APPENDIX C: WIND

C.a: Pedestrian Wind Study, Parkmerced Project EIR
RWDI, November 18, 2009

C.b: Wind Impacts and Mitigation from the Proposed Parkmerced Project
Memorandum from Donald Ballanti, November 19, 2009

C.c: Revised Building Heights/Footprints for the Parkmerced Project
Memorandum from Donald Ballanti, November 9, 2009

REVISED FINAL REPORT

PEDESTRIAN WIND STUDY
PARKMERCED PROJECT EIR
SAN FRANCISCO, CALIFORNIA

Project Number: #1010052 **November 18, 2009**

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1. INTRODUCTION

Rowan Williams Davies & Irwin Inc. (RWDI) was retained by Turnstone Consulting to conduct a Pedestrian Wind Study for the proposed Parkmerced Project EIR in San Francisco, California. The purpose of the study was to assess the wind environment around the development in terms of pedestrian comfort and hazard relative to wind metrics specified in the San Francisco Planning Code Section 148. The study objective was achieved through wind tunnel testing of two 1:400 (1" = 33') scale models for the following three development configurations:

A – Existing: all existing buildings on-site and in the surroundings;

B – Proposed Project: proposed Parkmerced Project present with existing buildings on-site and in the surroundings; and,

C – Cumulative: proposed Parkmerced Project with existing buildings on-site and in the surroundings, as well as anticipated proposed buildings to the north (San Francisco State University), to the east (along 19th Avenue) and to the south (along Brotherhood Way).

Image 1 – *Proximity of Development Site*
(image courtesy of Google Earth)

The 152-acre Parkmerced Project Site is located in the Lake Merced District in the southwest corner of San Francisco, southwest of San Francisco's downtown core, as shown in Image 1 above. The development site is generally bounded by 19th Avenue on the east, Lake Merced Boulevard on the west, Holloway Avenue and the San Francisco State University (SFSU) campus to the north, with the southern limits approximated by Brotherhood Way.

The Project Site contains 3,221 existing rental apartments in 170 two-story residential buildings (townhouses) and 11 residential tower buildings that are 13 stories tall, as well as associated parking, building services, a leasing/operations office, and a private pre-school/day care facility. There are also about 75 acres (3,269,300 square feet) of existing open space throughout the Project Site in a network of lawns, courtyard areas, private open space, and playgrounds.

The proposed Parkmerced Project is a long-term mixed-use development program to comprehensively re-plan and redesign the Parkmerced site, increase residential density, provide new commercial and retail services and transit facilities, and improve utilities within the development site. About 1,683 of the existing apartments located in 11 tower buildings would be maintained, and over a period of approximately 30 years, the remaining 1,538 existing apartments would be demolished in phases and fully replaced, and an additional 5,679 net new units would be added to the Project Site. With project implementation, there would be a total of 8,900 units on the Project Site, a new neighborhood core, a new Pre K-5 school and day care facility, fitness center, as well as new open space uses. New buildings would range in height from 1 to 14 stories tall.

Cumulative development projects anticipated in the vicinity of the Project Site include the following: the San Francisco State University (SFSU) Master Plan development, which includes upgrades and expansions to existing buildings and construction activities resulting in about 970,000 gsf of net new campus space; construction of 192 dwelling units and 14,000 gsf of retail and commercial space on the 77-111 Cambon Drive property (directly east of the Project Site along 19th Avenue); and construction of about 445,000 gsf of residential area directly south of the Project Site along Brotherhood Way).

Image 2 – *Wind Tunnel Model Coverage of Study Area*

The test model was constructed using the design information and drawings listed in Appendix A. Given the extent of the area under study, as shown in Image 2, it was necessary to construct two overlapping models, eight feet in diameter, to include the aerodynamic effects of upwind buildings and terrain. Large scale terrain changes were incorporated into the test models. Photographs of the study model in RWDI's boundary-layer wind tunnel are included in Figure 1 (page 31). Photographs of the three modeled test configurations: Existing; Proposed Project; and Cumulative, are shown in Figures 1a, 1b and 1c on pages 32, 33 and 34, respectively.

This report summarizes the methodology of the wind tunnel studies (conducted in September 2009), for pedestrian wind conditions, describes the wind comfort and wind hazard metrics, and presents the test results and recommendations of conceptual wind control measures, where necessary.

2. PRINCIPAL RESULTS

The results of the tests are discussed in detail in Section 5 of this report and may be summarized as follows:

- Existing wind conditions were generally improved for the Proposed Project Configuration, as the number of test locations with a 10%-exceedance (90th percentile) of 11 mph or less was increased from 179 of 215 test locations for the Existing Configuration, to 190 of 219 test locations for the Proposed Project Configuration. For the Cumulative Configuration, wind conditions were further improved, as 196 test locations had a 10%-exceedance (90th percentile) of 11 mph or less.

- The number of test locations with a one-hour wind speed below the 26 mph threshold increased from 189 for the Existing Configuration to 209 for the Proposed Project Configuration and 210 for the Cumulative Configuration. Of those locations with a one-hour wind speed above the threshold, six and three locations in the Proposed Project and Cumulative Configurations, respectively, were new when compared to the Existing Configuration.

- Increased wind speeds were predicted for the areas at the southeast corner of the site, near Chumasero Drive and Brotherhood Way, as well as near Juniper Serra Boulevard. Mitigation concepts have been described.

3. METHODOLOGY

As shown in Figure 1 (page 31), two wind tunnel models were built to represent the northwest and southeast extents of the site. The model configurations were based on areas previously identified in a Pedestrian Wind Assessment (issued on July 10, 2009 for separate use by the project design team), as being potentially windy areas. Each model included the Proposed Project and all relevant surrounding buildings and topography within a 1600 ft radius (Figures 1a through 1c on pages 32 through 34). The mean speed profile and turbulence of the natural wind approaching the modelled area were simulated in RWDI's boundary-layer wind tunnel. The models were instrumented with a total of 220 permanently mounted wind speed sensors to measure mean and gust wind speeds at a full-scale height of approximately 5 ft. These measurements were recorded for eight wind directions (south-southeast through northwest), which represent 76% of the total winds, and 98% of the strong winds (greater than 20 mph).

Wind speeds for the other eight compass directions were assumed to be the same and equal to the average values of the eight measured directions. This assumption is similar to the commonly used San Francisco wind ordinance methodology, where four key wind directions are measured and the remaining directions are estimated.

The equivalent wind speeds were calculated according to the specifications in the San Francisco Planning Code Section 148, whereby the mean hourly wind speed is increased when the turbulence intensity is greater than 15% according to the following formula:

$$EWS = Vm(2*TI+0.7)$$

Where: *EWS* = equivalent wind speed

Vm = mean pedestrian-level wind speed

TI = turbulence intensity

4. METEOROLOGICAL DATA

To take into account the local wind climate, the availability of meteorological data for the region was examined (Image 3 on page 7). Pedestrian wind studies for San Francisco's Downtown C-3 District currently rely upon data recorded from 1945 – 1950 atop the Old Federal Building at 50 United Nations Plaza. Considering the distance (5.6 miles), the limited period of record and age of the data, the use of other sources was considered. Nearly 50 years of wind data observations made at San Francisco International Airport are available. Although the period of record of data is extensive, the airport is inland facing and located some nine miles to the southeast. Wind patterns at the International Airport could be influenced by local topography (e.g., hills and valleys).

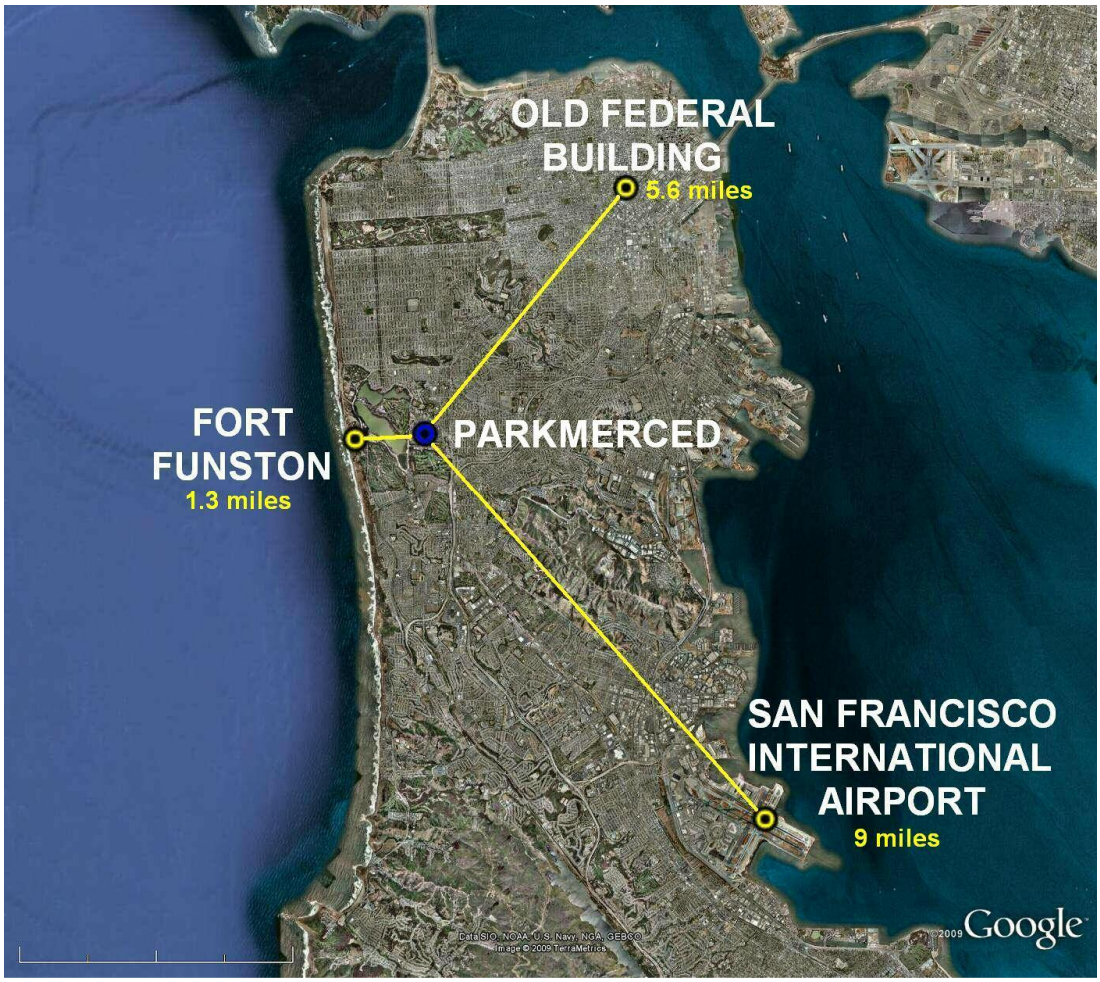


Image 3 – *Proximity of Meteorological Data Sources*
(image courtesy of Google Earth)

Wind data from Fort Funston was assessed given its similar west coast orientation and close proximity of 1.3 miles west of Parkmerced. A total of 11 years of data recorded by the Bay Area Air Quality Management District were available for Fort Funston, and included the years 1991, 1992, 1995, 1996, 1999, and 2000 through 2005, inclusive. Although the period of record was not as extensive as the International Airport, it was considered a more applicable data set for the Parkmerced wind study given its close proximity, coastal location and verification as meeting EPA's quality control standards.

Wind roses of the annual directional frequency distributions were plotted for the three potential data sources considered above for comparison. The overall topography on the San Francisco Peninsula is considered to be of moderate relief, thus a significant shift of the overall regional wind patterns on the Peninsula would not be expected. The wind roses are included in Image 4

on page 8 and it is readily apparent that all three sources indicate a predominance of westerly winds. The airport and downtown data both have a bias toward wind approaching from the west and west-northwest, while the Fort Funston data indicate a prevalence of wind approaching from west and west-southwest. This slight directional shift is relatively subtle and in agreement with the overall trend of prevalent westerly winds on the San Francisco Peninsula.

Image 4 - *Comparison of Regional Annual Wind Frequency*
(image courtesy of Google Earth)

The Fort Funston wind data were analyzed further in order to provide a data set for wind tunnel analysis that focused on the time of day that an assumed higher percentage of the population would be outdoors. For wind studies in the Downtown District, only data from 7am through 6pm are used as this is considered a peak period for pedestrian activity in a downtown setting. Given the residential focus of the Parkmerced Project, wind records from 6am through midnight were used and were considered to be more indicative of the hours when typical pedestrian

activity and outdoor use would be expected. These data are presented in the annual wind rose in Figure 2 on page 35 (upper wind rose) that graphically depicts the distribution of wind frequency and direction. Winds from the west, west-southwest, west-northwest and southwest are prevalent. When the strong winds (e.g., winds exceeding 20 mph) are considered (as shown in the lower wind rose of Figure 2), winds from the west-northwest, south, south-southwest and northwest directions are prevalent. Winds from these directions could potentially be the source of uncomfortable or even severe wind conditions, depending on the site exposure and development design. The significant occurrence of non-prevailing wind directions with higher wind speeds corroborates the need to test many wind directions, as recognized in the modified test methodology used in this study.

The wind tunnel results were processed to calculate the 10%-exceeded (90^{th} percentile) wind speed, the percent of time that winds are 11 mph or higher, and the hours per year that winds exceed 26 mph. The first two of these metrics are roughly equivalent to the pedestrian comfort criterion specified in Section 148 of the Planning Code. The third metric is wind hazard criterion specified in Section 148 of the Planning Code. Since wind speeds recorded at the Fort Funston Station are true hourly mean wind speeds, frequencies of wind exceeding 26 mph can be determined directly from the data base and do not require adjustment as is required in other wind studies for the Downtown District when a different set of meteorological data (Old Federal Building) is used.

5. TEST RESULTS

Table 1, located on pages 15 through 22, presents the wind comfort results for the configurations tested. For each measurement point, the measured 10% exceeded (90^{th} percentile) equivalent wind speed and the percentage of time that the wind speed exceeds 11 mph is shown.

Table 2 on pages 23 through 30 presents the wind hazard results, and lists the predicted wind speed to be exceeded one hour per year. The predicted number of hours per year that the Section 148 wind hazard criterion (26 mph) is exceeded is also provided.

The results at each wind measurement location are graphically depicted on a site plan in Figures 3a-1 through 3c-1 (pages 36, 38 and 40) for the west side of the site, and Figures 3a-2 through 3c-2 (pages 37, 39 and 41) for the east side of the site.

Wind speed measurements were taken at 216 locations for the Existing Configuration and at 220 locations for the Proposed Project Configuration and the Cumulative Configuration. Under the Existing Configuration, 4 locations (Test Points 160, 161, 163, and 169) are occupied by existing buildings, so only 216 locations were tested. These existing buildings would be demolished as part of the Proposed Project. Under the Proposed Project Configuration and the Cumulative Configuration, Test Points 160, 161, 163, and 169 were added with the removal of the buildings.

One sensor (Test Point 213) malfunctioned during the wind tunnel testing and did not provide usable data. For the Existing Configuration, 215 test points provided usable data. For the Proposed Project Configuration and the Cumulative Configuration, 219 test points provided usable data.

5.1 WIND COMFORT CONDITIONS

For the Existing Configuration, the average measured 90th percentile equivalent wind speed for the 215 test locations was approximately 9 mph. The highest 90th percentile equivalent wind speed (14 mph) occurred at eight measurement points (Locations 20, 83, 87 and 109 on Figure 3a-1, page 36; and 157, 172, 174, and 191 on Figure 3a-2, page 37). A total of 179 of the 215 test locations had a 90th percentile wind speed of 11 mph or less (Table 1 on pages 15 through 22 and Figures 3a-1 and 3a-2 on pages 36 and 37, respectively).

