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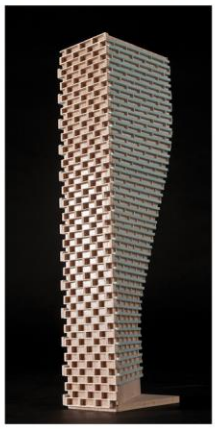
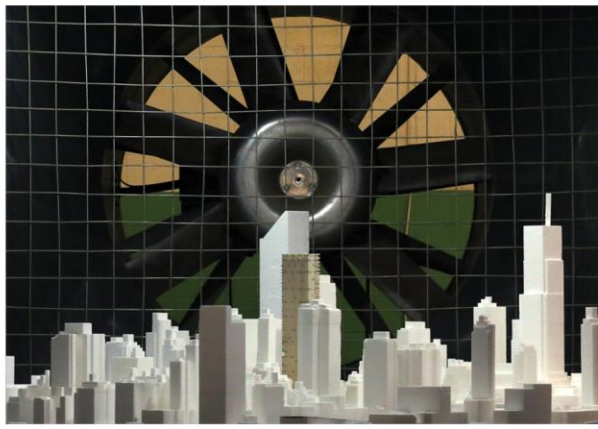
PEDESTRIAN LEVEL WIND STUDY

Lansdowne 2.0
Ottawa, Ontario

Report: 23-053-PLW





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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy Zoning By-law Amendment application requirements for the second redevelopment phase of Lansdowne Park, known as Lansdowne 2.0, in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate pedestrian wind conditions within and surrounding the subject site, and to identify areas where conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where required.

The study involves simulation of wind speeds for selected wind directions in a three-dimensional (3D) computer model using the computational fluid dynamics (CFD) technique, combined with meteorological data integration, to assess pedestrian wind comfort and safety within and surrounding the subject site according to City of Ottawa wind comfort and safety criteria. The results and recommendations derived from these considerations are detailed in the main body of the report (Section 5), illustrated in Figures 3A-40B, and summarized as follows:

1) Wind conditions in the vicinity of the building access points serving the proposed development and over all grade-level public sidewalks, surface parking, walkways, drop-off areas, the East Court, the Great Lawn, the west elevation of the proposed Event Centre, and the walking and bike pathways within Lansdowne Park within and surrounding the subject site are considerable acceptable for the intended pedestrian uses throughout the year.

2) Following the introduction of the proposed development, conditions over Aberdeen Square and the stadium field are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing throughout the three colder months. Conditions over the South Court are predicted to be suitable for standing, or better, throughout the year. Notably, landscaping elements that could not be implemented in the simulation model (that is, dense plantings and trees) are expected to improve pedestrian comfort around seating areas within the South Court during the colder seasons.

3) Areas to the north and at the southeast corner of the new Event Centre are predicted to be suitable for mostly sitting during the summer, becoming suitable for a mix of sitting and standing during the three colder seasons. Owing to the acceleration of prevailing winds through the between Towers 1 and 2 over the ceremonial stairs and passageway leading to the public promenade, conditions over these areas are predicted to be suitable for walking, or better, throughout the year. Conditions over the public promenade are predicted to be suitable for sitting during the summer with standing conditions to the northeast near the northeast corner of the new north stadium stands (NSS), and suitable for a mix of sitting and standing throughout the colder months with conditions suitable for walking, or better, near the northeast corner of the new NSS.

    a. The noted conditions within the public promenade and to the north and southeast of the new Event Centre may be considered acceptable depending on programming. Specifically, if the windier areas within these spaces will not accommodate seating or more sedentary activities, then the noted conditions would be considered acceptable.

    b. If required by programming, comfort levels around sensitive areas within the windier areas of the public promenade may be improved by implementing taller perimeter guards in place of standard height guards along the west and east perimeters of the promenade and along the north and south perimeters of the Level 2 amenity terrace serving Tower 3, in combination with wind barriers or canopies located around sensitive areas. Comfort levels around seating areas to the north and southeast of the Event Centre may be improved with the implementation of targeted wind barriers around sensitive areas, which could take the form of wind screens, clusters of coniferous trees in dense arrangements, or a combination of both options.

    c. The extent of the mitigation measures is dependent on the programming of the noted areas. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the development progresses. This work is expected to support the future Site Plan Control application.

4) The main and upper concourses of the new NSS are predicted to be acceptable for the intended pedestrian uses throughout the year. The upper fan decks overlooking the field are predicted to be suitable for standing, or better, throughout the year, and notably, the introduction of the roof over the new NSS improves wind conditions within the fan decks. Conditions within the pathway linking the north and south stadium stands via the west elevation of the new Event Centre are predicted to be suitable for sitting during the summer, and standing, or better, throughout the remainder of the year.

5) Wind conditions within the new NSS are predicted to be suitable for suitable for mostly sitting during the summer, and a mix of sitting and standing throughout the three colder seasons, with windier conditions suitable for walking, or better, without the roof over the NSS, and strolling, or better, with the roof at the outer extents of the upper rows. The introduction of the roof over the NSS improves conditions within the stands, with conditions becoming suitable for sitting within the majority of the upper-level rows throughout the year.

6) Regarding the common amenity terraces serving the proposed development along the north elevations of Towers 1 and 2, wind conditions during the typical use period, defined as May to October, inclusive, are predicted to be suitable for mostly sitting, with limited areas of standing conditions along the north perimeters. The noted conditions are considered acceptable given the limited extent of standing conditions.

7) Regarding the remaining common amenity terraces serving the proposed development, conditions within the Level 7 terrace between Towers 1 and 2 and the Level 2 terrace between Towers 2 and 3 are predicted to be suitable for a mix of mostly standing and strolling during the typical use period, while a mix of sitting and standing conditions are predicted within the west Level 7 and the Level 3 amenity terraces.

    a. To improve comfort levels, it is recommended that tall wind screens, in place of standard height guards, be implemented along the north and west perimeters of the Level 3 terrace serving Tower 1 and along the full perimeters of the Level 2, eastern Level 3, and western and central Level 7 terraces.

b. In addition, targeted mitigation inboard of the terrace perimeters is recommended, which could take the form of arrangements of dense plantings, tall wind screens, and canopies located around designated seating areas.

c. The extent of the mitigation measures is dependent on the programming of the terraces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses. This work is expected to support the future Site Plan Control application.

8) The foregoing statements and conclusions apply to common weather systems, during which no dangerous wind conditions, as defined in Section 4.4, are expected anywhere over the subject site. During extreme weather events, (for example, thunderstorms, tornadoes, and downbursts), pedestrian safety is the main concern. However, these events are generally short-lived and infrequent and there is often sufficient warning for pedestrians to take appropriate cover.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by the City of Ottawa to undertake a pedestrian level wind (PLW) study to satisfy Zoning By-Law Amendment application requirements for the second phase of redevelopment of Lansdowne Park, known as Lansdowne 2.0, in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate pedestrian wind conditions within and surrounding the subject site, and to identify areas where conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where required.

Our work is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, City of Ottawa wind comfort and safety criteria, architectural drawings prepared by BBB Architects in March 2023, surrounding street layouts and existing and approved future building massing information obtained from the City of Ottawa, as well as recent satellite imagery.

2. TERMS OF REFERENCE

The proposed Zoning By-law & Official Plan Amendments for Lansdowne 2.0 represent the next step in the evolution and progression of Lansdowne towards a redevelopment approach that will allow the site to succeed as an important residential, sports, culture, recreation, commercial, and entertainment destination, and a more vibrant day-to day hub for Ottawa.

The work described below requires both an Official Plan and Zoning By-law Amendment to align the proposed development plan with the City's planning policy framework. In general, the proposed development includes two components – a public infrastructure component and a private infrastructure component.

These two principal components are advanced through a number of important elements, including:

- Increase residential density to foster daily vibrancy to the area through proposing three high-rise towers including a combination of condominium and rental including affordable housing units.
    - The private infrastructure component could include up to 1,200 new residential units on-site, which could be provided in three new towers atop the proposed retail podium.

- The proposed heights of the towers as per the 2022 Council-endorsed concept are 29, 34, and 40 storeys, with the proposed maximum height limited to 40 storeys. Approximately 739 new parking spaces could be provided for the new residential units and located within the underground parking lot and within Level 1 and Level 1.5 (mezzanine) of the podium and north stadium stands.

/ Add mixed-used retail space through replacing the current 3,809m² (41,000 ft²) retail space attached to the arena/stadium complex along Exhibition Way, with 9,290m² (100,000 ft²) of new mixed-use retail space in the podium of the new residential towers.
    - The new north stadium stands will be integrated with a new retail podium, which will provide additional retail options to the existing Lansdowne Park, enhance the existing public realm along Exhibition Way, and enhance the protected viewpoint of Aberdeen Pavilion from Bank Street.

/ Replace the existing City facilities on-site through proposing a new 5,500-seat standalone multipurpose Event Centre and a re-designed and reconstructed 12,000-seat north stadium stands.
    - The public infrastructure component will include a new event centre which is intended to replace the existing 9,500 seat TD Place Arena which is located within the north stadium stands.
    - In addition to the new event centre, the north stadium stands will be replaced with 11,200 new seats, which will accommodate 12,000 spectators with additional standing-only areas.

/ Consolidate service access & loading through including a common access point for service & loading is provided for the Event Centre, Stadium, Residential and Retail.

/ Facilitate City-led enhancements to the public realm and programming as per the direction of the Lansdowne Guiding Principles which will form an important part of Lansdowne 2.0.

Overall, the proposal intends to re-visit the form and function of Lansdowne, and specifically Exhibition Way, as a place of exhibition, open to the City as a whole that fosters public gathering, vibrancy, and a centre of activity for the City. There will be a continued focus on placemaking, and the careful integration and enhancement of all new features with the objectives of the existing site – including a shared commitment to recognizing and celebrating Algonquin history, art and culture, respecting heritage

building views, animating Exhibition Way, providing access to the Great Lawn, and preserving an incorporating existing public and private components of Lansdowne today.

The subject site for the PLW study is bordered by Exhibition Way to the north, the South Court and the Great Lawn to the east, the existing stadium field and the south stadium stands to the south, and the Rideau at Lansdowne condo development and the existing commercial building at 979 Bank Street to the west. As part of the private infrastructure component, Towers 1, 2, and 3 rise to 40-, 34-, and 29-storeys from the west to the east along the north elevation of the site, with Towers 1 and 2 sharing a seven-storey podium. The three towers share a ground floor, which accommodates a public promenade to the south of the three towers at Level 2. This public promenade provides access to the main concourse of the north stadium stands (NSS) and is accessed from the grade-level via an outdoor staircase and passageway between Towers 1 and 2. The new Event Centre is situated to the east of the stadium field, with an elevated pathway along the west elevation of the Event Centre connecting the NSS to the south stadium stands. Access to underground parking is provided at the west elevation of the stadium. The NSS includes a potential roof over the upper seating levels.

Above an underground parking level comprising parking spaces, bike storage, residential lockers, shared building support spaces, mechanical rooms, and the performance level of a music hall, the ground floor of Towers 1 and 2 comprise retail frontage and the music hall fronting Exhibition Way, with shared building support spaces along the rear elevation adjoining covered surface parking. The residential lobby for Tower 1 is situated to the west, while the residential lobby serving Tower 2 is situated to the north along Exhibition Way. A ramp down to a truck parking facility is situated between Towers 2 and 3, and the ground floor of Tower 3 comprises a residential lobby and covered surface parking to the southeast and southwest. A mezzanine level accommodates covered surface parking, while the second level of Towers 1 and 2 comprise commercial spaces and Level 2 of Tower 3 comprises an indoor amenity. An outdoor amenity space is situated between Towers 2 and 3 at this level. At Level 3, Towers 1 and 2 step back from their north and south elevations to accommodate outdoor amenity terraces along the north and east elevations and private terraces to the south. Tower 3 steps back from the southeast and northwest at this level. Level 3 of Towers 1-3 comprise residential units with indoor amenities situated at the centre of the north elevation of Towers 1 and 2. Levels 4-6 of Towers 1 and 2 and Levels 4-29 of Tower 3 comprise residential units, and at Level 7, Towers 1 and 2 step back from the west and north elevations to

accommodate outdoor amenity terraces. Tower 3 steps back from the southeast elevation at this level. Level 7 of Towers 1 and 2 are comprised of indoor amenity spaces. At Level 8, Towers 1 and 2 step back from their west and east elevations, respectively, and the remaining levels above the podium for each tower rise with rectangular planforms and are reserved for residential occupancy. Each tower is topped with a mechanical penthouse (MPH).

Level 1 of the NSS includes building operations areas, team spaces, a lower concourse to the west, and viewing patios. The mezzanine level includes a mezzanine concourse, club spaces, and building operations. Level 2 of the NSS comprises the main concourse. The NSS stands further include an upper concourse with fan decks overlooking the field, and two upper fan decks to the east and west that overlook the field.

The lower level of the proposed Event Centre comprises building operation and mechanical spaces, building support spaces, and team areas. The main level comprises the concourse level, while the second level includes a sports bar, media spaces, the Loge Club, Stageview Club, and other club spaces and suites.

The near-field surroundings, defined as an area within 200-metres (m) of the subject site include the TD Place field to the south and southeast followed by the existing south stadium stands, the Rideau at Lansdowne high-rise condo development to the south-southwest and a commercial mid-rise building to the immediate west-southwest followed by a mix of mostly low- and mid-rise massing from the southwest clockwise to the west, low-rise commercial buildings from the west clockwise to the north-northeast, and the Aberdeen Pavilion and Lansdowne Park from the northeast clockwise to the south-southwest. Beyond Lansdowne Park, the Rideau Canal is situated from the south clockwise to the northeast. The far-field surroundings, defined as an area beyond the near-field but within a 2-kilometre (km) radius of the subject site, are characterized by mostly low-rise massing with clusters of taller mid- and high-rise buildings in all directions, and the southern extent of the urban massing of the downtown core from the north-northeast clockwise to the north. Notably, Carleton University is situated approximately 1.3 km to the southwest and Dow's Lake, the Dominion Arboretum, and the Fletcher Wildlife Garden are located at the west-southwest extent of the far-field.

Site plans for the proposed massing scenario with and without the roof over the NSS are illustrated in Figures 1A and 1B, while the existing massing scenario is illustrated in Figure 1C. Figures 2A-2L illustrate

the computational models used to conduct the study. The existing massing scenario includes the existing massing and any future developments approved by the City of Ottawa.

3. OBJECTIVES

The principal objectives of this study are to (i) determine pedestrian level wind conditions at key areas within and surrounding the development site; (ii) identify areas where wind conditions may interfere with the intended uses of outdoor spaces; and (iii) recommend suitable mitigation measures, where required.

4. METHODOLOGY

The approach followed to quantify pedestrian wind conditions over the site is based on CFD simulations of wind speeds across the study site within a virtual environment, meteorological analysis of the Ottawa area wind climate, and synthesis of computational data with City of Ottawa wind comfort and safety criteria[1]. The following sections describe the analysis procedures, including a discussion of the noted pedestrian wind criteria.

4.1 Computer-Based Context Modelling

A computer based PLW study was performed to determine the influence of the wind environment on pedestrian comfort over the proposed development site. Pedestrian comfort predictions, based on the mechanical effects of wind, were determined by combining measured wind speed data from CFD simulations with statistical weather data obtained from Ottawa Macdonald-Cartier International Airport. The general concept and approach to CFD modelling is to represent building and topographic details in the immediate vicinity of the study site on the surrounding model, and to create suitable atmospheric wind profiles at the model boundary. The wind profiles are designed to have similar mean and turbulent wind properties consistent with actual site exposures.

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

[1] City of Ottawa Terms of References: Wind Analysis
https://documents.ottawa.ca/sites/default/files/torwindanalysis_en.pdf

4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the site for 12 wind directions. The CFD simulation model was centered on the study building, complete with surrounding massing within a radius of 640 m. The process was performed for two context massing scenarios, as noted in Section 2.

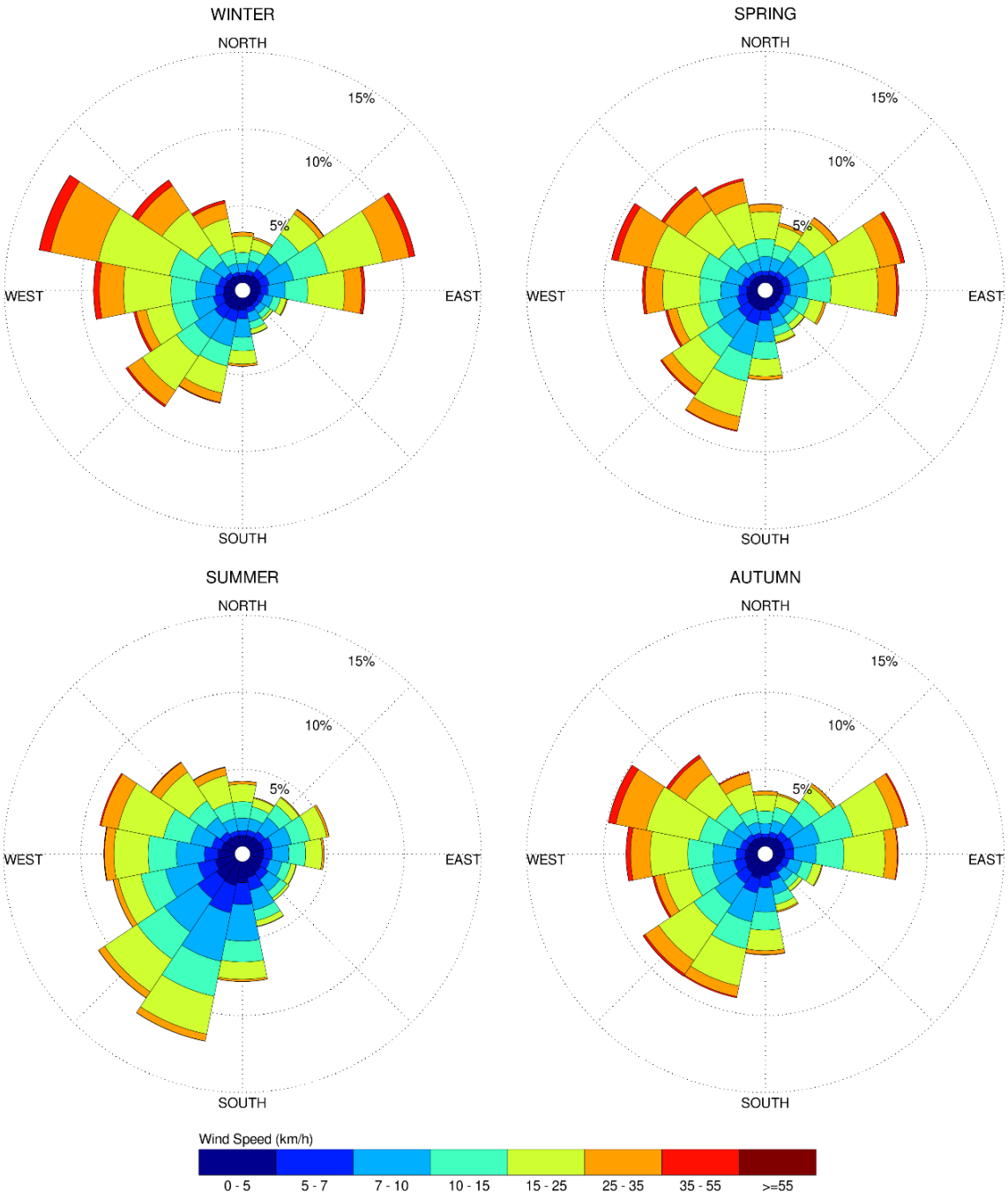
Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade, the common amenity terraces serving the proposed development, the public promenade, the elevated pathway linking the stands, the NSS concourses and fan decks, and select rows within the NSS were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. Gradient height represents the theoretical depth of the boundary layer of the earth's atmosphere, above which the mean wind speed remains constant. Further details of the wind flow simulation technique are presented in Appendix A.

4.3 Historical Wind Speed and Direction Data

A statistical model for winds in Ottawa was developed from approximately 40 years of hourly meteorological wind data recorded at Ottawa Macdonald-Cartier International Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were analyzed for each month of the year to determine the statistically prominent wind directions and corresponding speeds, and to characterize similarities between monthly weather patterns.

The statistical model of the Ottawa area wind climate, which indicates the directional character of local winds on a seasonal basis, is illustrated on the following page. The plots illustrate seasonal distribution of measured wind speeds and directions in kilometers per hour (km/h). Probabilities of occurrence of different wind speeds are represented as stacked polar bars in sixteen azimuth divisions. The radial direction represents the percentage of time for various wind speed ranges per wind direction during the measurement period. The prominent wind speeds and directions can be identified by the longer length of the bars. For Ottawa, the most common winds occur for westerly wind directions, followed by those from the east, while the most common wind speeds are below 36 km/h. The directional prominence and relative magnitude of wind speed changes somewhat from season to season.

SEASONAL DISTRIBUTION OF WIND
OTTAWA MACDONALD-CARTIER INTERNATIONAL AIRPORT



Notes:

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

4.4 Pedestrian Wind Comfort and Safety Criteria – City of Ottawa

Pedestrian comfort and safety criteria are based on the mechanical effects of wind without consideration of other meteorological conditions (that is, temperature, relative humidity). The comfort criteria assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Five pedestrian comfort classes are based on 20% non-exceedance mean wind speed ranges, which include (1) Sitting; (2) Standing; (3) Strolling; (4) Walking; and (5) Uncomfortable. More specifically, the comfort classes and associated mean wind speed ranges are summarized as follows:

1) **Sitting:** Mean wind speeds no greater than 10 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 16 km/h.

2) **Standing:** Mean wind speeds no greater than 14 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 22 km/h.

3) **Strolling:** Mean wind speeds no greater than 17 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 27 km/h.

4) **Walking:** Mean wind speeds no greater than 20 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 32 km/h.

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

The pedestrian safety wind speed criterion is based on the approximate threshold that would cause a vulnerable member of the population to fall. A 0.1% exceedance gust wind speed of 90 km/h is classified as dangerous. The gust speeds, and equivalent mean speeds, are selected based on 'The Beaufort Scale', presented on the following page, which describes the effects of forces produced by varying wind speed levels on objects. Gust speeds are included because pedestrians tend to be more sensitive to wind gusts than to steady winds for lower wind speed ranges. For strong winds approaching dangerous levels, this effect is less important because the mean wind can also create problems for pedestrians.

THE BEAUFORT SCALE

Number	Description	Gust Wind Speed (km/h)	Description
2	Light Breeze	9-17	Wind felt on faces
3	Gentle Breeze	18-29	Leaves and small twigs in constant motion; wind extends light flags
4	Moderate Breeze	30-42	Wind raises dust and loose paper; small branches are moved
5	Fresh Breeze	43-57	Small trees in leaf begin to sway
6	Strong Breeze	58-74	Large branches in motion; Whistling heard in electrical wires; umbrellas used with difficulty
7	Moderate Gale	75-92	Whole trees in motion; inconvenient walking against wind
8	Gale	93-111	Breaks twigs off trees; generally impedes progress

Experience and research on people's perception of mechanical wind effects has shown that if the wind speed levels are exceeded for more than 20% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if a mean wind speed of 10 km/h (equivalent gust wind speed of approximately 16 km/h) were exceeded for more than 20% of the time most pedestrians would judge that location to be too windy for sitting. Similarly, if mean wind speed of 20 km/h (equivalent gust wind speed of approximately 32 km/h) at a location were exceeded for more than 20% of the time, walking or less vigorous activities would be considered uncomfortable. As these criteria are based on subjective reactions of a population to wind forces, their application is partly based on experience and judgment.

Once the pedestrian wind speed predictions have been established throughout the site, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for discrete regions within and surrounding the subject site. This step involves comparing the predicted comfort classes to the desired comfort classes, which are dictated by the location type for each region (that is, a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their typical windiest desired comfort classes are summarized on the following page. Depending on the programming of a space, the desired comfort class may differ from this table.

DESIRED PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES

Location Types	Desired Comfort Classes
Primary Building Entrance	Standing
Secondary Building Access Point	Walking
Public Sidewalk / Bicycle Path	Walking
Outdoor Amenity Space	Sitting / Standing
Café / Patio / Bench / Garden	Sitting / Standing
Transit Stop (Without Shelter)	Standing
Transit Stop (With Shelter)	Walking
Public Park / Plaza	Sitting / Standing
Garage / Service Entrance	Walking
Parking Lot	Walking
Vehicular Drop-Off Zone	Walking

5. RESULTS AND DISCUSSION

The following discussion of the predicted pedestrian wind conditions for the subject site is accompanied by Figures 3A-10C, illustrating wind conditions at grade level for the proposed and existing massing scenarios, and by Figures 11A-14D, 15A-18B, 19A-22B, 23A-26B, 27A-30B, 31A-D, 32A-35D, and 36A-39B, which illustrate wind conditions over the public promenade and main concourse, the upper concourse, the east fan deck, the west fan deck, select rows within the new NSS, select rows within the existing NSS, the elevated pathway linking the north and south stadium stands, and the common amenity terraces serving Towers 1-3, respectively. Conditions are presented as continuous contours of wind comfort throughout the subject site and correspond to the comfort classes presented in Section 4.4. Conditions suitable for sitting are represented by the colour blue, standing by green, strolling by yellow, and walking by orange; uncomfortable conditions are represented by the colour magenta.

Wind comfort conditions over the noted common amenity terraces are also reported for the typical use period, which is defined as May to October, inclusive. Figures 40A ad 40B illustrate comfort conditions over the common amenity terraces, respectively, consistent with the comfort classes in Section 4.4. The details of these conditions are summarized in the following pages for each area of interest.

5.1 Wind Comfort Conditions – Grade Level

Sidewalks along Frank Clair Lane: Following the introduction of the proposed development, wind comfort conditions with and without the roof over the proposed NSS over the nearby sidewalks along Frank Clair Lane are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for strolling, or better, throughout the remainder of the year. The windier strolling conditions are located along the parking ramp at the west elevation, and near the scoreboard during the winter. The noted conditions are considered acceptable for public sidewalks and walkways.

Conditions along Frank Clair Lane with the existing massing are predicted to be suitable for mostly sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year, with strolling conditions during the spring and winter predicted beneath the scoreboard. While the introduction of the proposed development is predicted to produce windier conditions along Frank Clair Lane in comparison to existing conditions, wind conditions with the proposed development are nevertheless considered acceptable for the intended pedestrian uses.

West Elevation of Stadium Field: Following the introduction of the proposed development, wind conditions at the west elevation of the field are predicted to suitable for sitting during the summer, becoming suitable for a mix of sitting and standing during the spring, autumn, and winter. Conditions over the noted area with the existing massing are predicted to be suitable for sitting during the summer, becoming suitable for sitting to the south and standing to the northwest during the three colder seasons. These conditions are consistent with and without the roof over the new NSS.

Sidewalks and Drop-Off Areas along Exhibition Way: Following the introduction of the proposed development, with and without the roof over the proposed NSS, conditions over the public sidewalks and drop-off areas along Exhibition Way are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for mostly standing during the autumn, and suitable for a mix of standing and strolling during the spring and winter. The noted conditions are considered acceptable for public sidewalks and drop-off areas.

Conditions along Exhibition Way with the existing massing are predicted to be mostly suitable for sitting during the spring, summer, and autumn, becoming suitable for standing, or better, during the winter season. While the introduction of the proposed development is predicted to produce windier conditions

along Exhibition Way in comparison to existing conditions, wind conditions with the proposed development are nevertheless considered acceptable for the intended pedestrian uses.

Sidewalks along Paul Askin Way: Following the introduction of the proposed development, conditions over the public sidewalks along Paul Askin Way are predicted to be suitable for a mix of sitting and standing throughout the year. The noted conditions remain similar with and without the roof over the new NSS and are considered acceptable for public sidewalks.

Conditions over the sidewalks along Paul Askin Way with the existing massing are predicted to be mostly suitable for sitting throughout the year. While the introduction of the proposed development is predicted to produce windier conditions along Paul Askin Way in comparison to existing conditions, wind conditions with the proposed development are nevertheless considered acceptable for the intended pedestrian uses.

Aberdeen Square: Following the introduction of the proposed development, wind comfort conditions within Aberdeen Square with and without the roof over the new NSS are predicted to be suitable for sitting during the summer, and a mix of sitting and standing during the remainder of the year. Wind conditions over Aberdeen Square with the existing massing are predicted to be suitable for sitting throughout the year.

South Court: Following the introduction of the proposed development, wind conditions over the South Court with and without the roof over the new NSS are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for mostly standing during the spring and autumn, and suitable for a mix of standing and strolling during the winter. With the existing massing, wind conditions over the South Court are predicted to be suitable for sitting during the summer, suitable for sitting during the autumn with standing conditions to the east of the South Court, and suitable for standing to the east and west and sitting elsewhere within the court during the spring and winter. Notably, landscaping elements that could not be implemented in the simulation model (that is, dense plantings and trees), as described in Section 4.1, are expected to improve pedestrian comfort around seating areas within the South Court during the colder seasons.

East Court: Prior to the introduction of the proposed development, wind conditions over the East Court are predicted to be calm and suitable for mostly sitting throughout the year. These conditions remain mostly unchanged following the introduction of the proposed development and are considered acceptable.

Walkways to the Northeast of Tower 3 and North of the New Event Centre: With and without the roof over the proposed NSS, wind conditions over the proposed walkways to the northeast of Tower 3 are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for a mix of mostly standing and strolling throughout the remainder of the year. Conditions over the walkway between Tower 3 and the new Event Centre are predicted to be suitable for mostly sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. The noted conditions are considered acceptable for public walkways and pathways.

