CHAPTER 2

Meteorological Records

2.1 CLIMATE

The climate of the Okanagan Basin is somewhat less continental than the rest of the interior of the Province. The warm summer with fairly low humidity as well as the relatively mild winters provide an attractive environment for agriculture and recreation. The typical climatic conditions of major urban centres in the Okanagan Valley are shown in Table 2.1. These are only a few of the climatic stations shown in Figure 2.1.

2.1.1 Weather Records

Out of some 80 stations in or adjacent to the Okanagan Basin (Table 2.2a, b and c and Figure 2.1) there are 14 stations located above the average elevation of the Basin (3,900 feet) of which 11 have been in operation during the last three years. Most of these were established for the study. Thus, while there appears to be adequate climatic coverage at lower elevations within the inhabited areas, there are only a few stations at the higher elevations where orographic features cause a high degree of variability in weather patterns,

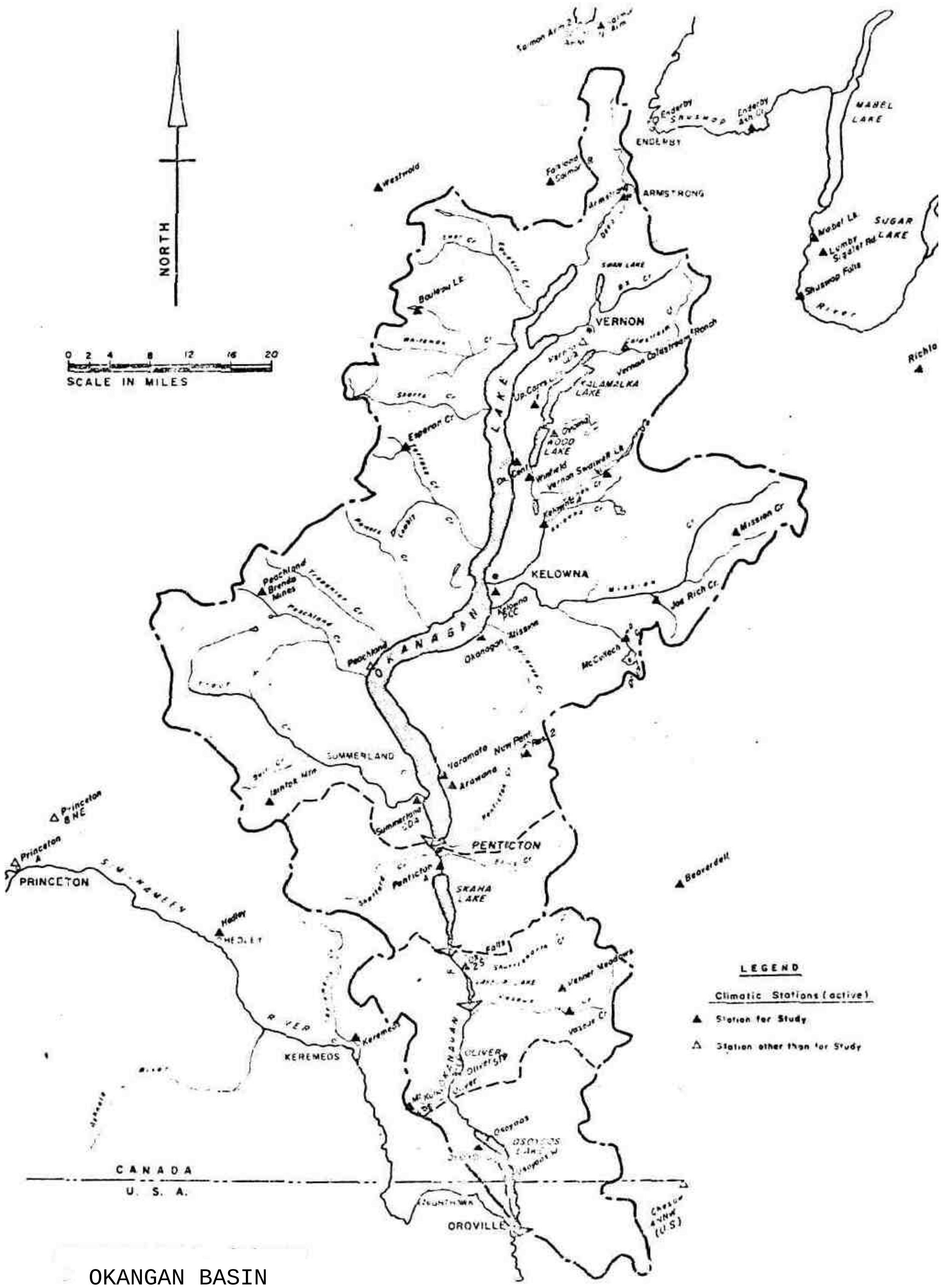
The lack of data above 3,900 feet where most of the runoff originates as snow melt has been partially offset by the establishment of snow courses within the higher elevations of the basin by the British Columbia Water Resources Service (Table 2.3 and Figure 2.2). These snow courses are sampled during the winter months for snow water contents which information is used in preparing Inflow forecasts to Okanagan Lake. The installation of standpipe storage precipitation gauges at a number of high elevation climatic stations during the study will improve this network.

