4.1 Climate and Meteorology/Air Quality

D.J. Hoitink and B.G. Fritz

The Hanford Site lies within the semiarid shrub-steppe Pasco Basin of the Columbia Plateau in south-central Washington State. The region's climate is greatly influenced by the Pacific Ocean, the Cascade Mountain Range to the west, and other mountain ranges located to the north and east. The Pacific Ocean moderates temperatures throughout the Pacific Northwest and the Cascade Range generates a rain shadow that limits rain and snowfall in the eastern half of Washington State. The Cascade Range also serves as a source of cold air drainage, which has a considerable effect on the wind regime on the Hanford Site. Mountain ranges to the north and east of the region shield the area from the severe winter storms and frigid air masses that move southward across Canada.

Climatological data for the Hanford Site are compiled at the Hanford Meteorology Station (HMS). The HMS is located on the Hanford Site's Central Plateau, just outside the northeast corner of the 200 West Area and about 4 km (3 mi) west of the 200 East Area. Meteorological measurements have been made at the HMS since late 1944. Prior to the establishment of the HMS, local meteorological observations were made at the Old Hanford Townsite (1912 through late 1943) and in Richland (1943-1944). A climatological summary for Hanford is provided in Hoitink *et al.* (2004). [(a)]

Data from the HMS capture the general climatic conditions for the region and describe the specific climate of Hanford's Central Plateau. The size of the Hanford Site and its topography give rise to substantial spatial variations in wind, precipitation, temperature, and other meteorological characteristics. This is observed for the differences in the annual distribution of wind directions and speeds measured at the HMS and at the 300 Area. To accurately characterize meteorological differences across the Hanford Site, the HMS operates a network of monitoring stations. These stations, which currently number 30, are located throughout the Site and in neighboring areas (Figure 4.1-1). A 124-m (408-ft) instrumented meteorological tower operates at the HMS. A 61-m (200-ft) instrumented tower operates at each of the 100-N, 300, and 400 area meteorology-monitoring sites. Most of the other network stations use instrumented towers with heights of about 9.1 m (30 ft). The data collected at each tower varies with at least three variables collected at all towers and up to seven characteristics collected at some (Table 4.1-1). Data are collected and processed at each station, and information is transmitted to the HMS every 15 minutes. This monitoring network has been in full operation since the early 1980s.

For the following descriptions in this section the seasons are defined as follows: Winter – December through February; spring – March through May; summer – June through August; and autumn – September through November.

[(a)] Hanford climatological data summaries have been updated annually since 1995. Earlier climatological reports that have been extensively cited include Glantz *et al.* (1990) and Stone *et al.* (1983).

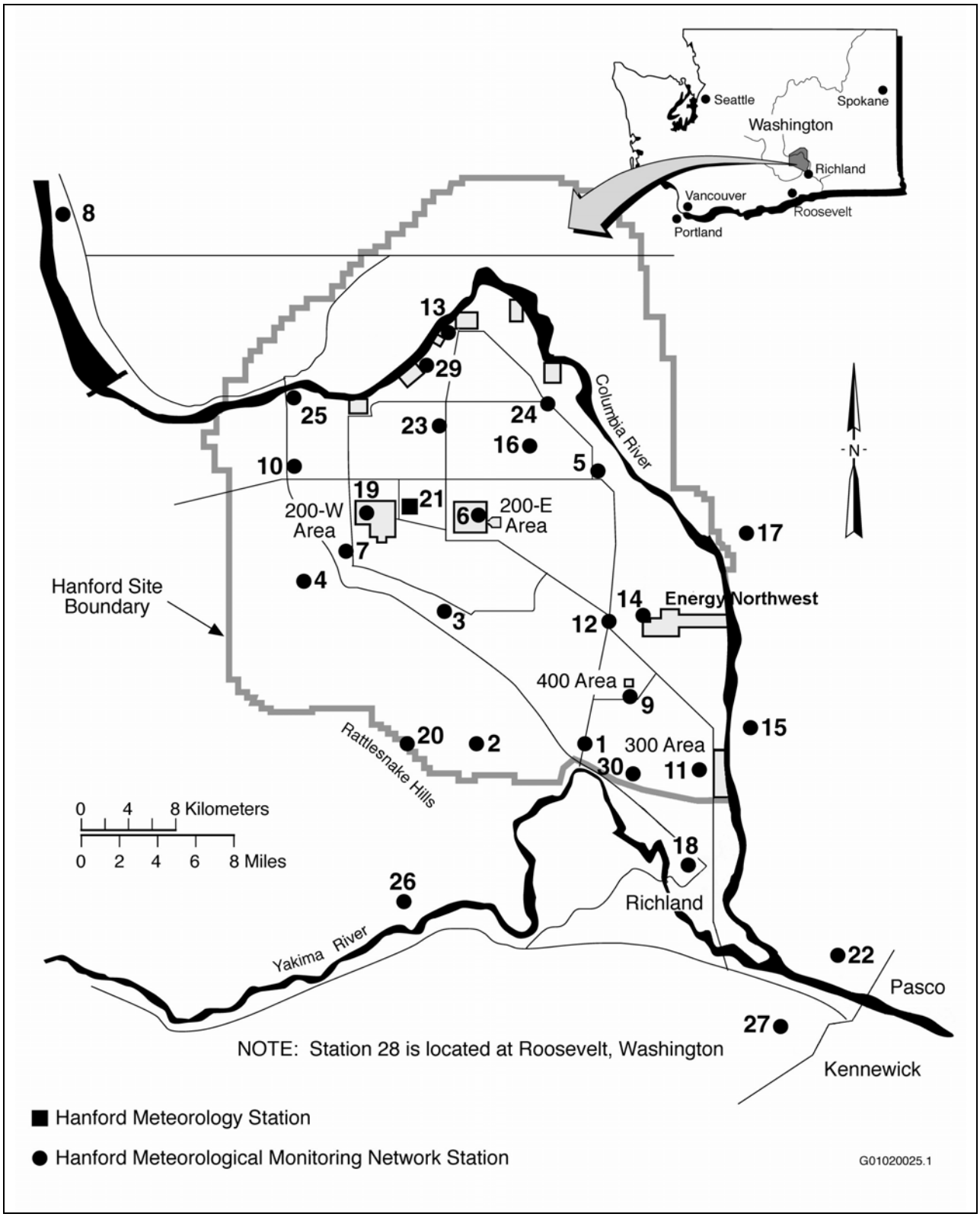

Figure 4.1-1. Hanford Meteorological Monitoring Network, Hanford Site, Washington

Table 4.1-1. Station Numbers, Names, and Meteorological Data Measured at each Station in the Hanford Meteorological Monitoring Network, Washington