New Event Centre Public Areas: With and without the roof over the new NSS, wind comfort conditions to the north and at the southeast corner of the proposed Event Centre are predicted to be suitable for mostly sitting during the summer, becoming suitable for a mix of sitting and standing during the spring, autumn, and winter seasons. Where conditions are suitable for standing, they are also suitable for sitting for at least 75% of the time during the autumn and at least 70% of the time during the spring and winter, where the target is 80% to achieve the sitting comfort class.

Depending on the programming of these areas, conditions within the noted areas may be considered acceptable. Specifically, if the windier areas within the noted spaces will not accommodate seating or more sedentary activities, then the conditions would be considered acceptable. If required by programming, comfort levels may be improved with the implementation of targeted wind barriers around sensitive areas, which could take the form of wind screens, clusters of coniferous trees in dense arrangements, or a combination of both options.

Great Lawn: Following the introduction of the proposed development, wind comfort conditions during the summer over the Great Lawn are predicted to be suitable for standing to the northwest and sitting elsewhere, becoming suitable for a mix of sitting and standing at the southwest corner and standing elsewhere during the autumn. Conditions are predicted to be suitable for mostly standing during the spring, while conditions during the winter are predicted to be suitable for mostly standing with strolling

conditions to the northwest. These conditions remain similar with and without the roof over the new NSS. Prior to the introduction of the proposed development, wind conditions over the Great Lawn are predicted to be suitable for sitting during the summer, becoming suitable for standing to the east and sitting to the west during the spring, autumn, and winter. While the introduction of the proposed development produces windier conditions over the Great Lawn, wind conditions with the proposed development remain mostly similar to those under the existing massing during the primary use seasons of spring, summer, and autumn, and furthermore, the Great Lawn has limited seating areas. As such, conditions over the Great Lawn with the proposed development are considered acceptable.

West Elevation of the New Event Centre: Conditions along the west elevation of the new Event Centre are predicted to be suitable for mostly sitting throughout the year, which is considered acceptable.

Nearby Lansdowne Park Pathways to the South and East of the New Event Centre: Prior to the introduction of the proposed development, wind comfort conditions over the nearby existing pathways within Lansdowne Park to the south and east of the new Event Centre are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. Wind conditions following the introduction of the proposed development are predicted to be similar over the noted pathways, with and without the roof over the new NSS. The noted conditions are considered acceptable for public pathways and bicycle paths.

Stadium Field: Under the existing massing, wind comfort conditions over the stadium field are predicted to be suitable for sitting during the summer and autumn. During the spring, the east end of the field is predicted to have conditions suitable for standing, while the remainder of the field is suitable for sitting, and during the winter season when the use of the field is limited, the standing conditions extend to the middle of the field. With the proposed development, conditions over the field are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing during the three colder seasons. The majority of the field is predicted to be suitable for standing during the spring, autumn, and winter, with sitting conditions predicted at the west end of the field and over the eastern portion of the east end zone. These conditions remain similar with and without the roof over the new NSS.

Surface Parking to the South of Towers 1-3: Wind conditions over the covered surface parking beneath the public promenade are predicted to be calm and suitable for sitting throughout the year, which is considered acceptable.

Public Promenade and Ceremonial Stair: Owing to prevailing winds accelerating between Towers 1 and 2 over the ceremonial stair and passageway to the public promenade, and as illustrated in Figures 11A-14B, wind comfort conditions over the ceremonial stair and passageway leading to the public promenade are predicted to be suitable for a mix of sitting and standing during the summer with a limited region of strolling conditions, becoming suitable for walking, or better, during the spring, autumn, and winter. These conditions are similar with and without the roof over the new NSS, with slightly windier conditions within the passageway with the roof over the new NSS.

Conditions over the public promenade between Towers 1-3 and the new NSS during the summer are predicted to be suitable sitting, with conditions suitable for standing to the south of Tower 3. Conditions over the promenade during the spring, autumn, and winter are predicted to be suitable for a mix of sitting and standing. At the northeast corner of the new NSS, conditions are predicted to be suitable for strolling during the spring and autumn, and walking, or better, during the winter. These conditions are similar with and without the roof over the new NSS.

The noted conditions within the public promenade may be considered acceptable depending on programming. Specifically, if the windier areas of the promenade will not accommodate seating or more sedentary activities, then the noted conditions would be considered acceptable. If required by programming, comfort levels around sensitive areas may be improved by implementing taller perimeter guards in place of standard height guards along the west and east perimeters of the promenade and along the north and south perimeters of the Level 2 amenity terrace serving Tower 3, in combination with wind barriers or canopies located around sensitive areas.

The extent of the mitigation measures is dependent on the programming of the public promenade. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the development progresses. This work is expected to support the future Site Plan Control application.

Building Access Points: Owing to the protection of the building façades, conditions in the vicinity of the building access points serving the Towers 1-3 and the new Event Centre are predicted to be suitable for standing, or better, throughout the year. Wind conditions in the vicinity of the building access points serving the new NSS beneath the public promenade and from the field are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable.

5.2 Wind Comfort Conditions – NSS and Event Centre Elevated Pathway

Main Concourse: Wind conditions within the main concourse serving the new NSS, as illustrated in Figures 11A-14B, are predicted to be suitable for sitting throughout the year with and without the roof over the new NSS. The noted conditions are considered acceptable.

Upper Concourse: With and without the roof over the new NSS, wind comfort conditions over the upper concourse are predicted to be suitable for mostly sitting throughout the year, which is considered acceptable.

East Upper Fan Deck: Wind conditions over the eastern upper fan deck without the roof over the new NSS are predicted to be suitable for sitting during the summer, becoming suitable for mostly sitting with limited areas of standing conditions during the autumn season. During the winter, conditions are suitable for standing within the exposed areas of the deck and suitable for sitting elsewhere. Conditions over the deck with the roof over the new NSS are predicted to be calmer than those without the roof, with conditions predicted to be suitable for sitting during the summer, suitable for mostly sitting during the autumn, and suitable for standing, or better, during the spring and winter.

West Upper Fan Deck: With and without the roof over the new NSS, wind conditions within the western upper fan deck are predicted to be suitable for sitting during the summer, becoming suitable for a mix of mostly sitting and standing throughout the remainder of the year. Notably, comfort conditions are slightly improved within the fan deck with the inclusion of the roof over the new NSS.

Seats: Wind conditions within select rows within the new NSS are illustrated in Figures 27A-30B. Without the roof over the new NSS, wind conditions during the summer within the stands are predicted to be suitable for mostly sitting, with limited areas suitable for standing at the outer extents of the upper rows. During the autumn and spring seasons, conditions within the stands are mixed between sitting and standing, with the uppermost rows having limited conditions suitable for strolling at their outer extents. During winter, conditions within the stands are predicted to be suitable for a mix of sitting and standing with limited areas of strolling and walking at the outer extents of the upper rows.

Wind conditions within the stands are predicted to be improved with the inclusion of the roof over the new NSS. Specifically, during the summer, the standing conditions are limited to the outer extents of the uppermost rows, while the strolling conditions within the uppermost rows are mostly eliminated during the autumn and spring seasons and the majority of the stands are suitable for sitting. During the winter, conditions are suitable for mostly sitting and standing, with limited strolling conditions at the outer extents of the uppermost rows. With the roof over the new NSS, the majority of the upper level of the stands are suitable for sitting throughout the year.

Wind conditions within the existing stands are illustrated in Figures 31A-D for rows at similar elevations as those shown in Figures 27A-30B. Within the existing NSS, wind conditions are mostly suitable for sitting throughout the year, with limited areas of standing conditions during the spring and winter over small areas at the northwest and southeast corners of the stands.

Event Centre Elevated Pathway: As illustrated in Figures 32A-35B, conditions over the elevated pathway connecting the north and south stadium stands with and without the roof over the new NSS are predicted to be suitable for sitting during the summer, becoming suitable for sitting during the autumn with limited areas suitable for standing, and suitable for a mix of sitting and standing during the spring and winter.

5.3 Wind Comfort Conditions – Common Amenity Terraces

The proposed development is served by several common amenity terraces. Wind comfort conditions during the typical use period and recommendations regarding mitigation are described as follows. Notably, the wind comfort conditions within these terraces are similar with and without the roof over the new NSS.

Outdoor Amenity Terrace at Level 2: As illustrated in Figures 40A-B, wind conditions within the outdoor amenity terrace serving Towers 1-3 at Level 2 are predicted to be suitable for a mix of standing and strolling, with conditions suitable for strolling at the centre of the terrace and standing elsewhere.

Tower 1 Level 3 Amenity Terrace: Wind comfort conditions within the common amenity terrace serving Tower 1 at Level 3 are predicted to be suitable for sitting to the south and along the east perimeter and standing elsewhere.

Tower 2 Level 3 Amenity Terrace: Conditions within the common amenity serving Tower 2 at Level 3 are predicted to be suitable for sitting to the west and south, and suitable for standing to the northeast.

West Amenity Terrace at Level 7: Conditions within the common amenity terrace to the west at Level 7 are predicted to be suitable for sitting near the façade of Tower 1 and standing elsewhere.

North Amenity Terraces at Level 7: Wind conditions within the common amenity terraces along the north elevations of Towers 1 and 2 at Level 7 are predicted to be suitable for sitting, with limited areas of standing conditions along the north perimeters of the terraces. Where conditions are suitable for standing, they are also suitable for sitting for at least 76% of the time, where the target is 80% to achieve the sitting comfort class. Given the limited extent of standing conditions, the noted conditions are considered acceptable.

Amenity Terrace Between Towers 1 and 2: Wind conditions over the common amenity terrace situated between Towers 1 and 2 are predicted to be suitable for standing along the tower elevations and strolling throughout the centre of the terrace.

The windy conditions within the amenity terraces are attributable to the exposure of the noted terraces to prominent westerly and northwesterly winds in combination with downwash incident on Towers 1-3 and the channeling and acceleration of winds between Towers 1 and 2 and Tower 2 and 3.

With the exception of the Level 7 amenity terraces at the north elevations of Towers 1 and 2, to improve comfort levels within the amenity terraces serving Towers 1-3 it is recommended that tall wind screens, in place of standard height guards, be implemented along the full perimeters of the Level 2 terrace, the Level 3 terrace serving Tower 2, and the western and central Level 7 terraces. It is also recommended that tall wind screens be implemented along the west and north perimeters of the amenity terrace serving Tower 1 at Level 3. In addition, targeted mitigation inboard of the terrace perimeters is recommended, which could take the form of arrangements of dense plantings, tall wind screens, and canopies located above designated seating areas.

The extent of the mitigation measures is dependent on the programming of the terraces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses. This work is expected to support the future Site Plan Control application.

5.4 Wind Safety

Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no pedestrian areas within or surrounding the subject site are expected to experience conditions that could be considered dangerous, as defined in Section 4.4.

5.5 Applicability of Results

Pedestrian wind comfort and safety have been quantified for the specific configuration of existing and foreseeable construction around the subject site. Future changes (that is, construction or demolition) of these surroundings may cause changes to the wind effects in two ways, namely: (i) changes beyond the immediate vicinity of the subject site would alter the wind profile approaching the subject site; and (ii) development in proximity to the subject site would cause changes to local flow patterns.

6. CONCLUSIONS AND RECOMMENDATIONS

A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-40B. Based on computer simulations using the CFD technique, meteorological data analysis of the Ottawa wind climate, City of Ottawa wind comfort and safety criteria, and experience with numerous similar developments, the study concludes the following:

1) Wind conditions in the vicinity of the building access points serving the proposed development and over all grade-level public sidewalks, surface parking, walkways, drop-off areas, the East Court, the Great Lawn, the west elevation of the proposed Event Centre, and the walking and bike pathways within Lansdowne Park within and surrounding the subject site are considerable acceptable for the intended pedestrian uses throughout the year.

2) Following the introduction of the proposed development, conditions over Aberdeen Square and the stadium field are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing throughout the three colder months. Conditions over the South Court are predicted to be suitable for standing, or better, throughout the year. Notably, landscaping elements that could not be implemented in the simulation model (that is, dense plantings and trees) are expected to improve pedestrian comfort around seating areas within the South Court during the colder seasons.

3) Areas to the north and at the southeast corner of the new Event Centre are predicted to be suitable for mostly sitting during the summer, becoming suitable for a mix of sitting and standing during the three colder seasons. Owing to the acceleration of prevailing winds through the between Towers 1 and 2 over the ceremonial stairs and passageway leading to the public promenade, conditions over these areas are predicted to be suitable for walking, or better, throughout the year. Conditions over the public promenade are predicted to be suitable for sitting during the summer with standing conditions to the northeast near the northeast corner of the new north stadium stands (NSS), and suitable for a mix of sitting and standing throughout the colder months with conditions suitable for walking, or better, near the northeast corner of the new NSS.

a. The noted conditions within the public promenade and to the north and southeast of the new Event Centre may be considered acceptable depending on programming. Specifically, if the windier areas within these spaces will not accommodate seating or more sedentary activities, then the noted conditions would be considered acceptable.

b. If required by programming, comfort levels around sensitive areas within the windier areas of the public promenade may be improved by implementing taller perimeter guards in place of standard height guards along the west and east perimeters of the promenade and along the north and south perimeters of the Level 2 amenity terrace serving Tower 3, in combination with wind barriers or canopies located around sensitive areas. Comfort levels around seating areas to the north and southeast of the Event Centre may be improved with the implementation of targeted wind barriers around sensitive areas, which could take the form of wind screens, clusters of coniferous trees in dense arrangements, or a combination of both options.

c. The extent of the mitigation measures is dependent on the programming of the noted areas. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the development progresses. This work is expected to support the future Site Plan Control application.

4) The main and upper concourses of the new NSS are predicted to be acceptable for the intended pedestrian uses throughout the year. The upper fan decks overlooking the field are predicted to be suitable for standing, or better, throughout the year, and notably, the introduction of the roof over the new NSS improves wind conditions within the fan decks. Conditions within the pathway linking the north and south stadium stands via the west elevation of the new Event Centre are predicted to be suitable for sitting during the summer, and standing, or better, throughout the remainder of the year.

5) Wind conditions within the new NSS are predicted to be suitable for suitable for mostly sitting during the summer, and a mix of sitting and standing throughout the three colder seasons, with windier conditions suitable for walking, or better, without the roof over the NSS, and strolling, or better, with the roof at the outer extents of the upper rows. The introduction of the roof over the NSS improves conditions within the stands, with conditions becoming suitable for sitting within the majority of the upper-level rows throughout the year.

6) Regarding the common amenity terraces serving the proposed development along the north elevations of Towers 1 and 2, wind conditions during the typical use period, defined as May to October, inclusive, are predicted to be suitable for mostly sitting, with limited areas of standing conditions along the north perimeters. The noted conditions are considered acceptable given the limited extent of standing conditions.

7) Regarding the remaining common amenity terraces serving the proposed development, conditions within the Level 7 terrace between Towers 1 and 2 and the Level 2 terrace between Towers 2 and 3 are predicted to be suitable for a mix of mostly standing and strolling during the typical use period, while a mix of sitting and standing conditions are predicted within the west Level 7 and the Level 3 amenity terraces.

    a. To improve comfort levels, it is recommended that tall wind screens, in place of standard height guards, be implemented along the north and west perimeters of the Level 3 terrace serving Tower 1 and along the full perimeters of the Level 2, eastern Level 3, and western and central Level 7 terraces.

    b. In addition, targeted mitigation inboard of the terrace perimeters is recommended, which could take the form of arrangements of dense plantings, tall wind screens, and canopies located around designated seating areas.

    c. The extent of the mitigation measures is dependent on the programming of the terraces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses. This work is expected to support the future Site Plan Control application.

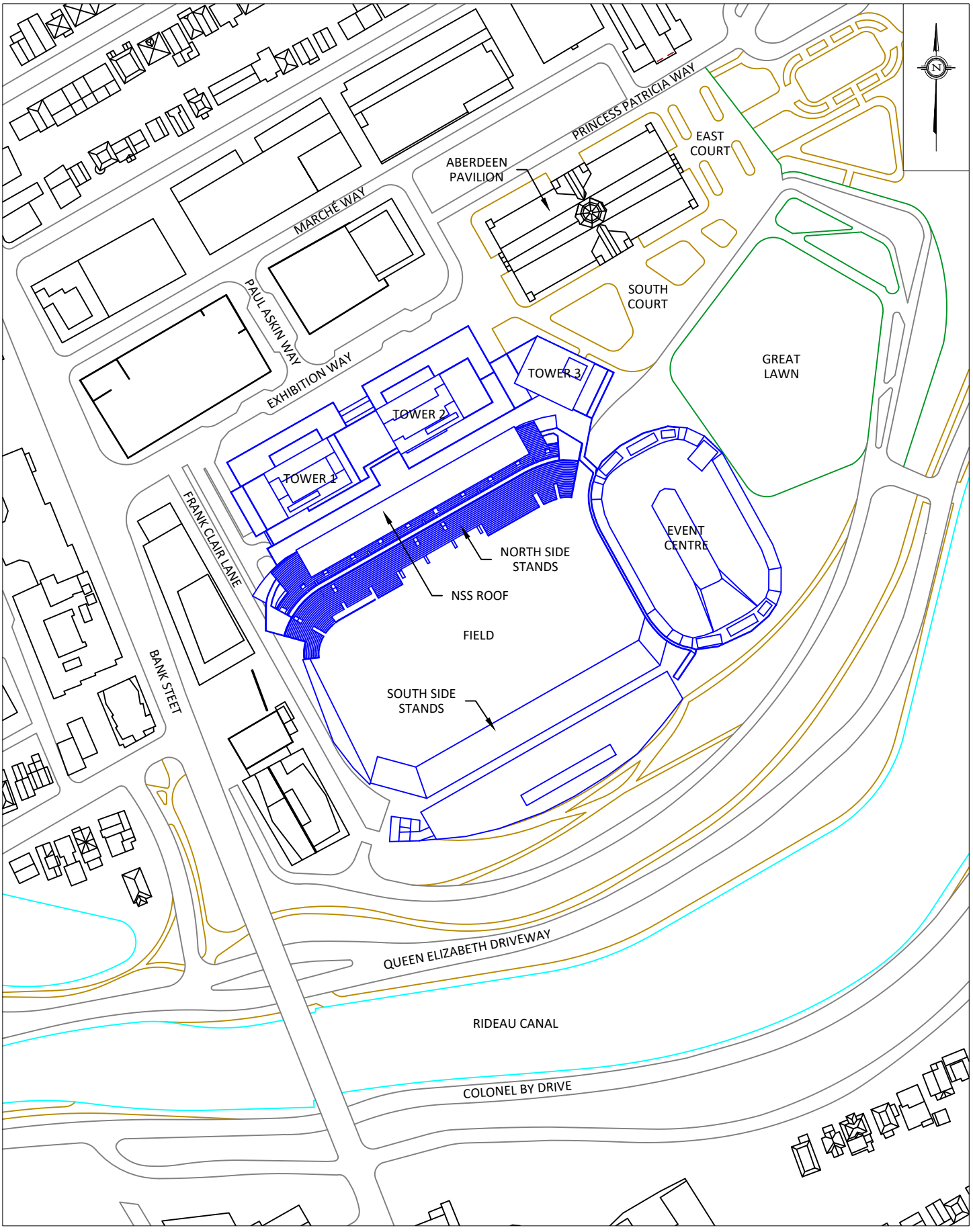
8) The foregoing statements and conclusions apply to common weather systems, during which no dangerous wind conditions, as defined in Section 4.4, are expected anywhere over the subject site. During extreme weather events, (for example, thunderstorms, tornadoes, and downbursts), pedestrian safety is the main concern. However, these events are generally short-lived and infrequent and there is often sufficient warning for pedestrians to take appropriate cover.

Sincerely,

Gradient Wind Engineering Inc.

David Huitema, M.Eng.
Wind Scientist

Justin Ferraro, P.Eng.
Principal



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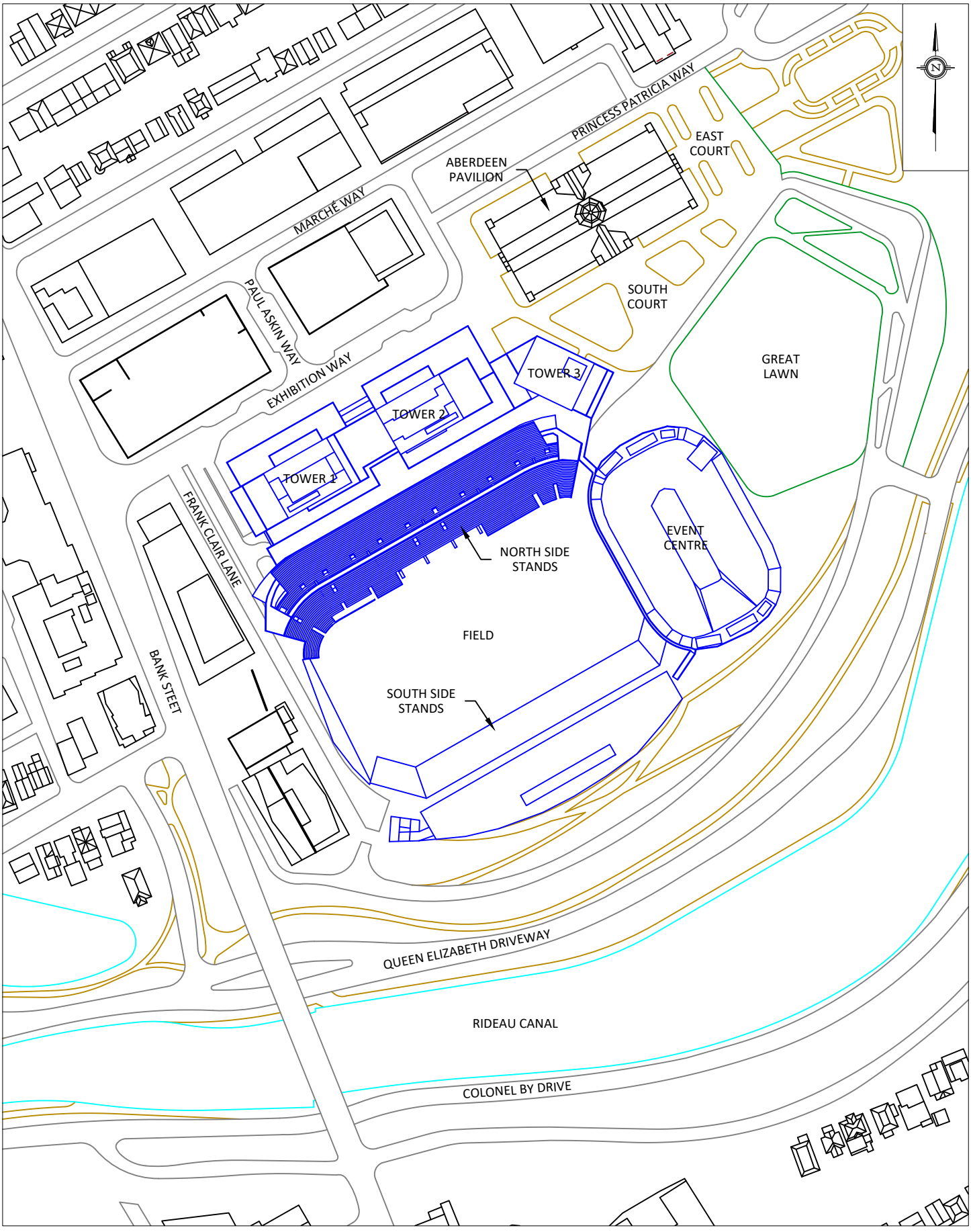
PROJECT	LANSDOWNE 2.0, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:2000
DRAWING NO.	23-053-PLW-1A
DATE	MAY 29, 2023
DRAWN BY	S.K.
DESCRIPTION	FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT WITH NORTH SIDE STANDS ROOF



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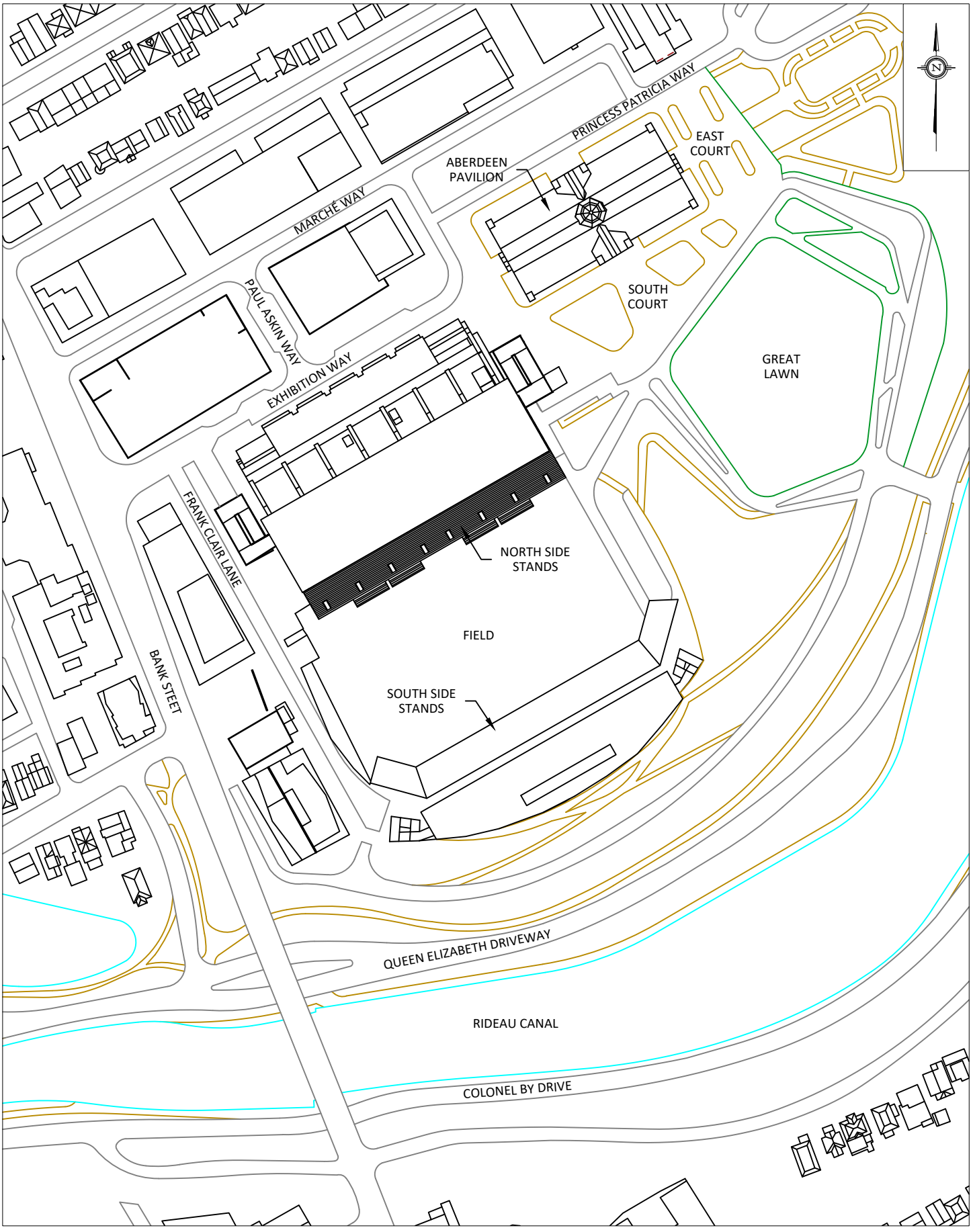
SCALE	1:2000
DRAWING NO.	23-053-PLW-1B
DATE	MAY 29, 2023
DRAWN BY	S.K.

DESCRIPTION

FIGURE 1B:
PROPOSED SITE PLAN AND SURROUNDING CONTEXT
WITHOUT NORTH SIDE STANDS ROOF



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PROJECT	LANSDOWNE 2.0, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:2000
DRAWING NO.	23-053-PLW-1C
DATE	MAY 29, 2023
DRAWN BY	S.K.