Evaporation data previously recorded only at Summerland has been extended to other parts of the basin including some of the higher elevation sites and, in support of this, radiation and wind measurements are now being observed as indicated in Table 2.2a). Six additional Class A pans were introduced In 1971 and two temporary experimental US X-5 pans were placed on Mount Kobau in 1972. Other observations at some sites included sunshine, rainfall intensity and humidity. With minor changes, much of this enhanced network is expected to continue to add to the growing data base revelant to the determination of water quantity in the Basin.

TABLE 2.1

Representative Climatic Data, Okanagan Valley - Taken in part from B.C. Department of Agriculture Publications entitled Agricultural Outlook Conferences 1996.

Station	Elevation	Mean Annual Precip-itation	Mean January Precip-itation	Mean July Precip-itation	Mean Annual Temper-ature	Mean January Temper-ature	Mean July Temper-ature	Mean Data Last Spring Frost	Mean Data First Fall Frost	Mean Frost-free Period	Degree Days 42° F.	Mean Growing Season (Mean daily temp. 42° F)
	ft.	in.	in.	in.	°F.	°F.	°F.	-	-	day	-	day
Salmon Arm	1660	21.0	-	-	45	-	-	May 6	Oct. 5	153	3391	199
Armstrong	1200	17.06	1.84	1.13	44	21	66	May 23	Sept. 14	114	3063	194
Vernon (Coldstream)	1582	15.22	1.55	1.06	45	22	67	May 6	Oct. 5	147	3248	200
Okanagan Centre	1140	13.38	1.39	0.95	48	27	68	-	-	134	-	-
Kelowna	1590	12.09	1.06	0.78	47	26	68	May 12	Oct. 3	143	3442	200
McCulloch	4100	26.82	2.87	1.78	37	16	56	-	-	20	-	-
Summerland (Research Sta.)	1491	11.00	1.06	0.86	48	25	70	Apr. 24	Nov. 9	198	3756	212
Penticton (Airport)	1140	11.32	1.08	0.89	48	27	68	May 7	Oct. 3	149	3530	217
Oliver	1008	10.71	1.07	0.76	49	26	71	May 3	Oct. 1	152	4021	226



OKANGAN BASIN
AND SURROUNDING AREA
CLIMATIC STATIONS

Figure 2.1

Table 2.2(a)

Climatological Stations - Okanagan Basin and Adjoining Area
Active During All or a Portion of Period 1921-1973
Note: Stations Still Active Indicated by
Absence of Date at End of Record