Site Number	**Site Name**	**Meteorological Data**
1	Prosser Barricade	WS, WD, T, P
2	Emergency Operations Center	WS, WD, T, P
3	Army Loop Road	WS, WD, T, P
4	Rattlesnake Springs	WS, WD, T, P
5	Edna Railroad Crossing	WS, WD, T
6	200 East Area	WS, WD, T, P, AP
7	200 West Area	WS, WD, T, P
8	Beverly, Washington	WS, WD, T, P
9	Fast Flux Test Facility (61 m or 200 ft)	WD, T, TD, DP, P, AP
10	Yakima Barricade	WS, WD, T, P, AP
11	300 Area (61 m or 200 ft)	WS, WD, T, TD, DP, P, AP
12	Wye Barricade	WS, WD, T, P
13	100-N Area (61 m or 200 ft)	WS, WD, T, TD, DP, P, AP
14	Energy Northwest	WS, WD, T, P
15	Franklin County	WS, WD, T
16	Gable Mountain	WS, WD, T
17	Ringold, Washington	WS, WD, T, P
18	Richland Airport	WS, WD, T, AP
19	Plutonium Finishing Plant	WS, WD, T, AP
20	Rattlesnake Mountain	WS, WD, T, P
21	Hanford Meteorology Station (125 m or 410 ft)	WS, WD, T, P, AP
22	Tri-Cities Airport	WS, WD, T, P
23	Gable West	WS, WD, T
24	100-F Area	WS, WD, T, P
25	Vernita Bridge	WS, WD, T
26	Benton City, Washington	WS, WD, T, P
27	Vista	WS, WD, T, P
28[(a)]	Roosevelt, Washington	WS, WD, T, P, AP
29	100-K Area	WS, WD, T, P, AP
30	Hazardous Material Management and Emergency Response Training Center	WS, WD, T

Legend:

AP - Atmospheric Pressure
DP - Dew Point Temperature
P - Precipitation
T - Temperature
TD - Temperature Difference (between 10-m and 60-m Tower Levels)
WD - Wind Direction
WS - Wind Speed

(a) Roosevelt is located on the Columbia River 57 mi west/southwest of the site.

4.1.1 Wind

Wind data at the HMS are collected at 2.1 m (7 ft) above the ground and at the 15.2-, 61.0-, and 121.9-m (50-, 200-, and 400-ft) levels on the 124-m (408-ft) tower. Each of the three 61-m (200-ft) towers has wind-measuring instrumentation at the 10-, 25-, and 60-m (33-, 82-, and 197-ft) levels. The short towers measure winds at 9.1 m (30 ft) above ground level.

The prevailing surface winds on Hanford's Central Plateau are from the northwest (Figure 4.1-2). Winds from the northwest occur most frequently during the winter and summer. Winds from the southwest also have a high frequency of occurrence on the Central Plateau. During the spring and fall, there is an increase in the frequency of winds from the southwest and a corresponding decrease in winds from the northwest.

In the southeastern portion of the Hanford Site (including the 300 [Station 11] and 400 [Station 9] Areas), the prevailing wind direction near the surface is from the southwest during most months; winds from the northwest are much less common (Figure 4.1-2). In the 100 Area and along the Columbia River, local winds are strongly influenced by the topography near the river. At the 100-K (Station 29) and 100-N (Station 13) Areas, the prevailing wind direction is from the west. At the 100-F (Station 24) Area and near the Old Hanford Townsite (Edna Railroad crossing [Station 5]), winds often have a northwesterly or southeasterly component.

Stations that are relatively close together can exhibit significant differences in wind patterns. For example, the stations at Rattlesnake Springs (Station 4) and the 200 West Area (Station 7) are separated by about 5 km (3 mi), yet the wind patterns at the two stations are very different (Figure 4.1-2). Care should be taken when assessing the appropriateness of the wind data used in estimating environmental impacts. When possible, wind data from the closest representative station should be used for estimating local dispersion conditions.

Monthly and annual joint-frequency distributions of wind direction versus wind speed for the HMS are reported in Hoitink *et al.* (2004). Monthly average wind speeds at 15.2 m (50 ft) above the ground are lower during the winter months, averaging 2.7 to 3.1 m/s (6 to 7 mph), and faster during the summer, averaging 3.6 to 4.0 m/s (8 to 9 mph) (Table 4.1-2). The fastest wind speeds at the HMS are usually associated with flow from the southwest (Table 4.1-2). However, the summertime drainage winds from the northwest frequently exceed speeds of 13 m/s (30 mph). The maximum speed of the drainage winds (and their frequency of occurrence) tends to decrease as one moves toward the southeast across the Hanford Site. The HMS averages 156 days per year with peak wind gusts greater or equal to 11 m/s (25 mph) (ranging from a low of about 7 in January to high of nearly 20 in June and July), and 56 days with peak gusts greater or equal to 16 m/s (35 mph) (from a low of about 3 days in September and October to a high of about 6 during the months April through July) (Table 4.1-3).

Surface features have less influence on winds aloft than winds near the surface. However, substantial spatial variations are found in the wind distributions across Hanford at 60 m (197 ft) above ground level (Figure 4.1-3). For releases at greater heights, the most representative data may come from the closest representative 61-m (200-ft) tower rather than the nearest 9.1-m (30-ft) tower.

