed configuration included the subject 51-57 Tannery Street & 208 Emby Drive Development.

The computational studies used in this Pedestrian Level Wind 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.

3. OBJECTIVES OF THE STUDY

1. To quantitatively assess, by computational fluid dynamic (CFD) simulation, 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 in necessary cases.

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. Accurate digital models of the proposed Development site, and the immediate surroundings are built, and studied computationally using software by Meteodyn Inc. with resulting wind speeds stored for a surface spanning the areas 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 using this method, utilise the computational fluid dynamics (CFD) program. The testing method has been developed for these kinds of environmental studies, and has been adapted with specific settings, testing procedures and protocols, accordingly.

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. Gust Equivalent Mean (GEM) values are extracted from the software for existing and proposed built scenarios, which accounts for sixteen (16) wind directions, at a surface that is uniformly at 1.5 m level above the ground in the entire field.

The wind speeds at the areas of interest were subsequently combined with the design probability distribution of gradient wind speed and direction (wind statistics) recorded at Pearson International Airport, 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 two seasons, which can be found in Figures 5a – 5d.

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 2022. 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.

4.3 Statistical Wind Climate Model

The design probability distribution of mean-hourly wind speed and wind direction at reference height is shown for Pearson International Airport in Figure 4. Seasonal distributions are shown for two seasons from the hours of 6am-11pm (Figures 4a & 4b). From this, it is apparent that winds can occur from any direction; however, historical data indicates the directional characteristics of strong winds are mainly northwest through southwest and from the east, and said winds are most likely to occur during the winter season.

4.4 Pedestrian Level Wind Velocity Study and Computational Setup

A digital model was created of the proposed Development and pertinent surroundings, including existing buildings. The model is based upon information gathered from client drawings and Google Earth. SRM Architects Inc. provided the architectural drawings. The structures and features that would have an impact on the wind flows are included in the digital model. The existing and proposed scenarios have both been simulated in the commercially available wind simulation software by Meteodyn Inc.

A three dimensional 'mesh' is created of varying size, appropriate to the distance from the study area. In these studies, a section plane was placed at a height of 1.5m from the ground (typical level of pedestrian activity) to extract simulated GEM wind speeds. These wind speeds are an ensemble average wind speed and hence more representative of the wind microclimate in the study area. The velocities obtained from the simulation are recorded and combined with historical meteorological data via post-processing.

4.5 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 5 presents results for the GEM wind speed that is exceeded 20% of the time. The GEM is the greater of the mean wind speed or the gust wind speed divided by 1.85. The gust wind speed is obtained as the sum of the local mean speed and the product of the peak factor and rms (i.e. mean + peak factor * rms). The peak factor is assumed to be 3.0 following the Gaussian distribution assumption and the rms was recalculated from the local turbulent kinetic energy obtained from the CFD simulation. These speeds are directly related to the pedestrian comfort at a particular point. The overall comfort ratings for the existing and proposed settings are depicted in Figure 5. Table 1, below, summarizes the comfort criteria used in the presentation of the results depicted in Figure 5.

Table 1: Comfort Criteria

ACTIVITY	Gust Equivalent Mean Speed Exceeded 20% of the Time	Description
COMFORT	***km/h***	
Sitting	0-10	Light breezes desired for outdoor seating areas where one can read a paper without having it blown away.
Standing	0-15	Gentle breezes suitable for passive pedestrian activities where a breeze may be tolerated.
Walking	0-20	Relatively high speeds that can be tolerated during intentional walking, running and other active movements.
Uncomfortable	>20	Strong winds, considered a nuisance for most activities.

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 10km/h, more than 20% of the time. 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 Background and Theory of Wind Movement section. 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 15km/h. 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 20km/h. 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 20km/h.

The figures represent the average person's response to wind force for the 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. People dwelling near the shore of an ocean, large lake or open field are more tolerant of wind than people residing in a sheltered wind environment.

4.6 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 prescribed in the City of Mississauga Terms of Reference for Wind. The safety ratings for the existing and proposed settings are depicted in Figure 6.

Table 2: Safety Criteria

ACTIVITY	**Mean Wind Speed Exceeded 9 Times per year**	**Description**
SAFETY	***km/h***	
Exceeded	>90	Excessive gust speeds that can adversely affect safety and a pedestrian's balance and footing. Wind mitigation is typically required.

4.7 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 clothing choices. The comfort criterion 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.

5. RESULTS

5.1 Study Site and Test Conditions

Proposed Development

The proposed Development is located at 51-57 Tannery Street & 208 Emby Drive, within the City of Mississauga, and occupies a portion of the block of land bound by Tannery Street to the northwest, Broadway Street to the northeast, Thomas Street to the southeast, and Joymar Drive to the southwest. The Development site is currently occupied by low-rise residential and commercial/industrial buildings that will be removed.

The proposed Development involves construction of a 14 storey "L" shaped residential building with a 12 storey "L" shaped wing extending to the northwest. A driveway is proposed along the southwestern property line, providing access to the Main Residential Entrance located along the southwestern façade. Outdoor Amenity Spaces are proposed to the northeast and southwest and west of the building, at-grade.

The proposed Development is in a configuration as shown in Figure 2.

Surrounding Area

The proposed Development site is surrounded by a mix of low through mid-rise residential buildings, commercial and industrial buildings, mature vegetation, and open spaces, as indicated in Figure 1.

The proposed Development shares the block with low-rise residential, commercial and industrial buildings and open spaces. The Canadian Pacific Railway runs in a northwest/southeast direction along the northeast property boundary of the Development site. Mid-rise residential buildings front Tannery Street to the immediate northwest through north of the site, and low-rise commercial buildings and open spaces are located beyond. The approved 4 storey residential building located at 60 Tannery Street, to the immediate west of the proposed Development site, was included in the model of the surrounds. Lands to the north of Broadway Street are predominantly occupied by low-rise residential and commercial buildings with a few mid-rise buildings fronting Queen Street South. Lands south of Thomas Street are predominantly occupied by low-rise residential neighbourhoods, mature vegetation, and a large surface parking area accommodating the Streetsville GO Station. Lands west of Joymar Drive are occupied by low-rise residential neighbourhoods. Streetsville Secondary School, a large low-rise building and open sports field, is located west of the intersection of Tannery Street and Joymar Drive.