DESCRIPTION

FIGURE 1C:
EXISTING SITE PLAN AND SURROUNDING CONTEXT

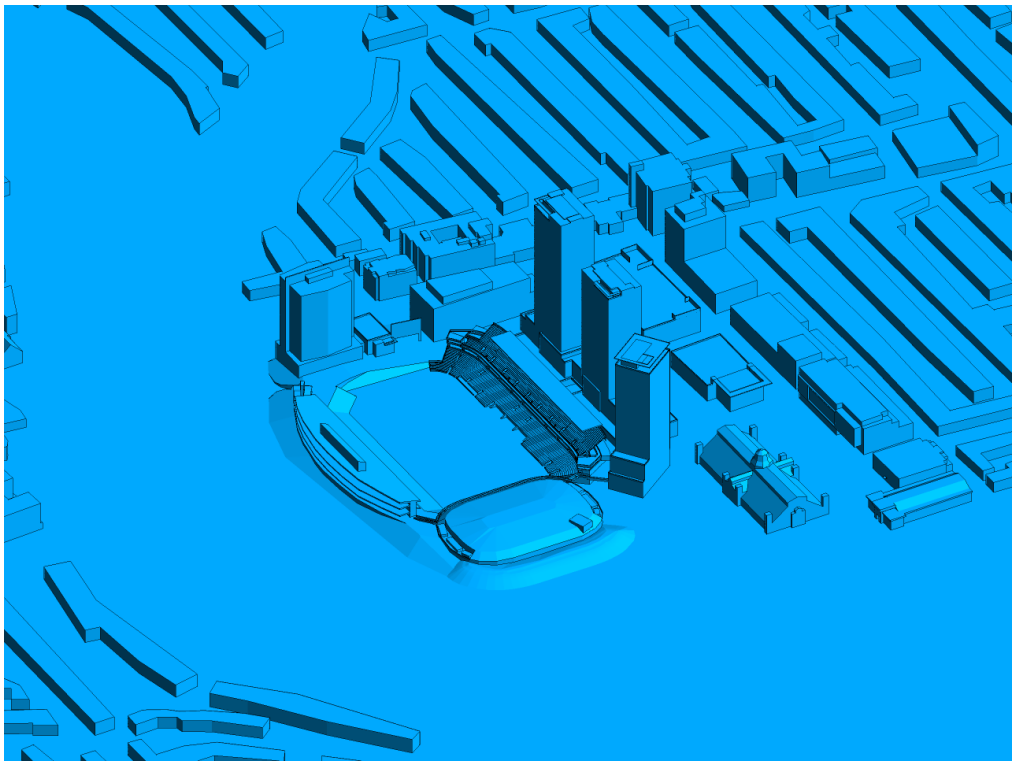


FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING WITH NSS ROOF, EAST VIEW

