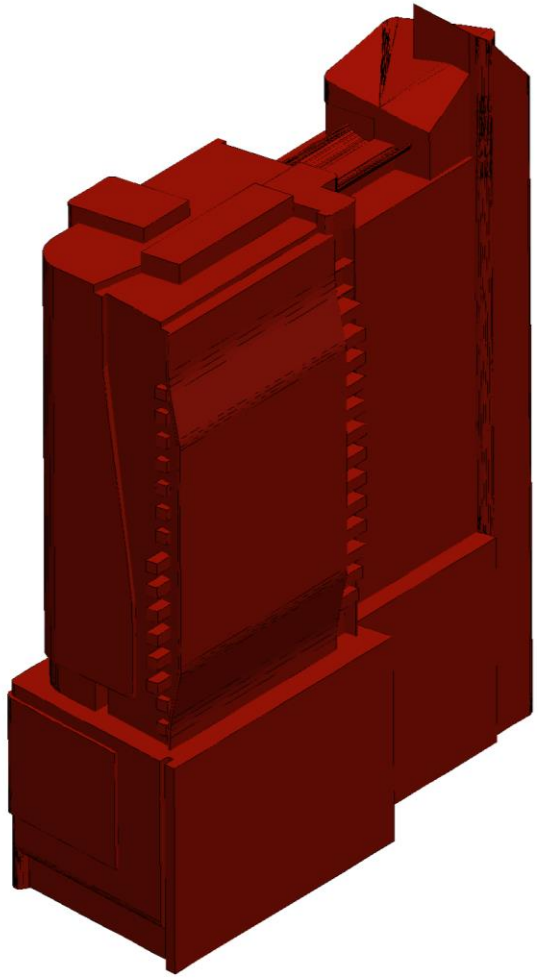
APPENDIX B

2270 BROADWAY PEDESTRIAN WIND REVIEW

2270 Broadway
Oakland, CA

Pedestrian Wind Review
RWDI # 1500437
February 11, 2015



SUBMITTED TO

David Delasantos, Architect
MBH Architects
2470 Mariner Square Loop
Alameda, CA 94501
Davidd@mbharch.com

SUBMITTED BY

Rowan Williams Davies & Irwin Inc.
650 Woodlawn Road West
Guelph, Ontario, Canada N1K 1B8
519.823.1311

Jesse Brydges, E.I.T.
Technical Coordinator
Jesse.Brydges@rwdi.com

Jon Barratt, P.Eng.
Project Manager
Jon.Barratt@rwdi.com

Ray Sinclair, Ph.D.
Vice President, Project Director
Ray.Sinclair@rwdi.com

1. Introduction

Rowan Williams Davies & Irwin Inc. (RWDI) was retained by MBH Architects to assess the pedestrian wind comfort and safety conditions for the proposed 2270 Broadway development in Oakland, California. The objective of this qualitative analysis was to estimate the pedestrian wind conditions around the proposed development. This assessment is based on the following:

- a review of regional long-term meteorological data for the Oakland area;
- the Sketchup model provided by MBH Architects and received by RWDI on October 29, 2014;
- our engineering judgment and knowledge of wind flows around buildings [1] [2];
- use of software developed by RWDI (*WindEstimator*[2]) for estimating the potential wind comfort conditions around generalized building forms;
- The use of RWDI's proprietary Computational Fluid Dynamics (CFD) software *Virtualwind*™ for visualizing wind flow patterns; and
- Use of both the City of Oakland Significant Wind Impact Criterion and the RWDI wind comfort and safety criteria.

In the absence of wind tunnel testing, this qualitative approach provides a screening-level estimation of potential wind conditions and identifies anticipated areas of accelerated wind speeds or areas of relative calm. To quantify the wind comfort conditions or refine any conceptual wind control measures, physical scale model tests in a boundary layer wind tunnel facility can be carried out at a later date. Note that other wind issues, such as those relating to cladding and structural wind loads, door pressures, stack effect, exhaust re-entrainment, etc. are not considered in the scope of this assessment.

[1] C.J. Williams, H. Wu, W.F. Waechter and H.A. Baker (1999). "Experience with Remedial Solutions to Control Pedestrian Wind Problems". *10th International Conference on Wind Engineering*. Copenhagen, Denmark.
[2] H. Wu, C.J. Williams, H.A. Baker and W.F. Waechter (2004). "Knowledge-based Desk-Top Analysis of Pedestrian Wind Conditions". ASCE Structure Congress 2004. Nashville, Tennessee.

2. Building and Site Information

The project site, currently a parking lot, is bound by Broadway to the west, 23rd Street to the north, Webster Street to the east and Grand Avenue to the south. The proposed development consist of a 25-story tower with an overall height of approximately 289 feet, including the spire on the east end of the building. The buildings surrounding the site are generally low to mid-rise to the west and north, with high-rise to the east and south. Beyond the immediate surroundings, low to mid-rise buildings prevail with San Francisco Bay to the west and mountains to the east.

All reference to wind directionality and locations around the study site are based on true north, as indicated below.

Pedestrian areas on and around the development include building entrances, drop-off areas, sidewalks, terraces and rooftop gardens.

Geographic Location of the Propose Development, Courtesy of *Google Earth*™

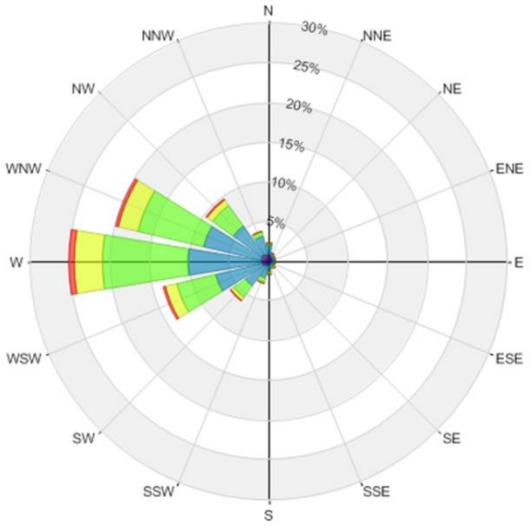
3. Meteorological Data

Meteorological data from the Metropolitan Oakland International Airport for the period of 1980 to 2012 were used as reference for wind conditions in the region.

