PNWD--2090-HEDR

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INTERIM REPORT ON THE METEOROLOGICAL DATABASE

For the Hanford Environmental Dose Reconstruction Project

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DISCLAIMER

PREFACE

The primary objective of the Hanford Environmental Dose Reconstruction (HEDR) Project is to estimate the radiation dose that individuals may have received as a result of emissions since 1944 from the Hanford Site near Richland, Washington, operated by the U.S. Department of Energy (DOE). An additional objective is to describe the uncertainties inherent in such estimates. An independent Technical Steering Panel directs the project, which is conducted by Battelle Pacific Northwest Laboratories (BNW) staff.

The HEDR Project work includes a number of technical and administrative tasks. This report describes the sources of meteorological data used by the Atmospheric Transport Task to estimate air concentrations and surface contamination in the Hanford vicinity using the Regional Atmospheric Transport Code for Hanford Emissions Tracking (RATCHET). Air concentrations and surface deposition are used in estimating dose. The report fulfills HEDR Project Milestones 0405A and 0402D.

SUMMARY

The Hanford Environmental Dose Reconstruction (HEDR) Project is estimating radiation doses that individuals may have received from operations at Hanford from 1944 to the present. An independent Technical Steering Panel (TSP) directs the project, which is being conducted by the Battelle, Pacific Northwest Laboratories in Richland, Washington. The goals of HEDR, as approved by the TSP, include dose estimates and determination of confidence ranges for these estimates.

The HEDR Project is developing a computer model that will be used for these dose estimates. The HEDR integrated code (HEDRIC) consists of four models and the associated interfaces. The **S**ource **T**erm **R**elease **M**odel (STRM) uses the laws of science and the data on Hanford operations to produce an estimate of the amounts of radionuclides vented to the atmosphere through the operating plant stacks. The second model, **R**egional **A**tmospheric **T**ransport **C**ode for **H**anford **E**missions **T**racking (RATCHET), combines the release data with information on atmospheric conditions including wind direction and speed. The RATCHET model uses these data to produce estimates of time-integrated air concentrations and surface contamination. These estimates are used in calculating dose by the **D**ynamic **ES**timates of **C**oncentrations **A**nd **R**adionuclides in **T**errestrial **E**nvironment**S** (DESCARTES) and the **C**alculations of **I**ndividual **D**oses from **E**nvironmental **R**adionuclides (CIDER), the remaining models in HEDRIC.

This letter report describes the current status of the meteorological database. The report defines the meteorological data available for use in RATCHET calculations, describes the data collection procedures and the preparation and control of the meteorological database. This report also provides an initial assessment of the data quality. The available meteorological data are adequate for atmospheric calculations. Initial checks of the data indicate the data entry accuracy meets the data quality objectives.

The report includes three major sections. The introduction (Section 1.0) provides background information and an overview of the meteorological

database development effort. Section 2.0 includes a description of the data set and quality controls used in building the meteorological database. Section 3.0 details the meteorological data available from each location from which data have been obtained.

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

This letter report describes the status of the Hanford Environmental Dose Reconstruction (HEDR) Project interim atmospheric model database in satisfaction of HEDR Milestones 0405A and 0402D (Shipler 1992). This introduction gives an overview of the computer model used for HEDR dose estimates, discusses the importance of meteorological conditions in dose reconstruction, and describes the domain and period of interest for the HEDR atmospheric model.

1.1 OVERVIEW OF HEDR INTEGRATED CODE

Figure 1.1 shows the interaction of the major components of the HEDR Integrated Code (HEDRIC). The HEDRIC consists of four models and their associated interfaces. The first model is based on knowledge of operations at the nuclear reactors and chemical processing plants. The records that were kept at the plants describe the materials that went into the processes. Data from those records are entered into a mathematical model that simulates operation of the processes. That model, the **S**ource **T**erm **R**elease **M**odel (STRM), uses knowledge of the chemistry and physics of Hanford plant operations and plant records to produce an estimate of the amounts of radionuclides vented through operating plant stacks to the atmosphere. The second model, **R**egional **A**tmospheric **T**ransport **C**ode for **H**anford **E**mission **T**racking (RATCHET), combines the release data with information on meteorological conditions, including wind direction and speed, and produces estimates of time-integrated air concentrations and surface contamination. As Figure 1.1 indicates, the third model, **D**ynamic **ES**timates of **C**oncentrations **A**nd **R**adionuclides in **T**errestrial **E**nvironment**S** (DESCARTES), uses data on air concentrations and surface contamination to calculate radionuclide progress through the food chain. Ultimately, DESCARTES describes the radionuclide concentration in food available to the population in the HEDR Project area.

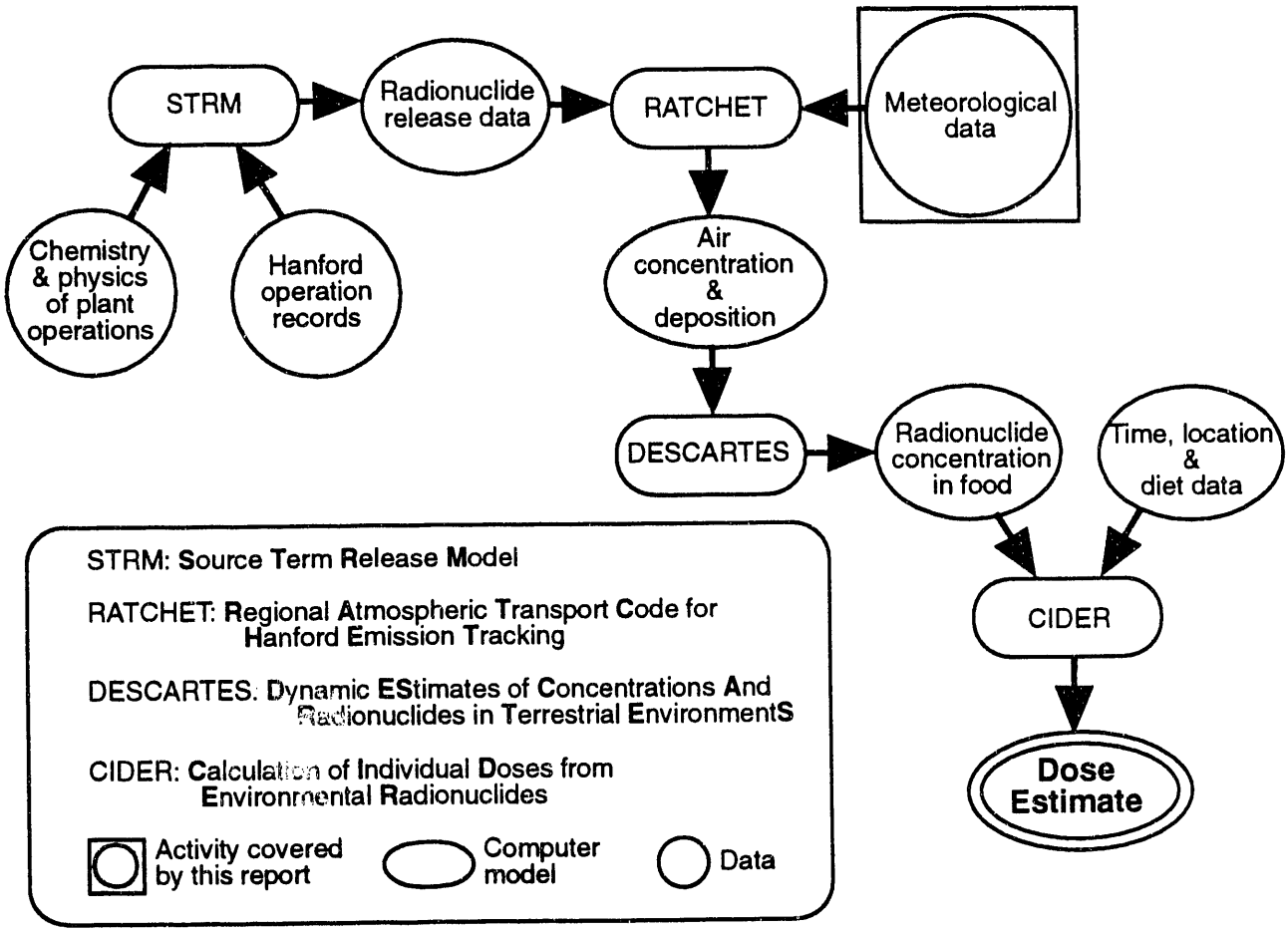


FIGURE 1.1. Hanford Environmental Dose Reconstruction Integrated Codes

The final model, Calculation of Individual Doses from Environmental Radionuclides (CIDER), uses time, location, and diet information for an individual and the results from DESCARTES to calculate dose estimates. This report focuses on the meteorological data used as input to the RATCHET code.

1.2 NEED FOR METEOROLOGICAL DATA

Whenever any substance is released into the atmosphere, the fate of that substance is largely determined by meteorological conditions. Wind speed and direction, atmospheric stability, mixing layer depth, and precipitation (when present) determine the transport, dilution, deposition rate, and distribution of the substance. Realistic dose reconstruction requires a meteorological

database that describes the temporal and spatial changes in the atmosphere during periods of significant radionuclide releases to the air.

1.3 MODEL DOMAIN

Time-integrated air concentrations and surface contamination from radionuclides released to the air are to be calculated for the rectangular domain (indicated in the box with tick marks) shown in Figure 1.2. The RATCHET domain is a rectangle centered at 46° 40′ N, 118° 45′ W. It extends 395.9 kilometers (246 miles) east to west and 492.5 kilometers (306 miles) south to north. The area covered is approximately 195,000 square kilometers (75,000 square miles). The tick marks are 12 miles apart.

The Hanford site (shown in cross hatch) is near the center of the figure. The figure details specific locations for which data have been included in the meteorological database. (Section 3.0 contains a description of each location.)

1.4 PERIOD OF INTEREST

The HEDR Project has divided the operations at the Hanford site into several time periods based on magnitude of releases (Shipler and Napier 1992). The first period of interest, between December 1944 and December 1949, corresponds to the interval of the largest radionuclides releases to the atmosphere (Heeb 1992).

1.5 CONTENT OF THIS REPORT

This report covers the preparation of the meteorological database for dose reconstruction for this period. Section 2.0 provides a description of the data set, procedures used to enter the data into the database, and data quality checks used to assure the database is an accurate reproduction of the historical records. The report contains a discussion on the accuracy of the data, the adequacy of the data for representing the meteorological conditions in the HEDR region, sources of errors and uncertainties in the data, and their probable sizes. Wind roses (see Section 2.7 for explanation) are also described for selected stations.

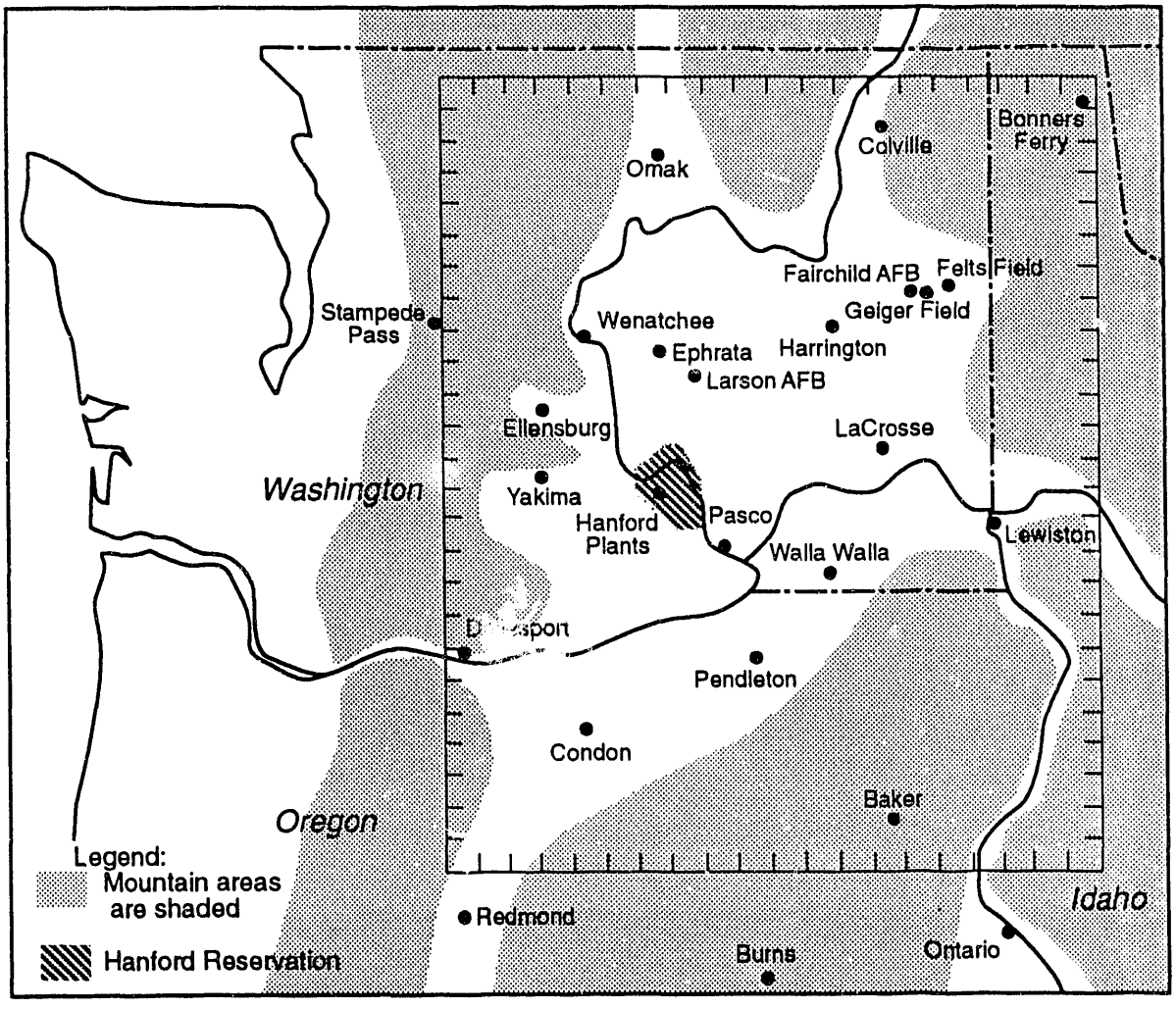


FIGURE 1.2. Map of HEDR Model Domain and Meteorological Stations

Section 3.2 contains detailed descriptions of the stations used in the HEDR meteorology database. These descriptions include station locations, available data and the method used to obtain them, and local topography and its probable effect on station winds. The models and computer code that use the data to estimate the air concentrations and surface contamination are described in separate reports (Ramsdell and Burk 1992; Ramsdell 1992).

2.0 DESCRIPTION OF THE DATA SET

Data suitable for use in the RATCHET Model are available for 25 locations for the HEDR period of interest. A list of these stations, followed by their abbreviations, is contained in Table 2.1. The locations of these stations are shown in Figure 1.2, and a more detailed description of each station is given in Section 3.0 of this report.

2.1 WEATHER SERVICE OPERATING PROCEDURES

All of the stations, except the Hanford Meteorological Station (see Section 2.2), followed standard weather service procedures (Changery 1978). During the period of interest, wind speeds were measured using rotating 3-cup anemometers mounted on the roofs of buildings, on towers, or on beacons. To obtain a wind speed, the observer watched a display showing instrument output for a single 1-minute period at the observation time (30 minutes past the hour), made a visual estimate of the average, and recorded the result (to the nearest whole mile per hour) as the hourly wind speed.

TABLE 2.1. HEDR Meteorological Data Stations

Station Name	Abbreviation	Station Name	Abbreviation
Washington State		**Oregon State**	
Colville	COL	Baker	BKE
Dallesport	DLS	Burns	BNO
Ellensburg	ELN	Condon	CON
Ephrata	EPH	Ontario	ONO
Fairchild AFB	SKA	Pendleton	PDT
Hanford Meteorological Station	HMS	Redmond	RDM
Harrington	HAR		
LaCrosse	LAC		
Larson AFB	MWH	**Idaho State**	
Omak	OMK	Bonners Ferry	BON
Pasco	PSC	Lewiston	LWS
Spokane (Felts Field)	SFF		
Spokane (Geiger Field)	GEG		
Stampede Pass	SMP		
Walla Walla	ALW		
Wenatchee	EAT		
Yakima	YKM		

During most of the 1940s, wind direction was measured by wind vanes that used output lights. The dials of these instruments had 8 lights to indicate 16 wind directions. For winds from each direction (north, northeast, east, southeast, south, southwest, west, or northwest), one light became illuminated.

For intermediate wind directions, two adjacent lights were illuminated (for example, a south-southeasterly wind was indicated by illumination of the south and southeast lights). To calculate the wind direction, the observer used a method similar to that for wind speed. Specifically, the observer watched the dial for 1 minute at the observation time and visually estimated the average. The result was recorded to the nearest compass point on a 16-point compass (northerly, north-northeasterly, northeasterly, east-northeasterly, and so forth), each comprised of a 22.5-degree direction band.

Between 1947 and the early 1950s, wind vanes at the observing stations were gradually replaced by vanes that indicated direction on dials showing 0 to 360 degrees. Observers recorded wind directions based on the 16 compass points until 1965, when observers started recording directions in 10-degree increments.

Weather conditions (including precipitation, cloud cover, and ceiling) were visually estimated and recorded by the observer. The RATCHET model uses these weather observations to calculate estimated precipitation rates and atmospheric stability.

2.2 HANFORD METEOROLOGICAL STATION OPERATING PROCEDURES

Instrumentation and observation techniques at the Hanford Meteorological Station in the early 1950s are described by Jenne (1954). These techniques are assumed to have been followed from the beginning of observations in 1944. Wind speed and direction were continuously recorded on strip charts. Hourly observations were obtained by averaging the values on the strip charts.