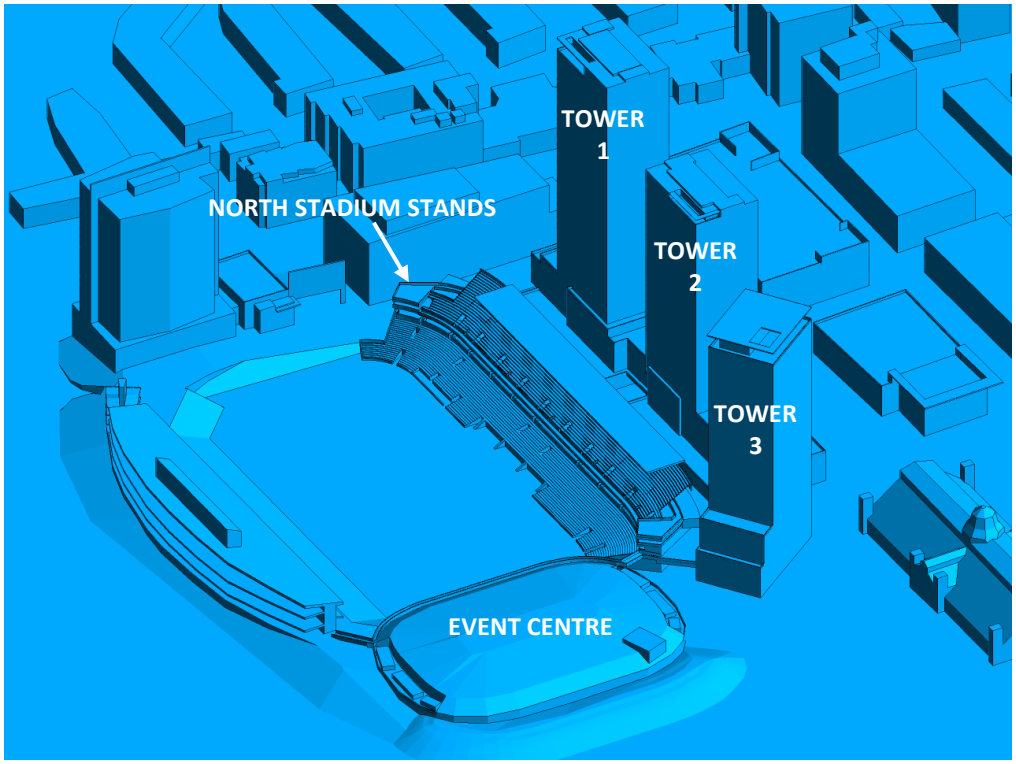


FIGURE 2B: CLOSE UP OF FIGURE 2A

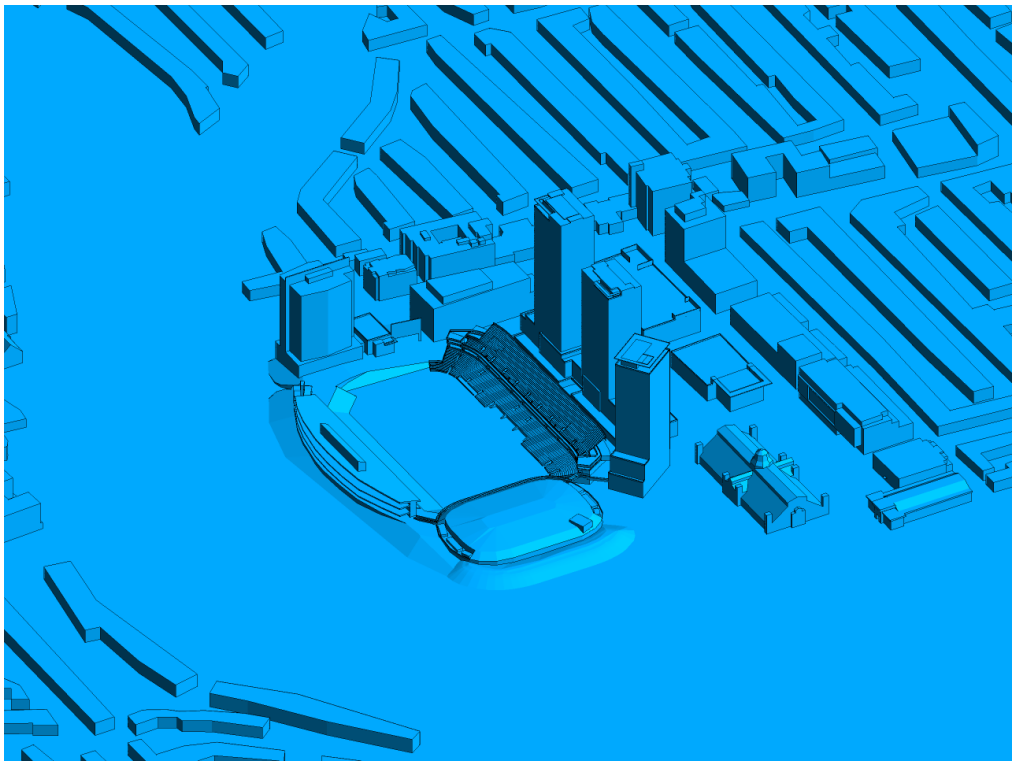


FIGURE 2C: COMPUTATIONAL MODEL, PROPOSED MASSING WITHOUT NSS ROOF, EAST VIEW

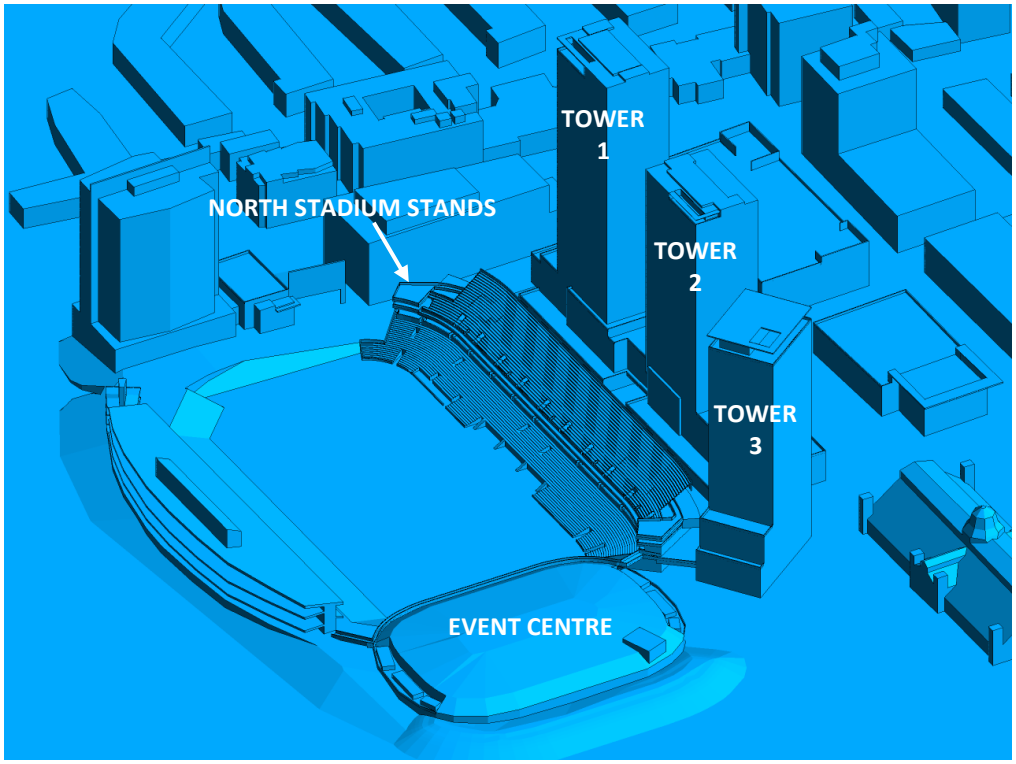


FIGURE 2D: CLOSE UP OF FIGURE 2C

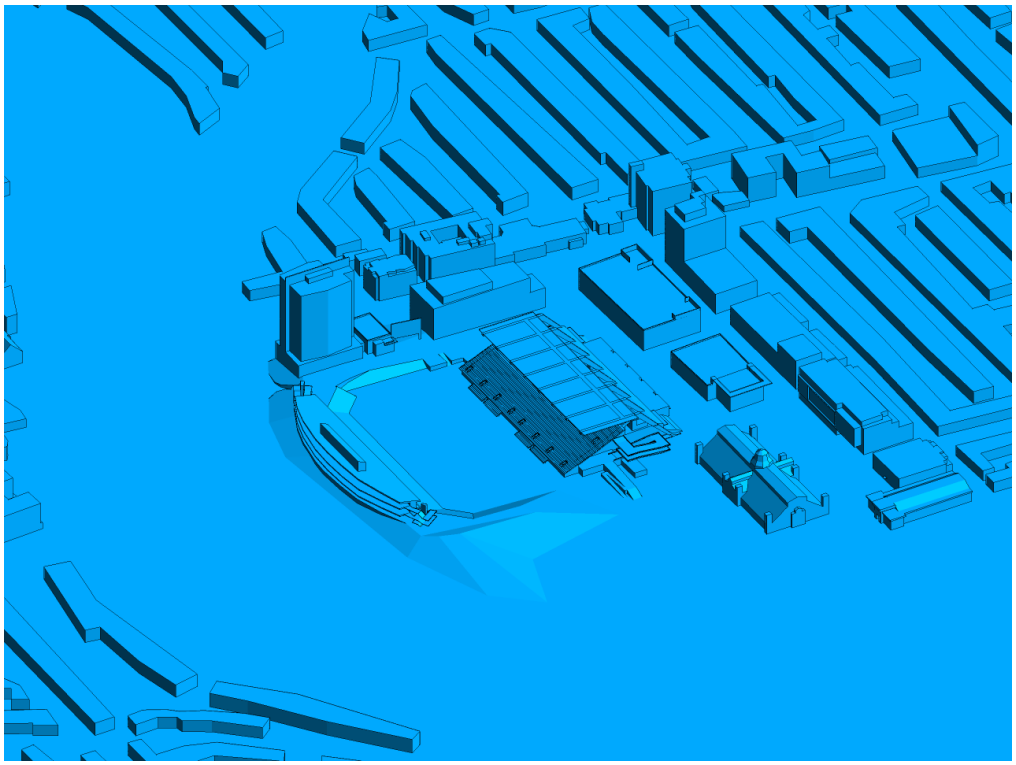


FIGURE 2E: COMPUTATIONAL MODEL, EXISTING MASSING, EAST VIEW

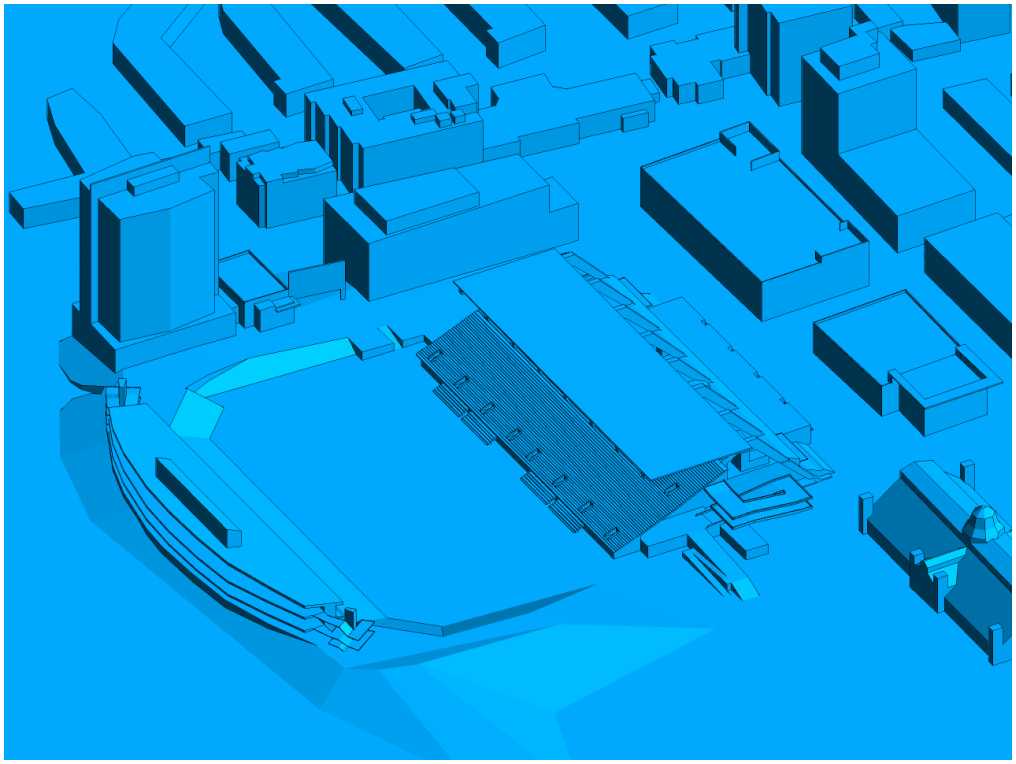


FIGURE 2F: CLOSE UP OF FIGURE 2E

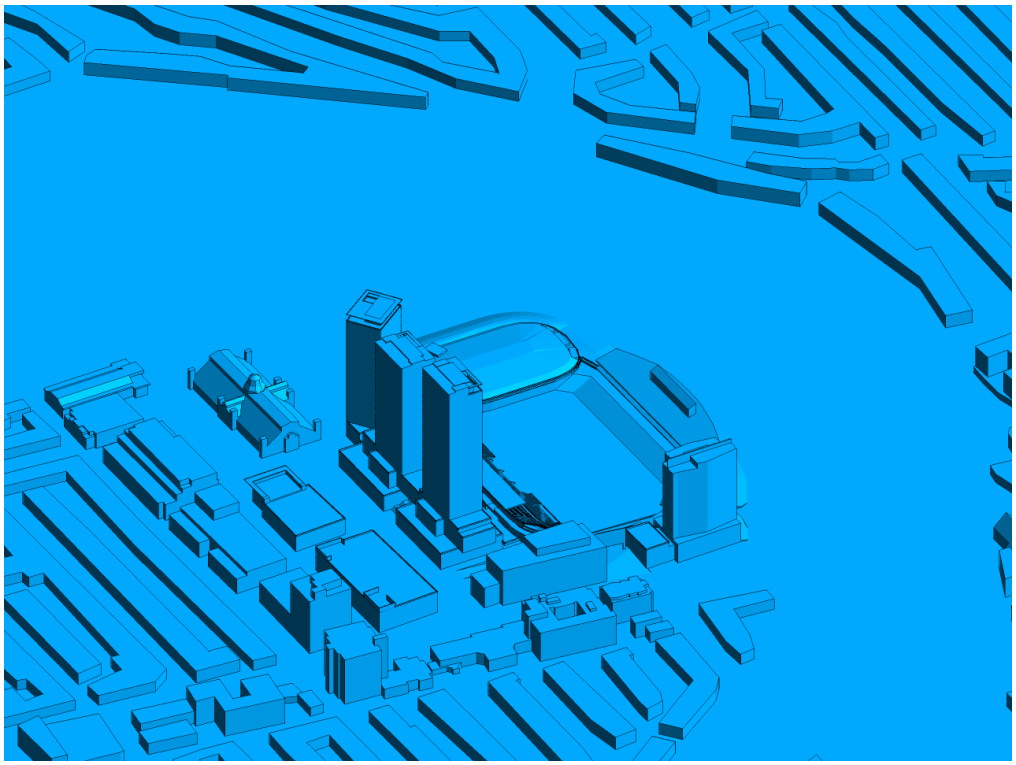


FIGURE 2G: COMPUTATIONAL MODEL, PROPOSED MASSING WITH NSS ROOF, WEST VIEW

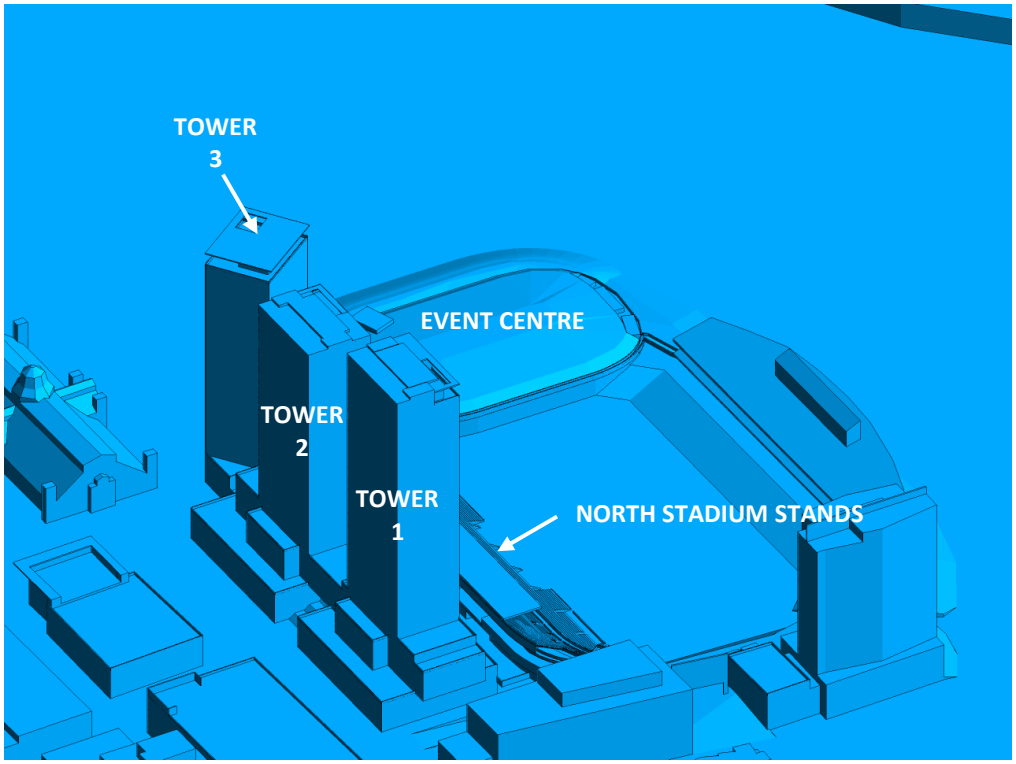


FIGURE 2H: CLOSE UP OF FIGURE 2G

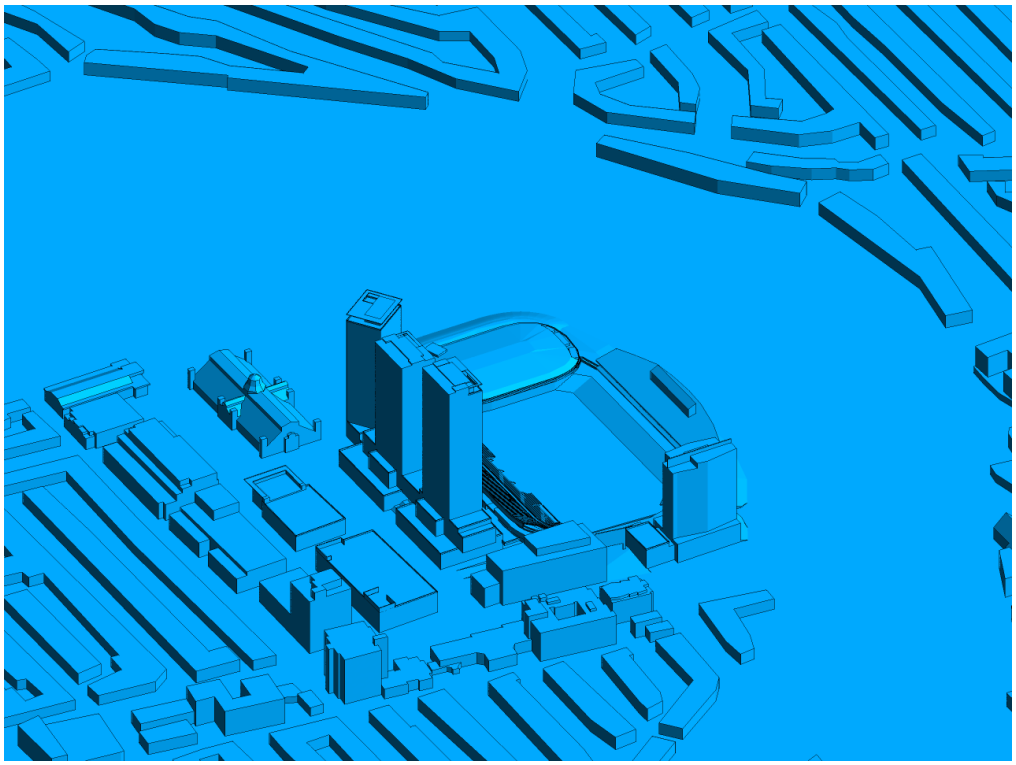


FIGURE 2I: COMPUTATIONAL MODEL, PROPOSED MASSING WITHOUT NSS ROOF, WEST VIEW

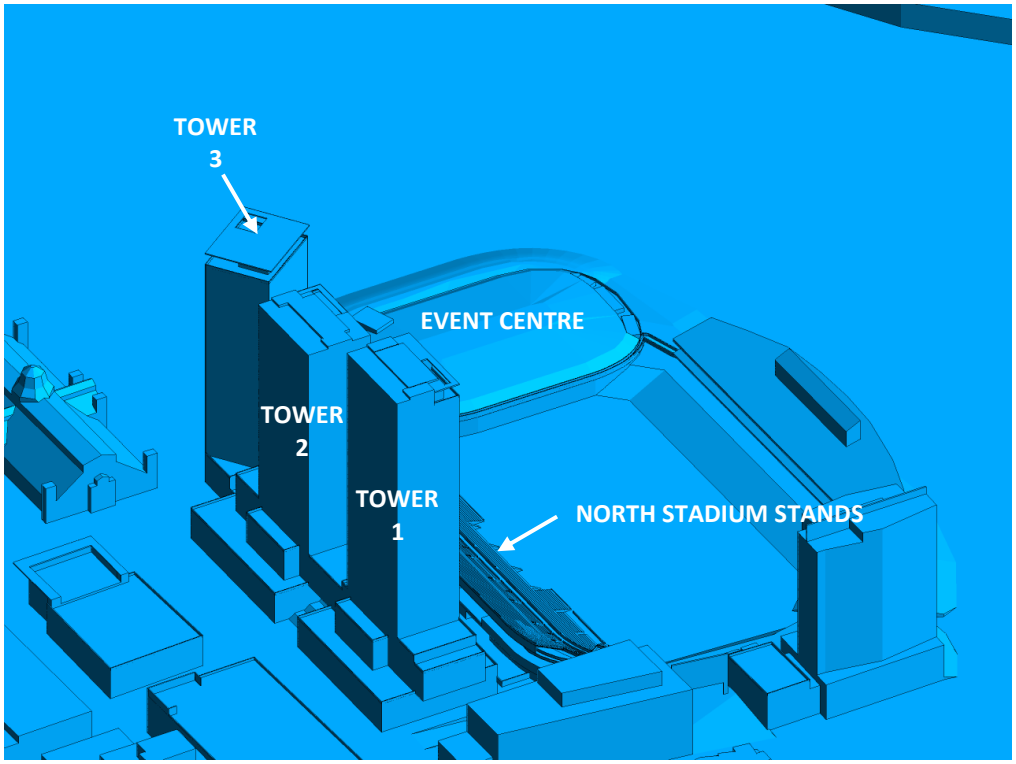


FIGURE 2J: CLOSE UP OF FIGURE 2I

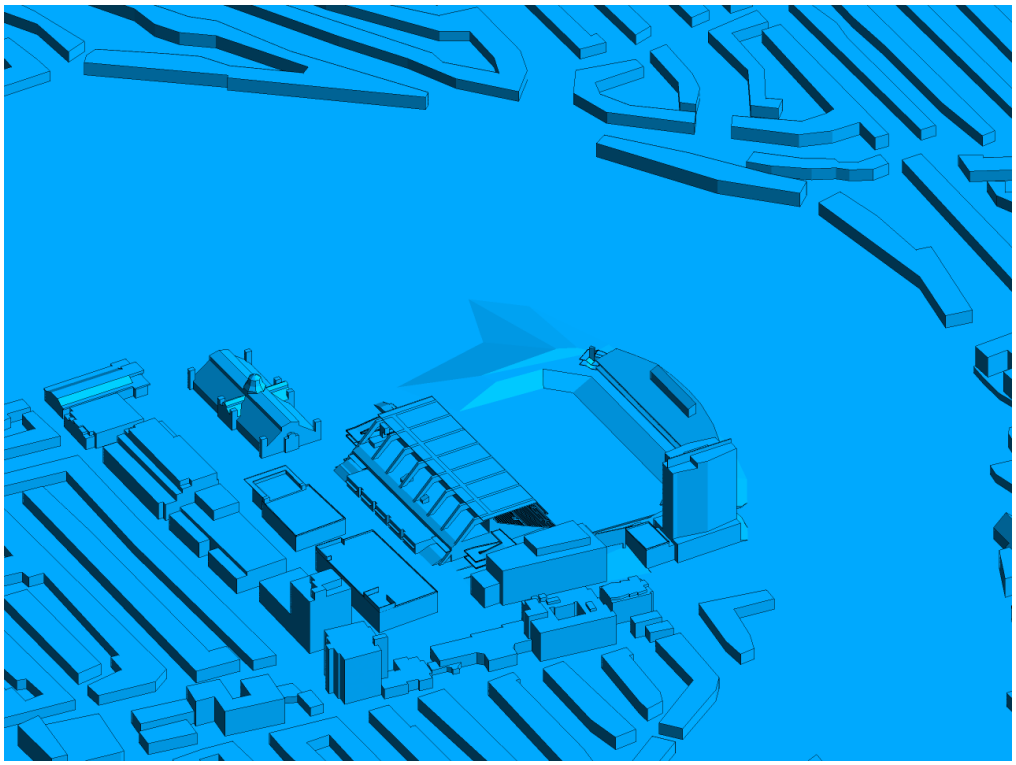


FIGURE 2K: COMPUTATIONAL MODEL, EXISTING MASSING, WEST PERSPECTIVE

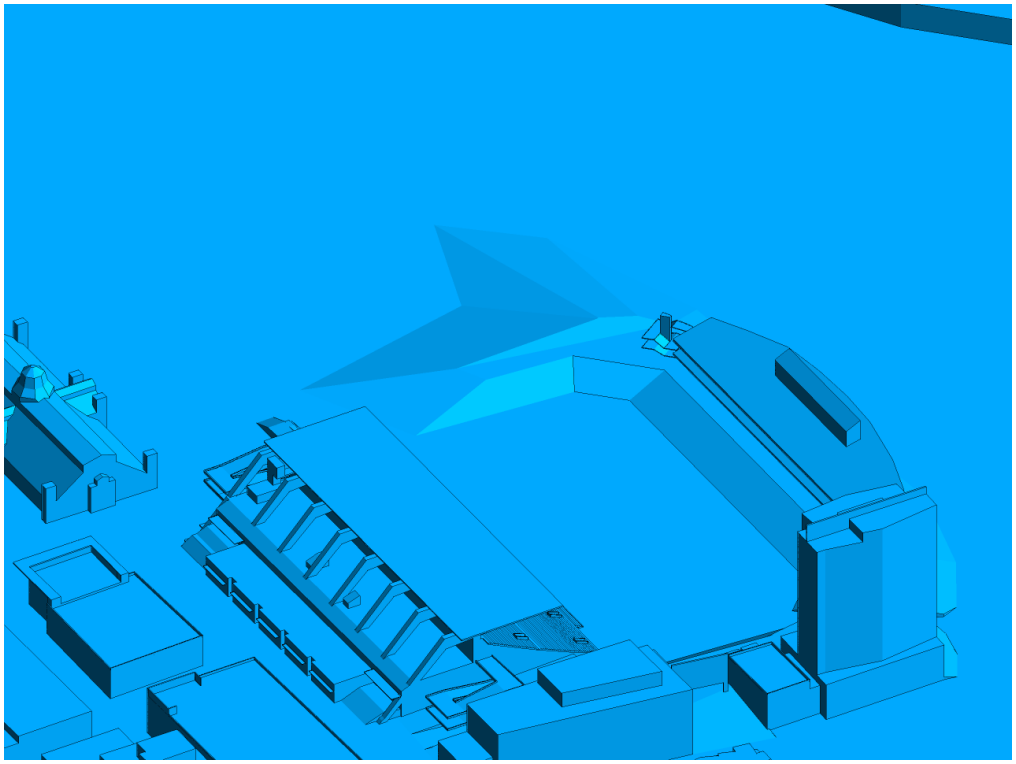


FIGURE 2L: CLOSE UP OF FIGURE 2K

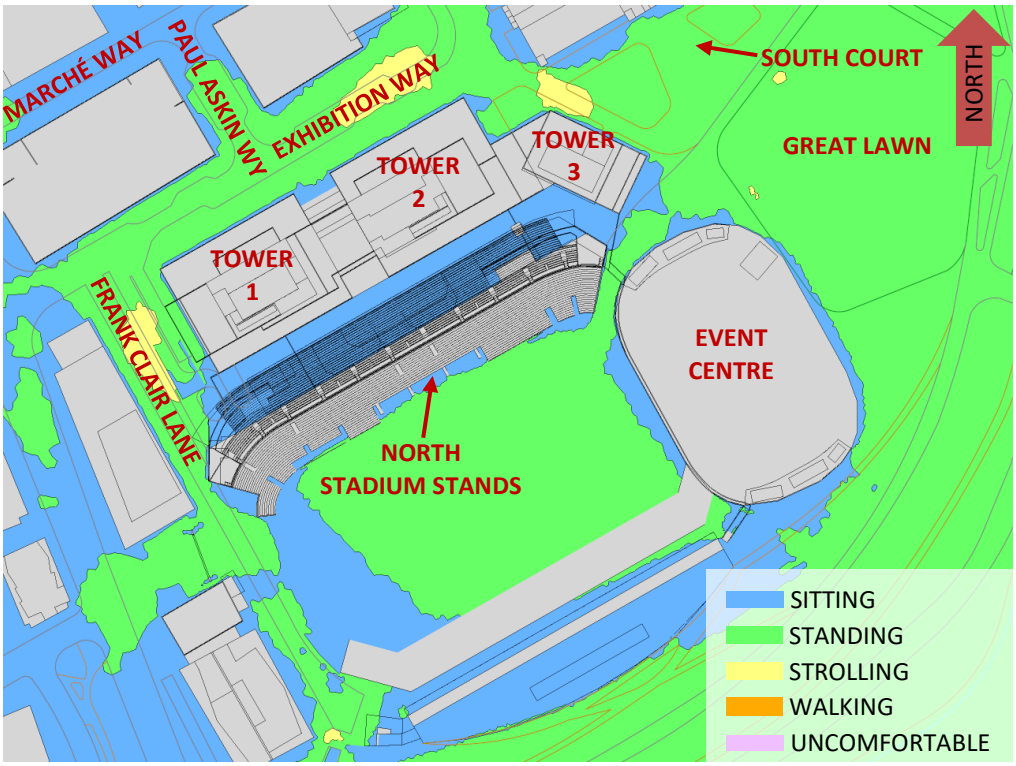


FIGURE 3A: SPRING – WIND COMFORT, TD PLACE – PROPOSED WITH NSS ROOF

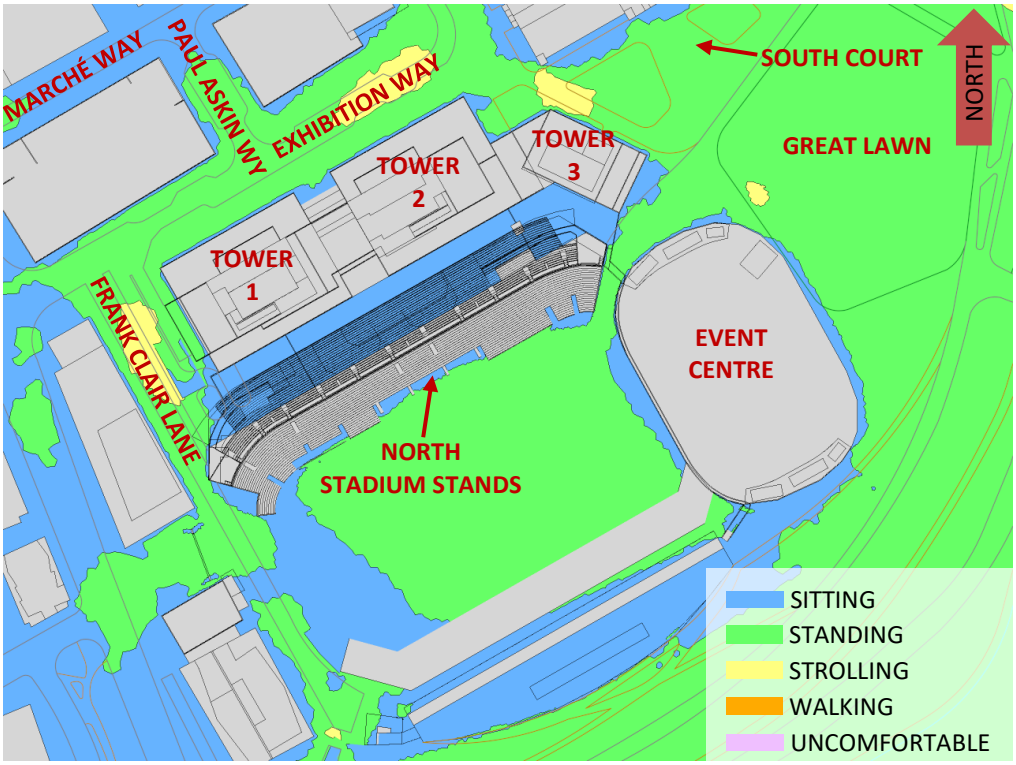


FIGURE 3B: SPRING – WIND COMFORT, TD PLACE – PROPOSED WITHOUT NSS ROOF

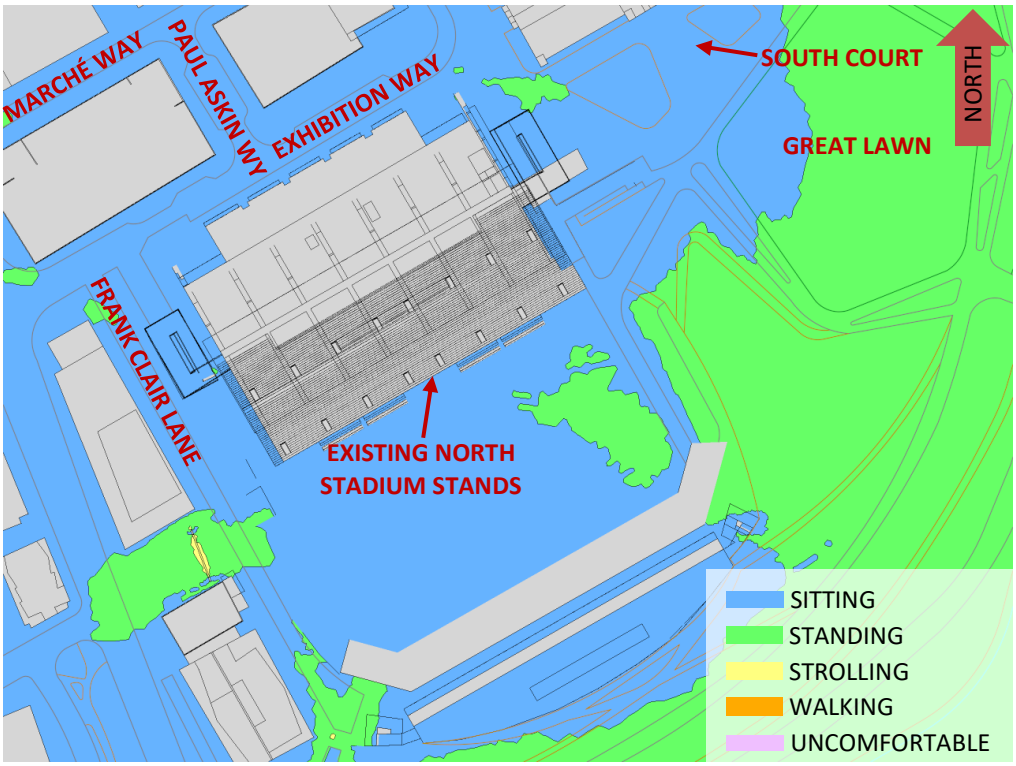


FIGURE 3C: SPRING – WIND COMFORT, TD PLACE – EXISTING

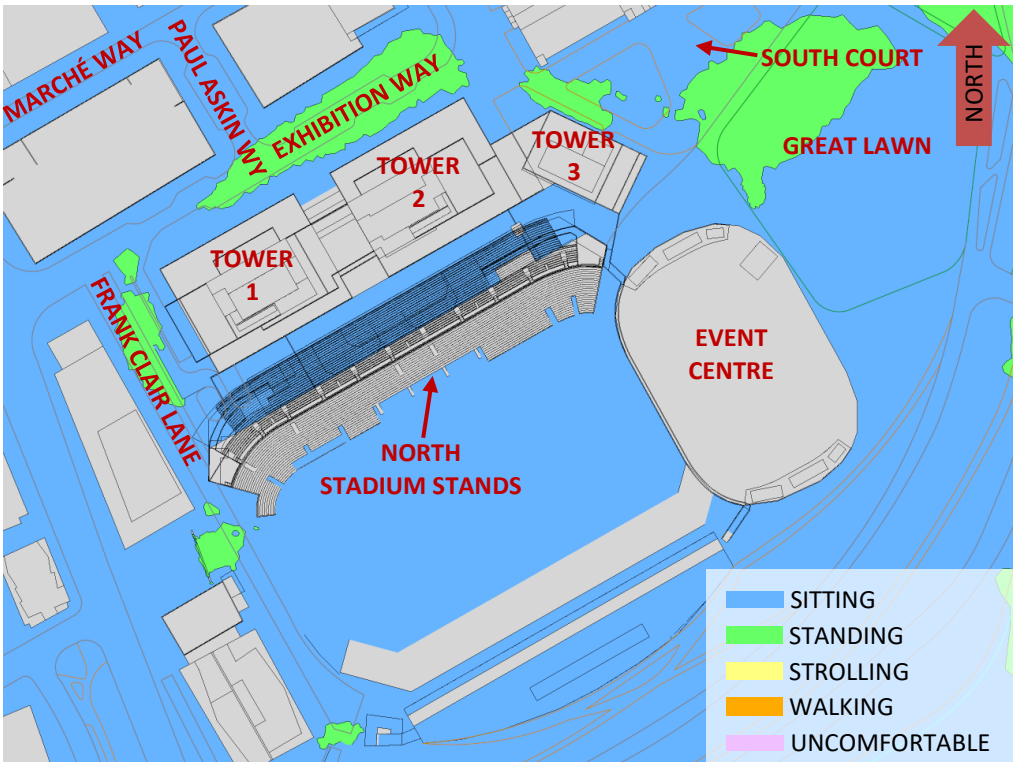


FIGURE 4A: SUMMER – WIND COMFORT, TD PLACE – PROPOSED WITH NSS ROOF

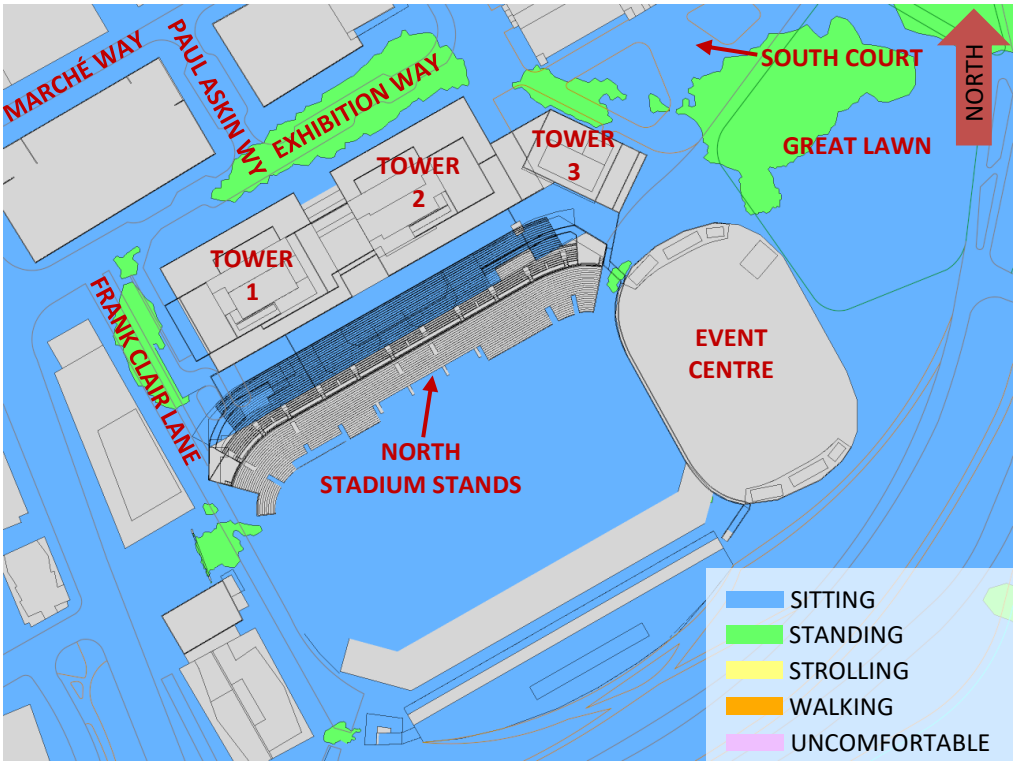


FIGURE 4B: SUMMER – WIND COMFORT, TD PLACE – PROPOSED WITHOUT NSS ROOF

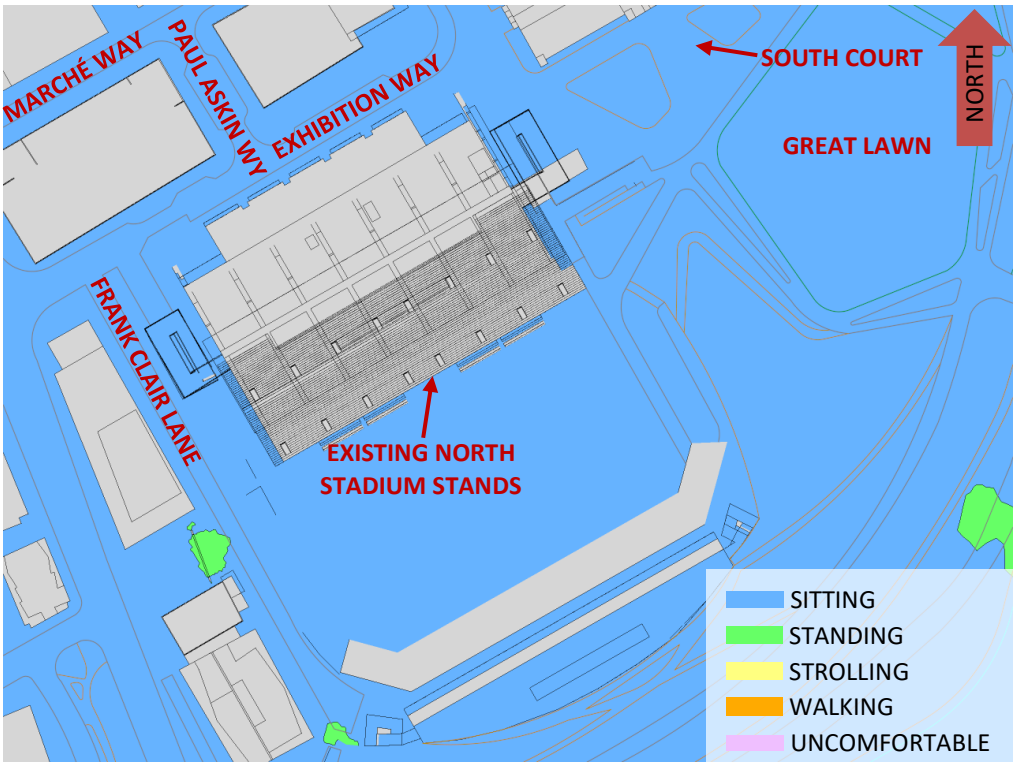


FIGURE 4C: SUMMER – WIND COMFORT, TD PLACE – EXISTING

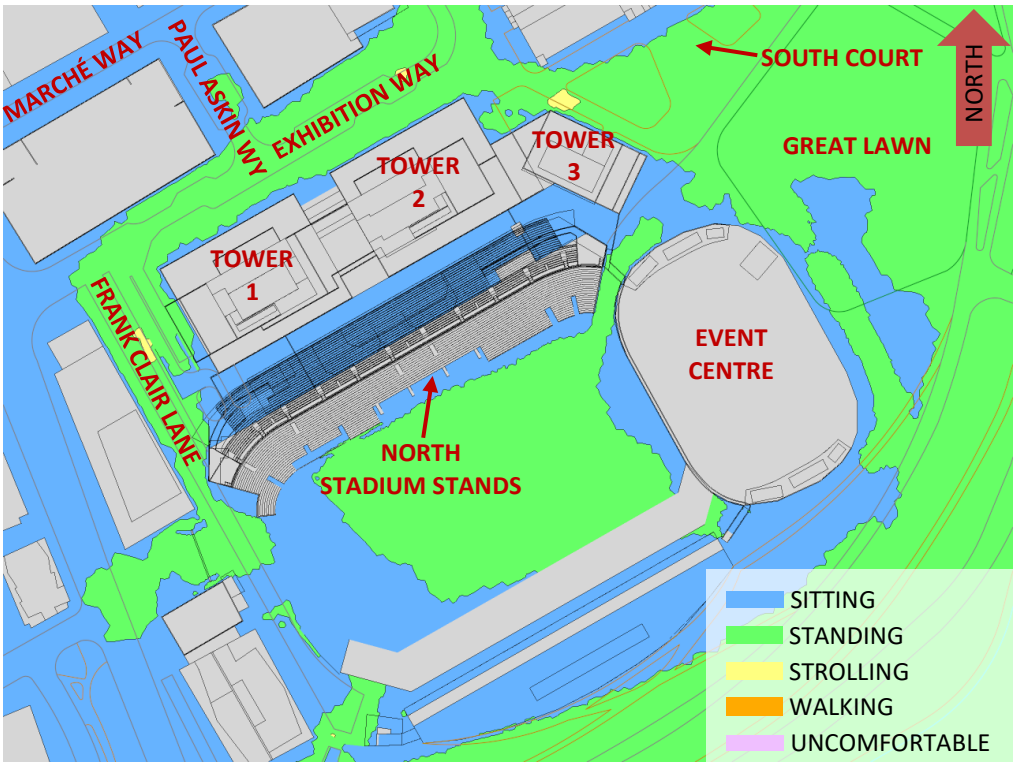


FIGURE 5A: AUTUMN – WIND COMFORT, TD PLACE – PROPOSED WITH NSS ROOF

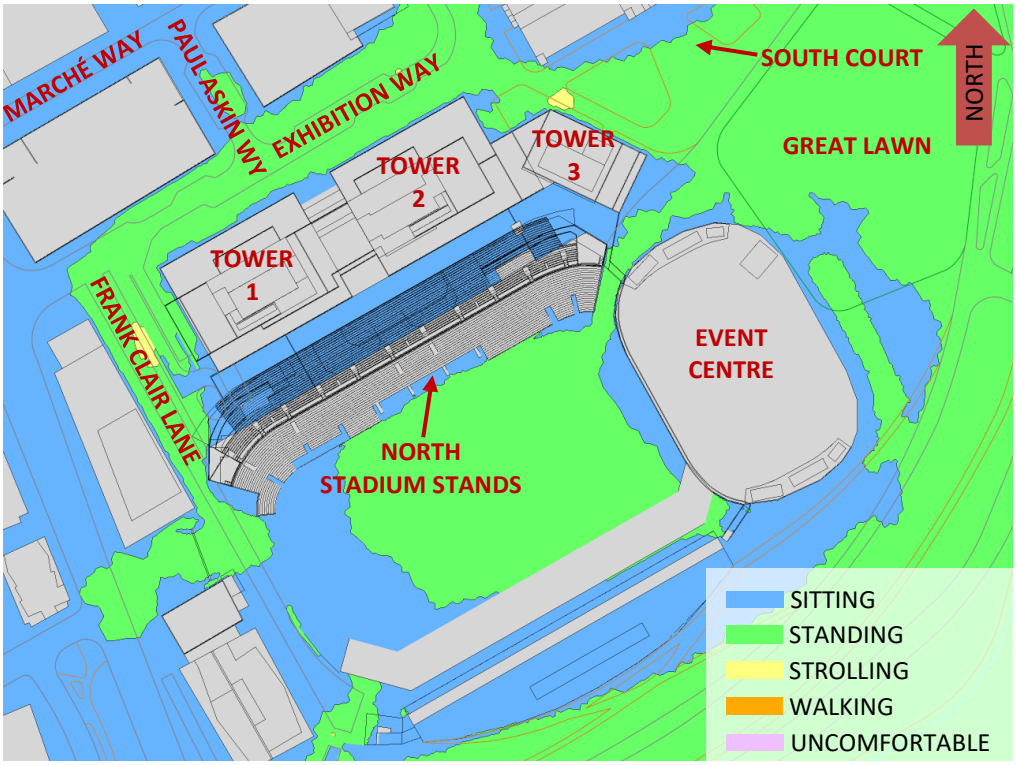


FIGURE 5B: AUTUMN – WIND COMFORT, TD PLACE – PROPOSED WITHOUT NSS ROOF

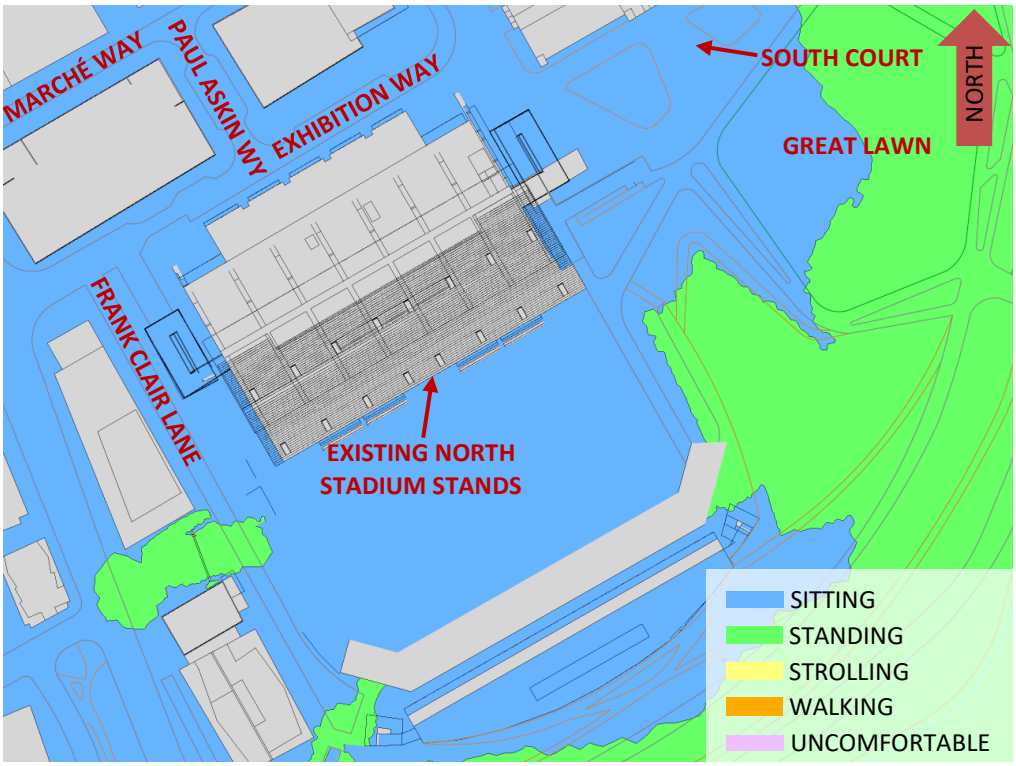


FIGURE 5C: AUTUMN – WIND COMFORT, TD PLACE – EXISTING

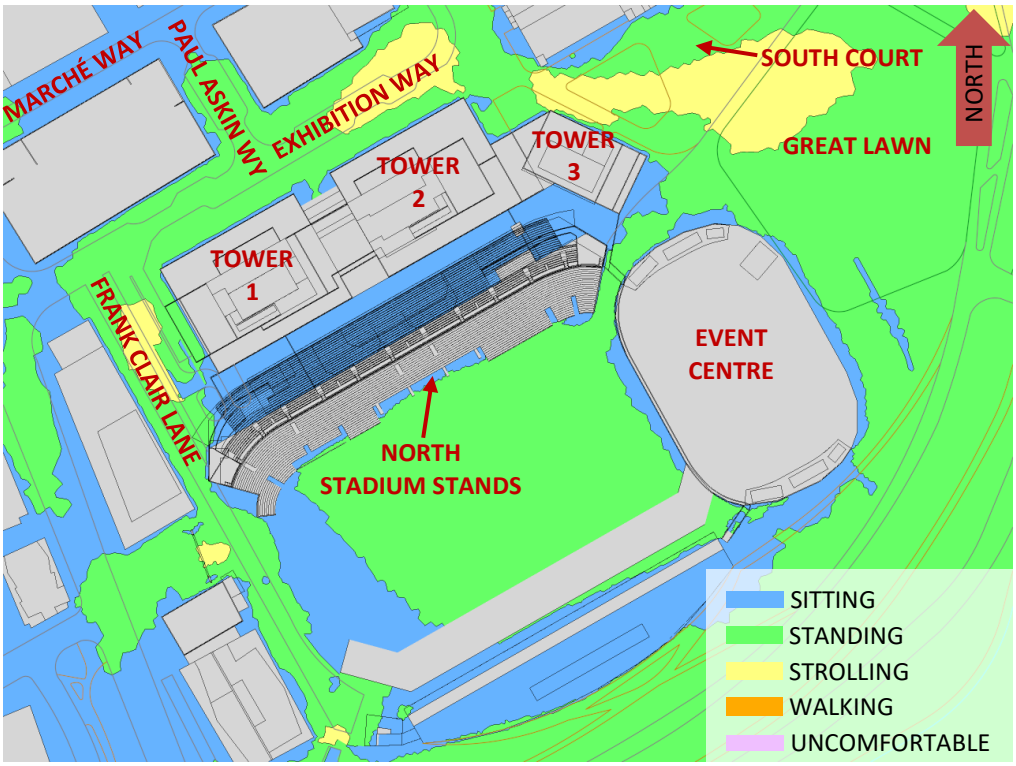


FIGURE 6A: WINTER – WIND COMFORT, TD PLACE – PROPOSED WITH NSS ROOF

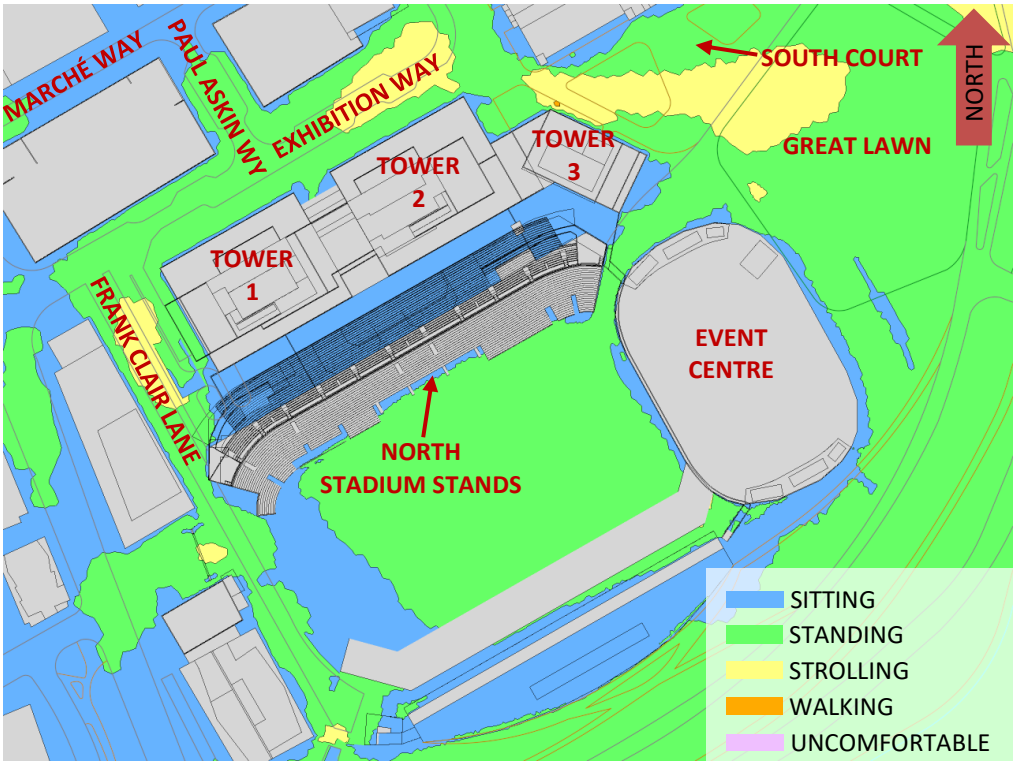


FIGURE 6B: WINTER – WIND COMFORT, TD PLACE – PROPOSED WITHOUT NSS ROOF

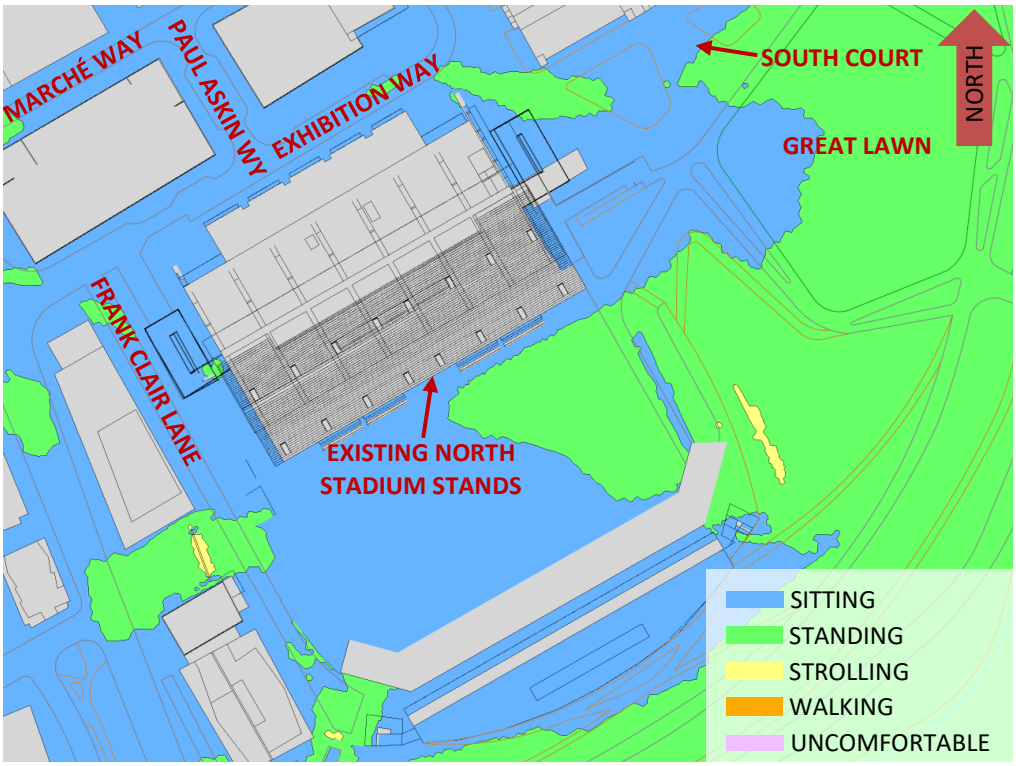


FIGURE 6C: WINTER – WIND COMFORT, TD PLACE – EXISTING

FIGURE 7A: SPRING – WIND COMFORT, ABERDEEN – PROPOSED WITH NSS ROOF

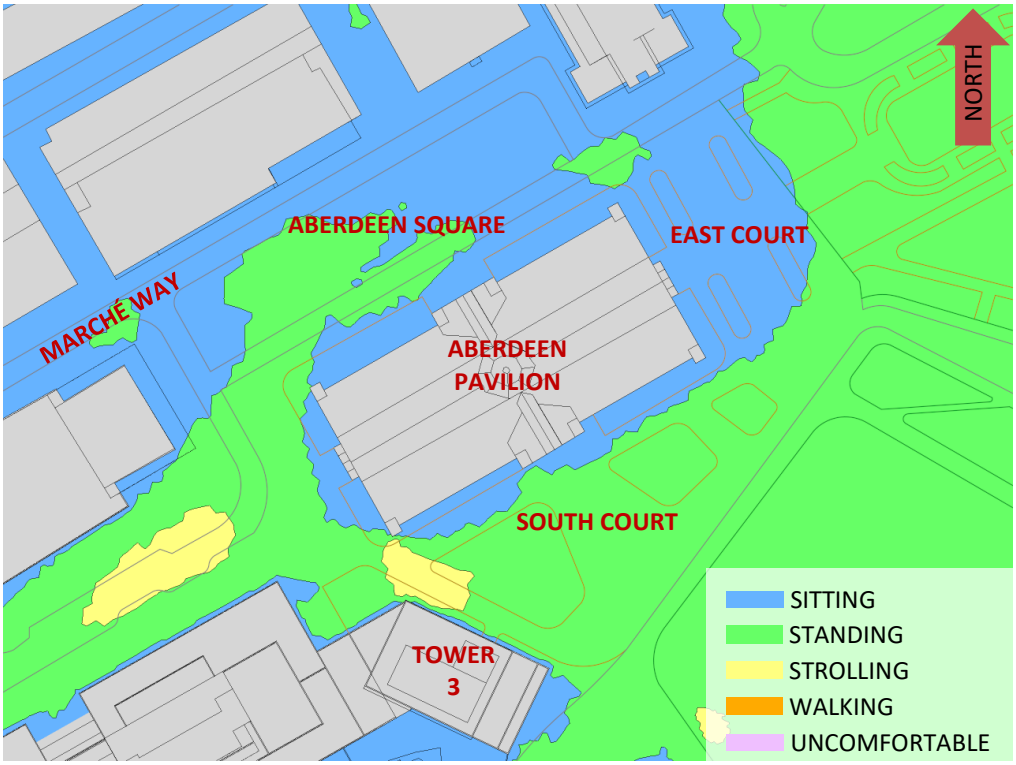


FIGURE 7B: SPRING – WIND COMFORT, ABERDEEN – PROPOSED WITHOUT NSS ROOF

FIGURE 7C: SPRING – WIND COMFORT, ABERDEEN – EXISTING

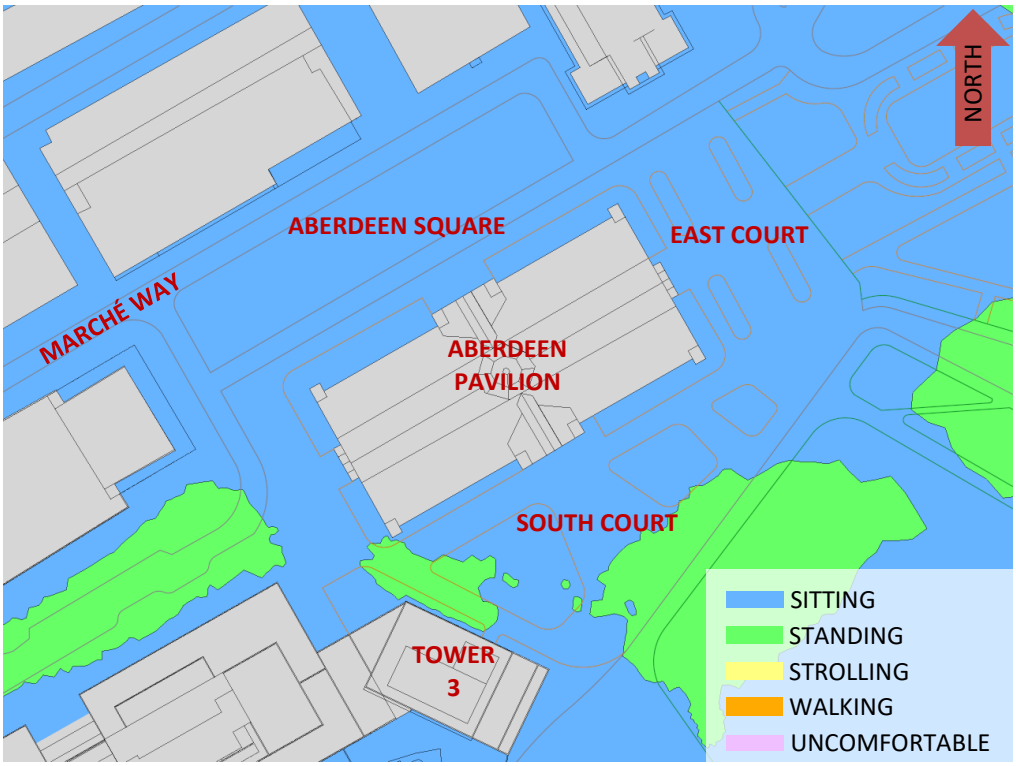