Station Name	Latitude °	Latitude '	Longitude °	Longitude '	Elevation (feet)	Period of Record Began Year	Began Mo.	Ended Year	Ended Mo.	Observing Program
Arawana	49	35	119	34	1,700	1970	12	1971	05	P,T,H,S,S/P
						1971	05			P,T,E,W,H,S,S/P
Armstrong	50	27	119	12	1,187	1913	03	1931	10	P,T
						1932	04	1969	08	P,T
						1969	12			
Armstrong Mountainview	50	28	119	07	1,520	1971	07	1972	05	P,T
Beaverdell	49	27	119	07	2,520	1925	09	1939	10	P
						1962	04	1967	10	P
						1967	11			P,S
Bouleau Lake	50	17	119	38	4,500	1970	12			S/P
Carrs Landing	50	08	119	24	3,200	1968	09			F/P
Enderby	50	32	119	07	1,180	1909	07	1927	07	P,T
						1971	05			
Enderby Ashton Creek	50	33	118	55	1,150	1965	06			P,T
Esperon Creek	50	04	119	43	4,600	1970	11			S/P
Falkland Salmon River	50	28	119	22	1,500	1959	03			P,T
Hedley	49	21	120	05	1,771	1922	04	1930	12	P,T
					1,720	1931	01	1969	04	P,T
						1970	01			P,T
Isintok Mountain	49	54	119	58	6,300	1970	12			S/P
Joe Rich Creek	49	51	119	08	2,870	1928	09	1946	04	P
						1948	06			P,T
Kelowna Airport	49	58	119	23	1,405	1959	03	1959	07	X
						1960	07	1961	10	X
						1962	03	1968	09	X
						1968	10	1973	03	P,T,I,X
						1973	04			P,T,I,S,X
Kelowna Bridge	49	53	119	30	1,130	1971	06	1973	08	W,Q
						1973	09			W
Kelowna PCC	49	52	119	29	1,134	1968	09	1968	09	I
						1968	10			P,T,I
Keremeos	49	13	119	50	1,165	1920	03	1929	12	P,T
						1931	01	1956	10	P,T
	49	12	119	47	1,410	1956	11			P,T
Lumby Sigalet Road	50	22	118	46	1,800	1970	11	1972	10	P
						1972	11			P,T
Mabel Lake	50	23	118	47	1,310	1924	07			P
McCulloch	49	48	119	12	4,100	1923	11	1935	12	P
						1936	01	1967	10	P,T
						1967	11	1971	05	P,T,S
						1971	05			P,T,E,W,S
Mission Creek	49	57	118	57	5,850	1970	12			F/P
Mount Kobau Observatory	49	07	119	40	6,116	1966	05	1966	05	P,T
						1966	06	1966	08	P,T,R
						1966	09	1967	08	P,T,W,R
						1967	09	1972	06	P,T,W,R,F/P
						1972	06			P,T,E,W,R,F/P
Naramata	49	36	119	36	1,130	1971	04			P,T,E,W
New Penticton Reservoir #2	49	38	119	25	5,100	1970	11			S/P
Okanagan Centre	50	04	119	27	1,155	1925	03	1925	12	P
						1926	01	1963	10	P,T
					1,140	1963	10			P,T
Okanagan Falls 2S	49	19	119	33	1,100	1970	11			P
Okanagan Mission	49	48	119	31	1,340	1970	11			P
Oliver	49	10	119	34	1,008	1938	06	1954	12	T
						1955	01	1966	07	P,T
	49	10	119	33	1,000	1966	07			P,T
Oliver STP (formerly Oliver 2)	49	11	119	33	997	1924	01	1924	12	P,T
						1925	01	1936	07	P,T,S
						1936	08	1938	03	P,T
						1938	04	1941	12	P,T,S
						1942	01	1954	12	P,S
						1955	01	1971	12	P,T,S
						1972	01	1972	04	P,T,H,S
						1972	04			P,T,I,H,S
Osoyoos	49	03	119	26	950	1918	06	1921	05	P
	49	01	119	28	913	1924	03	1927	08	P,T
	49	02	119	30	980	1938	01	1938	01	P,T
						1938	08	1939	04	P,T
						1940	04	1940	05	P,T
						1942	04	1942	06	P,T
						1943	04	1943	06	P,T
						1944	04	1944	05	P,T
						1954	04	1961	07	P,T
	49	02	119	28	1,000	1961	08	1962	11	P,T
	49	04	119	31	1,025	1962	11			P,T

Table 2.2(a) (cont.)