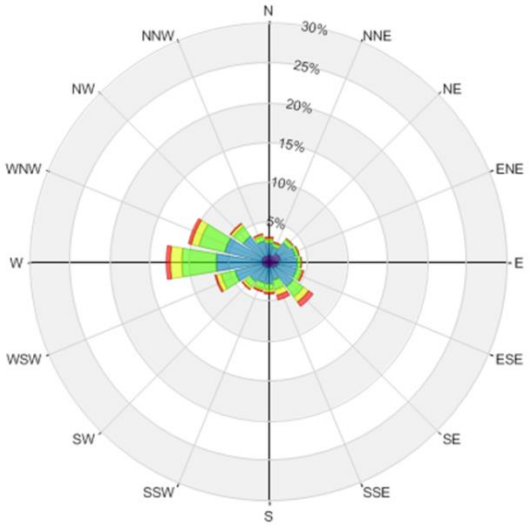
The distributions of wind frequency and directionality for summer (May through October) and winter (November through April) seasons are shown in the wind roses to the right. Winds from the west-southwest through northwest directions are predominant in both seasons, with secondary winds from the southeast also prevalent during the winter. Strong winds of a mean speed greater than 20 mph measured at the airport (red bands) occur more often in the winter (3.4%) than the summer (1.8%). These strong winds could potentially be the source of uncomfortable or even severe wind conditions, depending upon the site exposure or development design.

Based on the local wind directionality and the orientation of the buildings and streets in the area, winds from the **west and west-northwest** were selected for the *Virtualwind*™ simulations. Simulating these wind directions will provide the most representative wind impacts on pedestrian areas.

Wind Speed (mph)	Probability (%) Summer	Winter
Calm	8.3	14.2
1-5	10.1	15.1
6-10	39.1	40.9
11-15	31.3	19.6
16-20	9.5	6.9
>20	1.8	3.4



Summer Winds
(May – October)



Winter Winds
(November – April)

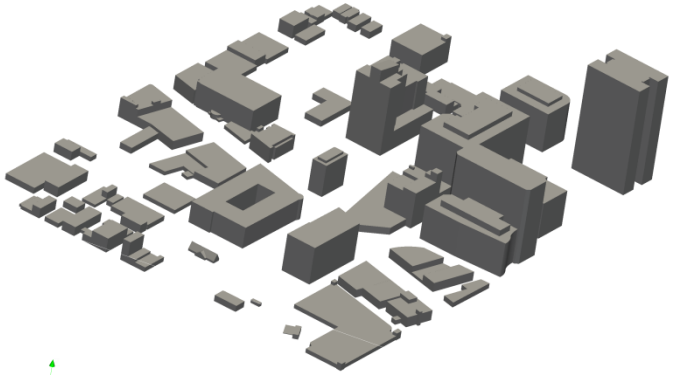
Directional Distribution (%) of Winds (Blowing From) the Metropolitan Oakland International Airport (1980 – 2012)

4. Computer Model

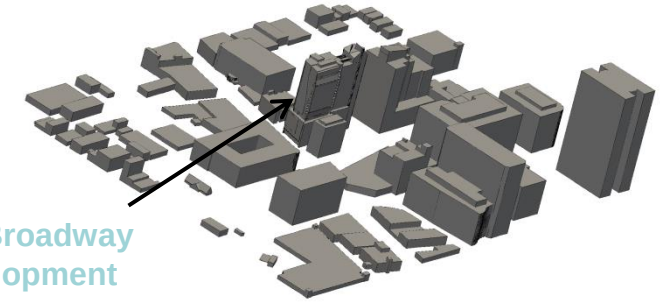
Wind flows around the proposed development and its surroundings were simulated using *Virtualwind*™, which is a proprietary software developed by RWDI for the qualitative assessment of pedestrian wind conditions. The prevailing winds from the west and west-northwest were simulated for the 2270 Broadway project.

Three configurations were simulated in *Virtualwind*™; the Existing Configuration, Proposed Configuration and a Future Configuration. As shown in the images below, the *Virtualwind*™ models included all relevant surrounding buildings with sufficient massing details that would affect wind flows in the area of the 2270 Broadway site. It is worth noting that landscaping was not considered at this stage of the assessment.

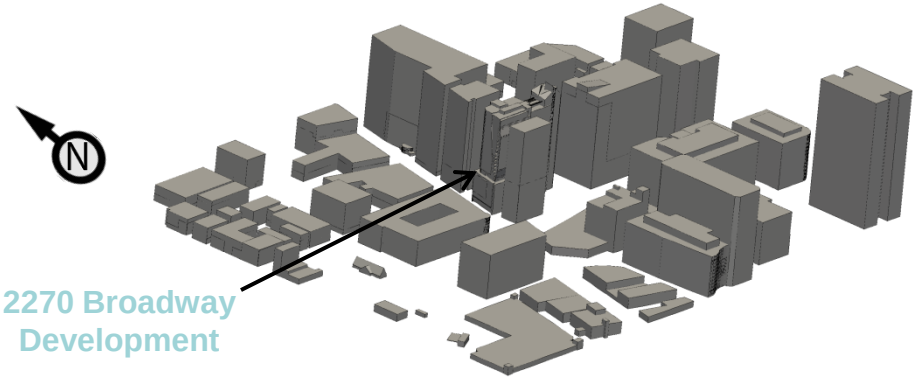
The Future Configuration is based on the maximum allowable heights in the surrounding Broadway Valdez District, as detailed by the Existing and Proposed Draft Zoning and Height Area Maps (Appendix A).



Computer Model of the Existing Configuration Including Existing Project Site and the Existing Surroundings



Computer Model of the Proposed Configuration Including the 2270 Broadway Development and Existing Surroundings



Computer Model of the Future Configuration Including the 2270 Broadway Development and Maximum Allowable Zoning Heights of the Surrounding Buildings

5. Wind Criteria

The predicted wind conditions around the project have been compared to both the City of Oakland Significant Wind Impact Criterion and the RWDI wind comfort and safety criteria.

5.1 City of Oakland Significant Wind Impact Criterion

The City of Oakland considers a significant wind impact to occur if a project were to "create winds exceeding 36 mph for more than one hour during daylight hours during a year". A wind analysis only needs to be done if the project's height is 100 feet or greater (measured to the roof) and one of the following conditions exists: (a) the project is located adjacent to a substantial water body (i.e., Oakland Estuary, Lake Merritt, or San Francisco Bay); or (b) the project is located in Downtown. Since the proposed project exceeds 100 feet in height and is located in Downtown, it is subject to the thresholds of significance.

