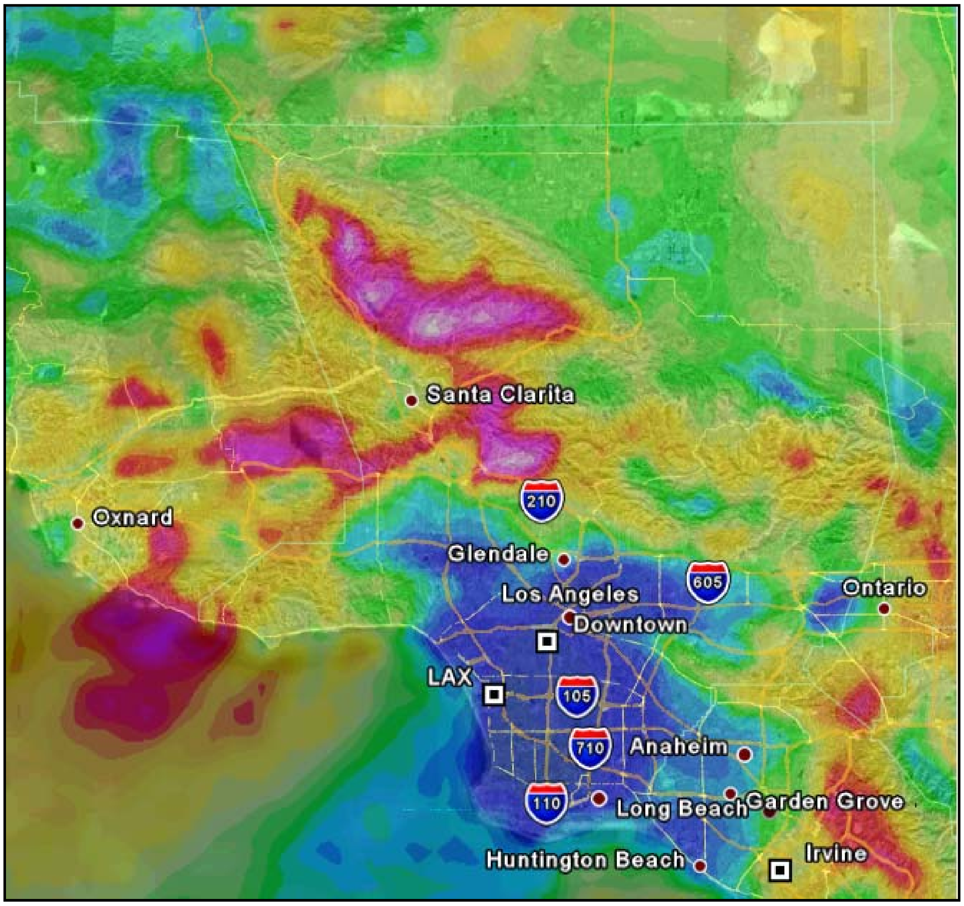
STRUCTURAL ENGINEERS ASSOCIATION OF SOUTHERN CALIFORNIA

Summary Report:
Study of Historical and Design Wind Speeds in the Los Angeles Area



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Prepared by:

Structural Engineers Association of Southern California
SEAOSC Ad-Hoc Wind Committee (listed in alphabetical order)

Casey K. Hemmatyar, P.E., S.E.
Richard L. Hess, P.E., S.E.
Anurag Jain, Ph.D., P.E.
James S. Lai, P.E., S.E.
Michael D. Lapraik, P.E., S.E.
Jon A. Peterka, Ph.D., P.E. (Colorado)
Marco A. Petrilli, P.E., S.E.
Richard J. Phillips, P.E., S.E.
Gary R. Searer, P.E., S.E. (Chair)
Carl Sramek*, P.E., S.E.
Joseph Valancius, P.E., S.E.
Thomas D. VanDorpe*, P.E., S.E.

*Corresponding Member

STRUCTURAL ENGINEERS ASSOCIATION
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Background and Committee Assignment

In 2007, California adopted the 2006 *International Building Code* (ICC), which references the ASCE standard, *Minimum Design Loads for Buildings and Other Structures* (ASCE/SEI 7-05). The basic wind speed map in Figure 6-1 of ASCE 7-05 (Figure 1609 of the 2007 *California Building Code*) shows a special wind region in the southern half of Los Angeles County and states that "special wind regions shall be examined for unusual wind conditions."

The Structural Engineers Association of Southern California (SEAOSC) commissioned this *ad-hoc* wind committee to investigate the history of recorded wind speeds in Los Angeles area and to make recommendations regarding how the special wind region currently shown in the southern portion of Los Angeles County ought to be implemented.

History of Design Wind Loads in the Los Angeles County Area

Starting with the 1927 *Uniform Building Code* (UBC, published by the International Conference of Building Officials), design wind pressures for buildings in California, including the Los Angeles County area, ranged in value from 10 pounds per square foot (psf) for low-rise structures to 20 psf for mid-rise and high-rise structures. In the 1937 UBC, the minimum design pressure was increased to 15 psf with a maximum of 20 psf; these minimum design pressures for buildings stayed in effect through the 1958 UBC.

In the 1961 UBC, wind load provisions became more complicated and included a figure showing wind pressures; nearly all of California was listed as having a wind pressure of 20 psf. Using the wind pressure of 20 psf, design wind loads ranged from 15 psf for low-rise structures to 30 psf for high-rises. Santa Ana winds were shown in the vicinity of Los Angeles on the map but no mandatory increases in design wind speed were implemented in the Los Angeles County area. Design wind loads for the Los Angeles County area remained essentially unchanged through the 1979 UBC.

