# A SITE-SPECIFIC EVALUATION OF TORNADO AND HIGH-WIND RISKS AT WEST VALLEY SITE, NEW YORK

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## A. GEOGRAPHIC LOCATION

The facility at West Valley site, New York, is located at 42°34'N and 78°47'W at an elevation of 1325 ft. The site is 15 miles southeast of Lake Erie and 20 miles south of Buffalo, New York (see Figure A.1).

West Valley site is nestled on the northern slope of a large hill 1550 ft high adjacent to a prominent ridge as shown in Figure A.2. This ridge, which is situated immediately to the northeast of the West Valley site, is the dominant feature of the ambient topography, attaining a maximum elevation of 1750 ft and extending for 15 miles towards the northwest and 20 miles towards the southeast with respect to the West Valley site. Smaller ridges, consistently oriented from the northwest to the southeast, appear as one continues northeastward.

Isolated peaks of higher altitudes appear as one proceeds towards the southwest. These peaks are not broad enough to impede southwesterly or westerly flow towards the site. The hill on which the West Valley site is separated from the ridge to the northeast by a relatively low channel, through which the South Branch Eighteenmile Creek flows.

All topographic features increase in height as one travels southeastward, towards inland New York. A gradual declivity extends to the northwest, towards the shores of Lake Erie.

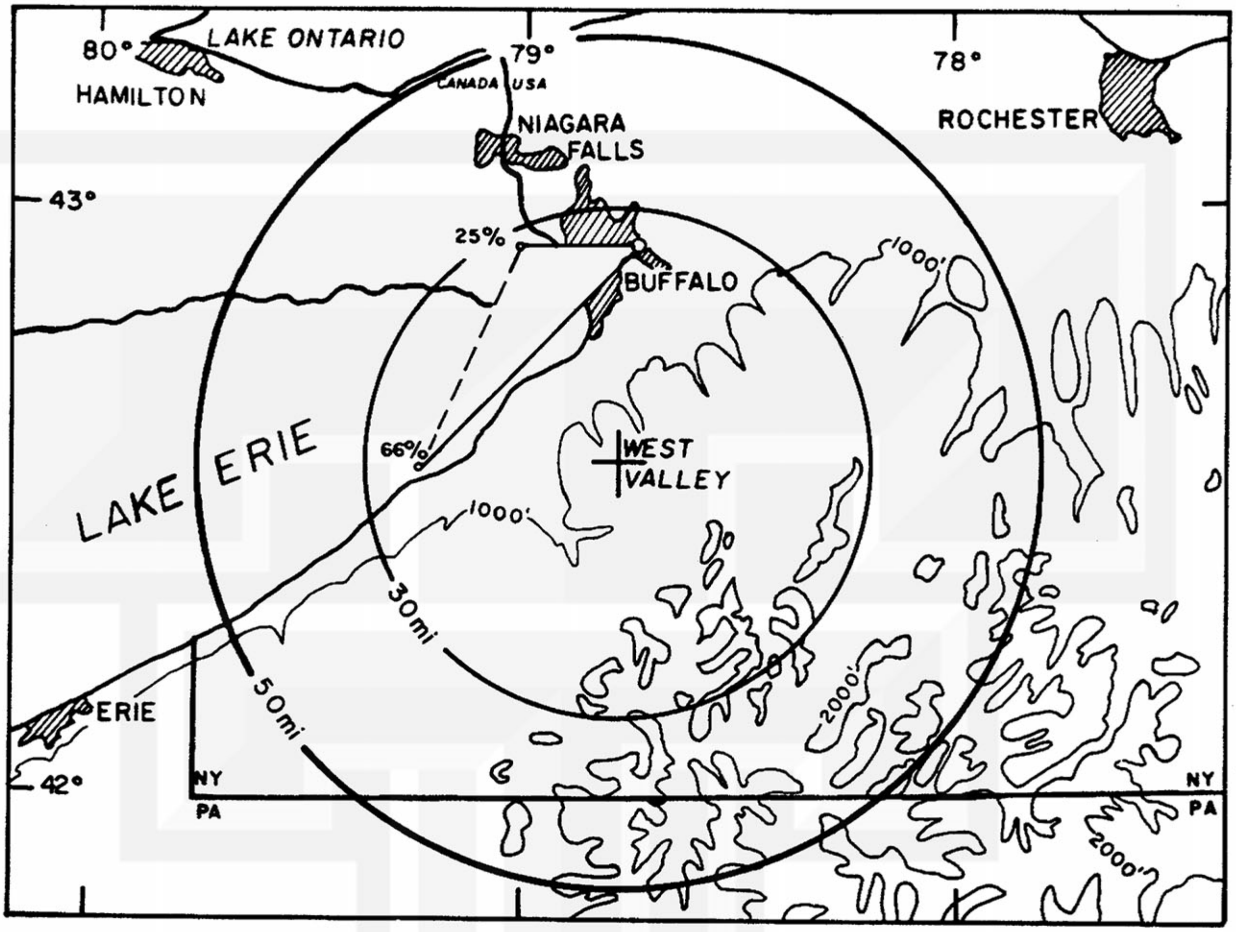


Figure A.1 West Valley site, New York, and vicinity. The nearest climatological station is located 20 miles north of the site at the city of Buffalo. The wind rose depicts only the most prevalent directions of high winds, as the percentage of high winds corresponding to the remaining compass points are much too low to be shown in the scale.

## B. HIGH-WIND PROBABILITIES

Owing to the absence of recorded data for the West Valley site itself, data for the city of Buffalo, New York, was utilized. Monthly "fastest-mile" windspeeds and directions were collected for the period January 1950 - December 1978, inclusive. No wind directions were reported for the months of April and May, 1973.

As shown in Table B.1, the dominant direction of high wind is from the southwest (66%) and the west (25%). This is to be expected due to the orientation of Lake Erie, which offers little or no obstruction to the southwesterly flow in the vicinity of Buffalo. It is assumed that this data provides an adequate representation of the West Valley winds, with only a minimal margin of error.

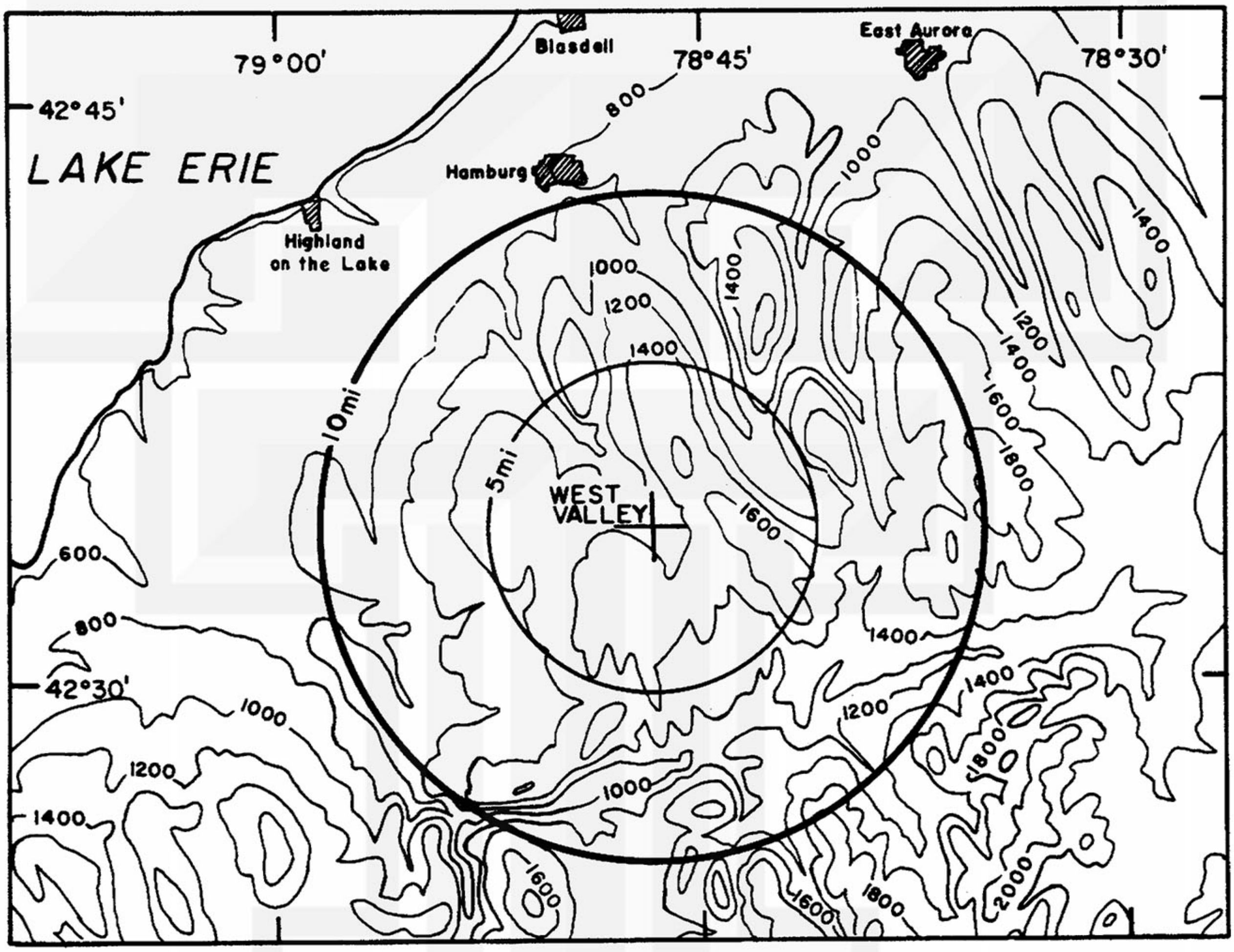


Figure A.2 Immediate topography of the West Valley site, New York. Circles of 5 and 10 mile radii are drawn. The contour interval is 200 feet.