Jenne (1954, Section 5.02, "Entries on Form R-143, Daily Hourly Wind Log") gives a detailed set of rules for determining the reported hourly wind direction. The rules are designed to make the choice of a wind direction as

objective as possible. They are based on six possible wind-direction categories ranging from an easy category (with nearly steady direction for an entire hour) to much more difficult categories (with winds varying among several sectors). The wind direction is defined as the direction most representative for the hour. In actuality, the rules are designed so the chosen direction is the direction from which the wind comes for the largest number of minutes.

Each wind speed and direction recorded for the Hanford Station is based on a full-hour record, rather than the 1-minute observation periods used at the Weather Service Stations. Therefore, the Hanford data are more representative of hourly atmospheric transport at that station than the Weather Service data are at their respective stations.

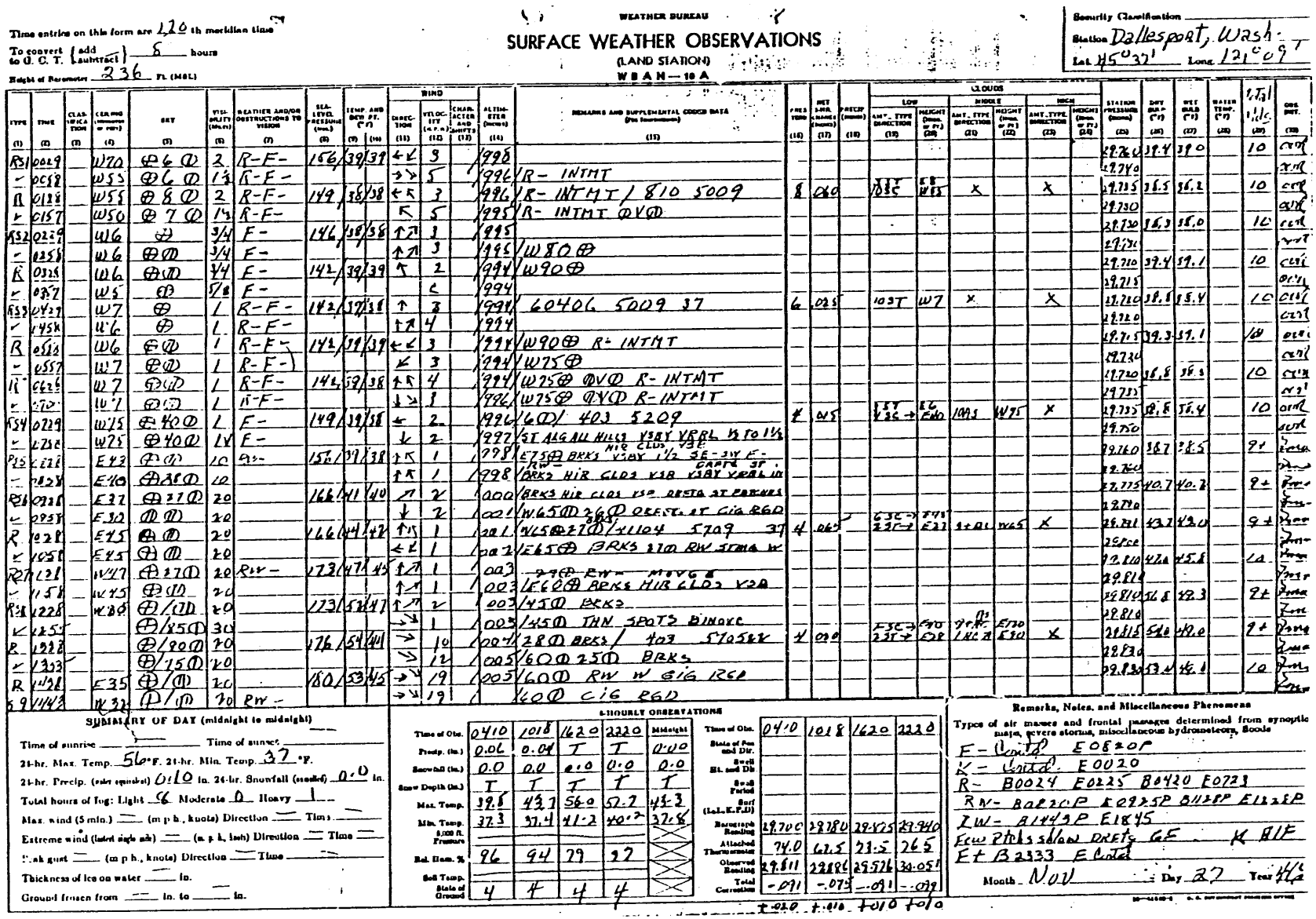
2.3 USE OF ONE SPOKANE STATION

Three stations are clustered near Spokane (Felts Field, Geiger Field, and Fairchild AFB). Use of all three stations produces an unduly strong weighting of the Spokane vicinity in the RATCHET wind field. For this reason, data from only one of these stations are used. The Fairchild AFB station was selected because data are available for 1944 through 1949.

2.4 DATA SOURCES

Data from the Hanford Meteorological Station were obtained from a digital file provided by the Hanford Meteorological Program. This file was produced from original handwritten records.

Data from the other stations were obtained from the National Climatic Data Center Archive in the form of magnetic tapes, when available, and as microfiche copies or paper photocopies of original handwritten records made by the observers for other periods. A general description of these data is given by Changery (1978). In some cases, the archived microfiche or photocopy records were difficult to read. Figure 2.1 shows an example of a photocopied record that is readily legible. Figure 2.2 shows a record with poor legibility, and Figure 2.3 shows a record with crossed out values and misplaced



WEATHER BUREAU

SURFACE WEATHER OBSERVATIONS

(LAND STATION)

WBAN—10A

Time entries on this form are 120 th meridian time

To convert to G. C. T. (add / subtract) 8 hours

Height of Barometer 236 Ft. (MSL)

Security Classification

Station Dallesport, Wash.

Lat. 45° 37' Long. 121° 09'

TYPE (1)	TIME (2)	CLASSIFICATION (3)	CEILING (hundreds or feet) (4)	SKY (5)	VISIBILITY (miles) (6)	WEATHER AND/OR OBSTRUCTIONS TO VISION (7)	SEA-LEVEL PRESSURE (mbs.) (8)	TEMP. AND DEW PT. (°F) (9) (10)	WIND DIRECTION (11)	WIND VELOCITY (m.p.h.) (12)	WIND CHARACTER AND REMARKS (13)	ALTIMETER (inches) (14)	REMARKS AND SUPPLEMENTAL CODED DATA (See Instructions) (15)	PAST WEATHER (16)	WET-BULB CHANGES (inches) (17)	PRECIP. (inches) (18)	CLOUDS LOW AMT.-TYPE DIRECTION (19)	CLOUDS LOW HEIGHT (hundreds of ft.) (20)	CLOUDS MIDDLE AMT.-TYPE DIRECTION (21)	CLOUDS MIDDLE HEIGHT (hundreds of ft.) (22)	CLOUDS HIGH AMT.-TYPE DIRECTION (23)	CLOUDS HIGH HEIGHT (hundreds of ft.) (24)	STATION PRESSURE (inches) (25)	DRY-BULB (°F) (26)	WET-BULB (°F) (27)	WATER TEMP. (°F) (28)	1/10 LOW	CODE (30)
RS	0029		W70	⊕6⊙	2	R-F-	156	39/39	←↙	3		996											29.26	39.4	39.0		10	CUM
																							29.24					
↙	0058		W55	⊕6⊙	1½	R-F-			→↘	5		996	R- INTMT										29.25					
R	0138		W55	⊕8⊙	2	R-F-	149	38/38	←↖	3		996	R- INTMT / 810 5009	8	060		10C	5	CB W55	X		X					10	CUM
↙	0157		W50	⊕7⊙	1½	R-F-			↖	5		995	R- INTMT ⊙V⊙										29.23					
RS2	0229		W6	⊕	3/4	F-	146	38/38	↑↗	3		995											29.23	38.3	38.0		10	CUM
↙	0258		W6	⊕⊙	3/4	F-			↑↗	3		995	W80⊕										29.21					
R	0328		W6	⊕⊙	3/4	F-	142	39/39	↑	2		994	W90⊕										29.20	39.4	39.1		10	CUM
↙	0357		W5	⊕	5/8	F-				2		994											29.21					OCN
RS3	0427		W7	⊕	1	R-F-	142	37/38	↑	3		994	60406 5009 37	6	025		10ST	W7	X		X		29.21	38.8	38.4		10	CUM
↙	0445		W6	⊕	1	R-F-			↑↗	4		994											29.22					CUM
R	0522		W6	⊕⊙	1	R-F-	142	39/39	←↙	3		994	W90⊕ R- INTMT										29.21	39.3	39.1		10	CUM
↙	0557		W7	⊕⊙	1	R-F-			↙	3		994	W75⊕										29.23					CUM
R	0626		W7	⊕⊙	1	R-F-	144	39/38	↑↖	4		994	W75⊕ ⊙V⊙ R- INTMT										29.20	38.8	38.3		10	CUM
																							29.23					NW
↙	0700		W7	⊕⊙	1	R-F-			↓↘	3		996	W75⊕ ⊙V⊙ R- INTMT										29.23	38.8	38.4		10	CUM
RS4	0729		W75	⊕40⊙	1	F-	149	39/38	←	2		996	6⊙/ 403 5209	4	015		EST W36→	E6 E40	10RS	W75	X		29.23	38.8	38.4		10	CUM
																							29.25					CUM
↙	0758		W75	⊕40⊙	1½	F-			↓	2		997	ST ALGAL HILLS V3BY V8RL ½ TO 1½															
PS5	0822		E42	⊕⊙	10	9+-	156	39/38	↑↖	1		998	E75⊕ BRKS HIR CLDS V3E RW- CAPE 3F.										29.26	38.7	38.5		9+	
	0852		E40	⊕BRS⊙	10				↑↖	1		998	BRK2 HIR CLDS V3B V3BY V8RL IN										29.25					
RS6	0938		E32	⊕27⊙	20		166	41/40	↗	2		000	BRKS HIR CLDS V3B DESTA 3F FARMERS										29.27					
↙	0958		E30	⊙⊙	20				↓	2		001	W45⊙ 26⊙ DESTA 3F CIG RGD										29.27					
R	1028		E45	⊕⊙	20		166	44/42	↑↖	1		001	W45⊕27⊙/X1104 5709 37 BRKS	4	065		E3E→ E3C→	E7S E22	1+BL	W45	X		29.27	43.2	42.0		9+	
	1058		E45	⊕⊙	20				←↙	1		002	E65⊕ BRKS 27⊙ RW- STMS W										29.26					
R	1127		W47	⊕27⊙	20	RW-	173	47/45	↑↗	1		003	27⊙ RW- MSVG &										29.24	47.0	45.8		10	
↙	1158		W45	⊕⊙	20				↑↗	1		003	LE6⊕ BRKS HIR CLDS V3B										29.24					
RS7	1228		W30	⊕/⊙	20		173	52/47	↑↗	2		003	/45⊙ BRK2										29.24	51.8	48.3		8+	
									↘↓	1		003	/45⊙ THN SPOTS BINOKE										29.24					
↙	1254			⊕/85⊙	30				→	10		004	/28⊙ BRK2 / 403 5705BR	4	010		E3E→ E3C→	E30 E28	1NC 2	E30	X		29.25	54.0	49.0		9+	
R	1328			⊕/90⊙	20		176	54/41	↘	12		005	/60⊙ 25⊙ BRK2										29.23					
↙	1353			⊕/15⊙	20				↘↓	19		005	/60⊙ RW W CIG RGD										29.23	53.4	46.1		10	
R	1428		E35	⊕/⊙	20		180	53/45	→↘	19		005	/60⊙ CIG RGD															
S9	1443		W32	⊙/⊙	20	RW-			→↘	19			/60⊙ CIG RGD															

SUMMARY OF DAY (midnight to midnight)

Time of sunrise ____ Time of sunset ____

24-hr. Max. Temp. 56 °F. 24-hr. Min. Temp. 37 °F.

24-hr. Precip. (rain equivalent) 0.10 in. 24-hr. Snowfall (melted) 0.0 in.

Total hours of fog: Light 6 Moderate 0 Heavy 1

Max. wind (5 min.) ____ (m.p.h., knots) Direction ____ Time ____

Extreme wind (fastest single mile) ____ (m.p.h., knots) Direction ____ Time ____

Peak gust ____ (m.p.h., knots) Direction ____ Time ____

Thickness of ice on water ____ in.

Ground frozen from ____ in. to ____ in.

4-HOURLY OBSERVATIONS

Time of Obs.	0410	1018	1620	2220	Midnight
Precip. (in.)	0.06	0.04	T	T	0.00
Snowfall (in.)	0.0	0.0	0.0	0.0	0.0
Snow Depth (in.)	T	T	T	T	T
Max. Temp.	39.8	43.1	56.0	52.2	43.3
Min. Temp.	37.3	37.4	41.2	40.2	37.8
5,000 ft. Pressure					
Rel. Hum. %	96	94	79	92	
Soil Temp.					
State of Ground	4	4	4	4	

Time of Obs.	0410	1018	1620	2220
State of Sea and Dir.				
Swell Ht. and Dir.				
Swell Period				
Surf (Ht.L.H.F.H.)				
Barometer Reading	29.700	29.780	29.575	29.940
Attached Thermometer	74.0	62.5	73.5	76.5
Observed Reading	29.811	29.886	29.576	30.051
Total Correction	-.091	-.075	-.091	-.089

+.020 +.010 +.010 +.010

Remarks, Notes, and Miscellaneous Phenomena

Types of air masses and frontal passages determined from synoptic maps, severe storms, miscellaneous hydrometeors, floods

E- Cont. E0820P

K- Cont. E0020

R- B0024 E0225 B0420 E0723

RW- B0220P E0925P B1128P E1328P

IW- B1443P E1845

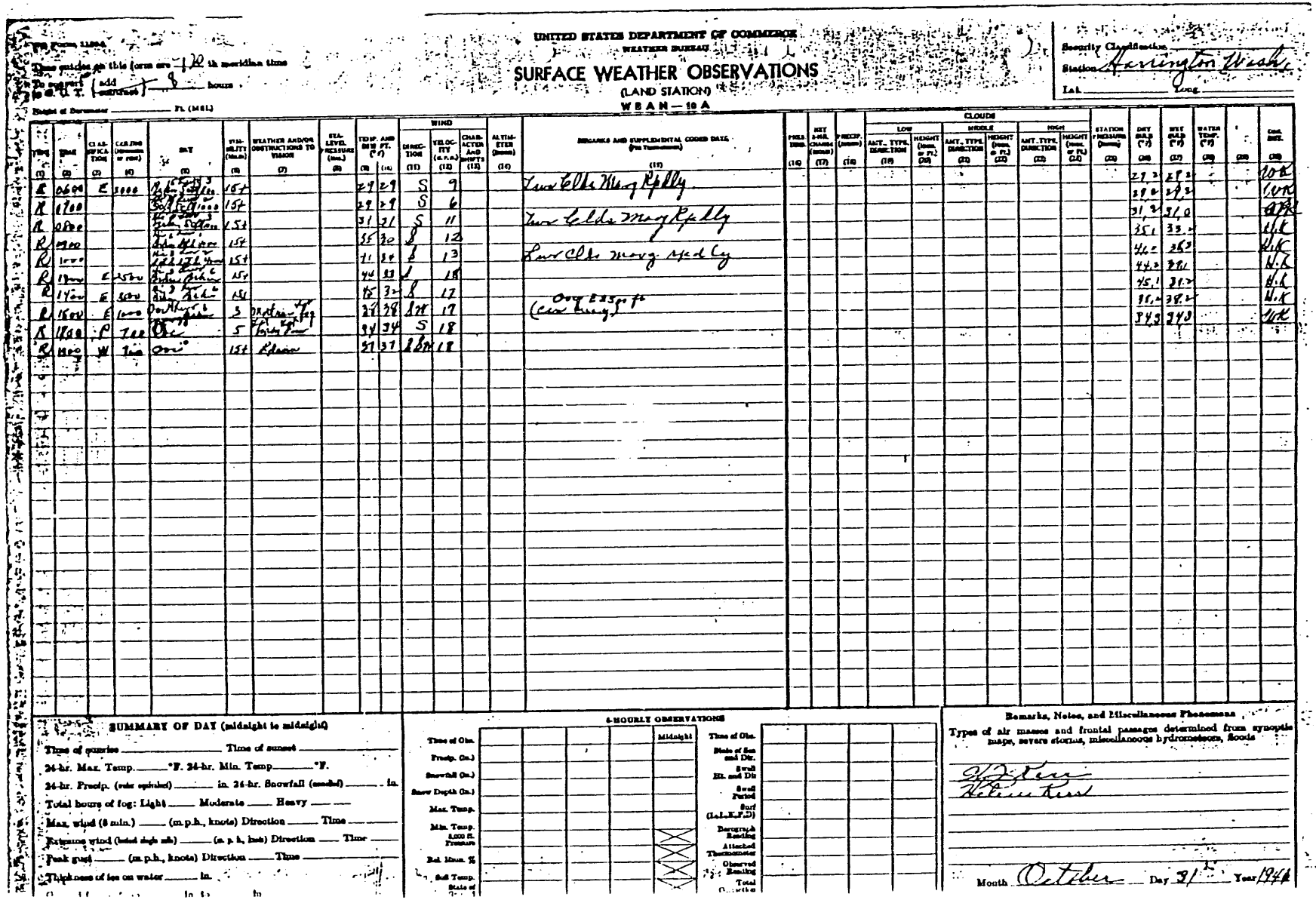
Ecw Ptkls s&low DRFTS GF K BIF

E+ B2333 E Cntd

Month NOV Day 27 Year 46

2.4

FIGURE 2.1. Legible Station Record (Dallesport, Washington, November 27, 1946)



UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU

SURFACE WEATHER OBSERVATIONS
(LAND STATION)
WBAN — 10A

Security Classification
Station Harrington Wash.
Lat. Long.