In the 1982 UBC, the formulation for wind design changed from using a wind pressure map to a basic wind speed map that was based on a fastest-mile wind. Nearly all of southern California, including Los Angeles County, was below the 70 mile per hour (mph) contour. A "special wind region" was shown on the map near Los Angeles County; however, the region did not extend to Los Angeles proper and never affected design wind loads in the area. This formulation resulted in design pressures for buildings that varied from 12 psf for low-rise structures to as much as 37 psf for high-rise structures, depending on exposure. In the 1991 UBC, design wind loads for buildings dropped slightly to 10 psf to 36 psf, and remained unchanged through the 1997 UBC.

As noted above, in 2007, ASCE 7-05 was incorporated into the California Building Code. ASCE 7-05 has a markedly more complex procedure to calculate design wind loads. Although it is difficult to compare design values from the older codes with such a complex procedure, use of ASCE 7 with an 85-mph basic wind speed results in design wind loads for structures that are generally equal to loads from the 1991 through 1997 UBC (i.e., 10 psf to 36 psf). Use of an arbitrarily higher basic wind speed such as 100 mph in the special wind region results in design loads from 14 psf to 51 psf -- assuming that the topographic factor is set to 1.0 (i.e., no topographic effects), resulting in increases in design loads of 40%

over more recent building codes, even without considering topographic effects. Topographic effects, which were not explicitly considered in prior codes, can result in significant *additional* increases in design forces.

History of ANSI A58.1 and ASCE 7 Basic Wind Speeds

In 1972, American National Standards Institute, Inc. (ANSI) released ANSI A58.1-1972, *Building Code Requirements for Minimum Design Loads in Buildings and Other Structures*. In its first edition, the City of Los Angeles was shown below the 60 mph fastest mile wind contour, and all of Los Angeles County was shown below 70 mph. In ANSI A58.1's second edition in 1982, all contours below 70 mph were abandoned, thereby causing Los Angeles City and County to be "rounded up" to 70 mph. In addition, "special wind regions" were added to the map, and the following instructions were provided:

> "**6.5.2.1 Special Wind Regions.** Special consideration shall be given to those regions for which records or experience indicate that the wind speeds are higher than those indicated in Fig. 1 and Table 7. Some such regions are indicated in Fig. 1; however, all mountainous terrain, gorges, and ocean promontories shall be examined for unusual wind conditions, and the authority having jurisdiction shall, if necessary, adjust the values given in Fig. 1 and Table 7 to account for the higher local winds. Where necessary, such adjustment shall be based on meteorological advice and an estimate of the basic wind speed obtained in accordance with the provisions of 6.5.2.2."

The 1982 ANSI map showed a special wind region east of Los Angeles, but this special wind region did not reach Los Angeles. In 1988, the ANSI A58.1 standard was then incorporated into the American Society of Civil Engineers' *Minimum Design Loads for Buildings and Other Structures* (ASCE 7). The map showing basic wind speeds remained unchanged in the 1988 and 1993 versions of ASCE 7. In 1995, another edition of ASCE 7 was released; the basic wind speed map was converted from fastest-mile wind speeds to 3-second gusts. Although the minimum basic wind speed contour was changed from a 70 mph speed based on fastest-mile to an 85 mph basic wind speed based on a 3-second gust, this did not result in any substantive change to wind design forces, since the new maps merely incorporated the "gust response factor" into their new contours. However, in the conversion of the map from fastest-mile basis to a 3-second gust, the special wind regions were dramatically altered, with significant changes in the size, shape, and location, particularly in the western United States. Whereas the 1993 special wind region stopped short of Los Angeles and the Pacific Ocean, the 1995 version grew larger and reached over Los Angeles all the way to the Pacific Ocean. Further, less dramatic changes in the regions occurred in the 1988 version and in the 2010 public comment version of ASCE 7. A historical progression of wind maps for the western United States is shown in Appendix A.

Given that the special wind regions changed substantially over time, the Committee questioned individuals who worked on the various editions of ANSI A58.1 and ASCE 7 as to the reasons behind the changes. Two individuals responded (Mehta and Vickery), both relaying approximately the same information: that the special wind regions were added to the 1982 ANSI standard by a single meteorologist, Hugh Church, and that since that time, no review of the special wind regions in California has been undertaken by either committee, and no data has been provided to the committees to justify changing the special wind region. Although these individuals spoke based on their personal recollection and could not speak for the past ANSI A58.1 or ASCE 7 committees as a whole, their recollections seem to indicate that the various changes in California, including the extension of the special wind region across Los Angeles to the Pacific Ocean, occurred inadvertently during copying and recopying of the maps through time, and not as a result of deliberate incorporation of new data.

Actual Measured Winds in the Los Angeles County Area

As part of our study, the Committee obtained wind data from three stations in the Los Angeles area from the National Climatic Data Center (NCDC)/National Oceanic and Atmospheric Administration (NOAA): Los Angeles Civic Center (Table 1), Los Angeles International Airport (Table 2), and Long Beach Dougherty Field (Table 3). The data presented in these tables has some limitations, since the historical data was measured in a variety of ways: 3-second gust, 5-second gust(1), fastest mile(2), highest velocity (3), 5-minute wind (4), and peak gust (5). The recorded data has been converted to 3-second gusts to facilitate comparison, but no adjustments have been made to account for any variation in instrument height or exposure that may have occurred over time.

