538 KARANGAHAPE ROAD,
AUCKLAND, NEW ZEALAND

WIND DESIGN REVIEW
PROJECT # 2405832
29 JULY 2024

SUBMITTED TO

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DOCUMENT CONTROL

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1. INTRODUCTION

RWDI Australia Pty Ltd (RWDI) was retained to undertake a pedestrian wind assessment of the proposed development located at 538 Karangahape Road in Auckland, New Zealand. The project site, shown within its existing surround context in Image 1a, is located along a ridge line and is bounded by Karangahape Road to the north, Gundry Street to the east, and Abbey Street to the south. The site exhibits a gentle downwards slope from Karangahape Road to Abbey Street and is located approximately 300 m to the south of Western Park and approximately 50 m to the east of Ponsonby Road and Newton Road intersection.

The proposed development is a 10-storey commercial office building with an approximate height of 46 m that will replace the existing low-rise structure on the site (see Image 1b for 3d Model). The development consists of a retail space along Abbey Street front with the primary entrance to the building located along Gundry Street.

This desk-based report discusses the potential impacts of the proposed massing of the tower on the local wind microclimate and assesses the outdoor wind comfort based on the usability of spaces. The findings of the report are informed by Computational Fluid Dynamics (CFD) simulations for the prevailing wind directions. Conceptual wind control measures and design advice has also provided, where necessary, to alleviate likely adverse wind conditions.

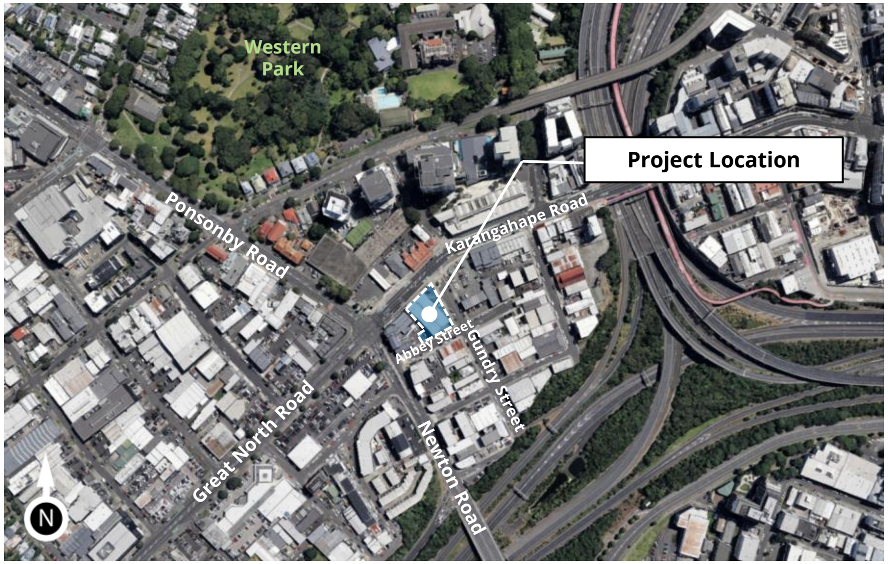


Image 1a: Aerial View of the Existing Site and Surroundings

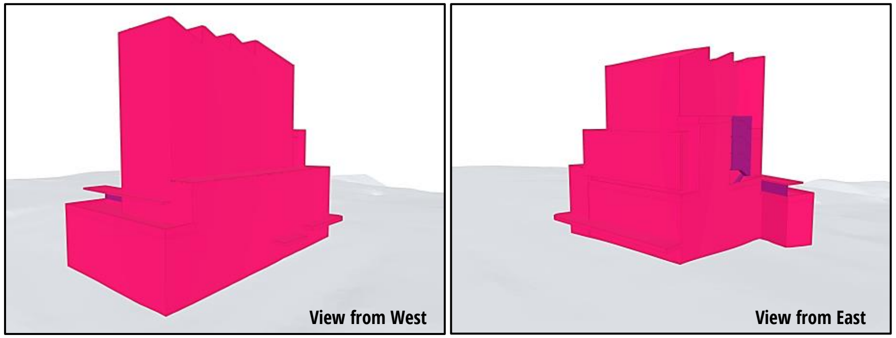


Image 1b: 3D Model of the Proposed Development

2. BACKGROUND AND METHODOLOGY

2.1 Objectives and Scope

The objective of this assessment is to provide an evaluation of the wind comfort conditions around the proposed development site. Predicting outdoor wind conditions is a complex process that involves the combined assessment of building geometry, orientation, position and height of surrounding buildings, upstream terrain and the local wind climate. Computational Fluid Dynamics is a useful tool for this as it not only combines the impact of these various parameters but can also provide a visual reference for the merits of a particular design of the building.

This analysis was, therefore, based on the following:

- A review of the regional long-term meteorological data.
- Use of the Orbital Stack Direct, an in-house CFD tool, to provide numerical estimation of potential wind conditions around the site for the prevailing winds. The simulation models have been based on the drawings and information received by RWDI between March and July 2024.
- Our engineering judgement, experience, and expert knowledge of wind flows around buildings including wind tunnel studies and CFD assessments undertaken for similar projects in the region.