FIGURE 8A: SUMMER – WIND COMFORT, ABERDEEN – PROPOSED WITH NSS ROOF

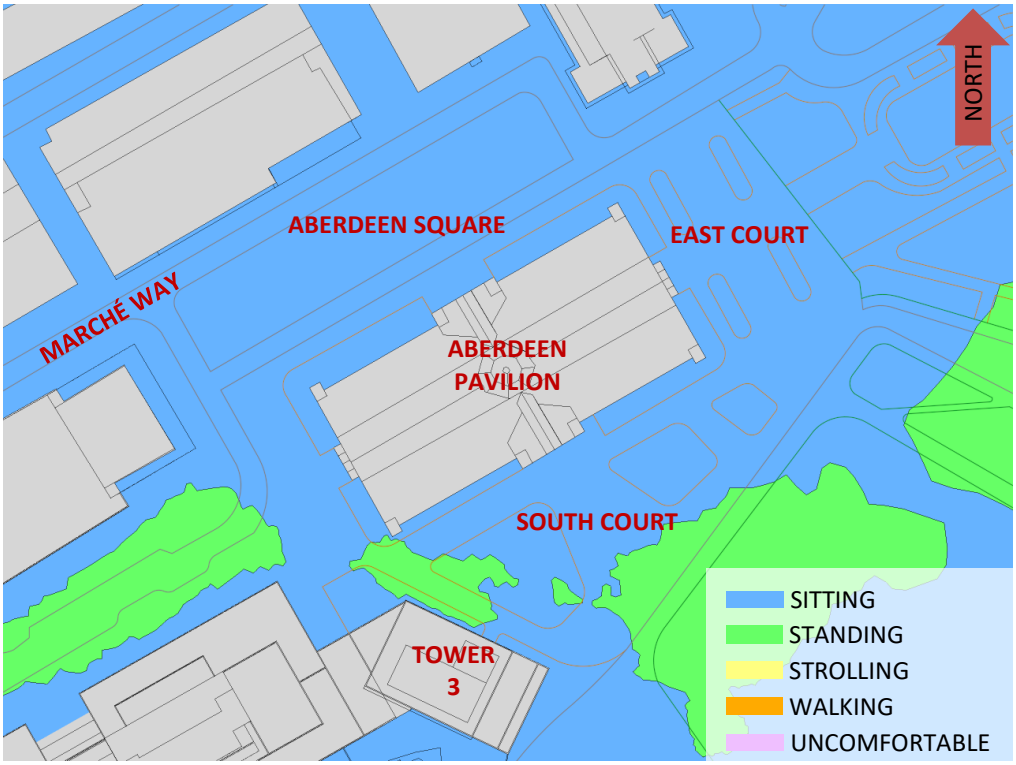


FIGURE 8B: SUMMER – WIND COMFORT, ABERDEEN – PROPOSED WITHOUT NSS ROOF

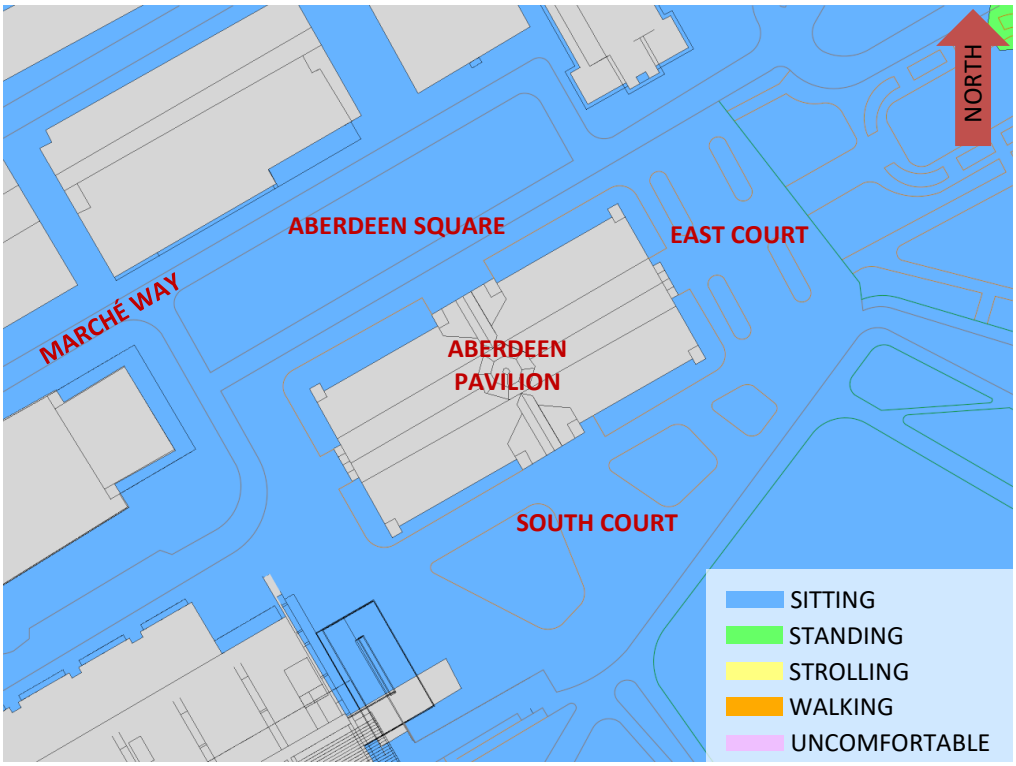


FIGURE 8C: SUMMER – WIND COMFORT, ABERDEEN – EXISTING

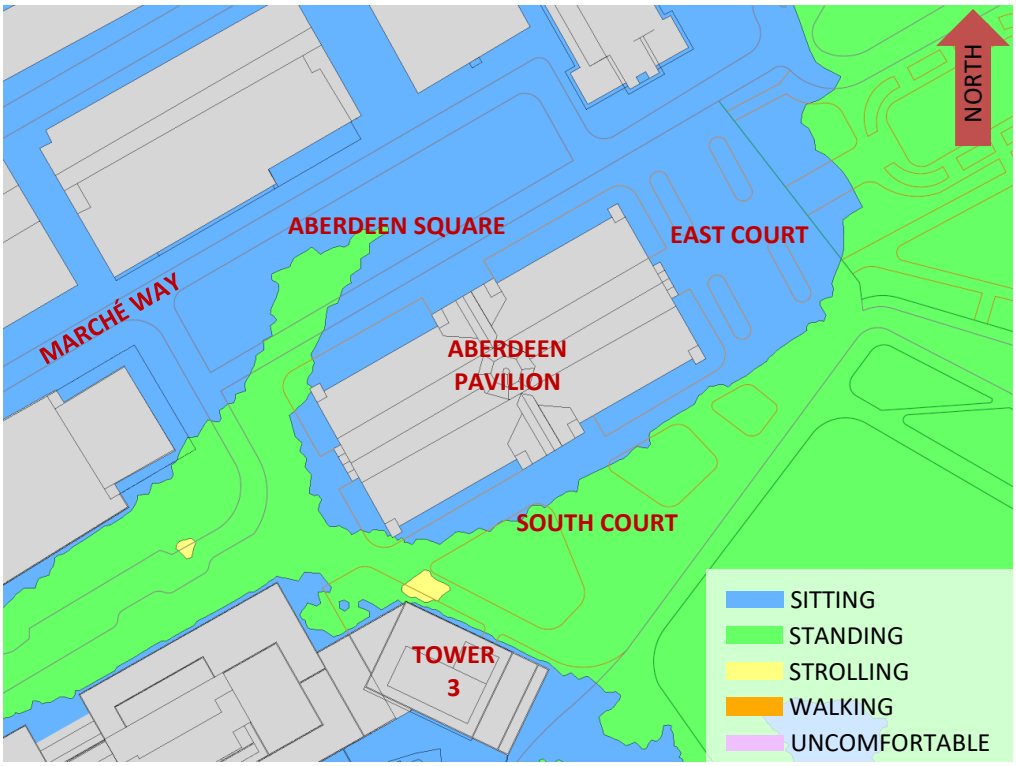


FIGURE 9A: AUTUMN – WIND COMFORT, ABERDEEN – PROPOSED WITH NSS ROOF

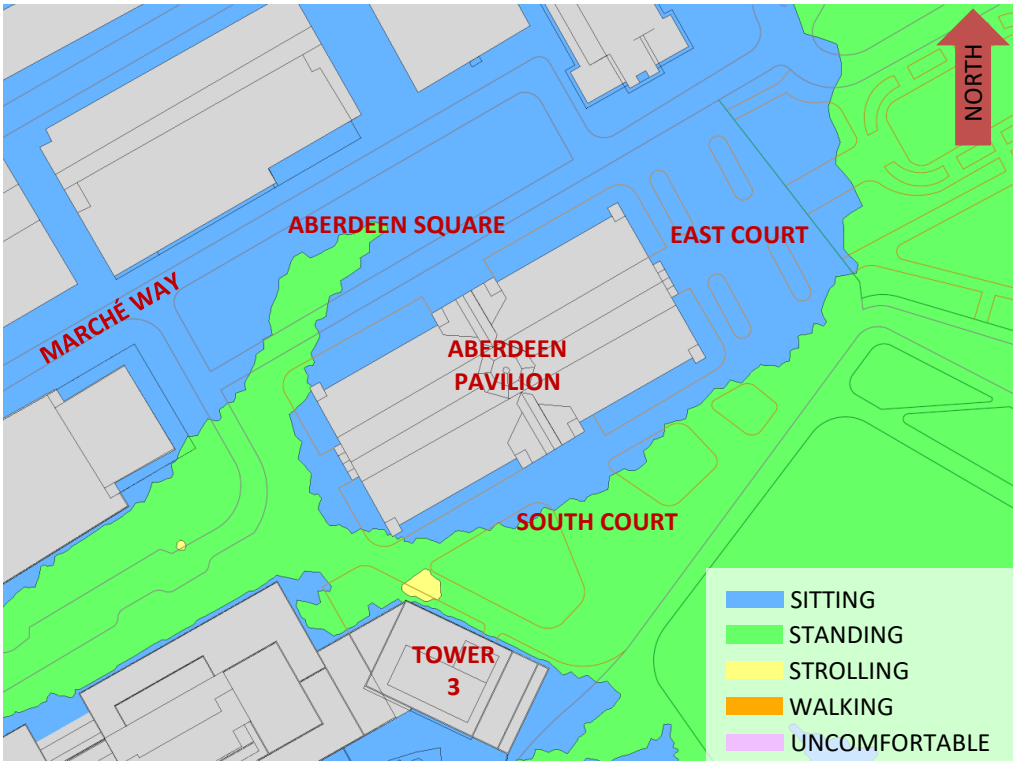


FIGURE 9B: AUTUMN – WIND COMFORT, ABERDEEN – PROPOSED WITHOUT NSS ROOF

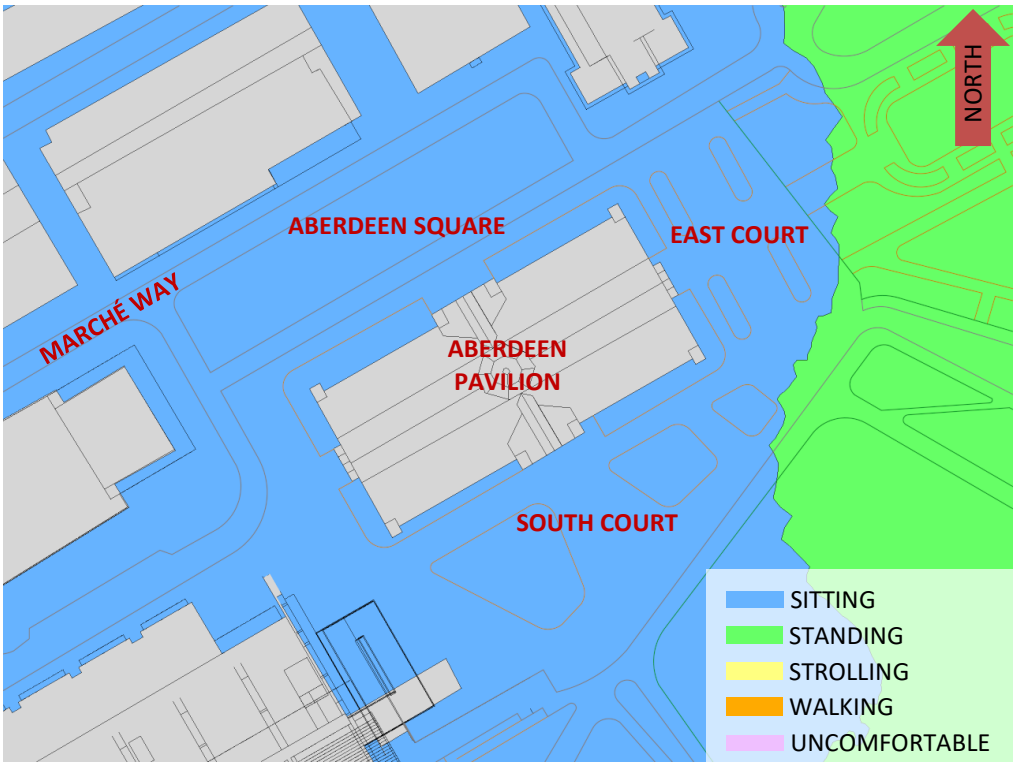


FIGURE 9C: AUTUMN – WIND COMFORT, ABERDEEN – EXISTING

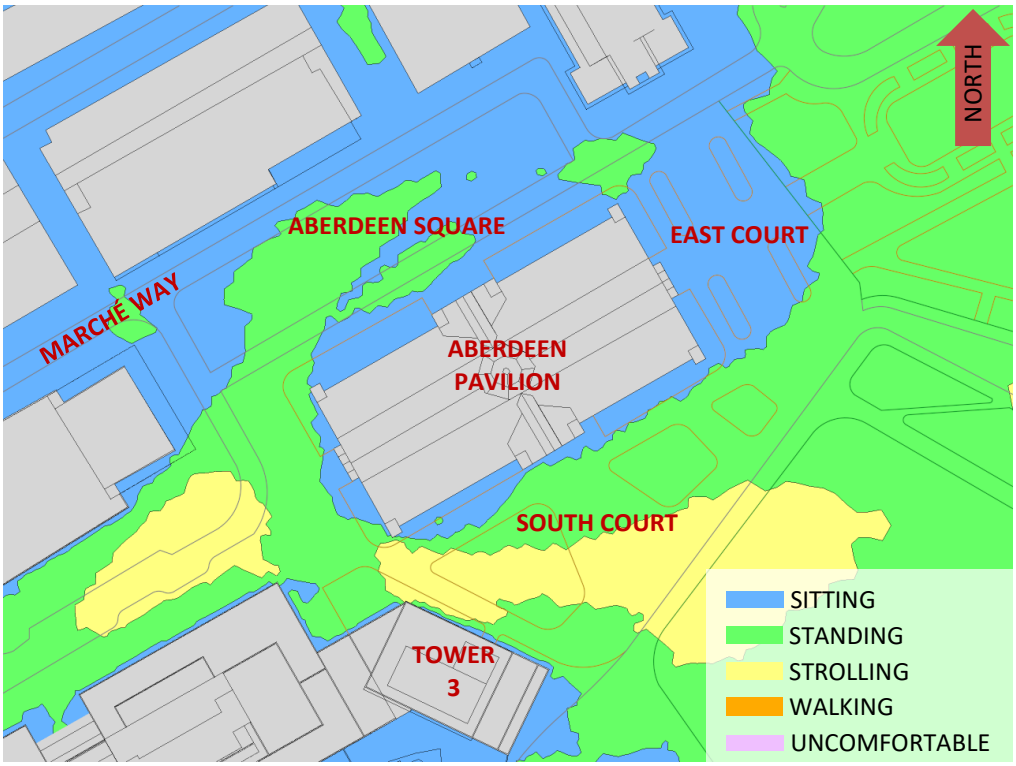


FIGURE 10A: WINTER – WIND COMFORT, ABERDEEN – PROPOSED WITH NSS ROOF

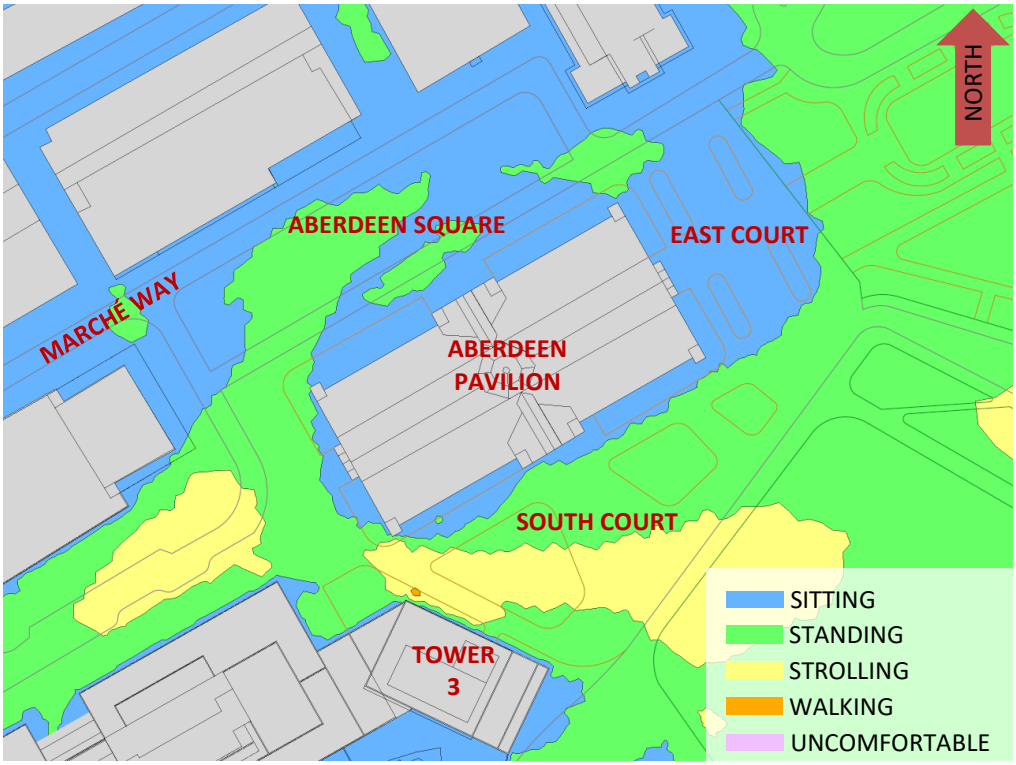


FIGURE 10B: WINTER – WIND COMFORT, ABERDEEN – PROPOSED WITHOUT NSS ROOF

FIGURE 10C: WINTER – WIND COMFORT, ABERDEEN– EXISTING

FIGURE 11A: SPRING – WIND COMFORT, PROMENADE LEVEL WITH NSS ROOF

FIGURE 11B: SPRING – WIND COMFORT, PROMENADE LEVEL WITHOUT NSS ROOF

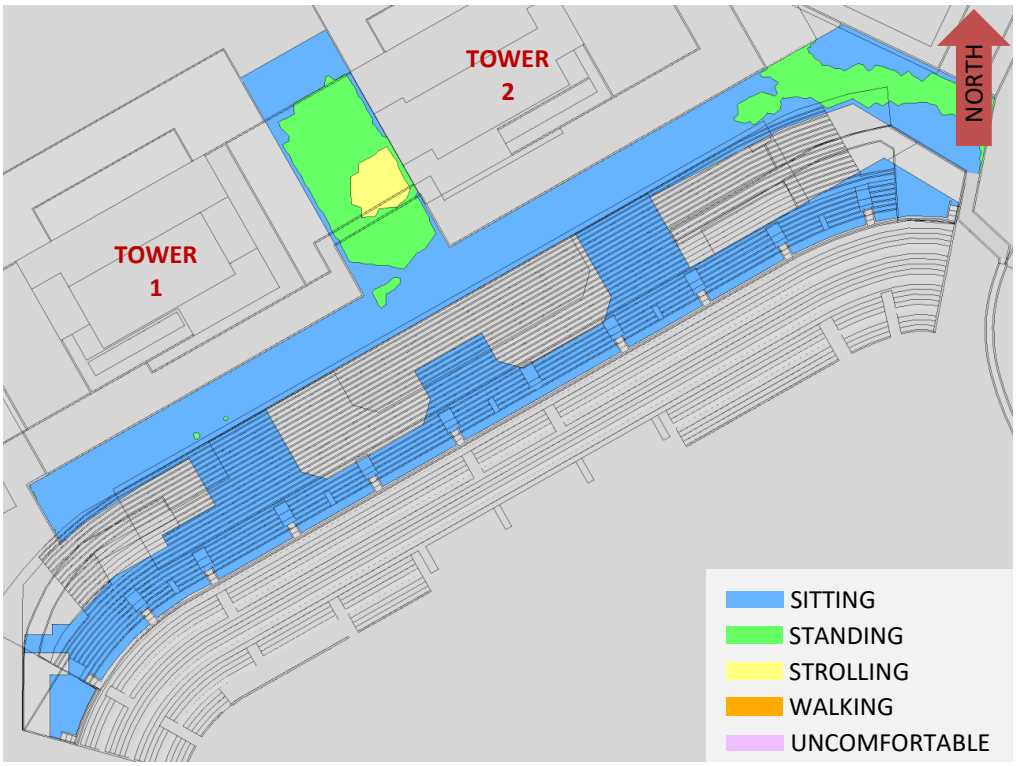


FIGURE 12A: SUMMER – WIND COMFORT, PROMENADE LEVEL WITH NSS ROOF

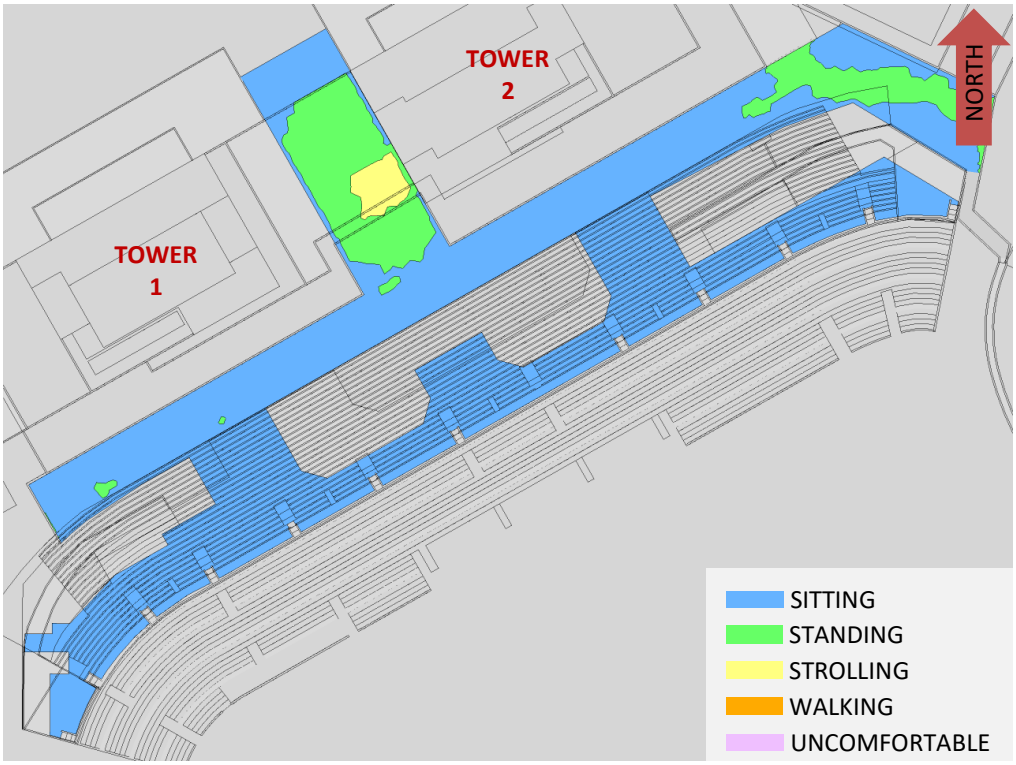


FIGURE 12B: SUMMER – WIND COMFORT, PROMENADE LEVEL WITHOUT NSS ROOF

FIGURE 13A: AUTUMN – WIND COMFORT, PROMENADE LEVEL WITH NSS ROOF

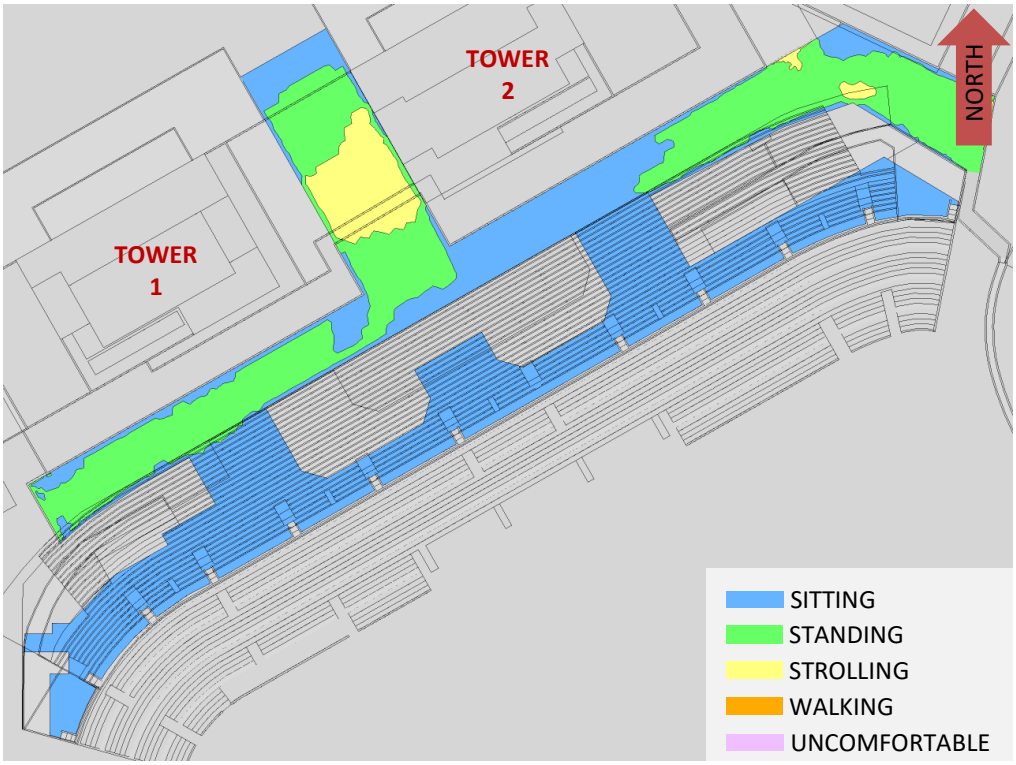


FIGURE 13B: AUTUMN – WIND COMFORT, PROMENADE LEVEL WITHOUT NSS ROOF

FIGURE 14A: WINTER – WIND COMFORT, PROMENADE LEVEL WITH NSS ROOF

FIGURE 14B: WINTER – WIND COMFORT, PROMENADE LEVEL WITHOUT NSS ROOF

FIGURE 15A: SPRING – WIND COMFORT, UPPER CONCOURSE WITH NSS ROOF

FIGURE 15B: SPRING – WIND COMFORT, UPPER CONCOURSE WITHOUT NSS ROOF

FIGURE 16A: SUMMER – WIND COMFORT, UPPER CONCOURSE WITH NSS ROOF

FIGURE 16B: SUMMER – WIND COMFORT, UPPER CONCOURSE WITHOUT NSS ROOF

FIGURE 17A: AUTUMN – WIND COMFORT, UPPER CONCOURSE WITH NSS ROOF

FIGURE 17B: AUTUMN – WIND COMFORT, UPPER CONCOURSE WITHOUT NSS ROOF

FIGURE 18A: WINTER – WIND COMFORT, UPPER CONCOURSE WITH NSS ROOF

FIGURE 18B: WINTER – WIND COMFORT, UPPER CONCOURSE WITHOUT NSS ROOF

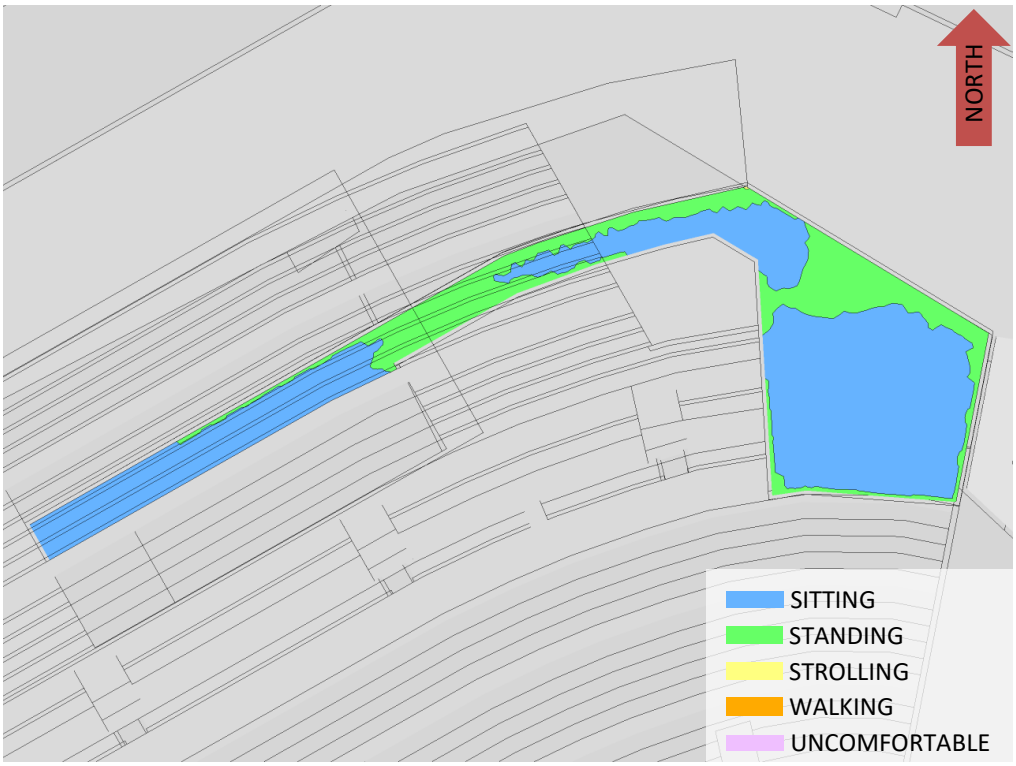


FIGURE 19A: SPRING – WIND COMFORT, UPPER EAST FAN DECK WITH NSS ROOF

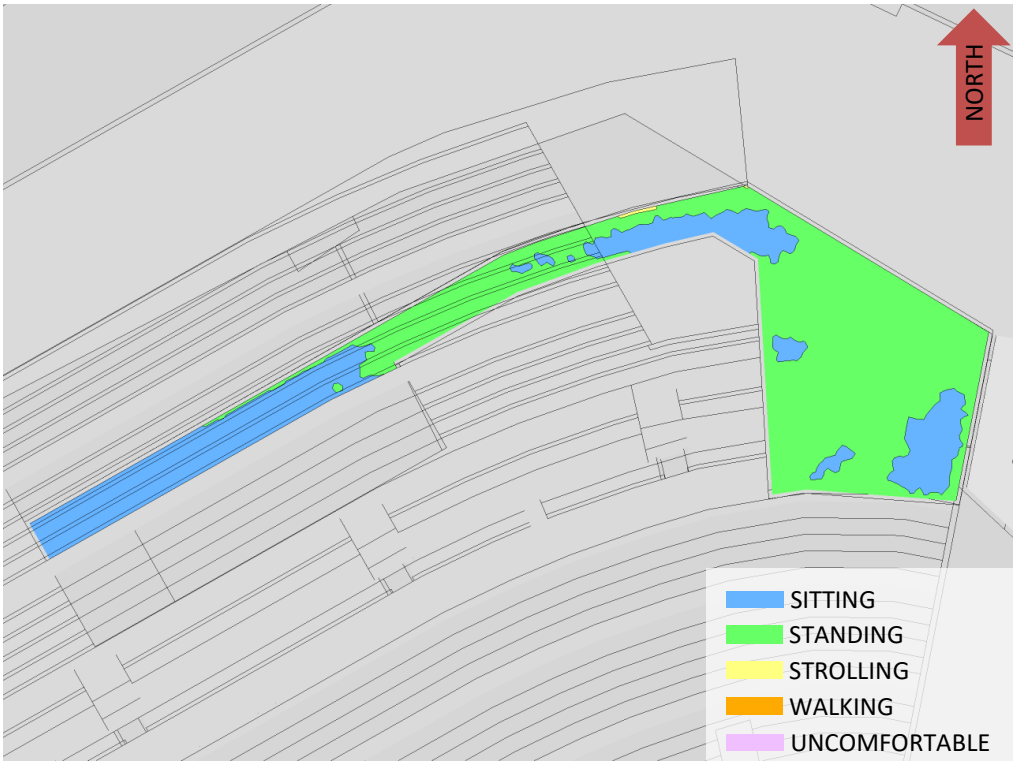


FIGURE 19B: SPRING – WIND COMFORT, UPPER EAST FAN DECK WITHOUT NSS ROOF

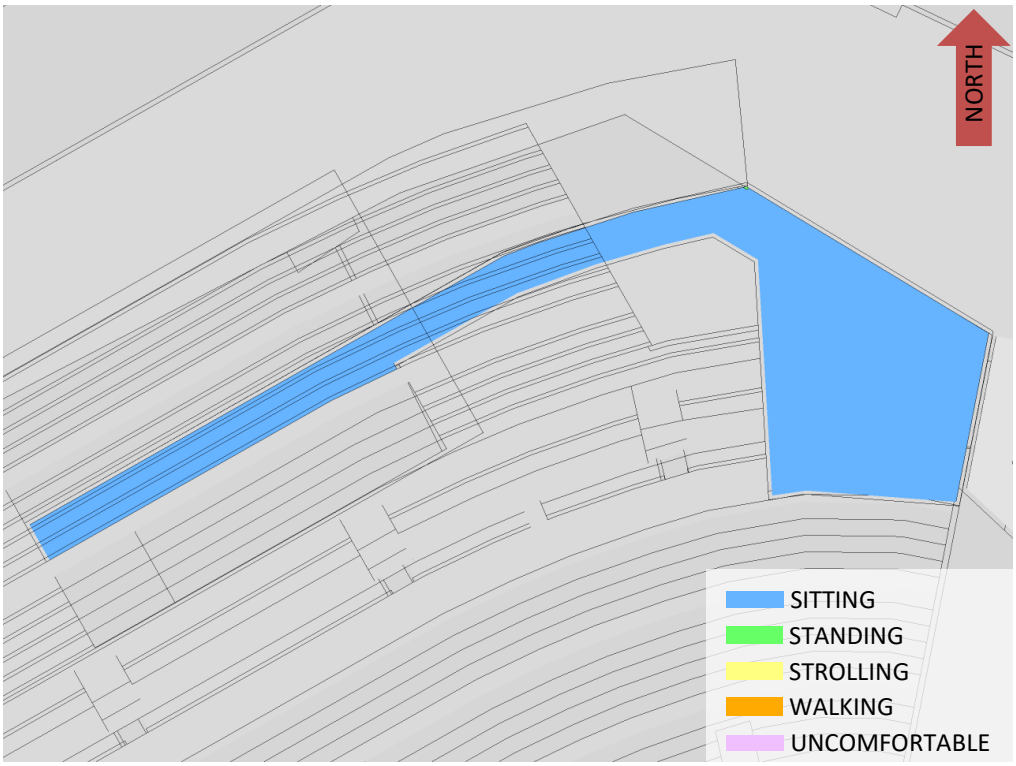


FIGURE 20A: SUMMER – WIND COMFORT, UPPER EAST FAN DECK WITH NSS ROOF

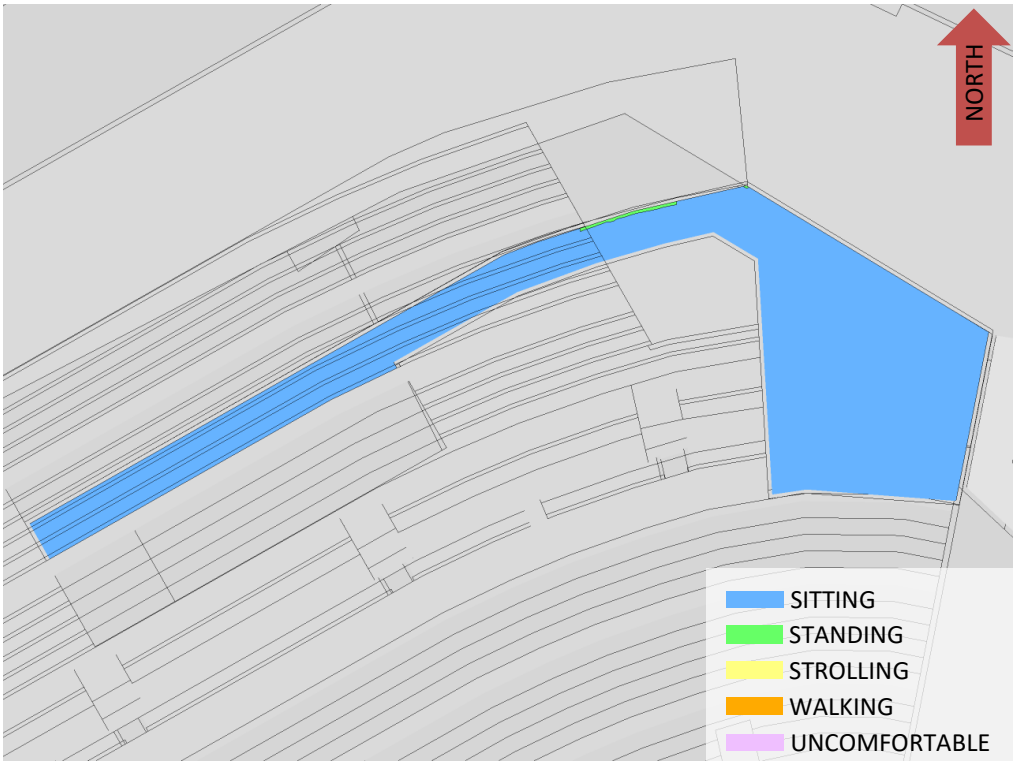


FIGURE 20B: SUMMER – WIND COMFORT, UPPER EAST FAN DECK WITHOUT NSS ROOF