Table 1: Maximum Recorded Wind Speed for Los Angeles Civic Center, Los Angeles County

Year	Maximum Wind Speed (mph)	Max. Equiv. 3-Second Gust (mph)	Year	Maximum Wind Speed (mph)	Max. Equiv. 3-Second Gust (mph)	Year	Maximum Wind Speed (mph)	Max. Equiv. 3-Second Gust (mph)
2008	31	31	1984	No data	No data	1960	36 (2)	46
2007	39 (1)	40	1983	No data	No data	1959	48 (2)	60
2006	35 (1)	36	1982	No data	No data	1958	38 (2)	48
2005	28 (1)	29	1981	No data	No data	1957	38 (2)	48
2004	29 (1)	30	1980	No data	No data	1956	36 (2)	46
2003	33 (1)	34	1979	No data	No data	1955	40 (2)	51
2002	30 (1)	31	1978	No data	No data	1954	37 (2)	47
2001	30 (1)	31	1977	31 (2)	41	1953	40 (2)	51
2000	30 (1)	31	1976	30 (2)	39	1952	38 (2)	48
1999	25 (1)	26	1975	27 (2)	36	1951	35 (2)	45
1998	No data	No data	1974	33 (2)	43	1950	35 (2)	45
1997	No data	No data	1973	33 (2)	43	1949	No data	No data
1996	No data	No data	1972	33 (2)	43	1948	37 (3)	37
1995	No data	No data	1971	33 (2)	43	1947	34 (3)	34
1994	No data	No data	1970	31 (2)	41	1946	48 (3)	48
1993	No data	No data	1969	33 (2)	43	1945	No data	No data
1992	No data	No data	1968	28 (2)	37	1944	No data	No data
1991	No data	No data	1967	29 (2)	38	1943	43 (3)	43
1990	No data	No data	1966	27 (2)	36	1942	36 (3)	36
1989	No data	No data	1965	31 (2)	41	1941	36 (3)	36
1988	No data	No data	1964	47 (2)	59	1940	33 (4)	46
1987	No data	No data	1963	34 (2)	44	1939	30 (4)	41
1986	No data	No data	1962	33 (2)	43	1938	26 (4)	36
1985	No data	No data	1961	40 (2)	51	1937	No data	No data

Table 2: Maximum Recorded Wind Speed for Los Angeles International, Los Angeles County

Year	Maximum Wind Speed (mph)	Max. Equiv. 3-Second Gust (mph)	Year	Maximum Wind Speed (mph)	Max. Equiv. 3-Second Gust (mph)	Year	Maximum Wind Speed (mph)	Max. Equiv. 3-Second Gust (mph)
2008	47	47	1988	51 (5)	51	1968	38 (5)	38
2007	49 (1)	50	1987	47 (5)	47	1967	38 (5)	38
2006	49 (1)	50	1986	41 (5)	41	1966	43 (2)	43
2005	43 (1)	44	1985	52 (5)	52	1965	45 (5)	45
2004	46 (1)	47	1984	51 (5)	51	1964	55 (5)	55
2003	48 (1)	49	1983	52 (5)	52	1963	32 (5)	32
2002	40 (1)	41	1982	60 (5)	60	1962	49 (5)	49
2001	44 (1)	45	1981	48 (5)	48	1961	46 (5)	46
2000	38 (1)	39	1980	46 (5)	46	1960	36 (5)	36
1999	53 (1)	54	1979	45 (5)	45	1959	46 (5)	46
1998	48 (1)	49	1978	45 (5)	45	1958	55 (5)	55
1997	48 (1)	49	1977	41 (5)	41	1957	59 (5)	59
1996	46 (1)	47	1976	53 (2)	65	1956	51 (5)	51
1995	40 (5)	40	1975	46 (5)	46	1955	48 (5)	48
1994	41 (5)	41	1974	46 (5)	46	1954	45 (5)	45
1993	44 (5)	44	1973	46 (5)	46	1953	57 (5)	57
1992	39 (5)	39	1972	45 (5)	45	1952	62 (5)	62
1991	48 (5)	48	1971	43 (5)	43	1951	54 (2)	67
1990	45 (5)	45	1970	45 (5)	45	1950	46 (2)	57
1989	41 (5)	41	1969	41 (5)	41	1949	No data	No data

Table 3: Maximum Recorded Wind Speed for Long Beach Daugherty Field, Los Angeles County

Year	Maximum Wind Speed (mph)	Max. Equiv. 3-Second Gust (mph)	Year	Maximum Wind Speed (mph)	Max. Equiv. 3-Second Gust (mph)	Year	Maximum Wind Speed (mph)	Max. Equiv. 3-Second Gust (mph)
2008	48	48	1991	49 (5)	49	1974	30 (2)	39
2007	48 (1)	49	1990	40 (5)	40	1973	36 (2)	46
2006	41 (1)	42	1989	38 (5)	38	1972	27 (2)	36
2005	43 (1)	44	1988	46 (5)	46	1971	30 (2)	39
2004	39 (1)	40	1987	37 (5)	37	1970	35 (2)	45
2003	39 (1)	40	1986	39 (5)	39	1969	33 (2)	43
2002	36 (1)	37	1985	54 (5)	54	1968	35 (2)	45
2001	41 (1)	42	1984	44 (5)	44	1967	28 (2)	37
2000	46 (1)	47	1983	35 (2)	45	1966	28 (2)	37
1999	41 (1)	42	1982	44 (2)	55	1965	32 (2)	42
1998	45 (1)	46	1981	33 (2)	43	1964	37 (2)	47
1997	39 (1)	40	1980	33 (2)	43	1963	44 (2)	55
1996	39 (1)	40	1979	37 (2)	47	1962	32 (2)	42
1995	43 (5)	43	1978	29 (2)	38	1961	39 (2)	50
1994	39 (5)	39	1977	29 (2)	38	1960	33 (2)	43
1993	40 (5)	40	1976	30 (2)	39	1959	40 (2)	51
1992	43 (5)	43	1975	33 (2)	43	1958	No data	No data

The Committee also obtained data from Weather Underground (www.wunderground.com) for Burbank, El Monte, Hawthorne, Santa Monica, Palmdale, Torrance, Van Nuys, Ontario, and Oxnard; this data is shown in Tables 4 through 12, respectively. The data from Weather Underground did not appear to have been checked before being published and occasionally contained anomalous wind speed data; anomalous data that did not correlate with data from other nearby stations on the same date was discounted. Maximum wind data are noted with a superscript asterisk, and 3-second gust data have no superscript.