Note that other microclimate issues such as those relating to cladding and structural wind loads, door operability, building air quality, noise, vibration, etc. are not part of the scope of this assessment.

2.2 CFD in Urban Wind Modelling

CFD is a numerical technique that can be used for simulating wind flows in complex environments. For this analysis, CFD techniques were used to generate a virtual wind tunnel where flows around the site and its surroundings were simulated in full scale. The computational domain that covered the site and its surroundings was divided into millions of small cells where calculations were performed, yielding a prediction of wind conditions across the entire study domain. CFD excels as a tool for wind modelling, presenting early design advice, comparing different design and site scenarios, resolving complex flow physics, and helping diagnose problematic wind conditions.

While the computational modelling method used in the current assessment does not explicitly simulate the transient behaviour of turbulent wind, its effects were estimated based on other calculated quantities. RWDI has found this approach to be appropriate for the assessment of typical wind comfort conditions. Wind safety issues, which relate to transient, higher-speed gusts, are discussed qualitatively, based on the CFD predictions and our extensive wind-tunnel experience for similar projects. In order to quantify the transient behaviour of wind and refine any conceptual mitigation measures, a more detailed assessment would be required using either boundary-layer wind tunnel or more detailed transient computational modelling.

2. BACKGROUND AND METHODOLOGY

2.3 Simulation Model

Wind flows were simulated using Orbital Stack, an in-house computational fluid dynamics (CFD) tool that has been validated using RWDI's historical wind tunnel test data and experience. Simulations have been carried out for the proposed configuration of site using massing models of the various buildings within the precinct (Images 2a and 2b). Note that stairs and landings along the western setback of the development were modelled as 50% permeable to account for the web forge steel grating design. The porous mesh around the stairway was modelled with a porosity of 70%. For the purposes of this computational study, the 3D models were simplified to include only the necessary elements that are likely to affect the local wind flows in the area and around the site. Landscaping and other smaller architectural and accessory features were not included in the computer model in order to provide more conservative wind estimates.

2.4 Methodology

Select predominant wind directions were simulated accounting for the effects of the atmospheric boundary layer and terrain impacts. The wind field was assumed to be steady in time and, as such, the transient effects of strong wind gusts and vortex shedding was not included directly. Turbulence was modeled in the wind simulations by a Reynolds Averaged Navier-Stokes (RANS) approach using the k-epsilon (RNG) turbulence closure. These results were then combined with the meteorological data to determine the qualitative variation of wind speeds in the areas of concern (i.e., 1.5 m above local grade). These conditions were then assessed against the wind criteria for pedestrian comfort and the spaces were categorised accordingly.

Image 2a: Computer Model of the Proposed Development and Surrounding Context
(Top-down View)

