DRAFT REPORT

CITY OF EDMONTON: WIND STUDY TERMS OF REFERENCE

SPECIALITY WIND ENGINEERING SERVICES
RWDI # 2001621
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SUBMITTED TO

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1 INTRODUCTION

The City of Edmonton has retained RWDI to assist the UFCSD with the Wind Study Terms of Reference. The Terms of Reference will provide direction for determining wind impacts to areas surrounding potential developments and a clear path for any possible mitigation options. The ultimate goal is that the Terms of Reference will create guidelines to inform wind-responsive building design strategies and to create comfortable spaces that align with planned outdoor pedestrian usage throughout the year.

Wind is a crucial parameter that defines human comfort. The mechanical force of wind on people can impact daily common activities in varying levels. Typically, higher the wind speed, greater the wind force on a person; the more active a person is in an instance, the greater the wind speed they can tolerate. The Pedestrian Wind Terms of Reference deal with the mechanical effects of wind on people and how conducive it is to pedestrian use of outdoor areas in the city.

Temperature, humidity, sunlight, air quality, noise and other environmental factors also have an influence on outdoor comfort, and some of these factors may be incorporated in a future edition of these Terms of Reference.

This document represents a first draft of a Terms of Reference and this document will be refined based on engagement with internal and external stakeholders. Throughout the report, there are informational notes to the reader to clarify details; these notes are in ***highlighted bold italics***.

2 QUALIFICATION OF APPLICATION

2.1 Applicants

This section is to be completed through further discussions with the City

- ***Define who can submit a wind study***
- ***Define the responsibilities and liabilities of the applicants***

2.2 Consultants

Pedestrian wind comfort and safety studies are to be conducted by professionals who specialize in and can demonstrate extensive experience in dealing with wind and microclimate issues in the built environment. If the Planning and Building Department is not satisfied with the level of experience demonstrated, a peer review of the wind study will be required. The cost of the peer review is to be borne by the applicant.

This section is to be completed through further discussions with the City

2.3 Triggers and Process

It is important to consider the potential impacts of a proposed development on the local microclimate early in the planning and design process as this allows enough time to consider appropriate wind control and mitigation strategies, including significant changes to site and building designs. Properties, circumstances, etc. of a project that, through precedents, are known to be causative factors for noticeable wind impacts around the project are referred to as triggers. If the project exceeds the conditions specified under the list of triggers, then a wind assessment would be requested for the project.

Wind assessments can be done through physical scale modelling in wind tunnels, computational modelling and experience-based desktop reviews. Each method has its benefits and drawbacks and it is essential that the right approach be chosen for the type, context and approval stage of the project.

Prior to the preparation of pedestrian wind comfort and safety studies for submission to the City, the consultant should consult with the Development and Zoning Services as follows:

- Consult with the Development Officer and Urban Designer processing the development application, to agree upon the most appropriate approach for the wind comfort and safety study, based on the triggers described in this document.
- At the discretion of the City, the consultant may be asked to submit the intended test scenarios and sensor locations for review by the Development Officer and Urban Designer prior to any wind tunnel testing.
- If the proposed development is predicted to create wind conditions that are considered unacceptable or unsafe, the Development Officer and Urban Designer should be consulted to discuss potential strategies going forward.

The timing of these meetings in the development process may be decided through discussions with the City.

2.3.1 Triggers

Decisive triggers and approaches for wind assessments at the different application stages are as follows:

HEIGHT TRIGGERS		
HEIGHT TRIGGERS		
Significant	**Moderate**	**Low**
>60 m	>40 m and <60 m	>20 m and <40 m
The trigger chart will be updated to include factors like proximity to sensitive areas, size of the development, multi-building projects and design changes to be considered in evaluating the need for a wind study in the Rezoning Application.		

2.3.2 Development Process

Pre-Application Consultation for Projects with Significant Triggers

A consultation meeting involving the project applicant, consultant and Development Planner is suggested prior to or during rezoning, whereby the required wind study approach may be decided on. A preliminary massing study is suggested for developments that meet the criteria for Significant triggers. The study will be conducted using Computational Fluid Dynamics (CFD) method following the Pre-Application Consultation by a qualified consultant to identify building massing that needs to be altered in order to avoid adverse wind conditions. This effort, earlier on in the design, will help reduce the wind tunnel study iterations required in subsequent applications.

General issues to be addressed in the preliminary massing study include the following:

- Height of the proposed development in relation to the height of surrounding structures
- The orientation and general massing of the development with respect to the primary wind directions
- Location and shape of specific design features that induce wind activity
- Potential impact of wind speed increases created by the development on the surroundings
- Outline of basic wind mitigation features to be included in development design including base and podium conditions, canopies and tower orientation

Rezoning Application

Project triggers should be evaluated and the approach for a wind study will be decided. The submission to the city should include a wind study report that shows satisfactory wind conditions on and around the project. If needed, appropriate measures for wind control should be implemented and their effectiveness demonstrated by additional wind studies.