Osoyoos West	49 02	119 29	1,030	1967	04	1970	05	P,T
	49 02	119 28	1,010	1970	06	1971	11	P,T
			1,015	1971	11			P,T
Oyama	50 06	119 22	1,300	1965	06			P,T
Peachland	49 45	119 45	1,250	1971	03	1973	06	P,T
	49 46	119 45	1,390	1973	07			P,T
Peachland Brenda Mines	49 52	120 00	4,790	1968	04	1970	05	P,T
			4,800	1970	05	1970	10	P,T
				1970	10	1970	11	P,T,F/P
				1970	12	1971	06	P,T,S,F/P
				1971	07	1972	09	P,T,E,W,H,S,F/P
				1972	09			P,T,H,S,F/P
Peachland CNR Dock	49 45	119 45	1,130	1971	07	1971	10	W
Penticton Airport	49 28	119 36	1,121	1941	04	1944	06	P,T,X
				1944	07	1959	07	P,T,W,X
				1959	08	1971	09	P,T,X
				1971	10	1973	04	P,T,I,S,X
				1973	05			P,T,I,E,W,S,X
Princeton Airport	49 28	120 31	2,283	1936	11	1938	02	P,T,X
				1938	03	1966	09	P,T,W,X
				1966	10	1969	01	P,T,X
				1969	02			P,T,W,X
Princeton 8NE	49 32	120 26	3,200	1971	11			P
Richland	50 13	118 30	2,350	1962	06			P,T
Salmon Arm	50 42	119 14	1,660	1911	07	1936	07	P,T,S
				1936	08	1938	03	P,T
				1938	04	1964	05	P,T,S
				1964	06			P,T,I,S
Salmon Arm 2	50 41	119 17	1,200	1950	04	1962	07	P,T
			1,300	1962	08			P,T
Shuswap Falls	50 18	118 49	1,450	1930	01	1949	02	P
				1950	04	1964	11	P
				1964	12			P,T
Summerland CDA	49 34	119 39	1,491	1919	11	1925	07	P,T,W,S
				1925	08	1926	12	P,T,S
				1927	01	1936	07	P,T,W,S
				1936	08	1938	03	P,T,S
				1938	04	1941	06	P,T,W,S
				1941	07	1955	03	P,T,S
				1955	04	1955	04	P,T,S,R
				1955	05	1958	03	P,T,I,S,R
				1958	04	1971	05	P,T,I,E,W,S,R
				1971	06			P,T,I,E,W,S,R,Q
Trapping Creek	49 39	118 57	3,800	1966	06			F/P
Vaseux Creek	49 15	119 19	3,800	1970	11			S/P
Venner Meadows	49 17	119 20	4,600	1971	01			S/P
Vernon Coldstream Ranch	50 14	119 12	1,582	1901	01			P,T
Vernon Silver Star Lodge	50 22	119 04	5,300	1970	07	1970	11	P,T
				1970	12	1972	04	P,T,S,S/P
				1972	04	1973	06	S/P
Vernon Southwest	50 15	119 19	1,300	1966	04	1967	04	P,T,S
	50 14	119 19	1,180	1967	05	1971	03	P,T,S
				1971	04	1973	10	P,T,E,W,S
Vernon Swalwell Lake	50 03	119 15	4,450	1970	12			S/P
Vernon Upper Air	50 14	119 17	1,821	1971	10	1972	03	P,T,W,X
				1972	04			P,T,I,W,X
Westwold	50 29	119 45	2,025	1921	05	1964	02	P,T
	50 28	119 45	2,020	1964	03			P,T
Winfield Wood Lake	50 03	119 23	1,500	1969	03	1971	09	P

INSTRUMENTATION CODE FOR TABLE

- P. Precipitation (daily measurement by AES standard raingauge).
- T. Temperature (daily maximum and minimum measured in a Stevenson screen).
- I. Intensity of rainfall (tipping-bucket recording raingauge).
- E. Evaporation (Class A evaporation pan).
- W. Wind (recording anemometer or wind-run totalizer).
- H. Humidity (based on wet and dry bulb temperatures or hydrograph measurements).
- S. Sunshine (Campbell-Stokes sunshine recorder).
- R. Radiation (insolation measured by pyrheliometer).
- Q. Net radiation (measured by a net radiometer).
- X. Hourly aviation weather reports including pressure, wind, temperature, humidity, visibility, weather and cloud.
- F/P. Fischer and Porter digital recording precipitation gauge.
- S/P. Standpipe storage precipitation gauge.

<u>Table 2.2(b)</u>
<u>Climatological Stations - Okanagan Basin and Adjoining Area</u>
<u>Active During All or a Portion of the Period 1921-1970</u>
<u>But Closed Prior to Start of Study</u>