There were 36 of the 215 test locations that had a 90th percentile wind above 11 mph for the Existing Configuration. In general, the areas where 11 mph was exceeded included the towers at the northwest corner of the redevelopment site (northwest of the intersection of Acevedo Avenue and Arballo Drive); the area near the center of the redevelopment site (south of Serrano Drive and east of Arballo Drive); and the area east of Cambon Drive.

For the Proposed Project Configuration, four test locations were added with the removal of an existing building and the addition of a tower near the corner of 19th Avenue and Juniper Serra Boulevard (Figure 3b-2 on page 39). The average and maximum measured equivalent wind speed remain the same as the Existing Configuration (9 mph and 14 mph, respectively). In total, 190 of the 219 test locations had a 90th percentile wind less than 11 mph (Figures 3b-1 and 3b-2 on pages 38 and 39).

For the towers at the northwest corner of the Project Site, wind conditions were generally similar to those predicted for the Existing Configuration. Near the center of the redevelopment site (south of Serrano Drive and east of Arballo Drive), existing wind conditions were generally

improved, with a reduction from 13 locations above 11 mph to one (Location 87, Figure 3b-1 on page 38) with the Proposed Project Configuration. However, wind speeds increased around the Bucareli Drive area southwest of the center of the Project Site, resulting in new locations with winds above 11 mph (Locations 127, 129, 131, 135 and 138).

In the area east of Cambon Drive, existing wind conditions improved with the Proposed Project Configuration in the area north of Font Boulevard (Locations 148, 153, 157, 165, 178, and 180, see Figure 3b-2, page 39) whereas areas along Font Boulevard were predicted to exceed 11 mph (Locations 150, 183, 185, 186, 187 and 194). Winds in areas around Chumasero Drive were generally found to increase compared to the Existing Configuration. Locations 205 and 209 have winds reduced to below 11 mph while Locations 199, 201, 202, 203 and 216 had wind increased to above 11 mph.

For the Cumulative Configuration, the average and maximum measured equivalent wind speed remained the same as the Existing and Proposed Project Configurations (9 mph and 14 mph, respectively). Overall, 196 of the 219 test locations had 90th percentile winds below 11 mph (Figures 3c-1 and 3c-2 on pages 40 and 41, respectively). In comparison to the Proposed Project Configuration, there were no additional locations above 11 mph, and Locations 150, 172, 174, 185, 186 and 187 had winds reduced from above to below 11 mph.

5.2 WIND HAZARD CONDITIONS

For the Existing Configuration, 189 of the 215 test locations met the wind hazard criterion. Areas where the wind hazard criterion was not met were the towers at the northwest corner of the site; the area near the center of the site; and, the area east of Cambon Drive (red circled test points in Figures 3a-1 and 3a-2 on pages 36 and 37, respectively).

For the Proposed Project Configuration, 209 of the 219 test locations met the wind hazard criterion (Figures 3b-1 and 3b-2 on pages 38 and 39). In total, 22 existing wind hazard exceedences were eliminated, while six new locations that exceeded the wind hazard criterion were created. These new areas include the area near Bucareli Drive, along Font Boulevard, near the intersection of Brotherhood Way and Chumasero Drive, and east of Chumasero Drive.

For the Cumulative Configuration, 210 of the 219 test locations met the wind hazard criterion (Figures 3c-1 and 3c-2 on pages 40 and 41). When compared to the Proposed Project Configuration, four wind hazard exceedences were eliminated, while three wind hazard exceedences at new locations were created in the area along Chumasero Drive.

6. RECOMMENDATIONS

In our discussion of wind control recommendations, reference will be made to the following generalized wind flows. Large buildings tend to intercept the stronger winds at higher elevations and redirect them to ground-level. Such a *Downwashing Flow* (shown in Image 5 on page 12) is often the main cause for wind acceleration at the pedestrian level. Wind acceleration typically occurs at the corners of tall buildings where the downwashed wind passes around the edges of the building. When two buildings are situated side by side, wind tends to accelerate through the gap between the buildings due to a *Channelling Effect* (shown in Image 6 on page 12). If these building/wind combinations occur for prevailing winds, and especially for strong winds, there is an increased potential for the accelerated winds to create wind safety issues for pedestrians.

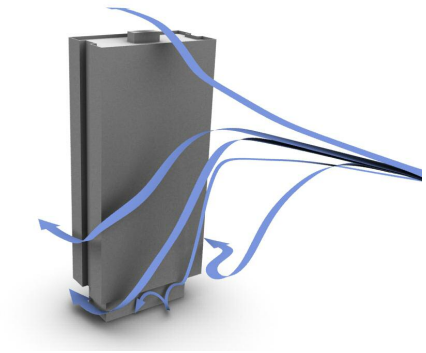


Image 5 – *Downwashing Flow*

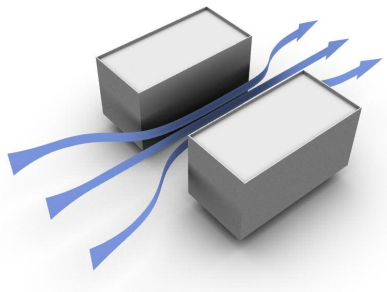


Image 6 – *Channelling Flow*

In general, the proposed massing provided shelter from the prevailing wind directions for several areas of the site, and resulted in reduced wind speeds in the area near the center of the site (south of Serrano Drive and east of Arballo Drive), as well as the areas east of Cambon Street and north of Font Boulevard.

Increased wind speeds were predicted for Bucareli Drive, Font Boulevard, and the area near the intersection of Chumasero Drive and Brotherhood Way. The buildings in these areas tend to be tall, with wide facades that intercept wind flow at higher elevations and redirect it toward ground-level (downwashing flow). However, for the Cumulative Configuration, the future building along Brotherhood Way provided shelter for the areas along Font Boulevard, resulting in generally comfortable wind conditions.

We recommend that wind mitigation be considered and could be in the form of building massing changes, such as the inclusion of a podium or terraced roof (Image 7 on page 13). These horizontal "shelves" help deflect wind flow away from grade, and can be considered for the buildings at the corner of Chumasero Drive and Brotherhood Way, and Juniper Serra Boulevard and Brotherhood Way. Alternatively, large canopies can be used (Image 8 on page 13). Landscaping is also effective at reducing wind speeds (Images 9 and 10 on page 13). However, landscaping alone may not be sufficient to mitigate the areas where the wind hazard criterion was not met.

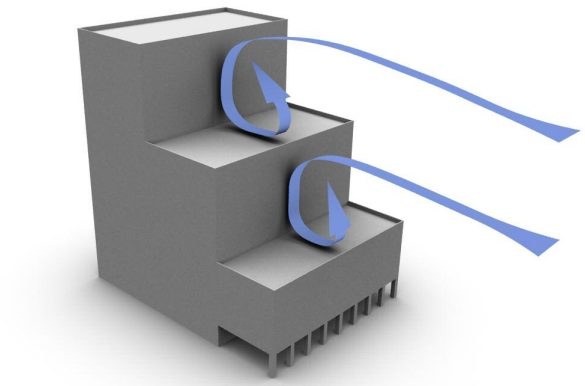


Image 7 – *Roof Terraces*

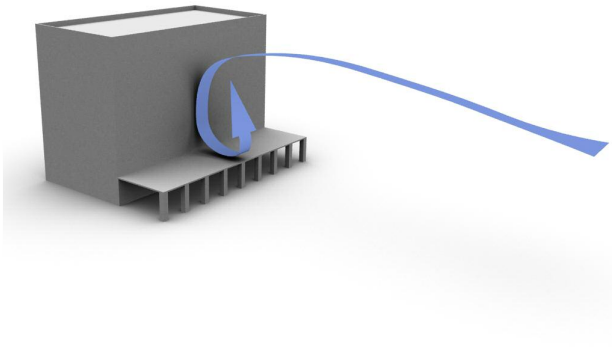


Image 8 – *Canopy/Colonnade*

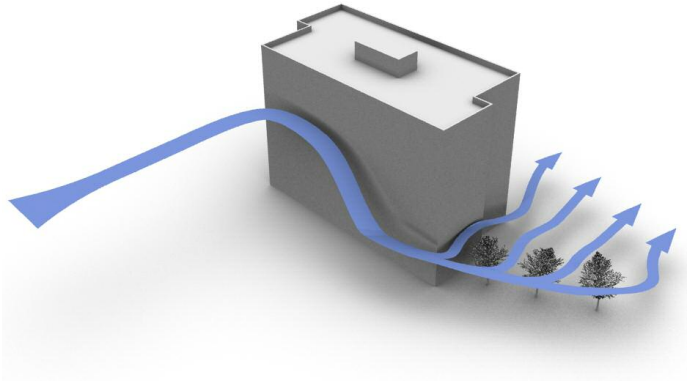


Image 9 – *Landscaping*

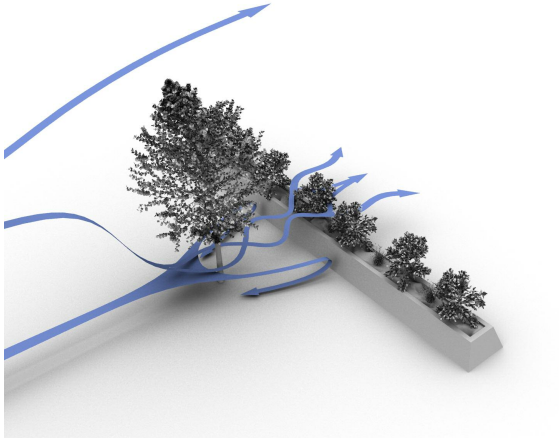


Image 10 – *Landscaping*

7. APPLICABILITY OF RESULTS

The results presented in this report pertain to the model of the proposed Parkmerced Project constructed using the architectural design drawings listed in Appendix A. Should there be any design changes that deviate from this list of drawings, the results presented may change. Therefore, if changes in the design are made, it is recommended that RWDI be contacted and requested to review their potential effects on wind conditions.

Table 1: Comfort Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Existing (mph)	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Project (mph)
1	10	7%	10	7%	0	10	7%	0
2	12	12%	10	7%	-2	10	7%	0
3	10	7%	7	2%	-3	7	1%	0
4	9	3%	8	2%	-1	8	1%	0
5	13	17%	12	14%	-1	12	14%	0
6	8	3%	8	3%	0	8	3%	0
7	8	3%	9	3%	1	9	3%	0
8	10	7%	12	15%	2	12	14%	0
9	11	8%	8	1%	-3	7	1%	-1
10	11	10%	11	10%	0	11	10%	0
11	10	8%	10	4%	0	10	5%	0
12	13	21%	12	13%	-1	12	14%	0
13	8	3%	7	3%	-1	8	3%	1
14	9	3%	10	6%	1	10	6%	0
15	9	4%	9	2%	0	9	2%	0
16	13	18%	13	17%	0	13	16%	0
17	8	2%	9	5%	1	9	5%	0
18	10	5%	9	5%	-1	9	5%	0
19	11	10%	10	5%	-1	10	5%	0
20	14	23%	11	8%	-3	10	8%	-1
21	7	1%	8	3%	1	8	3%	0
22	13	22%	11	8%	-2	11	8%	0
23	9	4%	10	7%	1	10	7%	0
24	6	1%	7	1%	1	7	1%	0
25	10	7%	11	10%	1	11	10%	0
26	9	4%	9	4%	0	8	3%	-1
27	10	7%	9	4%	-1	9	4%	0
28	13	17%	12	15%	-1	12	14%	0
29	13	18%	12	14%	-1	12	13%	0
30	10	7%	9	4%	-1	10	4%	1

Table 1: Comfort Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Existing (mph)	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Project (mph)
31	10	5%	10	6%	0	10	6%	0
32	9	4%	8	2%	-1	8	2%	0
33	9	4%	9	2%	0	9	2%	0
34	10	6%	10	5%	0	10	5%	0
35	9	4%	7	0%	-2	7	0%	0
36	6	0%	8	1%	2	8	1%	0
37	4	0%	8	3%	4	8	3%	0
38	9	5%	8	2%	-1	9	2%	1
39	8	1%	9	4%	1	8	4%	-1
40	9	5%	9	3%	0	9	3%	0
41	8	1%	10	8%	2	10	7%	0
42	9	4%	8	2%	-1	8	1%	0
43	9	3%	8	3%	-1	8	3%	0
44	9	5%	7	1%	-2	7	1%	0
45	8	3%	8	2%	0	7	1%	-1
46	10	6%	9	3%	-1	9	3%	0
47	8	2%	7	1%	-1	7	0%	0
48	12	16%	12	14%	0	12	13%	0
49	5	0%	7	0%	2	7	0%	0
50	7	1%	8	2%	1	8	2%	0
51	9	5%	9	3%	0	9	3%	0
52	5	0%	8	2%	3	8	2%	0
53	5	0%	9	5%	4	9	4%	0
54	7	1%	6	1%	-1	6	1%	0
55	9	4%	6	0%	-3	6	0%	0
56	6	0%	7	1%	1	7	2%	0
57	7	0%	7	2%	0	7	2%	0
58	7	2%	8	2%	1	8	3%	0
59	6	0%	6	0%	0	6	0%	0
60	6	0%	8	1%	2	7	1%	-1

Table 1: Comfort Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Existing (mph)	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Project (mph)
61	7	1%	6	0%	-1	6	0%	0
62	8	2%	7	1%	-1	7	1%	0
63	8	1%	5	0%	-3	5	0%	0
64	6	0%	7	2%	1	7	2%	0
65	7	2%	5	0%	-2	5	0%	0
66	8	1%	9	3%	1	9	3%	0
67	12	14%	8	2%	-4	8	2%	0
68	10	8%	7	1%	-3	7	1%	0
69	10	6%	7	1%	-3	7	1%	0
70	9	5%	6	0%	-3	6	0%	0
71	6	0%	7	1%	1	7	1%	0
72	9	2%	7	2%	-2	7	2%	0
73	11	10%	7	1%	-4	7	1%	0
74	6	0%	6	0%	0	6	0%	0
75	11	9%	7	1%	-4	7	1%	0
76	10	8%	8	1%	-2	8	1%	0
77	10	6%	6	0%	-4	6	0%	0
78	11	10%	9	4%	-2	9	4%	0
79	9	3%	8	1%	-1	8	1%	0
80	10	6%	9	4%	-1	9	3%	0
81	10	6%	9	4%	-1	8	3%	-1
82	12	15%	9	4%	-3	9	4%	0
83	14	24%	11	10%	-3	11	10%	0
84	8	1%	6	0%	-2	6	0%	0
85	10	6%	7	0%	-3	6	0%	-1
86	12	13%	9	3%	-3	9	2%	0
87	14	27%	12	15%	-2	12	13%	0
88	9	5%	7	1%	-2	7	1%	0
89	12	14%	9	4%	-3	9	4%	0
90	10	5%	11	10%	1	11	9%	0