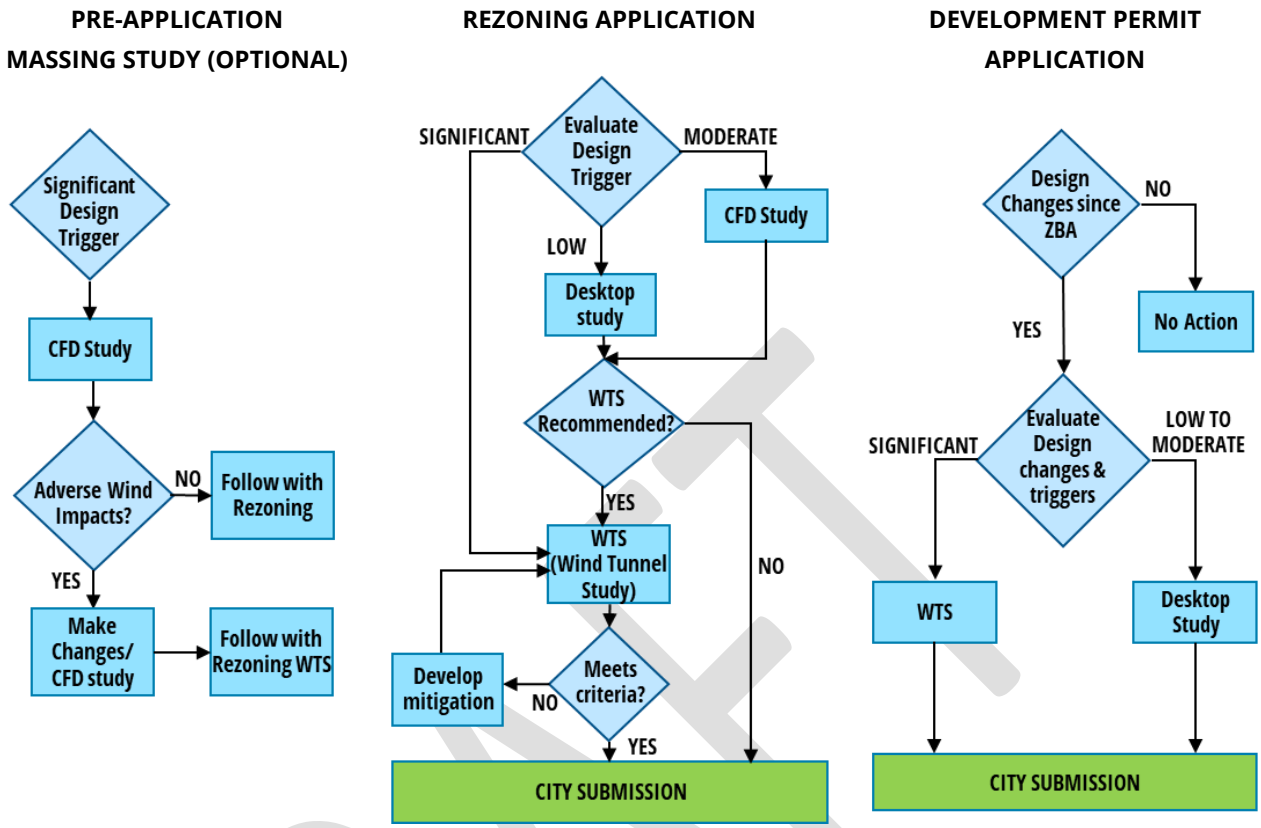
Development Permit Application

The design submitted should include all recommendations from the Rezoning Application wind studies required to obtain a wind-responsive design. If there have been design changes relevant to the project's wind responsiveness, a wind study may be required to evaluate the projects performance and ensure it continues to satisfy the recommended wind criteria.

Pre-Occupancy Confirmation

Confirm implementation of recommendations for wind mitigation in construction documents and/or pre-occupancy.

A flow-chart laying out the suggested process follows.



3 TECHNICAL REQUIREMENTS

3.1 Project Context Scenarios / Massing Scenarios

The perception of wind can vary regionally, based on differences in climatic parameters like daylight, temperature, humidity, etc. and parameters like clothing, age, health, and even tolerance to wind developed through acclimatization to the local climate. Therefore, the most objective way to assess the impact of a proposed development on wind conditions around it is to compare it to existing conditions. If the Project is expected to result in less than acceptable wind comfort, then further assessments should be conducted to evaluate a wind mitigation plan that can be implemented in the final design of the Project.