Note that the term “maximum wind” is not well-defined, and may mean anything from an instantaneous reading to a 5-second gust to a 5-minute wind.

Table 4: Maximum Recorded Wind Speed for Burbank Airport, Los Angeles County

Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)
2009	46	1999	39	1989	58*	1979	67*
2008	46	1998	52	1988	46	1978	63*
2007	49	1997	63	1987	34	1977	60*
2006	55	1996	59*	1986	58*	1976	52*
2005	40	1995	40	1985	52*	1975	50*
2004	45	1994	53*	1984	52*	1974	52
2003	50	1993	53*	1983	52*	1973	46
2002	53	1992	40	1982	58	1972	No data
2001	41	1991	46	1981	37	1971	No data
2000	No data	1990	52*	1980	58*	1970	No data

Table 5: Maximum Recorded Wind Speed for El Monte Airport, Los Angeles County

Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)
2009	46	2002	54*	1995	54*	1988	29
2008	32	2001	58*	1994	63*	1987	52*
2007	64*	2000	No data	1993	46*	1986	29
2006	34*	1999	62*	1992	53*	1985	61*
2005	23	1998	34	1991	34	1984	No data
2004	63*	1997	63*	1990	58*	1983	No data
2003	50*	1996	63*	1989	23	1982	No data

Table 6: Maximum Recorded Wind Speed for Hawthorne Airport, Los Angeles County

Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)
2009	40	1999	43	1989	33	1979	58*
2008	43	1998	58*	1988	43	1978	52*
2007	44	1997	34	1987	40	1977	40
2006	39	1996	58*	1986	47*	1976	52
2005	40	1995	32	1985	52*	1975	58*
2004	32	1994	58*	1984	40	1974	48
2003	37	1993	29	1983	61*	1973	58*
2002	32	1992	59*	1982	41	1972	No data
2001	32	1991	34	1981	52	1971	No data
2000	No data	1990	29	1980	52*	1970	No data

Table 7: Maximum Recorded Wind Speed for Santa Monica Airport, Los Angeles County

Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)
2009	41	1999	58*	1989	34	1979	52*
2008	37	1998	58*	1988	62*	1978	55*
2007	41	1997	61	1987	53*	1977	58*
2006	38	1996	48	1986	54*	1976	46
2005	37	1995	53*	1985	52	1975	46
2004	36	1994	51*	1984	52	1974	58
2003	41	1993	51*	1983	52*	1973	46
2002	32	1992	40	1982	60*	1972	No data
2001	34	1991	63	1981	46	1971	No data
2000	No data	1990	47	1980	52	1970	No data

Table 8: Maximum Recorded Wind Speed for Palmdale Airport, Los Angeles County

Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)
2009	81	1999	51	1989	46	1979	53*
2008	75	1998	64*	1988	63*	1978	55*
2007	84	1997	64*	1987	53*	1977	58*
2006	55	1996	58*	1986	58	1976	63
2005	46	1995	59*	1985	46	1975	69
2004	47	1994	60*	1984	61*	1974	58*
2003	46	1993	63*	1983	40	1973	52
2002	56	1992	58*	1982	54*	1972	No data
2001	62	1991	53*	1981	46	1971	No data
2000	No data	1990	58	1980	54*	1970	No data

Table 9: Maximum Recorded Wind Speed for Torrance Airport, Los Angeles County

Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)
2009	34	2005	63*	2001	63*	1997	40
2008	30	2004	25	2000	No data	1996	38
2007	40	2003	61*	1999	40	1995	No data
2006	58*	2002	63*	1998	58*	1994	No data

Table 10: Maximum Recorded Wind Speed for Van Nuys Airport, Los Angeles County

Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)
2009	55	2005	39	2001	38	1997	46
2008	45	2004	43	2000	No data	1996	40
2007	46	2003	52	1999	44	1995	No data
2006	38	2002	46	1998	46	1994	No data

Table 11: Maximum Recorded Wind Speed for Ontario Airport, San Bernardino County

Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)
2009	79	2005	56	2001	52	1997	58*
2008	64	2004	56	2000	No data	1996	64*
2007	75	2003	81	1999	59	1995	No data
2006	59	2002	58	1998	70	1994	No data

Table 12: Maximum Recorded Wind Speed for Oxnard Airport, Ventura County

Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)	Year	Max. Wind* or 3-Second Gust (mph)
2009	48	1999	52	1989	58*	1979	63*
2008	43	1998	81*	1988	55*	1978	58*
2007	84	1997	75*	1987	43	1977	46
2006	51	1996	53*	1986	85*	1976	52
2005	43	1995	44	1985	78*	1975	53
2004	44	1994	53	1984	54*	1974	52
2003	47	1993	53*	1983	52*	1973	58
2002	45	1992	53*	1982	61*	1972	No data
2001	43	1991	52	1981	60*	1971	No data
2000	No data	1990	53*	1980	48	1970	No data

Wind data from NCDC/NOAA was also obtained for three stations in Orange County: El Toro, Los Alamitos, and Tustin. Historical wind speeds from these stations are summarized as maximum 3-second gusts in Tables 13 through 15 respectively.