Table 1: Comfort Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Existing (mph)	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Project (mph)
91	10	6%	8	2%	-2	8	1%	0
92	5	0%	5	0%	0	5	0%	0
93	9	4%	5	0%	-4	5	0%	0
94	9	3%	9	4%	0	9	3%	0
95	9	3%	6	0%	-3	6	0%	0
96	9	5%	7	0%	-2	7	0%	0
97	13	17%	9	4%	-4	9	4%	0
98	6	0%	6	1%	0	6	1%	0
99	8	1%	7	1%	-1	7	2%	0
100	10	6%	9	3%	-1	9	3%	0
101	11	10%	8	2%	-3	8	2%	0
102	12	15%	7	0%	-5	7	0%	0
103	11	10%	8	1%	-3	7	1%	-1
104	8	1%	5	0%	-3	5	0%	0
105	10	6%	10	7%	0	10	6%	0
106	13	20%	10	7%	-3	10	6%	0
107	13	19%	10	7%	-3	10	6%	0
108	9	5%	7	1%	-2	7	1%	0
109	14	25%	11	10%	-3	11	10%	0
110	12	16%	10	4%	-2	10	5%	0
111	10	6%	10	7%	0	10	7%	0
112	12	16%	9	3%	-3	9	2%	0
113	7	1%	8	1%	1	8	1%	0
114	8	2%	8	2%	0	8	2%	0
115	11	10%	9	3%	-2	9	3%	0
116	9	3%	7	2%	-2	7	2%	0
117	9	2%	7	1%	-2	7	0%	0
118	7	0%	7	2%	0	7	1%	0
119	6	0%	8	2%	2	8	2%	0
120	6	0%	6	0%	0	6	0%	0

Table 1: Comfort Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Existing (mph)	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Project (mph)
121	4	0%	8	2%	4	8	2%	0
122	7	1%	9	3%	2	9	2%	0
123	9	4%	8	3%	-1	8	3%	0
124	9	3%	6	0%	-3	6	0%	0
125	8	2%	8	1%	0	8	1%	0
126	9	3%	8	3%	-1	8	3%	0
127	8	1%	12	15%	4	12	14%	0
128	9	4%	10	6%	1	10	6%	0
129	10	6%	12	15%	2	12	15%	0
130	9	3%	11	10%	2	11	10%	0
131	8	2%	12	13%	4	12	13%	0
132	9	4%	11	10%	2	11	10%	0
133	8	1%	7	1%	-1	7	1%	0
134	7	1%	6	0%	-1	6	0%	0
135	9	2%	12	14%	3	12	15%	0
136	8	2%	10	5%	2	10	6%	0
137	7	0%	5	0%	-2	5	0%	0
138	8	2%	12	14%	4	12	14%	0
139	9	4%	10	7%	1	10	7%	0
140	9	4%	10	8%	1	11	8%	1
141	9	3%	7	1%	-2	7	1%	0
142	8	2%	5	0%	-3	6	1%	1
143	9	3%	8	2%	-1	6	1%	-2
144	8	2%	9	3%	1	8	3%	-1
145	10	5%	9	4%	-1	7	1%	-2
146	9	5%	9	5%	0	8	2%	-1
147	9	4%	8	3%	-1	8	2%	0
148	13	18%	9	5%	-4	8	2%	-1
149	5	0%	8	2%	3	7	1%	-1
150	9	3%	12	12%	3	11	9%	-1

Table 1: Comfort Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Existing (mph)	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Project (mph)
151	9	3%	10	5%	1	8	1%	-2
152	9	2%	8	2%	-1	7	2%	-1
153	13	18%	10	6%	-3	9	5%	-1
154	6	0%	5	0%	-1	5	1%	0
155	8	2%	7	1%	-1	7	1%	0
156	6	0%	6	0%	0	6	0%	0
157	14	25%	11	10%	-3	10	7%	-1
158	8	2%	7	1%	-1	6	0%	-1
159	8	1%	7	0%	-1	6	0%	-1
160	-	-	8	2%	-	8	2%	0
161	-	-	8	3%	-	8	3%	0
162	7	1%	7	1%	0	7	1%	0
163	-	-	9	4%	-	7	1%	-2
164	9	4%	11	10%	2	9	3%	-2
165	12	15%	9	3%	-3	8	2%	-1
166	10	5%	9	3%	-1	8	2%	-1
167	11	9%	10	6%	-1	8	2%	-2
168	8	2%	7	1%	-1	7	1%	0
169	-	-	10	7%	-	8	3%	-2
170	8	3%	8	2%	0	7	1%	-1
171	11	10%	9	2%	-2	7	1%	-2
172	14	22%	12	13%	-2	10	7%	-2
173	9	5%	6	1%	-3	6	1%	0
174	14	23%	14	25%	0	11	10%	-3
175	9	5%	8	1%	-1	6	0%	-2
176	6	0%	6	0%	0	5	0%	-1
177	11	10%	9	3%	-2	9	3%	0
178	13	20%	10	5%	-3	9	4%	-1
179	8	3%	6	1%	-2	6	0%	0
180	12	14%	11	10%	-1	11	10%	0

Table 1: Comfort Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Existing (mph)	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Project (mph)
181	5	0%	10	8%	5	10	5%	0
182	7	0%	9	3%	2	8	2%	-1
183	5	0%	12	13%	7	12	14%	0
184	7	0%	9	3%	2	8	2%	-1
185	6	0%	13	19%	7	11	8%	-2
186	9	4%	12	14%	3	10	6%	-2
187	6	0%	12	13%	6	10	6%	-2
188	8	2%	11	10%	3	11	9%	0
189	10	5%	7	1%	-3	6	1%	-1
190	11	10%	11	8%	0	11	8%	0
191	14	24%	10	4%	-4	10	5%	0
192	11	9%	6	0%	-5	6	0%	0
193	11	10%	10	7%	-1	11	9%	1
194	10	7%	12	13%	2	12	13%	0
195	10	6%	11	10%	1	11	10%	0
196	8	2%	8	1%	0	8	2%	0
197	10	7%	10	6%	0	10	7%	0
198	8	3%	11	9%	3	10	8%	-1
199	10	8%	12	15%	2	12	15%	0
200	10	6%	9	4%	-1	9	4%	0
201	9	5%	12	16%	3	12	16%	0
202	10	8%	13	20%	3	13	20%	0
203	11	10%	12	14%	1	12	14%	0
204	11	10%	9	4%	-2	9	5%	0
205	12	15%	9	3%	-3	9	3%	0
206	11	9%	8	1%	-3	7	1%	-1
207	11	10%	7	1%	-4	7	1%	0
208	7	1%	5	0%	-2	5	0%	0
209	12	16%	11	10%	-1	11	10%	0
210	12	15%	13	18%	1	13	17%	0

Table 1: Comfort Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Existing (mph)	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11mph	Speed Change Relative to Project (mph)
211	12	12%	12	12%	0	12	12%	0
212	7	1%	8	2%	1	8	2%	0
213	-	-	-	-	-	-	-	-
214	9	4%	11	10%	2	11	10%	0
215	12	15%	12	16%	0	12	16%	0
216	10	7%	14	21%	4	14	21%	0
217	7	0%	11	10%	4	11	10%	0
218	10	7%	10	8%	0	10	8%	0
219	9	3%	10	6%	1	10	6%	0
220	11	8%	11	10%	0	11	10%	0
Average mph and %	9.1	6.0%	8.9	4.9%	-0.3	8.6	4.4%	-0.2

Table 2: Wind Hazard Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Existing (mph)	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Project (mph)
1	21	< 1	21	< 1	0	21	< 1	0
2	25	< 1	25	< 1	0	23	< 1	0
3	21	< 1	22	< 1	0	21	< 1	0
4	19	< 1	19	< 1	0	16	< 1	0
5	26	< 1	23	< 1	0	23	< 1	0
6	19	< 1	20	< 1	0	19	< 1	0
7	21	< 1	20	< 1	0	19	< 1	0
8	22	< 1	24	< 1	0	23	< 1	0
9	22	< 1	19	< 1	0	18	< 1	0
10	23	< 1	22	< 1	0	22	< 1	0
11	21	< 1	19	< 1	0	19	< 1	0
12	29	4	25	< 1	-4	25	< 1	0
13	20	< 1	20	< 1	0	20	< 1	0
14	20	< 1	22	< 1	0	22	< 1	0
15	20	< 1	18	< 1	0	18	< 1	0
16	27	2	28	3	1	28	3	0
17	20	< 1	21	< 1	0	21	< 1	0
18	20	< 1	21	< 1	0	21	< 1	0
19	23	< 1	19	< 1	0	19	< 1	0
20	27	2	22	< 1	-2	22	< 1	0
21	20	< 1	20	< 1	0	20	< 1	0
22	27	2	21	< 1	-2	21	< 1	0
23	22	< 1	22	< 1	0	22	< 1	0
24	20	< 1	16	< 1	0	16	< 1	0
25	23	< 1	24	< 1	0	23	< 1	0
26	22	< 1	20	< 1	0	20	< 1	0
27	22	< 1	19	< 1	0	19	< 1	0
28	31	12	29	5	-7	28	4	-1
29	28	3	25	< 1	-3	25	< 1	0
30	20	< 1	19	< 1	0	19	< 1	0

Table 2: Wind Hazard Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Existing (mph)	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Project (mph)
31	19	< 1	22	< 1	0	22	< 1	0
32	22	< 1	19	< 1	0	19	< 1	0
33	20	< 1	18	< 1	0	18	< 1	0
34	20	< 1	19	< 1	0	19	< 1	0
35	19	< 1	13	< 1	0	13	< 1	0
36	13	< 1	16	< 1	0	16	< 1	0
37	10	< 1	18	< 1	0	19	< 1	0
38	20	< 1	17	< 1	0	17	< 1	0
39	16	< 1	21	< 1	0	21	< 1	0
40	22	< 1	21	< 1	0	21	< 1	0
41	15	< 1	22	< 1	0	22	< 1	0
42	18	< 1	17	< 1	0	17	< 1	0
43	19	< 1	20	< 1	0	20	< 1	0
44	22	< 1	16	< 1	0	15	< 1	0
45	19	< 1	20	< 1	0	17	< 1	0
46	22	< 1	19	< 1	0	18	< 1	0
47	17	< 1	17	< 1	0	16	< 1	0
48	24	< 1	24	< 1	0	23	< 1	0
49	13	< 1	16	< 1	0	15	< 1	0
50	17	< 1	17	< 1	0	17	< 1	0
51	24	< 1	22	< 1	0	21	< 1	0
52	12	< 1	17	< 1	0	17	< 1	0
53	13	< 1	20	< 1	0	20	< 1	0
54	18	< 1	17	< 1	0	18	< 1	0
55	19	< 1	16	< 1	0	15	< 1	0
56	13	< 1	18	< 1	0	18	< 1	0
57	13	< 1	18	< 1	0	18	< 1	0
58	17	< 1	22	< 1	0	21	< 1	0
59	14	< 1	14	< 1	0	14	< 1	0
60	16	< 1	17	< 1	0	16	< 1	0

Table 2: Wind Hazard Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Existing (mph)	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Project (mph)
61	19	< 1	16	< 1	0	16	< 1	0
62	17	< 1	15	< 1	0	15	< 1	0
63	15	< 1	13	< 1	0	13	< 1	0
64	13	< 1	22	< 1	0	21	< 1	0
65	20	< 1	13	< 1	0	12	< 1	0
66	16	< 1	18	< 1	0	19	< 1	0
67	24	< 1	17	< 1	0	17	< 1	0
68	23	< 1	18	< 1	0	17	< 1	0
69	22	< 1	15	< 1	0	15	< 1	0
70	25	< 1	17	< 1	0	16	< 1	0
71	15	< 1	19	< 1	0	19	< 1	0
72	19	< 1	17	< 1	0	18	< 1	0
73	26	< 1	16	< 1	0	16	< 1	0
74	13	< 1	14	< 1	0	14	< 1	0
75	25	< 1	16	< 1	0	16	< 1	0
76	22	< 1	16	< 1	0	16	< 1	0
77	21	< 1	15	< 1	0	15	< 1	0
78	23	< 1	21	< 1	0	21	< 1	0
79	20	< 1	16	< 1	0	16	< 1	0
80	22	< 1	19	< 1	0	19	< 1	0
81	24	< 1	20	< 1	0	20	< 1	0
82	26	< 1	20	< 1	0	19	< 1	0
83	27	2	22	< 1	-2	21	< 1	0
84	17	< 1	13	< 1	0	13	< 1	0
85	23	< 1	15	< 1	0	14	< 1	0
86	26	< 1	18	< 1	0	18	< 1	0
87	29	4	24	< 1	-4	23	< 1	0
88	22	< 1	16	< 1	0	15	< 1	0
89	28	3	22	< 1	-3	22	< 1	0
90	20	< 1	22	< 1	0	22	< 1	0

Table 2: Wind Hazard Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Existing (mph)	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Project (mph)
91	21	< 1	17	< 1	0	16	< 1	0
92	14	< 1	13	< 1	0	13	< 1	0
93	28	2	12	< 1	-2	12	< 1	0
94	22	< 1	18	< 1	0	18	< 1	0
95	20	< 1	13	< 1	0	13	< 1	0
96	21	< 1	14	< 1	0	14	< 1	0
97	25	< 1	20	< 1	0	20	< 1	0
98	13	< 1	17	< 1	0	18	< 1	0
99	18	< 1	19	< 1	0	19	< 1	0
100	20	< 1	19	< 1	0	19	< 1	0
101	23	< 1	18	< 1	0	19	< 1	0
102	27	2	14	< 1	-2	14	< 1	0
103	23	< 1	15	< 1	0	15	< 1	0
104	16	< 1	11	< 1	0	11	< 1	0
105	26	< 1	21	< 1	0	21	< 1	0
106	27	2	21	< 1	-2	21	< 1	0
107	30	6	24	< 1	-6	24	< 1	0
108	21	< 1	18	< 1	0	18	< 1	0
109	28	3	25	< 1	-3	25	< 1	0
110	25	< 1	22	< 1	0	23	< 1	0
111	20	< 1	23	< 1	0	23	< 1	0
112	29	4	22	< 1	-4	21	< 1	0
113	16	< 1	17	< 1	0	17	< 1	0
114	19	< 1	18	< 1	0	18	< 1	0
115	24	< 1	19	< 1	0	19	< 1	0
116	19	< 1	22	< 1	0	22	< 1	0
117	18	< 1	15	< 1	0	15	< 1	0
118	15	< 1	23	< 1	0	23	< 1	0
119	13	< 1	19	< 1	0	20	< 1	0
120	13	< 1	16	< 1	0	15	< 1	0

Table 2: Wind Hazard Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Existing (mph)	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Project (mph)
121	10	< 1	18	< 1	0	18	< 1	0
122	19	< 1	19	< 1	0	19	< 1	0
123	21	< 1	21	< 1	0	21	< 1	0
124	19	< 1	14	< 1	0	14	< 1	0
125	18	< 1	16	< 1	0	16	< 1	0
126	18	< 1	25	< 1	0	25	< 1	0
127	17	< 1	27	1	0	26	< 1	0
128	20	< 1	21	< 1	0	21	< 1	0
129	19	< 1	24	< 1	0	24	< 1	0
130	18	< 1	23	< 1	0	23	< 1	0
131	17	< 1	23	< 1	0	23	< 1	0
132	18	< 1	22	< 1	0	22	< 1	0
133	17	< 1	17	< 1	0	18	< 1	0
134	20	< 1	13	< 1	0	13	< 1	0
135	18	< 1	25	< 1	0	26	< 1	0
136	18	< 1	22	< 1	0	24	< 1	0
137	14	< 1	15	< 1	0	14	< 1	0
138	17	< 1	23	< 1	0	23	< 1	0
139	19	< 1	22	< 1	0	23	< 1	0
140	20	< 1	21	< 1	0	22	< 1	0
141	21	< 1	21	< 1	0	20	< 1	0
142	17	< 1	13	< 1	0	16	< 1	0
143	22	< 1	21	< 1	0	17	< 1	0
144	17	< 1	18	< 1	0	19	< 1	0
145	19	< 1	19	< 1	0	16	< 1	0
146	22	< 1	23	< 1	0	21	< 1	0
147	19	< 1	18	< 1	0	17	< 1	0
148	30	7	21	< 1	-7	18	< 1	0
149	10	< 1	18	< 1	0	16	< 1	0
150	19	< 1	25	< 1	0	25	< 1	0