FIGURE 21A: AUTUMN – WIND COMFORT, UPPER EAST FAN DECK WITH NSS ROOF

FIGURE 21B: AUTUMN – WIND COMFORT, UPPER EAST FAN DECK WITHOUT NSS ROOF

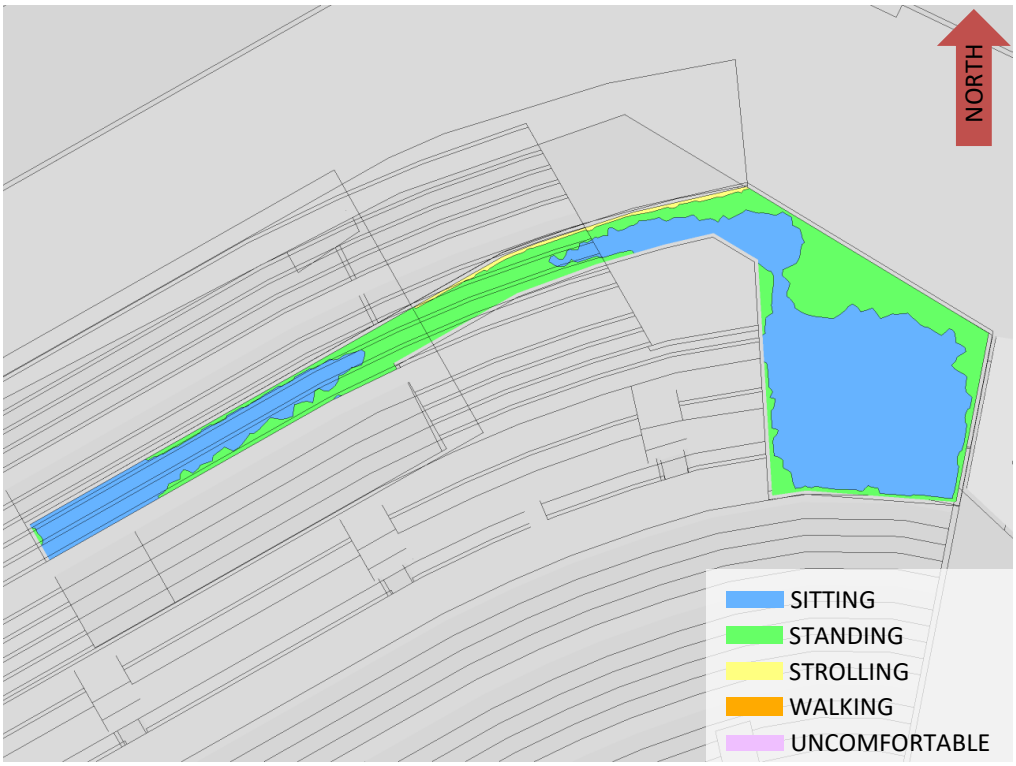


FIGURE 22A: WINTER – WIND COMFORT, UPPER EAST FAN DECK WITH NSS ROOF

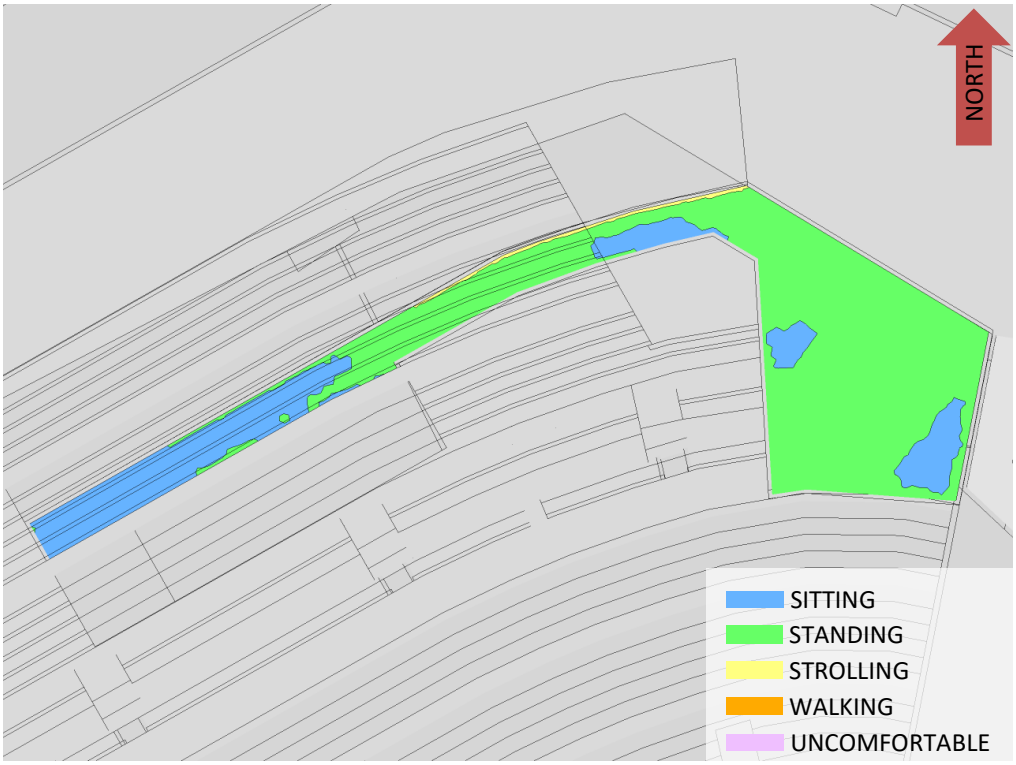


FIGURE 22B: WINTER – WIND COMFORT, UPPER EAST FAN DECK WITHOUT NSS ROOF

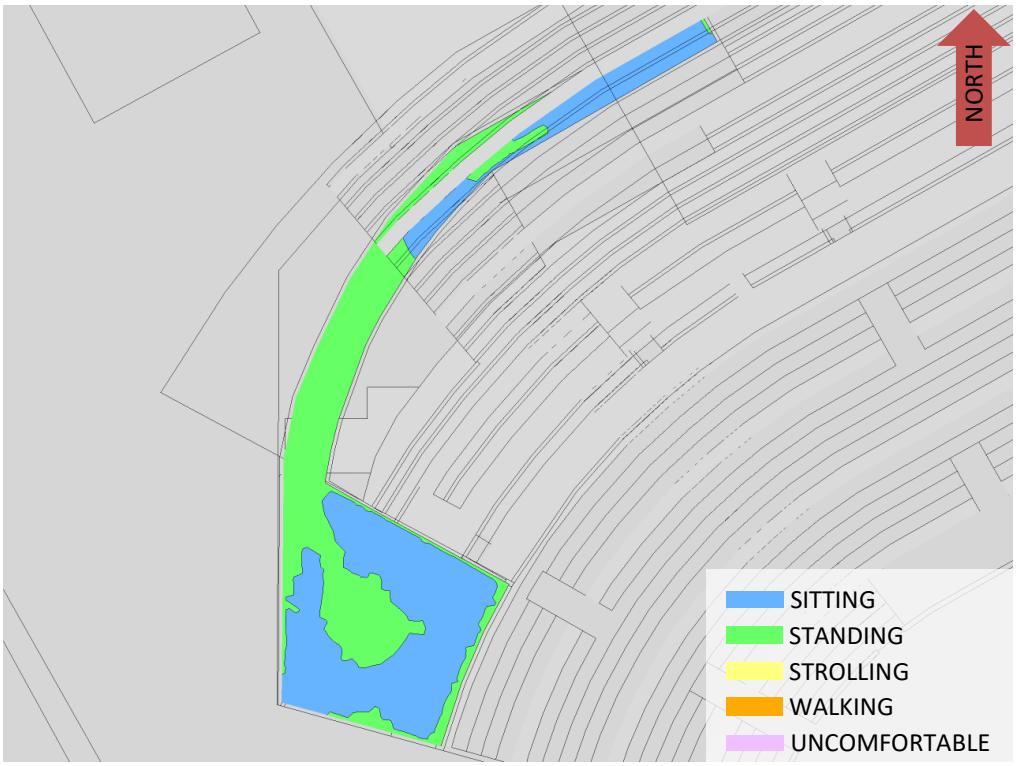


FIGURE 23A: SPRING – WIND COMFORT, UPPER WEST FAN DECK WITH NSS ROOF

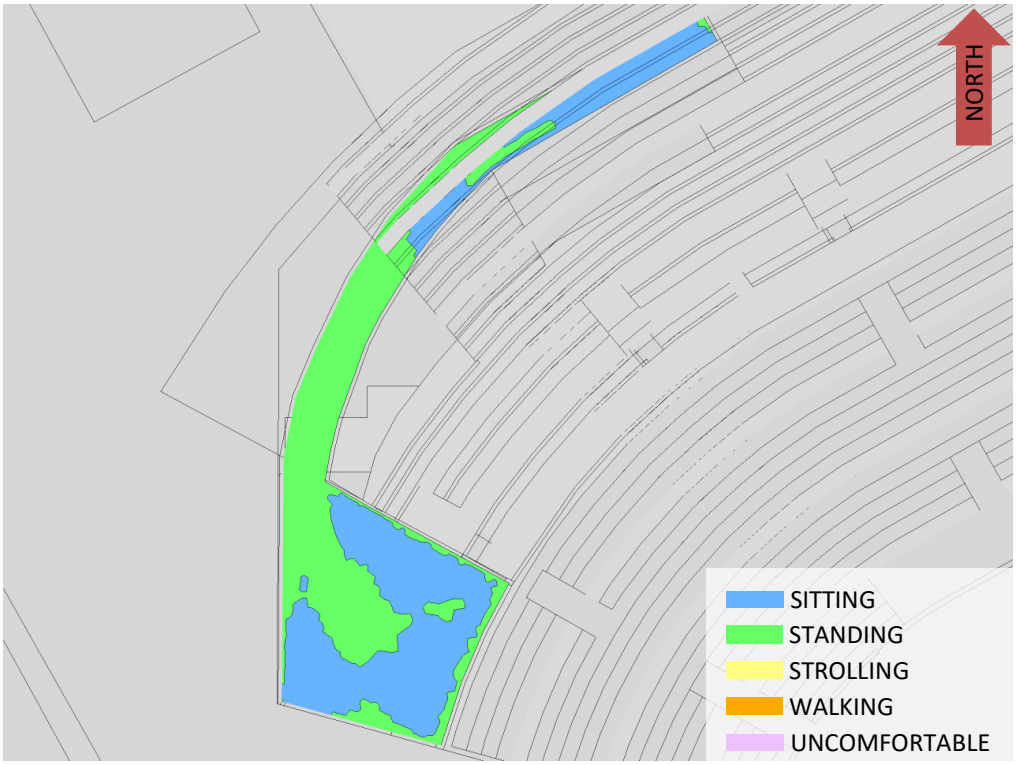


FIGURE 23B: SPRING – WIND COMFORT, UPPER WEST FAN DECK WITHOUT NSS ROOF

FIGURE 24A: SUMMER – WIND COMFORT, UPPER WEST FAN DECK WITH NSS ROOF

FIGURE 24B: SUMMER – WIND COMFORT, UPPER WEST FAN DECK WITHOUT NSS ROOF

FIGURE 25A: AUTUMN – WIND COMFORT, UPPER WEST FAN DECK WITH NSS ROOF

FIGURE 25B: AUTUMN – WIND COMFORT, UPPER WEST FAN DECK WITHOUT NSS ROOF

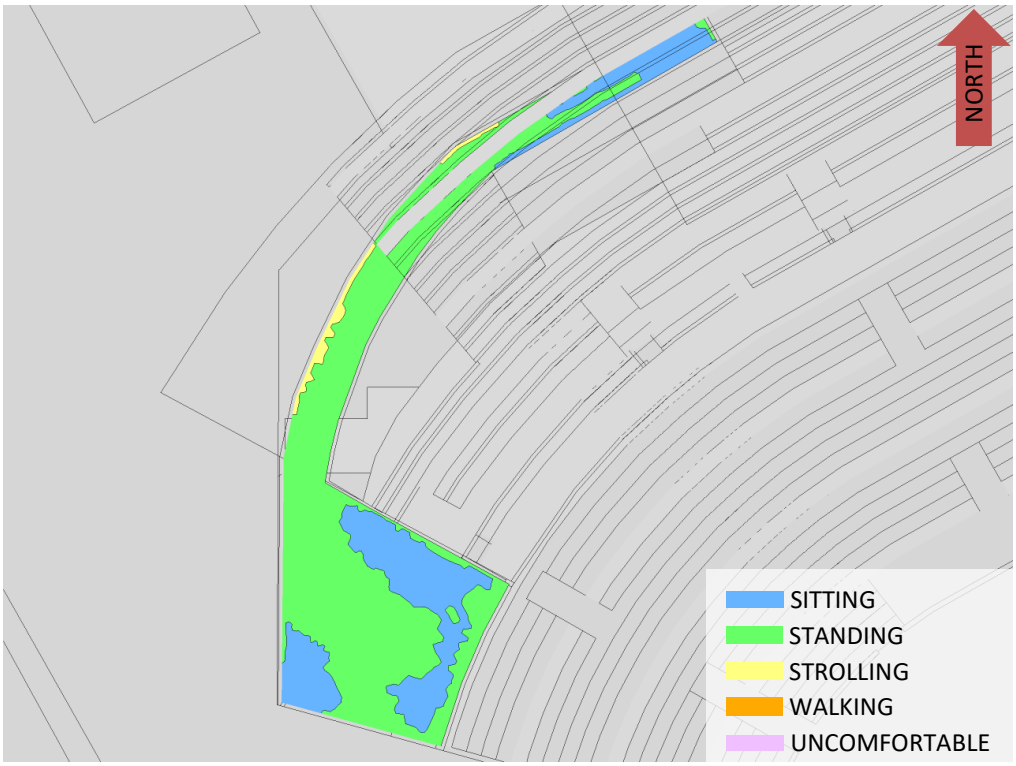


FIGURE 26A: WINTER – WIND COMFORT, UPPER WEST FAN DECK WITH NSS ROOF

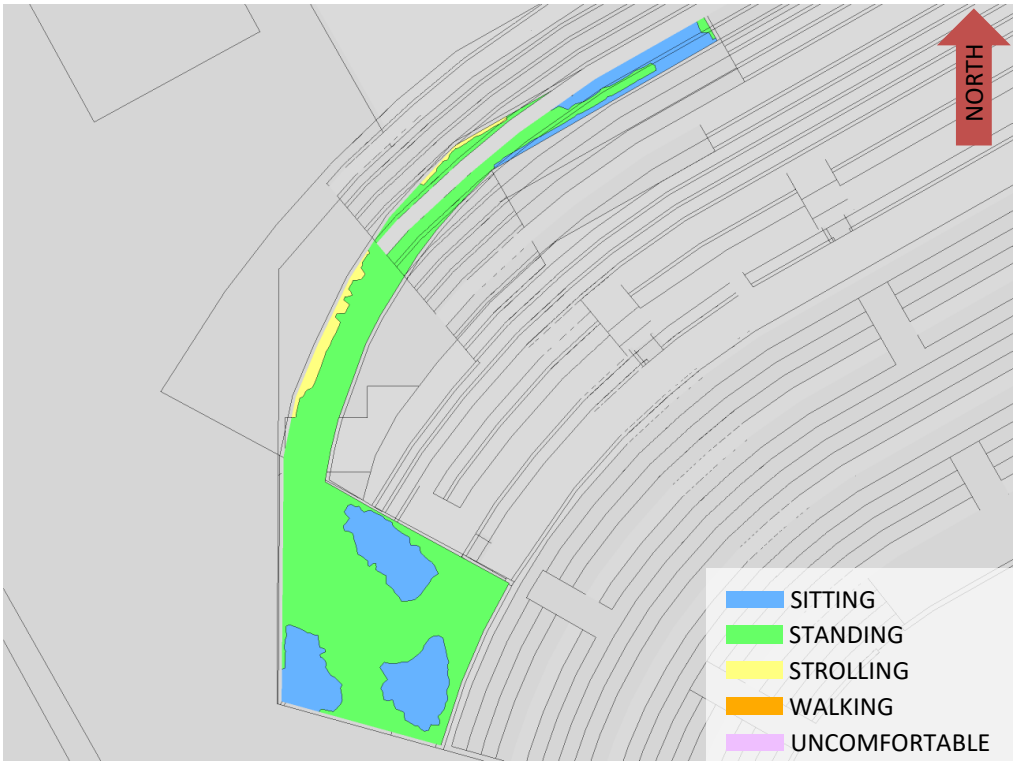


FIGURE 26B: WINTER – WIND COMFORT, UPPER WEST FAN DECK WITHOUT NSS ROOF

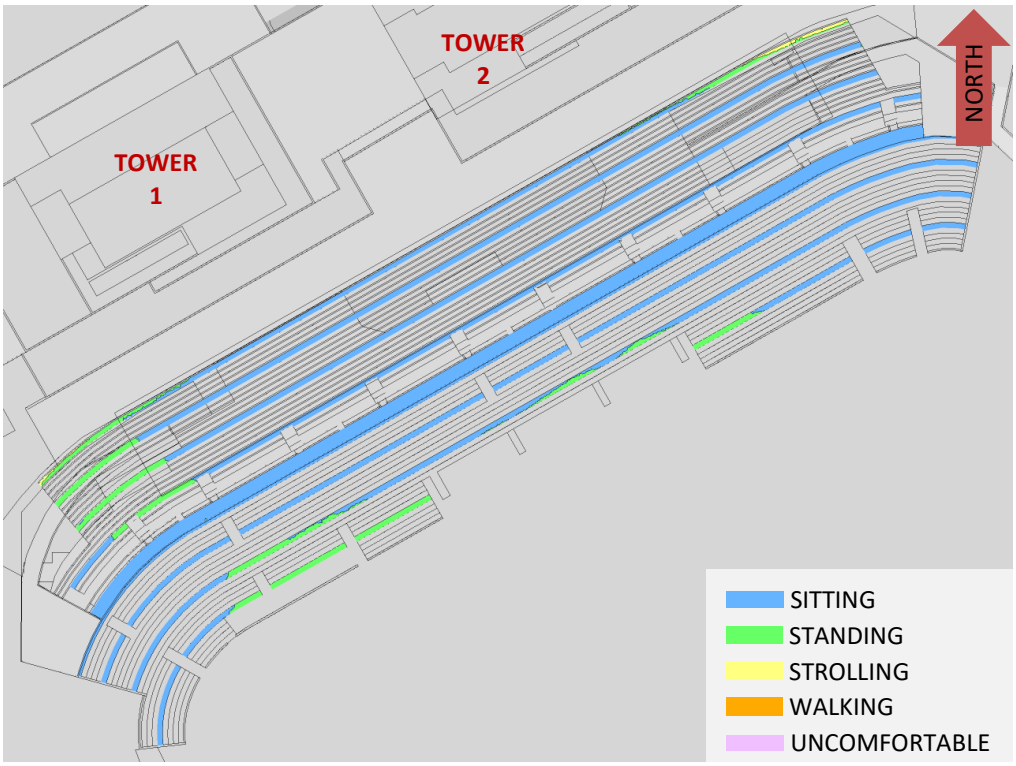


FIGURE 27A: SPRING – WIND COMFORT, SELECT NEW NSS ROWS WITH NSS ROOF

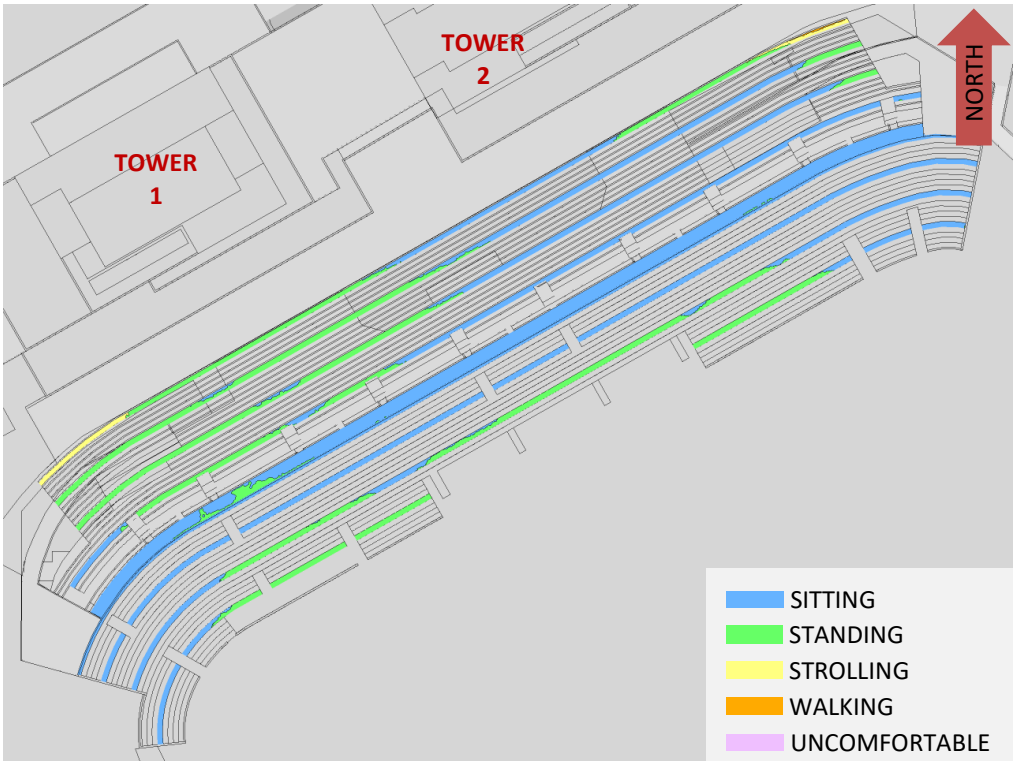


FIGURE 27B: SPRING – WIND COMFORT, SELECT NEW NSS ROWS WITHOUT NSS ROOF

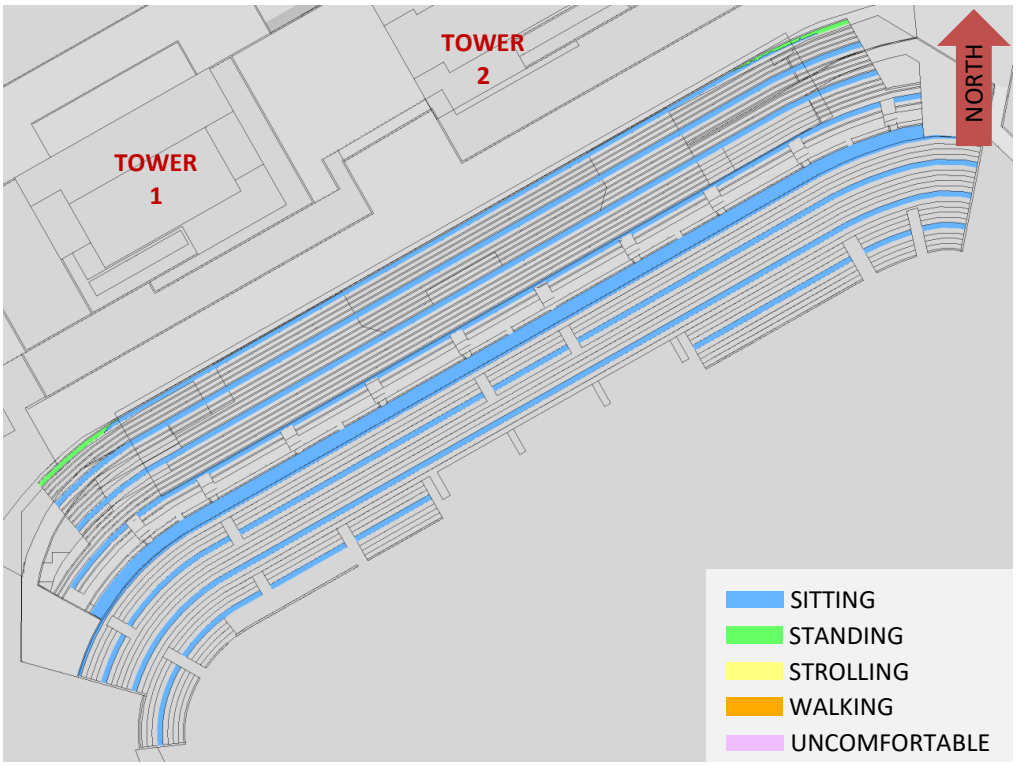


FIGURE 28A: SUMMER – WIND COMFORT, SELECT NEW NSS ROWS WITH NSS ROOF

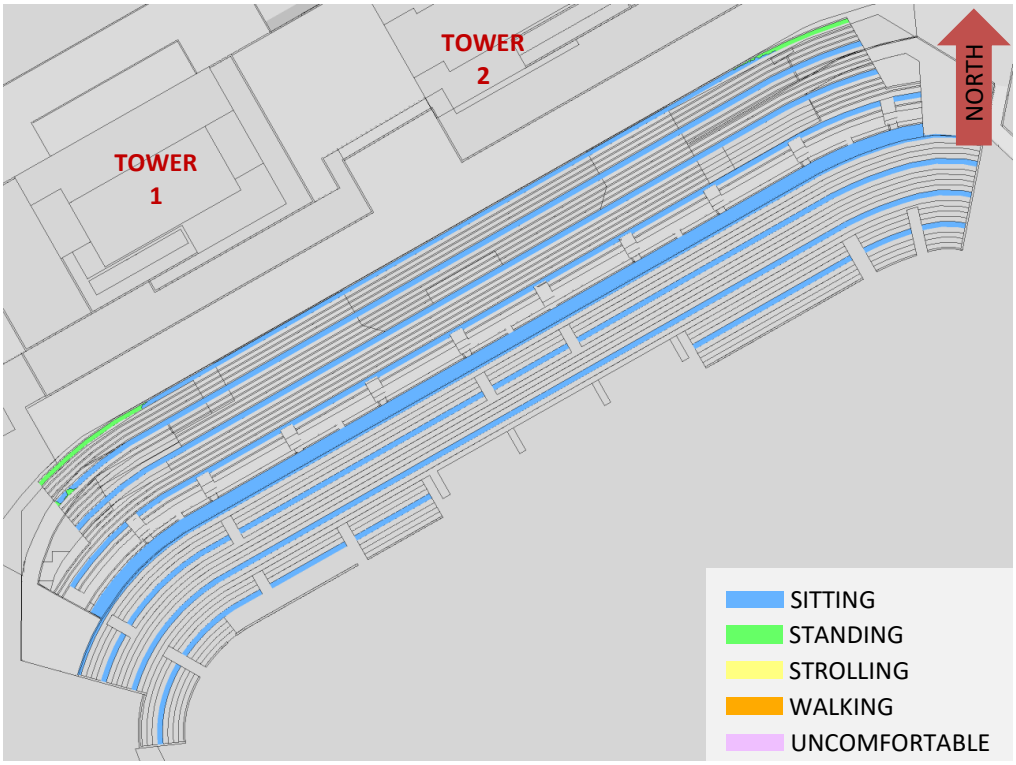


FIGURE 28B: SUMMER – WIND COMFORT, SELECT NEW NSS ROWS WITHOUT NSS ROOF

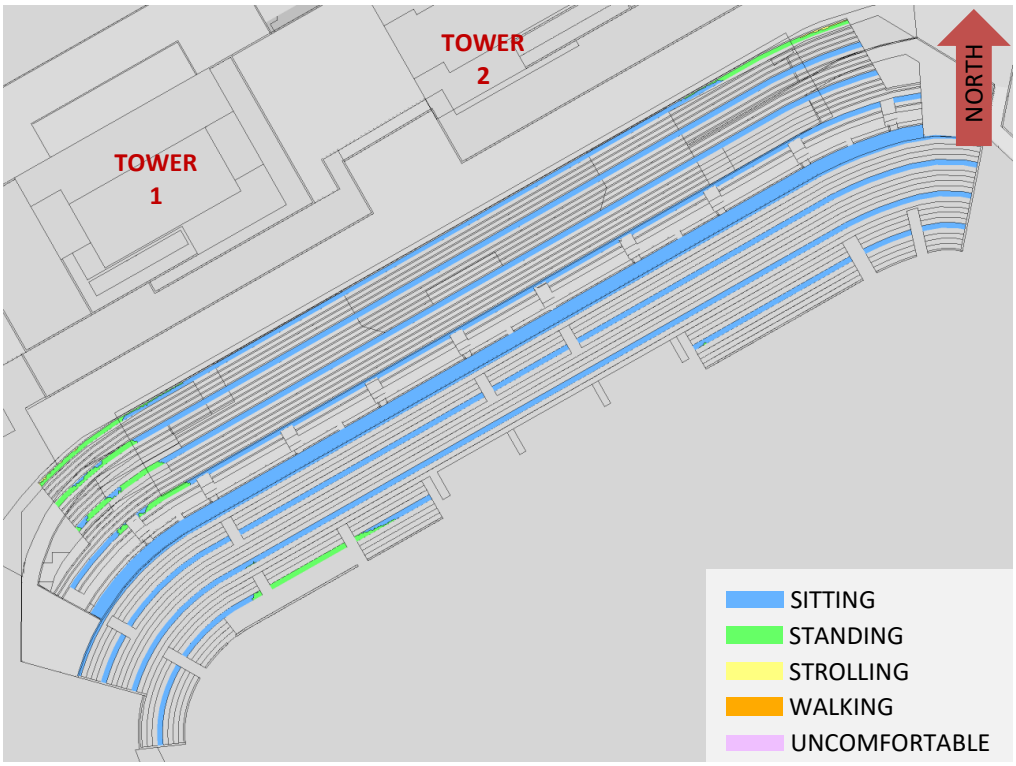


FIGURE 29A: AUTUMN – WIND COMFORT, SELECT NEW NSS ROWS WITH NSS ROOF

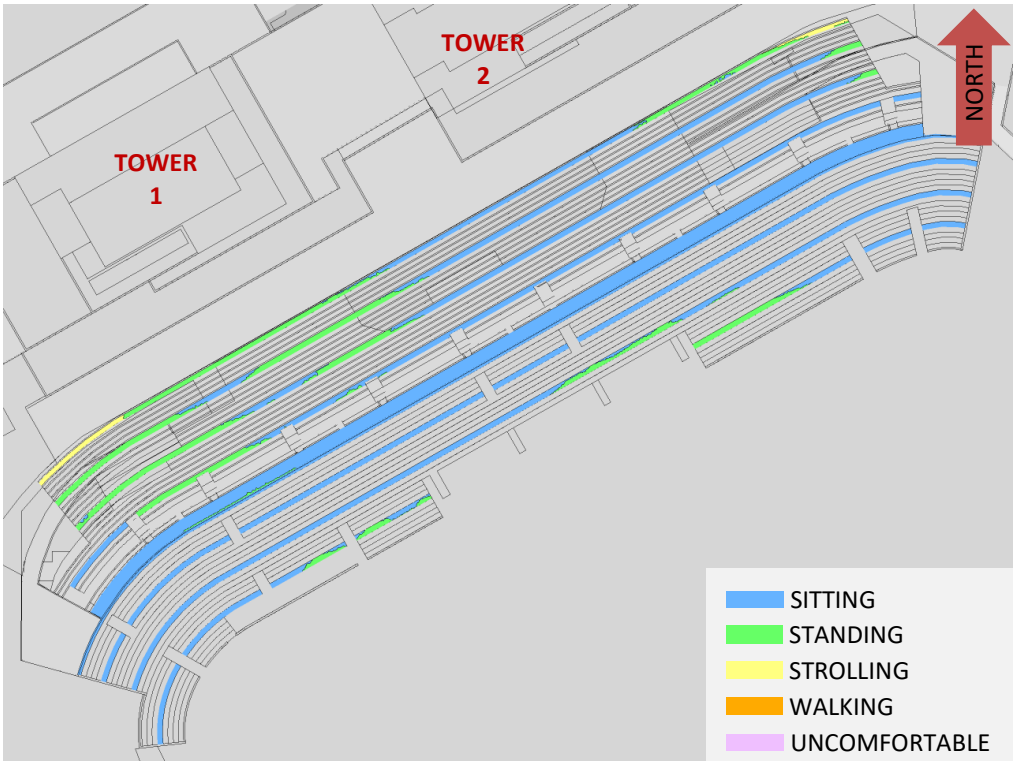


FIGURE 29B: AUTUMN – WIND COMFORT, SELECT NEW NSS ROWS WITHOUT NSS ROOF

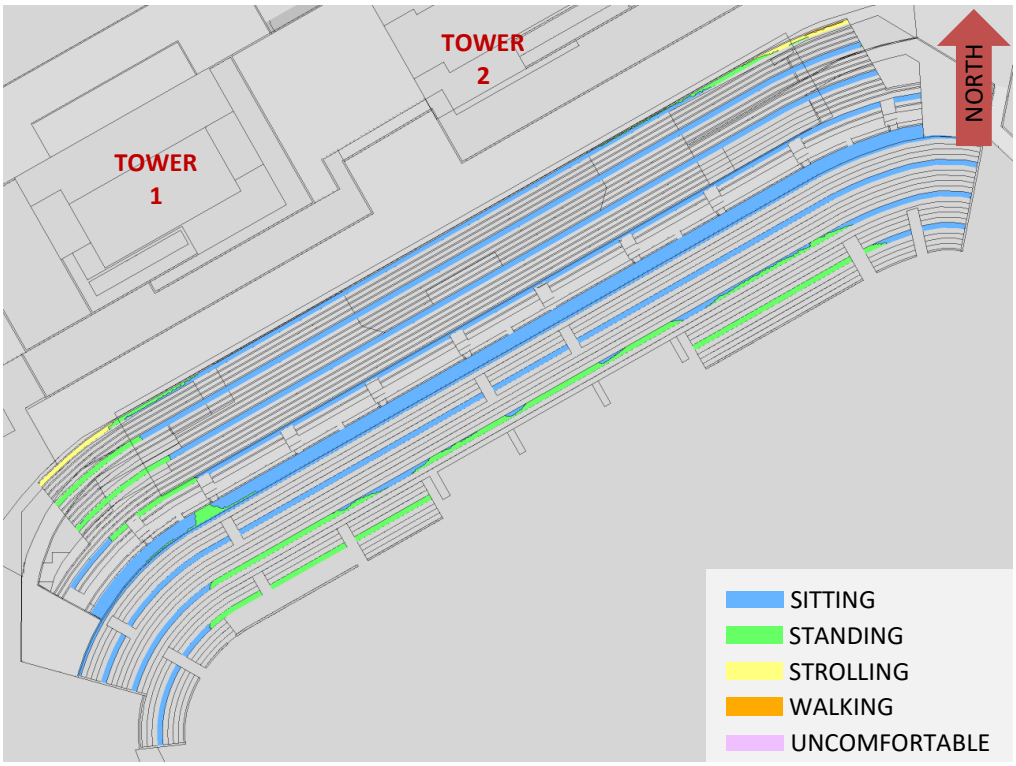


FIGURE 30A: WINTER – WIND COMFORT, SELECT NEW NSS ROWS WITH NSS ROOF

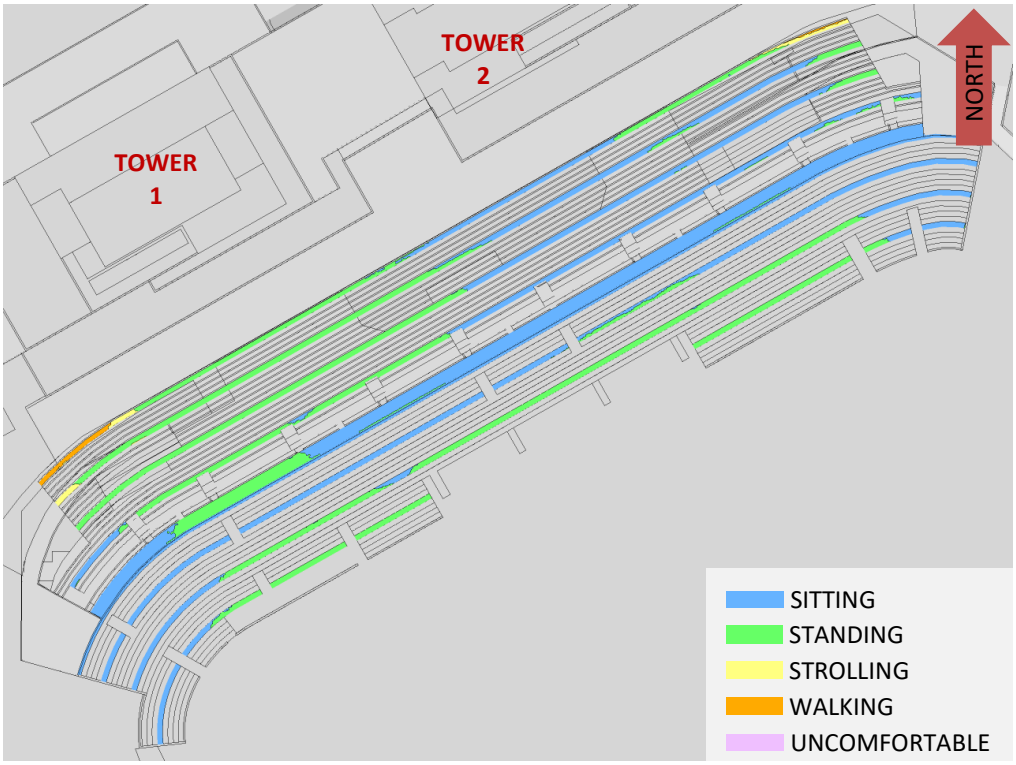


FIGURE 30B: WINTER – WIND COMFORT, SELECT NEW NSS ROWS WITHOUT NSS ROOF

FIGURE 31A: SPRING – WIND COMFORT, SELECT EXISTING NSS ROWS

FIGURE 31B: SUMMER – WIND COMFORT, SELECT EXISTING NSS ROWS

FIGURE 31C: AUTUMN – WIND COMFORT, SELECT EXISTING NSS ROWS

FIGURE 31D: WINTER – WIND COMFORT, SELECT EXISTING NSS ROWS

FIGURE 32A: SPRING – WIND COMFORT, EVENT CENTRE PATHWAY WITH NSS ROOF

FIGURE 32B: SPRING – WIND COMFORT, EVENT CENTRE PATHWAY WITHOUT NSS ROOF

FIGURE 33A: SUMMER – WIND COMFORT, EVENT CENTRE PATHWAY WITH NSS ROOF

FIGURE 33B: SUMMER – WIND COMFORT, EVENT CENTRE PATHWAY WITHOUT NSS ROOF

FIGURE 34A: AUTUMN – WIND COMFORT, EVENT CENTRE PATHWAY WITH NSS ROOF