Table 13: Maximum Recorded Wind Speed for El Toro Airfield, Orange County

Year	Maximum 3-Second Gust (mph)	Year	Maximum 3-Second Gust (mph)	Year	Maximum 3-Second Gust (mph)	Year	Maximum 3-Second Gust (mph)
1999+	No data	1986	51	1973	48	1960	59
1998	47	1985	63	1972	59	1959	51
1997	51	1984	59	1971	53	1958	53
1996	63	1983	46	1970	54	1957	72
1995	46	1982	82	1969	51	1956	75
1994	31	1981	59	1968	51	1955	41
1993	39	1980	63	1967	62	1954	68
1992	52	1979	47	1966	81	1953	69
1991	45	1978	47	1965	41	1952	54
1990	41	1977	44	1964	58	1951	61
1989	59	1976	68	1963	48	1950	58
1988	59	1975	54	1962	52	1949	68
1987	62	1974	59	1961	60	1948	68

Table 14: Maximum Recorded Wind Speed for Los Alamitos Airport, Orange County

Year	Maximum 3-Second Gust (mph)		Year	Maximum 3-Second Gust (mph)		Year	Maximum 3-Second Gust (mph)		Year	Maximum 3-Second Gust (mph)
1971+	No data		1965	41		1959	43		1953	54
1970	48		1964	48		1958	40		1952	54
1969	44		1963	44		1957	61		1951	54
1968	40		1962	46		1956	61		1950	45
1967	40		1961	46		1955	46		1949	47
1966	45		1960	46		1954	46		1948	44

Table 15: Maximum Recorded Wind Speed for Tustin Airport, Orange County

Year	Maximum 3-Second Gust (mph)		Year	Maximum 3-Second Gust (mph)		Year	Maximum 3-Second Gust (mph)		Year	Maximum 3-Second Gust (mph)
1999+	No data		1990	49		1981	40		1972	55
1998	43		1989	52		1980	47		1971	48
1997	48		1988	60		1979	52		1970	61
1996	53		1987	53		1978	51		1969	48
1995	47		1986	49		1977	43		1968	44
1994	56		1985	58		1976	63		1967	47
1993	47		1984	46		1975	55		1966	No data
1992	55		1983	62		1974	60		1965	No data
1991	55		1982	58		1973	56		1964	No data

As the data shows, with the exception of Palmdale, the maximum 3-second gust for any of the above stations in Los Angeles County in the last 50+ years is 67 miles per hour, and Palmdale has a maximum recorded 3-second gust of 84 mph. Wind speeds of similar magnitude were recorded in areas outside of Los Angeles County, with a maximum 3-second gust of 82 mph at El Toro in Orange County and maximum gusts of 81 mph at Ontario Airport in San Bernardino County and 85 mph at Oxnard Airport in Ventura County.

General Wind Patterns in Los Angeles County

As part of our study, the Committee reviewed data regarding the general nature and pattern of winds in Los Angeles County.

A NOAA study of wind patterns by Bruno and Ryan (2000) provided the following summary of general wind patterns in the Los Angeles area:

> "For downtown Los Angeles, the predominant wind direction is from the west-southwest for most of the year. The average annual wind speed is 6.2 mph. But there are significant diurnal and seasonal exceptions to this normal. Generally, most of the Los Angeles Basin experiences light and variable gravity or land breezes during the night and morning hours. Winds then reverse to onshore sea breeze patterns during the late morning or afternoon hours, depending on distance from the ocean and local topography. The direction of this onshore wind flow varies from west-southwest (at LAX and downtown) to south-southeast (at Long Beach, EI Monte and Pasadena) to southeast or east (at Van Nuys and Burbank). Afternoon sea breezes normally range from 10 to 15 mph, but can be enhanced by increases in onshore pressure gradients.

> "At downtown Los Angeles, strongest mean monthly wind speeds occur in March, with lightest winds usually recorded in August and September. A peak wind (one minute average) of 49 mph was recorded from the north during a Santa Ana windstorm in January 1946. Wind gusts to 70 mph or more have a return period of more than 100 years, while winds can gust from 55 to 60 mph once in 25 years. (Some studies have suggested greater return periods.) Strongest winds, from a northerly direction, occur in winter as a result of Santa Ana katabatic conditions. More rarely, strong southeasterly winds gust to 50 mph or more as a result of the transition of a north Pacific winter storm across the district.
>
> "The average annual wind speed at LAX is 7.5 mph, the highest value at any official weather station (excluding beach sites) within the Los Angeles Basin… Winds are less strong at Long Beach Airport, where the annual average wind speed is 6.3 mph. Lightest annual average winds across the basin include Pasadena at 3.1 mph, Reseda with 3.0 mph, and San Dimas at only 2.2 mph."

Santa Ana Wind Effects

The wind patterns in and around Los Angeles are often affected by Santa Ana winds. The Santa Ana winds originate in the high altitude plateaus of the Mojave Desert and the Great Basin; the airflow moves downward in a southwesterly direction towards the Pacific Ocean.

According to Bruno and Ryan (2000),

> "Offshore winds from the northeast or east must reach 30 mph or more below passes and canyons to reach minimum criteria for Santa Ana wind advisories. More typically wind speeds are in the 40 to 55 mph range, and in extreme cases winds can gust locally to over 100 mph.
>
> "High pressure areas build in the fall and winter over the Great Basin as cold air translates into that region from Canada. When the surface pressure gradient reaches or exceeds ten millibars as measured from Tonopah, Nevada to LAX, wind gusts can reach 70 mph in the mountains and below passes and canyons near Los Angeles. If in addition to strong gradients from the Great Basin, pressure gradients increase to eight millibars or more from San Francisco to LAX, a general Santa Ana condition will ensue that will affect most of the Los Angeles Basin. In this event, winds may gust to 40 mph or more at LAX and at downtown Los Angeles. Santa Ana winds typically affect southern California via three main sources: (1) The Santa Clara River Valley, impacting the San Fernando Valley, Malibu Hills and Ventura County; (2) Cajon Pass, affecting Fontana, Santa Ana, eastern and southern Los Angeles County; and (3) Banning Pass, which affects southern Orange County."