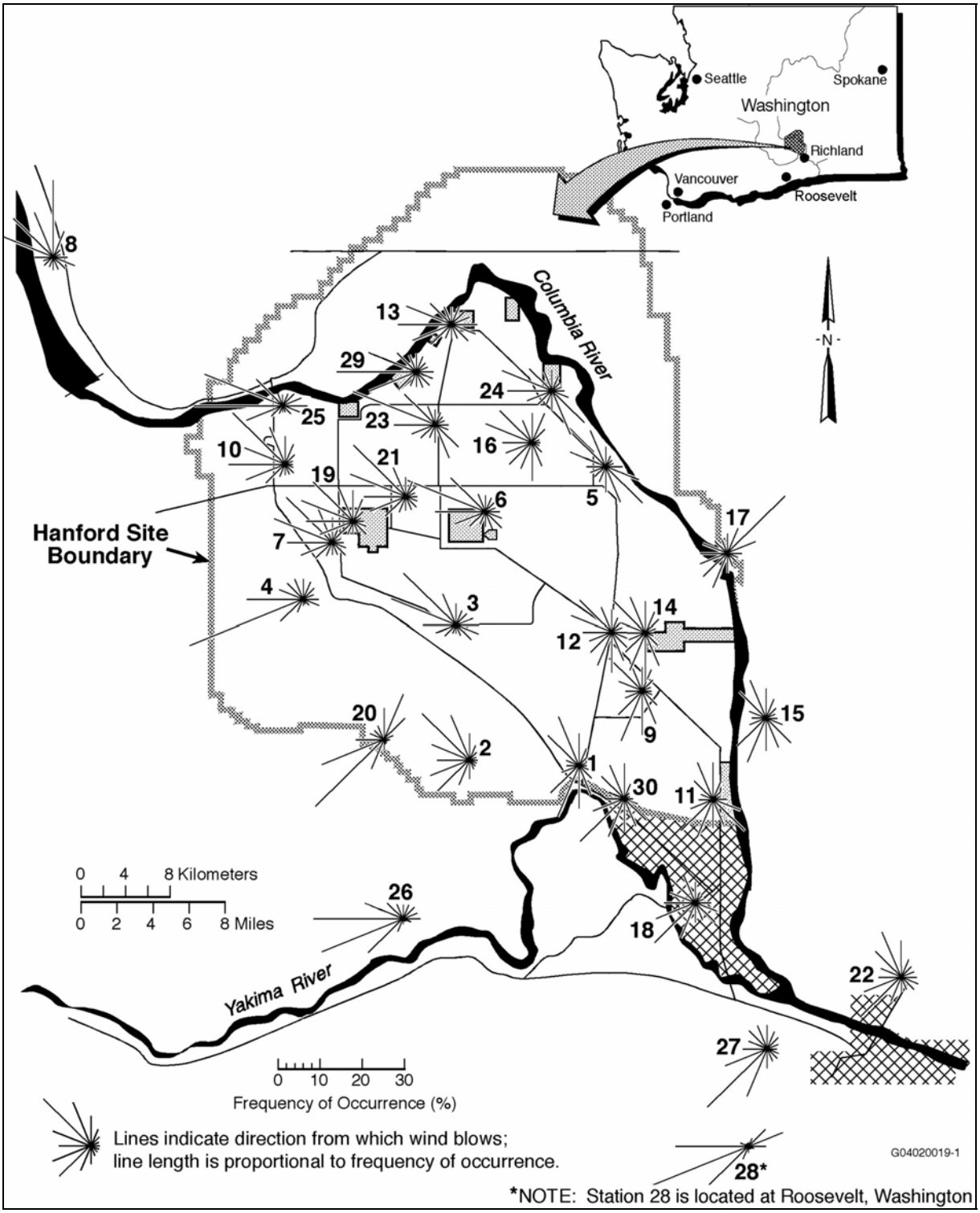

Figure 4.1-2. Wind Roses at the 9.1 m (30 ft) Level of the Hanford Meteorological Monitoring Network, Washington, 1982 to 2003 (after Hoitink *et al.* 2004)

Table 4.1-2. Monthly and Annual Prevailing Wind Directions, Average Speeds, and Peak Gusts at 15-m (50-ft) Level, 1945 through 2003, Hanford Meteorology Station, Washington (Hoitink *et al.* 2004)

							Peak Gusts		
Month	**Prevailing Direction**	**Average Speed (mph)**	**Highest Average (mph)**	**Year**	**Lowest Average (mph)**	**Year**	**Speed (mph)**	**Direction**	**Year**
January	NW	6.3	10.3	1972	2.9	1985	80	SW	1972
February	NW	7.1	11.1	1999	4.6	1963	65	SW	1971
March	WNW	8.2	10.7	1977[a]	5.9	1958	70	SW	1956
April	WNW	8.8	11.1	1972[a]	7.4	1989[a]	73	SSW	1972
May	WNW	8.8	10.7	1983	5.8	1957	71	SSW	1948
June	NW	9.1	10.7	1983[a]	7.7	1950[a]	72	SW	1957
July	NW	8.6	10.7	1983	6.8	1955	69	WSW	1979
August	WNW	8.0	9.5	1996	6.0	1956	66	SW	1961
September	WNW	7.5	9.2	1961	5.4	1957	65	SSW	1953
October	NW	6.6	9.1	1946	4.4	1952	72	SW	1997
November	NW	6.4	10.0	1990	2.9	1956	67	WSW	1993
December	NW	6.0	8.3	1968	3.3	1985	71	SW	1955
Annual	NW	7.6	8.8	1999	6.2	1989	80	SW	Jan-72

(a) Also in earlier years

Table 4.1-3. Number of Days with Peak Gusts above Specific Thresholds at 15-m (50-ft) Level, 1945 through 2003, Hanford Meteorology Station, Washington (Hoitink *et al.* 2004)

	Days with Peak Gusts ≥11 m/s (25 mph)					Days with Peak Gusts ≥16 m/s (35 mph)				
Month	**Avg**	**Max**	**Year**	**Min**	**Year**	**Avg**	**Max**	**Year**	**Min**	**Year**
January	7.6	21	1953	0	1985[a]	4.0	14	1953	0	1985[a]
February	8.6	17	1976[a]	2	1952[a]	3.8	14	1976	0	2001[a]
March	13.2	21	1977	4	1992	5.5	14	1997	0	1992
April	17.0	26	1954	8	1946	6.3	12	1972	1	1967
May	18.8	26	1978	9	1945	6.2	13	2002	0	1957
June	19.7	26	1963	11	1950[a]	6.3	12	2002[a]	1	1982
July	19.5	26	1995	11	1955	5.6	11	1994[a]	1	1982[a]
August	15.9	24	2000	7	1945	4.2	12	1996	0	1978[a]
September	11.3	17	2002[a]	7	1975[a]	3.4	7	2003[a]	0	1975
October	9.0	19	2003	3	1987[a]	3.4	11	1997	0	1993[a]
November	8.3	16	1990	0	1979	3.8	10	1998	0	1997[a]
December	7.4	15	1968	0	1985	4.2	11	1957	0	1985[a]
Annual	156.6	192	1999	123	1952	56.7	86	2002	31	1978