2. BACKGROUND AND METHODOLOGY

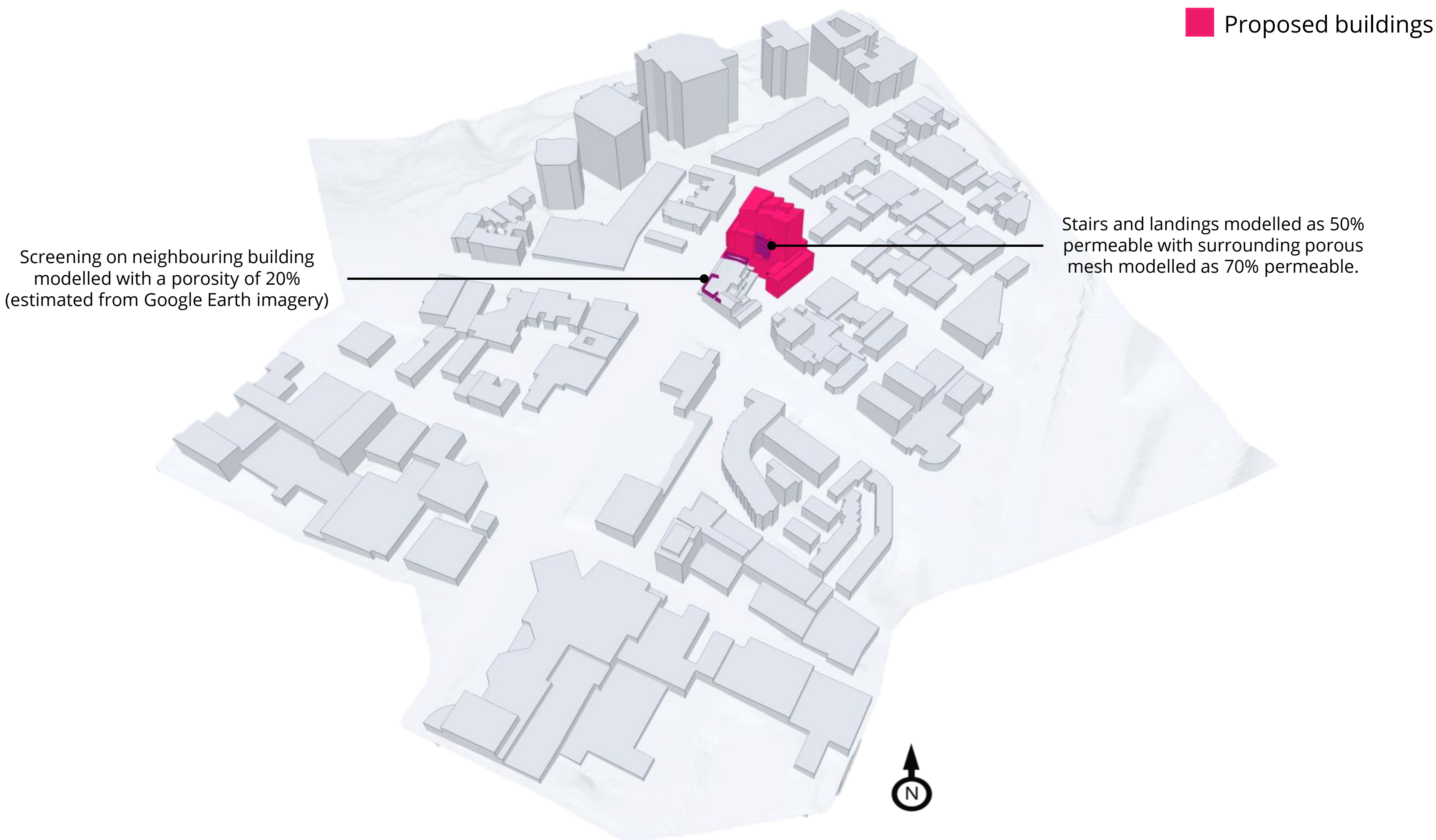


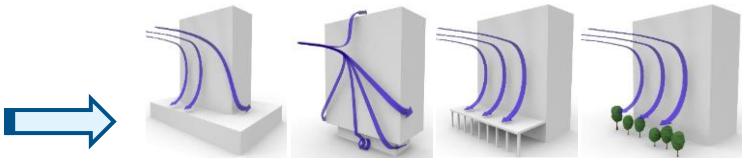
Image 2b: Computer Model of the Proposed Development and Surrounding Context
(Iso View)

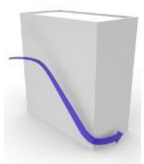
2. BACKGROUND AND METHODOLOGY

2.5 Factors Affecting Wind Flows

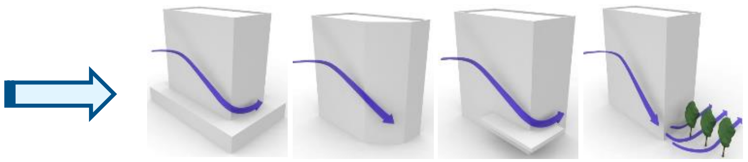
In our discussion of wind conditions in and around the proposed development, reference may be made to the following generalised wind flows (see Image 3). If these building / wind combinations occur for prevailing winds, there is a greater potential for increased wind activity and uncomfortable or potentially unsafe conditions. Design details such as setting back a tower from the edges of a podium for a prevailing wind direction, deep canopies close to ground level, wind screens / tall trees with dense foliage, etc. can help reduce high wind activity. The choice and effectiveness of these measures would depend on the exposure and orientation of the site with respect to the prevailing wind directions and the size and massing of the proposed buildings.

Downwashing
Tall buildings tend to intercept the stronger winds at higher elevations and redirect them to the ground level. This is often the main cause for wind accelerations around large buildings at the pedestrian level.





Corner Acceleration
Winds approach at an oblique angle to a tall façade and are deflected down causing a localised increase in the wind activity or corner acceleration around the exposed building corner(s) at pedestrian level.



Channelling
When two buildings are situated side by side or an underpass is created, wind flow tends to accelerate through the space due to channeling effect caused by the narrow gap.