REDUCTION OF WINDSPEEDS TO 10-m AGL

Since the wind data at Buffalo, New York, were measured at various elevations, it is necessary to reduce the windspeeds to the common height of 10-m (32.8 ft) AGL.

During the 29-year period (1950-1978), the height of the anemometer changed from 96 ft to 20 ft in 1959, and later raised to the

Table B.1 Frequencies of the direction of the fastest-mile wind of the month at Buffalo, New York. Based on 346-month data in the period 1950-1978.

| Wind Directions | N | NE | E | SE | S | SW | W | NW |
|---|---|---|---|---|---|---|---|---|
| Frequencies | 2 | 6 | 3 | 2 | 9 | 227 | 85 | 12 |
| (in %) | (1) | (1) | (1) | (1) | (2) | (66) | (25) | (3) |

10-m level in 1977. Windspeeds measured at the earlier heights were reduced to that at the 10-m height by assuming a commonly-used power function:

$$W_h = W_{10} h^n \qquad \text{(B.1)}$$

where h = H/10 m is the non-dimensional normalized height, $W_h$ is the windspeed at h, $W_{10}$, the windspeed at 10-m AGL, and n , the power. As shown in Table B.2, the mean peak windspeed (fastest-mile) of the month decreased from 46.9 mph to 36.3 mph as the anemometer height lowered from 96 to 20 ft AGL. Recorded values at 10-m level indicated a mean peak windspeed of 35.5 mph.

Table B.2 Mean values of the fastest-mile windspeed of the month measured at different heights AGL. Based on the 348-month data at Buffalo, New York.

| Periods | Jan 1950-Mar 1959 | Apr 1959-Mar 1977 | Apr 1977-Dec 1978 |
|---|---|---|---|
| Anemometer heights (ft) | 96 | 20 | 33 |
| Mean fastest mile (mph) | 46.9 | 36.3 | 35.5 |

Figure B.1 shows the anemometer height against mean windspeed plotted on semi-log coordinates. The plotted values in Table B.2 are approximated as a linear distribution and the slope of the line is used to obtain the power n. The slope suggests that n is approximately 1/6. The value 0.165 is used in the computation. A parallel slope, if drawn passing through the 10-m height point, gives the same value of n.

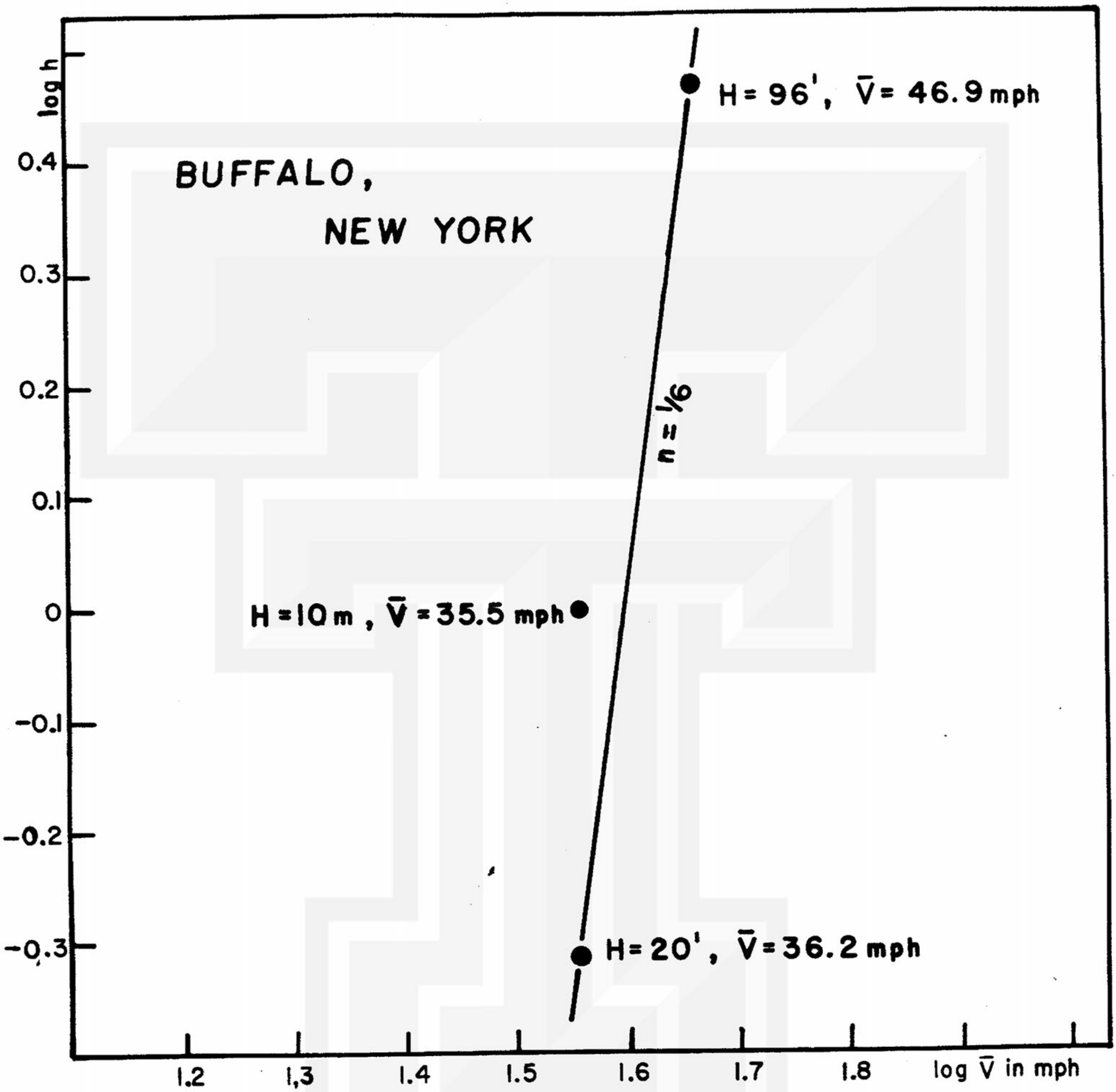


Figure B.1 Determination of the power n applicable to Buffalo, New York. The mean peak windspeed changed from 46.9 mph to 36.3 mph when the anemometer height reduced from 96 to 20 ft AGL.

The equation for windspeed reduction used in this study is the inverse of Eq. (B.1) or

$$W_{10} = W_h\, h^{-n} \qquad \text{(B.2)}$$

where $W_h$ is the anemometer windspeed measured at the normalized height, h.

The correction factors to be applied to the Buffalo winds are given in Table B.3. The values of 0.84 and 1.09, when multiplied by windspeeds measured at heights of 96 ft and 20 ft respectively, convert all measured windspeeds into the windspeeds that would have been measured had the Buffalo anemometer been fixed at a constant 10-m height during the entire 29 year period.

SEASONAL VARIATION OF PEAK SPEEDS BY MONTH were determined after adjusting all windspeeds to the 10-m AGL height. Table B.4 and Figure B.2 show the seasonal variation of the fastest-mile winds for Buffalo. The fastest winds occur during the winter and early spring months; the lowest winds occur during the summer, as the mean atmospheric flow moves north into Canada.

Table B.3 Correction factors for reducing peak windspeeds to 10-m height AGL for Buffalo, New York. (n = 1/6 estimated as 0.165)

| Periods | Jan 1950-Mar 1959 | Apr 1959-Mar 1977 | Apr 1977-Dec 1978 |
|---|---|---|---|
| Normalized heights (h) | 2.93 | 0.61 | 1.00 |
| Corrections with n=1/6 | 0.84 | 1.09 | 1.00 |

Table B.4 Seasonal variation of the maximum, mean, and minimum values of peak windspeed of the month. Based on the 348-month data in 1950-1978 at Buffalo, New York. Windspeeds, in mph, are reduced to the 10-m height AGL.