Urban surrounds present relatively coarse terrain that moderate pedestrian level winds, whereas the low-rise buildings and open spaces allow wind the opportunity to accelerate on approach. Transition zones from more open to urban settings often prove problematic, as winds exacerbated by relatively more open settings are redirected to flow over, around, down, and between buildings.

Figure 1 depicts the site and its immediate surrounds. The site plan is shown in Figure 2 and the computational geometry model is shown in Figure 3.

Macroclimate

For the proposed Development, the upstream wind flow during calculation was conditioned to simulate an atmospheric boundary layer passing over suburban/open terrain. The terrain within the site's immediate vicinity was incorporated into the proximity model. Historical meteorological data recorded at Pearson International Airport was used in this analysis. The data is divided into two seasons, winter and summer, and the resulting wind roses are presented as mean velocity and percent frequency in Figures 4a & 4b. 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 1.5*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 predominantly suburban.

Winter (November through April) has the highest mean velocities with prevailing winds from the north through west to southwest, as indicated in Figure 4a. Summer (May through October) has lower mean wind velocities with prevailing winds from the north through west to southwest, with additional significant components from the southeast, as indicated in Figure 4b. Reported pedestrian comfort conditions generally pertain to winter conditions unless stated otherwise.

5.2 Pedestrian Level Wind Velocity Study

In the computational model, the full wind field measuring 480m in radius was studied to determine conditions related to comfort and safety. For the existing setting, the subject building was removed, and the "existing" site model recalculated with the current site.

The design probability distribution gradient wind speed and direction, taken from historical meteorological data for the area (see Figure 4) 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 a seasonal basis in Figures 5a – 5d.

The ratings for a given location are conservative by design; when the existing surroundings and proposed building's fine massing details and actual landscaping are taken into consideration, the results tend toward a more comfortable site than testing alone would indicate.

Venturi action, scour action, downwash and other factors, as discussed in the Background and Theory of Wind Movement section, 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 exposed to a predominantly suburban/open setting to prevailing and remaining compass points with winds flowing over and between low through mid-rise buildings, mature vegetation, and open spaces. As such, the surroundings can be expected to influence wind at the site to varying degrees.

5.3 Review of CFD Results

The areas of interest surrounding the proposed Development include Public Streets, Internal Site Areas, Outdoor Amenity Spaces, and Pedestrian Entrances to the proposed Development. The pedestrian level comfort results are graphically depicted for the two seasons in Figures 5a – 5d and safety results are graphically depicted in Figures 6a and 6b. The following discusses anticipated wind conditions and suitability for the areas' intended uses.

Public Street Conditions

Tannery Street

In the existing setting, the contour results along Tannery Street within the zone of influence of the proposed Development site indicate wind conditions that are generally suitable for standing or sitting throughout the year. The relatively comfortable conditions can be attributed to the surrounds that allow fairly consistent winds to flow over Tannery Street. The neighbouring mid-rise buildings flanking Rutledge Road provide blockage to dominant northwesterly winds for leeward portions of Tannery Street, resulting in localised comfortable conditions rated for sitting throughout the year.

With inclusion of the proposed Development, a realignment of winds was noted along portions of Tannery Street. Increases in winds were noted proximate to the proposed Development, sufficient to change the comfort categories from sitting to standing along areas near the intersection of Tannery Street and Rutledge Road. Localised walking conditions were also noted proximate to the westmost and northmost corners of the proposed Development in the winter months. This can be attributed to the proposed

Development redirecting winds from specific directions to flow down and around the building and ultimately along portions of Tannery Street proximate to the building.

As such, inclusion of the proposed Development will result in a realignment of winds along localized areas of Tannery Street, causing slightly windier conditions proximate to the building's corners. Tannery Street remains comfortable and suitable for the intended purpose throughout the year with inclusion of the proposed Development. Consideration of fine design and landscape elements that were too fine to include in the computational model will result in more comfortable conditions than those reported.

With inclusion of the proposed Development, Tannery Street remains within the pedestrian level wind velocity safety criteria, as depicted in Figures 6a and 6b.

Broadway Street

In the existing setting, Broadway Street realises wind conditions that are suitable for sitting throughout the majority of the year, with localised standing conditions in the winter months. The comfortable conditions can be attributed to the low-rise buildings flanking the street that direct large portions of the wind climate to flow up and over the pedestrian level.

With inclusion of the proposed Development, Broadway Street realises increases in winds throughout the winter season, sufficient to change the street from mainly suitable for sitting to suitable for standing. This can be attributed to the proposed Development redirecting winds from dominant northwesterly directions that formerly flowed over the low-rise site to flow around the building and over portions of Broadway Street.

Broadway Street remains comfortable and suitable for the intended purpose throughout the year in the proposed setting and consideration of fine design and landscape elements that were too fine to include in the computational model will result in more comfortable conditions than those reported.

With inclusion of the proposed Development, Broadway Street remains within the pedestrian level wind velocity safety criteria, as depicted in Figures 6a and 6b.

Rutledge Road

Rutledge Road is mainly rated for sitting or standing throughout the year in the existing setting, with the exception of very localised walking conditions between the flanking mid-rise buildings in the winter season. Windy conditions along portions of the street can be attributed to the flanking mid-rise buildings directing winds to flow through the gap between.

With inclusion of the proposed Development Rutledge Road is predicted to realise fairly similar conditions to the existing setting, with exceptions. The proposed Development provides blockage from portions of the southeasterly wind climate, improving the localised walking conditions to standing in the proposed setting. Conversely, localised areas of Rutledge Road proximate to the intersection with Tannery Street realise windier conditions in the proposed setting, changing ratings from sitting to standing throughout the year. This can be attributed to the proposed Development redirecting winds from specific directions to flow down and around the building and ultimately along portions of Rutledge Road proximate to the intersection with Tannery Street.

Rutledge Road remains comfortable and suitable for the intended purpose throughout the year with inclusion of the proposed Development and consideration of fine design and landscape elements that were too fine to include in the computational model will result in more comfortable conditions than those reported.