The following three scenarios should be assessed for every project:

- **Existing Scenario:** Existing site and all existing surrounding buildings, significant topographic features, developments under construction and projects that were approved for construction in the last 5 years.
- **Proposed Scenario**: Proposed project in place of existing site.
- **Mitigation Scenario(s), if warranted:** Where mitigation is required to achieve acceptable pedestrian wind comfort levels, as concluded from the Proposed Scenario, re-evaluate the Proposed scenario with recommended mitigation measures in order to demonstrate the benefits of those measures.

3.2 Areas of Interest

The scope of the assessment should cover all key pedestrian areas on and within one block of the Project in all directions. Key pedestrian areas where wind conditions should be assessed include, but are not limited to:

- Entrances and perimeter of the Project
- Building perimeters and major entrances of neighbouring buildings.
- Privately Owned Public Spaces (POPS)
- Public parks or recreational areas.
- Publicly accessible above-grade locations

Further analysis is currently being conducted at RWDI for the extent or study area. The areas of interest will be updated through discussions with the City.

3.3 Proximity Model and Scale for Wind Tunnel Studies

All surrounding features within at least 350 m radius of the project site should be modelled, including all massing details that would affect the wind flow around the site. Scales 1:300 to 1:400 are recommended, and the choice should be such that all areas of interest are accurately modelled and able to be instrumented for wind tunnel testing.

If a scale outside the range is chosen, the wind study report should explain the reason for the choice and why the recommended scales would not be appropriate for the study. Note that the model scale chosen for optimal data quality could vary depending on the test equipment and instrumentation used.

3.4 Design Criteria

Comfort and Safety Criteria that should be met for all development applications.

- **Comfort**: Commonly experienced wind speeds have been categorized into ranges based on the activity level of a person that the winds would be conducive to. Lower wind speeds are desirable for relaxed activities and active pedestrians would be tolerant of higher wind speeds.
- **Safety**: It is important to assess wind conditions in the pedestrian realm from a safety perspective as strong wind gusts can deter safe pedestrian use of outdoor spaces. Wind speeds associated with such conditions are infrequent, deserve special attention due to their potential impact on pedestrian safety.

The recommended criteria are shown in the table that follows.

RWDI is conducting further analysis on the comfort wind speed thresholds for winter, considering the City's desire to extend outdoor comfort in the shoulder seasons, as described in the Winter City Design Guidelines.

WIND CRITERIA FOR PEDESTRIAN COMFORT AND SAFETY				
COMFORT CATEGORY	MINIMUM OCCURRENCE (% OF TIME)		DESCRIPTION	AREA OF APPLICATION
	SUMMER May – Oct	WINTER Nov-Apr		
Sitting	≤ 10	≤ 8	Light breezes desired for outdoor seating areas where one can read a paper without having it blown away.	Park benches, restaurant seating, balconies, amenity terraces, etc. intended for relaxed, and usually seated activities.
Standing	≤ 15	≤ 12	Gentle breezes suitable for passive pedestrian activities where a breeze may be tolerated	Main entrances, bus-stops and other outdoor areas where seated activities can be avoided.
Walking	≤ 20	≤ 16	Relatively high speeds that can be tolerated during intentional walking, running and other active movements.	Sidewalks, parking lots, alleyways and areas where pedestrian activity is infrequent.
Uncomfortable	> 20	> 16	Strong winds, considered a nuisance for most activities.	May be accepted in areas not intended for pedestrian access

NOTES:

The criteria for winter are under review; further analysis is being done at RWDI.

1) Gust Equivalent Mean (GEM) speed = maximum of either mean speed or gust speed/1.85.
2) Comfort calculations are to be based on wind events recorded between 6:00 and 23:00 daily.
3) Threshold wind speeds are lower in the winter to account for wind-chill, in order to consider outdoor comfort in alignment with the Winter City Design Guidelines.

SAFETY CRITERION	GUST SPEED (km/h)	MINIMUM OCCURRENCE (% OF TIME) Annual	DESCRIPTION	AREA OF APPLICATION
Exceeded	> 90	0.1 (9 hours in a year)	Excessive gust speeds that can adversely affect a pedestrian's balance and footing. Wind mitigation is typically required.	All areas assessed

NOTES:

1) Wind safety assessment is to be based on wind events recorded for 24 hours a day.

3.5 Meteorological Data Specifications

- The most recent wind records available from Edmonton International Airport should be used for the assessment of pedestrian wind comfort and safety.
- A minimum of 30 years of hourly wind data should be used.
- The Data is to be presented and used on a two-season basis defined as follows:
    - Summer: Hourly winds occurring during the period of May through October.
    - Winter: Hourly winds occurring during the period of November through April.
- Appropriate hours of pedestrian usage for a typical project (e.g., between 6:00 and 23:00) should be considered for wind comfort, while data for 24 hours should be used to assess wind safety.