The three primary regions that are affected by the Santa Ana winds are shown in Figure 1. As can be seen from this figure, southern Los Angeles County is not in the main path of the Santa Ana winds. In fact, the only area significantly affected by the main paths of Santa Ana winds stretches between Lancaster and Palmdale to Santa Clarita, generally following State Route 14.

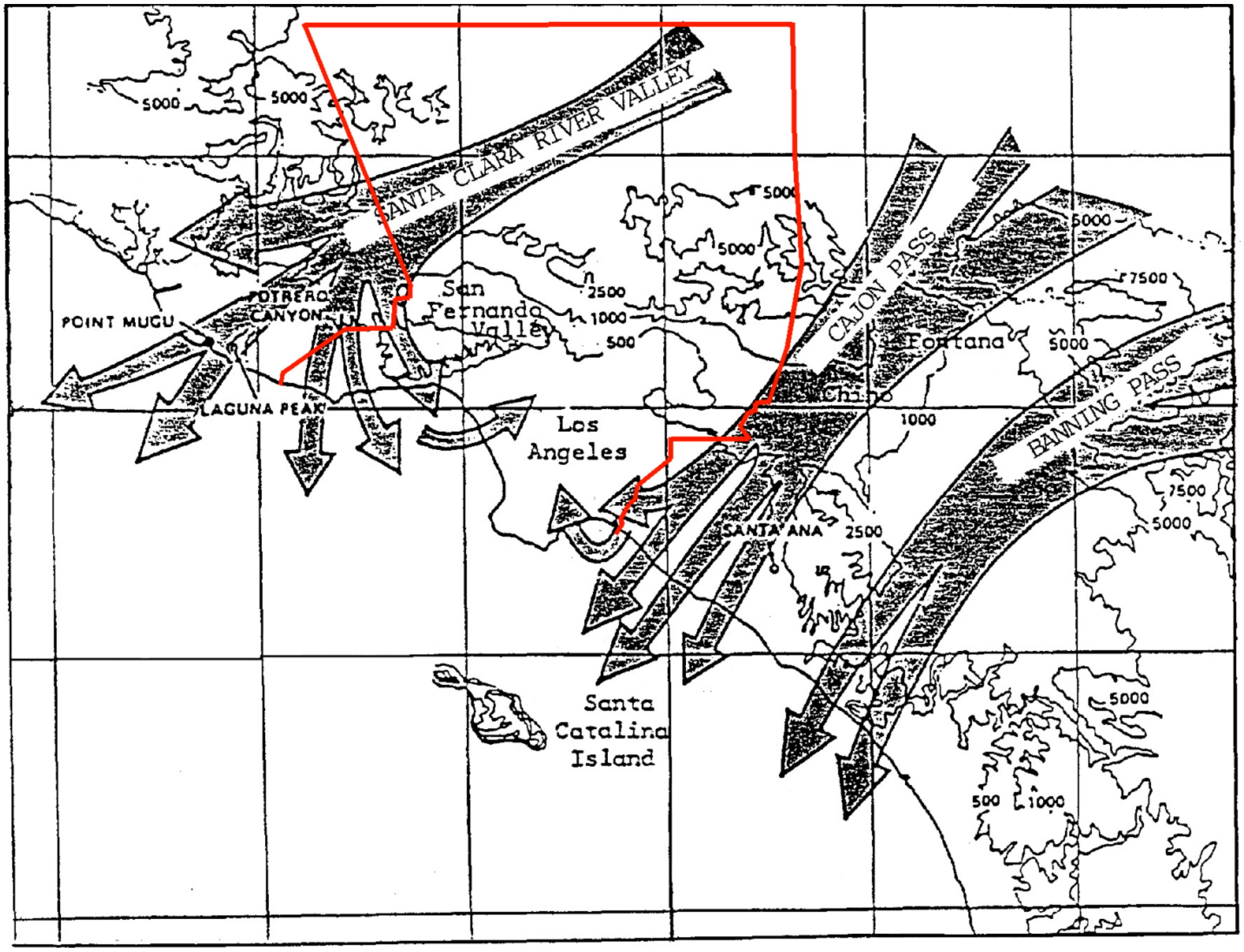

Figure 1: The three main channels of the Santa Ana winds (from Bruno and Ryan, 2000), with the approximate border of Los Angeles County shown in red.

CPP, Inc., a consulting engineering firm that specializes in wind tunnel tests and wind simulations, has performed a number of numerical simulations of Santa Ana wind events. A sample run is shown in Figure 2, with relatively higher wind speeds in red and relatively lower wind speeds in blue. The simulations are quite costly to run, and far more simulations would be necessary to convert the results into a design basis wind speed; however, the basic pattern of high and low wind speeds does show that the southern portion of Los Angeles County is almost completely shielded from significant Santa Ana winds. Further, the Santa Ana winds, while elevated in and around Lancaster and Palmdale, do not appear to have significant effects on these two cities -- presumably because there are no significant mountains or valleys to constrict and channel the Santa Ana winds. Similarly, the City of Santa Clarita is situated in a region of "normal" or perhaps slightly elevated wind speeds, with higher Santa Ana winds in the sparsely populated surrounding mountains. Note that this map also includes the effects of large-scale topographic features, so a direct or simple correlation to the basic wind speed parameter is not possible.