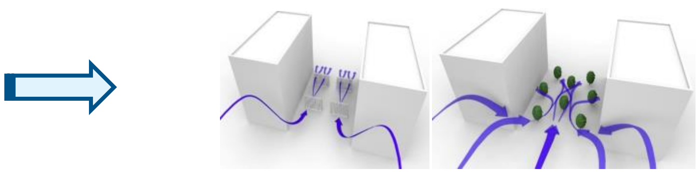
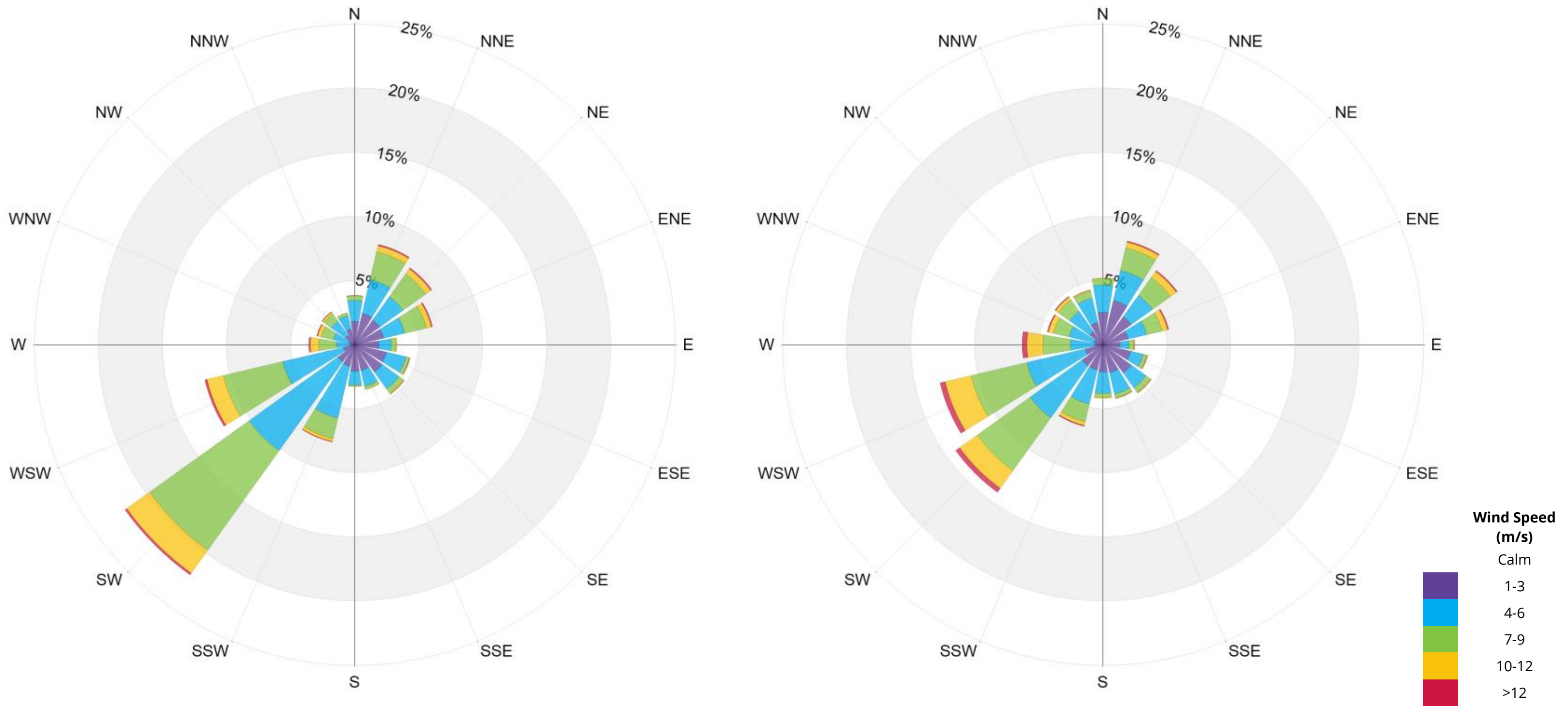


Image 3: General Wind Flow around Buildings with Examples of Common Wind Measures

3. METEOROLOGICAL DATA

Meteorological data recorded at Auckland International Airport from 1999 to 2019 were analysed and used as a reference for wind conditions in the study area. Image 3 graphically depicts the directional distributions of wind frequencies and speeds for the summer (Nov-Apr) and winter (May-Oct) seasons. The observation site is situated approximately 17 km to the south of the project site and therefore is representative of the local wind climate at the site. Winds from the southwest and northeast directions are predominant in both summer and winter seasons as indicated by the wind roses. Strong winds typically frequent from the southwest direction with secondary winds from the northeast directions.



Summer (Nov - Apr) **Winter (May - Oct)**

Image 4: Directional Distribution of Winds Approaching Auckland International Airport
Recorded from 1999-2019

4. PEDESTRIAN WIND CRITERIA

An abridged version of the RWDI pedestrian wind comfort criteria are used in the current study. The wind comfort levels are categorised based on typical/intended pedestrian activity and are expressed in terms of their suitability for various levels of human activity. The categorisation, shown in Image 5, is based on conservative average wind speeds; higher the activity level, higher the wind speed one can typically tolerate while engaged in the activity. These criteria for wind forces represent average wind tolerance and can be subjective with regional differences in wind climate and thermal conditions as well as variations in age, health, clothing, etc. also impacting and individual's perception of the wind climate. Additionally, equivalent categories from the Auckland Unitary Plan are included for comparison. The RWDI Wind Criteria is similar to the controls proposed in Auckland Unitary Plan, both in terms of wind speeds and the probabilities of exceedance.

Professional judgement incorporating RWDI's experience of a large number of similar projects has been applied, informed by the CFD results, to identify areas within and around the proposed development that are likely to have instances of strong winds. Mitigation measures, in the form of landscaping and architectural elements, can be applied to improve pedestrian comfort conditions and to reduce the frequency of, or even eliminate, any strong winds. Note the wind safety conditions are assessed qualitatively using the available information from the CFD studies.