With inclusion of the proposed Development, Rutledge Road remains within the pedestrian level wind velocity safety criteria, as depicted in Figures 6a and 6b.

Emby Drive

In the existing setting, Emby Drive is mainly rated for standing in the winter season and sitting throughout the summer. With inclusion of the proposed Development, portions of Emby Drive proximate to the proposed Development realise windier conditions, becoming rated for standing throughout the summer season. This can be attributed to the proposed Development redirecting winds from specific directions to flow down and around the building and ultimately along portions of Emby Drive proximate to the building.

As such, Emby Drive remains comfortable and suitable for the intended purpose throughout the year and consideration of fine design and landscape elements will result in more comfortable conditions than those reported.

With inclusion of the proposed Development, Emby Drive remains within the pedestrian level wind velocity safety criteria, as depicted in Figures 6a and 6b.

Internal Site Conditions

Internal site conditions are generally predicted to be suitable for sitting year-round adjacent to the façades of the proposed Development. These areas realise comfortable conditions as they are within the aerodynamic shade region of the proposed building for winds emanating from specific directions. This includes private at-grade terraces along the building, and as such these spaces are expected to be suitable for the intended uses throughout the year.

Areas around the site more removed from the building are generally rated suitable for standing throughout the year, with localised areas proximate to the building's corners rated suitable for walking throughout the winter season. The windier conditions, rated for walking, near the building corners can be attributed to the proposed Development redirecting winds from large portions of the wind climate to flow along the façades and around the corners.

As such, internal site conditions are predicted generally comfortable and suitable for their intended uses, and consideration of fine design and landscape elements will result in more comfortable conditions than reported.

The internal site areas fall within the pedestrian level wind velocity safety criteria as depicted in Figure 6a and 6b.

Outdoor Amenity Space Conditions

An Outdoor Amenity Space is proposed to the southeast of the Main Entrance, at-grade. The space is rated for sitting throughout the summer and will be appropriate for the intended use.

A Play Area Outdoor Amenity Space is also proposed to the west of the building at-grade. The area is rated suitable for standing throughout the year and would benefit from a mitigation plan which may include fencing/porous wind screens, coniferous trees, raised planters, trellises, and/or others situated throughout the space. A mitigation plan for the space will be developed at the Site Plan stage.

An Outdoor Amenity Space is proposed along the northeastern façade of the building at-grade. The space is rated for sitting throughout the summer and will be appropriate for the intended use.

Consideration of fine design and landscape elements will result in more comfortable conditions than reported in the Outdoor Amenity Spaces. The Outdoor Amenity Spaces also fall within the pedestrian level wind velocity safety criteria as depicted in Figure 6a and 6b.

Pedestrian Entrance Conditions

The Main Residential Entrance to the building is located centrally near the interior corner of the building along the southwest façade. The Main Residential Entrance is protected from the majority of the dominant wind climate by the building, and as such realises comfortable conditions, suitable for sitting year-round. The Main Residential Entrance will experience conditions appropriate for the intended use throughout the year.

Additional secondary entrances located along the building façades are similarly in the aerodynamic shade region for large amounts of the wind climate and as such similarly realise conditions suitable for sitting throughout the year. As such, secondary entrances to the proposed Development will be comfortable and appropriate for the intended uses year-round.

Wind conditions comfortable for standing or better are preferable at building entrances, while conditions suitable for walking are suitable for walkways. The Main Residential Entrance and secondary entrances to the proposed Development will be comfortable and suitable for the intended uses throughout the year.

The entrances remain within the pedestrian level wind velocity safety criteria as depicted in Figures 6a and 6b.

5.4 Summary

The observed wind velocity and flow patterns at the proposed Development site are largely influenced by approach wind characteristics that are dictated by the surrounding areas to prevailing and less dominant wind directions. These surroundings present a predominantly suburban/open terrain to prevailing winds, moderating the wind to some extent, resulting in moderate conditions in the existing setting, suitable for mainly sitting or standing throughout the year.

Once the subject site is developed, ground level wind conditions remain fairly similar to the existing setting, with localized areas of increased pedestrian level winds mainly noted proximate to the proposed Development's corners. This results in localised wind conditions that are predicted suitable for walking at times through the winter months, but generally remain comfortable and appropriate to the areas' intended purposes throughout the year. Consideration of fine design details and mitigative landscape features will result in more comfortable conditions than reported. The relationship between surface roughness and wind is discussed in the Background and Theory of Wind Movement section and shown graphically in Figure A of the same section.

A mitigation plan is recommended for the Play Area Outdoor Amenity Space to the west of the building which may include fencing/porous wind screens, coniferous trees, raised planters, trellises, and/or others situated throughout the space. An appropriate mitigation plan for the space will be developed at the Site Plan stage.

The proposed Development is predicted to realise wind conditions acceptable to a typical open/suburban context, based on this preliminary Computational Fluid Dynamics analysis.