Time entries on this form are 120 th meridian time
To convert to G.C.T. (add / subtract) 8 hours

Height of Barometer Ft. (MSL)

Type (1)	Time (2)	Classification (3)	Ceiling (hundreds of feet) (4)	Sky (5)	Visibility (miles) (6)	Weather and/or Obstructions to Vision (7)	Sea-Level Pressure (mbs.) (8)	Temp. and Dew Pt. °F (9)	(10)	Wind Direction (11)	Wind Velocity (m.p.h.) (12)	Character and Amount (13)	Altimeter (inches) (14)	Remarks and Supplemental Coded Data (for Transmission) (15)	Field Rec'd (16)	Net 3-hr. Change (mbs.) (17)	Precip. (inches) (18)	Clouds: Low Amt., Type, Direction (19)	Low Height (hundreds of ft.) (20)	Middle Amt., Type, Direction (21)	Middle Height (hundreds of ft.) (22)	High Amt., Type, Direction (23)	High Height (hundreds of ft.) (24)	Station Pressure (inches) (25)	Dry Bulb (°F) (26)	Wet Bulb (°F) (27)	Water Temp. (°F) (28)	(29)	(30)	Obs. Init. (31)
R	0600	E	5000		15+			29	29	S	9			Two Clds Mag Pdly											29.3	29.3				10K
R	1200				15+			29	29	S	6														29.8	29.3				10K
R	1800				15+			31	31	S	11			Two Clds Mag Pdly											31.2	31.0				9K
R	0000				15+			35	30	S	12														35.1	33.2				11K
R	0600				15+			41	38	S	13			Two Clds Mag Pdly											41.2	36.3				11K
R	1200				15+			44	38	S	18														44.3	39.1				11K
R	1800	E	4500		15+			45	37	S	17														45.1	39.2				11K
R	0000	E	5000		15+			41	38	SW	17			Ceil Unlimited											41.2	38.2				11K
R	0600	E	1000		3	Fog		37	34	S	18														37.3	34.3				11K
R	1200	P	700		5	Fog		37	37	SW	18																			
R	1800	W	700		15+	Clear		57	37	SW	18																			

SUMMARY OF DAY (midnight to midnight)

Time of sunrise _____ Time of sunset _____

24-hr. Max. Temp. _____ °F. 24-hr. Min. Temp. _____ °F.

24-hr. Precip. (rain equivalent) _____ in. 24-hr. Snowfall (melted) _____ in.

Total hours of fog: Light _____ Moderate _____ Heavy _____

Max. wind (5 min.) _____ (m.p.h., knots) Direction _____ Time _____

Extreme wind (fastest single mile) _____ (m. p. h, knots) Direction _____ Time _____

Peak gust _____ (m.p.h., knots) Direction _____ Time _____

Thickness of ice on water _____ in.

6-HOURLY OBSERVATIONS

Time of Obs.					Midnight	Time of Obs.				
Precip. (in.)						State of Sea and Dir.				
Snowfall (in.)						Swell Ht. and Dir.				
Snow Depth (in.)						Swell Period				
Max. Temp.						Surf (Ast.E.F.D)				
Min. Temp.						Barograph Reading				
1000 B. Pressure						Attached Thermometer				
Rel. Hum. %						Observed Reading				
Soil Temp.						Total				
State of										

Remarks, Notes, and Miscellaneous Phenomena

Types of air masses and frontal passages determined from synoptic maps, severe storms, miscellaneous hydrometeors, floods

Month October Day 31 Year 1946

2.5

FIGURE 2.2. Station Record with Poor Legibility (Harrington, Washington, October 31, 1946)

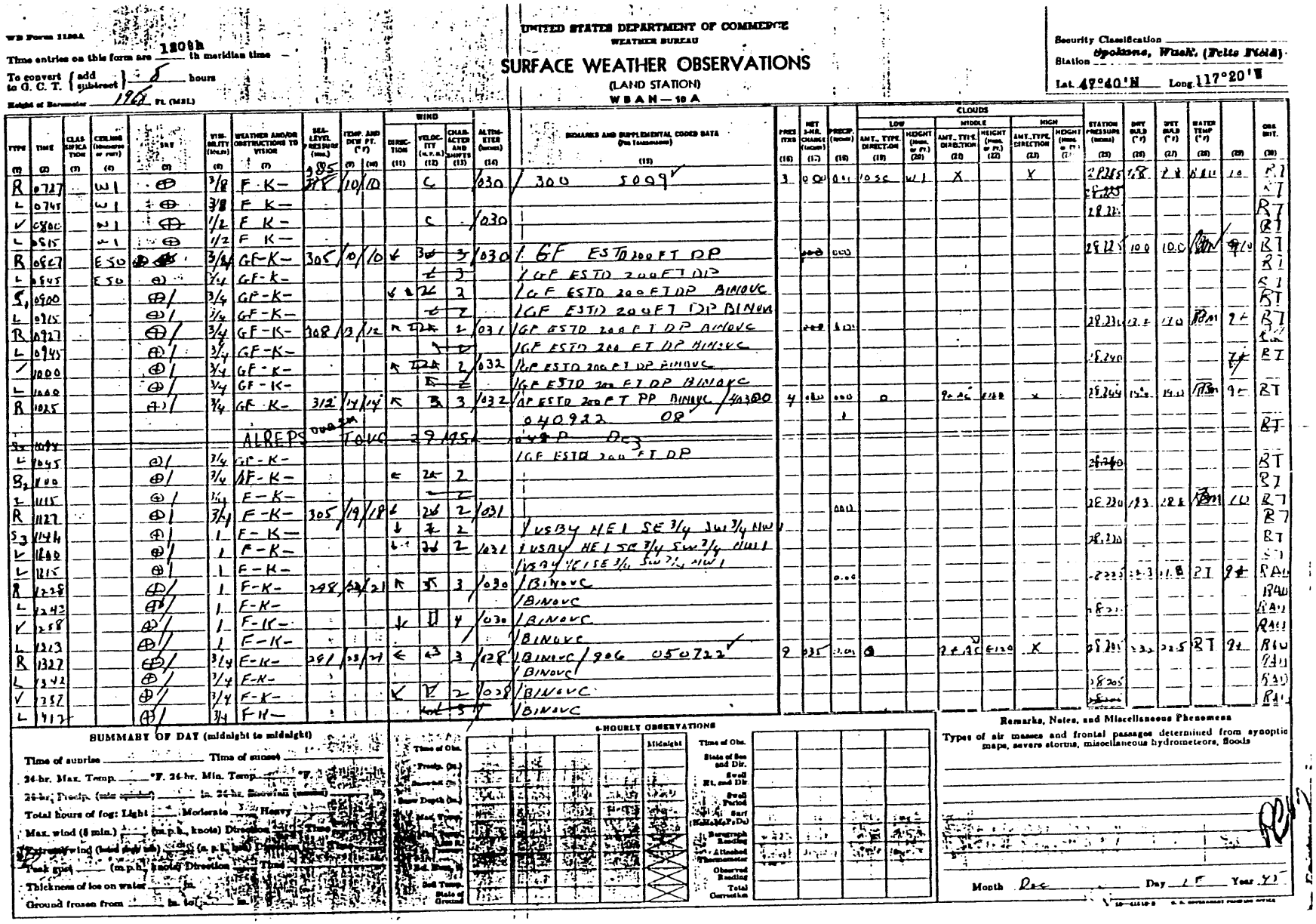


FIGURE 2.3. Station Record with Crossed Out and Misplaced Numbers (Spokane, Washington, Felts Field, December 15 1945)

numbers that make it difficult to determine wind data. Data were omitted if they could not be read with high confidence. Only a few points were illegible.

Data from microfiche and paper copies were entered manually. As data were being entered into the database, range checks were made to prevent gross errors. Wind direction was required to be in the range 0 to 16 when direction was recorded using the 16 points of the compass and 0 to 36 when direction was recorded in tens of degrees. All wind speeds were required to be in the range 0 to 50 (miles per hour [mph] or knots [kn] depending upon the units used in the original records).

Ceiling height, reported in levels of 100-foot increments, was limited to heights between 0 and 30,000 feet. Sky cover was recorded in tenths, ranges were limited to between 0 and 9 (with overcast conditions reported as 9). Precipitation types were limited to no greater than 5; codes for precipitation types ranged between 1 and 39. Additional quality checks were done after data entry to check for missing values and for data out of order. Wind speeds not in the range of 0 to 50 were flagged, as were changes of more than 10 units between consecutive hours. A check was also done to ensure that if a *calm* code was entered for wind speed, it was also entered for direction and vice versa.

Until hour 22, September 25, 1945, data were recorded using Pacific War Time, then Pacific Standard Time was used. When War Time was used, one hour was subtracted so the database uniformly used Standard Time.

2.5 UNCERTAINTIES AND REPRESENTATIVENESS OF WIND DATA

Several factors lead to errors and uncertainties in the recorded wind data (both speed and direction). For example, anemometers may have systematic or random errors. Instruments can also record wind speeds distorted by nearby structures and/or the structure on which they are mounted. The second case is especially true for instruments mounted on building roofs. Spatial and temporal variations in wind fields also lead to limitations on the accuracy of wind data. Local topography tends to channel or block air flow or to generate local affects such as upslope and downslope winds. The station wind speed and

direction may not be representative of the region surrounding the station. Additionally, 1-minute averages of wind speed and direction differ from the true average of the observation hour.

The fact that wind speeds are reported to the nearest mile per hour and that wind directions are reported to the nearest point of the compass (22.5 degrees) is, in part, a statement that uncertainties in the data prevent smaller reporting increments.

Because wind observations are within a few meters of the ground, they may differ from the winds at the height of the plume center. Ideally, transport modeling is done with the aid of winds measured at a number of heights up to the plume top. Unfortunately, no upper-level wind data are available in the RATCHET domain region for the period of interest.

2.6 STATION TOPOGRAPHY

The local topography of the HEDR stations has been assessed through an examination of U.S. Geographical Survey (USGS) 1:250,000 topographic maps and is included in the station descriptions in Section 3.0. The stations can be divided into three topographic categories:

- those in the large, flat region of the Columbia Basin, with no local topography sufficient to affect the wind flow
- those in mountainous regions, generally in the bottoms of basins or river valleys that are expected to produce strong local effects
- stations in various intermediate situations.

Several of the HEDR stations are within the large, flat region of the Columbia Basin. This region slopes gradually upward from 150 to 210 meters (500 to 700 feet) on the Hanford reservation to 650 meters (2100 feet) near Spokane, approximately 190 km (120 miles) to the northeast. With the exception of the Saddle Mountains, which slice into the western part of the basin just north of Hanford, local variations in height are less than 100 meters or so (only a few hundred feet) and have little effect on winds measured at the stations. Results from HEDR Phase I studies (Ramsdell and Burk 1991) indicate that maximum radionuclide deposition occurred within this basin. Therefore,

the most significant doses calculated for HEDR will be based on wind fields over comparatively flat terrain and subject to relatively little small-scale spatial variability.

Most of the other stations are in the Cascade Mountains, Blue Mountains, or the mountains of Idaho. Most of these stations are located at airports that are in locally flat regions in river valleys or basins. In several cases, surrounding mountains rise a thousand meters or more (thousands of feet) above the station. Winds associated with large-scale weather systems (synoptic winds) are channeled or blocked by these local topographic features. Under conditions with weak synoptic winds, local temperature differences between the peaks and valleys generate upslope or downslope winds that are also channeled by local terrain. The winds observed at a station depend on the exact location of the station relative to local topography. Furthermore, winds may vary substantially between neighboring valleys and basins, depending on their geometry and orientation.

The Stampede Pass station, located between two peaks at the summit of a mountain pass, is a unique case in which winds are strongly influenced by surrounding terrain. Winds at stations within mountainous regions are not very representative of the surrounding area, and winds in these regions are less well resolved than in flatter terrain. For these reasons, transport within mountainous regions of the HEDR domain is subject to much more uncertainty than transport within the Columbia Basin. Fortunately, these regions are less frequently involved in HEDR radionuclide transport calculation than the Columbia Basin.

Most other stations had topography between these two extremes. For example, Walla Walla is surrounded by rolling hills with high mountains to the southeast. Winds at stations located in similar terrain experience moderate amounts of local topographic influence and represent winds in some parts of the surrounding region.

2.7 WIND ROSES

Wind roses are a way to examine the importance of local topography on winds at the HEDR meteorological stations. A wind rose is a graphical

representation of the distribution of wind directions at a particular station. Preliminary wind roses for December 1944 through December 1947 are shown in Section 3.0 for most of the HEDR Meteorological Database stations. Roses have not yet been computed for other stations.

Figure 2.4 shows examples of wind roses for the Hanford station. The bottom wind rose shows the distribution of wind directions for all data. The upper-left wind rose shows the distribution of directions during low wind speed and calm conditions, and the upper-right wind rose shows the distribution of directions during high wind speed conditions.

The length of each wind rose bar and the associated number indicate the percentage of the time that wind came from that particular direction. These roses were computed based on 3-hour interval wind data (when available). Roses labeled *all winds* show the percentages based on all hours, including calm. The roses marked *high winds* are similar to the others, except the wind speed is greater than 1.8 meters per second (m/s) (4 mph). Roses labeled *low winds* include only those hours with wind speed less than 1.8 m/s (4 mph), including calm.

The heading for the low and high speed wind roses show the percentages for low and high speed conditions. For example, *low winds 15.1%* indicates that wind speeds were below 1.8 m/s (4 mph) 15.1 percent of the time. The percentages of time that winds are calm and variable (having no clearly defined direction) are listed at the bottom of the wind rose. For example, of the 15.1 percent of the hours that wind speed is less than 1.8 m/s (1300 hours per year), the wind is calm (below instrument threshold) 5.5 percent of the time (approximately 73 hours) and the wind direction is variable another 6.5 percent of the time (approximately 86 hours).

Wind roses for low and high wind speeds provide information on locally induced circulation patterns. For example, the comparison of the *low winds* rose for Hanford with the *high winds* rose shows that easterly winds are more likely to occur during low wind speeds than during high wind speeds. The wind

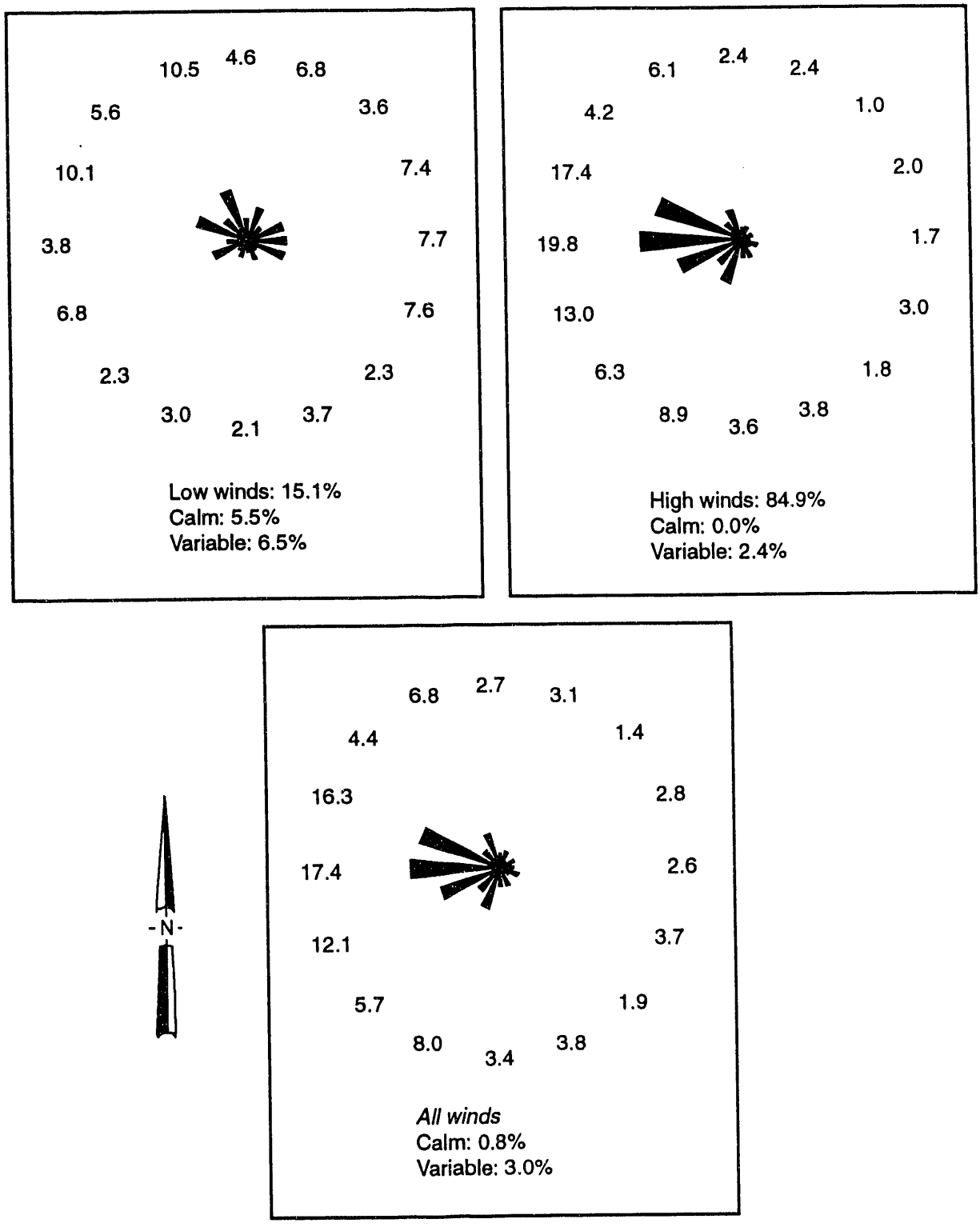


FIGURE 2.4. Example of Wind Roses for the Hanford Station Computed Using 3-Hour Intervals for December 1944 Through December 1947

roses for Pasco and Ellensburg show even more dramatic differences between low and high speeds. (See Section 3.0 for illustrations of these wind roses.)