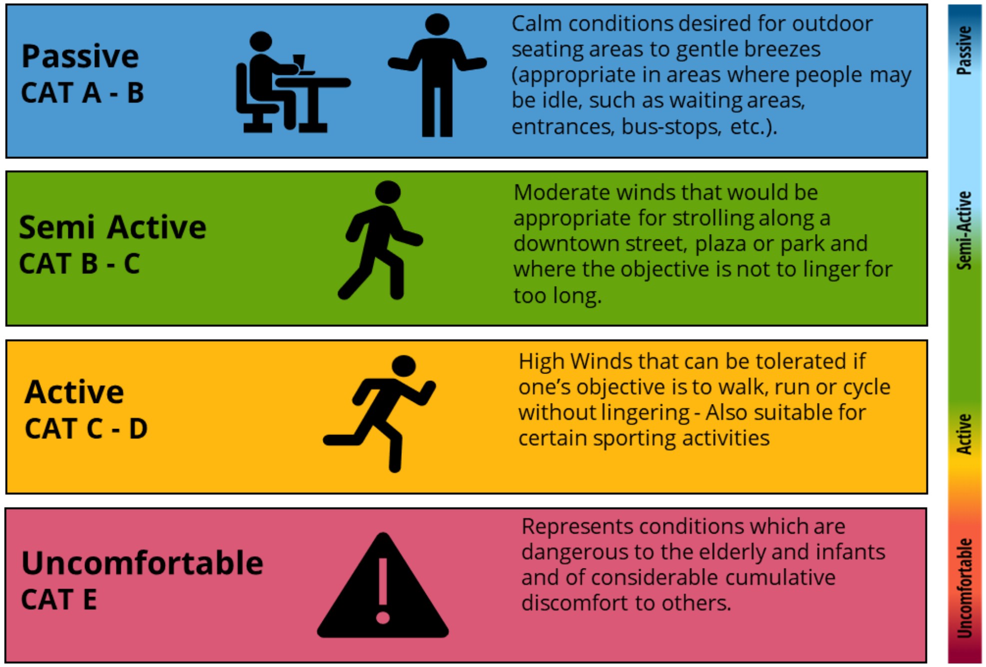


Image 5: Pedestrian Wind Comfort Criteria and Scale

5. RESULTS AND DISCUSSIONS

The following pages present the results of the pedestrian wind comfort study for the site. Pedestrian wind comfort results are presented for the averaged seasonal wind conditions for the ground level areas around the site. The full set of results, including the statistical average wind speeds (or ventilation potential) around the sites which indicate areas that may be more stagnant/breezy, streamlines for flow visualisation, etc. can be accessed via the OrbitalStack platform at: 538 Karangahape Road | OrbitalStack. Please contact support@orbitalstack.com for further assistance to access the results.

The predicted wind comfort conditions on the ground level and public domain areas around the proposed development site are presented in Images 6a and 6b for the summer and winter seasons. The categories based on Auckland Unitary Plan are also provided in the images. Note that landscaping has not been included in the current round of simulations to present a conservative estimate of the site wind conditions. A summary of the wind comfort conditions is noted below:

- Wind conditions within and around the project site are generally comfortable for semi-active use at most, falling within Categories B and C as per the Unitary Plan. These conditions are characterised by moderate winds, making them suitable for leisure strolling or lingering for short durations.
- Wind conditions are expected to be calmer during the colder winter months which is beneficial from a thermal comfort standpoint.
- Areas along Karangahape Road front of the building are typically comfortable for semi-active use (Cat B – C), particularly under the proposed awning. However, areas further from the building, along the road, experience stronger winds (CAT C - D) due to the alignment of the road with prevailing southwest winds. High winds that are likely to exceed comfort criteria (CAT E) are expected near the neighboring building across the street during summers. It is important to note that this is likely an existing site condition and is not influenced by the proposed building.
- Areas along Gundry Street front of the proposed development are expected to be comfortable for long-duration uses. The primary entrance to the development along this front is also expected to be comfortable for its intended use. The proposed awnings on the ground level are strategically employed to mitigate wind acceleration effects due to winds from the northeast (see Image 7).
- Wind comfort conditions within the adjacent existing car park of the neighboring building are improved by the proposed setback in the building massing. This setback captures the primary southwest winds and reduces their overall impact on ground-level areas (see Image 7). As a result, wind conditions are expected to be comfortable for the intended use of the car park. Slightly higher winds (CAT C – D) are likely to occur at the southwest corner of the building due to corner acceleration effects. However, these conditions are still considered comfortable for the intended use of the space as a sidewalk.