Station Name	Latitude		Longitude		Elevation (feet)	Period of Record				Observing Program
						Began		Ended		
	°	'	°	'		Year	Mo.	Year	Mo.	
Adra	49	44	119	35	3,289	1928	09	1953	08	P
Alvaston	50	03	119	27	1,330	1915	06	1921	12	P,T
						1923	01	1923	12	P,T
Apex Mountain Lodge	49	23	119	15	6,100	1965	06	1966	10	P,T
*Armstrong	50	27	119	12	1,187	1913	03	1931	10	P,T
						1932	04	1969	08	P,T
Armstrong Grandview	50	24	119	17	1,650	1959	03	1960	06	P
Armstrong Grandview Flats	50	24	119	17	1,600	1949	01	1953	02	P,T
Bankier	49	43	120	14	3,600	1954	08	1959	07	P,T
Big White Mountain Lodge	49	44	118	56	6,050	1965	01	1968	06	P,T
Bridesville	49	02	119	09	3,490	1957	06	1961	07	P,T
						1962	04	1965	02	P
Carmi	49	30	119	05	4,084	1924	01	1925	08	P
						1939	01	1956	10	P,T,W,X
						1956	10	1958	01	P,T,W
						1958	02	1963	01	P,T,W,X
						1963	02	1963	03	P,T
						1963	04	1969	03	P,T,I
Cherryville	50	14	118	35	2,180	1959	04	1961	08	P,T
Chute Lake	49	44	119	31	3,916	1928	09	1944	04	P
						1944	05	1961	09	P,T
	49	41	119	32	3,916	1961	11	1962	10	P,T
Copper Mountain	49	18	120	34	3,946	1938	10	1946	06	P,T,X
*Enderby	50	32	119	07	1,180	1909	07	1927	07	P,T
Enderby Valecairn Farm	50	32	119	10	1,100	1966	02	1967	03	P
Falkland	50	30	119	33	1,929	1924	01	1931	04	P
Glenemma	50	22	119	19	-	1921	02	1925	02	P,T
Hedley NP Mine	49	20	119	59	4,500	1939	02	1955	05	P,T
Kelowna	49	54	119	28	1,160	1902	05	1962	09	P,T
Kelowna Airport	49	53	119	24	1,400	1950	06	1951	01	P
Kelowna Bankhead	49	54	119	18	-	1916	02	1921	12	P,T
						1923	01	1931	06	P,T
Kelowna Bowes Street	49	53	119	28	1,150	1961	08	1969	11	P,T
Kelowna CDA	49	50	119	25	1,590	1950	01	1958	05	P,T
	49	52	119	25	1,590	1958	05	1970	04	P,T
Kelowna Lakeview	49	51	119	34	1,400	1952	05	1960	12	P,T
Keremeos 2	49	13	119	50	1,361	1924	01	1943	09	P
Keremeos West	49	13	119	50	1,365	1962	08	1966	06	P
Kirton	49	40	119	57	2,900	1928	09	1933	12	P
						1934	05	1962	04	P
Lumby	50	14	118	58	1,700	1959	03	1967	12	P,T
Naramata	49	37	119	36	1,200	1924	01	1936	12	P,T
Okanagan Falls	49	21	119	32	1,650	1965	06	1968	09	P
Oliver Airport	49	11	119	34	995	1936	12	1937	09	X
						1938	06	1938	06	X
Oliver East	49	11	119	32	1,100	1962	08	1967	02	P
Osoyoos East	49	01	119	26	1,080	1962	08	1964	08	P
Osprey Lake	49	42	120	11	3,606	1928	09	1935	10	P
Peachland Trepanier Creek	49	47	119	50	1,800	1924	10	1943	05	P
Penticton	50	27	122	56	1,140	1907	04	1941	03	P,T
						1962	08	1965	09	P
Penticton Sewage Plant	49	30	119	36	1,129	1953	03	1954	09	I
						1954	10	1955	10	P,I
						1956	03	1967	02	P,I
						1967	03	1968	06	P
						1968	06	1969	11	P,I
Princeton	49	26	120	30	2,075	1901	01	1942	05	P,T
Rutland Mission Creek	49	58	119	27	3,000	1926	01	1935	09	P
						1935	10	1947	10	P,T
Summerland	49	36	119	40	1,100	1908	05	1923	06	P,T,S
Summerland CDA EL	49	34	119	39	1,135	1949	06	1953	12	P
						1954	01	1964	09	P,T
Vernon	50	15	119	16	1,383	1919	12	1920	03	P,T,X
						1920	04	1936	07	P,T,S,X
						1936	08	1938	03	P,T,X
						1938	04	1955	03	P,T,S,X
						1955	04	1960	04	P,T,S
Vernon BX	50	17	119	13	1,700	1960	04	1966	03	P,T,S
Woods Lake	50	03	119	27	1,330	1915	06	1939	01	P,T

*Reactivated - See Table 2.2(a)

Table 2.2(c)
Climatological Stations Re-activated, Installed or Upgraded for the Study