(a) Most recent of multiple occurrences

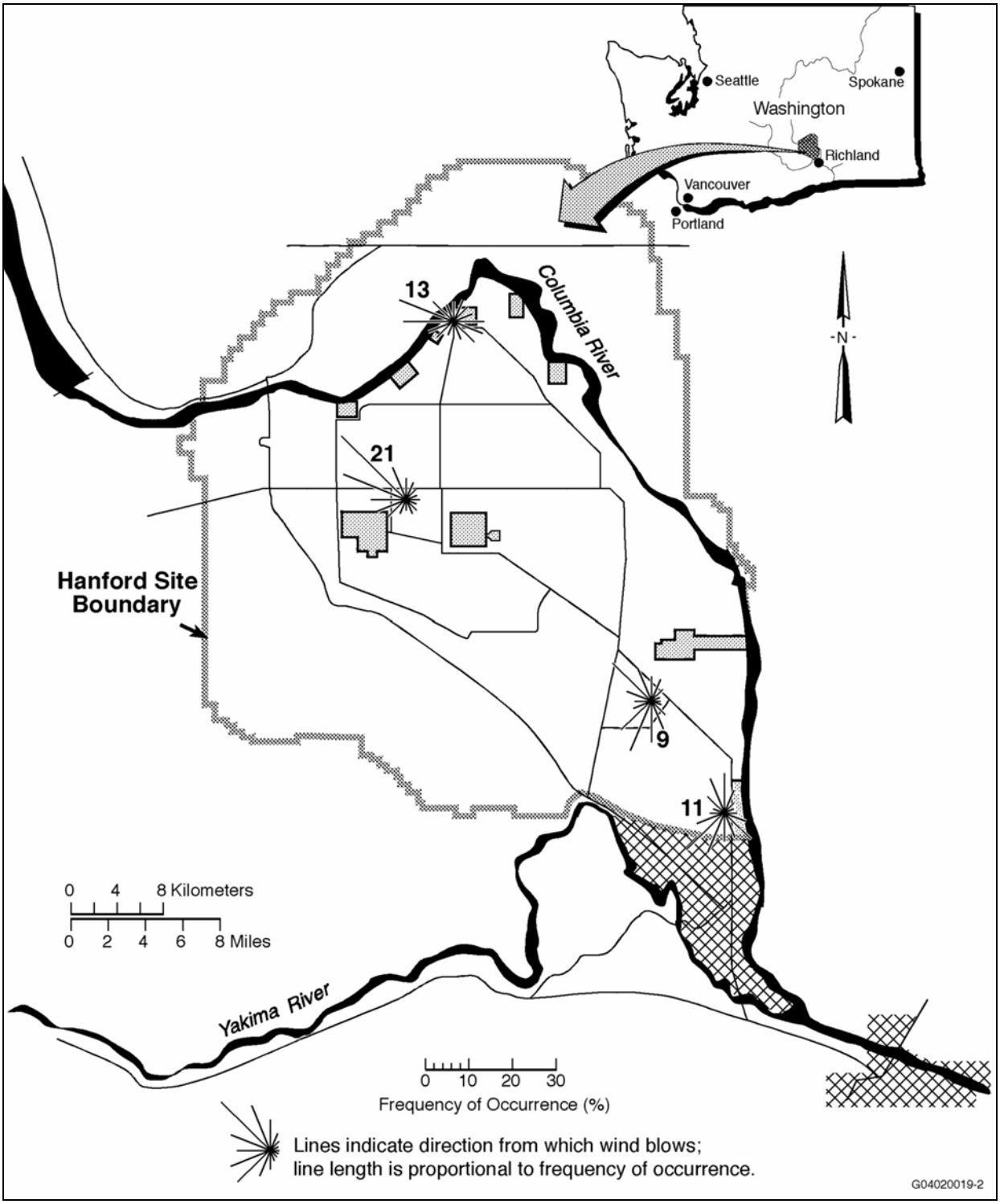

Figure 4.1-3. Wind Roses at the 60 m (197 ft) Level of the Hanford Meteorological Monitoring Network, Washington, 1986 to 2003 (after Hoitink *et al.* 2004)

4.1.2 Temperature and Humidity

The 124-m (408-ft) tower at the HMS has temperature-measuring instrumentation at the following levels: 0.9, 9.1, 15.2, 30.5, 61.0, 76.2, 91.4, and 121.9 m (3, 30, 50, 100, 200, 250, 300, and 400 ft). The three 61-m (200-ft) towers have temperature-measuring instrumentation at the following levels: 2, 10, and 60 m (~6.5, 33, and 197 ft). Temperatures are measured at the 2-m (~6.5-ft) level on the 9-m (30-ft) towers. Relative humidity/dew point temperature measurements are made at the HMS and at the three 61-m (200-ft) tower locations.

Monthly averages and extremes of temperature, dew point, and humidity are presented in Hoitink *et al*. (2004). Based on data collected from 1946 through 2003, the average monthly temperatures at the HMS range from a low of -0.7°C (31°F) in January to a high of 24.7°C (76°F) in July. The highest winter monthly average temperatures were 6.9°C (44°F) in February 1958 and February 1991, and the lowest average monthly temperature was -11.1°C (12°F) in January 1950. The highest monthly average temperature was 27.9°C (82°F) in July 1985 and the lowest summer monthly average temperature was 17.2°C (63°F) in June 1953.

Daily maximum temperatures at the HMS vary from an average of 2°C (35°F) in late December and early January to 36°C (96°F) in late July. There are, on average, 52 days during the summer months with maximum temperatures ≥32°C (90°F) and 12 days with maxima greater than or equal to 38°C (100°F). The greatest number of consecutive days on record with maximum daily temperatures ≥32°C (90°F) is 32 days. The record maximum temperature, 45°C (113°F) occurred at the HMS on July 13, 2002 and August 4, 1961.

From mid-November through early March, the average daily minimum temperature is below freezing; the daily minimum in late December and early January is -6°C (21°F). On average, the daily minimum temperature of ≤ -18°C (~0°F) occurs only 3 days per year; however, only about one winter in two experiences such low temperatures. The greatest number of consecutive days on record with minimum daily temperatures of ≤ -18°C (~0°F) is 11 days. The record minimum temperature, -31°C (-23°F) occurred on both February 1 and 3, 1950.

The annual average relative humidity at the HMS is 55%. It is highest during the winter months, averaging about 76%, and lowest during the summer, averaging about 36%. The annual average dewpoint temperature at the HMS is 1°C (34°F). In the winter, the dewpoint temperature averages about -3°C (27°F), and in the summer it averages about 6°C (43°F).

4.1.3 Precipitation

Average annual precipitation at the HMS is 17 cm (6.8 in.). During 1995, the wettest year on record, 31.3 cm (12.3 in.) of precipitation was measured; during 1976, the driest year, only 7.6 cm (3 in.) was measured. The wettest season on record was the winter of 1996-1997 with 14.1 cm (5.4 in.) of precipitation; the driest season was the summer of 1973 when only 0.1 cm (0.03 in.) of precipitation was measured. Most precipitation occurs during the late autumn and winter, with more than half of the annual amount occurring from November through February. Days with >1.3 cm (0.50 in.) precipitation occur on average less than one time each year.

Average snowfall ranges from 0.25 cm (0.1 in.) during October to a maximum of 13.2 cm (5.2 in.) during December and decreases to 1.3 cm (0.5 in.) during March. The record monthly snowfall of 59.4 cm (23.4 in.) occurred during January 1950. The seasonal record snowfall of 142.5 cm (56.1 in.)

occurred during the winter of 1992-1993. Snowfall accounts for about 38% of all precipitation from December through February.

4.1.4 Fog and Visibility

Fog has been recorded during every month of the year at the HMS; however, 89% of the occurrences are from November through February, with less than 3% from April through September (Table 4.1-4). The average number of days per year with fog (visibility ≤9.6 km [6 mi]) is 48, while those with dense fog (visibility ≤0.4 km [0.25 mi]) are 25. The greatest number of days with fog was 84 days during 1985-1986, and the least was 22 during 1948-1949. The greatest number of days with dense fog was 42 days during 1950-1951, and the least was 9 days during 1948-1949. The greatest persistence of fog was 114 hours (December 1985) and the greatest persistence of dense fog was 47 hours (December 1957).

Other phenomena causing restrictions to visibility (i.e., visibility < 9.6 km [6 mi]) include dust, blowing dust, and smoke from field burning. There are few such days; an average of 5 days per year have dust or blowing dust, and less than 1 day per year, on average, has reduced visibility from smoke.

Table 4.1-4. Number of Days with Fog by Season, Hanford Site, Washington

Category	Winter	Spring	Summer	Autumn	Total
fog	32	3	≤1	12	48
dense fog	17	1	≤1	7	25

4.1.5 Severe Weather

Concerns about severe weather usually center on hurricanes, tornadoes, and thunderstorms. Fortunately, Washington does not experience hurricanes. In addition, tornadoes are infrequent and generally small in the northwestern portion of the United States. The National Climatic Data Center maintains a database that provides information on the incidence of tornados reported in each county in the United States. (This database can be accessed via the Internet at http://www.ncdc.noaa.gov/ol/climate/severeweather/extremes.html).