5. RESULTS AND DISCUSSIONS

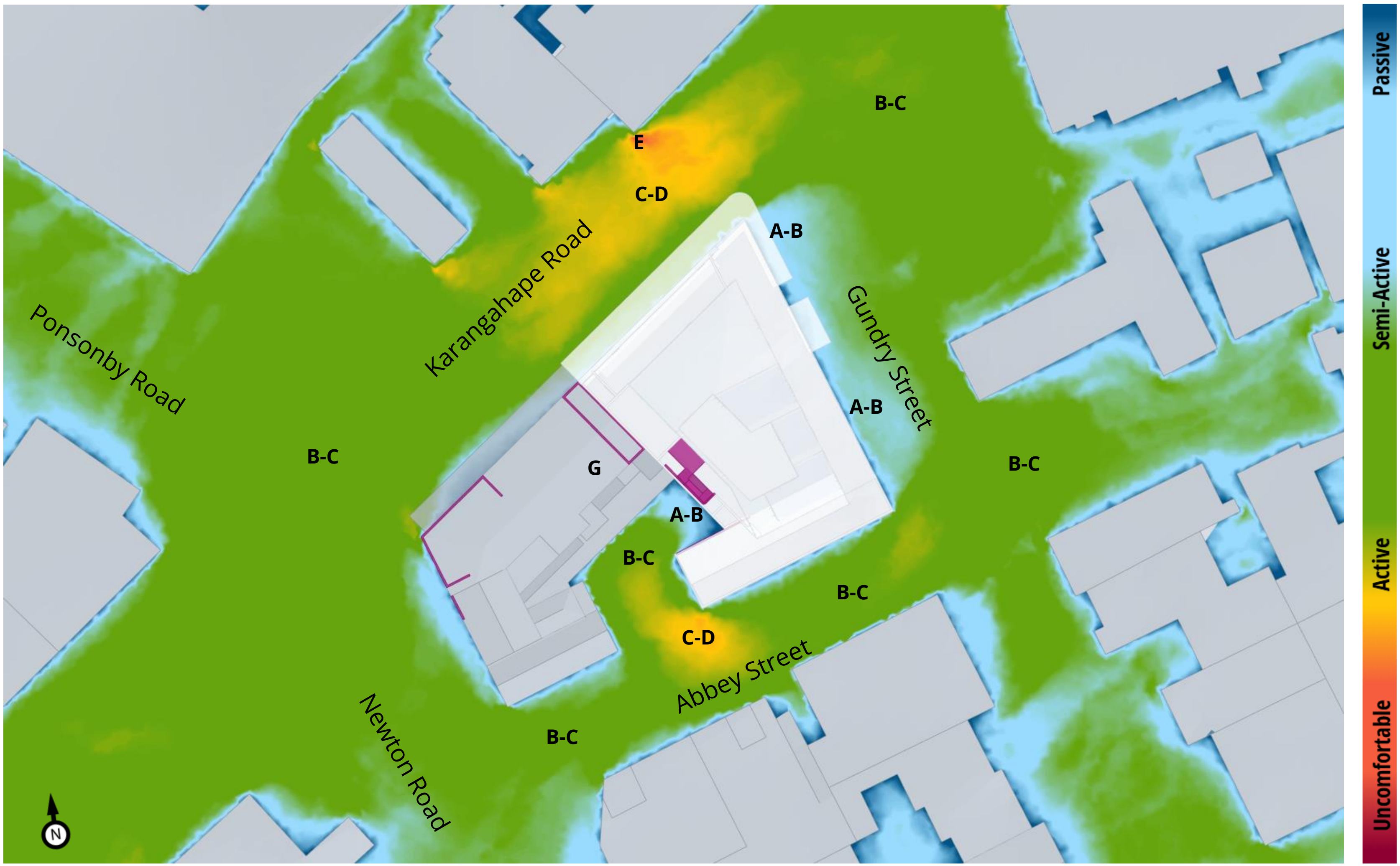


Image 6a: Expected Wind Comfort Conditions on the Ground Level and Public Domain during Summers
(Categories from Auckland Unitary Plan also Indicated)