Name	Elevation (ft. above MSL)	Instrumentation
Apex Mountain Lodge	6200	P,T.H.S/P
Arawana	1700	P,T,E,W,H,S,S/P
Armstrong	1200	P,T
Armstrong Mountainview	1520	P,T
Boulcau Lake	4500	S/P
Enderby	1160	P,T
Esperon Creek	4600	S/P
Isintok Microwave	6300	S/P
Kelowna A	1368	E,(P,T,I,W,H,X)
Kelowna Bridge	1130	W,Q
Lumby	1670	P,T
Lumby Sigalet Road	1800	P
McCullock	4100	E,W,(P,T,S)
Mission Creek	5850	T,W,H,F/P
Naramata	1130	P,T,E,W
New Penticton Reservoir	5100	S/P
Okanagan Falls 2S	1100	P,T
Okanagan Mission	1340	P
Peachland	1250	P,T
Peachland Brenda Mines	4790	E,W,H,S,F/P,(P,T)
Peachland Marina	1135	W
Summerland CDA	1491	Q,(P,T,I,E,W,S,R)
Vaseux Creek	3800	S/P
Venner Meadows	4600	S/P
Vernon Silver Star	5300	P,T,H,S,S/P
Vernon SW	1200	E,W,H,(P,T,S)
Vernon Swalwell Lake	4450	S/P
Vernon Upper Air	1830	P,T,I,W
Winfield	1650	P,T

Instrumentation prior to augmentation in brackets.

CODE

P. Precipitation (daily measurement by AES standard raingauge).

T. Temperature (daily maximum and minimum measured in Stevenson screen).

I. Intensity of rainfall (tipping-buck recording raingauge).

E. Evaporation (Class A evaporation pan).

W. Wind (recording anemometer or wind-run totalizer).

H. Humidity (based on wet and dry bulb temperatures or hygrograph measurements).

S. Sunshine (Campbell-Stokes sunshine recorder).

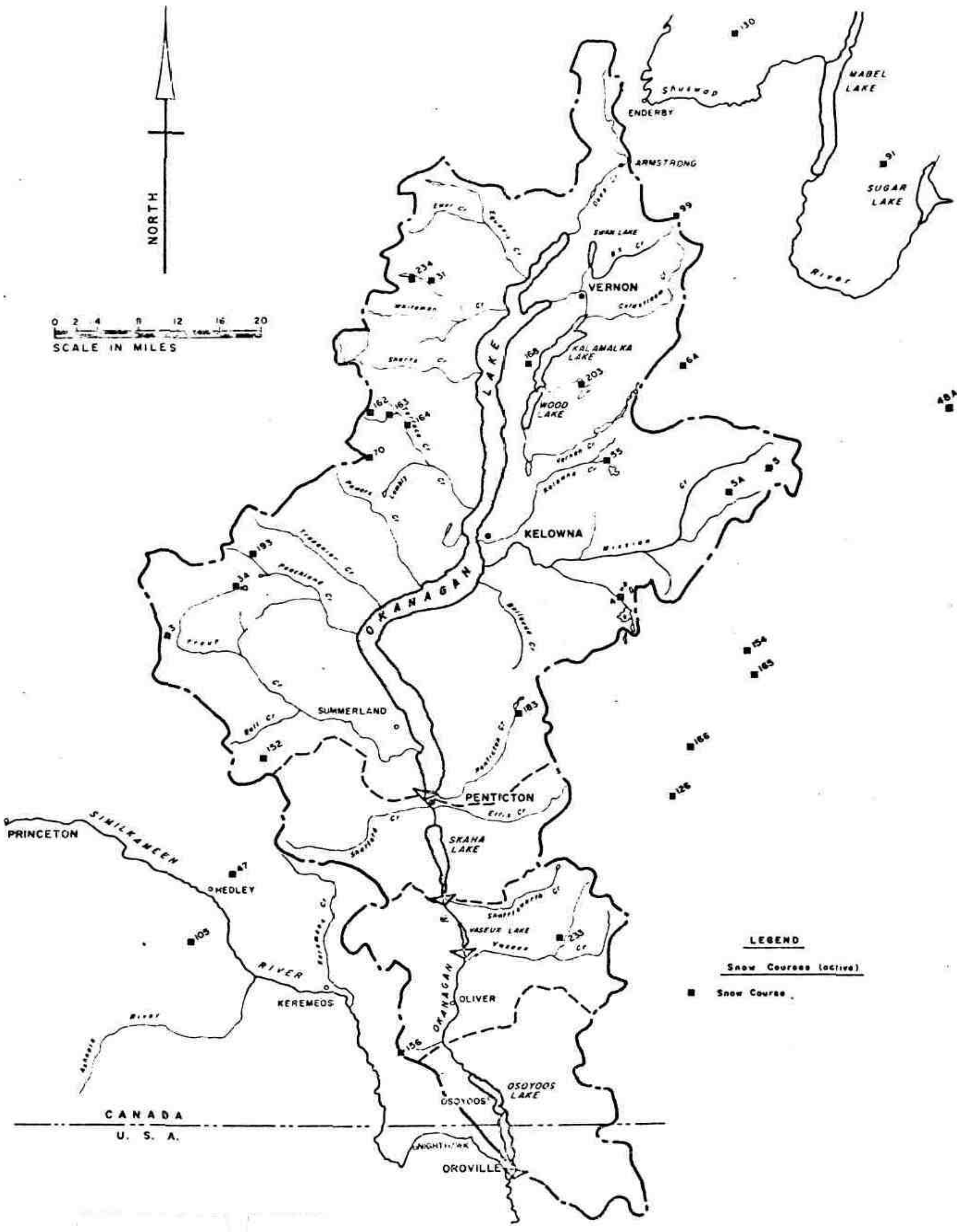
R. Radiation (insolation measured by pyrheliometer).