5.2 RWDI Wind Comfort and Safety Criteria

The RWDI wind comfort criteria deal with both pedestrian safety and comfort, as they relate to the force of the wind. Thermal effects (e.g., temperature, humidity, sun/shade, wind chill in cold regions, etc.) are not considered in these comfort criteria. These criteria, developed by RWDI through research and consulting practice since 1974, have been published in numerous academic journals and conference proceedings. They have also been widely accepted by municipal authorities as well as by the building design and city planning community. RWDI's criteria have been used in over 2500 pedestrian wind projects and adopted as part of environmental planning guidelines by several major cities around the world. The pedestrian wind comfort criteria used in this assessment are categorized by four typical pedestrian activities:

Sitting: Calm or light breezes desired for outdoor restaurants and seating areas where one can read a paper without having it blown away.

Standing: Gentle breezes suitable for main building entrances and bus stops.

Strolling: Moderate winds that would be appropriate for window shopping and strolling along a downtown street, plaza or park.

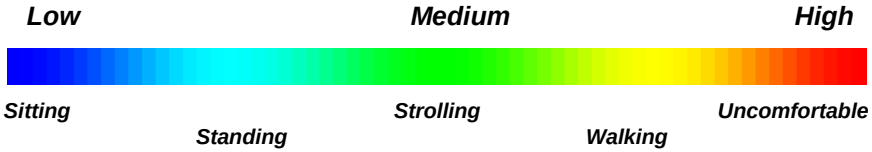
Walking: Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering.

Wind conditions are considered suitable for sitting, standing, strolling or walking if the appropriate wind speeds are expected for at least four out of five days (80% of the time). An **uncomfortable** designation means that the criterion for walking is not satisfied.

Safety is also considered by the criteria and is associated with excessive gust wind speeds that can adversely affect a pedestrian's balance and footing. If winds sufficient to affect a person's balance occur more than 0.1% of the time, the wind conditions are considered severe.

Wind control measures are typically required at locations where winds are rated as uncomfortable or they exceed the wind safety criterion. While safety exceedances are not specifically illustrated within *Virtualwind*™, they are most often accompanied by high mean wind speeds, meaning that uncomfortable categorizations can potentially exceed the criteria used to assess safety. To provide more refinement in relation to potential exceedances, a wind tunnel study would have to be employed.

In the *Virtualwind*™ simulations, the color of dark or light blue represents low wind speed areas comfortable for sitting or standing; green indicates medium wind speeds comfortable for strolling, and yellow regions are associated with higher winds speeds comfortable for walking. The red regions are associated with the highest wind speed that may not be suitable for pedestrian usage.



These comfort conditions are approximate and intended for reference; to determine overall wind comfort for an area, all wind directions need to be taken into consideration.

Where applicable, reference to the wind performance standards established in the City of Oakland Significant Wind Impact Criterion, which is outlined in the Broadway-Valdez Specific Plan EIR, will be made.

Winds approaching from the west and west-northwest were simulated in *Virtualwind*™ for this study. The results of the CFD simulations are presented in the following images and provide a qualitative depiction of the mean wind speeds, representative of the overall wind comfort. The images are taken on a horizontal plane that is 5 ft above the concerned floor level. The effect of wind flows on pedestrian comfort are described and conceptual mitigation measures are suggested, where necessary.

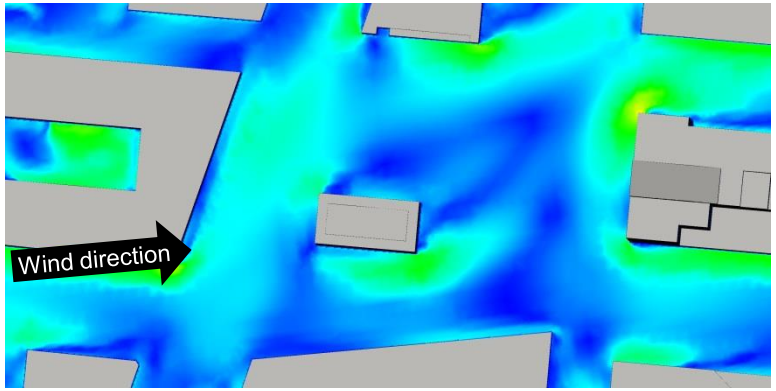
6. Results of Assessment – Overall Mean Wind Speeds

Overall, wind conditions for all simulated wind directions and building configurations are expected to meet both the City of Oakland Significant Wind Impact Criterion and the RWDI wind safety criterion. The following discussions focus on wind comfort levels for key pedestrian areas.

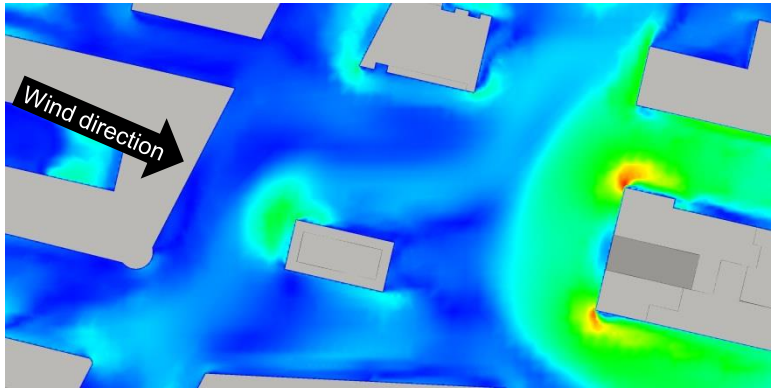
6.1 Grade Level - Existing Configuration

Wind conditions suitable for walking or strolling are typically considered appropriate for sidewalks and similar walkways at grade.

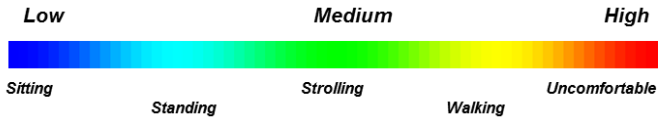
As shown in the images to the right, wind speeds in the existing configuration generally range from being comfortable for sitting to being comfortable for strolling in the vicinity of the proposed development. The 80 Grand Avenue building to the south of the site provides protection from the westerly winds that are channeled along Grand Ave. However, higher wind speeds, comfortable for strolling, occur at the southwest end of the site as a result of the westerly winds being redirected down the façade of the existing building. The existing building to the east currently experiences potentially uncomfortable wind speeds due to the exposure to the westerly winds, but these conditions are expected to satisfy both wind safety criteria.