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 45.8 | 41.4 | 43.7 | 41.0 | 37.6 | 36.3 | 35.7 | 33.7 | 36.1 | 38.1 | 40.4 | 41.9 | -- |
| Maximum | 76 | 68 | 61 | 56 | 53 | 47 | 51 | 51 | 50 | 53 | 55 | 61 | 76 |
| Minimum | 29 | 26 | 28 | 32 | 29 | 26 | 29 | 26 | 27 | 27 | 32 | 33 | 26 |

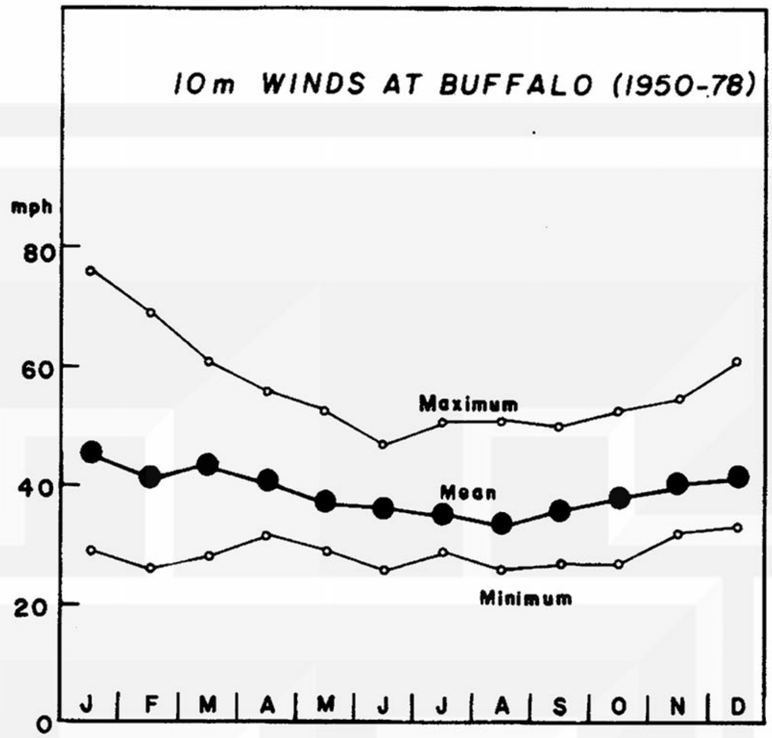


Figure B.2 Seasonal variation of the 10-m AGL winds at Buffalo, New York. (Data are from Table B.4).

Table B.5 shows the long-term variation of high winds at Buffalo, New York. All winds have been reduced to the common height of 10 meters.

Table B.5 Long-term variation of high winds at Buffalo, New York. (Based on 348-month data, 1950-1978).

| Year | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 43.1 | 40.0 | 35.5 | 40.1 | 40.6 | 36.2 | 39.4 | 38.3 | 39.2 | 44.7 |
| Maximum | 76 | 55 | 44 | 58 | 53 | 54 | 48 | 56 | 50 | 57 |
| Minimum | 29 | 29 | 27 | 27 | 29 | 26 | 29 | 26 | 28 | 33 |
| Year | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 |
| Mean | 39.7 | 38.8 | 37.4 | 40.9 | 40.7 | 43.8 | 39.2 | 39.9 | 36.7 | 38.2 |
| Maximum | 51 | 47 | 54 | 61 | 61 | 56 | 47 | 68 | 47 | 51 |
| Minimum | 27 | 32 | 32 | 32 | 33 | 35 | 33 | 32 | 32 | 32 |
| Year | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | |
| Mean | 36.6 | 40.2 | 38.8 | 36.1 | 41.7 | 40.0 | 40.5 | 37.9 | 35.7 | |
| Maximum | 45 | 61 | 56 | 41 | 51 | 51 | 54 | 54 | 60 | |
| Minimum | 32 | 32 | 32 | 32 | 28 | 31 | 32 | 30 | 26 | |

FREQUENCIES OF FASTEST-MILE WINDSPEED OF MONTH AND YEAR can be used in calculating the occurrence probabilities of specific windspeeds. Table B.6 shows the individual and cumulative frequencies of the fastest-mile wind of the month, for the 348-month period; Table B.7 shows the individual and cumulative frequencies of the fastest-mile wind of the year, for the 29-year period. Data is based on NOAA's "Climatological Data" publication.

Table B.6 Cumulative frequencies of the fastest-mile windspped of the month at Buffalo, New York for the 348 month period 1950-1978. Windspeeds are reduced to the height of 10-m AGL.

| Fastest mile | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
|---|---|---|---|---|---|---|---|---|---|---|
| Individual | -- | -- | -- | -- | -- | -- | 3 | 3 | 2 | 8 |
| Cumulative | 348 | 348 | 348 | 348 | 348 | 348 | 348 | 345 | 342 | 340 |
| Fastest mile | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
| Individual | 9 | 1 | 41 | 16 | 20 | 39 | 9 | 23 | 14 | 25 |
| Cumulative | 332 | 323 | 322 | 281 | 265 | 245 | 206 | 197 | 174 | 160 |
| Fastest mile | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
| Individual | 5 | 28 | 3 | 4 | 10 | 14 | 6 | 19 | 3 | 4 |
| Cumulative | 135 | 130 | 102 | 99 | 95 | 85 | 71 | 65 | 46 | 43 |
| Fastest mile | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 |
| Individual | 4 | 13 | -- | 2 | 4 | 3 | 4 | 1 | 1 | -- |
| Cumulative | 39 | 35 | 22 | 22 | 20 | 16 | 13 | 9 | 8 | 7 |
| Fastest mile | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 |
| Individual | 1 | 4 | -- | -- | -- | -- | -- | -- | 1 | -- |
| Cumulative | 7 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| Fastest mile | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 |
| Individual | -- | -- | -- | -- | -- | -- | 1 | -- | -- | -- |
| Cumulative | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |

The probability of any specific "windspeed month" (a month in which a specific maximum windspeed is attained, disregarding the particular day of the month that the speed is attained) occurring in a year can now be computed. The method is illustrated in detail in Appendix 1. Essentially, the probability for any chosen windspeed is merely the cumulative frequency corresponding to that windspeed divided by 29. In terms of probability, the calculated quotient represents the number of months out of any year in the future that one can expect the chosen windspeed to occur. The highest possible value, therefore, is twelve; every month out of the year will register the chosen windspeed. A value of zero is impossible, of course, as there is always some chance that any windspeed, no matter how huge, will occur. Figure B.3 shows the probability curves, graphed as a function of windspeed.

The probability of any windspeed year occurring can be computed directly from Table B.7. Each cumulative frequency is again divided by 29. For probabilities below 0.1, the year-graph and month-graph are nearly identical, becoming increasingly identical at smaller probabilities.

Table B.7 Cumulative frequencies of the fastest mile windspeed of the year at Buffalo, New York. Winds are reduced to 10-m AGL.

| Fastest mile | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|---|---|---|---|---|---|---|---|---|---|---|
| Individual | -- | 1 | -- | -- | 1 | 1 | -- | 3 | 1 | -- |
| Cumulative | 29 | 29 | 28 | 28 | 28 | 27 | 26 | 26 | 23 | 22 |
| Fastest mile | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 |
| Individual | 1 | 4 | -- | 1 | 4 | 1 | 3 | 1 | 1 | -- |
| Cumulative | 22 | 21 | 17 | 17 | 16 | 12 | 11 | 8 | 7 | 6 |
| Fastest mile | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 |
| Individual | 1 | 3 | -- | -- | -- | -- | -- | -- | 1 | -- |
| Cumulative | 6 | 5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| Fastest mile | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 |
| Individual | -- | -- | -- | -- | -- | -- | 1 | -- | -- | -- |
| Cumulative | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |

It will be noted that the probability curve of Figure B.3 approaches a straight line at low probabilities. If this straight-line portion of the curve is extrapolated, the equation of its graph is

$$W_p = W_{0.1} - (W_{0.01} - W_{0.1})(1 + \log P) \qquad \text{(B.3)}$$

with $W_p$ denoting the windspeed corresponding to probability P, $W_{0.1}$ and $W_{0.01}$ denoting the windspeeds corresponding to probabilities 0.1 and 0.01, respectively. It will be seen that $W_{0.1}$ is roughly equivalent to 67 mph, and $W_{0.01}$ corresponds to 82 mph.