3.6 Wind Study Approach: Technical Requirements

3.6.1 Quantitative Wind Tunnel Study

- The wind simulation facility should be capable of simulating the earth's atmospheric boundary layer and appropriate profiles for each of the wind directions tested.
- Project and Proximity Model
    - The model should be constructed to include all massing and architectural features on the project that would influence wind flow around it. Typically dimensions less than 1 m do not have a notable impact on wind related to pedestrian comfort.
    - The surrounding context (proximity model) within approximately 350 m of the centre of the proposed development site should be modelled
    - Structures and natural features beyond the modelled surroundings should be appropriately represented in the wind tunnel upwind of the scale model.
    - Scale should be selected to allow representation of sufficient architectural detail on the proposed development and surrounding context. Typically scales of 1:300 or 1:400 have proven to be effective.
- Wind speed measurement
    - 36 wind directions should be tested
    - Sensors used to measure wind speeds should be omni-directional.
    - The measurements should represent the wind speed at a full-scale height of approximately 1.5 m above local grade.
    - Sensors and instrumentation should be capable of measuring mean wind speed and wind speed fluctuations with time, including peak gusts of three to ten second duration. Peak gusts can be directly measured from wind tunnel testing or estimated by "mean wind speeds + 3*RMS" wind speed.
    - Sampling time in the wind tunnel should represent a minimum of one hour of full-scale time.

- Sensor placement
    - Sensors should be placed at a full-scale distance of at least every 10 m along a street frontage of the study buildings and at all locations where pedestrians will travel or gather.
    - Locations to be instrumented include entrances to the project building(s) and major entrances to buildings across the street from the project in all directions, sidewalks, seating areas, bus stops, plazas, etc.
    - A typical development project would require a minimum of 40 sensor locations on and around the proposed development to provide adequate coverage.
- Presentation of Results
    - Wind speeds should be presented in km/h.
    - The analysis should consider the probability of all wind directions tested using meteorological data obtained in accordance with the Meteorological Data Source section.
    - Assessment should be based on the standard wind comfort criteria described in this document. The potential wind comfort and safety categories should be assessed for areas of interest.
    - The results should be presented in both tabular and graphic forms for all the test scenarios, with seasonal comfort data and annual safety data.
    - The results table should include wind speed and associated wind speed category (refer to Design Criteria) at each measurement location for assessment against the comfort and safety criteria.

3.6.2 Qualitative Computational Fluid Dynamics (CFD)

- The CFD simulation should appropriately represent the atmospheric boundary layer for winds approaching the project.
- A minimum of sixteen (16) wind directions at equal intervals should be simulated. The complete assessment should consider the probability of all wind directions using meteorological data obtained in accordance with the Meteorological Data Source section.
- Assessment should be based on the standard wind comfort criteria described in this document. The potential wind comfort and safety categories should be assessed for areas of interest.
- Presentation of Results
    - The results and conclusions should be presented in both textual and graphic forms for all the study scenarios.
    - Presentation of the wind speeds should include horizontal planes at pedestrian level (i.e. 1.5 m above local grade). Vertical slices (or axonometric views) depicting flow patterns may be included to understand flow mechanisms in critical areas.
    - The text should include interpretation of the results, discussions about causative flow mechanisms and recommendations for mitigation of adverse or undesirable wind conditions.
    - Where conditions are predicted to be unacceptable for the intended pedestrian usage, design alternatives and wind control strategies should be recommended to improve the wind comfort to acceptable levels or appropriate adjustments to pedestrian usage should be suggested.

3.6.3 Qualitative Desktop Assessment

- Previous wind tunnel results for nearby projects and/or for a similar development in Edmonton or other cities should be used as a reference.
- Assessment should be based on the standard wind comfort criteria described in this document.
- Where conditions are assessed to be unacceptable for the intended pedestrian usage, design alternatives and wind control strategies should be recommended to improve the wind comfort to acceptable levels or appropriate adjustments to pedestrian usage should be suggested.
- The conclusions should be presented in both textual and graphic forms for all the study scenarios. The graphic should include a colour coded representation of comfort and safety categories generally expected at key pedestrian areas on a site plan.

3.7 Mitigation

This section will be developed to include the following:

- ***Basic building aerodynamic principles and wind flow mechanisms relevant to city planning.***
- ***General wind control strategies for common wind flow mechanisms.***
- ***Examples of wind control features in the form of graphical illustrations and/or photographs***
- ***Reference to preexisting guidelines on the City's website***
- ***The use of landscaping as part of a mitigation strategy is acceptable but should be selected and sized to be effective at the time of installation. Landscaping can only be recommended as a mitigation measure, where the wind conditions are suitable for it to thrive and for its maintenance.***
- ***Prior to final site works inspection by the Planning and Building Department, the Consultant should issue a letter confirming that the wind mitigation measures have been installed in accordance with the recommendations of the Pedestrian Wind Comfort and Safety Study.***