6. FIGURES

Figure 1: Site Aerial Photo

Figure 2a: Site Plan

SRM architects+ urban★designers

MONTCREST Asset Management

SITE PLAN

A0.1

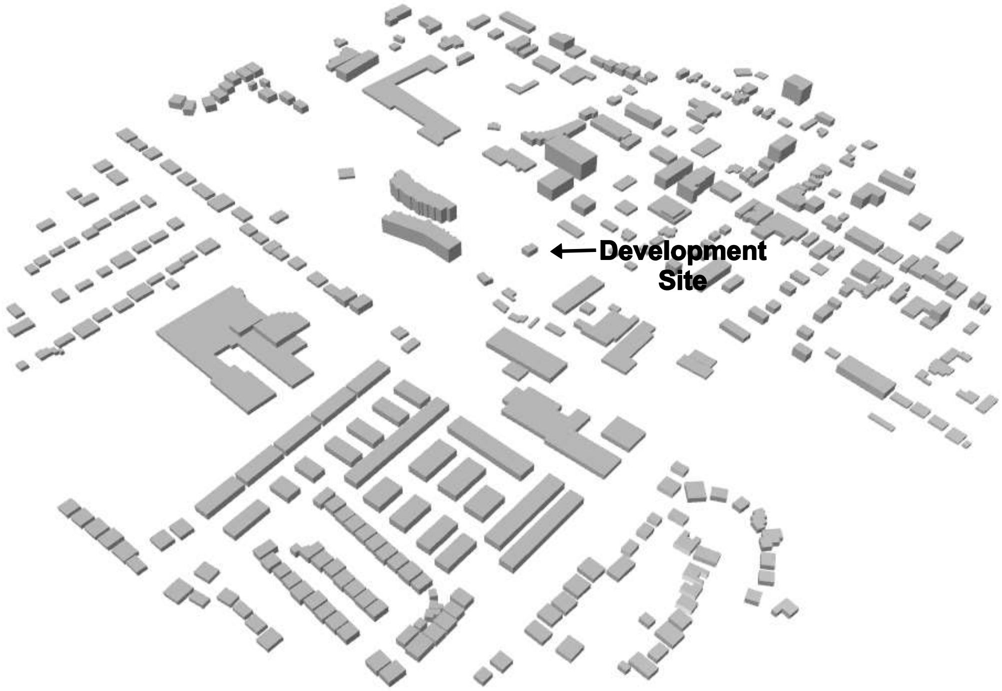
ISSUED FOR OFFICIAL PLAN AMENDMENT
NOT FOR CONSTRUCTION

Scale 1 : 300 FULL SIZE

2024-05-01

Theakston Environmental

Figure 3: Computational Geometry



a) Existing Setting

b) Proposed Setting

Figure 4a: Winter Wind Rose - Pearson International Airport

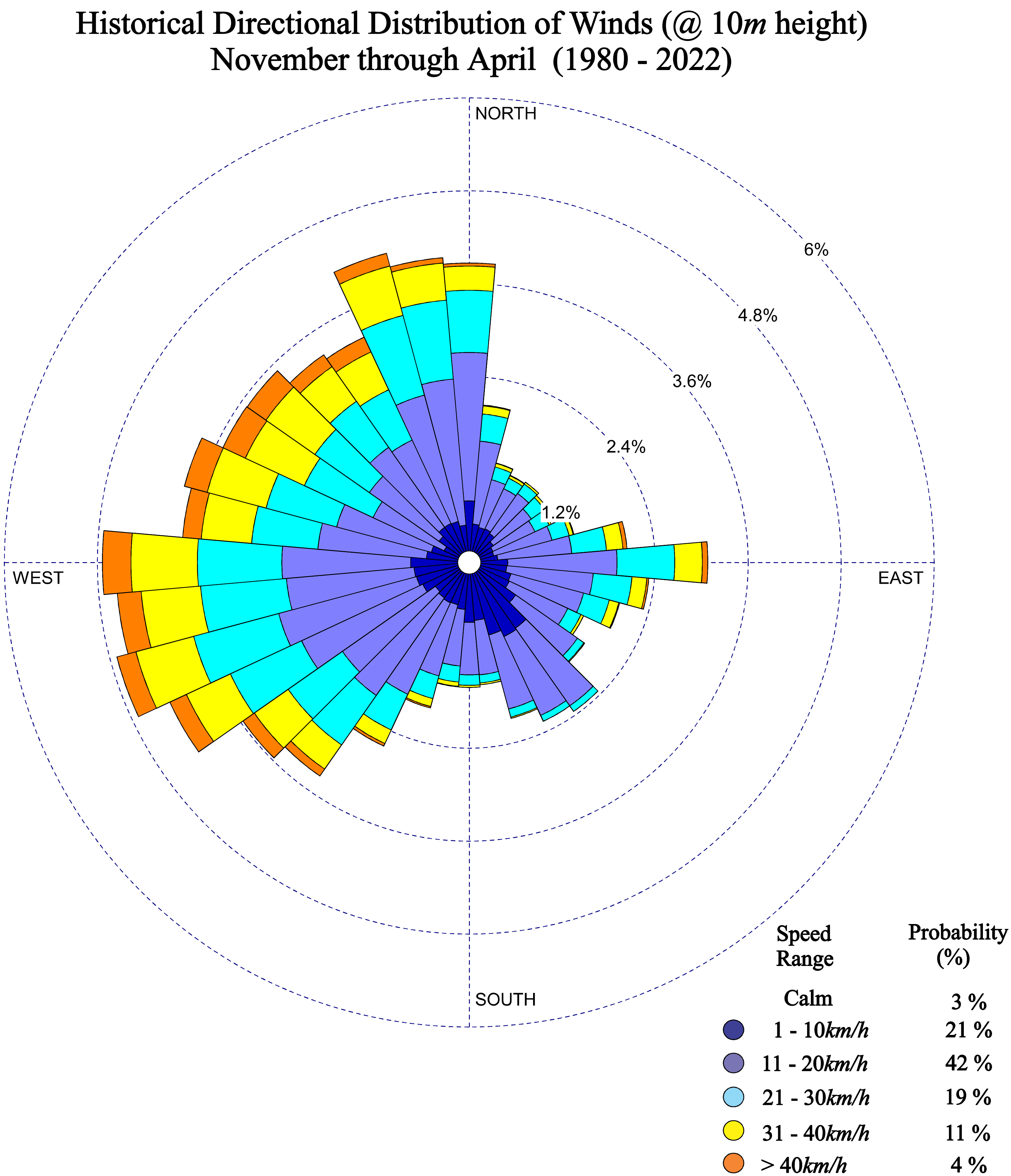


Figure 4b: Summer Wind Rose - Pearson International Airport

Historical Directional Distribution of Winds (@ 10*m* height)
May through October (1980 - 2022)