Table 2: Wind Hazard Results

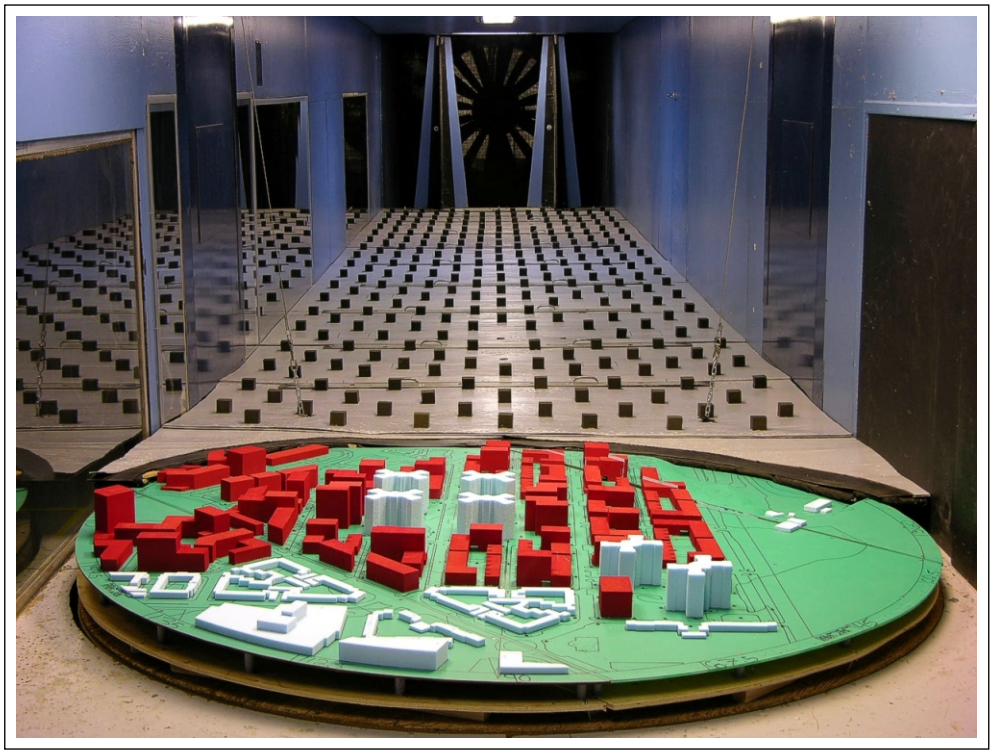
References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Existing (mph)	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Project (mph)
151	21	< 1	20	< 1	0	19	< 1	0
152	20	< 1	25	< 1	0	25	< 1	0
153	29	5	24	< 1	-5	22	< 1	0
154	14	< 1	15	< 1	0	15	< 1	0
155	22	< 1	17	< 1	0	18	< 1	0
156	15	< 1	18	< 1	0	17	< 1	0
157	29	5	23	< 1	-5	22	< 1	0
158	18	< 1	17	< 1	0	16	< 1	0
159	16	< 1	14	< 1	0	12	< 1	0
160	-	-	20	< 1	-	20	< 1	0
161	-	-	24	< 1	-	23	< 1	0
162	20	< 1	19	< 1	0	19	< 1	0
163	-	-	21	< 1	-	19	< 1	0
164	22	< 1	25	< 1	0	18	< 1	0
165	26	< 1	18	< 1	0	18	< 1	0
166	19	< 1	18	< 1	0	17	< 1	0
167	21	< 1	23	< 1	0	18	< 1	0
168	17	< 1	18	< 1	0	17	< 1	0
169	-	-	24	< 1	-	19	< 1	0
170	20	< 1	19	< 1	0	15	< 1	0
171	23	< 1	18	< 1	0	16	< 1	0
172	30	8	28	3	-5	23	< 1	0
173	26	< 1	20	< 1	0	19	< 1	0
174	29	5	29	5	0	23	< 1	-5
175	22	< 1	16	< 1	0	15	< 1	0
176	15	< 1	16	< 1	0	15	< 1	0
177	26	< 1	25	< 1	0	24	< 1	0
178	27	2	25	< 1	-2	25	< 1	0
179	21	< 1	17	< 1	0	17	< 1	0
180	26	< 1	26	< 1	0	25	< 1	0

Table 2: Wind Hazard Results

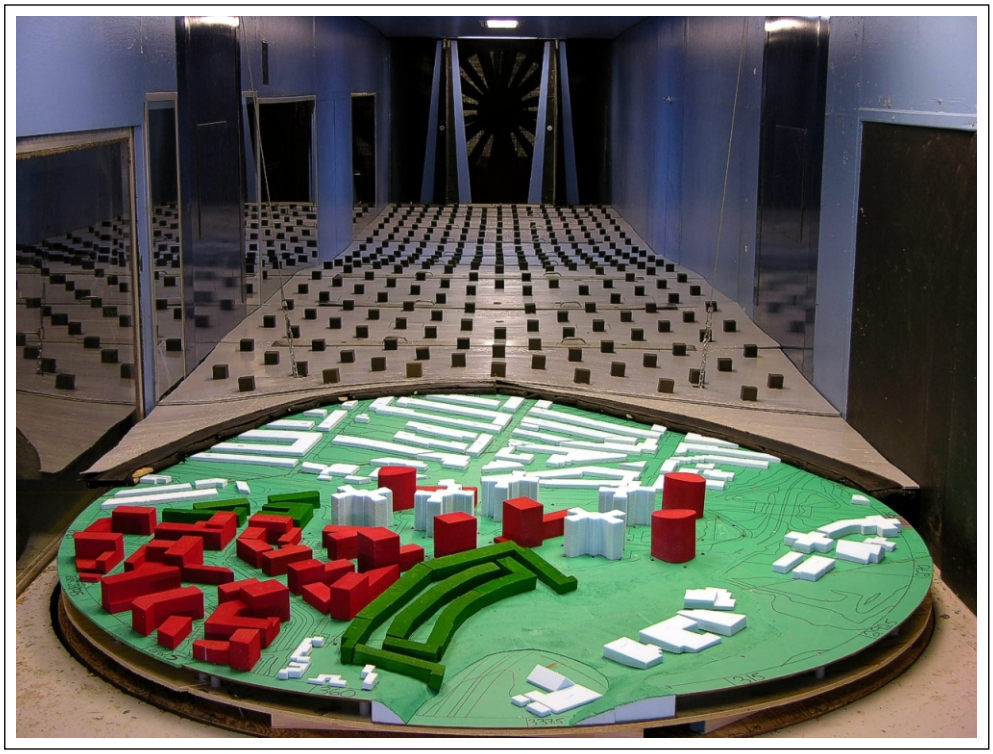
References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Existing (mph)	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Project (mph)
181	13	< 1	22	< 1	0	20	< 1	0
182	15	< 1	18	< 1	0	17	< 1	0
183	11	< 1	24	< 1	0	25	< 1	0
184	15	< 1	22	< 1	0	21	< 1	0
185	13	< 1	27	2	0	22	< 1	-2
186	20	< 1	25	< 1	0	21	< 1	0
187	12	< 1	26	< 1	0	22	< 1	0
188	21	< 1	26	< 1	0	24	< 1	0
189	20	< 1	20	< 1	0	19	< 1	0
190	22	< 1	22	< 1	0	23	< 1	0
191	27	2	21	< 1	-2	21	< 1	0
192	25	< 1	13	< 1	0	14	< 1	0
193	27	2	23	< 1	-2	27	2	2
194	28	3	26	< 1	-3	27	2	2
195	21	< 1	23	< 1	0	23	< 1	0
196	17	< 1	17	< 1	0	17	< 1	0
197	25	< 1	23	< 1	0	24	< 1	0
198	21	< 1	23	< 1	0	23	< 1	0
199	24	< 1	24	< 1	0	24	< 1	0
200	24	< 1	26	< 1	0	27	2	2
201	22	< 1	28	3	3	29	4	1
202	23	< 1	29	6	6	29	6	0
203	22	< 1	25	< 1	0	25	< 1	0
204	22	< 1	20	< 1	0	20	< 1	0
205	27	2	19	< 1	-2	19	< 1	0
206	26	< 1	16	< 1	0	16	< 1	0
207	25	< 1	20	< 1	0	19	< 1	0
208	15	< 1	14	< 1	0	14	< 1	0
209	26	< 1	25	< 1	0	25	< 1	0
210	26	< 1	25	< 1	0	25	< 1	0

Table 2: Wind Hazard Results

References	Existing Setting		Project			Cumulative		
Location Number	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Existing (mph)	Wind Speed Exceeded 1hour/year (mph)	Hours per Year Wind Speed Exceeds 26mph	Hours Change Relative to Project (mph)
211	26	< 1	30	7	7	29	4	-3
212	19	< 1	19	< 1	0	19	< 1	0
213	-	-	-	-	-	-	-	-
214	21	< 1	22	< 1	0	22	< 1	0
215	29	5	24	< 1	-5	24	< 1	0
216	21	< 1	32	10	10	32	12	2
217	15	< 1	24	< 1	0	24	< 1	0
218	22	< 1	23	< 1	0	22	< 1	0
219	19	< 1	22	< 1	0	1	< 1	0
220	21	< 1	24	< 1	0	24	< 1	0
Average mph and hours per year	20.4	0.4	20.1	0.2	-0.3	19.5	0.2	0.0

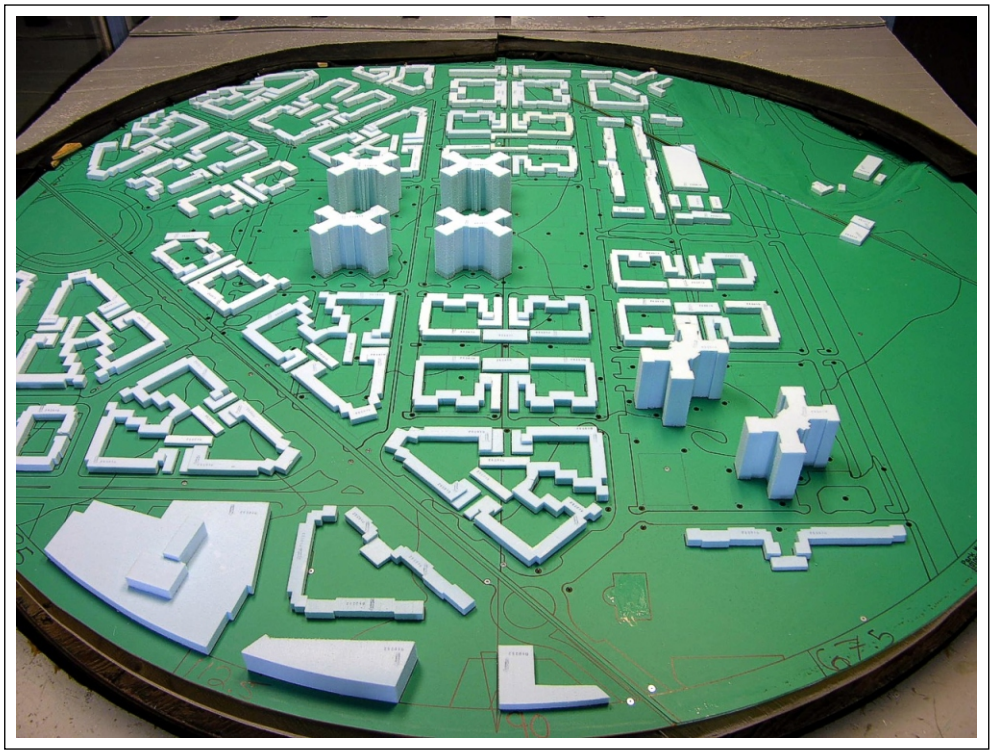


West - Proposed Project Configuration

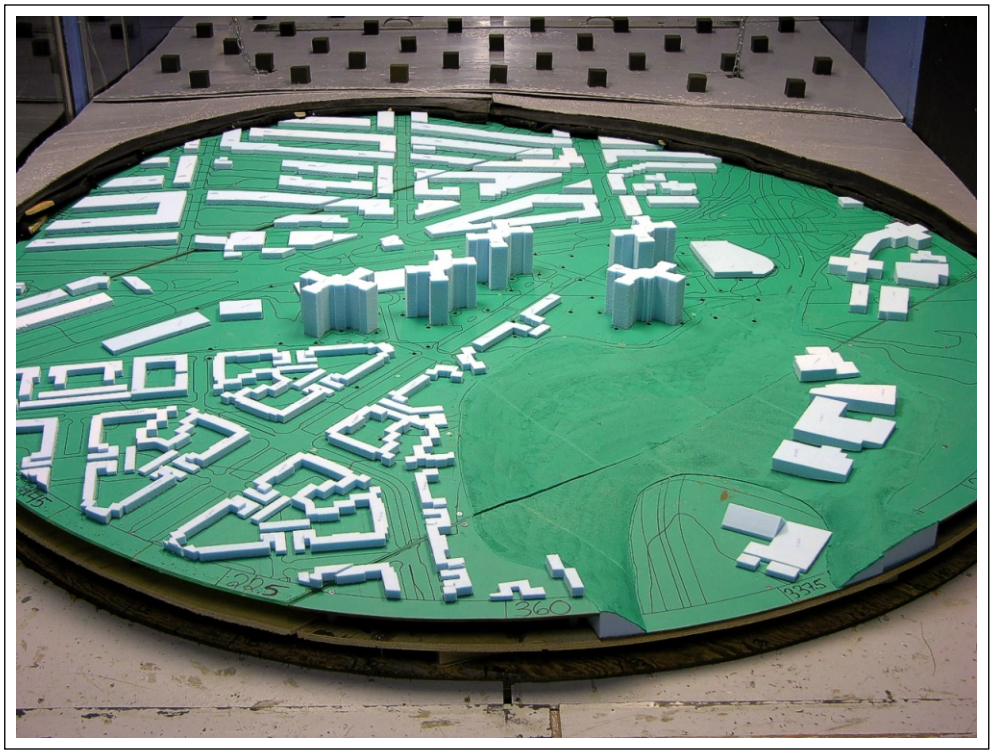


East - Cumulative Configuration

Wind Tunnel Study Model		Figure: 1	RWDI
Parkmerced Master Plan - San Francisco, California	Project #1010052	Date: October 1, 2009	