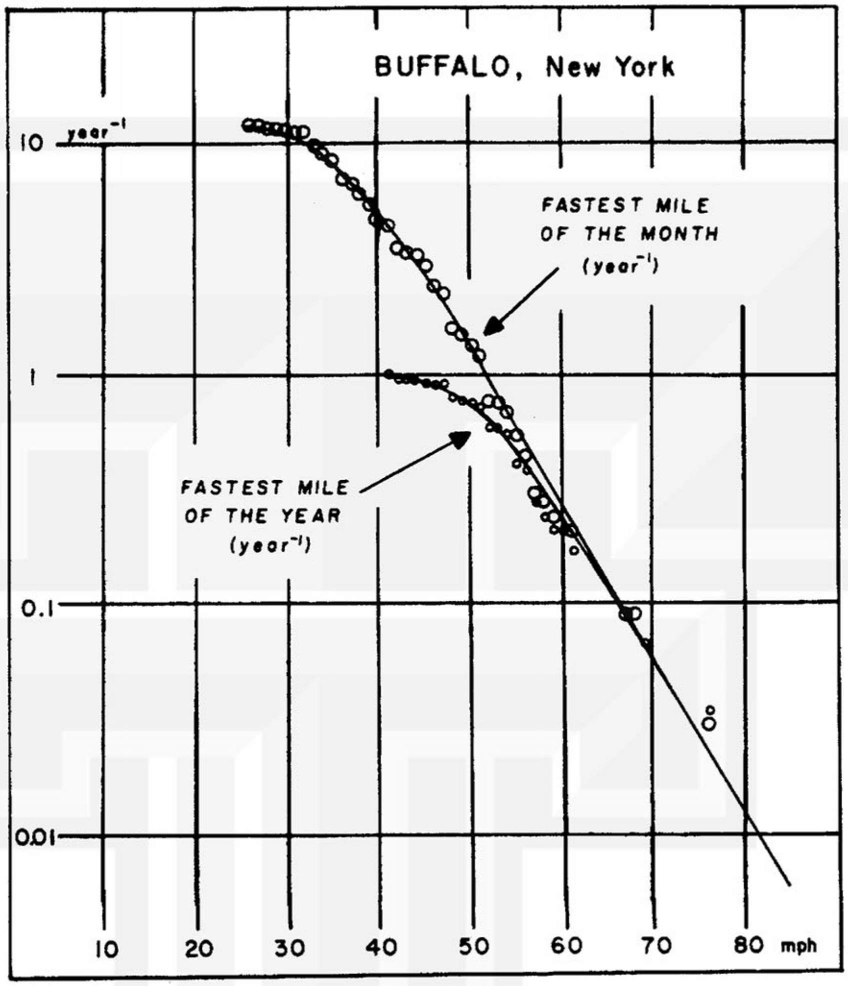


Figure B.3 Probabilities of fastest-mile windspeed of the month and the year. Windspeed probabilities at low probabilities were obtained by extrapolating the probability of the peak speed of the month.

The equation of probability then becomes

$$W_p = 67 - 15(1 + \log P) \quad \text{fastest mile} \qquad \text{(B.4)}$$

where $W_p$ denotes fastest mile.

Table B.8 shows the correlation between windspeed and probability as a function of probability itself. The information can be interpreted as expressing the maximum wind that can be expected for any length of time, where time is the reciprocal of the probability corresponding to the windspeed in question. For example, the maximum wind that can be expected over a ten-year span at the West Valley site is 67 mph; over 100 years, 82 mph; over 1000 years, 97 mph. It is important to note that these values are for straight-line winds only; the chance of a 200 mph straight-line wind is extremely miniscule. However, such a wind may be generated by tornado; hence, the probability of a tornado striking the West Valley site must therefore be computed.

Table B. 8 Fastest-mile windspeeds at Buffalo, New York, given as a function of occurrence probabilities.

| Probabilities | $10^{-1}$ | $10^{-2}$ | $10^{-3}$ | $10^{-4}$ | $10^{-5}$ | $10^{-6}$ year |
|---|---|---|---|---|---|---|
| Fastest-mile | 66.8 | 82.0 | 97.2 | 112.4 | 127.6 | 142.8 mph |

## C. TORNADO PROBABILITIES

In order to assess the probability of a tornado striking the West Valley site, the physical environment of the site and its vicinity must be precisely analyzed. For this purpose, the region within a 100-mile radius of the site was partitioned into sub-boxes having dimensions of exactly 15' latitude by 15' longitude. These sub-boxes, as shown in Figure C.1, were numbered from 1 to 151.

Figure C.2 shows the cumulative path lengths, in miles for each sub-box, of all tornadoes occurring during the period 1916-1977 as taken from the DAPPLE Tornado Tape (1978). The probability of a tornado occurring in a box which as been struck often in the past is greater than that of a box which has been relatively tornado-free.

This information was then used to compute tornado probabilities under the DAPPLE method (Abbey, 1976; Abbey and Fujita, (1975, 1979)), explained in detail in Appendix 4. Under this method, each sub-box was analyzed with regards to linear distance from the West Valley site, maximum elevation, latitude, land-water area, and population as follows:

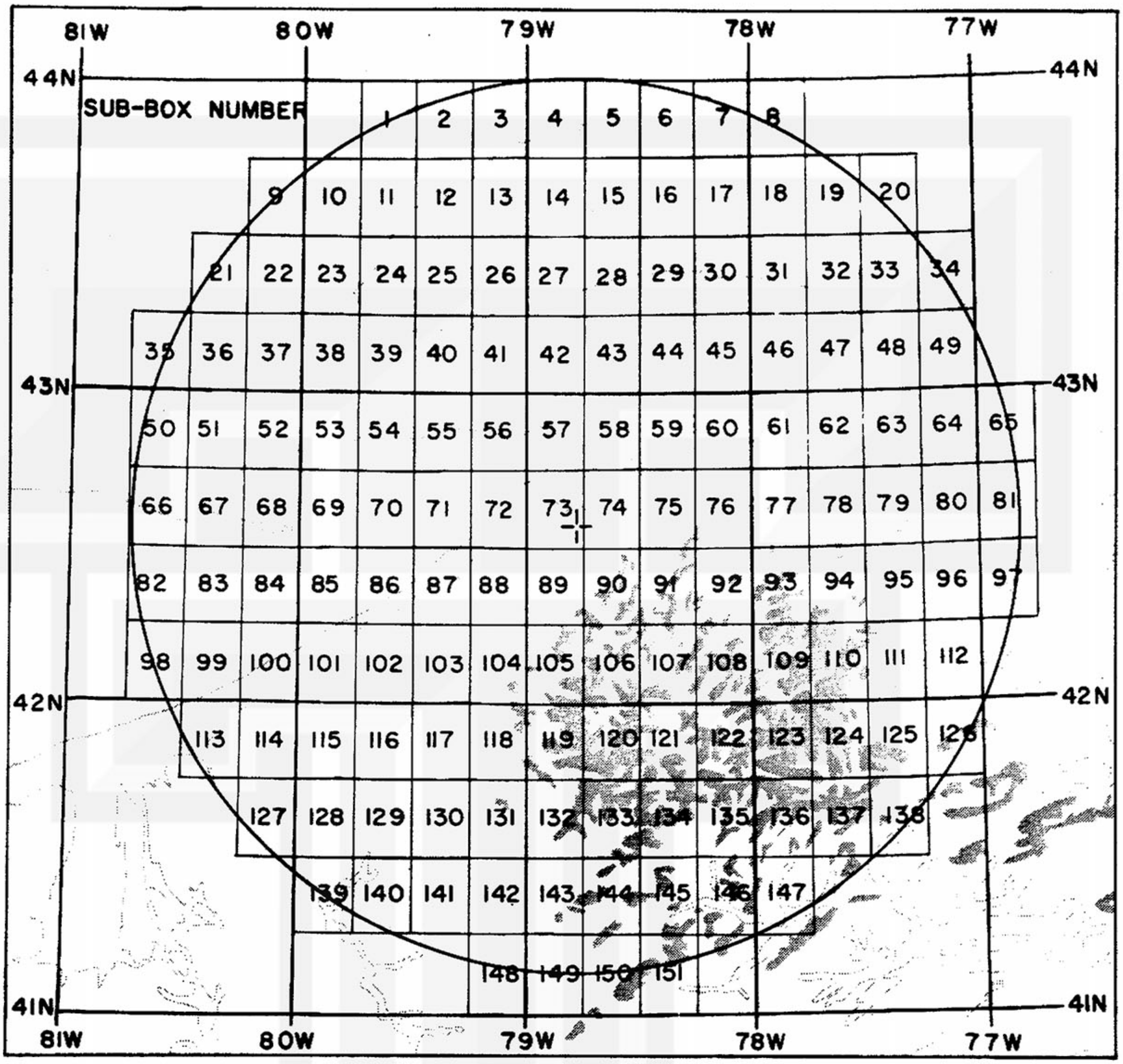


Figure C.1 Identification numbers of the sub-boxes (15' lat. by 15' long.) within a 100-mile range of the West Valley site, New York. The site is located in sub-box No. 73. Shaded areas indicate elevations at and above 2000 feet.

DISTANCE FUNCTION, F(D): Computed from Table 2.1 (Appendix 2), with m = 0.5. Added weight is placed on sub-boxes of close proximity to the West Valley site, while less weight on sub-boxes farther away.

HEIGHT FUNCTION, F($\Delta$H): Computed from Table 2.2 (Appendix 2). More weight is placed on a sub-box whose maximum elevation most closely matches that of the West Valley site. The function dampens the effect of sub-boxes containing mountains, in which a tornado is assumed not likely to occur. It will be noted that the values of the height function for nearly all sub-boxes is identically one; this is due to the relative homogeneity of the West Valley topography.