This database reports that in the ten counties closest to the Hanford Site (Benton, Franklin, Grant, Adams, Yakima, Klickitat, Kittitas, and Walla Walla counties in Washington and Umatilla and Morrow counties in Oregon), there have been only 18 tornadoes recorded from 1950 through March 2001. Of these, 12 tornadoes had maximum wind speeds estimated to be in the range of 18 to 32 m/s (40 to 72 mph), three had maximum wind speeds in the range of 33 to 50 m/s (73 to 112 mph), and three had maximum wind speeds in the range of 51 to 71 m/s (113 to 157 mph). There were no deaths or substantial property damage (in excess of $50,000) associated with any of these tornadoes.

Ramsdell and Andrews (1986) report that for the 5° block centered at 117.5° west longitude and 47.5° north latitude (the area in which the Hanford Site is located), the expected path length of a tornado is 7.6 km (5 mi), the expected width is 95 m (312 ft), and the expected area is about 1.5 km^2 (1 mi^2). The estimated probability of a tornado striking a point on the Hanford Site is 9.6 x 10^{-6}/yr (Ramsdell and Andrews 1986). The probabilities of extreme winds associated with tornadoes striking a point can be estimated using the distribution of tornado intensities for the region (Table 4.1-5).

Table 4.1-5. Estimate of the Probability of Extreme Winds Associated with Tornadoes Striking a Point at Hanford, Washington (after Ramsdell and Andrews 1986)

Wind Speed (m/s)	Wind Speed (mph)	Probability Per Year
28	62	2.6×10^{-6}
56	124	6.5×10^{-7}
83	186	1.6×10^{-7}
111	249	3.9×10^{-8}

The average occurrence of thunderstorms in the vicinity of the HMS is 10 per year. They are most frequent during the summer; however, they have occurred in every month. Thunderstorms can generate high-speed winds and hail. Using the National Weather Service criteria for classifying a thunderstorm as "severe" (i.e., hail with a diameter ≥19 mm [3/4 in.] or wind gusts of ≥25.9 m/s [58 mph]), only 1.9% of all thunderstorm events surveyed at the HMS have been "severe" storms, and all met the criteria based on their wind gusts. High-speed winds at Hanford are more commonly associated with strong cold frontal passages. In rare cases, intense low-pressure systems can generate winds of near hurricane force (Table 4.1-6).

Table 4.1-6. Estimates of Extreme Winds at the Hanford Site, Washington (Hoitink *et al.* 2004)

	Peak Gusts			
Return Period (yr)	15.2 m (50 ft) above Ground (m/s)	15.2 m (50 ft) above Ground (mph)	61 m (200 ft) above Ground (m/s)	61 m (200 ft) above Ground (mph)
2	27	60	30	67
10	32	71	36	80
100	38	85	43	96
1000	44	98	50	111

4.1.6 Atmospheric Dispersion

Atmospheric dispersion (the transport and diffusion of gases and particles within the atmosphere) is a function of wind speed, duration and direction of wind, intensity of atmospheric turbulence, and mixing depth. Atmospheric turbulence is not directly measured at the Hanford Site; instead, the impact of turbulence on atmospheric dispersion is characterized using atmospheric stability. Atmospheric stability describes the thermal stratification or vertical temperature structure of the atmosphere. Generally, six or seven different classes of atmospheric stability are used to describe the atmosphere. These classes range from extremely unstable (when atmospheric turbulence is greatest) to extremely stable (when atmospheric mixing is at a minimum and wind speeds are low). When the atmosphere is unstable, pollutants can rapidly diffuse through a large volume of the atmosphere. When the atmosphere is stable, pollutants will diffuse much more slowly in a vertical direction. Horizontal dispersion may be limited during stable

conditions; however, plumes may also fan out horizontally during stable conditions, particularly when the wind speed is low. Most major pollutant incidents have been associated with stable conditions when inversions can trap pollutants near the ground.

Conditions likely to increase dispersion are most common in the summer when neutral and unstable stratification exists, about 56% of the time (Stone *et al.* 1983). Conditions less likely to promote dispersion are most common during the winter when moderately to extremely stable stratification exists, about 66% of the time (Stone *et al.* 1983). Less favorable conditions also occur periodically for surface and low-level releases in all seasons from about sunset to about an hour after sunrise as a result of ground-based temperature inversions and shallow mixing layers. Occasionally, there are extended periods of poor dispersion conditions associated with stagnant air in stationary high-pressure systems. These instances tend to occur during the winter months (Stone *et al.* 1983).

Stone *et al.* (1972) estimated the probability of extended periods of poor dispersion conditions. The probability of an inversion once established persisting more than 12 hr varies from a low of about 10% in May and June to a high of about 64% in September and October. These probabilities decrease rapidly for durations of >12 hr and are associated with extended surface-based inversions (Table 4.1-7).

Table 4.1-7. Percent Probabilities for Extended Periods of Surface-Based Inversions, Hanford Site, Washington (after Stone *et al.* 1972)

	Inversion Duration		
Months	**12-hr**	**24-hr**	**48-hr**
January-February	54.0	2.5	0.28
March-April	50.0	<0.1	<0.1
May-June	10.0	<0.1	<0.1
July-August	18.0	<0.1	<0.1
September-October	64.0	0.11	<0.1
November-December	50.0	1.2	0.13

Many simple dispersion models use the joint frequency distribution of atmospheric stability, wind speed, and wind direction to compute diffusion factors for both chronic and acute releases. Joint frequency distributions for atmospheric stability, wind speed, and transport direction have been estimated for the data collected at the 100-N, 200, 300, and 400 Areas from two different release heights (9.1 m and 60 m [30 ft and 197 ft]) (Tables A1 through A8, Appendix A). For each station, the joint frequency distributions were determined using local wind data measured at 9.1 m (30 ft) or 60 m (197 ft) above ground level, and atmospheric stability measurements made at the HMS.

The annual sector-average atmospheric dispersion coefficient (X/Q') where X is the air concentration (Ci/m^3) and Q' is the emission rate (Ci/s) were estimated for ground level and 60 m (197 ft) releases (Tables A9 through A16, Appendix A). The 95% centerline atmospheric dispersion estimates (E/Q') for the four major Hanford operating areas (100, 200, 300, and 400 Areas) were estimated from atmospheric data (Tables A17 through A24, Appendix A). These dispersion factors are presented as a function of direction and distance from the release point and are based on meteorological data collected during the years 1983 through 2002.

4.1.7 Nonradiological Air Quality

The Clean Air Act (CAA) is the basis for federal regulation of air quality in the United States (42 USC 7401). The CAA was first passed during 1967 and had comprehensive amendments during 1970, 1977, and 1990. Section 108 of the CAA calls for the U.S. Environmental Protection Agency (EPA) to promulgate a list of air pollutants that are emitted by numerous or diverse sources and whose presence in the atmosphere may reasonably be anticipated to endanger public health or welfare. In response to this mandate, EPA has issued regulations in 40 CFR 50 setting national ambient air quality standards. These standards are not directly enforceable, but other enforceable regulations are based on these standards. The states have primary responsibility for ensuring that air quality within the state meets the national ambient air quality standards through state implementation plans that are approved by EPA. Areas that meet ambient air quality standards are said to be "in attainment." Areas that do not meet one or more ambient air standards are designated as "nonattainment areas." The CAA also establishes a permitting program for construction or modification of large sources of air pollutants in both attainment and nonattainment areas and an operating permit program. In 2003, Washington State Department of Ecology completed the *Columbia Plateau Windblown Dust Natural Events Action Plan* (Ecology 2003).