FIGURE 34B: AUTUMN – WIND COMFORT, EVENT CENTRE PATHWAY WITHOUT NSS ROOF

FIGURE 35A: WINTER – WIND COMFORT, EVENT CENTRE PATHWAY WITH NSS ROOF

FIGURE 35B: WINTER – WIND COMFORT, EVENT CENTRE PATHWAY WITHOUT NSS ROOF

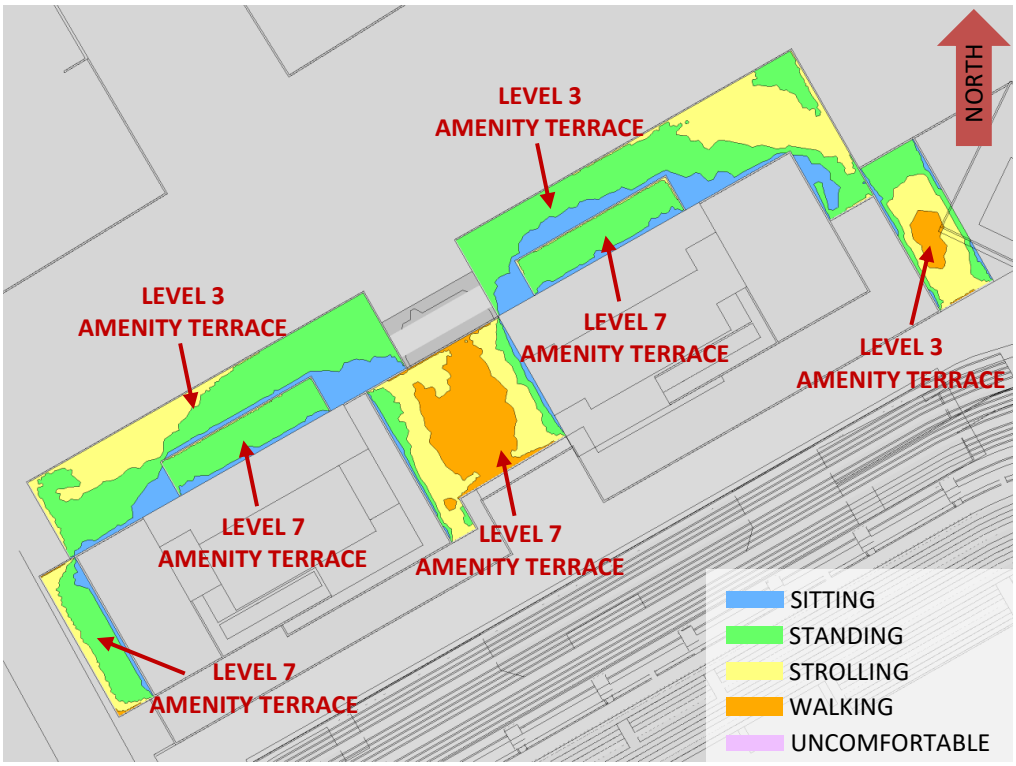


FIGURE 36A: SPRING – WIND COMFORT, AMENITY TERRACES WITH NSS ROOF

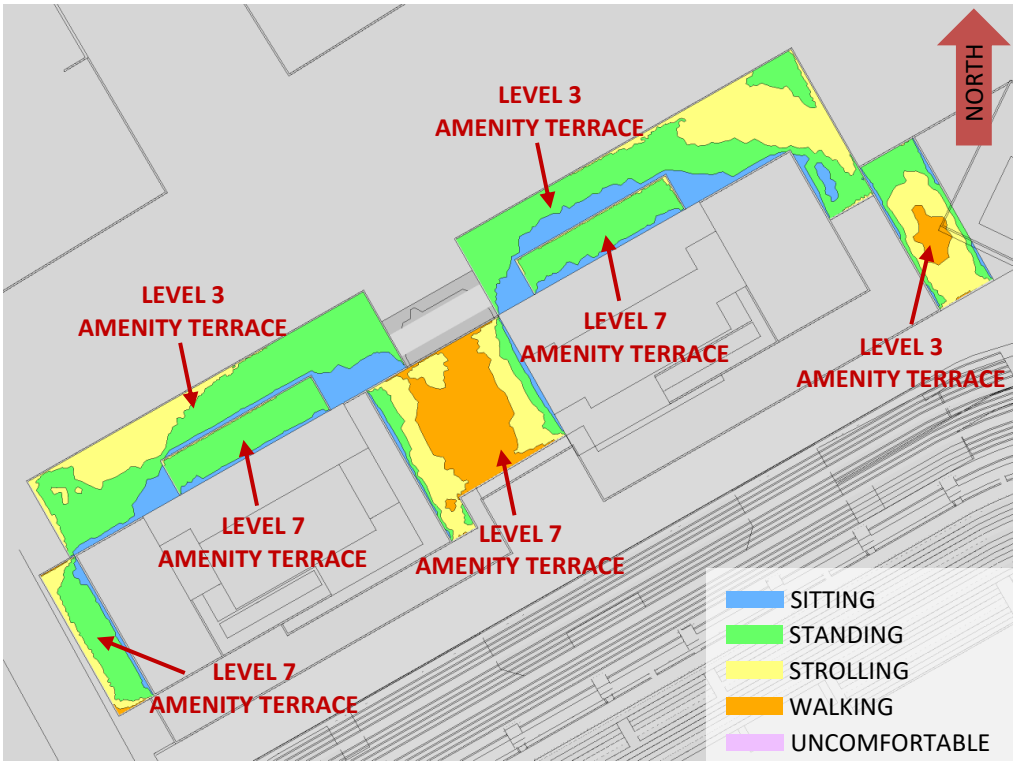


FIGURE 36B: SPRING – WIND COMFORT, AMENITY TERRACES WITHOUT NSS ROOF

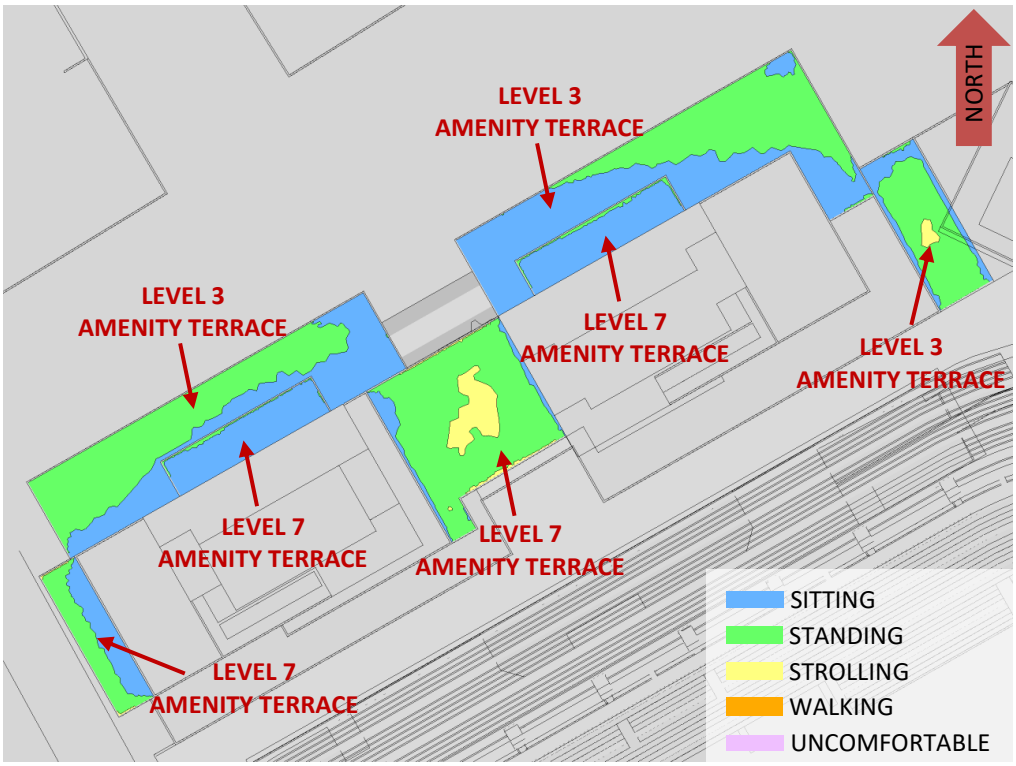


FIGURE 37A: SUMMER – WIND COMFORT, AMENITY TERRACES WITH NSS ROOF

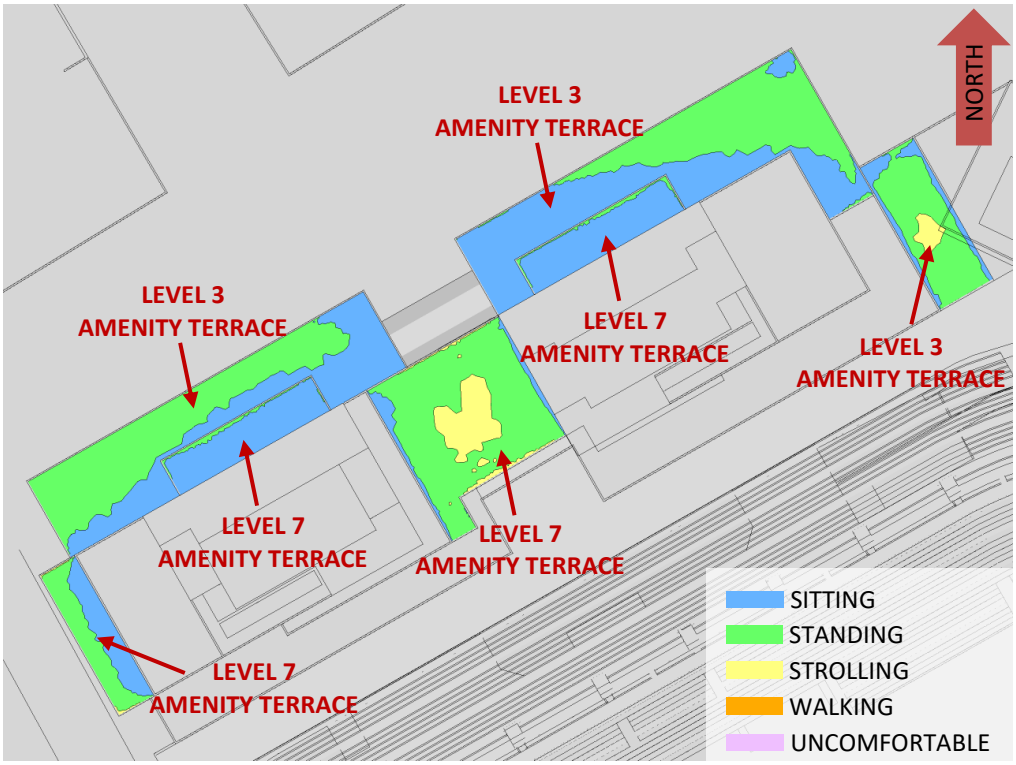


FIGURE 37B: SUMMER – WIND COMFORT, AMENITY TERRACES WITHOUT NSS ROOF

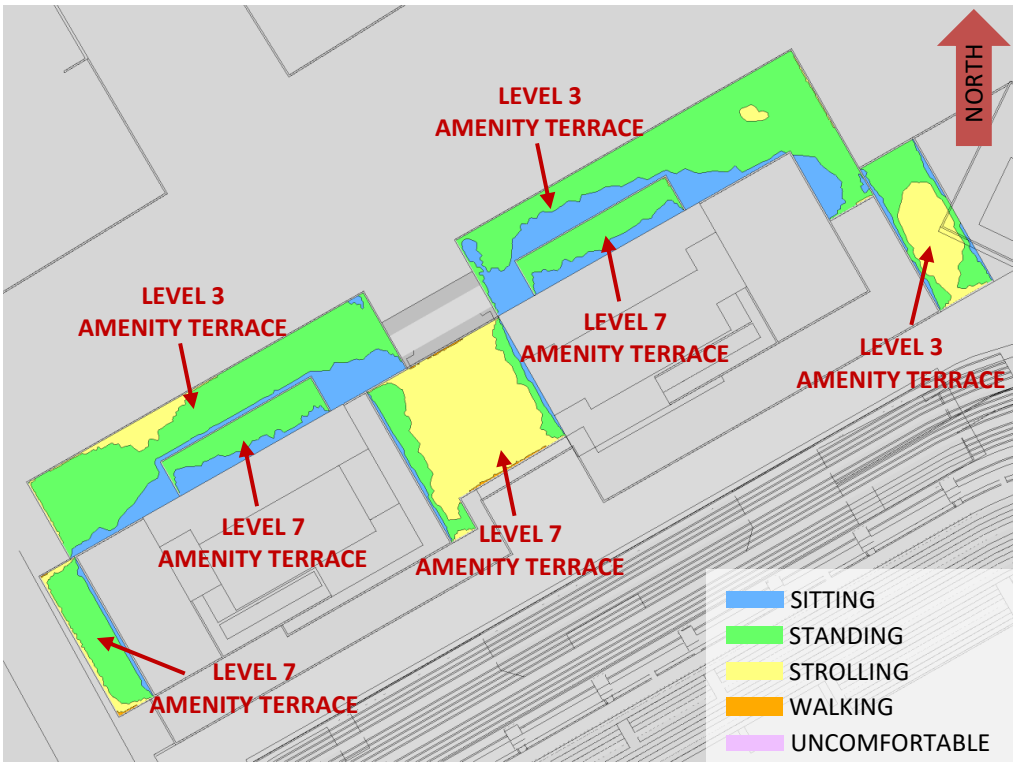


FIGURE 38A: AUTUMN – WIND COMFORT, AMENITY TERRACES WITH NSS ROOF

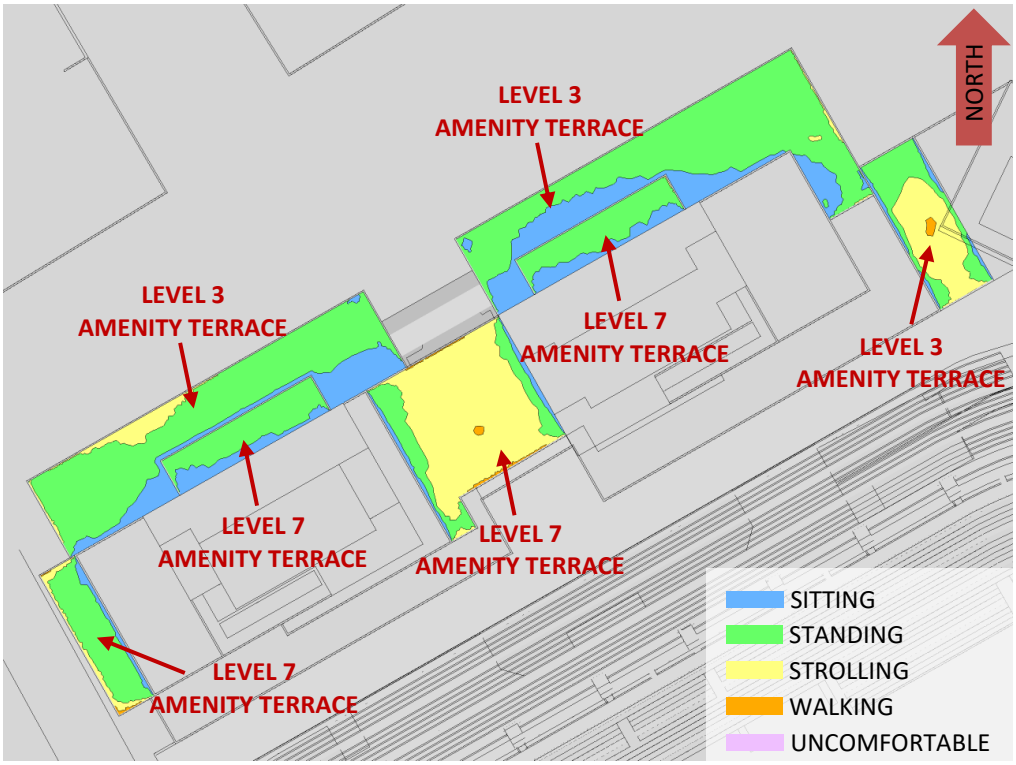


FIGURE 38B: AUTUMN – WIND COMFORT, AMENITY TERRACES WITHOUT NSS ROOF

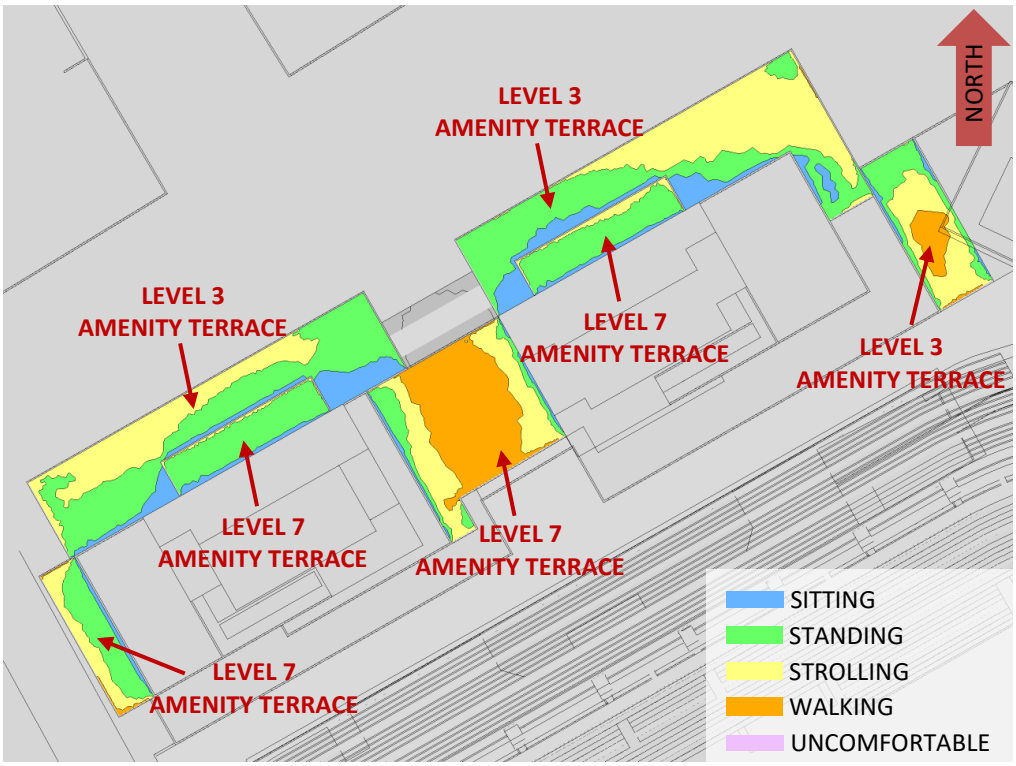


FIGURE 39A: WINTER – WIND COMFORT, AMENITY TERRACES WITH NSS ROOF

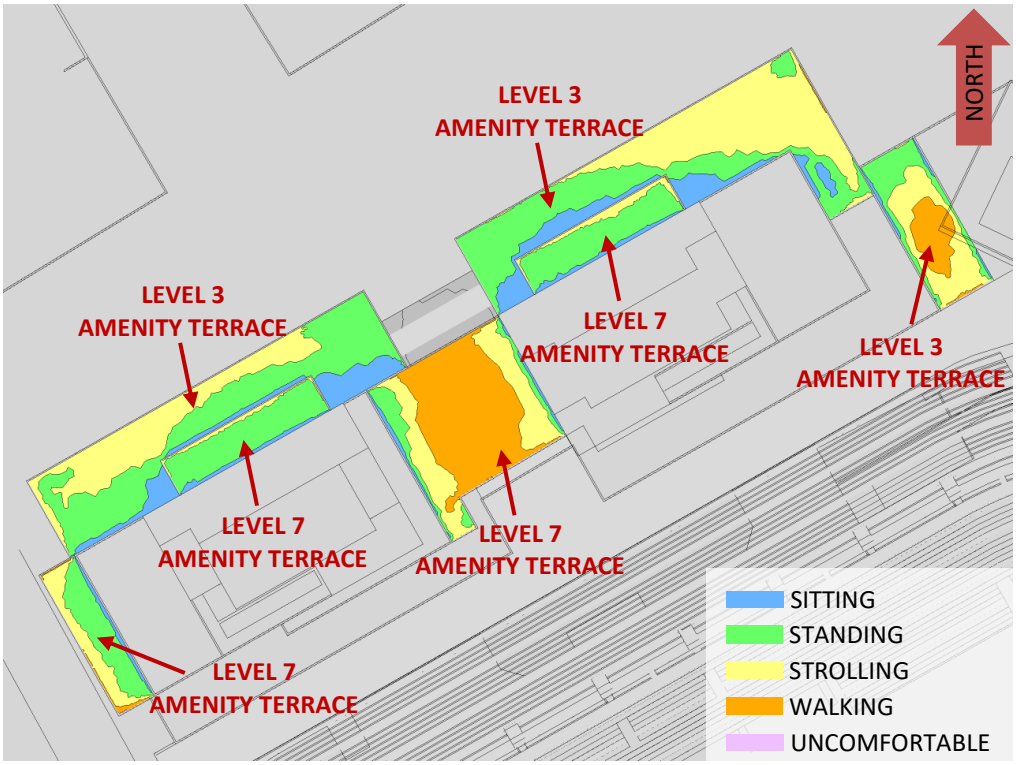


FIGURE 39B: WINTER – WIND COMFORT, AMENITY TERRACES WITHOUT NSS ROOF

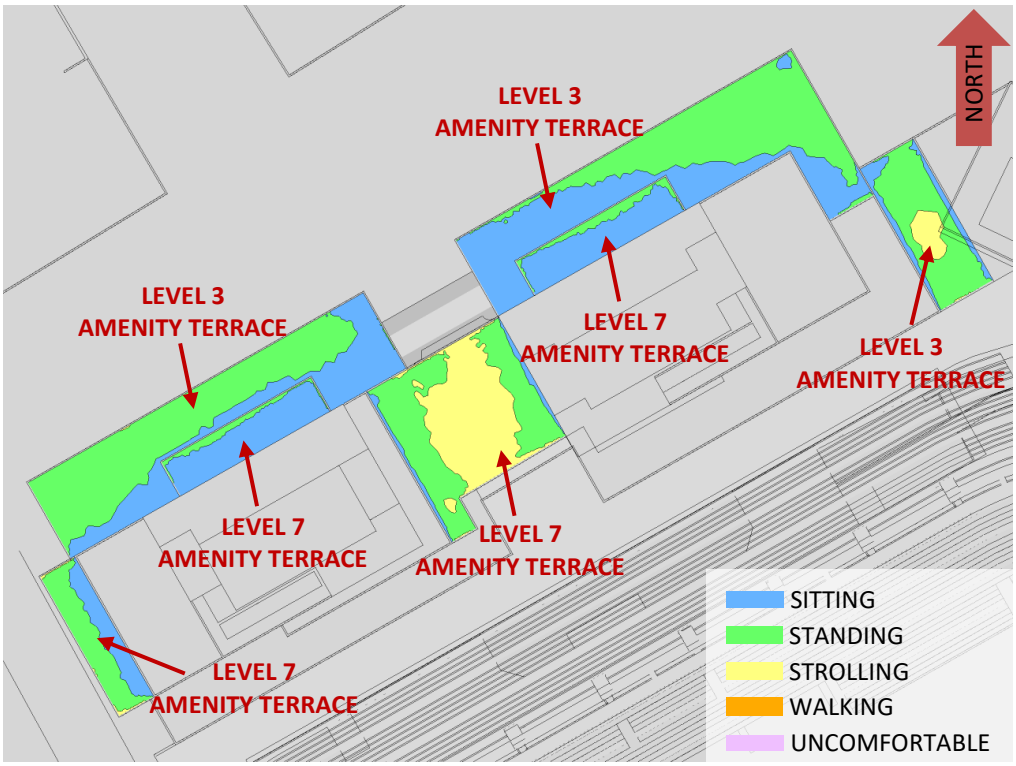


FIGURE 40A: TYPICAL USE PERIOD – WIND, AMENITY TERRACES WITH NSS ROOF

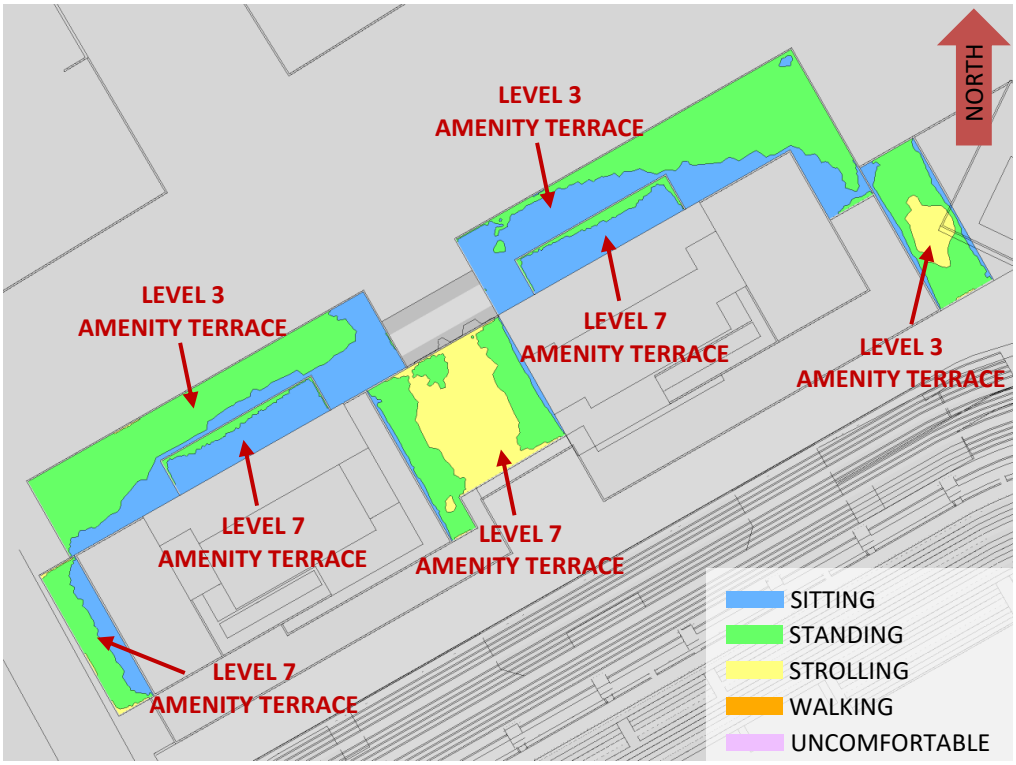
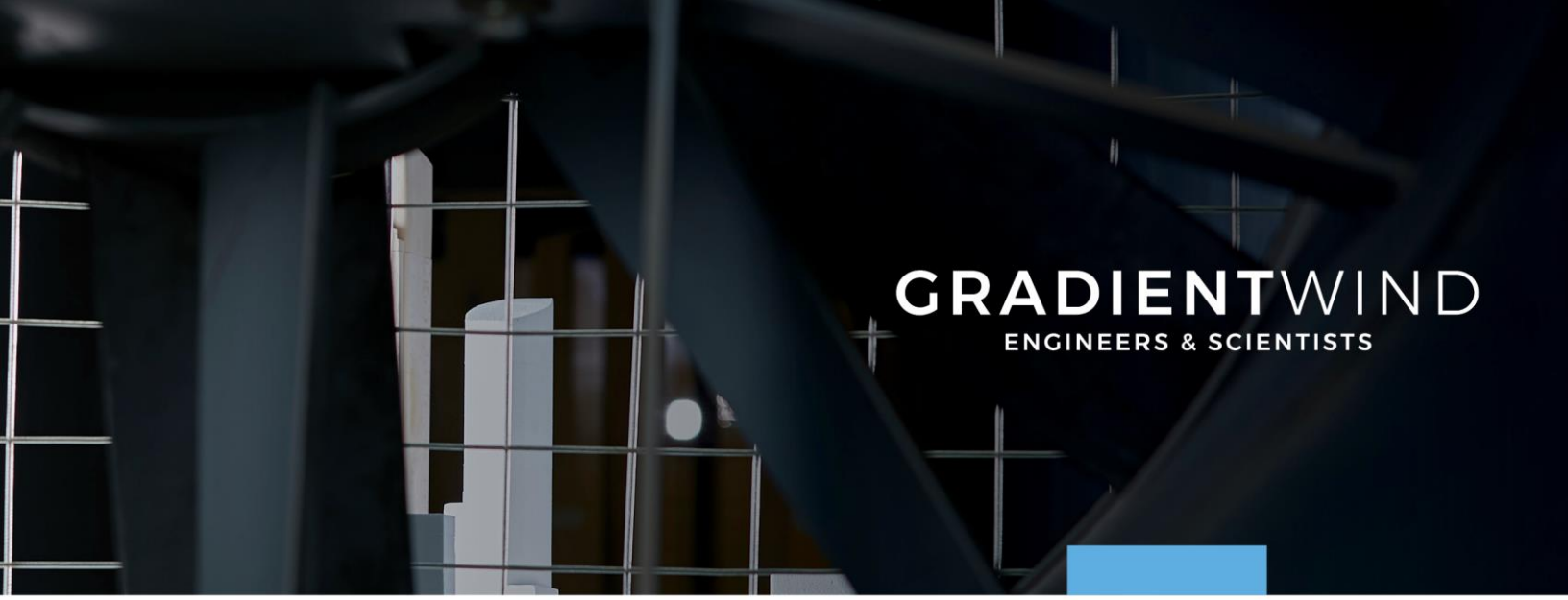
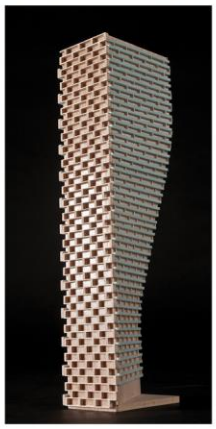
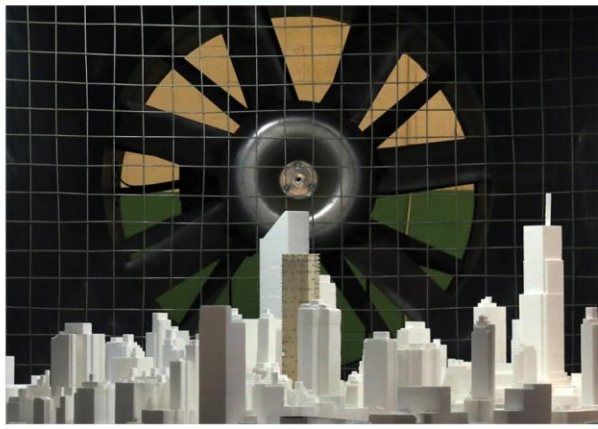


FIGURE 40B: TYPICAL USE PERIOD – WIND, AMENITY TERRACES WITHOUT NSS ROOF







APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

The atmospheric boundary layer (ABL) is defined by the velocity and turbulence profiles according to industry standard practices. The mean wind profile can be represented, to a good approximation, by a power law relation, Equation (1), giving height above ground versus wind speed (1), (2).

$$U = U_g \left(\frac{Z}{Z_g}\right)^{\alpha} \qquad \text{Equation (1)}$$

where, $\boldsymbol{U}$ = mean wind speed, $\boldsymbol{U_g}$ = gradient wind speed, $\boldsymbol{Z}$ = height above ground, $\boldsymbol{Z_g}$ = depth of the boundary layer (gradient height), and α is the power law exponent.

For the model, U_g is set to 6.5 metres per second, which approximately corresponds to the 60% mean wind speed for Ottawa based on historical climate data and statistical analyses. When the results are normalized by this velocity, they are relatively insensitive to the selection of gradient wind speed.

Z_g is set to 540 m. The selection of gradient height is relatively unimportant, so long as it exceeds the building heights surrounding the subject site. The value has been selected to correspond to our physical wind tunnel reference value.