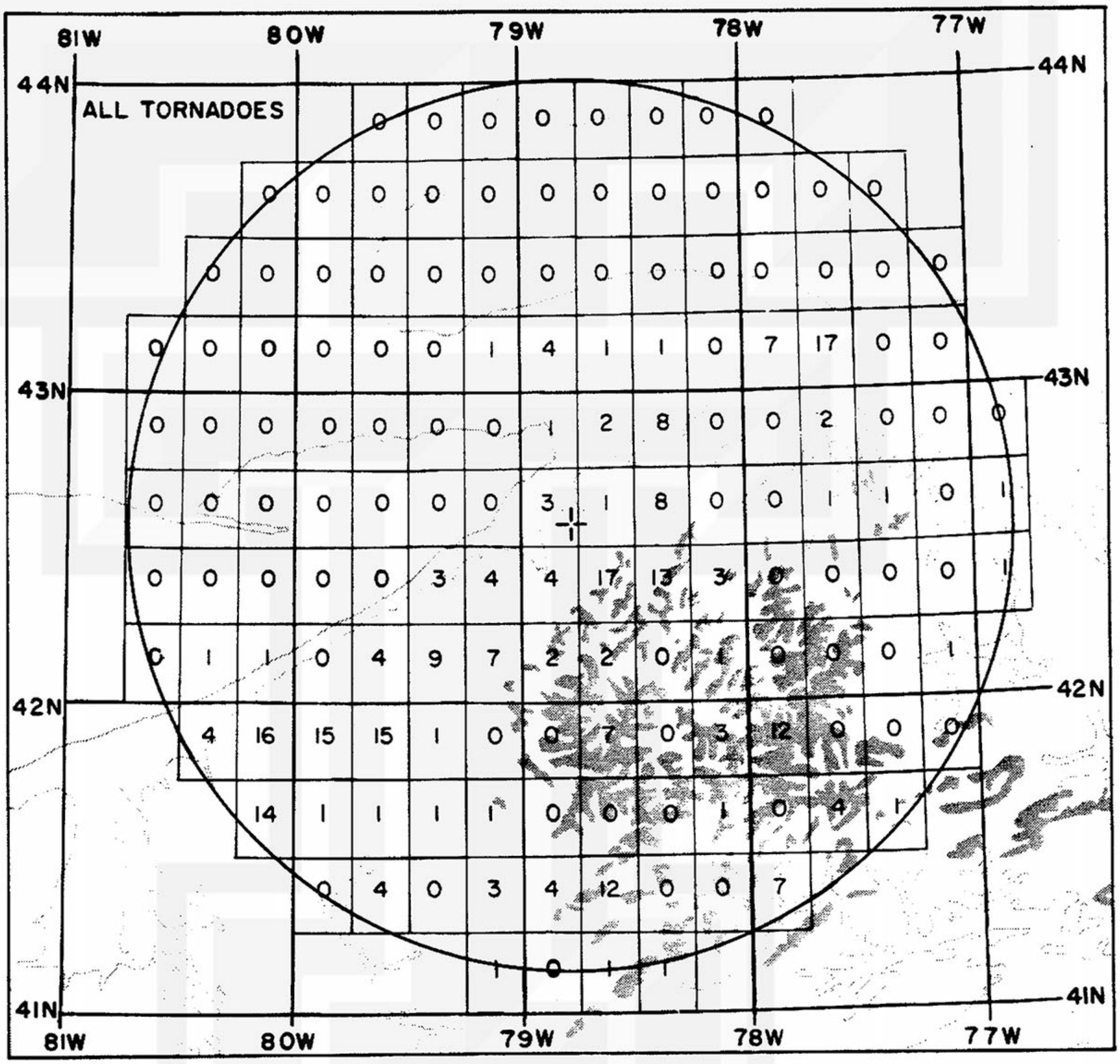


Figure C.2 Path lengths (in miles) of all tornadoes in each sub-box within a 100-mile range of the West Valley site, New York.

LATITUDE FACTOR, $C_\phi$: Computed from Table 2.3 (Appendix 2). Due to the gradual convergence of meridians as one approaches the north pole, each sub-box has a slightly smaller area than its neighbor immediately to the south. Therefore, southern sub-boxes stretch over a wider region and are consequently responsible for more area than the northern sub-boxes. Southern sub-boxes must be issued more weight.

POPULATION FACTOR, $C_P$ : Assumed to be identically one for each sub-box. The factor is designed to decrease the effect of any sub-box which is sparsely populated, as it is then difficult, if not impossible, to accurately determine tornado paths through such a region. Thousands of people, however, live in the West Valley site vicinity and the factor is not needed for this locale. Therefore, each sub-box is weighted equally.

LAND FACTOR, $C_L$ : Designed to place more weight on any sub-box which encloses a large percentage of land as opposed to water. The factor is unnecessary for inland sub-boxes, but mandatory for sub-boxes enclosing a segment of coastline. Tornado statistics are not applicable for Lake Erie since, by definition, tornado only exist on land. Therefore, any tornado statistics related to a sub-box which contains 80% water is in reality statistics for the 20% land portion. This data must be suppressed. Sub-boxes entirely over water or entirely within Canada, where no tornado statistics is at present utilized, were assigned the value zero.

The ultimate goal is to multiply all five of the above factors and functions together to derive a unique weighting function, $\psi$ , for each sub-box. Values of the DAPPLE factors for each sub-box and the corresponding weighting function are computed in Table C.1.

The total tornado mileage was distributed into mileage of weak (F0+F1), strong (F2+F3), and violent (F4+F5) tornadoes; these values appear in Table C.1, along with the product of each of these values and the corresponding weighting function.

These products were subsequently totaled, then divided by the sum of all weighting functions to obtain values of weighted path lengths. These were then divided by the number of weighted years (see Appendix 3) to derive "length per year" values; which were then divided by the area of the sub-box to obtain values of length per year per square mile, $\bar{L}$ (Area is in actuality the area of a sub-box at 37°N; discrepancies due to latitudes of different sub-boxes are nullified by the latitude factor) Refer to Table C.2.

Table C.1 PARAMETERS FOR COMPUTING THE WEIGHTED PATH LENGTHS OF TORNADOES AT WEST VALLEY, NEW YORK.

Parameters are:- D, distance from site; F(D), distance function with m=0.5; F(ΔH), height function; $C_L$, land factor; $C_\phi$, latitude factor; $\psi$, weighting function; $L_w$, $L_s$, $L_v$, path lengths of weak, strong, and violent tornadoes; and $L'_w$, $L'_s$, $L'_v$, their weighted length, respectively. (The letter C, when used as an entry in the below chart, signifies that the sub-box in question contains Canadian land only; W signifies that the sub-box contains water only; CW signifies that the sub-box contains some combination of Canadian land and water.) D and L are expressed in miles.

| Box | D | F(D) | F(ΔH) | $C_L$ | $C_\phi$ | $\psi$ | $L_w$ | $L'_w$ | $L_s$ | $L'_s$ | $L_v$ | $L'_v$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100 | 0.00 | | | | C | | | | | | | |
| 2 | 95 | 0.28 | | | | C | | | | | | | |
| 3 | 92 | 0.35 | | | | CW | | | | | | | |
| 4 | 91 | 0.38 | | | | CW | | | | | | | |
| 5 | 91 | 0.38 | | | | CW | | | | | | | |
| 6 | 92 | 0.35 | | | | CW | | | | | | | |
| 7 | 97 | 0.22 | | | | CW | | | | | | | |
| 8 | 102 | 0.00 | | | | CW | | | | | | | |
| 9 | 101 | 0.00 | | | | C | | | | | | | |
| 10 | 92 | 0.35 | | | | C | | | | | | | |
| 11 | 85 | 0.48 | | | | CW | | | | | | | |
| 12 | 79 | 0.57 | | | | CW | | | | | | | |
| 13 | 76 | 0.61 | | | | CW | | | | | | | |
| 14 | 74 | 0.63 | | | | W | | | | | | | |
| 15 | 74 | 0.63 | | | | W | | | | | | | |
| 16 | 77 | 0.59 | | | | W | | | | | | | |
| 17 | 80 | 0.56 | | | | W | | | | | | | |
| 18 | 86 | 0.47 | | | | W | | | | | | | |
| 19 | 94 | 0.31 | | | | W | | | | | | | |
| 20 | 103 | 0.00 | | | | W | | | | | | | |
| 21 | 98 | 0.18 | | | | C | | | | | | | |
| 22 | 88 | 0.43 | | | | C | | | | | | | |
| 23 | 79 | 0.57 | | | | CW | | | | | | | |
| 24 | 71 | 0.66 | | | | CW | | | | | | | |
| 25 | 63 | 0.74 | | | | W | | | | | | | |
| 26 | 58 | 0.78 | 1.00 | 0.05 | 0.92 | 0.04 | 0 | -- | 0 | -- | 0 | -- | |
| 27 | 55 | 0.81 | 1.00 | 0.24 | 0.92 | 0.18 | 0 | -- | 0 | -- | 0 | -- | |
| 28 | 57 | 0.79 | 1.00 | 0.46 | 0.92 | 0.33 | 0 | -- | 0 | -- | 0 | -- | |
| 29 | 60 | 0.77 | 1.00 | 0.58 | 0.92 | 0.41 | 0 | -- | 0 | -- | 0 | -- | |
| 30 | 65 | 0.72 | 1.00 | 0.54 | 0.92 | 0.36 | 0 | -- | 0 | -- | 0 | -- | |
| 31 | 72 | 0.65 | 1.00 | 0.41 | 0.92 | 0.25 | 0 | -- | 0 | -- | 0 | -- | |
| 32 | 81 | 0.54 | 1.00 | 0.17 | 0.92 | 0.08 | 0 | -- | 0 | -- | 0 | -- | |
| 33 | 91 | 0.38 | 1.00 | 0.10 | 0.92 | 0.03 | 0 | -- | 0 | -- | 0 | -- | |
| 34 | 101 | 0.00 | 1.00 | 0.15 | 0.92 | 0.00 | 0 | -- | 0 | -- | 0 | -- | |