Wind roses also may be used to identify potential problems in the data. For example, the pattern of alternating high and low percentages seen for wind direction between southwest and northeast in the *low winds* rose for Hanford indicates the possibility of observer bias in collecting and recording the data.

Figure 2.5 depicts a unique, extra wind rose, based on hourly data from the Hanford Meteorological Station from 1955 through 1980 for all wind speeds, as tabulated by Stone, et al. (1983, Table 17, p. V-4). This fourth Hanford wind rose for 1955 through 1980 represents hourly data and many more years of data than the roses for 1944 through 1947 and is, therefore, expected to be closer to the true climatological mean. Comparison of the *All winds* wind rose (Figure 2.4) to the wind rose in Figure 2.5 shows the two patterns are quite

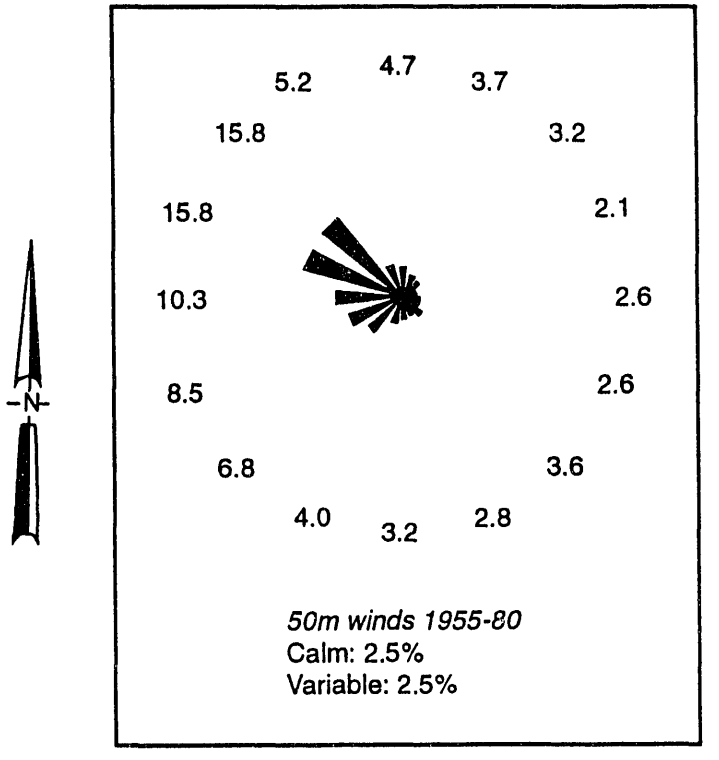


FIGURE 2.5. Example of a 50m Wind Rose: Hanford Station

similar. However, the pattern for 1944 through 1947 is shifted about one compass point counterclockwise. Thus, the greatest wind frequencies were westerly and west-northwesterly, rather than west-northwesterly and northwesterly, as seen in 1955 through 1980. Therefore, during the period of maximum release, near-normal wind directions were present at the Hanford site.

2.8 HEDR DATA QUALITY OBJECTIVES

This section evaluates the quality of the database in terms of the Data Quality Objectives for HEDR Task 0405: Atmospheric Model Database. Specific data quality objectives required for this task are shown in bold print.

> **Accuracy–the objective is that the database contain the same information as recorded by the stations. Data entry accuracy criteria will be established by evaluating model sensitivity to data entry errors. A representative subset of the data will be examined to determine data entry accuracy. Data entry errors identified during the examination will be corrected; more extensive data checks will be made if data entry accuracy falls below an acceptable level (Shipler 1992).**

As of the end of August 1992, all data for the years 1945 and 1946 and most data for 1947 were entered and checked for quality. As a further quality check to ensure against any large errors, the spatial and temporal meteorological patterns of the data were plotted and examined. Based on these checks, the HEDR meteorology database meets the QA objective (Shipler 1992) which states the database needs to be an accurate reproduction of the historical record.

An initial data entry check compared more than 6720 entries in the database against original records. Data entry errors in wind speed, direction, or both were detected for 17 hours; the error rate was 0.25 percent. When data entry errors in either speed or direction were considered separately, the error rates were smaller. Many of the detected data entry errors were as small as one of the units in which the data were recorded. The data entry errors in wind speed were most frequently 1 mph/kn and never more than 2 mph/kn. For 5 out of 12 detected errors, the wind direction was off by 1 compass point, and 4 were off by 2 points. Because these errors have a relatively small effect on plume transport, only three errors (0.04 percent)

were considered significant. In addition, during a 3-month period, wind data for one station were offset by 1 hour. This was caused by an error in applying the conversion from War Time to Standard Time. This error was specific to this 3-month time period and did not affect other periods. All errors detected in the data check have been corrected.

Precision–The objective is that uncertainties in the data be estimated from historical records and analysis of instrumentation and recording practices, insofar as possible (Shipler 1992).

The meteorological observation techniques used by the U.S. Weather Service Stations and by the Hanford Meteorological Station have been addressed in previous sections which present qualitative statements of the uncertainties in the data. An uncertainty also is associated with the fact that wind data from stations in mountainous regions do not fully represent the wind in the vicinity.

Completeness–the objective is to identify and obtain sufficient meteorological data from national meteorological data archives to reconstruct dispersion of radionuclides released from Hanford. Completeness will be measured by professional judgment (Shipler 1992).

Hanford meteorological data records and data indices of the National Climatic Data Center have been searched to identify meteorological data available for use in HEDR atmospheric dispersion calculations. The available data have been identified and obtained. A subset of these data were used for dispersion calculations in Phase I of the HEDR Project. Additional data have been entered for use in future calculations. It is our judgment that these data are sufficient to reconstruct dispersion of radionuclides from Hanford.

Representativeness–The objective is that the database represent the known available Hanford and regional meteorological information (Shipler 1992).

The meteorological database being prepared for use in the HEDR Project contains sufficient data to reproduce the general wind patterns for the region of interest. It contains all of the Hanford data for the period of interest and most of the data available from the National Climatic Data Center. In addition, meteorological data may be available from other sources. However,

prior to using data from another source, it is necessary to establish the data quality. It is unlikely that additional meteorological data would cause any large changes in the results of the atmospheric dispersion calculations.

3.0 DESCRIPTIONS OF METEOROLOGICAL STATIONS

This section contains information sheets for each of the stations in the HEDR meteorological database. Except as noted, this information was obtained from Changery (1978).

3.1 EXPLANATION OF DATA SHEETS

The information contained on each of the data sheets is as follows:

Station: identifies the station name and abbreviation.

Type: describes the type of station (for example, Supplemental Aviation Weather Reporting Station or Air Force Base).

Location: details the latitude, longitude, and elevation above mean sea level of this station.

Measurement height: indicates the height of the wind instruments above the ground (meters and feet).

Instrument mounted: describes the type of structure on which the instruments were mounted (such as, on the roof of a building).

HEDR environmental grid coordinates: gives the X and Y coordinates of this point on the RATCHET model wind grid as it is being used for the HEDR project.

Data source: describes whether data was obtained from microfiche, photocopies, or magnetic tape. NWDI refers to the National Wind Data Index (Changery 1978). An entry such as *NWDI lists tape for 1948* indicates data are available from the National Climate Data Center but have not been obtained for HEDR use as of this date.

Data availability: explains how frequently and on which dates the data were taken at this station. In a few cases, magnetic tape were obtained from the National Climate Data Center for periods not listed in the NWDI.

Missing data: identifies historical periods for which data are not available. In most cases, this indicates that observations were not taken or, for other reasons, did not enter the archive. In a few cases, the missing data notation indicates that records in the archives were not legible. In addition to those noted, stations which recorded hourly data have an occasional hour of missing data. This total is no more than five hours per year per station. Stations with 6-hourly synoptic observations have more missing hours, such as Colville, with a total of 34 missing hours in 1946. This information was obtained from the data.

Local topography: provides a brief description of the topography near the station. The emphasis is on features that may affect air flow at the station. These descriptions are based on subjective evaluations of the station location using USGS 1:250,000 topographical maps.

Station moved: provides dates that stations were moved to new locations, followed by the new location or measurement height. (Most stations were moved to a new location, or instrument mounting heights were changed at least once during the period of interest.)

Wind roses: have been computed for several stations. This section shows and discusses wind roses for these stations (see Section 2.7).

3.2 DESCRIPTIONS OF STATIONS IN THE HEDR METEOROLOGICAL DATABASE

Each of the stations in the HEDR meteorology database is described in the tables that follow. Stations within each state are listed alphabetically.

TABLE 3.1. Station: Colville, Washington (COL)

Type: Not determined.

Location: 48:32:00N 117:53:00W 573 meters (1879 feet) elevation.

Measurement height: 11 meters (36 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 14.30, Y = 24.25.

Data source: Paper copy for 1944 through 1947.
NWDI lists paper copy for 1948 and 1949.

Data availability: 4 observations per day 1944 through 1947.

Missing data: A total of 34 hours was missing in 1946. These were mostly scattered single hours. No data 4/7-8/47 and 5/29/47.

Local topography: This station is located in a narrow basin formed by the Colville River and several small creeks and rivers. It is surrounded by peaks that rise about 600 meters (2,000 feet) above the basin floor.

Station was moved: 1/61 Measurement height: 9.1 meters (30 feet).

Station was moved: 8/66 Measurement height: 9.5 meters (31 feet).

Station was moved: 7/74 Measurement height: 10.1 meters (33 feet).

Wind Roses: Not yet computed for this station.

TABLE 3.2. Station: Dallesport, Washington (DLS)

Type: Flight Service Station

Location: 45:37:00N 121:09:00W 72 meters (236 feet) elevation.

Measurement height: 12.5 meters (41 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 1.34, Y = 7.46.

Data source: Paper copy for 1944 through 6/48.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour 12/44 through 12/47.

Missing data: No data 5/28 and 5/29/45; no data 7/9/45.
Bad copies 5/20 and 21/46.
No data May and June, 1946.

Local topography: This station is located near the center of the Columbia River Gorge where the river has carved a narrow east-west passage through the Cascade Mountains. This station is on a small flat region located at the Dalles Airport, Dallesport, Washington, across the river from the town of The Dalles, Oregon. Between 600 and 900 meters (1968 and 2952 feet) below the surrounding terrain and no more than 8 to 16 kilometers (5 to 10 miles) wide, the gorge strongly channels winds. Strong winds are frequently produced in the gorge by synoptic pressure gradients and by thermal pressure gradients between the east and west sides of the Cascades.

Station was moved: 3/61 Measurement height: 6.1 meters (20 feet).

Wind roses: High-speed westerly or northwesterly winds up the Columbia gorge are most common here. Low speed winds are remarkably uniform in their distribution. Figure 3.1 illustrates the wind roses for this station.

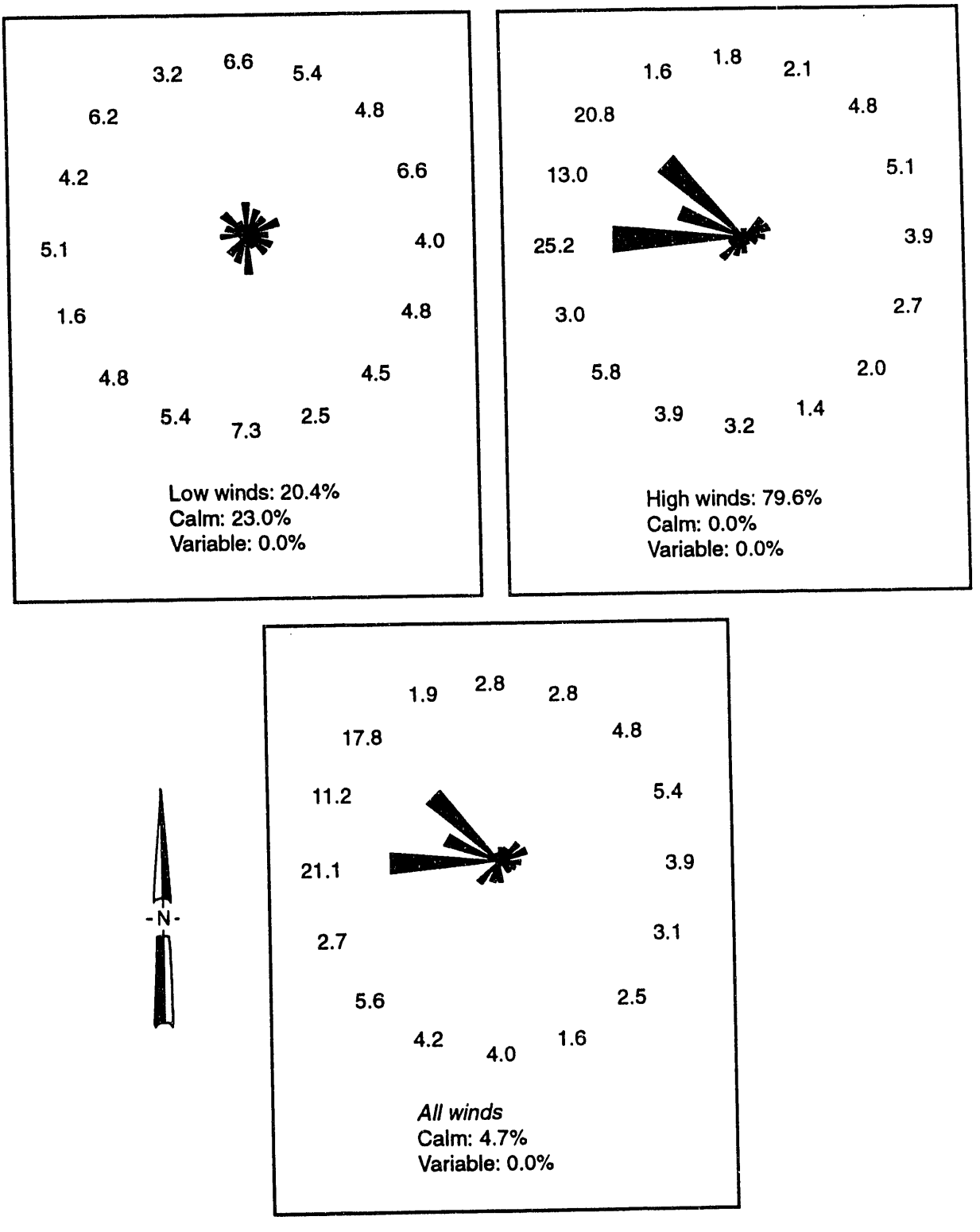


FIGURE 3.1. Wind Roses for The Dallesport Station

TABLE 3.3. Station: Ellensburg, Washington (ELN)

Type: Supplemental Aviation Weather Reporting Station

Location: 47:02:00N 120:31:00W 527 meters (1729 feet) elevation.

Measurement height: 18 meters (59 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 4.07, Y = 15.61.

Data source: Paper copy for 1944 through 1947.
NWDI lists tape for 1948 and 1949. The tape obtained had only 6/48 through 12/49.

Data availability: Observations taken every hour during 1944 to 1947.

Missing data: None.

Local topography: This station is located in the Kittitas Valley formed by the Yakima River and surrounded by Manastash and Umtanum Ridges to the southwest and by the Wenatchee Mountains to the northeast. The Kittitas Valley is a relatively flat ellipse about 32 kilometers long and 16 kilometers wide (20 miles long and 10 miles wide) with its major axis oriented from northwest to southeast. Surrounding peaks extend approximately 750 meters (2500 feet) above the valley floor.

Station was moved: 4/48. Measurement height: 18.3 meters (60 feet).

Station was moved: 7/52. Measurement height: 9.8 meters (32 feet).

Station was moved: 11/59. Measurement height: 5.2 meters (17 feet).

Instrument mounted: on a beacon tower.

Wind roses: During nearly half (43 percent) of all hours, strong winds blow down the Yakima River from the west-northwest or the northwest. When winds are low, they are more often north-northeasterly. Figure 3.2 illustrates the wind roses for this station.