α is determined based on the upstream exposure of the far-field surroundings (that is, the area that it not captured within the simulation model).

Table 1 presents the values of α used in this study, while Table 2 presents several reference values of α. When the upstream exposure of the far-field surroundings is a mixture of multiple types of terrain, the α values are a weighted average with terrain that is closer to the subject site given greater weight.

TABLE 1: UPSTREAM EXPOSURE (ALPHA VALUE) VS TRUE WIND DIRECTION

Wind Direction (Degrees True)	Alpha Value (α)
0	0.27
49	0.24
74	0.24
103	0.24
167	0.24
197	0.24
217	0.24
237	0.22
262	0.24
282	0.26
301	0.25
324	0.28

TABLE 2: DEFINITION OF UPSTREAM EXPOSURE (ALPHA VALUE)

Upstream Exposure Type	Alpha Value (α)
Open Water	0.14-0.15
Open Field	0.16-0.19
Light Suburban	0.21-0.24
Heavy Suburban	0.24-0.27
Light Urban	0.28-0.30
Heavy Urban	0.31-0.33

The turbulence model in the computational fluid dynamics (CFD) simulations is a two-equation shear-stress transport (SST) model, and thus the ABL turbulence profile requires that two parameters be defined at the inlet of the domain. The turbulence profile is defined following the recommendations of the Architectural Institute of Japan for flat terrain (3).

$$I(Z) = \begin{cases} 0.1\left(\frac{Z}{Z_g}\right)^{-\alpha-0.05}, & Z > 10\ \text{m} \\ 0.1\left(\frac{10}{Z_g}\right)^{-\alpha-0.05}, & Z \leq 10\ \text{m} \end{cases} \qquad \text{Equation (2)}$$

$$L_t(Z) = \begin{cases} 100\ \text{m}\sqrt{\frac{Z}{30}}, & Z > 30\ \text{m} \\ 100\ \text{m}, & Z \leq 30\ \text{m} \end{cases} \qquad \text{Equation (3)}$$

where, I = turbulence intensity, L_t = turbulence length scale, Z = height above ground, and α is the power law exponent used for the velocity profile in Equation (1).

Boundary conditions on all other domain boundaries are defined as follows: the ground is a no-slip surface; the side walls of the domain have a symmetry boundary condition; the top of the domain has a specified shear, which maintains a constant wind speed at gradient height; and the outlet has a static pressure boundary condition.

REFERENCES

[1] P. Arya, "Chapter 10: Near-neutral Boundary Layers," in *Introduction to Micrometeorology*, San Diego, California, Academic Press, 2001.

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[3] Y. Tamura, H. Kawai, Y. Uematsu, K. Kondo and T. Okhuma, "Revision of AIJ Recommendations for Wind Loads on Buildings," in *The International Wind Engineering Symposium, IWES 2003*, Taiwan, 2003.