--continued-- SUB-BOXES, 35 to 79

| Box | D | F(D) | F(ΔH) | $C_L$ | $C_\phi$ | $\psi$ | $L_w$ | $L'_w$ | $L_s$ | $L'_s$ | $L_v$ | $L'_v$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | 102 | 0.00 | | | | C | | | | | | | |
| 36 | 89 | 0.41 | | | | C | | | | | | | |
| 37 | 78 | 0.58 | | | | C | | | | | | | |
| 38 | 68 | 0.69 | | | | C | | | | | | | |
| 39 | 58 | 0.78 | | | | CW | | | | | | | |
| 40 | 48 | 0.85 | | | | C | | | | | | | |
| 41 | 42 | 0.89 | 1.00 | 1.00 | 0.92 | 0.82 | 1 | 0.89 | 0 | -- | 0 | -- | Niagara Fall |
| 42 | 38 | 0.91 | 1.00 | 1.00 | 0.92 | 0.84 | 2 | 1.82 | 2 | 1.82 | 0 | -- | |
| 43 | 39 | 0.90 | 1.00 | 1.00 | 0.92 | 0.83 | 0 | -- | 1 | 0.90 | 0 | -- | Lockport |
| 44 | 44 | 0.88 | 1.00 | 1.00 | 0.92 | 0.81 | 1 | 0.88 | 0 | -- | 0 | -- | |
| 45 | 52 | 0.83 | 1.00 | 1.00 | 0.92 | 0.76 | 0 | -- | 0 | -- | 0 | -- | |
| 46 | 59 | 0.77 | 1.00 | 1.00 | 0.92 | 0.71 | 0 | -- | 7 | 5.39 | 0 | -- | |
| 47 | 72 | 0.65 | 1.00 | 0.93 | 0.92 | 0.56 | 0 | -- | 17 | 11.05 | 0 | -- | Rochester |
| 48 | 81 | 0.54 | 1.00 | 1.00 | 0.92 | 0.50 | 0 | -- | 0 | -- | 0 | -- | |
| 49 | 94 | 0.31 | 1.00 | 1.00 | 0.92 | 0.29 | 0 | -- | 0 | -- | 0 | -- | |
| 50 | 97 | 0.22 | | | | C | | | | | | | |
| 51 | 84 | 0.50 | | | | C | | | | | | | |
| 52 | 72 | 0.65 | | | | CW | | | | | | | |
| 53 | 60 | 0.77 | | | | CW | | | | | | | |
| 54 | 48 | 0.85 | | | | CW | | | | | | | |
| 55 | 37 | 0.91 | | | | CW | | | | | | | |
| 56 | 27 | 0.95 | 1.00 | 0.53 | 0.92 | 0.46 | 0 | -- | 0 | -- | 0 | -- | |
| 57 | 22 | 0.97 | 1.00 | 0.69 | 0.92 | 0.62 | 1 | 0.97 | 0 | -- | 0 | -- | Buffalo |
| 58 | 23 | 0.97 | 1.00 | 1.00 | 0.92 | 0.89 | 1 | 0.97 | 1 | 0.97 | 0 | -- | |
| 59 | 30 | 0.94 | 1.00 | 1.00 | 0.92 | 0.86 | 0 | -- | 0 | -- | 0 | -- | |
| 60 | 41 | 0.89 | 1.00 | 1.00 | 0.92 | 0.82 | 0 | -- | 0 | -- | 0 | -- | |
| 61 | 52 | 0.83 | 1.00 | 1.00 | 0.92 | 0.76 | 0 | -- | 0 | -- | 0 | -- | |
| 62 | 63 | 0.74 | 1.00 | 1.00 | 0.92 | 0.68 | 0 | -- | 2 | 1.48 | 0 | -- | |
| 63 | 75 | 0.62 | 1.00 | 1.00 | 0.92 | 0.57 | 0 | -- | 0 | -- | 0 | -- | |
| 64 | 86 | 0.47 | 1.00 | 1.00 | 0.92 | 0.43 | 0 | -- | 0 | -- | 0 | -- | |
| 65 | 99 | 0.13 | 1.00 | 1.00 | 0.92 | 0.12 | 0 | -- | 0 | -- | 0 | -- | |
| 66 | 94 | 0.31 | | | | CW | | | | | | | |
| 67 | 82 | 0.53 | | | | CW | | | | | | | |
| 68 | 69 | 0.68 | | | | CW | | | | | | | |
| 69 | 56 | 0.80 | | | | W | | | | | | | |
| 70 | 43 | 0.88 | | | | W | | | | | | | |
| 71 | 30 | 0.94 | 1.00 | 0.08 | 0.92 | 0.07 | 0 | -- | 0 | -- | 0 | -- | |
| 72 | 18 | 0.98 | 1.00 | 0.39 | 0.92 | 0.35 | 0 | -- | 0 | -- | 0 | -- | |
| 73 | 6 | 1.00 | 1.00 | 0.88 | 0.92 | 0.81 | 0 | -- | 3 | 3.00 | 0 | -- | SITE |
| 74 | 9 | 1.00 | 1.00 | 1.00 | 0.92 | 0.92 | 1 | 1.00 | 0 | -- | 0 | -- | |
| 75 | 21 | 0.98 | 1.00 | 1.00 | 0.92 | 0.90 | 0 | -- | 8 | 7.84 | 0 | -- | |
| 76 | 34 | 0.93 | 1.00 | 1.00 | 0.92 | 0.86 | 0 | -- | 0 | -- | 0 | -- | |
| 77 | 47 | 0.86 | 1.00 | 1.00 | 0.92 | 0.79 | 0 | -- | 0 | -- | 0 | -- | |
| 78 | 90 | 0.40 | 1.00 | 1.00 | 0.92 | 0.37 | 1 | 0.40 | 0 | -- | 0 | -- | |
| 79 | 71 | 0.66 | 1.00 | 1.00 | 0.92 | 0.61 | 0 | -- | 1 | 0.66 | 0 | -- | |