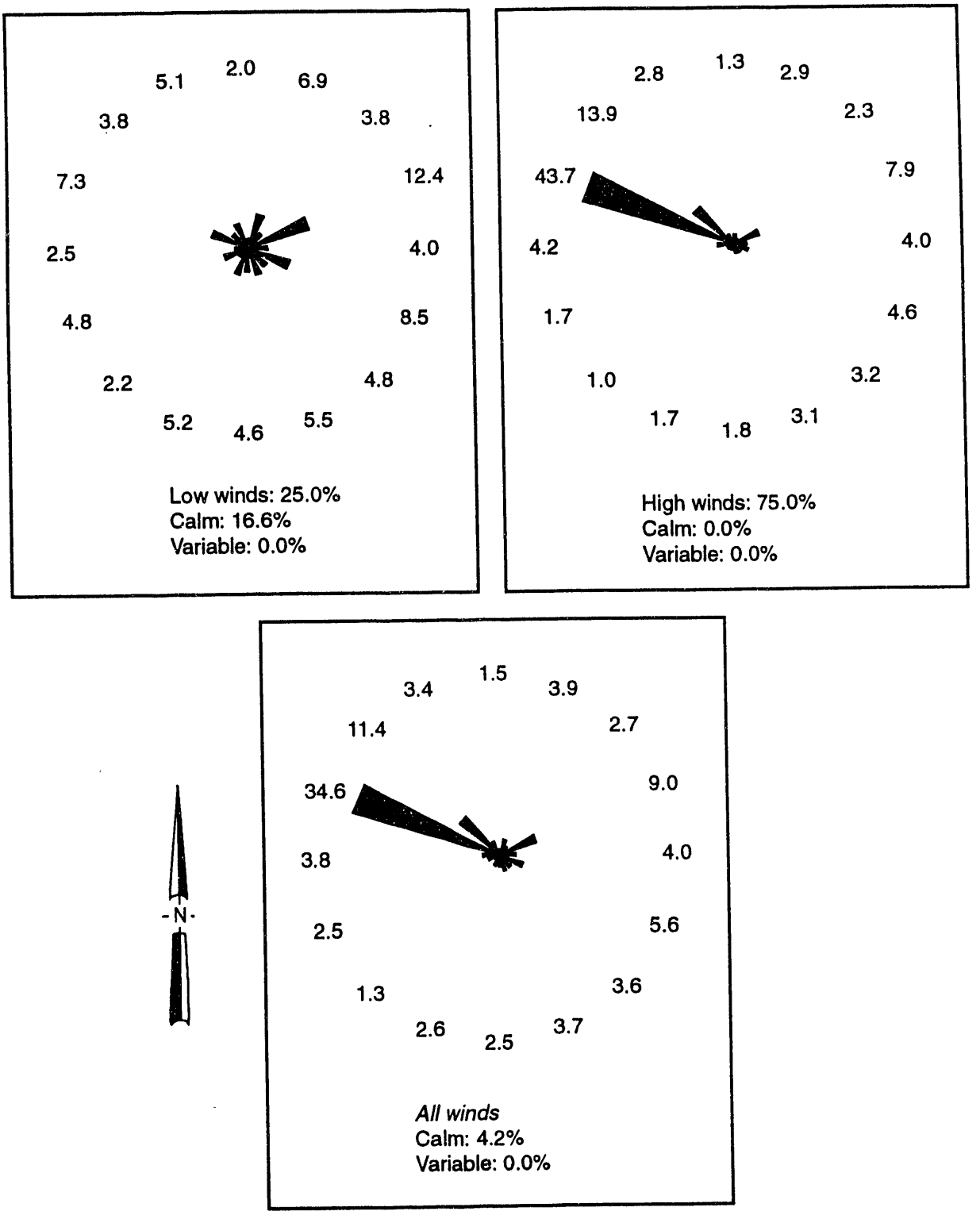


FIGURE 3.2. Wind Roses for the Ellensburg Station

TABLE 3.4. Station: Ephrata, Washington (EPH)

Type: Civil Aeronautics Administration

Location: 47:18:00N 119:32:00W 388 meters (1273 feet) elevation.

Measurement height: 8.2 meters (27 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 7.94, Y = 17.15.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour during 1944 to 1947.

Missing data: None.

Local topography: This station is located in the Columbia Basin. The terrain to the south and east of the station is extremely flat; in these directions no terrain within 40 kilometers (25 miles) is more than 100 meters (300 feet) different than the station elevation. Immediately to the west and north of the station, hills rise 300 meters (1000 feet) and more above the station elevation. Just north of Ephrata is the Grand Coulee, the channel followed by the Columbia River during an ice age and now holding Soap Lake, Blue Lake, Lenore Lake, Banks Lake, and other smaller lakes.

Station was moved: 3/47 Measurement height: 11.6 meters (30 feet).

Station was moved: 5/56 Measurement height: 10.1 meters (33 feet).

Station was moved: 5/59 Measurement height: 6.1 meters (20 feet).

Wind roses: The wind has an easterly component in only 20.7 percent of the data hours. In the remaining hours, the wind is almost evenly distributed between all angles from northerly through westerly to southerly. When winds are weak, a predominance of north-northwesterly and northerly winds indicates drainage from the hills to the north or down the Grand Coulee. Figure 3.3 illustrates the wind roses for this station.

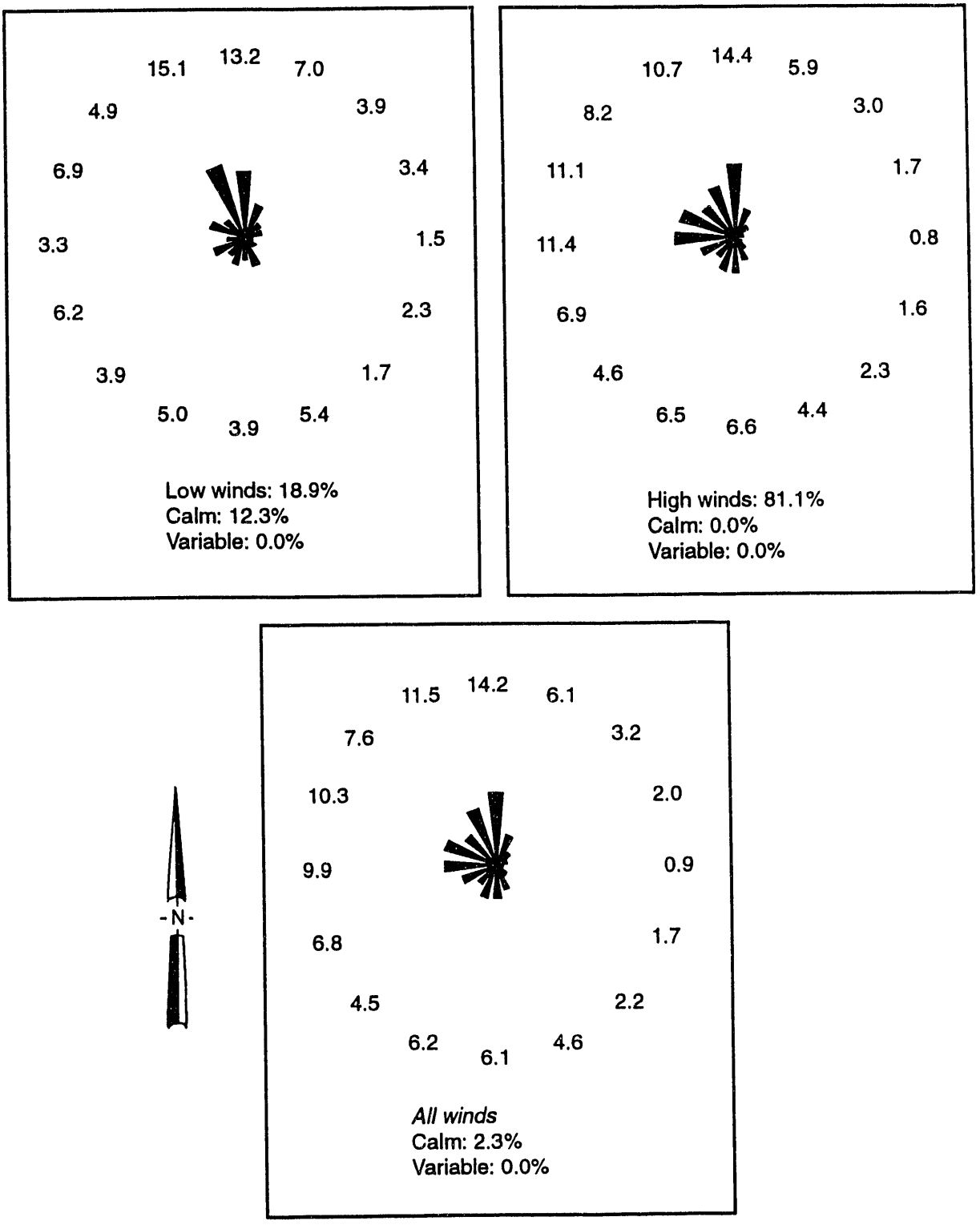


FIGURE 3.3. Wind Roses for the Ephrata Station

TABLE 3.5. Station: Fairchild AFB, Washington (SKA)

Type: Air Force Base

Location: 47:38:00N 117:39:00W 743 meters (2437 feet) elevation.

Measurement height: 10 meters (33 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 15.27, Y = 19.06.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour in the period 1944 to 1947.

Missing data: none.

Local topography: This station is located about 16 kilometers (10 miles) west of the center of Spokane. To the west and southwest, no significant terrain features are present for 120 kilometers (75 miles). To the northeast, the land gently slopes down about 8 kilometers (5 miles) to the Spokane River and then gradually climbs to hills that rise to approximately 300 meters (1000 feet) above the station.

Station was moved: 3/53 Measurement height: 25.9 meters (85 feet).

Station was moved: 4/55 Measurement height: 29.3 meters (96 feet).

Station was moved: 8/57 Measurement height: 33.5 meters (110 feet).

Station was moved: 4/58 Measurement height: 4.0 meters (13 feet).

Instrument mounted: 4/58 on a tower on the ground.

Station was moved: 3/59 Measurement height: 4.6 meters (15 feet).

Station was moved: 4/63 Measurement height: 3.4 meters (11 feet).

Station was moved: 11/66 Measurement height: 5.5 meters (18 feet).

Wind roses: The predominant wind directions are north-northeasterly and south-southwesterly with each direction accounting for between one-quarter and one-fifth of all hours of data. Weak winds are dominated by the north-northeasterly direction; strong winds are about equally divided between north-northeasterly and south-southwesterly with a slight prevalence of south-southwesterly winds. Figure 3.4 illustrates the wind roses for this station.

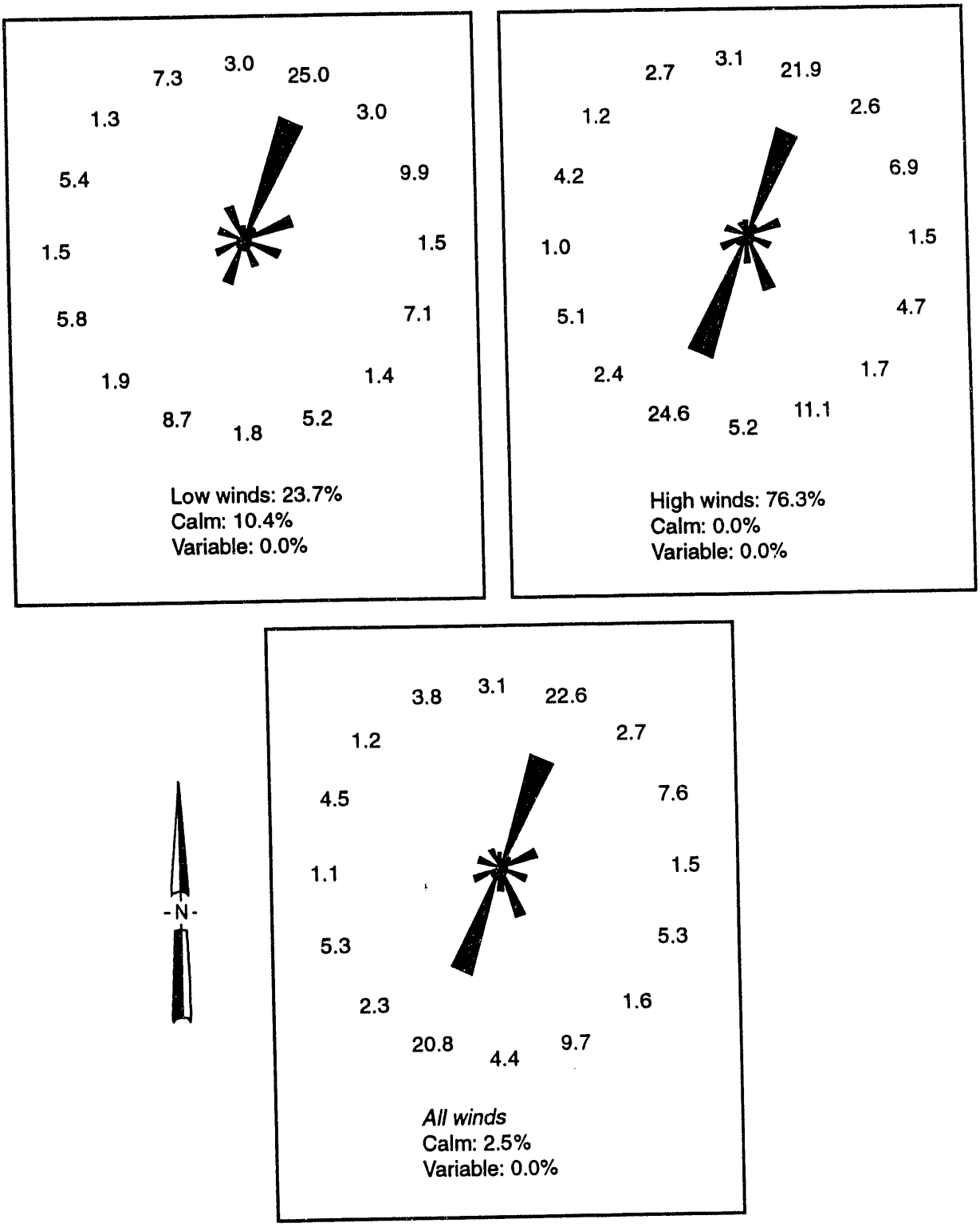


FIGURE 3.4. Wind Roses for the Fairchild AFB Station

TABLE 3.6. Station: Hanford Meteorological Station (HMS)

Type: Atomic Energy Commission/Department of Energy

Location: 46:33:47N 119:35:54W 223 meters (731 feet) elevation.

Measurement height: 1.2 meters (4 feet).

Instrument mounted: on a tower on the ground.

HEDR environmental grid coordinates: X = 7.64, Y = 12.90.

Data source: Digital file from Hanford Meteorology Program.

Data availability: Observations taken every hour from 12/7/44.

Missing data: 12/24 and 25/44, 24 hours missing (Christmas).
7/4/45, 7 hours missing (July 4th).
8/15 and 16/45, 38 hours missing (V-J celebration).
9/2 and 3/45, 24 hours missing (Labor Day).
11/21 and 22/45, 24 hours missing (Thanksgiving).
12/24 and 25/45, 24 hours missing (Christmas).
1/1/46, 23 hours missing (New Year's Day).
5/29 and 30/46, 24 hours missing (Memorial Day).
7/3 and 4/46, 24 hours missing (July 4th).
9/1 and 2/46, 24 hours missing (Labor Day).
No further holiday breaks.
No data missing in 1947.

Local topography: This station is located on the Hanford Reservation near the release site. It is near the western edge of a basin formed by the Columbia River and surrounded by Yakima Ridge and Rattlesnake Hills to the southwest, the Saddle Mountains to the north, Juniper Hills to the east, and Horse Heaven Hills to the south.

E. D. Skyllingstad and M. N. Schwartz (1989) indicate the topography of this basin is shown to channel winds on the Hanford Reservation. The effects of topography are most strongly seen as channeling of wind flow along the Columbia River by local mountains and as flow induced by thermal gradients between eastern and western Washington.

Station was moved: 1/47 Measurement height: 2.1 meters (7 feet).

Wind Roses: Westerly and nearly westerly winds dominate the wind roses for all winds and for high winds. Low winds most frequently come from directions between the west-southwest and north-northwest and rarely come from directions between southeast and southwest. Figure 3.5 illustrates the wind roses for this station.

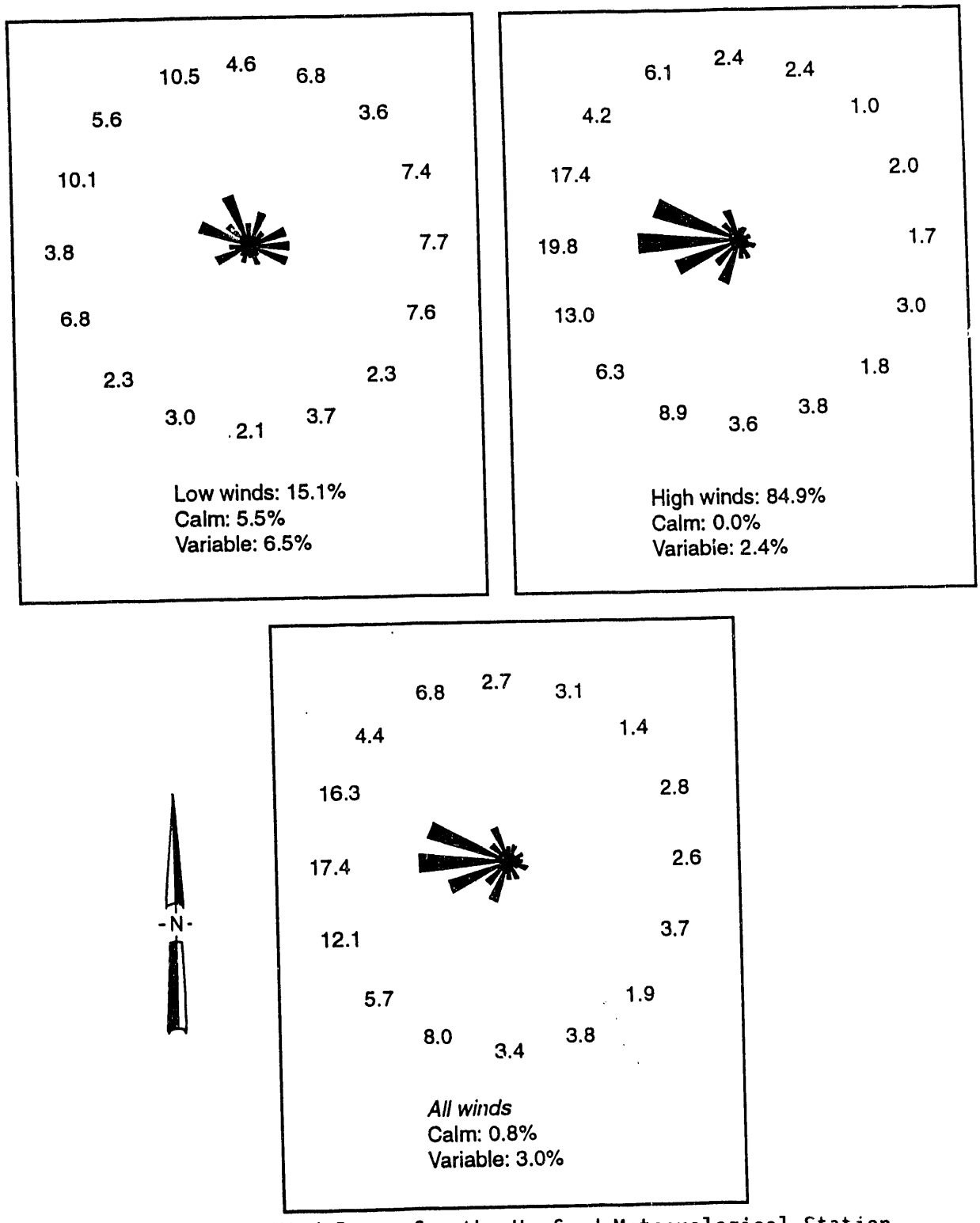


FIGURE 3.5. Wind Roses for the Hanford Meteorological Station

TABLE 3.7. Station: Harrington, Washington (HAR)

Type: Aviation Reports

Location: 47:29:00N 118:15:00W 664 meters (2178 feet) elevation.