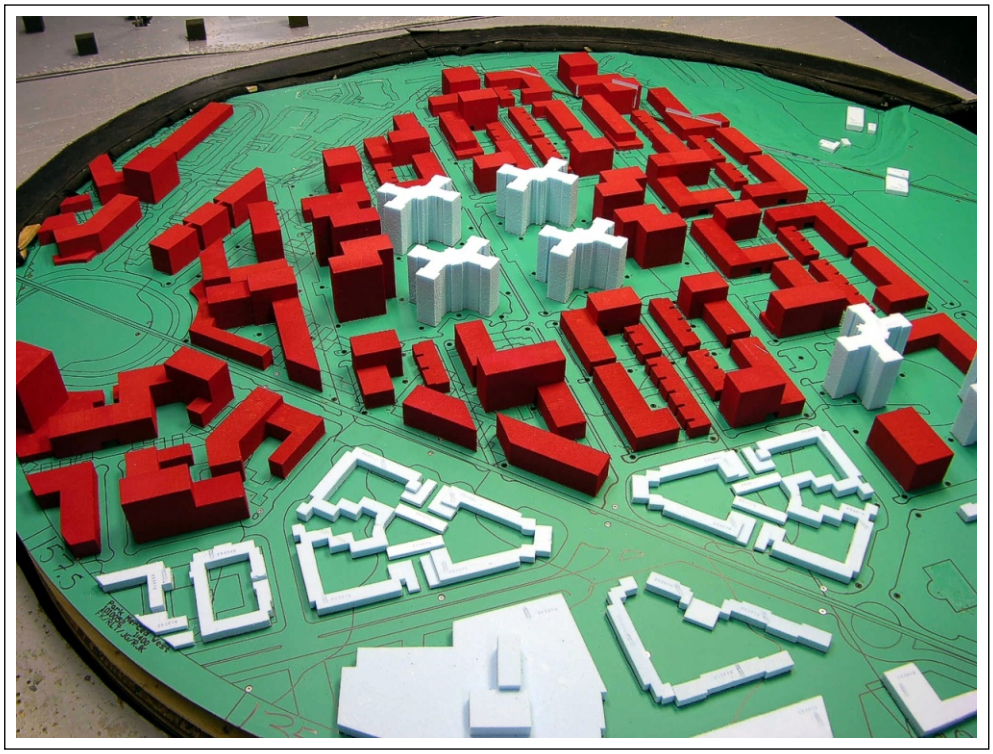


West

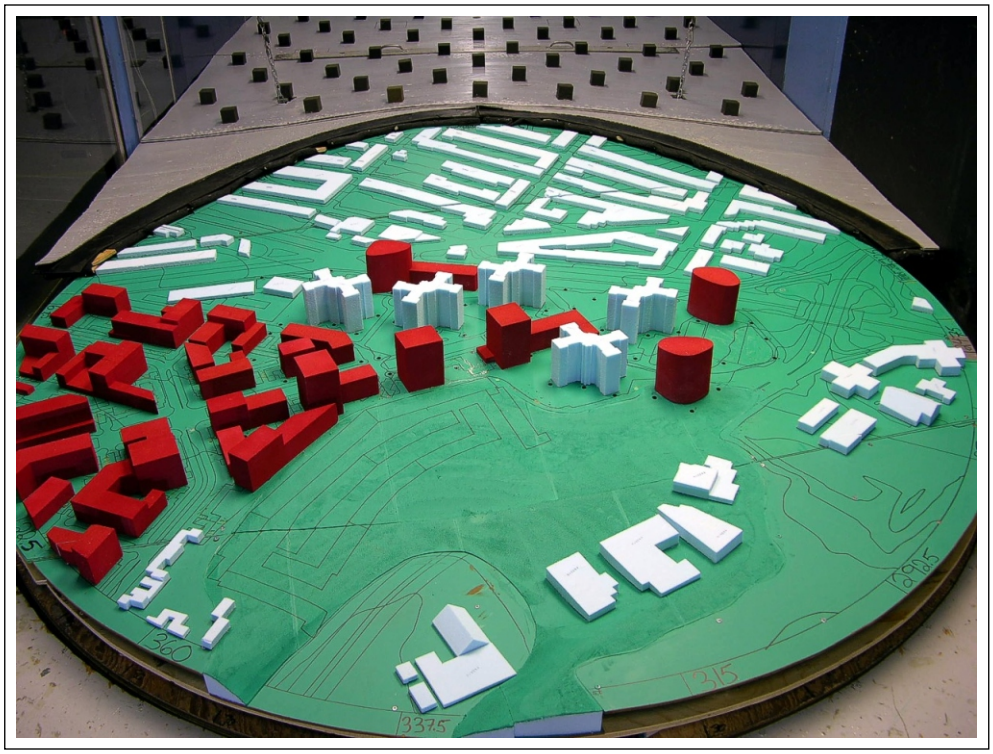


East

Wind Tunnel Study Model **Existing Configuration** Parkmerced Master Plan - San Francisco, California Project #1010052	Figure:	1a	RWDI
	Date:	October 1, 2009	

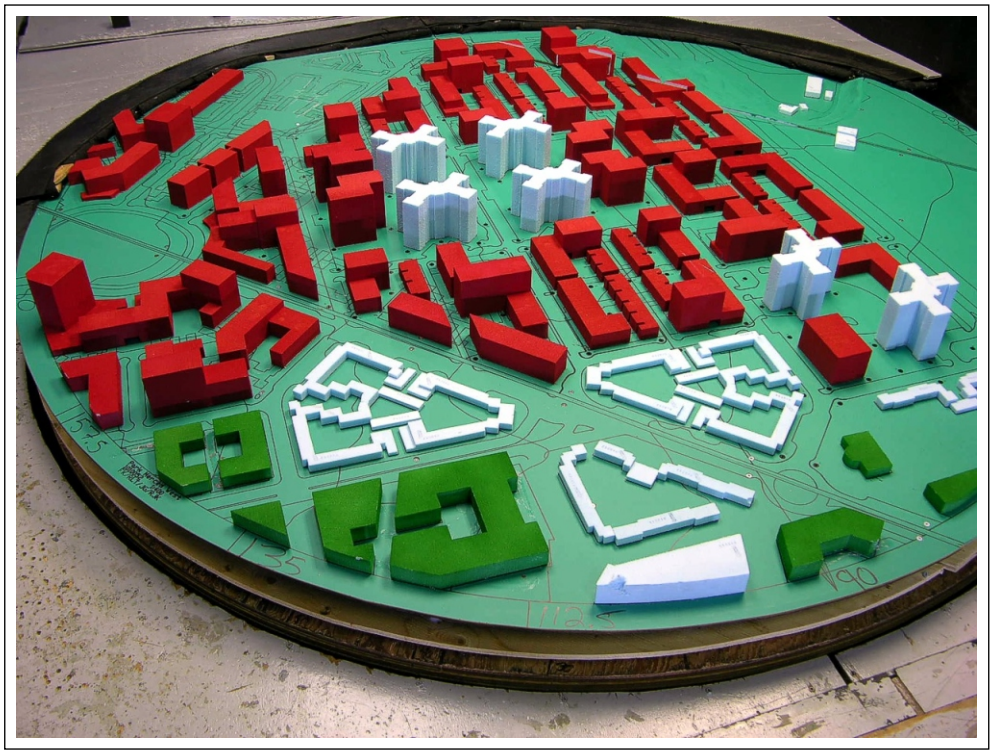


West

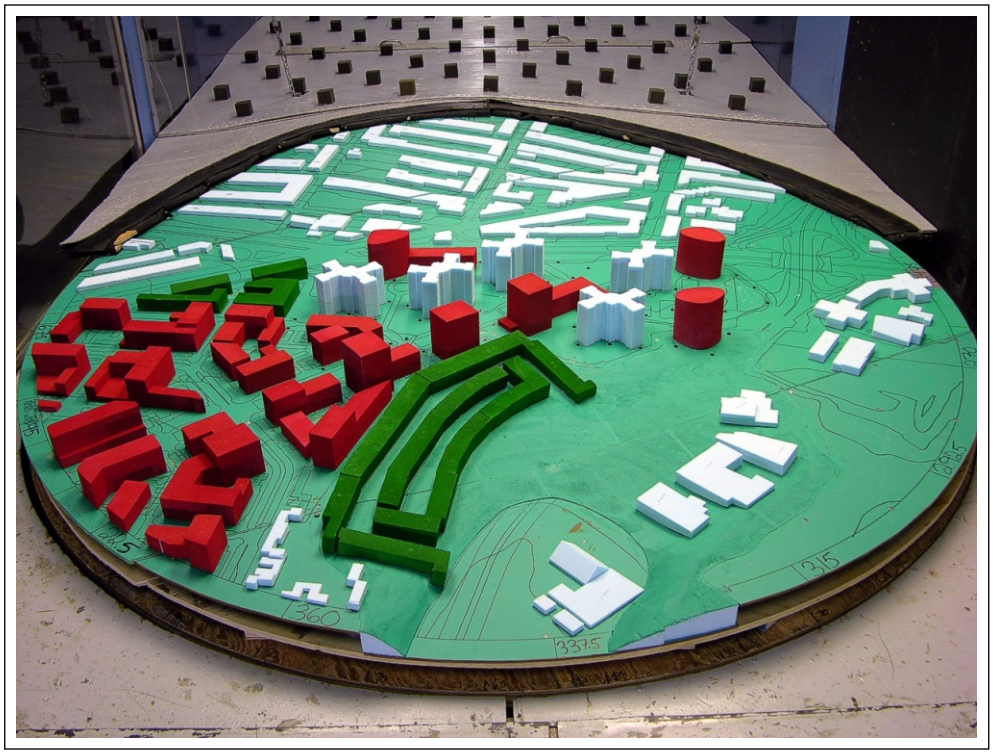


East

Wind Tunnel Study Model **Proposed Project Configuration**		Figure: 1b	RWDI
Parkmerced Master Plan - San Francisco, California	Project #1010052	Date: October 1, 2009	

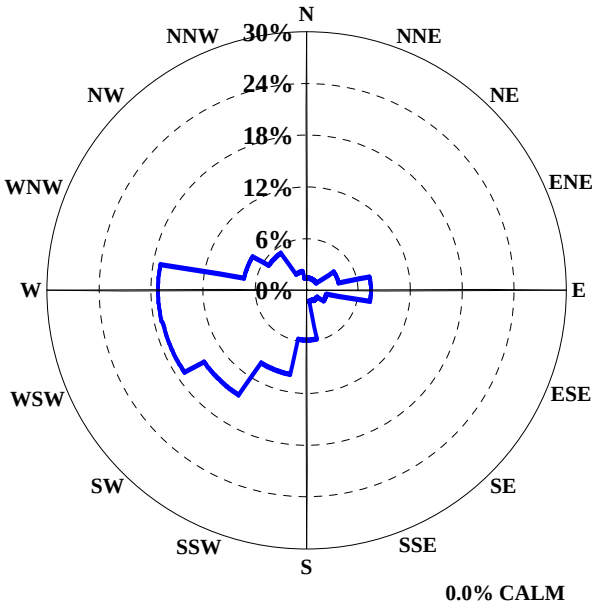


West

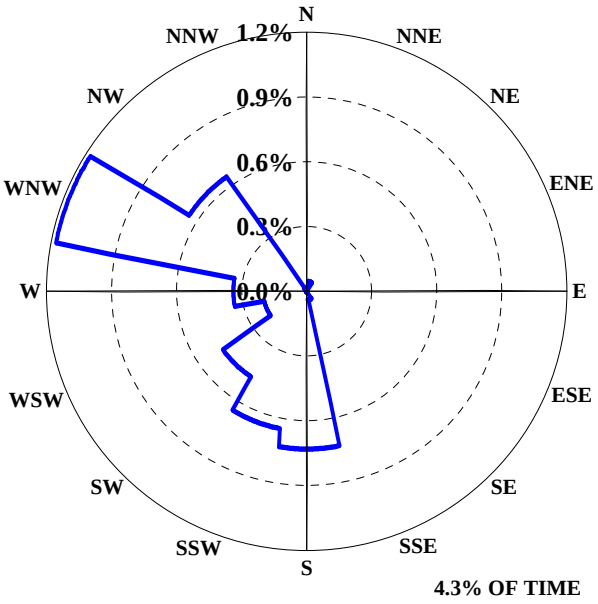


East

Wind Tunnel Study Model **Cumulative Configuration** Parkmerced Master Plan - San Francisco, California Project #1010052	Figure:	1c	RWDI
	Date:	October 1, 2009	

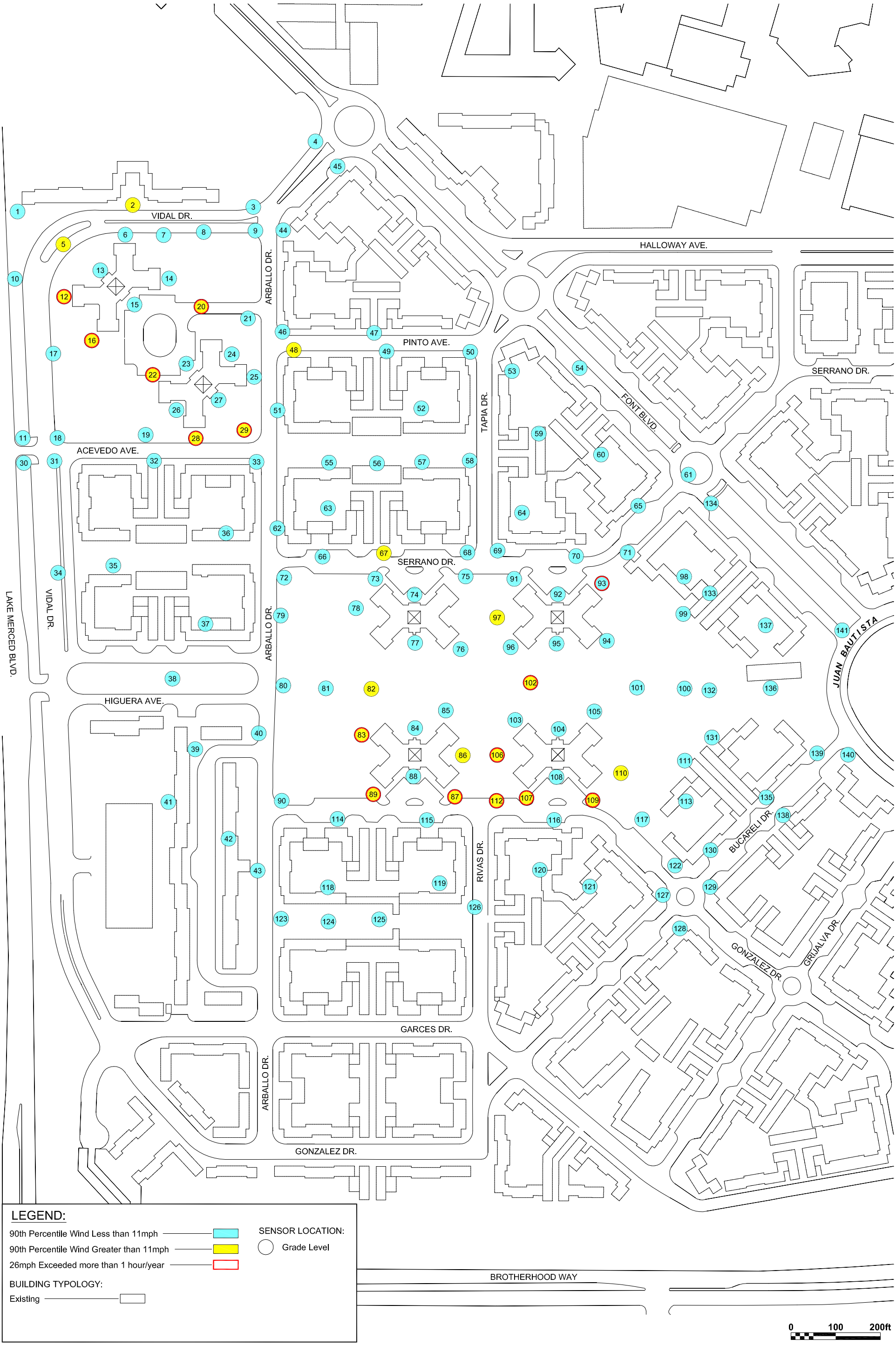


ALL ANNUAL WINDS - 6AM TO MIDNIGHT



ANNUAL WINDS - 6AM TO MIDNIGHT EXCEEDING 20 mph

Directional Distribution (%) of Winds (Blowing From) **Station: Fort Funston, San Francisco, CA (1990 - 2005)**	Figure: **2**	RWDI
Parkmerced Master Plan - San Francisco, CA Project #: 1010052	Date: September 25, 2009	