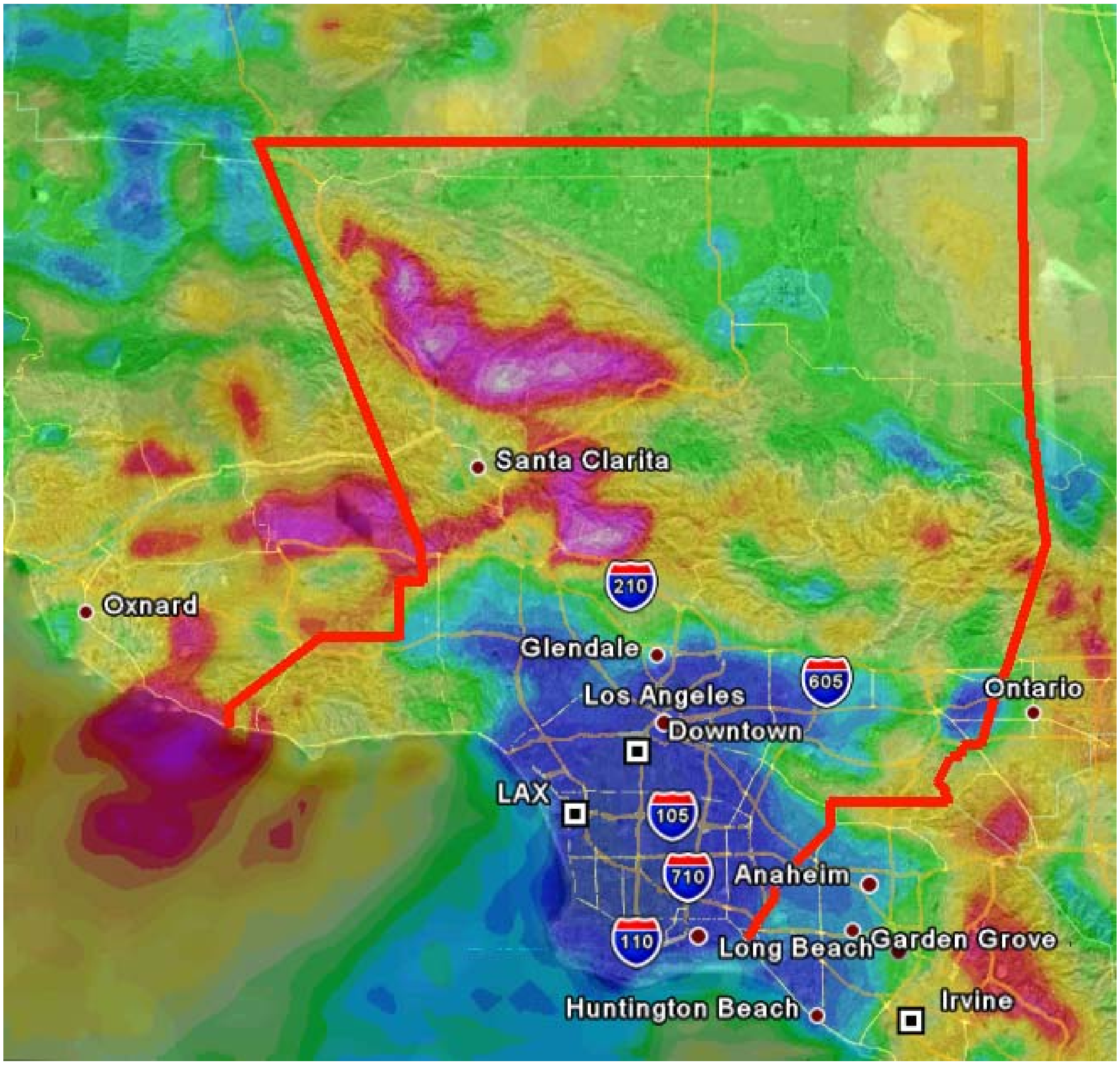

Figure 2: Numerical simulation of a Santa Ana wind event by CPP, Inc., with relatively higher wind speeds in red and relatively lower wind speeds in blue, and with the approximate border of Los Angeles County outlined in red.

NCDC/NOAA Summary Statements

The Committee reviewed summary statements from the National Climatic Data Center (NCDC)/National Oceanic and Atmospheric Administration (NOAA) regarding the expected wind conditions around the three major meteorological stations in Los Angeles County (Los Angeles Civic Center, Los Angeles International Airport, and Long Beach Dougherty Field).

Regarding the Los Angeles Civic Center area, the NCDC/NOAA states:

> "Prevailing winds are from the west during the spring, summer, and early autumn, with northeasterly wind predominating the remainder of the year. At times, the lack of air movement, combined with a frequent and persistent temperature inversion, is associated

> with concentrations of air pollution in the Los Angeles coastal basin and some adjacent areas. In fall, winter, and early spring months, occasional foehn-like descending Santa Ana winds come from the northeast over ridges and through passes in the coastal mountains. These Santa Ana winds may pick up considerable amounts of dust and reach speeds of 35 to 50 mph in north and east sections of the city, with higher speeds in outlying areas to the north and east, but rarely reach coastal portions of the city.

Regarding the Los Angeles International Airport area, the NCDC/NOAA states:

> "Prevailing daytime winds are from the west, but night and early morning breezes are usually light and from the east and northeast. Strongest winds observed at the station have been from the west and north following winter storms. During the fall, winter, and spring, gusty dry northeasterly Santa Ana winds blow over southern California mountains and through passes to the coast. These winds rarely reach L.A. International Airport but extremely dry air and dust clouds associated with them can be expected several times each year."

Regarding the Long Beach area, NCDC/NOAA states:

> "With the Pacific Ocean only 4 miles south, it might be expected that the sea breeze would be from a southerly component. However, the coastal hills to the southwest combine with the lowest mountain passes leading to the interior desert valleys east of the Los Angeles basin to produce a sea breeze from a westerly component in the afternoon and early evening hours. Occasionally, strong dry northeasterly winds descend the mountain slopes in the fall, winter, and early spring months, developing velocities in excess of 50 mph over localized sections of the Los Angeles basin, usually below canyons. However, these strong winds ordinarily by-pass the station. Actually, the highest winds at Long Beach are recorded in association with the winter and spring storms which invade southern California from the Pacific."