Measurement height: 9.8 meters (32 feet).

Instrument mounted: on a tower on the ground.

HEDR environmental grid coordinates: X = 12.95, Y = 18.20.

Data source: Paper copy for 1944 through 6/30/48.
Microfiche for 7/48 through 1949.

Data availability: 4 to 10 observations per day during 1944 to 1947.
5 to 11 observations per day. Wind data were entered only 1/1/48 through 6/30/48.
5 to 11 observations per day 7/1/48 to 12/31/49.

Missing data: No data 7/16/45.

Local topography: This station is located in a very flat region of the Columbia Basin. For 24 kilometers (15 miles) in all directions, no terrain feature is more than 100 meters (330 feet) above or below the station.

Wind roses: The predominant wind directions are north-northeasterly and south-southwesterly. Weak winds are dominated by calm conditions. Only 3 percent of the hours have winds that are not calm but have speeds less than 1.8 meters per second (4 miles per hour). The wind blows strongly during 69.9 percent of the hours, most often from the north-northeast and south-southwest with a slight prevalence of north-northeast. Figure 3.6 illustrates the wind roses for this station.

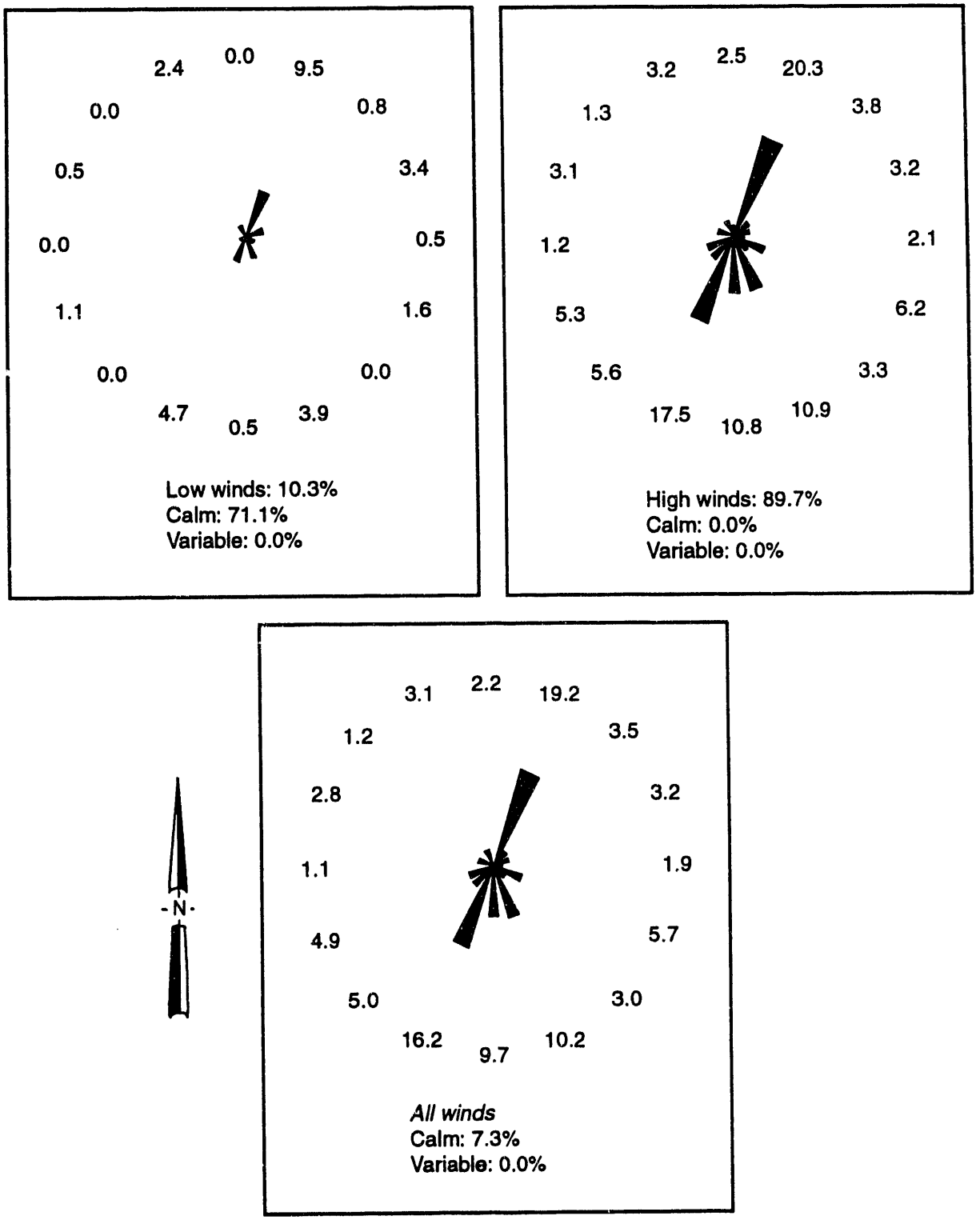


FIGURE 3.6. Wind Roses for the Harrington Station

TABLE 3.8. Station: LaCrosse, Washington (LAC)

Type: Weather Bureau Office

Location: 46:49:00N 117:53:00W 452 meters (1483 feet) elevation.

Measurement height: 13.1 meters (43 feet).

Instrument mounted: on a tower on the ground.

HEDR environmental grid coordinates: X = 14.41, Y = 14.36.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1/1 to 9/30/48.
Not listed by NWDI after 1948.

Data availability: Observations taken every hour during 1944 to 1947.

Missing data: No data 5/1/46.

Local topography: This station is surrounded by the rolling hills of the Palouse, which have elevation variations of less than about 100 meters (a few hundred feet). The Snake River passes about 16 kilometers (10 miles) southeast of LaCrosse.

Wind roses: The predominant wind directions are north-northeasterly and south-southwesterly. Weak winds are dominated by the north-northeasterly direction, while strong winds are dominated by south-southwesterly. Figure 3.7 illustrates the wind roses for this station.

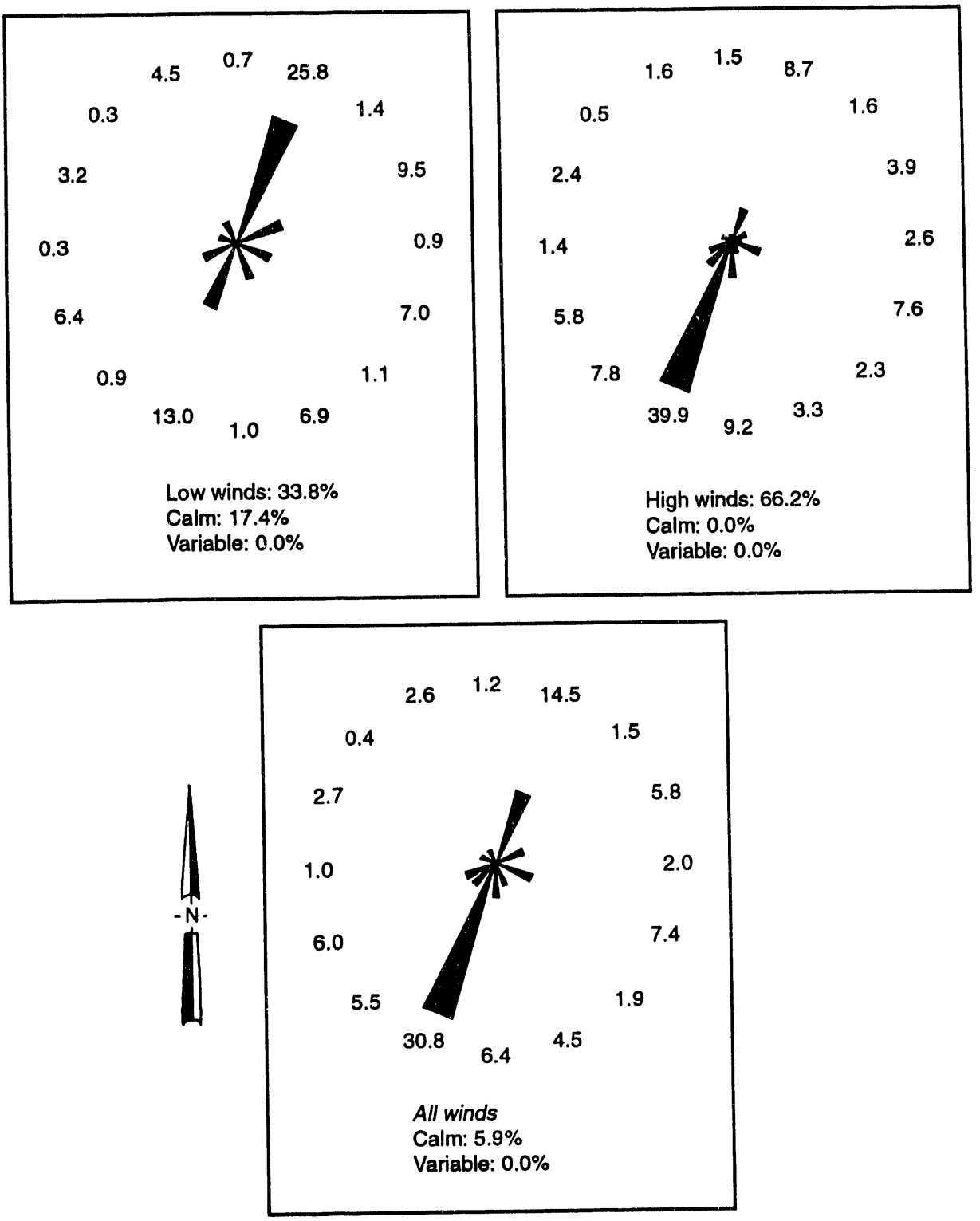


FIGURE 3.7. Wind Roses for the LaCrosse Station

TABLE 3.9. Station: Larson AFB, Washington (MWH)

Type: Army Air Field/Air Force Base

Location: 47:11:00N 119:20:00W 361 meters (1184 feet) elevation.

Measurement height: 8.5 meters (28 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 8.72, Y = 16.47.

Data source: Paper copy for 12/44 through 4/18/45.
Not listed by NWDI after 4/18/45.
Magnetic tape 3/49 through 12/49.

Data availability: Observations taken every hour until 4/18/45.
No further data after that.

Missing data: none.

Local topography: This station is located near Moses Lake in the center of the Columbia Basin. This region is very flat. Everything within a 24.2-kilometer (15-mile) radius is less than a 120-meter (400-foot) elevation change from the station.

Station was moved: 4/53 Measurement height: 32 meters (105 feet).

Station was moved: 4/57 Measurement height: 3.7 meters (12 feet).

Instrument mounted: 6/69 on a tower on the ground.

Station was moved: 6/68 Location: 47:12:00N 119:19:00W. Measurement height: 6/68 6.1 meters (20.0 feet).

Wind roses: At this station, north-northwesterly and northwesterly are the dominant wind directions with a secondary maximum for south-southeasterly winds. Winds are rarely from the sector between 0 and 90 degrees. Strong winds are most frequently from the north-northwest. Figure 3.8 illustrates the wind roses for this station.

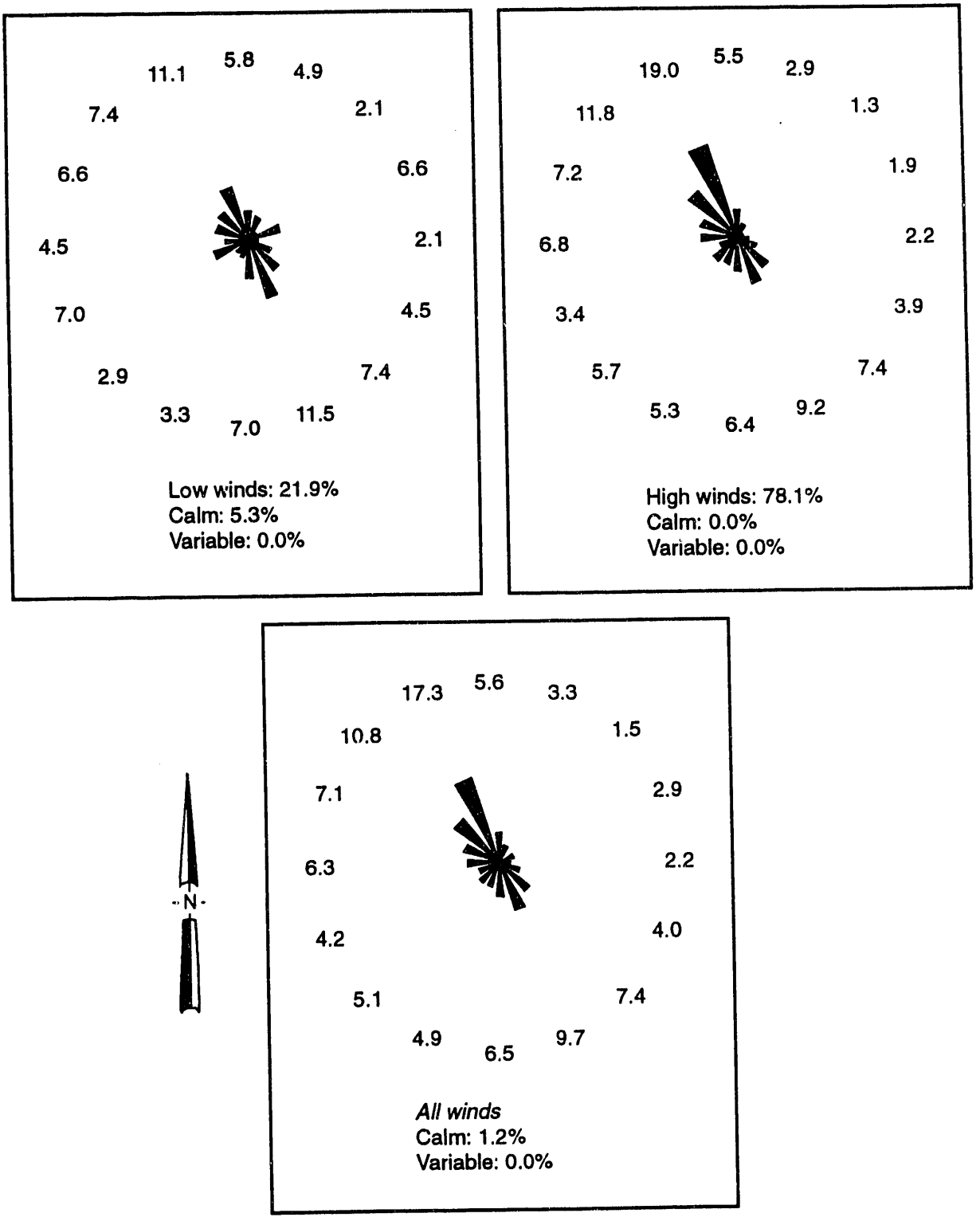


FIGURE 3.8. Wind Roses for the Larson AFB Station

TABLE 3.10. Station: Omak, Washington (OMK)

Type: Supplemental Aviation Weather Reporting Station

Location: 48:26:00N 119:32:00W 376 meters (1233 feet) elevation.

Measurement height: 7.3 meters (24 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 8.01, Y = 23.67.

Data source: Paper copy for 1944 through 1947.
NWDI lists paper copy for 1948 and 1949.

Data availability: 4 observations per day during 1944 to 1947.

Missing data: None.

Local topography: This station is located along the Okanogan River in an approximately 8-kilometer (5-mile) diameter basin. The basin floor is at 250 to 400 meters (800 to 1300 feet). To the west, Buck Mountain rises to 1870 meters (6135 feet). To the east, Omak mountain rises to 1752 meters (5749 feet). The Okanogan River runs into Omak from the north through a narrow canyon and out of Omak through a narrow canyon to the southwest.

Wind Roses: Not yet computed for this station.

TABLE 3.11. Station: Pasco, Washington (PSC)

Type: Naval Air Station/Supplemental Aviation Weather Reporting Station

Location: 46:14:00N 119:07:00W 131 meters (430 feet) elevation.

Measurement height: 10 meters (33 feet).

Instrument mounted: on a beacon tower.

HEDR environmental grid coordinates: X = 9.54, Y = 11.01.

Data source: magnetic tape and microfiche.

Data availability: Observations taken every hour for 1944 through 1946.
Not listed by NWDI for 1947 and 1948.
Five to six observations per day on microfiche for 3/5/49 through 12/31/49. Wind data has been entered for every 3 hours during this period.

Missing data: Unknown.

Local topography: This station is located immediately south and east of the Hanford Reservation. It is at the southern apex of a basin formed by the Columbia River and surrounded by Yakima Ridge and Rattlesnake Hills to the northwest, Saddle Mountains to the north, Juniper Hills to the east, and Horse Heaven Hills to the south. The Columbia River flows into Pasco from the north and west and exits to the southeast. The Yakima River flows in from the west and the Snake River flows in from the northeast.