Pedestrian Wind Conditions - Existing Configuration

True North

Drawn by: ACM | Fig: 3a-1

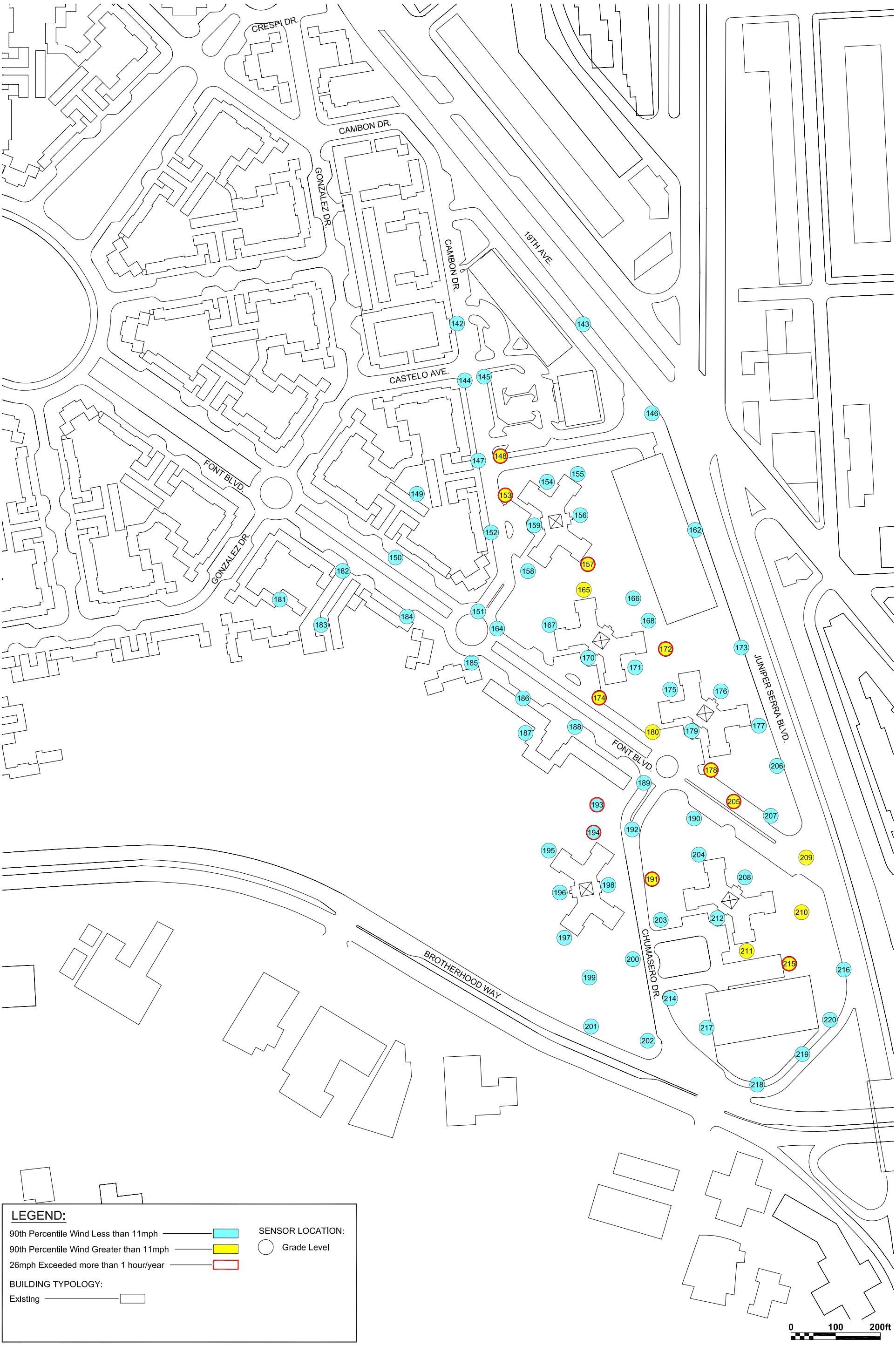
Approx. Scale: 1"=200'

Date Revised: Oct. 1, 2009

Parkmerced Master Plan - San Francisco, California

Project #1010052

RWDI



Pedestrian Wind Conditions - Existing Configuration

True North

Drawn by: ACM | Fig: 3a-2

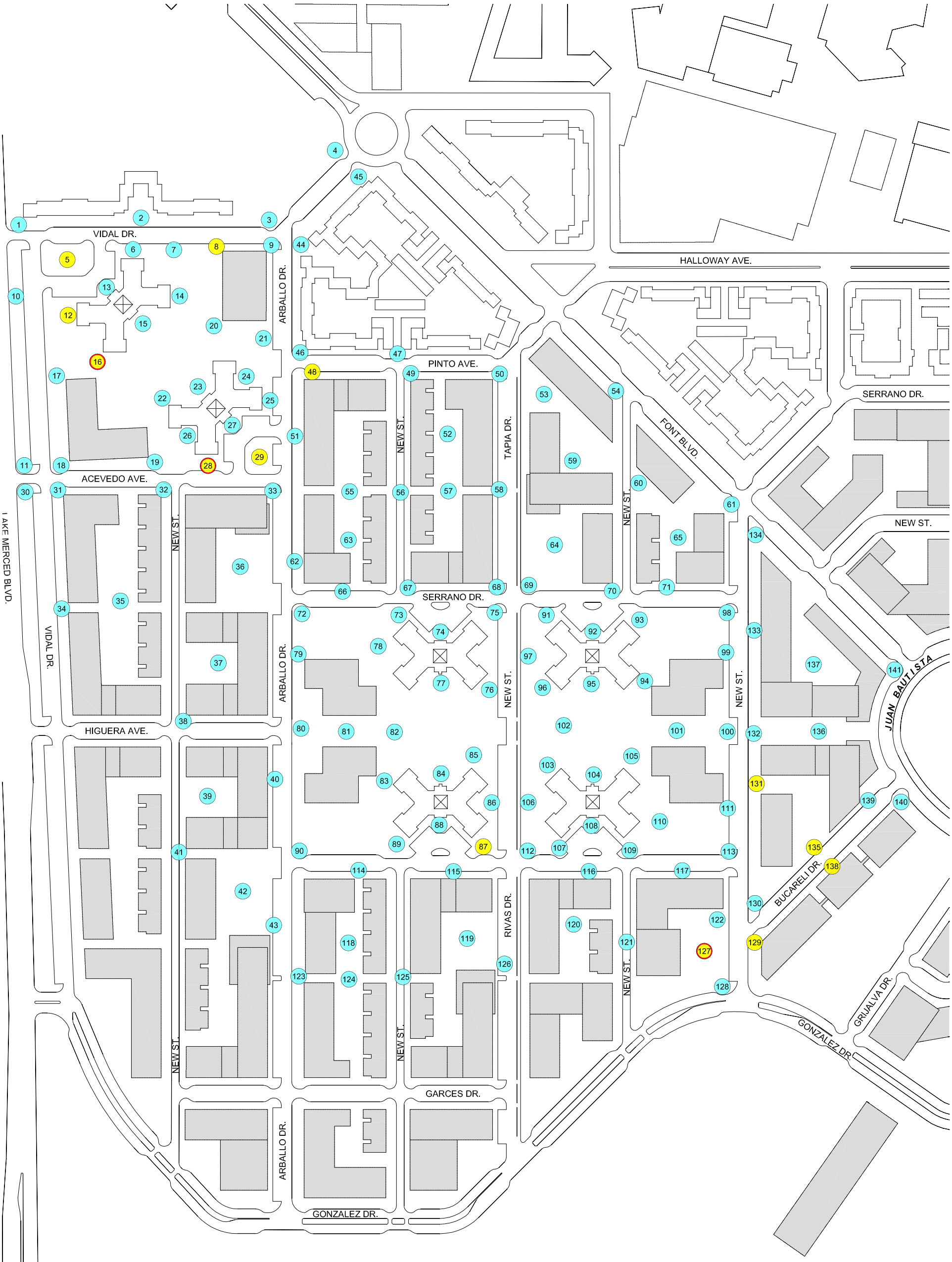
Approx. Scale: 1"=200'

Date Revised: Oct. 1, 2009

RWDI

Parkmerced Master Plan - San Francisco, California

Project #1010052



Pedestrian Wind Conditions - Proposed Project Configuration

True North

Drawn by: ACM | Fig: 3b-1

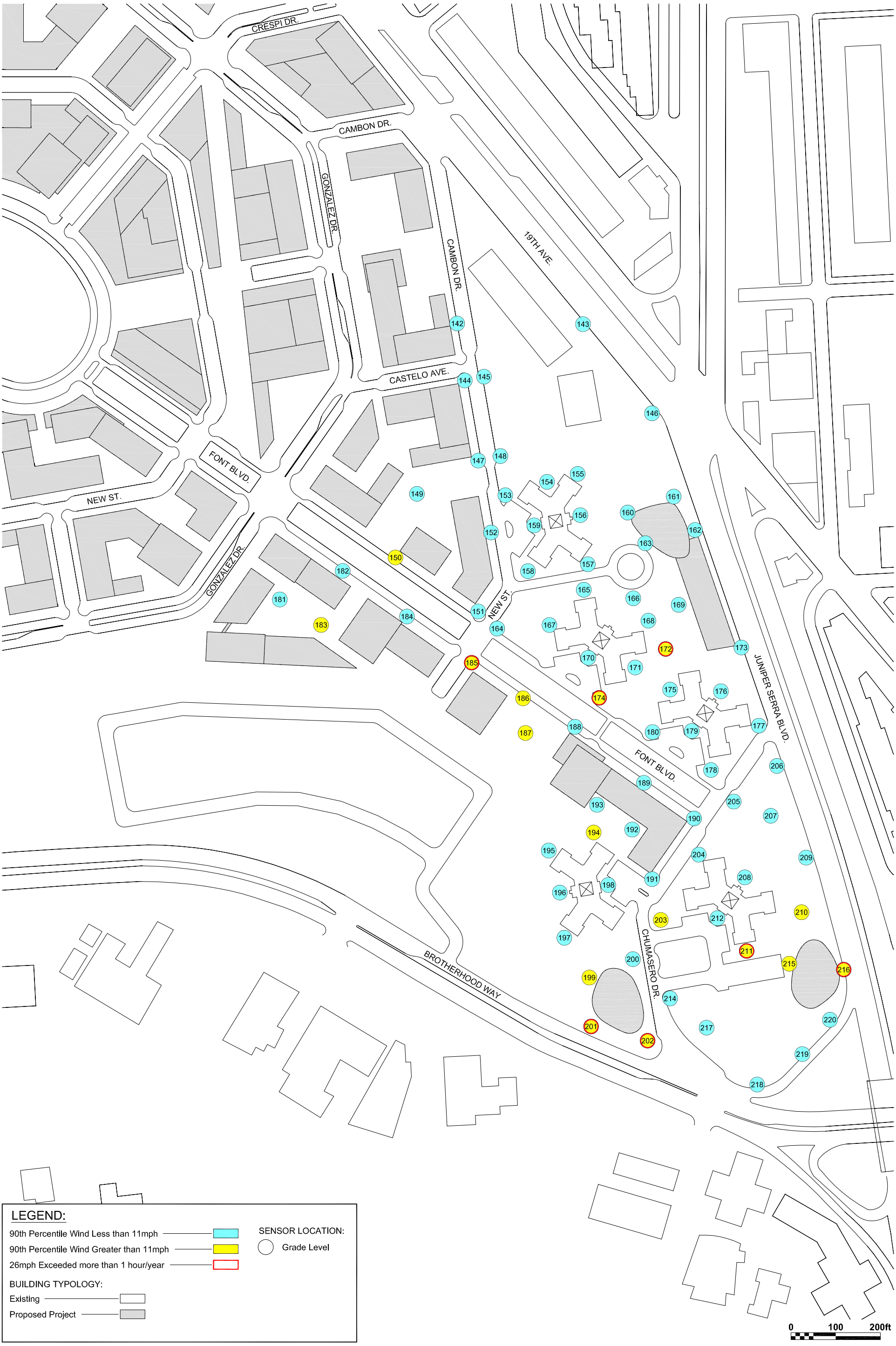
Approx. Scale: 1"=200'

Date Revised: Oct. 1, 2009

RWDI

Parkmerced Master Plan - San Francisco, California

Project #1010052



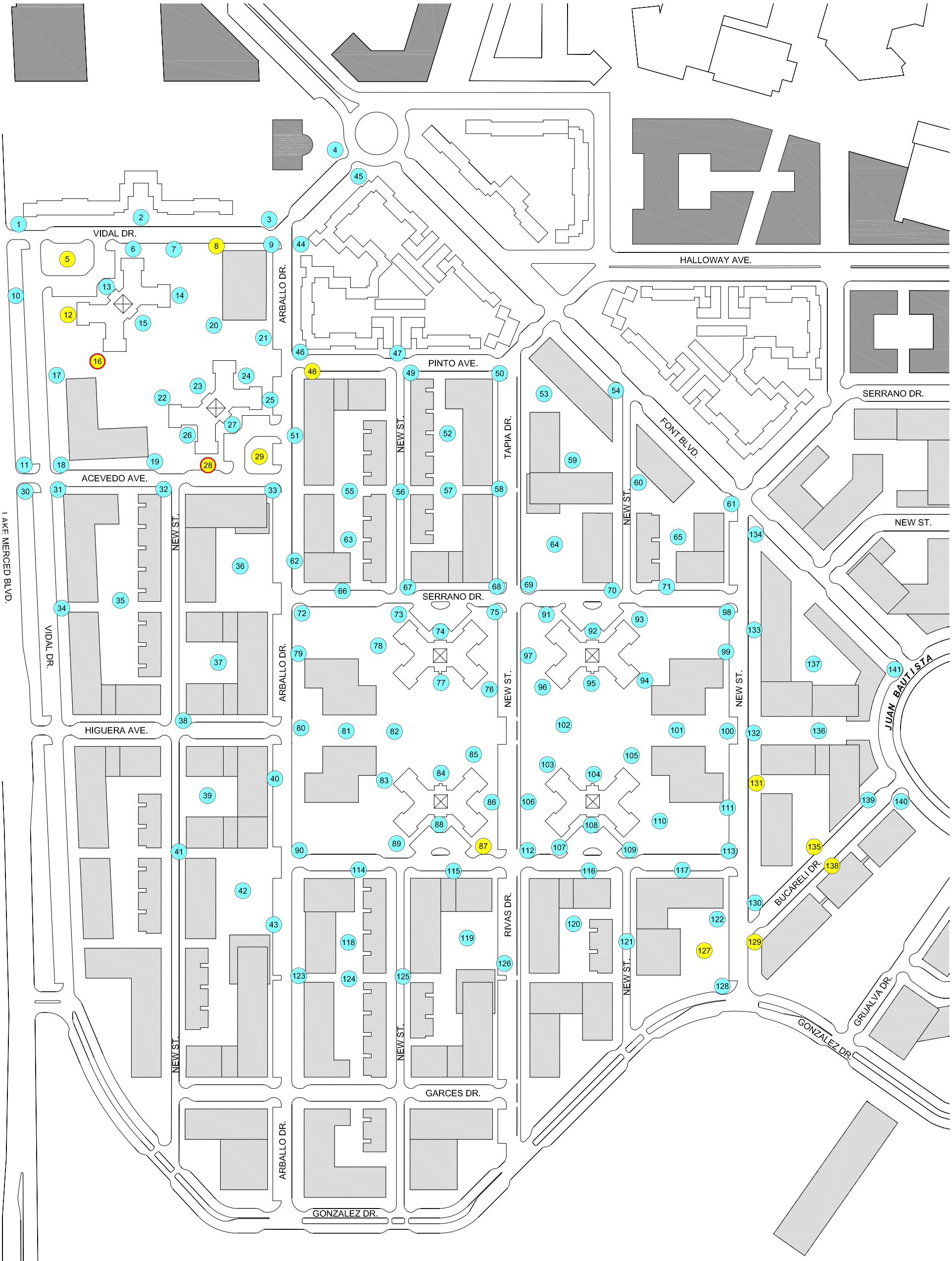
Pedestrian Wind Conditions - Proposed Project Configuration