As can be seen above, the maximum wind speeds expected by the NCDC/NOAA at these three stations are on the order of 50 miles per hour, and both stations that mention Santa Ana winds state that these winds rarely affect the area around the stations. Nowhere are gusts exceeding 85 mph even mentioned as a possibility. So while Santa Ana winds do affect the area, wind speeds in the Los Angeles basin do not appear to be elevated above 85 mph.

Local Topographic Effects

All building codes in California prior to the 2006 IBC ignored topographic effects, which can cause significant local increases in wind speed. The 2006 IBC, which references ASCE 7-05, now requires topographic effects to be considered. The variable K_{zt}, a multiplier of wind pressure, is intended to account for the presence of hills, ridges, and escarpments, and can range from 1.0 (level ground or no topographic effects) to a maximum of 2.96. Furthermore, ASCE 7-05 requires that mountainous terrain, gorges, and ocean promontories be examined for unusual wind conditions. Since the building code now explicitly accounts for local topographic effects and does so in a way that is divorced from basic wind speed, globally increasing the basic wind speed to account for local topographic effects is not justified. It is noted that K_{zt} does not specifically account for down-slope winds (which is how Santa Ana winds typically manifest in Los Angeles County), so if a designer goes to the effort of calculating both up-slope and down-slope design wind forces -- an unlikely but possible scenario -- the designer may not capture all of the topographic effects that could affect the structure.

History of Wind Failures in Los Angeles County

While an increase of basic wind speed above 85 mph might be reasonable if Los Angeles County were experiencing significant and widespread structural damage from wind, wind-related failures in California in general and in Los Angeles County in specific are extremely rare, and those few that do occur are typically associated with construction defects, long-term deterioration, or non-engineered appurtenances -- not as a result of underestimation of basic wind speed by the building code. The attention paid to seismic detailing of structures also contributes to the overall robustness of the building stock. Consequently, there does not exist a significant or compelling history of wind-related damage that could be used to justify an increase in design wind speeds -- even in areas that might be subject to somewhat higher wind loads than the majority of Los Angeles County.

Conclusions

Based on the above study, the SEAOSC *Ad-hoc* Wind Committee believes that use of a basic wind speed greater than 85 mph in the southern half of Los Angeles Basin is not supported by the available and reliable meteorological data. While gusts higher than 85 mph may rarely occur in geographically limited -- and mostly unpopulated -- northern regions of Los Angeles County, there does not appear to be sufficient data to support increasing the design basic wind speed beyond 85 mph at this time; further study would be required to justify such an increase.

Similarly, while an increase in basic design wind speed might be reasonable if Los Angeles County were experiencing significant and widespread structural damage from wind, wind-related failures in the County are extremely rare and those few that do occur are typically associated with construction defects or long-term deterioration, not underestimation of basic wind speed in design.

Consequently, the SEAOSC *Ad-hoc* Wind Committee recommends that the basic wind speed of 85 mph be used for the southern half of Los Angeles County unless and until such time that sufficient meteorological data indicate that an increase beyond 85 mph would be both justifiable and reasonable.

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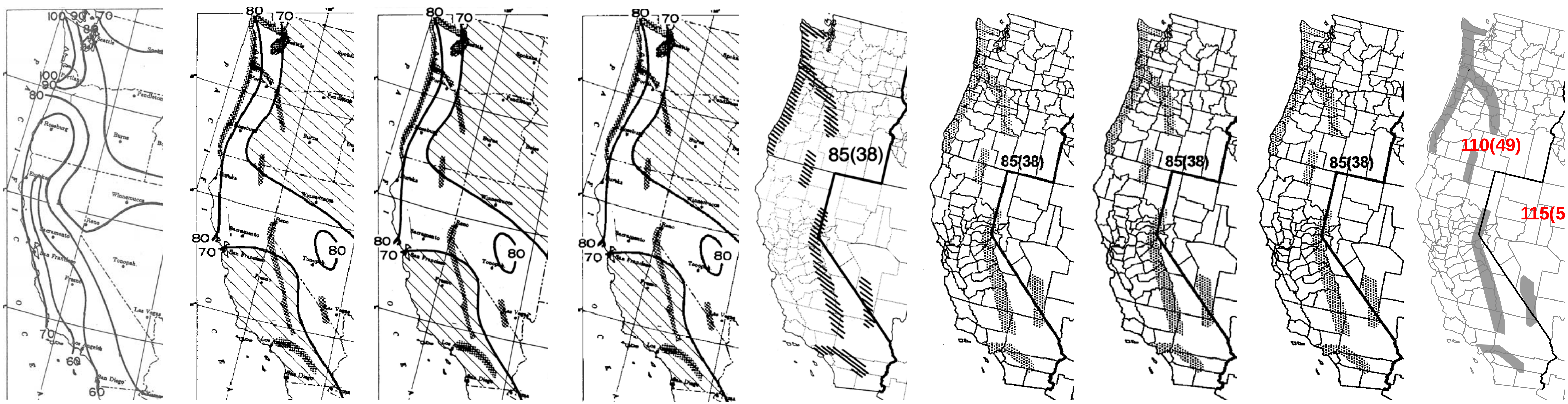
Appendix A: Historical Progression of ANSI A58.1 and ASCE 7 Wind Speed Maps



1972 ANSI | 1982 ANSI | 1988 ASCE 7 | 1993 ASCE 7 | 1995 ASCE 7 | 1998 ASCE 7 | 2002 ASCE 7 | 2005 ASCE 7 | 2010 ASCE 7

Historical Progression of ANSI A58.1 and ASCE 7 Wind Speed Maps