Wind Roses: Strong winds are strongly dominated by south-southwesterly, and weak winds are dominated by northwesterly. Figure 3.9 illustrates the wind roses for this station.

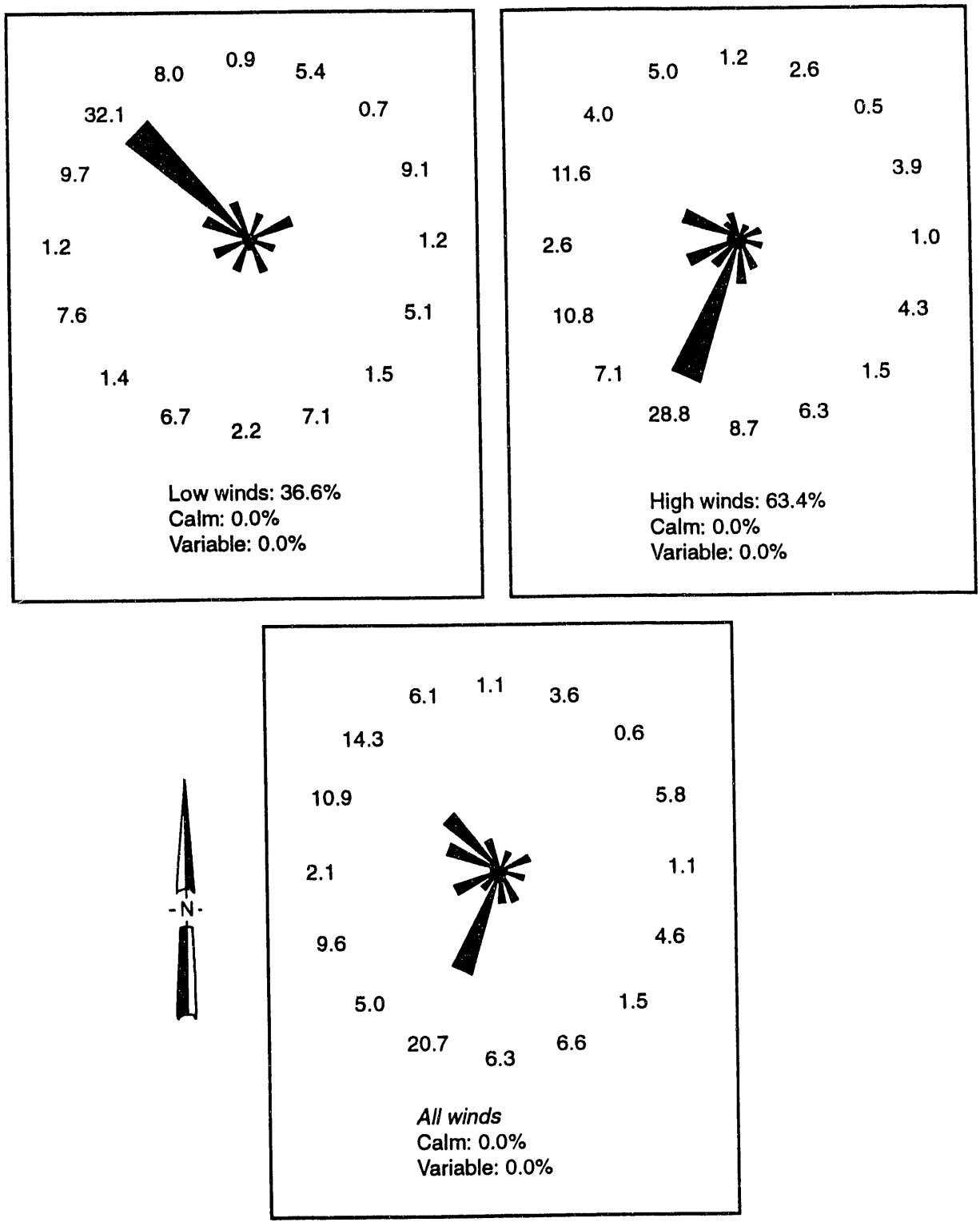


FIGURE 3.9. Wind Roses for the Pasco Station

TABLE 3.12. Station: Spokane, Washington (Felts Field) (SFF)

Type: Weather Bureau Airport Station

Location: 47:40:00N 117:20:00W 600 meters (1968 feet) elevation.

Measurement height: 16.1 meters (53 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 16.49, Y = 19.26.

Data source: Paper copy for 1944 through 1947.
Not listed by NWDI from 1948 to 1957.

Data availability: Observations taken every hour during 1944 to 1947.
For 1946 and 1947, only wind data have been entered. Other meteorological data are recorded in the records, but use a nonstandard coding.

Missing data: None.

Local topography: This station is located about 10 kilometers (6 miles) southwest of the center of the city of Spokane. To the west and southwest, no significant terrain features are in the area for 120 kilometers (75 miles). To the northeast, the land gradually climbs to hills that rise to around 300 meters (1000 feet) above the station.

Station was moved: 11/58 Measurement height: 12.2 meters (40 feet).

Station was moved: 7/64 Measurement height: 6.1 meters (20 feet).

Instrument mounted: 7/64 on a tower on the ground.

TABLE 3.13. Station: Spokane, Washington (Geiger Field) (GEG)

Type: Not determined.

Location: 47:37:00N 117:31:00W 721 meters (2365 feet) elevation.

Measurement height: 10 meters (33 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 15.79, Y = 18.97.

Data source: NWDI lists magnetic tape for 1941 through 1945.

Data availability: Observations taken every hour 1941 through 1947.

Missing data: Unknown.

Local topography: This station is located northwest of the center of Spokane. To the west of the station, one encounters first the city, then the Spokane River. Further to the west and southwest, no significant terrain features are found for 120 kilometers (75 miles). To the northeast, the land gradually climbs to hills that rise to approximately 300 meters (1000 feet) above the station.

Station was moved: 12/47 Measurement height: 8.8 meters (30 feet).

Station was moved: 7/57 Measurement height: 10.4 meters (34 feet).

Station was moved: 11/57 Measurement height: 6.1 meters (20 feet).

Instrument mounted: 11/57 on a tower on the ground.

Station was moved: 5/65 Location: 47:38:00N 117:32:00W. Measurement height: 6.1 meters (20.0 feet).

HEDR environmental grid coordinates: 5/65 X = 15.72, Y = 19.06.

Wind Roses: Not yet computed for this station.

TABLE 3.14. Station: Stampede Pass, Washington (SMP)

Type: Weather Bureau Office

Location: 47:17:00N 121:20:00W 1209 meters (3966 feet) elevation.

Measurement height: 8.8 meters (29 feet).

Instrument mounted: on a tower on the ground.

HEDR environmental grid coordinates: X = 0.91, Y = 17.05.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour during the period from 1944 to 1947.

Missing data: No data for 2/21/46 hours 1 to 12.
No data for 4/21/46 hours 1 to 12.
No data for 5/22/46 hours 1 to 12.

Local topography: This station is located at the summit of a pass in the Cascade Mountains. Peaks rise 100 or 200 meters (328 to 656 feet) above the station within 1 mile to the northwest and to the southeast. The more general environs of the station consist of numerous jumbled peaks and valleys in all directions, including a valley formed by the Yakima River that passes about 5 kilometers (3 or so miles) to the northeast of the station.

Wind roses: Not yet computed for this station.

TABLE 3.15. Station: Walla Walla, Washington (ALW)

Type: Flight Service Station

Location: 46:06:00N 118:17:00W 362 meters (1187 feet) elevation.

Measurement height: 7.6 meters (25 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 12.86, Y = 10.24.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour during the period from 1945 to 1947.

Missing data: No data for 8/19/47.

Local topography: This station is located in a relatively flat circular region about 16 kilometers (10 miles) in diameter and surrounded by rolling hills with less than 100 meters (328 feet) of elevation variation. The Walla Walla River drains through a gap to the west. Immediately to the southeast of Walla Walla are the Blue Mountains, which run from northeast to southwest and rise 1000 meters (3000 feet) above Walla Walla.

Station was moved: 3/46 Measurement height: 10.7 meters (35 feet).

Station was moved: 4/48 Measurement height: 11.3 meters (37 feet).

Station was moved: 7/49 Measurement height: 10.1 meters (33 feet).

Station was moved: 5/62 Measurement height: 6.1 meters (20 feet)

Instrument mounted: 5/62 on a tower on the ground.

Wind roses: Winds here are most frequently from directions near southerly. Winds with a northerly component are rare, occurring in only 12.7 percent of the hours. Figure 3.10 illustrates the wind roses for this station.

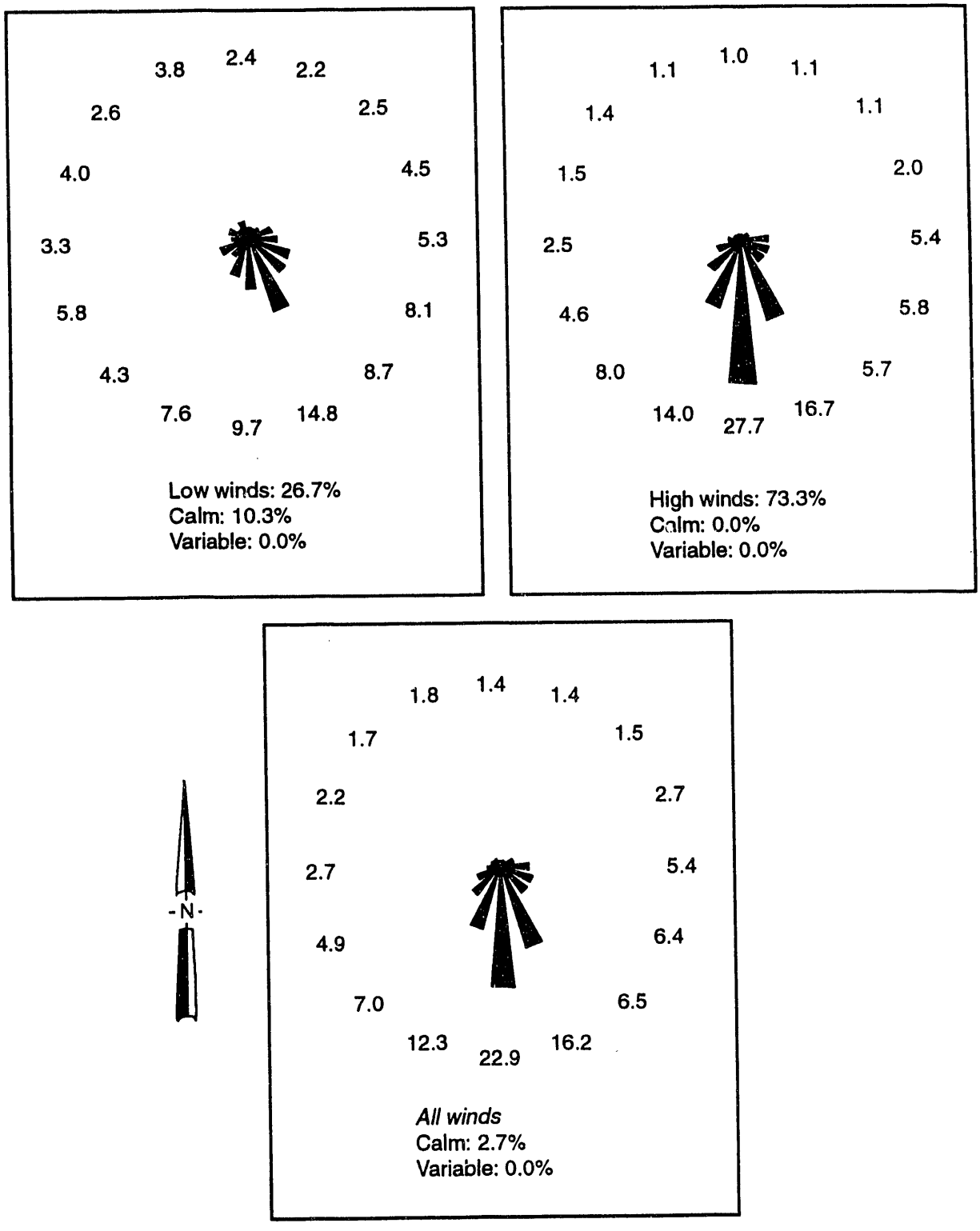


FIGURE 3.10. Wind Roses for the Walla Walla Station

TABLE 3.16. Station: Wenatchee, Washington (EAT)

Type: Supplemental Aviation Weather Reporting Station/Flight Service Station

Location: 47:24:00N 120:12:00W 376 meters (1233 feet) elevation.

Measurement height: 8.5 meters (28 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 5.35, Y = 17.72.

Data source: Paper copy for 1944 through 1947.
Microfiche for 1948 and 1949.

Data availability: Observations began 9/16/45 with 4 to 13 observations per day.
Observation frequency changed to 4 to 24 observations per day after 5/15/46.
Observation frequency changed to to 19 observations per day after 3/10/46.
12 to 18 observations per day for 1948 and 1949.

Missing data: No data 11/25/46.

Local topography: This station is located near the confluence of the Columbia and the Wenatchee Rivers. The river surface is 600 to 1100 meters (2000 to 3600 feet) below the tops of surrounding peaks and ridges. The Columbia River flows past the town of Wenatchee from the north toward the south, makes a bend to run toward the east past the station and then turns sharply toward the south about 8 kilometers (5 miles) beyond the station.

Station was moved: 11/59. Measurement height: 11.9 meters (39 feet).

Instrument mounted: on the roof of a building.

Data availability: Observations taken every hour after 11/59.

Station was moved: 3/66 Measurement height: 6.1 meters (20 feet).

Instrument mounted: on a tower on the ground.

Wind roses: Winds of all speeds at this station are dominated by flow down the local Columbia riverbed, with half (49.8 percent) of all hours having winds from west-northwest, west, or west-southwest. Figure 3.11 illustrates the wind roses for this station.

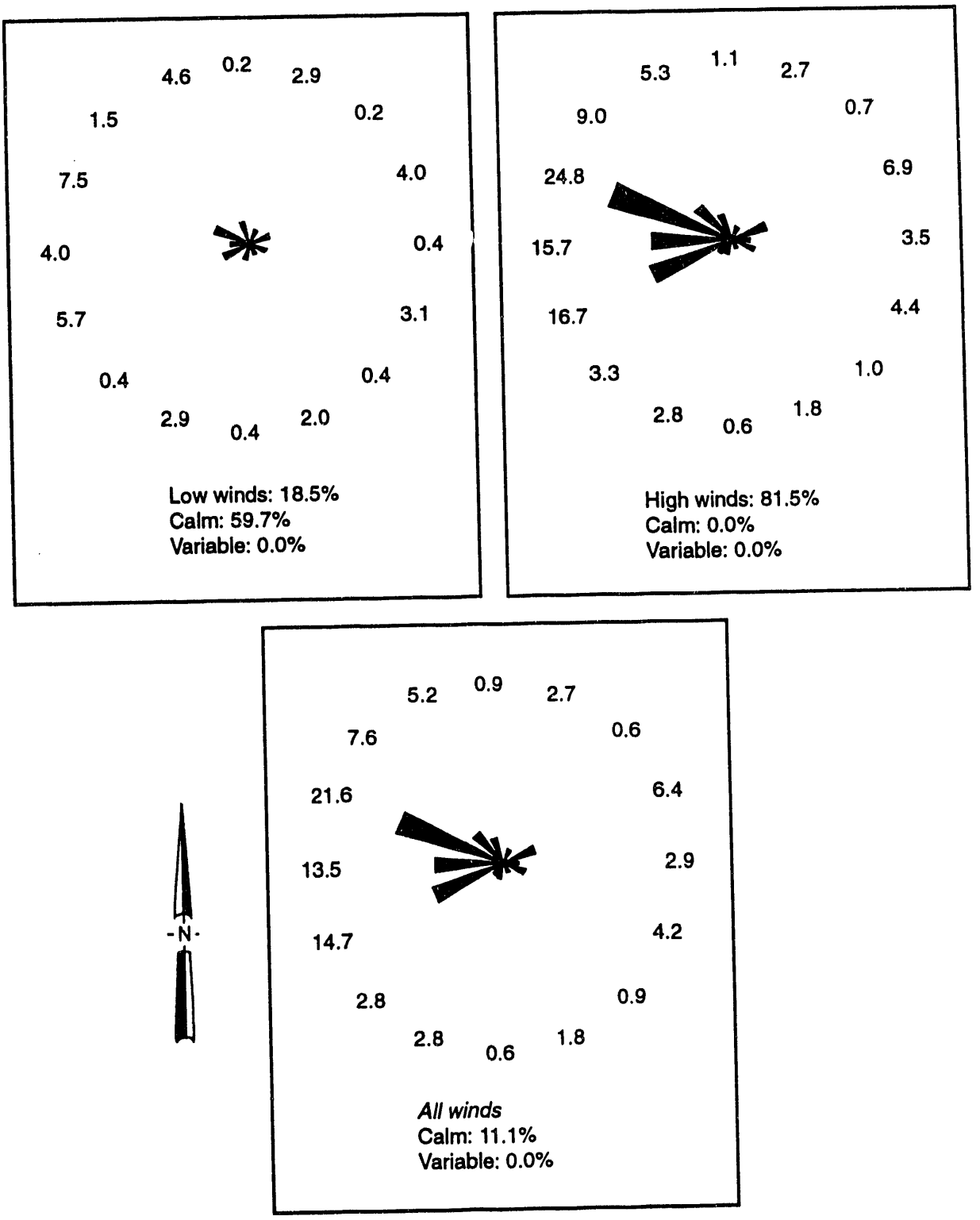


FIGURE 3.11. Wind Roses for the Wenatchee Station

TABLE 3.17. Station: Yakima, Washington (YKM)

Type: Weather Bureau Airport Station

Location: 46:34:00N 120:32:00W 326 meters (1069 feet) elevation.