True North

Drawn by: ACM	Fig: **3b-2**	RWDI
Approx. Scale:	1"=200'	
Date Revised:	Oct. 1, 2009	

Parkmerced Master Plan - San Francisco, California

Project #1010052



Pedestrian Wind Conditions - Cumulative Configuration

True North

Drawn by: ACM | Fig: 3c-1

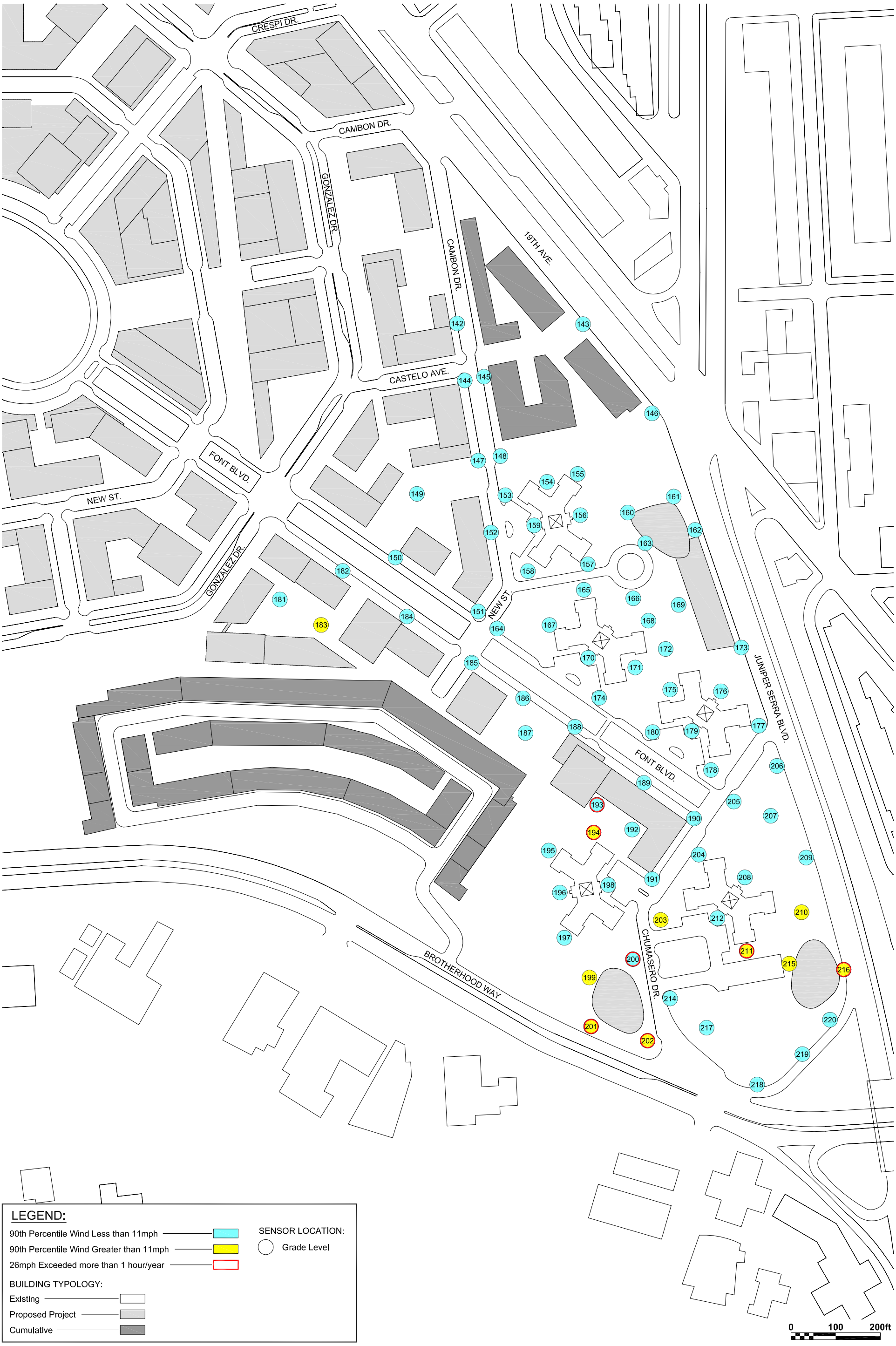
Approx. Scale: 1"=200'

Date Revised: Oct. 1, 2009

RWDI

Parkmerced Master Plan - San Francisco, California

Project #1010052



Pedestrian Wind Conditions - Cumulative Configuration

True North

Drawn by: ACM	Fig:	3c-2
Approx. Scale:		1"=200'
Date Revised:		Oct. 1, 2009

RWDI

Parkmerced Master Plan - San Francisco, California

Project #1010052

APPENDIX A – DRAWING LIST FOR MODEL CONSTRUCTION

The drawings and information listed below were received from Turnstone Consulting and were used to construct the scale model of the proposed Parkmerced development. Should there be any design changes that deviate from this list of drawings, the results may change. Therefore, if changes in the design area made, it is recommended that RWDI be contacted and requested to review their potential effects on wind conditions.

Description	File Name	File Type	Date Received
3D Model – Contour Lines	VPM_no roof_CENTRAL.rvt	Revit	16/03/09
3D Model	20090814_Parkmerced Model.3dm	Rhino	19/08/09
3D Model	20090825_Parkmerced Model.3dm	Rhino	26/08/09
Revised Road Layout	AP00000S0_bound.dwg	AutoCAD	26/08/09
Surrounding Building Confirmation		Fax	09/09/09

Donald Ballanti
Certified Consulting Meteorologist

1424 Scott Street
El Cerrito, CA 94530
(510) 234-6087

MEMORANDUM

To: Nancy Clark

From: Don Ballanti

Date: November 19, 2009

Subject: Wind Impacts and Mitigation for the Proposed Parkmerced Project

INTRODUCTION

The proposed Parkmerced Project is a long-term mixed-use development program to comprehensively re-plan and redesign the Parkmerced site, increase residential density, provide new commercial and retail services and transit facilities, and improve utilities within the development site. About 1,683 of the existing apartments located in 11 tower buildings would be maintained, and over a period of approximately 30 years, the remaining 1,538 existing apartments would be demolished in phases and fully replaced, and an additional 5,679 net new units would be added to the project site. With project implementation, there would be a total of 8,900 units on the project site, a new neighborhood core, a new school and day care facility, fitness center, as well as new open space uses. New buildings would range in height from 1 to 14 stories tall.

The firm of Rowan Williams Davies & Irwin Inc. (RWDI) was retained by Turnstone Consulting to conduct a pedestrian wind study for the proposed Parkmerced Project EIR in San Francisco, California.[1] The purpose of the study was to assess the wind environment around the development in terms of pedestrian comfort and hazard relative to wind metrics specified in the San Francisco Planning Code Section 148.

The results of the following three test scenarios are reported here:

(1) Existing conditions.

[1] Rowan Williams Davies & Irwin Inc, *Revised Final Report Pedestrian Wind Study Parkmerced Project EIR*, San Francisco, California, November 18, 2009.

(2) Existing conditions plus the proposed project.

(3) Existing conditions plus cumulative development plus project.

Cumulative development projects anticipated in the vicinity of the Project Site include the following: the San Francisco State University (SFSU) Master Plan development, which includes upgrades and expansions to existing buildings and construction activities resulting in about 970,000 gsf of net new campus space; construction of 192 dwelling units and 14,000 gsf of retail and commercial space on the 77-111 Cambon Drive property (directly east of the project site along 19th Avenue); and construction of about 445,000 gsf of residential area directly south of the project site along Brotherhood Way).

METHODOLOGY

Study Protocol

The Parkmerced project is located in a section of San Francisco where no previous wind tunnel studies have been prepared. San Francisco's wind code and wind tunnel methodology was developed initially for the Downtown C-3 district and is based on a downtown wind database. San Francisco's wind code also specifies wind metrics specific to a downtown are where pedestrian activity is primarily during the daytime.

The approach used for wind tunnel modeling for the Parkmerced project differs somewhat from that specified in San Francisco's wind code which does not apply to the project area. A study protocol was prepared prior to testing and approved by MEA. The protocol laid out the methodology to be utilized and how this methodology would differ from that applied to downtown projects. The major protocol topics are discussed below.

<u>Wind Data Base</u>

San Francisco's wind code and wind tunnel utilizes a wind database from the U.S. Weather Bureau weather station atop the Old Federal Building at 50 United Nations Plaza during the years 1945-1950. The project is located at the western edge of San Francisco near the Pacific Ocean, so the downtown wind data would not be usable for the project site.

The Bay Area Air Quality Management District has operated a wind monitoring site at Fort Funston since 1990. While this site was established for air quality purposes, it is very close to the Parkmerced site and located such that it provides an excellent characterization of winds approaching the project site and so was selected for use for the Parkmerced project. The data consists of 11 years worth of hourly wind observations data subject to EPA quality assurance standards.

The downtown database is restricted to the hours of 7 am to 6 pm, which represents the peak times for pedestrian activity in a downtown environment. Given the residential nature of the project, the database included the hours from 6 am to midnight, which would be more reflective of possible hours of anticipated typical pedestrian activity and outdoor use with the proposed project.

Wind Directions Tested

The San Francisco wind ordinance methodology for wind tunnel tests requires that four wind directions be modeled: northwest, west-northwest, west and west-southwest. These directions were based on the strongest winds per the downtown database. The Fort Funston wind database shows more variability in direction. Analysis of the frequency distribution shows that for the highest wind category, the vast majority of highest wind occurrences could be captured by testing 8 wind directions (south-southeast through northwest). This adds 4 additional wind tests (southwest, south-southwest, south and south-southeast) to the 4 directions tested for downtown projects. These directions include about 99.2% of the occurrences of winds in the highest category. Testing using the four standard wind directions, by contrast, would include about 40.5% of the occurrences of wind in the highest category.

Area to Be Modeled

Qualitative computer wind simulations of the existing site and the project were commissioned by the project applicant. The computer wind simulations clearly showed that the windiest areas within the project site (for both existing and proposed) were found at the northwest corner of the project site and the southeast corner of the project site. These two areas were tested in the wind tunnel. Each was an 8-foot diameter circle at the scale of 1:400. These areas modeled went beyond the areas of interest so that the effects of upwind structures and terrain are included.

Significance Criteria

The San Francisco Planning Code establishes a wind hazard criterion for the Downtown C-3 and other districts. The hazard criterion is set at an hourly averaged wind speed of 26 mph, which is not to be exceeded more than one hour of the year. For environmental documents, exceedance of the wind hazard criterion is considered a significant impact.

San Francisco Planning Code establishes pedestrian comfort wind criteria for C-3 Districts under Section 148 of the Planning Code. Section 148 of the Planning Code sets comfort levels of 7 mph equivalent wind speed for public seating areas and 11 mph equivalent wind speed for areas of substantial pedestrian use, each not to be exceeded more than 10% of the time year round from 7 am to 6 pm.

The San Francisco Planning Code wind provisions do not apply to the project area. As it is a coastal location with higher base wind speeds, the common metrics of wind in San Francisco (11 mph comfort criterion and 26 mph hazard criterion) were utilized, but impacts were based on whether the project substantially changes the wind for the worse rather than if these metrics are exceeded for a certain amount of time.

The wind tunnel data is presented as the hours per year that the hazard wind level (26 mph, hourly averaged) would be exceeded, and the percent of time that the wind exceeds 11 mph (hourly averaged). As exceedance of the comfort criterion is not considered a significant impact in San Francisco, the following threshold of significance was used:

> *A significant wind impact would be a substantial increase in the number of hours that the 26 mph wind hazard criterion is exceeded or a substantial increase in the area subjected to winds greater than the 26 mph wind hazard criterion.*

Model and Boundary Layer

The test model was constructed using the design information provided by the project applicant. Given the extent of the area under study, it was necessary to construct two overlapping models, eight feet in diameter, to include the aerodynamic effects of upwind buildings and terrain. Large scale terrain changes were incorporated into the test models. The mean speed profile and turbulence of the natural wind approaching the modeled area were simulated in the boundary-layer wind tunnel.

Measurement Protocols

The models were instrumented with a total of 220 permanently mounted wind speed sensors to measure mean and gust wind speeds at a full-scale height of approximately 5 ft. Because of one malfunctioning sensor, the total number of measurement points was 219. Sensors were located at public parks, outdoor recreation areas, major pedestrian corridors and locations were the wind simulation studies suggest high winds can be expected, rather than over the entirety of the project site nor the area modeled. These measurements were recorded for eight wind directions (south-southeast through northwest).

Data Analysis

The equivalent wind speeds were calculated according to the specifications in the San Francisco Planning Code Section 148, whereby the mean hourly wind speed is increased when the turbulence intensity is greater than 15% according to the following formula:

$EWS = V_m(2*TI+0.7)$

Where:

EWS = equivalent wind speed
V_m = mean pedestrian-level wind speed
TI = turbulence intensity

For measured turbulence intensities less than 15%, EWS is taken to be equal to V_m.

Each wind-tunnel measurement results in a ratio that relates the speed of ground-level wind to the speed at the reference elevation, in this case the height of the instrumentation at Fort Funston. The wind data for Fort Funston are then used to calculate the percentage of the time that the specific ground-level wind speed is exceeded for each directional component. The sum of these is the total percentage of time that the specified ground-level wind speed is exceeded.

The wind tunnel results were processed to calculate the 10%-exceeded (90^{th} percentile) wind speed, the percent of time that winds are 11 mph or higher, and the hours per year that winds exceed 26 mph. The first two of these metrics are roughly equivalent to the pedestrian comfort criterion specified in Section 148 of the Planning Code. The third metric is the wind hazard criterion specified in Section 148 of the Planning Code. Since

wind speeds recorded at the Fort Funston Station are true hourly mean wind speeds, frequencies of wind exceeding 26 mph can be determined directly from the data base and do not require adjustment as is required in other wind studies for the Downtown District when a different set of meteorological data (Old Federal Building) is used.

RESULTS

Existing Conditions

The average measured 90th percentile equivalent wind speed for the 215 test locations was approximately 9 mph. A total of 179 of the 215 test locations had a 90th percentile wind speed of 11 mph or less, while 36 of the 215 test locations that had a 90th percentile wind above 11 mph. In general, the areas where 11 mph was exceeded included the towers at the northwest corner of the redevelopment site (northwest of the intersection of Acevedo Avenue and Arballo Drive); the area near the center of the redevelopment site (south of Serrano Drive and east of Arballo Drive); and the area east of Cambon Drive.

Under existing conditions, 189 of the 215 test locations met the wind hazard criterion. Areas where the wind hazard criterion was not met were the towers at the northwest corner of the site; the area near the center of the site; and, the area east of Cambon Drive. For the 26 locations exceeding the wind hazard criterion, the total hours per year above 26 mph was 99.

Project Impacts

The project would modify winds slightly within the project site. The average and maximum measured equivalent wind speed remain the same as with existing conditions (9 mph and 14 mph, respectively). In total, 190 of the 219 test locations had a 90th percentile wind less than 11 mph, compared to 189 of 215 test locations for existing conditions.