Mean Wind Speeds – West Winds



Mean Wind Speeds – West-Northwest Winds

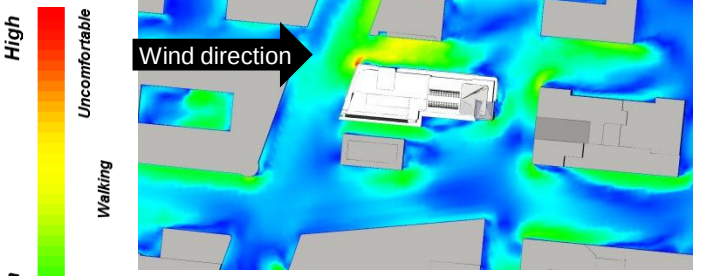


6.2 Grade Level - Proposed Configuration

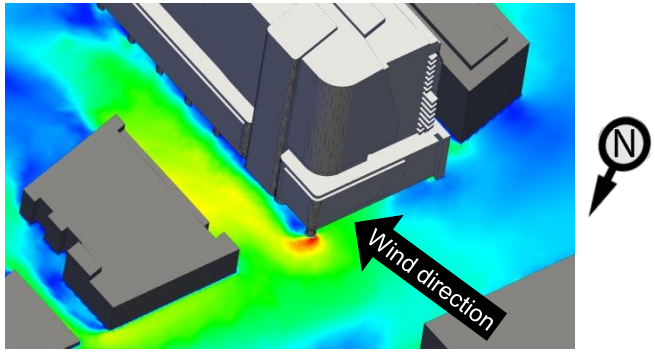
As previously mentioned, wind speeds suitable for walking or strolling are appropriate for sidewalks. Lower wind speeds conducive to standing or sitting are preferred at main entrances and drop-off areas where pedestrians are apt to linger. Various building entrances will be located on the north, west and east sides of the 2270 Broadway building. A drop-off area is also proposed underneath the development.

Wind speeds comfortable for walking or better or anticipated for the majority of grade level areas for the Proposed Configuration. These speeds are considered appropriate for the sidewalks and open lots around the development, but may be considered undesirable at the entrances of the building. It is worth noting that the drop-off area beneath the building is expected to be comfortable for sitting, and thus will be appropriate for entrances. Higher wind speeds are expected around the northwest corner of the building where winds from the west quadrant will be downwashed and accelerate around the northwest building corner (see explanations below). These localized flow accelerations are expected to result in potentially uncomfortable wind conditions in the vicinity of the northwest building corner, particularly during strong wind events. The areas to the south of the proposed building adjacent to the existing 80 Grand Avenue building are expected to be generally comfortable for strolling or better, which is considered appropriate as there are no primary entranced proposed in these areas. No safety exceedances are anticipated, and the wind speeds will meet the City of Oakland Significant Wind Impact Criterion, which is outlined in the Broadway-Valdez Specific Plan EIR.

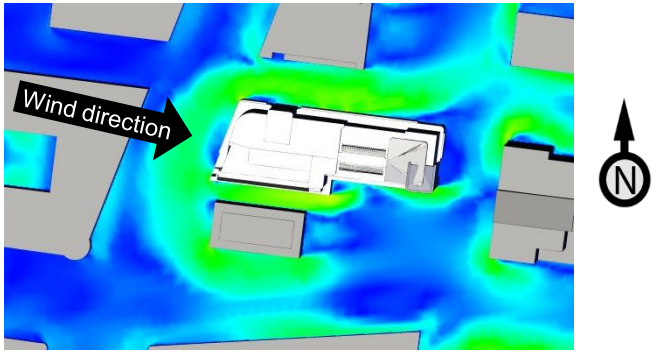
Should lower wind speeds be desired at the northwest corner to improve wind comfort, overhead canopies that extend at least 8 ft from the façade and wrap around the building corner are expected to be an effective means of keeping the accelerated winds elevated above the pedestrian areas. Windscreens and landscaping placed to the west of the building entrances at the northeast end on the tower will help reduce the wind speeds in these area, if desired. It is worth mentioning that the entrances on the west side of the building are anticipated to be sufficiently sheltered by the undercut along this façade, but further benefit can be achieved by extending a canopy (at least 6 ft) from this façade.



Mean Wind Speeds – West Winds

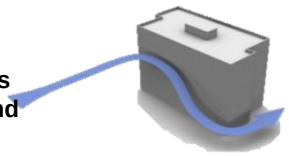


Mean Wind Speeds – Northwest Corner (West Winds)



Mean Wind Speeds – West-northwest Winds

Corner acceleration **occurs when large facades intercept winds and redirect them around building corners at higher speeds.**



Corner Acceleration

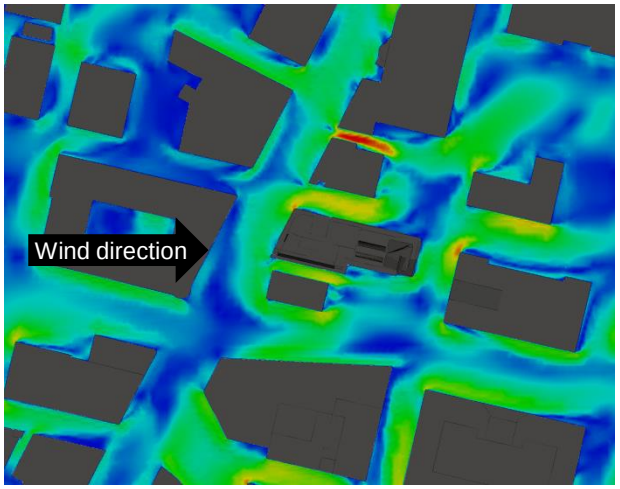
Downwashing

Downwashing **occurs when tall buildings intercept winds and redirect them downwards, resulting in higher speeds and is very common with large buildings.**

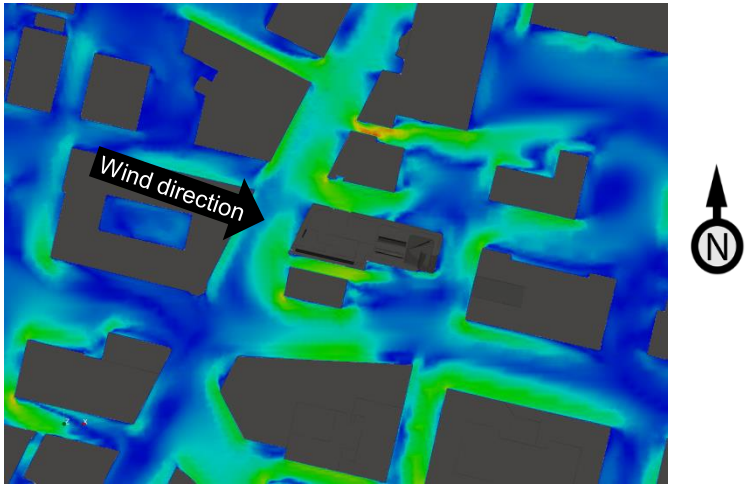
6.3 Grade Level - Future Configuration

The addition of the future surrounding buildings is anticipated to result in slightly calmer wind speeds around the 2270 Broadway building compared to the proposed configuration. This is largely a result of the sheltering provided by the taller surrounding buildings. However, similar to the proposed configuration, the entrances around the base of the building may have higher than desired wind speeds. If desired, the improvement measures recommended for the proposed configuration are expected to remain effective. The wind speeds in the drop-off area beneath the building are expected to remain comfortable for sitting.