--continued-- SUB-BOXES, 80 to 124

| Box | D | F(D) | F(ΔH) | $C_L$ | $C_\phi$ | $\psi$ | $L_w$ | $L'_w$ | $L_s$ | $L'_s$ | $L_v$ | $L'_v$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 85 | 0.48 | 1.00 | 1.00 | 0.92 | 0.44 | 0 | -- | 0 | -- | 0 | -- | |
| 81 | 98 | 0.18 | 1.00 | 1.00 | 0.92 | 0.17 | 1 | 0.18 | 0 | -- | 0 | -- | |
| 82 | 96 | 0.25 | | | | W | | | | | | | |
| 83 | 83 | 0.51 | | | | W | | | | | | | |
| 84 | 71 | 0.66 | | | | W | | | | | | | |
| 85 | 58 | 0.78 | 1.00 | 0.05 | 0.93 | 0.04 | 0 | -- | 0 | -- | 0 | -- | |
| 86 | 45 | 0.87 | 1.00 | 0.31 | 0.93 | 0.25 | 0 | -- | 0 | -- | 0 | -- | |
| 87 | 33 | 0.93 | 1.00 | 0.75 | 0.93 | 0.65 | 0 | -- | 3 | 2.79 | 0 | -- | Fredonia |
| 88 | 22 | 0.97 | 1.00 | 1.00 | 0.93 | 0.90 | 0 | -- | 4 | 3.88 | 0 | -- | |
| 89 | 14 | 0.99 | 1.00 | 1.00 | 0.93 | 0.92 | 2 | 1.98 | 2 | 1.98 | 0 | -- | |
| 90 | 16 | 0.99 | 1.00 | 1.00 | 0.93 | 0.92 | 2 | 1.98 | 15 | 14.85 | 0 | -- | |
| 91 | 26 | 0.96 | 1.00 | 1.00 | 0.93 | 0.89 | 1 | 0.96 | 12 | 11.52 | 0 | -- | |
| 92 | 36 | 0.92 | 1.00 | 1.00 | 0.93 | 0.86 | 0 | -- | 3 | 2.76 | 0 | -- | |
| 93 | 48 | 0.85 | 1.00 | 1.00 | 0.93 | 0.79 | 0 | -- | 0 | -- | 0 | -- | |
| 94 | 61 | 0.76 | 1.00 | 1.00 | 0.93 | 0.71 | 0 | -- | 0 | -- | 0 | -- | Hornell |
| 95 | 73 | 0.64 | 1.00 | 1.00 | 0.93 | 0.60 | 0 | -- | 0 | -- | 0 | -- | |
| 96 | 86 | 0.47 | 1.00 | 1.00 | 0.93 | 0.44 | | | | | | | |
| 97 | 99 | 0.13 | 1.00 | 1.00 | 0.93 | 0.12 | 0 | -- | 1 | 0.13 | 0 | -- | |
| 98 | 100 | 0.00 | | | | W | | | | | | | |
| 99 | 87 | 0.45 | 1.00 | 0.17 | 0.93 | 0.07 | 0 | -- | 1 | 0.45 | 0 | -- | |
| 100 | 75 | 0.62 | 1.00 | 0.36 | 0.93 | 0.21 | 1 | 0.62 | 0 | -- | 0 | -- | Erie |
| 101 | 64 | 0.73 | 1.00 | 0.88 | 0.93 | 0.60 | 0 | -- | 0 | -- | 0 | -- | |
| 102 | 53 | 0.82 | 1.00 | 1.00 | 0.93 | 0.76 | 0 | -- | 4 | 3.28 | 0 | -- | |
| 103 | 43 | 0.88 | 1.00 | 1.00 | 0.93 | 0.82 | 1 | 0.88 | 8 | 7.04 | 0 | -- | |
| 104 | 35 | 0.92 | 1.00 | 1.00 | 0.93 | 0.86 | 1 | 0.92 | 4 | 3.68 | 2 | 1.84 | Jamestown |
| 105 | 31 | 0.94 | 1.00 | 1.00 | 0.93 | 0.88 | 0 | -- | 2 | 1.88 | 0 | -- | |
| 106 | 32 | 0.94 | 1.00 | 1.00 | 0.93 | 0.87 | 1 | 0.94 | 1 | 0.94 | 0 | -- | |
| 107 | 38 | 0.91 | 0.99 | 1.00 | 0.93 | 0.85 | 0 | -- | 0 | -- | 0 | -- | Olean |
| 108 | 46 | 0.87 | 0.98 | 1.00 | 0.93 | 0.81 | 0 | -- | 1 | 0.85 | 0 | -- | |
| 109 | 56 | 0.80 | 0.99 | 1.00 | 0.93 | 0.64 | 0 | -- | 0 | -- | 0 | -- | |
| 110 | 67 | 0.70 | 0.99 | 1.00 | 0.93 | 0.64 | 0 | -- | 0 | -- | 0 | -- | |
| 111 | 79 | 0.57 | 1.00 | 1.00 | 0.93 | 0.53 | 0 | -- | 0 | -- | 0 | -- | |
| 112 | 91 | 0.38 | 1.00 | 1.00 | 0.93 | 0.35 | 1 | 0.38 | 0 | -- | 0 | -- | |
| 113 | 95 | 0.28 | 1.00 | 0.97 | 0.93 | 0.25 | 0 | -- | 4 | 1.12 | 0 | -- | |
| 114 | 85 | 0.48 | 1.00 | 1.00 | 0.93 | 0.23 | 1 | 0.48 | 15 | 7.20 | 0 | -- | |
| 115 | 74 | 0.63 | 1.00 | 1.00 | 0.93 | 0.59 | 0 | -- | 15 | 9.45 | 0 | -- | |
| 116 | 64 | 0.73 | 1.00 | 1.00 | 0.93 | 0.68 | 0 | -- | 15 | 10.95 | 0 | -- | |
| 117 | 56 | 0.80 | 1.00 | 1.00 | 0.93 | 0.74 | 1 | 0.80 | 0 | -- | 0 | -- | |
| 118 | 52 | 0.83 | 1.00 | 1.00 | 0.93 | 0.77 | 0 | -- | 0 | -- | 0 | -- | |
| 119 | 48 | 0.85 | 1.00 | 1.00 | 0.93 | 0.79 | 0 | -- | 0 | -- | 0 | -- | |
| 120 | 49 | 0.85 | 0.99 | 1.00 | 0.93 | 0.78 | 0 | -- | 1 | 0.85 | 6 | 5.10 | |
| 121 | 53 | 0.82 | 0.99 | 1.00 | 0.93 | 0.75 | 0 | -- | 0 | -- | 0 | -- | |
| 122 | 60 | 0.77 | 0.99 | 1.00 | 0.93 | 0.71 | 3 | 2.29 | 0 | -- | 0 | -- | |
| 123 | 67 | 0.70 | 0.97 | 1.00 | 0.93 | 0.63 | 12 | 8.15 | 0 | -- | 0 | -- | |
| 124 | 77 | 0.59 | 0.98 | 1.00 | 0.93 | 0.54 | 0 | -- | 0 | -- | 0 | -- | |

--continued-- SUB-BOXES, 125 to 151

| Box | D | F(D) | F(ΔH) | $C_L$ | $C_\phi$ | $\psi$ | $L_w$ | $L'_w$ | $L_s$ | $L'_s$ | $L_v$ | $L'_v$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 125 | 88 | 0.43 | 1.00 | 1.00 | 0.93 | 0.40 | 0 | -- | 0 | -- | 0 | -- | |
| 126 | 98 | 0.18 | 1.00 | 1.00 | 0.93 | 0.17 | 0 | -- | 0 | -- | 0 | -- | |
| 127 | 95 | 0.28 | 1.00 | 1.00 | 0.93 | 0.26 | 1 | 0.28 | 13 | 3.64 | 0 | -- | |
| 128 | 86 | 0.47 | 1.00 | 1.00 | 0.93 | 0.44 | 1 | 0.47 | 0 | -- | 0 | -- | |
| 129 | 79 | 0.57 | 1.00 | 1.00 | 0.93 | 0.53 | 1 | 0.57 | 0 | -- | 0 | -- | |
| 130 | 72 | 0.65 | 1.00 | 1.00 | 0.93 | 0.60 | 0 | -- | 1 | 0.65 | 0 | -- | |
| 131 | 68 | 0.69 | 1.00 | 1.00 | 0.93 | 0.64 | 1 | 0.69 | 0 | -- | 0 | -- | |
| 132 | 65 | 0.72 | 1.00 | 1.00 | 0.93 | 0.67 | 0 | -- | 0 | -- | 0 | -- | |
| 133 | 67 | 0.70 | 1.00 | 1.00 | 0.93 | 0.65 | 0 | -- | 0 | -- | 0 | -- | |
| 134 | 69 | 0.68 | 0.99 | 1.00 | 0.93 | 0.63 | 0 | -- | 0 | -- | 0 | -- | |
| 135 | 74 | 0.63 | 0.99 | 1.00 | 0.93 | 0.58 | 0 | -- | 1 | 0.84 | 0 | -- | |
| 136 | 81 | 0.54 | 0.98 | 1.00 | 0.93 | 0.49 | 0 | -- | 0 | -- | 0 | -- | |
| 137 | 88 | 0.43 | 1.00 | 1.00 | 0.93 | 0.40 | 2 | 0.86 | 2 | 0.86 | 0 | -- | |
| 138 | 98 | 0.18 | 1.00 | 1.00 | 0.93 | 0.17 | 0 | -- | 1 | 0.18 | 0 | -- | |
| 139 | 100 | 0.00 | 1.00 | 1.00 | 0.94 | 0.00 | 0 | -- | 0 | -- | 0 | -- | |
| 140 | 94 | 0.31 | 1.00 | 1.00 | 0.94 | 0.29 | 1 | 0.31 | 3 | 0.93 | 0 | -- | |
| 141 | 88 | 0.43 | 1.00 | 1.00 | 0.94 | 0.40 | 0 | -- | 0 | -- | 0 | -- | |
| 142 | 85 | 0.48 | 1.00 | 1.00 | 0.94 | 0.45 | 0 | -- | 3 | 1.44 | 0 | -- | |
| 143 | 82 | 0.53 | 1.00 | 1.00 | 0.94 | 0.50 | 4 | 2.12 | 0 | -- | 0 | -- | |
| 144 | 83 | 0.51 | 1.00 | 1.00 | 0.94 | 0.48 | 0 | -- | 12 | 6.12 | 0 | -- | |
| 145 | 85 | 0.48 | 0.99 | 1.00 | 0.94 | 0.45 | 0 | -- | 0 | -- | 0 | -- | |
| 146 | 90 | 0.40 | 0.99 | 1.00 | 0.94 | 0.37 | 0 | -- | 0 | -- | 0 | -- | |
| 147 | 96 | 0.25 | 1.00 | 1.00 | 0.94 | 0.24 | 6 | 1.50 | 1 | 0.25 | 0 | -- | |
| 148 | 101 | 0.00 | 1.00 | 1.00 | 0.94 | 0.00 | 0 | -- | 1 | -- | 0 | -- | |
| 149 | 100 | 0.00 | 1.00 | 1.00 | 0.94 | 0.00 | 0 | -- | 0 | -- | 0 | -- | |
| 150 | 100 | 0.00 | 1.00 | 1.00 | 0.94 | 0.00 | 0 | -- | 1 | -- | 0 | -- | |
| 151 | 102 | 0.00 | 1.00 | 1.00 | 0.94 | 0.00 | 1 | -- | 0 | -- | 0 | -- | |
| | | Total | | | | 54.56 | | 34.29 | | 133.62 | | 6.94 | |