Section 176 of the CAA states that federal agencies are not to engage in, support in any way, provide financial assistance for, license, permit, or approve any activity that does not conform to an applicable state implementation plan. The DOE has guidance (DOE 2000a) on how to apply the CAA conformity requirements and associated EPA regulations in a NEPA document and how to coordinate the CAA and NEPA public participation requirements.

Ambient air quality standards define levels of air quality that are necessary, with an adequate margin of safety, to protect the public health (primary standards) and the public welfare (secondary standards). "Ambient air" is that portion of the atmosphere, external to buildings, to which the general public has access (40 CFR 50.1). EPA has issued ambient air standards for sulfur oxides (measured as sulfur dioxide), nitrogen dioxide, carbon monoxide, lead, ozone, and PM_{10}. PM_{10} is an air pollutant consisting of small particles with an aerodynamic diameter less than or equal to 10 micrometers. The standards specify the maximum pollutant concentrations and frequencies of occurrence that are allowed for specific averaging periods. The averaging periods vary from 1 hour to 1 year, depending on the pollutant.

State and local governments have the authority to impose standards for ambient air quality that are stricter than the national standards (Table 4.1-8). Washington State has established more stringent standards for sulfur dioxide. In addition, Washington has established standards for total suspended particulates (WAC 173-470) and fluorides (WAC 173-481) that are not covered by national standards. The state standards for carbon monoxide, nitrogen dioxide, PM_{10}, and lead are identical to the national standards. Benton County, and subsequently the Hanford Site, is "in attainment" for all standards outlined in Table 4.1-8.

July 18, 1997, EPA issued new air quality standards for particulate matter with a diameter of 2.5 μm or less ($PM_{2.5}$) and an 8-hr ozone standard. Decisions on violations of the new particulate matter and ozone standard were to be delayed for 5 to 8 years to give states time to set up monitoring networks and obtain 3 years of data (Ecology 1997).

Table 4.1-8. U.S. Environmental Protection Agency (EPA) and Washington State Ambient Air Quality Standards [a]

Pollutant	EPA Primary	EPA Secondary	Washington State
Total Suspended Particulates			
annual geometric mean	NS[b]	NS	60 μg/m^3
24-hr average	NS	NS	150 μg/m^3
PM_{-10}[c]			
annual arithmetic mean	50 μg/m^3	50 μg/m^3	50 μg/m^3
24-hr average	150 μg/m^3	150 μg/m^3	150 μg/m^3
$PM_{2.5}$[d]			
annual arithmetic mean	15 μg/m^3	15 μg/m^3	NS
24-hr average	65 μg/m^3	65 μg/m^3	
Sulfur Dioxide			
annual average	0.03 ppm (≅80 μg/m^3)	NS	0.02 ppm (≅50 μg/m^3)
24-hr average	0.14 ppm (≅365μg/m^3)	NS	0.10 ppm (≅260 μg/m^3)
3-hr average	NS	0.50 ppm (≅1.3 mg/m^3)	NS
1-hr average	NS	NS	0.40 ppm (≅1.0 mg/m^3) [e]
Carbon Monoxide			
8-hr average	9 ppm (≅10 mg/m^3)	9 ppm (≅10 mg/m^3)	9 ppm (≅10 mg/m^3)
1-hr average	35 ppm (≅40 mg/m^3)	35 ppm (≅40 mg/m^3)	35 ppm (≅40 mg/m^3)
Ozone			
8-hr average	0.08 ppm (~157 μg/m^3)	0.08 ppm (~157 μg/m^3)	NS
1-hr average	0.12 ppm (≅235 μg/m^3)	0.12 ppm (≅235 μg/m^3)	0.12 ppm (≅235 μg/m^3)
Nitrogen Dioxide			
annual average	0.053 ppm (≅100 μg/m^3)	0.053 ppm (≅100 μg/m^3)	0.053 ppm (≅100 μg/m^3)
Lead			
quarterly average	1.5 μg/m^3	1.5 μg/m^3	1.5 μg/m^3
Radionuclides	NS	NS	[f]
Fluorides			
12-hr average	NS	NS	3.7 μg/m^3
24-hr average			2.9 μg/m^3
7 day average			1.7 μg/m^3
30 day average			0.84 μg/m^3

Abbreviations: ppm = parts per million; μg/m^3 = micrograms per cubic meter; mg/m^3 = milligrams per cubic meter.

(a) Source: 40 CFR 50 and WAC 173-470 – 173-481. Annual standards are never to be exceeded; short-term standards are not to be exceeded more than once per year unless otherwise noted. Particulate pollutants are in micrograms per cubic meter. Gaseous pollutants are in parts per million and equivalent micrograms (or milligrams) per cubic meter.

(b) NS = no standard.

(c) PM_{10} - small particles in the air with an aerodynamic diameter less than or equal to 10 micrometers.

(d) $PM_{2.5}$ - small particles in the air with an aerodynamic diameter less than or equal to 2.5 micrometers. Currently the $PM_{2.5}$ standard is not enforced by the EPA.

(e) 0.25 ppm not to be exceeded more than twice in any 7 consecutive days.

(f) Emissions of radionuclides in the air shall not cause a maximum accumulated dose equivalent of more than 25 mrem/yr to the whole body or 75 mrem/yr to a critical organ of any member of the public. Doses due to radon-220, radon-222, and their respective decay products are excluded from these limits.

4.1.7.1 Prevention of Significant Deterioration

Prevention of significant deterioration permits are issued to large sources of pollutants subject to ambient air standards in attainment areas. The Plutonium-Uranium Extraction (PUREX) and Uranium Trioxide (UO_3) facilities were issued a prevention of significant deterioration permit for nitrogen oxide emissions during 1980. These facilities were permanently shut down in the late 1980s and deactivated in the 1990s. None of the currently operating Hanford facilities have nonradiological emissions of sufficient magnitude to warrant consideration under prevention of significant deterioration regulations.

4.1.7.2 Emissions of Nonradiological Pollutants

Nonradiological pollutants are mainly emitted from power-generating and chemical-processing facilities located in the 200 and 300 Areas on the Hanford Site (Table 4.1-9). The 100, 400, and 600 Areas do not have any nonradiological emission sources of concern (Poston *et al.* 2004).