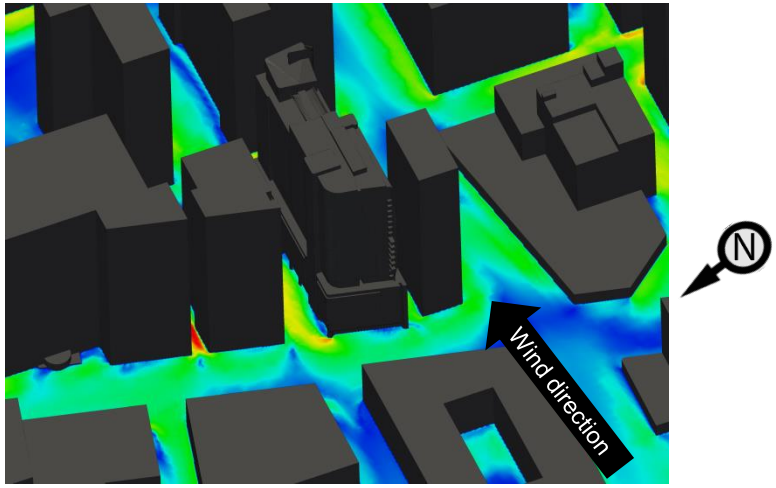
Similar to the Proposed Configuration, the winds speeds at grade are expected to meet the criteria used to assess safety, and the wind activity will meet the City of Oakland Significant Wind Impact Criterion, which is outlined in the Broadway-Valdez Specific Plan EIR.



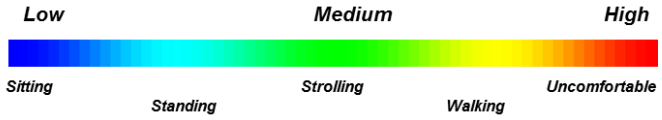
Mean Wind Speeds – West Winds



Mean Wind Speeds – West-northwest Winds



Mean Wind Speeds – Northwest Corner (West Winds)

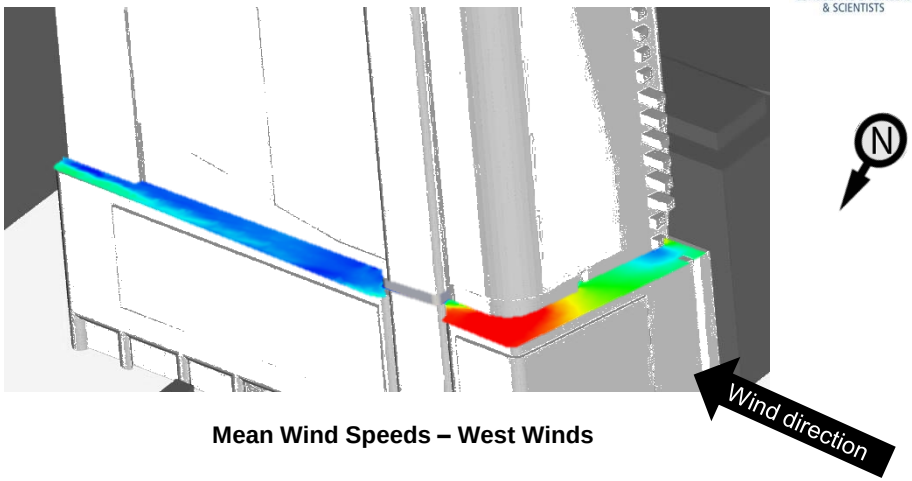


6.2 8th Floor Terrace – Proposed Configuration

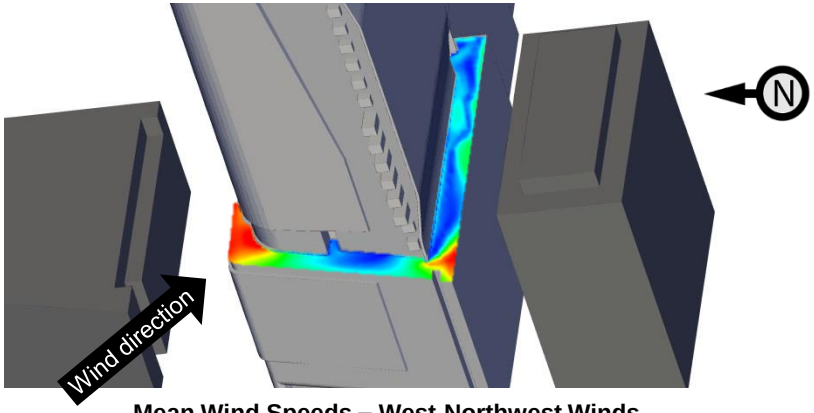
Ideally, wind speeds comfortable for sitting are desired on terraces.

Wind speeds on the 8th floor terrace are anticipated to range from being comfortable for sitting to being potentially uncomfortable, as shown in the images on this page. Similar to the wind flows at the northwest corner at grade level, winds are being downwashed and are accelerating around the northwest corner of this terrace level. Additionally, winds are accelerating over the edge of this terrace level and combining with the downwashed winds, resulting in high wind speeds.

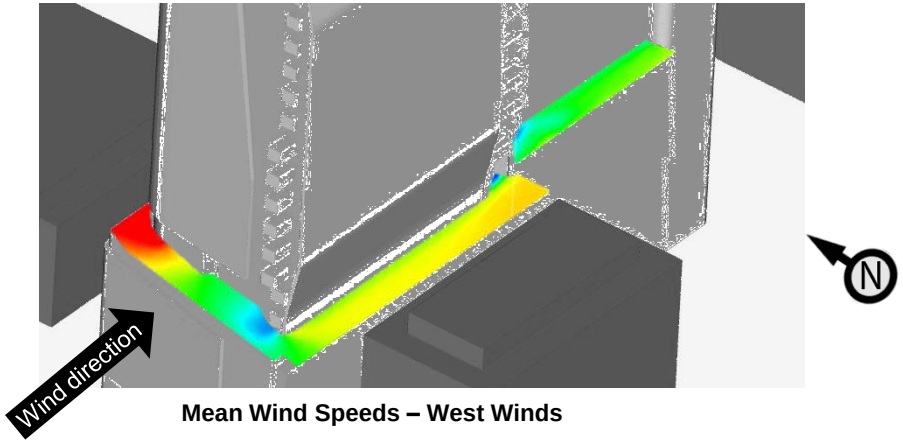
Lining this terrace level with parapets at least 6 ft tall will help offer pedestrians protection from horizontal winds and winds that are passing over the edge of this level, while implementing canopies (that extend to the edge of the building) at the northwest and southwest corners of this level will help reduce the impact of vertical winds. Partitions (screens, landscaping, etc.) along the south side of this terrace will help reduce the horizontal winds in this area.