Table C.2 Computation of $\overline{L}$, weighted path length for the site; $\overline{\overline{L}}$, length per year; and $\overline{\overline{\overline{L}}}$, length per year per area. L' denotes the weighted length in each sub-box and $\Sigma L'$, the total L' within a 100-mile radius of West Valley site, New York.

| | $\Sigma L'$ (miles) | $\Sigma \psi$ (--) | $\overline{L}$ (miles) | Weighted years | $\overline{\overline{L}}$ (mile/yr) | $\overline{\overline{\overline{L}}}$ (yr-mi) |
|---|---|---|---|---|---|---|
| Weak tornadoes | 34.29 | 54.56 | 0.63 | 25.2 | 0.0250 | 0.000105 |
| Strong tornadoes | 133.62 | 54.56 | 2.45 | 36.0 | 0.0681 | 0.000285 |
| Violent tornadoes | 6.94 | 54.56 | 0.13 | 43.9 | 0.0030 | 0.000012 |

The tornado probability is computed by multiplying each L value by a corresponding DAPPLE value, DAPPLE being a function of both windspeed and F-scale. See Table C.3 for calculated values.

Therefore, this table shows that one square-mile section of the West Valley site can expect a tornado within that one mile territory once in 10,000 years, at best. The time period increases for stronger tornadoes; a 300 mph tornado should occur once in 1½ billion years.

Table C.3 Computation of tornado probabilities at West Valley site, New York. $10^{-4}$, $10^{-5}$, etc., are expressed as -4, -5, etc. Based on DAPPLE tornado tape data, 1916-1977.

| | 50 | 100 | 150 | 200 | 250 | 300 |
|---|---|---|---|---|---|---|
| WEAK TORNADOES | | | | | | |
| DAPPLE | 0.075 | 0.0014 | 0.000026 | -- | -- | -- |
| Probabilities | 8.31-6 | 1.47-7 | 2.73-9 | -- | -- | -- |
| STRONG TORNADOES | | | | | | |
| DAPPLE | 0.31 | 0.049 | 0.0068 | 0.00060 | 0.00044 | -- |
| Probabilities | 8.39-5 | 1.40-5 | 2.33-6 | 1.71-7 | 1.26-8 | -- |
| VIOLENT TORNADOES | | | | | | |
| DAPPLE | 0.47 | 0.15 | 0.043 | 0.0091 | 0.0009 | 0.00012 |
| Probabilities | 5.75-6 | 1.91-6 | 5.33-7 | 1.13-7 | 1.12-8 | 1.49-9 |
| ALL TORNADOES | | | | | | |
| Probabilities | 9.82-5 | 1.60-5 | 2.86-6 | 2.84-7 | 2.35-8 | 1.49-9 |

Figure C.3 is a graph of tornado probabilities and high-wind probabilities. This graph shows which of the two atmospheric features would have a greater chance of generating any arbitrary wind. For winds below 129 mph, a straight-line wind should be the generating factor.

This graph can be used to determine windspeeds as a function of probability. Table C.4 has been computed in this manner.

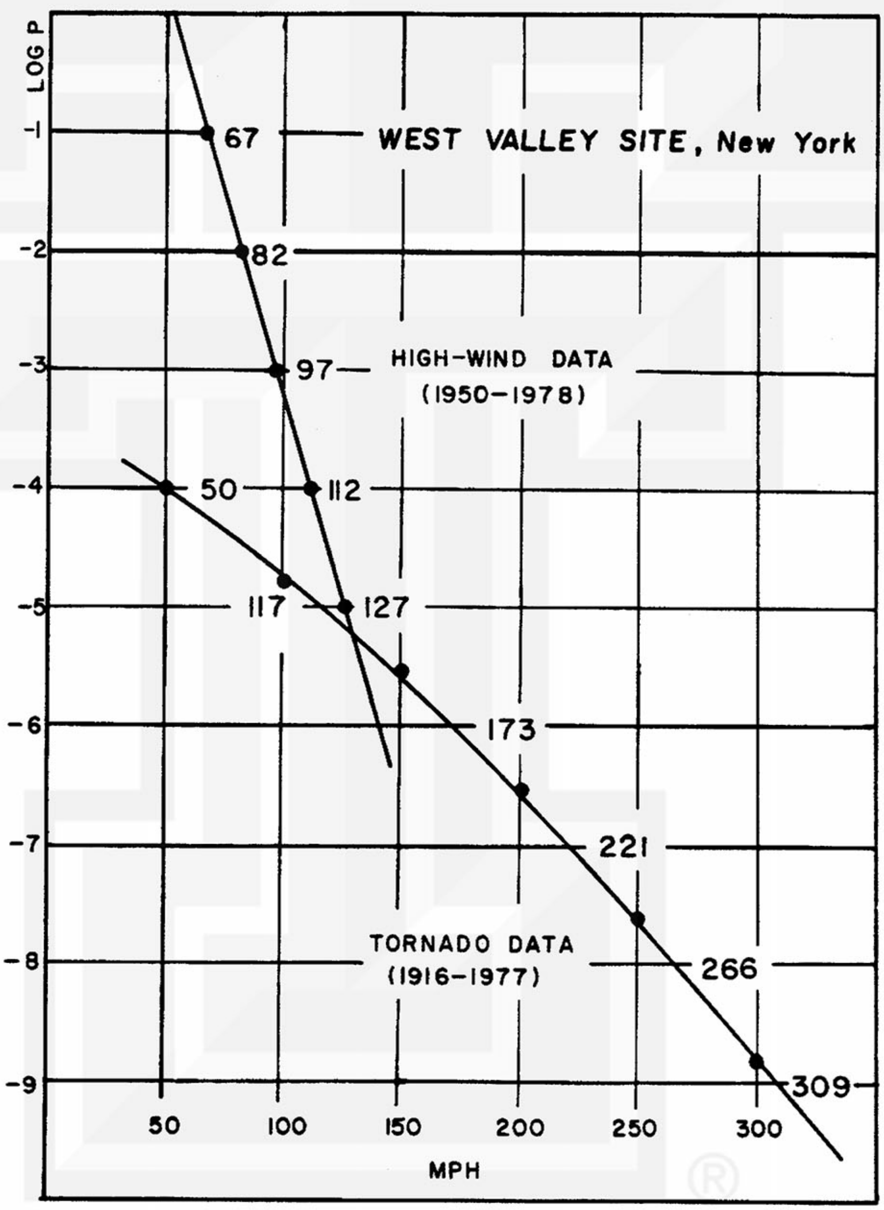


Figure C.3 Probability vs. windspeed curves applicable to the West Valley site, New York. The maximum windspeed with $10^{-7}$ per year probability is 221 mph.

Table C. 4 Windspeeds of high winds (HWD) and tornadoes (TOR) corresponding to $10^{-1}$ through $10^{-9}$ per year probabilities at West Valley site, New York. Based on high wind data (1950-1978) and DAPPLE tornado tape data (1916-1977). $10^{-1}$,$10^{-2}$, etc. are expressed as -1, -2, etc.

| | Probabilities per year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Log P | -1 | -2 | -3 | -4 | -5 | -6 | -7 | -8 |
| Storm types | HWD | HWD | HWD | HWD | HWD | TOR | TOR | TOR |
| Windspeeds | 67 | 82 | 97 | 112 | 127 | 173 | 221 | 266 |

## CONCLUSIONS

Straight-line winds are the governing factors in determining risks for probabilities of $10^{-5}$ or higher. At lower probabilities, tornadoes are the principal agents for generating large windspeeds.

The windspeed corresponding to a $10^{-9}$ probability (or, the maximum windspeed which may be expected over a billion year period) is 309 mph. A windspeed of 266 mph corresponds to a $10^{-8}$ probability.

The probability of a tornado generating maximum winds of 50 mph is 10-4 . In other words, a relatively weak tornado should occur in any chosen square-mile of the West Valley site only once in ten thousand years.

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