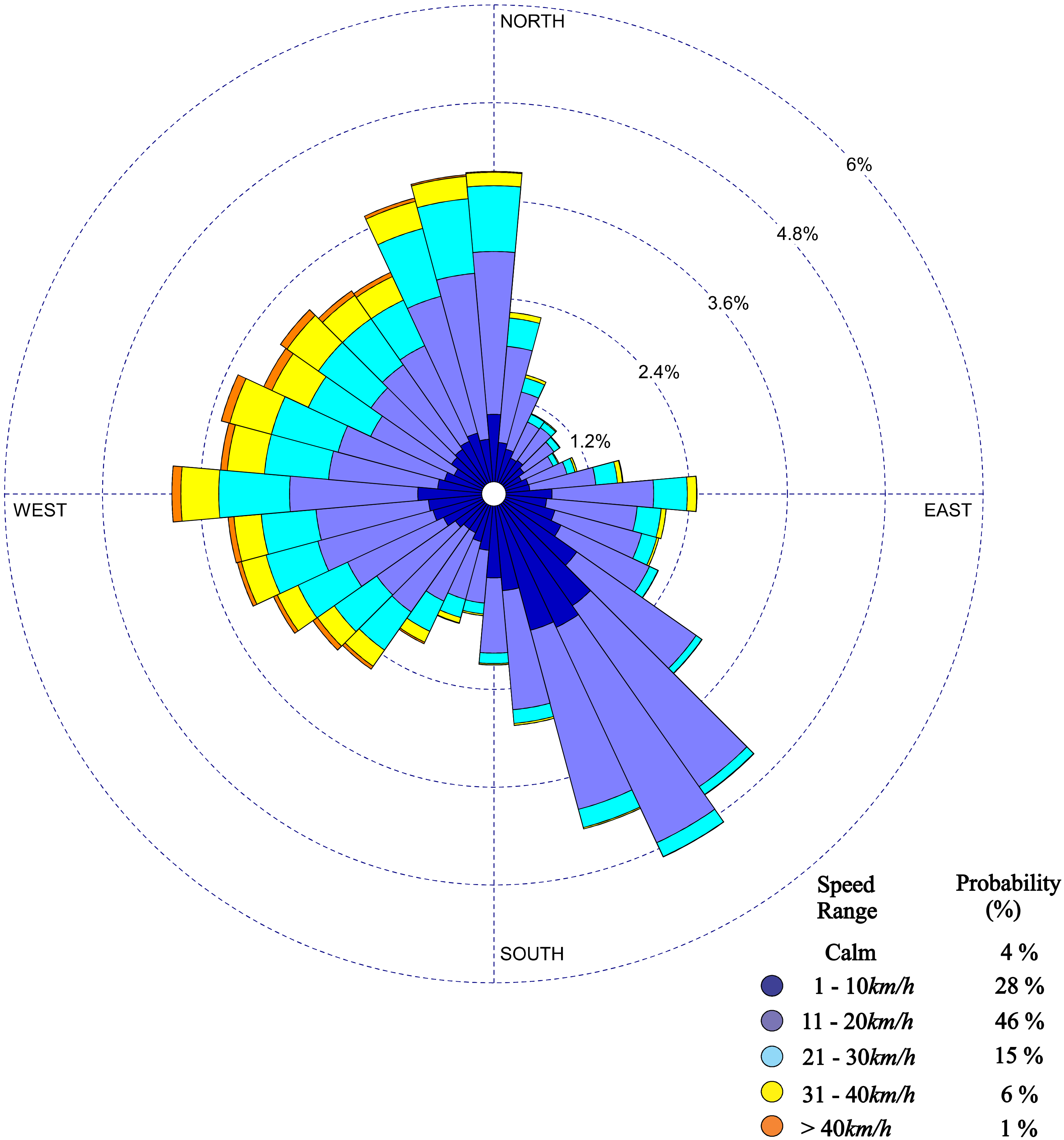
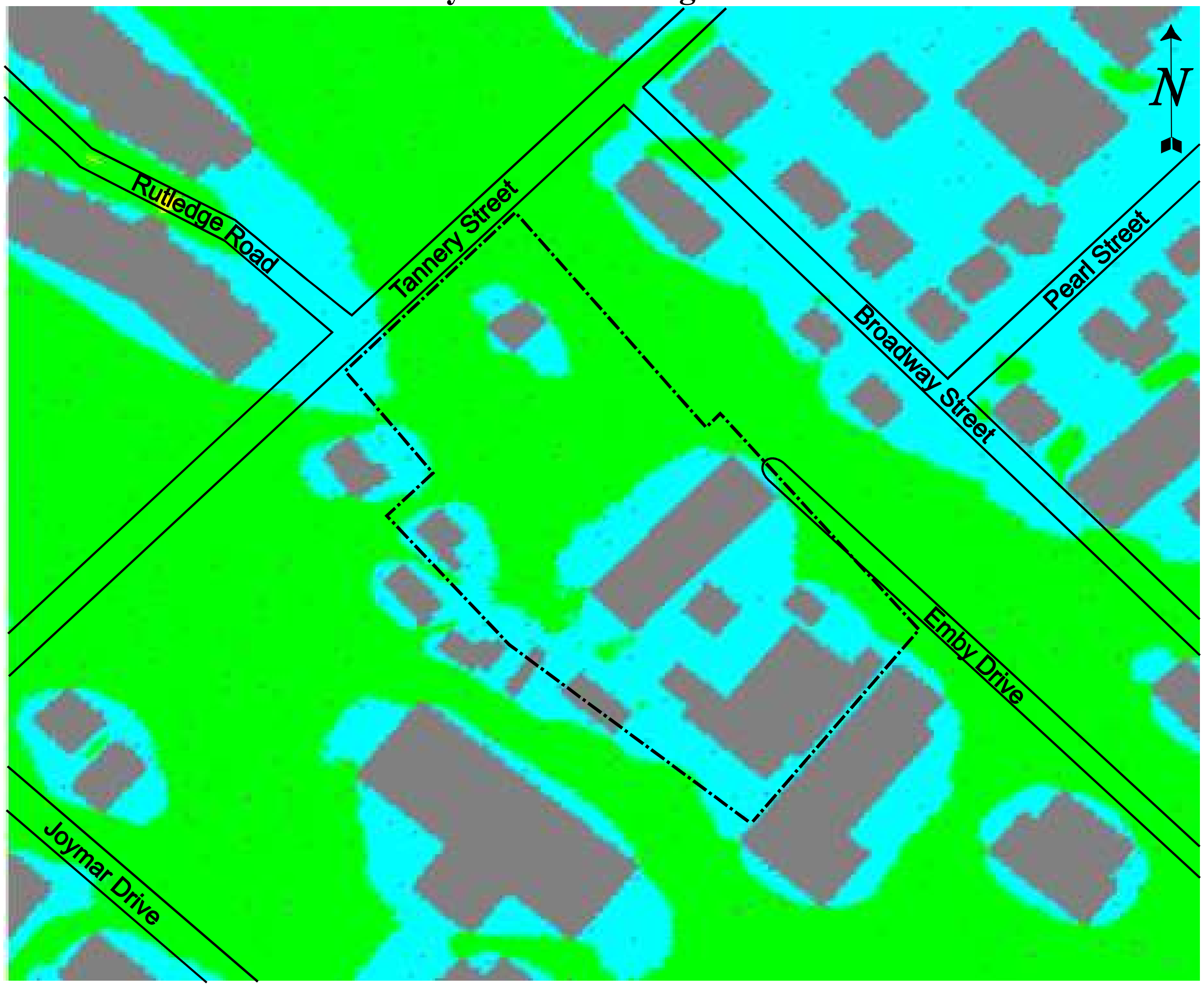