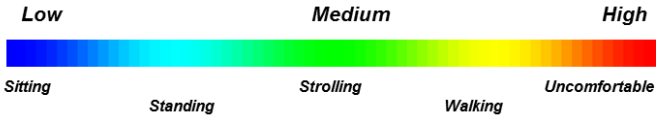
Mean Wind Speeds – West Winds



Mean Wind Speeds – West-Northwest Winds

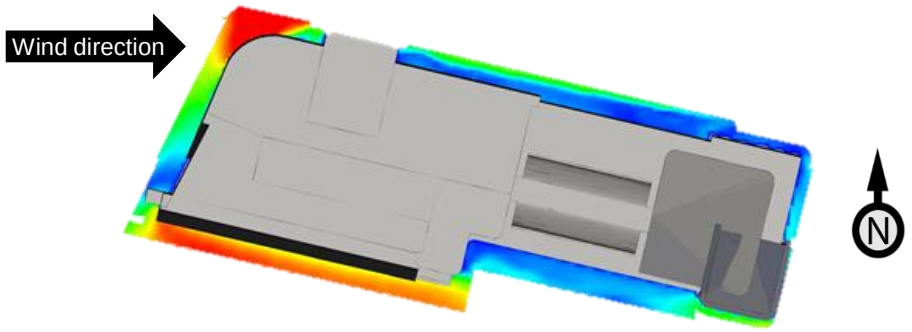


Mean Wind Speeds – West Winds

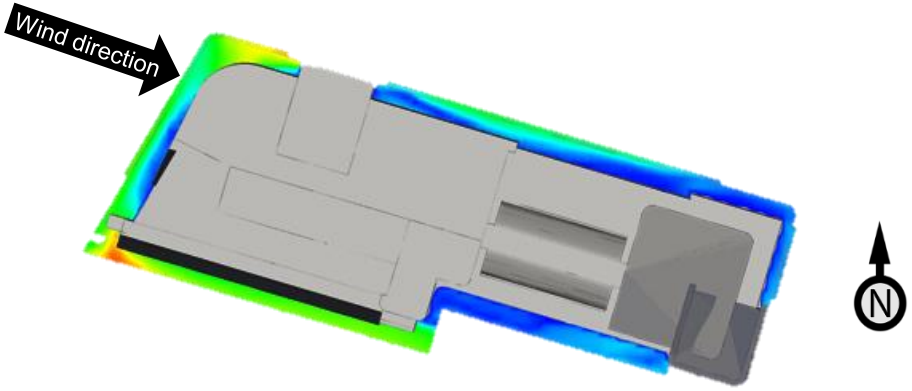


6.2 8th Floor Terrace – Future Configuration

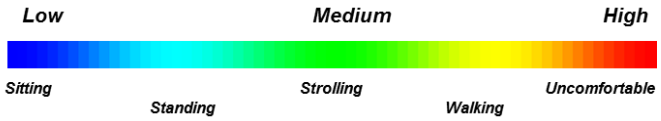
Overall, the wind speeds on the 8th floor terrace are anticipated to be similar to those in the Proposed Configuration with the addition of the future surrounding buildings. Slight increases in speeds are expected on the south side of the tower. The improvement measures previously mentioned are predicted to remain effective in reducing the overall wind speeds on this level.



Mean Wind Speeds – West Winds



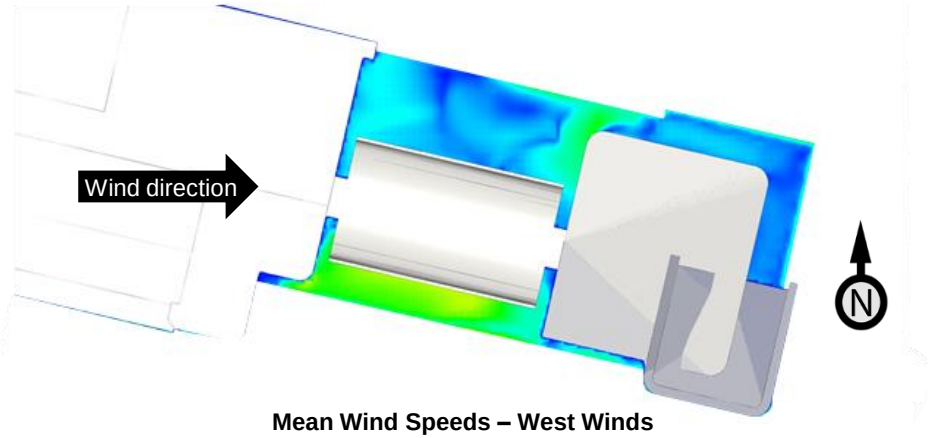
Mean Wind Speeds – West-Northwest Winds



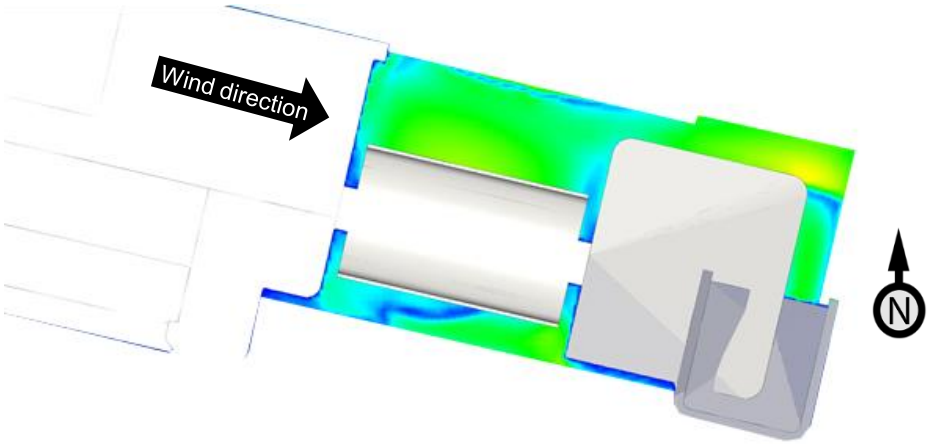
6.2 Rooftop Garden (24th Floor) – Proposed Configuration

Ideally, wind speeds comfortable for sitting and standing are desired on terraces and lounging areas, such as the rooftop garden on the 24th floor of the 2270 Broadway development.