Near the towers at the northwest corner of the project site, wind conditions were generally unchanged from existing conditions. Near the center of the project site (south of Serrano Drive and east of Arballo Drive), wind conditions were generally improved. However, wind speeds increased around the Bucareli Drive area southwest of the center of the project site.

In the area east of Cambon Drive, wind conditions improved with the proposed project in the area north of Font Boulevard whereas areas along Font Boulevard were predicted

increase. Winds in areas around Chumasero Drive were generally found to increase compared to existing conditions.

For the proposed project, 209 of the 219 test locations meet the wind hazard criterion. In total, 22 existing wind hazard exceedences were eliminated, while six new locations that exceeded the wind hazard criterion were created. These new areas include the area near Bucareli Drive, along Font Boulevard, near the intersection of Brotherhood Way and Chumasero Drive, and east of Chumasero Drive. For the 10 locations exceeding the wind hazard criterion, the total hours per year above 26 mph was 45, compared to 99 hours per year under existing conditions.

Cumulative Impacts

The addition of cumulative development would modify winds slightly within the project site. Under cumulative conditions, the average and maximum measured equivalent wind speed remained the same as for existing and proposed project conditions (9 mph and 14 mph, respectively). Overall, 196 of the 219 test locations would have a 90th percentile wind below 11 mph compared to 190 of the 219 test locations for project conditions and to 189 of 215 test locations for existing conditions.

Under cumulative conditions, 210 of the 219 test locations meet the wind hazard criterion. When compared to project conditions, four wind hazard exceedences were eliminated, while three wind hazard exceedences at new locations were created in the area along Chumasero Drive. For the 9 locations exceeding the wind hazard criterion, the total hours per year above 26 mph was 39, compared to 45 under project conditions and 99 hours per year under existing conditions.

MITIGATION MEASURES

The proposed project would not result in “a substantial increase in the number of hours that the 26 mph wind hazard criterion is exceeded” as the total number of hours of exceedance would drop with project construction. However, the project could, at least on a local basis, result in a “substantial increase in the area subjected to winds greater than the 26 mph wind hazard criterion” in that it does result in some new areas that exceed the wind hazard criterion. Because wind impacts are partially determined by building massing and orientation, and the wind tunnel tests were conducted on massing models and not specific building designs, the project is considered to have a *potentially significant* impact on wind.

The project would be built over a period of years. While the overall wind effect of the proposed development is to reduce winds, interim wind impacts may occur prior to project completion. To mitigate potential interim wind impacts the following is proposed:

> *Wind review will be required for all buildings over 100 feet in height. Wind tunnel testing may also be required for these buildings unless, upon review by a qualified wind consultant, it is determined that the exposure, massing, and orientation of the building are such that adverse wind impacts will not occur. Wind analysis shall be conducted to assess wind conditions for the building in conjunction with the anticipated pattern of development on surrounding blocks. The objective shall be to use all feasible means to eliminate wind hazards, if predicted.*

The wind tunnel results demonstrate that the 11 existing 13-story residential tower buildings are responsible for all the existing exceedances of the hazard criterion. Under proposed project and cumulative conditions, all predicted exceedances of the hazard criterion occur near these existing structures. New buildings close to these structures would have the potential to create new areas of exceedance of the hazard criterion, although this could be avoided with proper design. To mitigate potential interim wind impacts the following is proposed:

> *Wind tunnel testing will be required for all buildings over 50 feet in height that are closer than 200 feet from any of the existing 13-story buildings on site. Wind tunnel analysis shall be conducted to assess wind conditions for the building in conjunction with the anticipated pattern of development on surrounding blocks. The objective shall be to use all feasible means to eliminate wind hazards, if predicted.*

The following guidelines are examples of methods that can be used in the design of buildings to eliminate wind hazards and/or to address adverse wind impacts:

> • Western facades can be modulated through the use of architectural devices such as surface articulation, variation of planes, wall surfaces, and heights, as well as the placement of stepbacks, courtyards, plazas, and other features.
>
> • Landscaping in appropriate locations, can be used to mitigate wind. Porous materials (vegetation, hedges, screens, latticework, perforated or expanded metal) offer superior wind shelter as compared to a solid surface. Such wind

sheltering elements should be located west of the area being protected, and should be of sufficient height. Wind shadows behind porous wind screens provide shelter for a distance downwind equivalent to 3-5 times the height of the wind screen.

• “Breezeways” or notches at the upwind corners of the building should be avoided.

• Building stepbacks can be used to ameliorate ground level wind accelerations. If these stepback areas are used as terraces, they are likely to need properly designed wind screening elements or even partial enclosure to ensure usability. Any wind sheltering strategy should address the likely significant downward component of these winds, particularly below west facing building elements.

Donald Ballanti
Certified Consulting Meteorologist

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El Cerrito, CA 94530
(510) 234-6087

MEMORANDUM

To: Nancy Clark

From: Don Ballanti

Date: November 9, 2009

Subject: Revised Building Heights/Footprints for the Parkmerced Project

Wind tunnel testing was conducted on the "Representative Building Heights" model. The following is a qualitative discussion of wind conditions under the maximum allowable building heights identified in the proposed Special Use District. In certain areas of the project site, building heights under the "Representative Building Heights" model were not fully maximized to what would be allowable under the proposed Special Use District Zoning. Proposed zoning changes could allow for some building footprints to shift, and some building heights to increase.

Differences between the maximum allowable building mass versus the respresentive building heights tested in the wind tunnel indicate that a small number of buildings are affected. Changes in building heights and shifts in location or footprint were each considered to determined whether the change would increase substantially the potential for wind impacts given the massing, orientation and exposure of the building. The results of the wind tunnel studies were also considered to determined if changes to building massing would occur near where identified significant wind impacts exist or were predicted to occur with the proposed project.

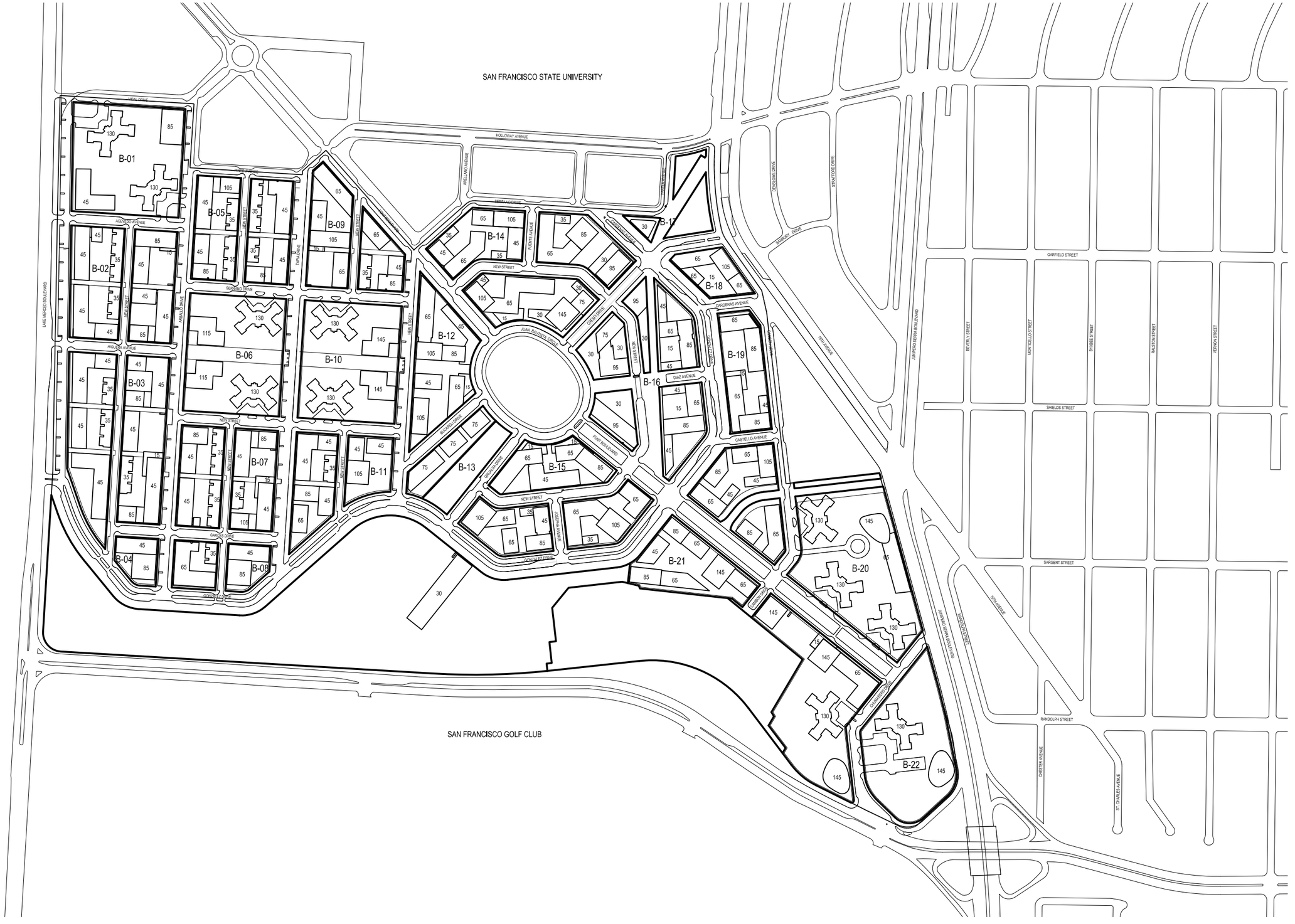
The largest potential for wind impacts would be where buildings are both taller and bulkier. This would occur within Block 01 where buildings of 65 and 85 feet could be increased to 130 feet, and both would have larger footprints. Also, on Block 06 two buildings 115 feet in height would be increased to 130 feet in height with larger footprints. Within Block 01 winds in exceeding the wind hazard criterion were predicted for the existing, project and cumulative cases, while no such exceedances were predicted near Block 06. At these locations the maximized building heights would have an increased potential for wind impacts, but all changes involve building over 100 feet in height that would be subject to wind tunnel testing and mitigation requirements.

There would be a lesser potential for wind impacts where building heights are increased but the building footprint is unchanged. This would occur at four locations: Blocks 11-13 and at the recreation building at the south end of the site. Height increases would be either 10 or 20 feet. None of the proposed changes would occur near areas where exceedence of the wind hazard criteria is forecast. At these locations, only minor wind changes could be expected.

There is even a lesser potential for wind impact where buildings remain the same height, but the building footprint increases. This would occur at two locations: Blocks 03 and 10. The building within Block 03 would be relatively short at 45 feet in height. The affected buildings within Block 10 are 145 feet in height. None of the proposed changes would occur near areas where exceedence of the wind hazard criteria is forecast. At these locations, only minor wind changes could be expected.

Moving a building from one site to another has little potential to affect wind impacts unless the move changes the exposure of the structure or places it where it interacts with other buildings. On Block 21 a building would be shifted to Block 22. This move could potentially generate significant changes in wind. Winds on both Block 21 and Block 22 were forecast to exceed the wind hazard criterion. The structure in question would be 145 feet in height, and thus would be subject to wind tunnel testing and mitigation requirements.

In summary, the maximum building heights scenario would have limited potential for greater wind impacts than those described in wind tunnel test results for the project. The mitigation measures developed for the project would be sufficient to ensure that future wind impacts under the maximum building heights scenario would be reduced to a less than significant level.



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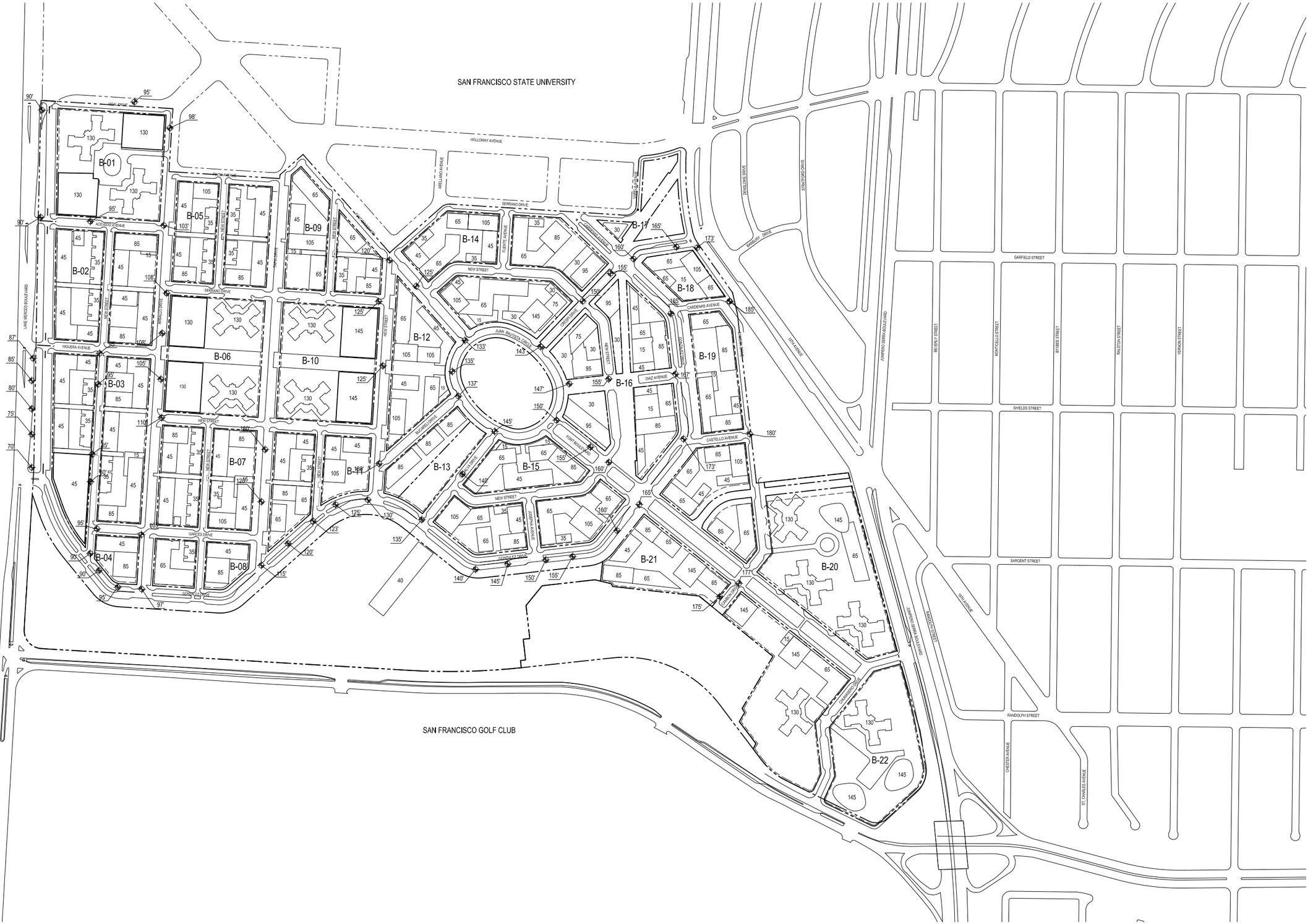
BUILDING HEIGHTS ISSUED 08.25.2009 FOR RWDI ASK-287

PARKMERCED INVESTORS LLC SOM

N 0 200' 400' 800'

FIGURE C.c.1



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BUILDING HEIGHTS FOR EIR SHADOW STUDY ASK-286

PARKMERCED INVESTORS LLC SOM

N 0 200' 400' 800'

FIGURE C.c.2