Table 4.1-9. Nonradioactive Constituents Discharged to the Atmosphere during 2003, Hanford Site, Washington (Poston *et al.* 2004)

Constituent	Release, kg (lb)
particulate matter	1,800 (3,900)
nitrogen oxides	16,000 (34,000)
sulfur oxides	3,800 (8,300)
carbon monoxide	17,000 (38,000)
lead	0.64 (1.4)
volatile organic compounds [a,b]	11,000 (25,000)
ammonia[c]	16,000 (36,000)
other toxic air pollutants [d]	8,100 (18,000)

(a) The estimate of volatile organic compound emissions does not include emissions from certain laboratory operations.
(b) Produced from burning fossil fuel for steam and electrical generators, calculated estimates from the 200 East and 200 West Areas tank farms, and operation of the 242-A evaporator and the 200 Area Effluent Treatment Facility.
(c) Estimated ammonia releases are from the 200 East Area and 200 West Area tank farms, and operation of the 242-A Evaporator and the 200 Areas Effluent Treatment Facility.
(d) Releases are a composite of calculated estimates of toxic air pollutants, excluding ammonia, from the 200 East Area and 200 West Area tank farms, and operation of the 242-A Evaporator and the 200 Areas Effluent Treatment Facility.

4.1.7.3 Offsite Monitoring

During 1998, the Washington State Department of Ecology (Ecology) conducted offsite monitoring near the Hanford Site for PM_{10} (Ecology 1999, 2000). PM_{10} was monitored at one location in Benton County, the Tri-Tech Vocational Center near the Hanford network's Vista Field meteorological monitoring site in Kennewick. The Benton Clean Air Authority currently conducts particulate monitoring at Tri-Tech Vocational Center to demonstrate compliance with EPA and Washington State standards (Table 4.1-8). During 2003, the maximum measured PM_{10} concentration was 138 $\mu g/m^3$, while the second highest measured concentration was 126 $\mu g/m^3$ (EPA 2004). The annual average PM_{10} concentration reported for Benton County was 24 $\mu g/m^3$ (EPA 2004). The maximum measured $PM_{2.5}$ concentration for Benton County during 2003 was 19 $\mu g/m^3$, while the 2003 annual average $PM_{2.5}$

concentration was 6.3 μg/m^3 (EPA 2004). These 2003 measured concentrations were less than EPA and Washington State standards.

4.1.7.4 Background Monitoring

During the last 10 years, carbon monoxide, sulfur dioxide, and nitrogen dioxide have been monitored periodically in communities and commercial areas southeast of Hanford. These urban measurements are typically used to estimate the maximum background pollutant concentrations for the Hanford Site because of the lack of specific onsite monitoring.

Particulate concentrations can reach relatively high levels in eastern Washington because of exceptional natural events (i.e., dust storms and large brushfires) that occur in the region. During June 1996, EPA adopted the policy that allows dust storms to be treated as uncontrollable natural events (EPA 1996). This means that EPA will not designate areas affected by dust storms as nonattainment. However, states are required to develop and implement a natural events action plan.

Areas that require more strict controls on air quality impacts are regions that have been determined to be nonattainment areas by the EPA. Federal Class I areas include certain national parks and wilderness areas. Actions on the Hanford Site are unlikely to have any impacts on these types of areas. The nearest nonattainment area to the Hanford Site is the Wallula area (located approximately 30 km [20 mi] southeast of the Site), which is a nonattainment area for PM_{10} (40 CFR 81.348, 66 FR 9663). The major source of PM_{10} in the Wallula area is from windblown dust. In making the nonattainment determination, EPA found that even if some of the data from the Wallula monitoring site are considered uncontrollable natural events and excluded from consideration in determining the air quality status of the area, the remaining data still show that the Wallula area has not attained the PM_{10} national ambient air quality standard (66 FR 9663).

The nearest Federal Class I areas to the Hanford Site are Mount Rainer National Park, located 160 km (100 mi) west of the Site; Goat Rocks Wilderness Area, located approximately 145 km (90 mi) west of the Site; Mount Adams Wilderness Area, located approximately 150 km (95 mi) southwest of the Site; and Alpine Lakes Wilderness Area, located approximately 175 km (110 mi) northwest of the Site (40 CFR 81.434). Operations at the Hanford Site should have no discernable effects on these areas because of their distance from the Site and because topography and prevailing winds tend to prevent Hanford emissions from reaching these Class I areas.

4.1.7.5 Onsite Monitoring

Monitoring of particulate matter mass concentrations in air on the Hanford Site began during February 2001. PM_{10} data have been collected at the Hanford Meteorological Station since February 2001, while $PM_{2.5}$ data collection began at the Hanford Meteorological Station during October 2001. The observed annual average PM_{10} concentration at the Hanford Meteorological Station during 2003 was 14 μg/m^3. Daily average PM_{10} concentrations on the Hanford Site were greater than the EPA standard on two days (Figure 4.1-4). The Benton Clean Air Authority conducts air monitoring that is responsible for determining Benton County's compliance with the EPA National Ambient Air Quality Standards (NAAQS), so concentrations on the Hanford Site that are higher than the EPA standard for PM_{10} are not considered for determining compliance with the EPA NAAQS. All of the elevated PM_{10} concentrations observed on the Hanford Site during 2003 were associated with high winds. The measured annual average $PM_{2.5}$ concentration at the Hanford Meteorological Station during 2003 was 6 μg/m^3, while the highest 24-hr average concentration observed was 29 μg/m^3. Both of these concentrations were less than EPA standards of 15 μg/m^3 and 65 μg/m^3, respectively (Table 4.1-8).

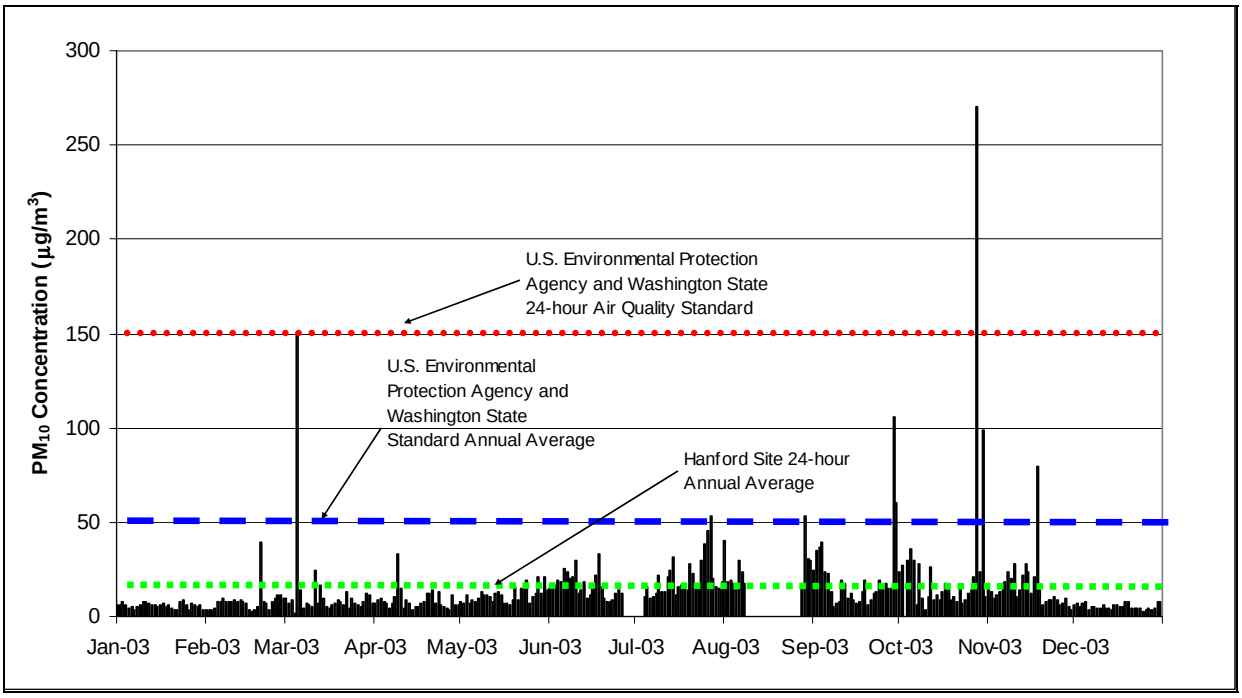

Figure 4.1-4. 24-hr Average Concentrations for Particulate Matter with a Diameter of 10 µm or less at the Hanford Meteorological Station, Washington, 2003