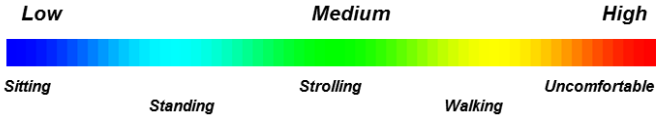
The wind speeds on the rooftop garden on the 24th floor are anticipated to be comfortable for sitting and standing and standing, with isolated areas potentially comfortable for strolling or walking. While the wind speeds comfortable for sitting and standing are considered appropriate for this area, the wind speeds comfortable for strolling and walking are slightly higher than desired for areas above grade. Parapets of at least 6ft high surrounding the 24th floor will help reduce the wind speeds across this level.



Mean Wind Speeds – West Winds



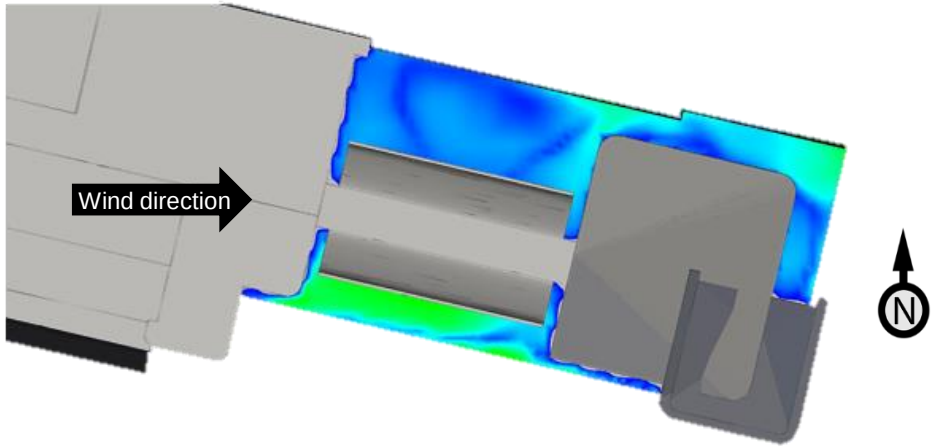
Mean Wind Speeds – West-Northwest Winds



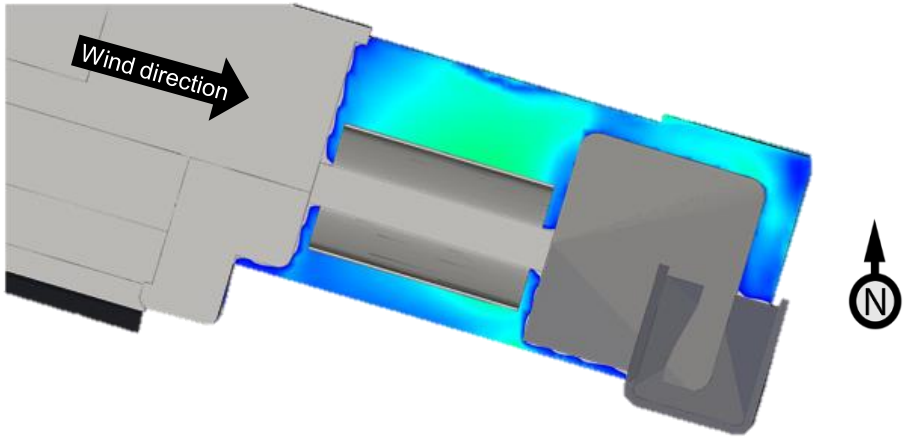
6.2 Rooftop Garden (24th Floor) – Future Configuration

Overall, the rooftop garden in the Future Configuration is expected to be similar to Proposed Configuration. Slight reductions in wind speeds were noted across this level when compared to the Proposed Configuration, and is likely a result of the added sheltering from the adjacent buildings to the north and south.

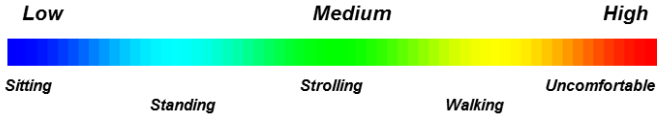
The recommendations previously mentioned in the Proposed Configuration will also help reduce the wind speeds on this level.



Mean Wind Speeds – West Winds



Mean Wind Speeds – West-Northwest Winds



7. Summary

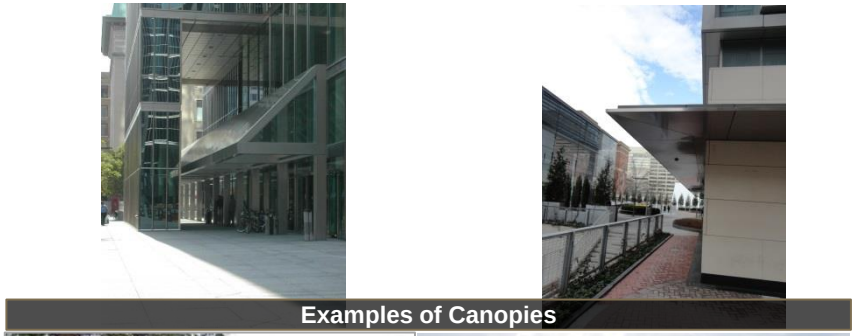
A qualitative analysis was conducted to estimate the pedestrian wind conditions around the 2270 Broadway development. Two significant wind directions, west and west-northwest, were simulated in this assessment and the resulting wind conditions were predicted.

Overall, suitable wind comfort conditions and no safety exceedances are anticipated at grade level. The wind activity on this level is also expected to meet the City of Oakland Significant Wind Impact Criterion, which is outlined in the Broadway-Valdez Specific Plan EIR.

The entrances along the north side of the building may experience slightly higher than desired wind speeds during high wind events, and the northwest corner of the building is anticipated to experience localized winds that are potentially uncomfortable. To improve wind comfort, the wind speeds at the northwest corner can be lowered by implementing an overhead canopy that extends at least 8 ft from the façade and that wraps around this corner, while the entrances on the north side of the building will benefit from landscaping or wind screens installed to the left of these features. For further benefit to the entrances on the west side of the building, canopies that extend at least 6 ft from the façade can be installed above the colonnade on the west side. Please note that all wind treatment suggestions are made in the interest of improving comfort only and are not required to achieve satisfaction of the City of Oakland Significant Wind Impact Criterion.