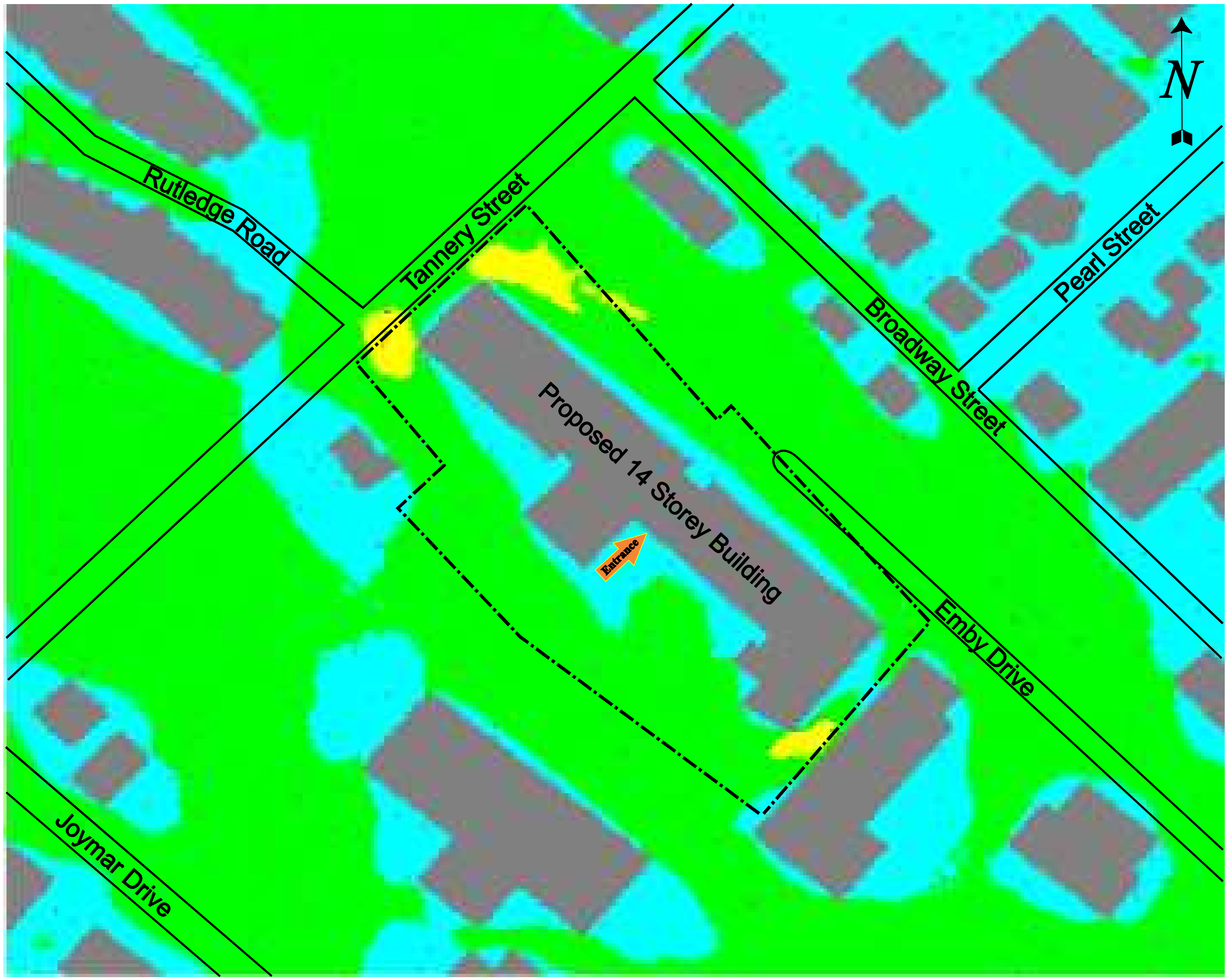
Figure 5a: Pedestrian Level Wind Velocity Comfort Categories