Measurement height: 17.7 meters (56 feet).

Instrument mounted: on a beacon tower.

HEDR environmental grid coordinates: X = 3.94, Y = 12.92.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour during the period from 1944 to 1947.

Missing data: No data 5/2/45.

Local topography: This station is located in a small basin formed by the Yakima River, Naches River, and Ahtanum Creek. This basin is surrounded by Umtanum Ridge to the north and east, Rattlesnake Hills to the southeast, Ahtanum Ridge to the south, and Cowiche Mountain to the west. The station is at the southern edge of the basin, just north of Ahtanum Ridge. Ahtanum Creek flows into this basin from the west through the broad, flat Ahtanum Valley. The Naches River flows in from the northwest through a broad valley. The Yakima River enters from through a narrow valley from the north and exits to the south through Union Gap, a narrow passage between Ahtanum Ridge and Rattlesnake Hills. The Moxee Valley runs towards the station from the east-southeast.

Station was moved: 7/50 Measurement height: 14.9 meters (49 feet).

Instrument mounted: 7/50 on the roof of a building.

Station was moved: 1/62 Measurement height: 6.1 meters (20 feet).

Instrument mounted: 1/62 on a tower on the ground.

Wind roses: The wind roses for this station show that westerly winds predominate across the Ahtanum Valley with directions ranging from southwesterly to northwesterly. For low winds, secondary maxima correspond to north-northwesterly winds down the Yakima River and east-southeasterly winds out of the Moxee Valley. Figure 3.12 illustrates the wind roses for this station.

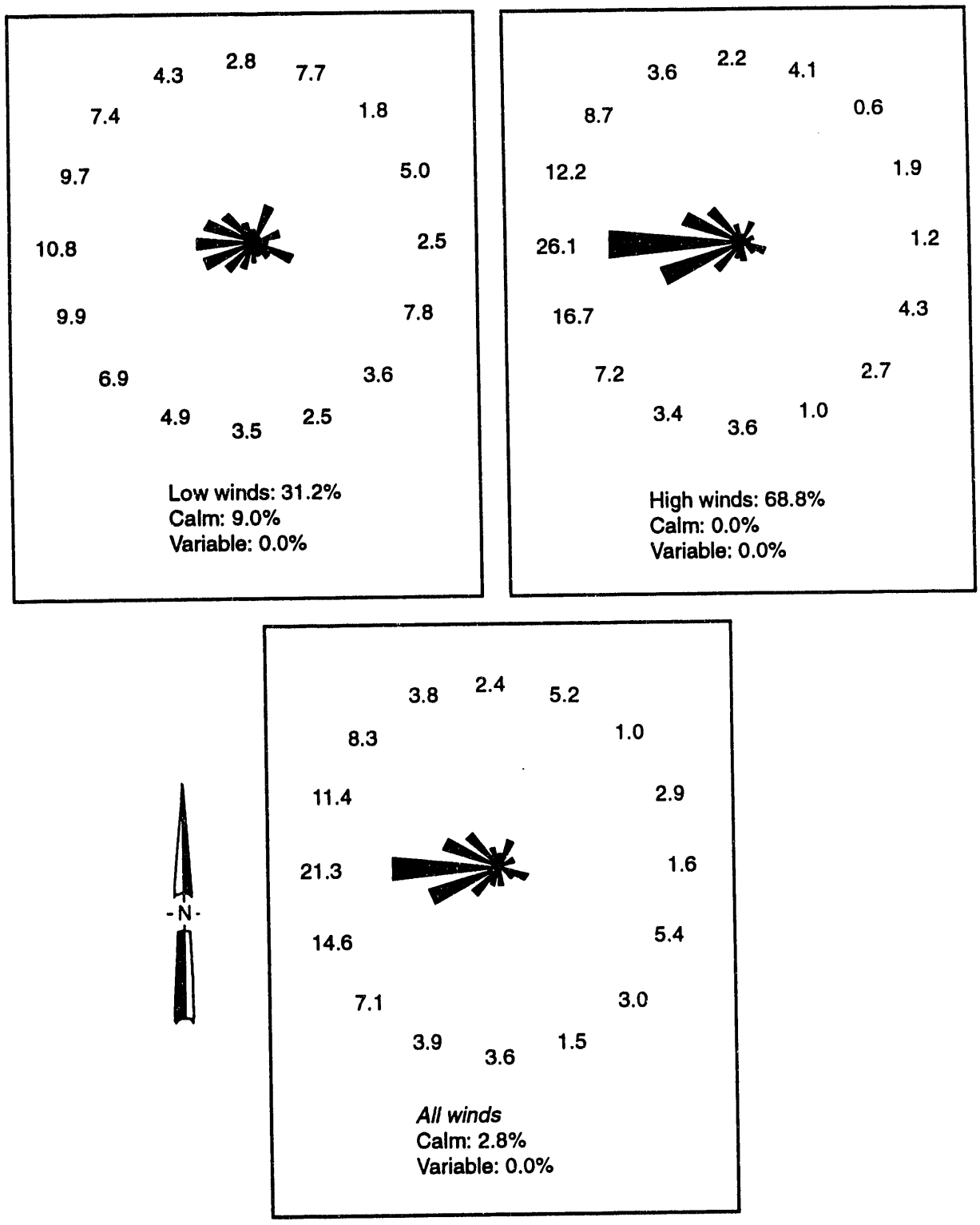


FIGURE 3.12. Wind Roses for the Yakima Station

TABLE 3.18. Station: Baker, Oregon (BKE)

Type: Civil Aeronautics Administration/Flight Service Station

Location: 44:50:00N 117:50:00W 1028 meters (3372 feet) elevation.

Measurement height: 8.5 meters (28 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 14.74, Y = 2.95.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Hourly data for December 1944 through 1947.

Missing data: Bad copy for half of 11/18/45.

Local topography: To the west of Baker, Elkhorn Ridge rises as high as 1500 meters (5000 feet) above the station.

Station was moved: 2/49 Location: 44:50:00N 117:49:00W.

Measurement height: 2/49 9.5 meters (31 feet).

HEDR environmental grid coordinates: 2/49 X = 14.81, Y = 2.95.

Station was moved: 1/54 Measurement height: 10.4 meters (34 feet).

Wind roses: Not yet computed for this station.

TABLE 3.19. Station: Burns, Oregon (BNO)

Type: Weather Bureau Office

Location: 43:35:00N 119:03:00W 1272 meters (4172 feet) elevation.

Measurement height: 14.3 meters (47 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 9.75, Y = -4.25.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour from 12/44 to 9/22/45.
Eight observations per day from 12/15/45 through the end of 1949.

Missing data: No data from 9/23/45 through 12/15/45.
Bad copy for 7/18/45.
No data 10/47 through 11/47.

Local topography: North and west of the station, mountains rise 1000 to 1300 meters (3000 to 4000 feet) above the station. To the south, the land slopes gradually downward to Malhauer and Harne Lakes.

Station was moved: 6/50 Measurement height: 18.9 meters (62 feet).

Station was moved: 5/52 Measurement height: 20.7 meters (68 feet).

Wind roses: Not yet computed for this station.

TABLE 3.20. Station: Condon, Oregon (CON)

Type: Weather Bureau Office

Location: 45:15:00N 120:11:00W 887 meters (2909 feet) elevation.

Measurement height: 8.8 meters (29 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 5.19, Y = 5.34.

Data source: Paper copy for 1944 through 9/22/45.
Not listed by NWDI after 1945.

Data availability: Observations taken every hour during December 1944 until 9/22/45. No data after that time.

Missing data: None.

Local topography: This station is located near the northern apex of a triangular shelf with rolling hills surrounding the shelf.

Wind roses: Not yet computed for this station.

TABLE 3.21. Station: Ontario, Oregon (ONO)

Type: Supplemental Aviation Weather Reporting Station

Location: 44:01:00N 117:01:00W 668 meters (2191 feet) elevation.

Measurement height: 17.4 meters (57 feet).

Instrument mounted: on a beacon tower.

HEDR environmental grid coordinates: X = 18.18, Y = -1.76.

Data source: Paper copy for 1944 through 1947.
NWDI lists magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour from 1944 through 1946.
8 to 16 observations per day 1/1/47 to 4/8/47.
Hourly observations from 4/9/47 through 12/31/47.

Missing data: No data for 2100 to 0800 hours during 12/6-31/46.

Local topography: This station is immediately west of the Snake River.

Station was moved: 8/51 Measurement height: 10.1 meters (32 feet).

Instrument mounted: on a tower on the ground.

Data availability: Observations taken every 3 hours.

Station was moved: 1/56 Measurement height: 10 meters (33 feet).

NOTE: According to NWDI, wind direction was an estimate.

Station was moved: 9/68 Measurement height: 7.6 meters (25 feet).

Wind rose: Not yet computed for this station.

TABLE 3.22. Station: Pendleton, Oregon (PDT)

Type: Weather Bureau Airport Station

Location: 45:41:00N 118:51:00W 459 meters (1506 feet) elevation.

Measurement height: 10.7 meters (35 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 10.60, Y = 7.84.

Data source: Magnetic tape 1944 through 1949.

Data availability: Observations taken every hour.

Missing data: Unknown.

Local topography: This station is located along the Umatilla River. The river channel is not deep enough to have much effect on winds at the station. The terrain around the station has elevation variations of less than about 100 meters (a few hundred feet). About 16 kilometers (10 miles) to the southeast of Pendleton is the edge of the Blue Mountains. These mountains, which rise about 750 meters (2500 feet) above Pendleton and run from northeast to southwest, have a rather abrupt edge that makes an impressive escarpment when viewed from Pendleton.

Station was moved: 4/47 Measurement height: 12.5 meters (41 feet).

Station was moved: 10/49 Measurement height: 11.3 meters (37 feet).

Station was moved: 5/54 Measurement height: 16.2 meters (53 feet).

Station was moved: 4/58 Measurement height: 6.1 meters (20 feet).

Instrument mounted: 4/58 on a tower on the ground.

Station was moved: 2/59 Measurement height: 16.2 meters (53 feet).

Instrument mounted: 2/59 on the roof of a building.

Station was moved: 9/60 Measurement height: 6.1 meters (20 feet).

Instrument mounted: 9/60 on a tower on the ground.

Wind roses: High winds tend to blow from the west-southwest. Weaker winds tend to flow from the southeast, down off the Blue Mountains, occasionally becoming strong winds. Figure 3.13 illustrates the wind roses for this station.

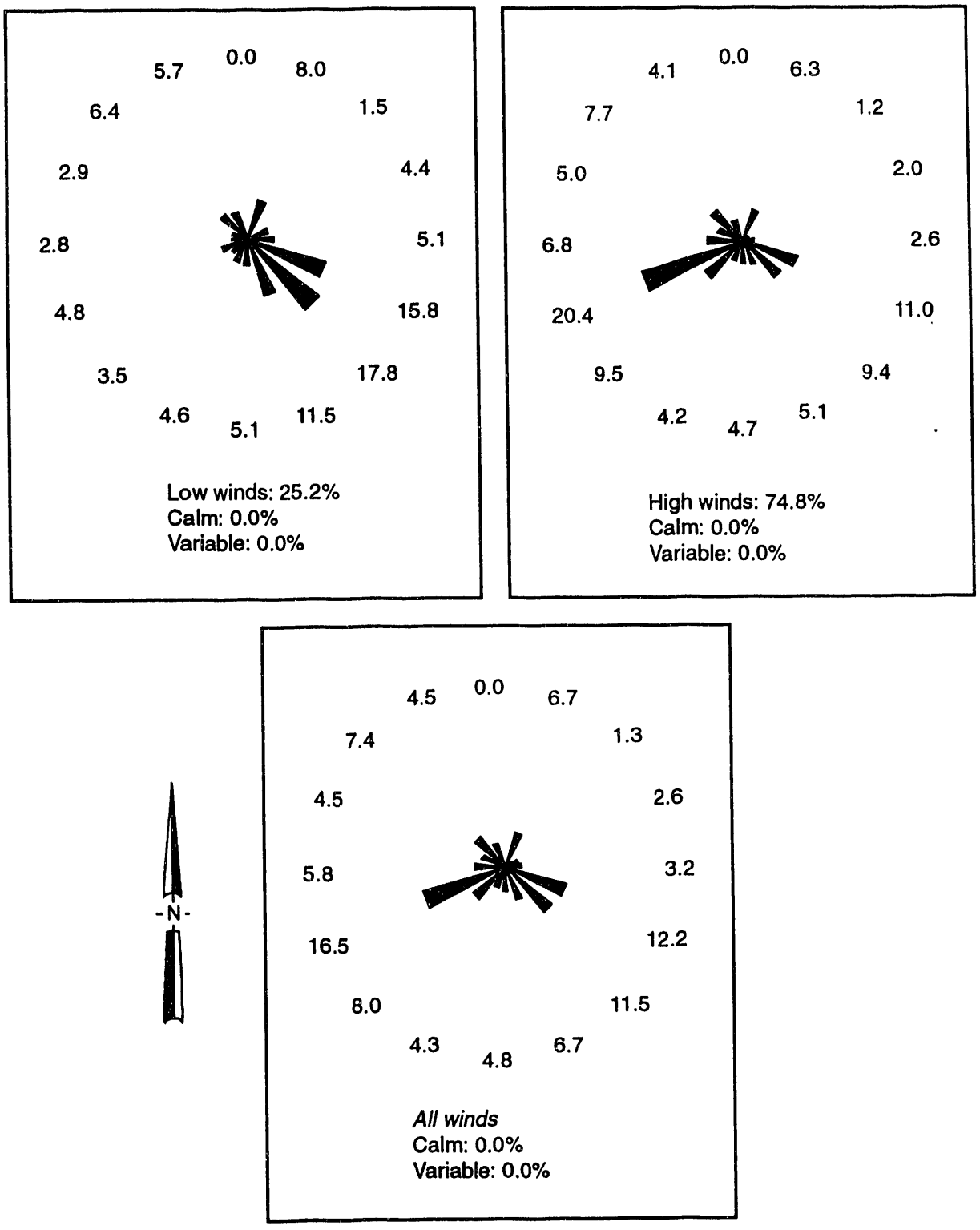


FIGURE 3.13. Wind Roses for the Pendleton Station

TABLE 3.23. Station: Redmond, Oregon (RDM)

Type: Federal Aviation Administration

Location: 44:16:00N 121:10:00W 934 meters (3064 feet) elevation.

Measurement height: 10 meters (33 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 1.04, Y = -0.32.

Data source: Paper copy for 1944 through 1947.
Magnetic tape for 1948 and 1949.

Data availability: Observations taken every hour during 1944 to 1947.

Missing data: No data for 8 hours of 8/18 and 19/45.
No data for 9/25/45 to 10/9/45.

Local topography: This station is located in central Oregon slightly east of the Deschutes River.

Station was moved: 10/45 Location: 44:16:00N 121:09:00W. Measurement height: 11.3 meters (37 feet).

HEDR environmental grid coordinates: 10/45 X = 1.11, Y = -0.32.

Station was moved: 3/48 Measurement height: 11.9 meters (39 feet).

Station was moved: 10/50 Measurement height: 9.5 meters (31 feet).

Station was moved: 7/64 Measurement height: 6.1 meters (20 feet).

Wind roses: Not yet computed for this station.

TABLE 3.24. Station: Bonners Ferry, Idaho (BON)

Type: Not determined.

Location: 48:42:00N 116:18:00W 583 meters (1912 feet) elevation.

Measurement height: 9.8 meters (31 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 20.31, Y = 25.21.

Data source: Paper copy for 1944 through 1947.
NWDI lists paper copy for 1948 and 1949.

Data availability: 4 observations per day 12/44 through 6/16/45.
2 observations per day 6/17/45 through 2/6/46.
4 observations per day 2/7/46 through 6/1/46.
2 observations per day 6/2/46 through 7/8/46.
4 observations per day 9/27/46 through 12/31/47.

Missing data: No data 3/12 to 3/14/45.
No data 4/22 to 4/29/45.
No data 7/29 to 7/30/45.
No data 7/8/46 through 9/26/46.

Local topography: This station is located near the Kootenai River. The river flows towards the station through a narrow canyon from the east. A triangular plain about 11 kilometers (7 miles) across is located south of the station. The river flows to the north through a 5-mile wide valley with a very flat bottom and containing a series of river meanders. On all sides of the valley, mountains rise steeply 600 to 1500 meters (2000 to 5000 feet) above the valley floor.

Station was moved: 4/45 Measurement height: 7.6 meters (25 feet).

Station was moved: 2/46 Measurement height: 11.9 meters (39 feet).

Station was moved: 9/46 Measurement height: 10.1 meters (33 feet).

Wind roses: Not yet computed for this station.

TABLE 3.25. Station: Lewiston, Idaho (LWS)

Type: Weather Bureau Airport Station

Location: 46:23:00N 117:01:00W 432 meters (1416 feet) elevation.

Measurement height: 7 meters (23 feet).

Instrument mounted: on the roof of a building.

HEDR environmental grid coordinates: X = 17.88, Y = 11.87.

Data source: Paper copy for 10/28/46 through 12/31/47.
Magnetic tape for 1948 and 1949.

Data availability: No data prior to 10/28/46, then observations taken every hour.

Missing data: Data missing during a 15-hour period on 11/30/47 and 12/1/47.

Local topography: This station is located near the banks of the Snake River at the western edge of the approximately 16-kilometer (10-mile) diameter basin formed by the confluence of the Clearwater and Snake Rivers. The Clearwater River flows in from the east, and the Snake River flows in from the south, then out toward the west. Hills immediately around the basin rise to about 100 meters (600 feet) above the basin floor.

Station was moved: 9/51 Measurement height: 12.2 meters (40 feet).

Station was moved: 3/66 Measurement height: 6.1 meters (20 feet).

Instrument mounted: on a tower on the ground.

Wind roses: not yet computed for this station.

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