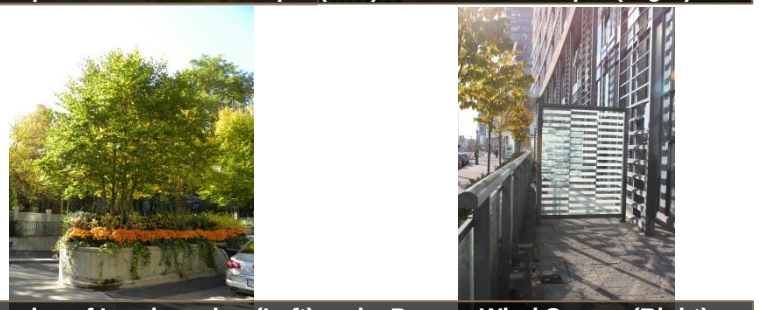
Isolated areas of higher than desired wind speeds are predicted on the 8th floor terrace. Lower wind speeds can be achieved by implementing parapets of at least 6 ft tall around this level, canopies that extend to the edge of the terrace at the northwest and southwest corners and partitions in the form of landscaping or screens on the south side of the terrace, in order to improve wind comfort.

The rooftop garden on the 24th floor is predicted to be comfortable primarily for sitting and standing, however the isolated areas where wind speeds are expected to be comfortable for strolling can be improved by implementing parapets of at least 6 feet tall around this area. Examples of the wind control features described in the report are shown on the right.



Examples of Canopies

Examples of a Porous Parapet (Left) and a Solid Parapet (Right)

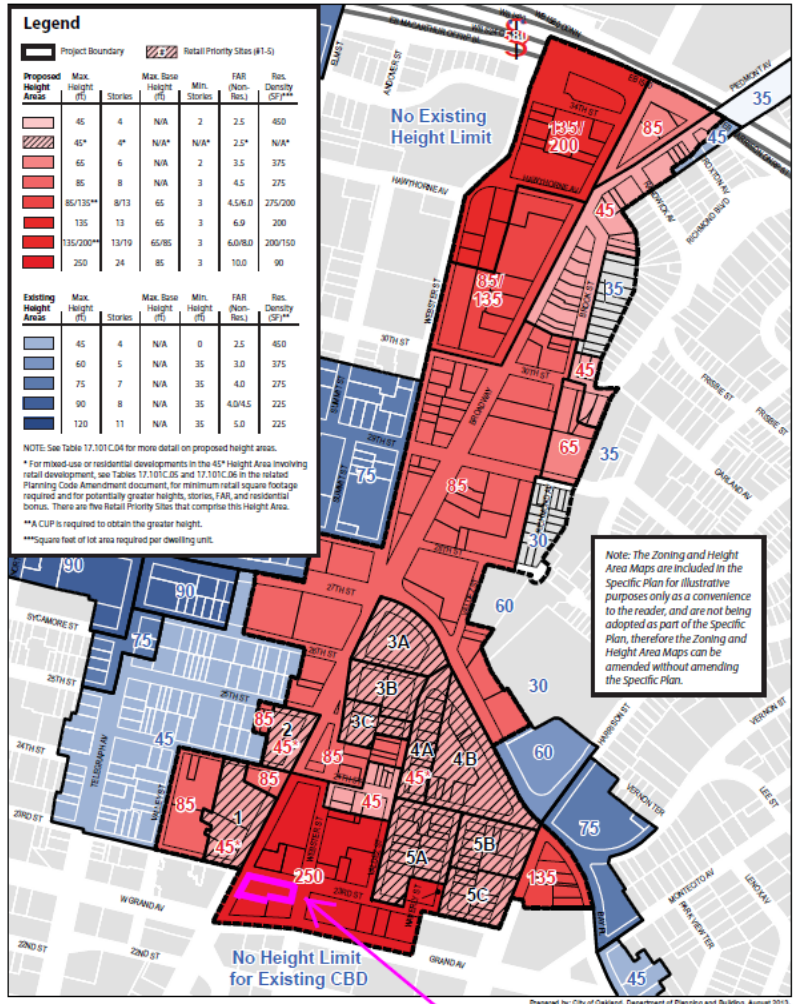


Examples of Landscaping (Left) and a Porous Wind Screen (Right)

8. Applicability of Results

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 design considered in this report. It is the responsibility of others to contact RWDI to initiate this process. If desired, the effectiveness of the wind treatment measures recommended within the report can be confirmed through a separate wind tunnel study.

Appendix A


Legend
Project Boundary
Retail Priority Sites (#1-5)
Proposed Height Areas
Max. Height (ft)
Stories
Max. Base Height (ft)
Min. Stories
FAR (Non-Res.)
Res. Density (SF)***
45
4
N/A
2
2.5
450
45*
4*
N/A*
N/A*
2.5*
N/A*
65
6
N/A
2
3.5
375
85
8
N/A
3
4.5
275
85/135**
8/13
65
3
4.5/6.0
275/200
135
13
65
3
6.9
200
135/200**
13/19
65/85
3
6.0/8.0
200/150
250
24
85
3
10.0
90
Existing Height Areas
Max. Height (ft)
Stories
Max. Base Height (ft)
Min. Height (ft)
FAR (Non-Res.)
Res. Density (SF)**
45
4
N/A
0
2.5
450
60
5
N/A
35
3.0
375
75
7
N/A
35
4.0
275
90
8
N/A
35
4.0/4.5
225
120
11
N/A
35
5.0
225
NOTE: See Table 17.101C.04 for more detail on proposed height areas.
* For mixed-use or residential developments in the 45* Height Area involving retail development, see Tables 17.101C.05 and 17.101C.06 in the related Planning Code Amendment document, for minimum retail square footage required and for potentially greater heights, stories, FAR, and residential bonus. There are five Retail Priority Sites that comprise this Height Area.
**A CUP is required to obtain the greater height.
***Square feet of lot area required per dwelling unit.
No Existing Height Limit
Note: The Zoning and Height Area Maps are included in the Specific Plan for illustrative purposes only as a convenience to the reader, and are not being adopted as part of the Specific Plan, therefore the Zoning and Height Area Maps can be amended without amending the Specific Plan.
No Height Limit for Existing CBD
2270 Broadway
Broadway Valdez District Specific Plan
Proposed Height Areas
FIGURE B.4: PROPOSED HEIGHT AREAS
0
300
600
ft
N
BROADWAY VALDEZ DISTRICT SPECIFIC PLAN | B5