Comfort Categories - Winter - Existing

Sitting Standing Walking Uncomfortable

Figure 5b: Pedestrian Level Wind Velocity Comfort Categories



Comfort Categories - Winter - Proposed

Sitting Standing Walking Uncomfortable

Figure 5c: Pedestrian Level Wind Velocity Comfort Categories

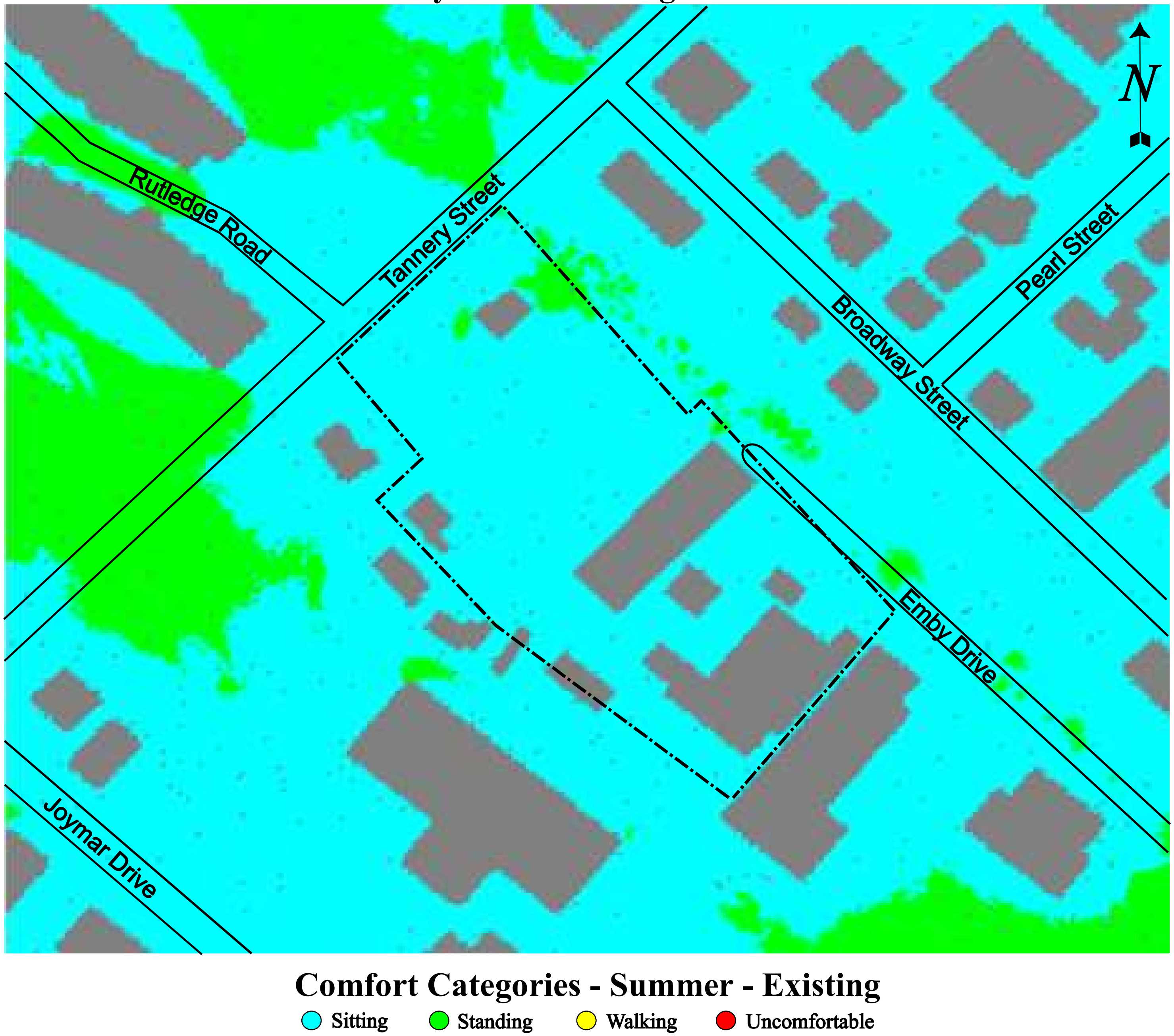


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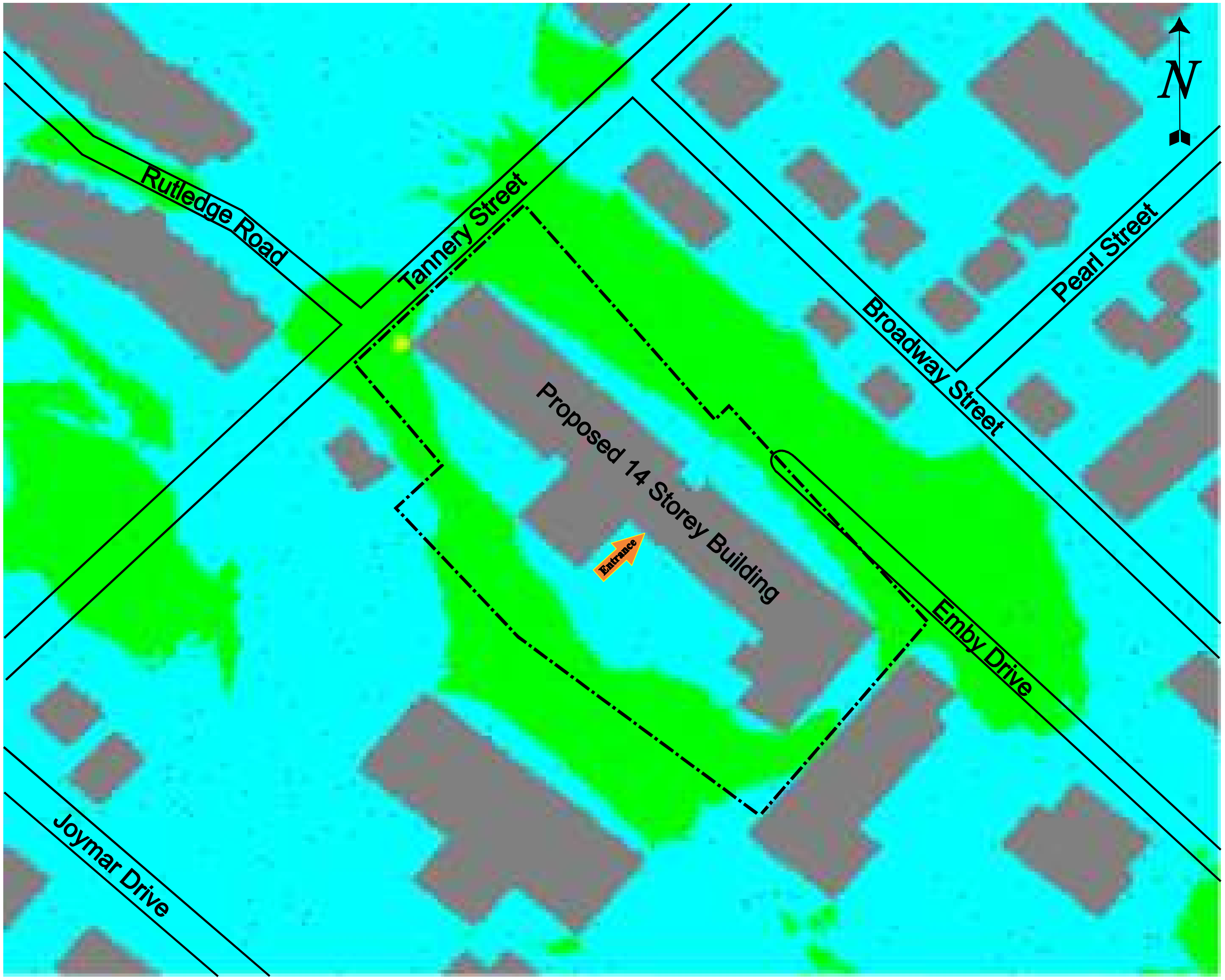
Figure 5d: Pedestrian Level Wind Velocity Comfort Categories