5. RESULTS AND DISCUSSIONS

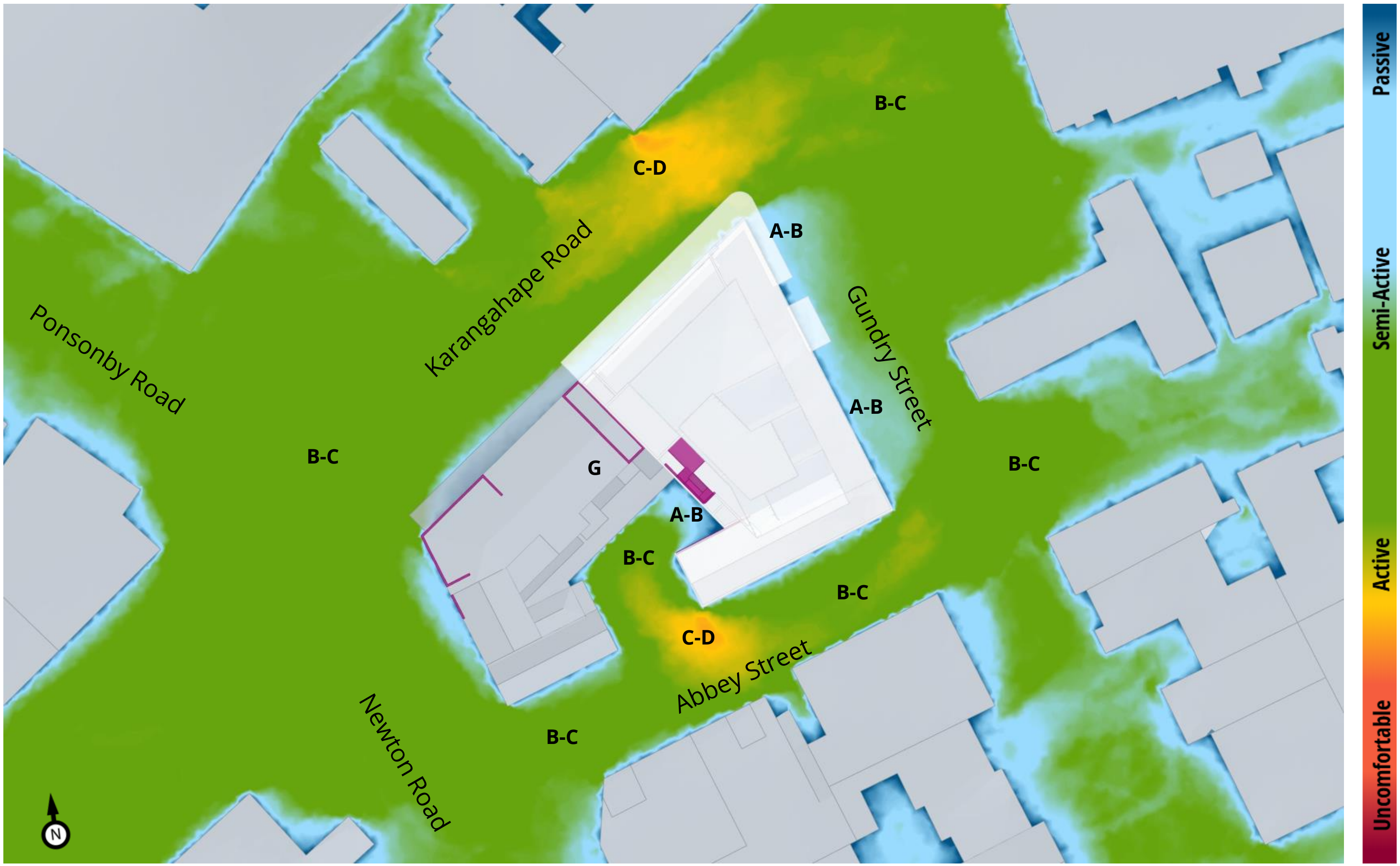


Image 6b: Expected Wind Comfort Conditions on the Ground Level and Public Domain during Winters
(Categories from Auckland Unitary Plan also Indicated)