4.1.8 Radiological Air Quality

Airborne effluents that may contain radioactive constituents are continually monitored at the Hanford Site. Samples are analyzed for gross alpha and gross beta activity as well as selected radionuclides. Radioactive emissions during 2002 originated in the 100, 200, 300, and 400 Areas. 100 Area emissions originated from the K Basins (irradiated fuel stored in two water-filled storage basins) and the Cold Vacuum Drying Facility, where fuel from the K Basins was prepared for storage. 200 Area emissions originated from the PUREX Plant, the Waste Encapsulation and Storage Facility, the Plutonium Finishing Plant, T Plant, 222-S Laboratory, underground storage tanks, and waste evaporators. Emissions from the 300 Area originated from the 324 Waste Technology Engineering Laboratory, 325 Radiochemical Processing Laboratory, 327 Post-Irradiation Laboratory, and 340 Vault and Tanks. 400 Area emissions originated at the Fast Flux Test Facility (FFTF) and Maintenance and Storage Facility (Rokkan *et al*. 2003).

4.1.8.1 Radiological Emissions

Standards for emissions of radionuclides from DOE facilities have been established by EPA (40 CFR Part 61) and Washington State (WAC 173-480 and WAC 246-247). Emissions may not exceed quantities that would result in a dose of 10 mrem in a year to a maximally exposed individual (MEI) of the public. Dose to a MEI is calculated through computer modeling that uses radiological emissions to the atmosphere as one input parameter (Table 4.1-10).

Table 4.1-10. Radionuclides Discharged to the Atmosphere at the Hanford Site, Washington, 2003 (Poston *et al.* 2004)

Release, Ci [(a)]					
Radionuclide	**100 Areas**	**200-East Area**	**200-West Area**	**300 Area**	**400 Area**
tritium (as HT) [(b)]	NM[(c)]	NM	NM	7.8 E+00	NM
tritium (as HTO) [(b)]	NM	NM	NM	3.5 E+01	6.6 E-01
cobalt-60	ND[(d)]	3.9 E-08	ND	ND	NM
strontium-90	9.0 E-06[(e)]	1.2 E-04[(e)]	3.0 E-05[(e)]	1.3 E-06[(e)]	NM
ruthenium-106	1.1 E-06	ND	ND	ND	NM
iodine-129	NM	1.4 E-03	NM	NM	NM
cesium-137	7.5 E-06	6.3 E-05	1.5 E-05	1.1 E-05[(f)]	4.9 E-06[(f)]
radon-220	NM	NM	NM	2.3 E+02	NM
uranium-234	NM	NM	NM	6.3 E-11	NM
uranium-235	NM	NM	NM	4.6 E-11	NM
uranium-238	NM	NM	NM	3.5 E-11	NM
plutonium-238	3.4 E-07	3.8 E-08	1.3 E-06	4.9 E-09	NM
plutonium-239/240	2.5 E-06[(g)]	1.7 E-06[(g)]	8.3 E-05[(g)]	1.7 E-07[(g)]	1.4 E-07[(g)]
plutonium-241	2.3 E-05	ND	7.2 E-05	ND	NM
americium-241	1.7 E-06	2.0 E-06	1.4 E-05	8.7 E-08[(h)]	NM
americium-243	NM	NM	NM	ND	NM

(a) 1 Ci = 3.7 E+10 becquerels.
(b) HT = Elemental tritium; HTO = tritiated water vapor.
(c) NM = Not measured.
(d) ND = Not detected (i.e., either the radionuclide was not detected in any sample during the year or the average of all the measurements made for that given radionuclide or type of radioactivity during the year was below background levels).
(e) This value includes gross beta release data. Gross beta and unspecified beta results were assumed to be strontium-90 in dose calculations.
(f) This value includes gross beta release data. Gross beta results were assumed to be cesium-137 in dose calculations.
(g) This value includes gross alpha release data. Gross alpha and unspecified alpha results were assumed to be plutonium-239/240 in dose calculations.
(h) This value includes unspecified gross alpha release data, treated as Am-241 in dose calculations.

4.1.8.2 Dose Assessments

In order to comply with the Clean Air Act (40 CFR 61, Subpart H), dose assessments are required to assure that no member of the public receives a dose greater than 10 mrem in a year. EPA requires the use of a computer model approved by the EPA to calculate doses. During 2003, the estimated annual dose to an offsite member of the public from all pathways (inhalation, ingestion, and absorption) due to radionuclide emissions to a hypothetical MEI was 0.023 mrem (0.23 µSv). This calculated MEI scenario was determined using the EPA-approved CAP88-PC model (EPA 2000). Model results were calculated using established standard parameters for the Hanford Site (Rokkan *et al*. 2003). Inhalation dose to an offsite MEI was also calculated. This calculation used environmental measurements to estimate

maximum air concentrations and the resulting dose. For 2003, the maximum annual dose to a member of the public from inhalation of air at the site perimeter was 0.02 mrem (0.2 µSv).

Another maximally exposed individual dose is estimated annually to comply with DOE Order 5400.5 (DOE 1993b). This dose assessment uses a multi-media pathway assessment computer model known as GENII (Napier *et al.* 1998). During 2003, the annual dose to a hypothetical maximally exposed individual was estimated to be 0.06 mrem (0.6 µSv) (Poston *et al.* 2004). The average individual dose to the population living within 80 km (50 mi) of Hanford was calculated to be 0.001 mrem (0.01 µSv) (Poston *et al.* 2004).

4.1.8.3 Environmental Monitoring

Both the Surface Environmental Surveillance Project (SESP) and the near-facility environmental monitoring project conduct Hanford Site environmental monitoring. The SESP conducts monitoring at locations across the Hanford Site, as well as at upwind and downwind locations. The near-facility monitoring project primarily collects samples near known effluent sources. Summaries of the 2003 monitoring data from both of these projects are available in the annual Hanford Site Environmental Report (Poston *et al.* 2004). The spatial coverage of these two monitoring networks is sufficient to identify some Hanford sources. However, the amount of radiological materials in air is so small that there is no difference between upwind and downwind samples for most radionuclides. Atmospheric dispersion reduces Hanford atmospheric emissions to background levels before those emissions leave the site (Poston *et al.* 2004).