Comfort Categories - Summer - Proposed

Sitting Standing Walking Uncomfortable

Figure 6a: Pedestrian Level Wind Velocity Safety Criteria

Safety Criteria - Existing

Exceeding Safety Criteria

Figure 6b: Pedestrian Level Wind Velocity Safety Criteria

Safety Criteria - Proposed

Exceeding Safety Criteria

7. 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:

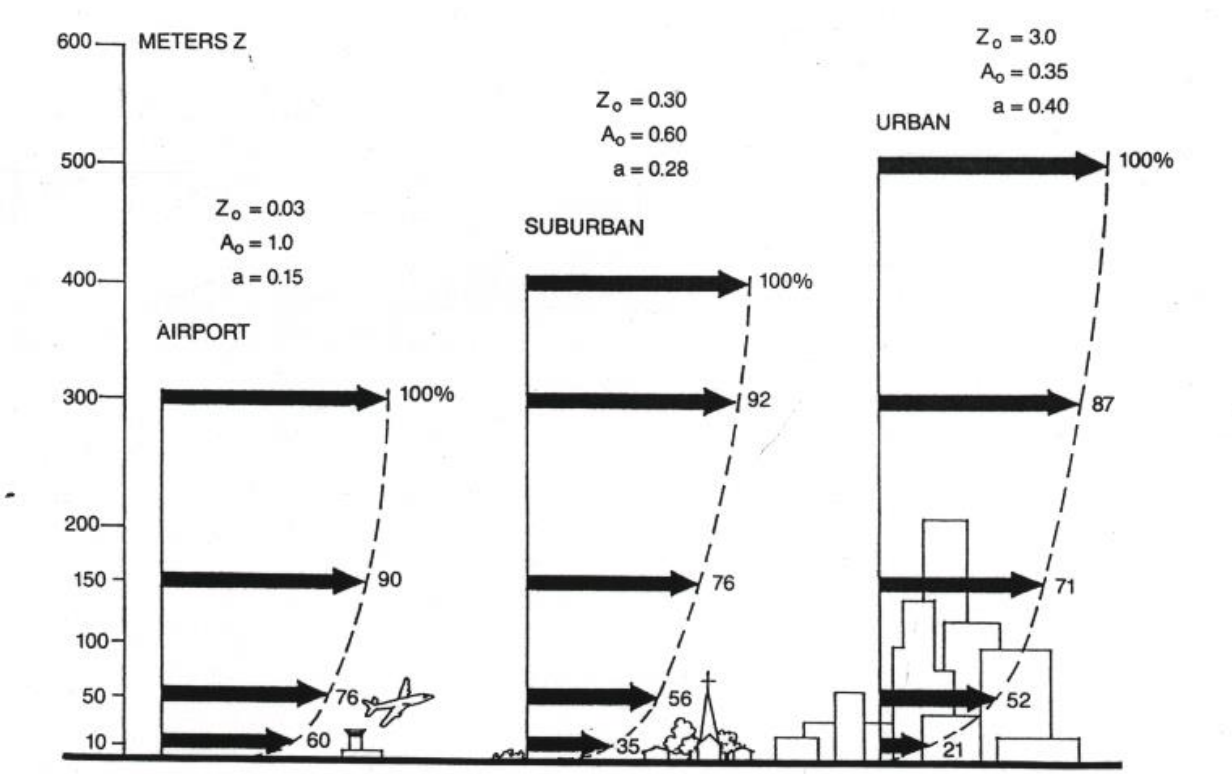


Figure A: Mean wind speed profiles for various terrain (from ASHRAE 1989).

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 300m 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.

Abbreviated Beaufort Scale

Beaufort Number	Description	Wind Speed			Observations
		km/h	*m/s*	h=2*m* for Urban *m/s*	
2	Slight Breeze	6-11	1.6-3.3	< ~2	Tree leaves rustle; flags wave slightly; vanes show wind direction; small wavelets or scale waves.
3	Gentle Breeze	12-19	3.4-5.4	< ~3	Leaves and twigs in constant motion; small flags extended; long unbreaking waves.
4	Moderate Breeze	20-28	5.5-7.9	< ~4	Small branches move; flags flap; waves with whitecaps.
5	Fresh Breeze	29-38	8.0-10.7	< ~6	Small trees sway; flags flap and ripple; moderate waves with many whitecaps.
6	Strong Breeze	39-49	10.8-13.8	< ~8	Large branches sway; umbrellas used with difficulty; flags beat and pop; larger waves with regular whitecaps.
7	Moderate Gale	50-61	13.9-17.1	< ~10	Sea heaps up, white foam streaks; whole trees sway; difficult to walk; large waves.
8	Fresh Gale	62-74	17.2-20.7	> ~10	Twigs break off trees; moderately high sea with blowing foam.
9	Strong Gale	75-88	20.8-24.4		Branches break off trees; tiles blown from roofs; high crested waves.

Wind speeds indicated above, in *km/h* and *m/s*, are at a reference height of 10 metres, as are the wind speeds indicated on the Figure 5 wind roses. The mean wind speeds at pedestrian level, for an urban climate, would be approximately 56% of these values. The 3rd column for wind speed is shown for reference, at a height of 2*m*, in an urban setting. The approximate Comfort Category Colours are shown above. The relationship between wind speed and height relative to terrain is discussed in the section above.

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