5. RESULTS AND DISCUSSIONS

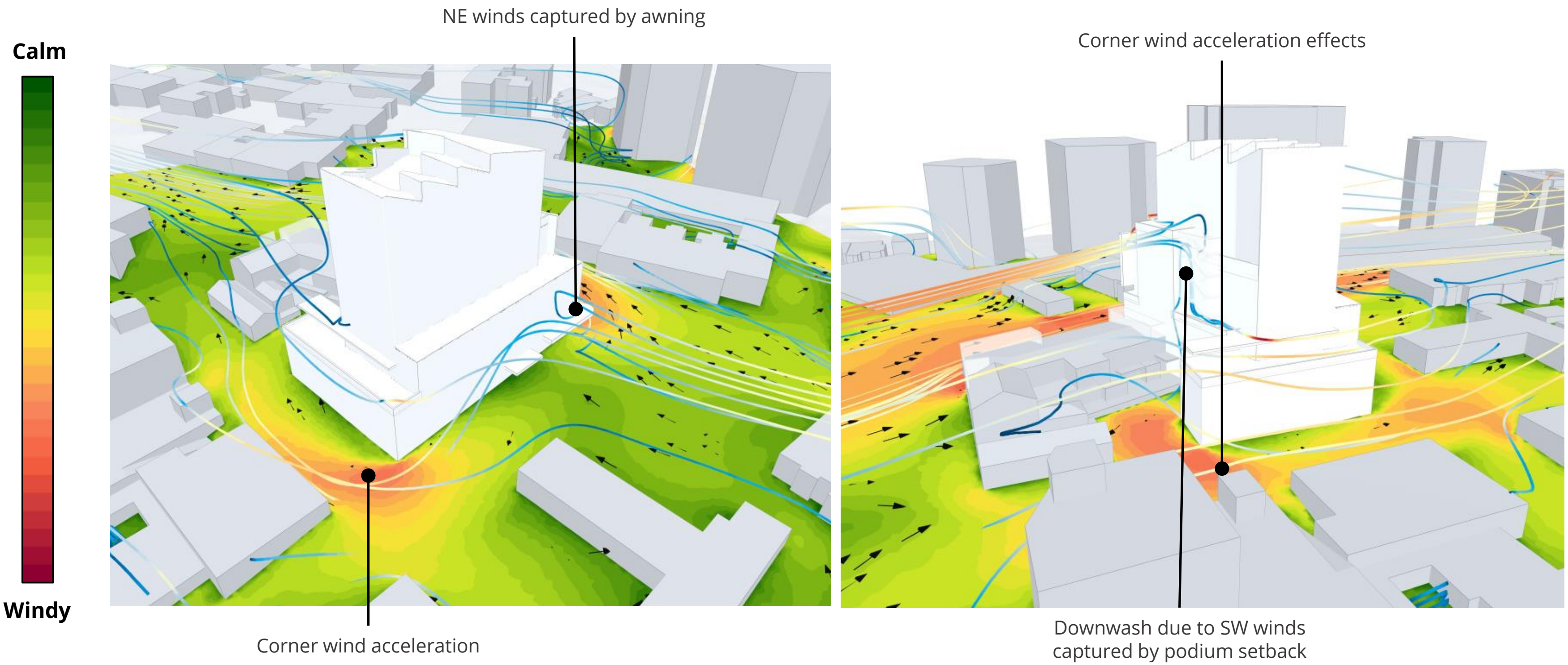


Image 7: Interaction of Prevailing Winds with Proposed Massing
Winds from 50° sector (Left) and 180° sector (right)

Note: Relative wind speeds and contours shown here are for informational purposes only and are not representative of the overall wind conditions at the site. The wind comfort conditions are evaluated using the probability of occurrence for all simulated directions and are shown in Images 6a and 6b.

6. SUMMARY AND LIMITATIONS

Wind conditions around the proposed development located at 538 Karangahape Road in Auckland, New Zealand are discussed in this report. This desktop-based review is based on the CFD analysis of the proposed massing of the buildings for the prevailing winds of the region using Orbital Stack. The wind comfort predictions indicate that the wind environment benefits from strategically placed awnings and setbacks along the eastern and western aspects of the development. Additionally, the design incorporates porosity within the western stairs and surrounding mesh which helps to maintain winds above ground level. As a result, wind comfort conditions within the public domain align well with the intended use of the various areas around the site and are expected to comply with Auckland Unitary Plan Standard H8.6.28 Wind. No further wind mitigation measures are necessary.

The findings of the report should be assessed based on the limitations listed below:

1. The analysis presented was based on the historical climate conditions for the region.
2. It is noted that the conditions presented herein depict statistical conditions for certain seasons. It would be prudent to be reminded that specific seasonal trends (e.g., a heatwave) would be expected to result in ambient conditions which could create longer durations of uncomfortable conditions. For a full assessment of comfort, thermal comfort studies can be undertaken
3. The effect of climate change (i.e., forward predictions of trends in meteorological conditions) has not been considered in the analysis. However, the use of the latest meteorological information should give some indication.
4. The CFD simulations were conducted using a steady-state analysis. This means that the wind speed predictions represent an 'average' of the expected conditions within and around the development. As such, RWDI would expect the comfort conditions to be more dynamic in reality than the 'static' images presented herein.
5. Gusts are an important part of the overall wind microclimate that can impact safety, and these have not been considered in the current assessment. A more detailed assessment would be required using either a boundary-layer wind tunnel or more detailed transient computational modelling to evaluate the gust response of the development as the design evolves.

7. APPLICABILITY OF ASSESSMENT

The assessment discussed in this report pertains to the proposed development in accordance with the drawings and information received between March and July 2024. In the event of any significant changes to the design, construction or operation of the building or addition of surroundings in the future, RWDI could provide an assessment of their impact on the wind conditions discussed in this report. It is the responsibility of others to contact RWDI to initiate this process.

Statement of Limitations

This report entitled "*538 Karangahape Road Wind Design Review*", dated 29 July 2024, was prepared by RWDI ("RWDI"). The findings and conclusions presented in this report have been prepared for the Client and are specific to the project described herein ("Project"). The conclusions and recommendations contained in this report are based on the information available to RWDI when this report was prepared.

Because the contents of this report may not reflect the final design of the Project or subsequent changes made after the date of this report, RWDI recommends that it be retained by Client during the final stages of the project to verify that the results and recommendations provided in this report have been correctly interpreted in the final design of the Project.

The conclusions and recommendations contained in this report have also been made for the specific purpose(s) set out herein. Should the Client or any other third party utilise the report and/or implement the conclusions and recommendations contained therein for any other purpose or project without the involvement of RWDI, the Client or such third party assumes any and all risk of any and all consequences arising from such use and RWDI accepts no responsibility for any liability, loss, or damage of any kind suffered by Client or any other third party arising therefrom.

Finally, it is imperative that the Client and/or any party relying on the conclusions and recommendations in this report carefully review the stated assumptions contained herein and to understand the different factors which may impact the conclusions and recommendations provided.