Q. Net radiation (measured by a net radiometer).

X. Hourly aviation weather reports including pressure, wind, temperature, humidity, visibility, weather and cloud.

F/P. Fischer and Porter digital recording precipitation gauge.

S/P. Standpipe storage precipitation gauge.



OKANAGAN BASIN
AND SURROUNDING AREA
SNOW COURSES

Figure 2.2

TABLE 2.3

ACTIVE SNOW COURSES - OKANAGAN BASIN AND SURROUNDING AREA

NUMBER	NAME	LATITUDE		LONGITUDE		ELEVATION (feet)	RECORD BEGAN
		°	'	°	'		
156	Mount Kobau	49	07	119	41	5,950	1966
105	Lost Horse Mountain	49	17	120	08	6,300	1960
47	Nickel Plate	49	23	120	02	6,200	1949
152	Isintok Lake	49	33	119	58	5,510	1965
3	Trout Creek	49	44	120	11	4,700	1935
3A	Summerland Reservoir	49	49	120	01	4,200	1935
193	Brenda Mine	49	53	120	00	4,800	1969
70	Whiterocks Mountain	50	01	119	45	6,000	1953
162	Esperon Cr. (Upper)	50	05	119	45	5,400	1966
163	Esperon Cr. (Middle)	50	04	119	42	4,700	1966
164	Esperon Cr. (Lower)	50	04	119	40	4,400	1966
234	Bouleau Lake	50	17	119	39	4,580	1971
31	Bouleau Creek	50	16	119	35	5,000	1947
130	Enderby	50	39	118	55	6,250	1963
91	Park Mountain	50	27	118	36	6,200	1958
48A	Monashee Pass	50	05	118	30	4,500	1949
99	Silver Star Mountain	50	22	119	03	6,050	1959
6A	Aberdeen Lake	50	09	119	03	4,300	1939
203	Oyama Lake	50	07	119	17	4,400	1969
168	Carrs Landing (Upper)	50	08	119	24	3,200	1967
55	Postill Lake	50	00	119	14	4,500	1950
5	Graystoke Lake	49	59	118	52	5,950	1935
5A	Mission Creek	49	57	118	55	5,850	1937
4	McCulloch	49	47	119	12	4,200	1935
183	New Penticton Res. No. 2	49	38	119	25	5,225	1967
233	Vaseux Creek	49	17	119	20	4,600	1971
154	Big White Mountain	49	43	118	56	5,500	1966
165	Trapping Cr. (Upper)	49	40	118	55	4,450	1966
166	Trapping Cr. (Lower)	49	33	119	03	3,050	1966
126	Carmi	49	30	119	05	4,100	1963

2.1.2 Precipitation

The Okanagan Basin lies in a zone of transition between the wet coastal climate with its winter maximum of precipitation and the truly continental climates further to the east with their strong summer peak in precipitation. The effects of strong topographic relief are well marked in the rainfall and snow-fall regime of the area. In addition, the considerable north-south extent of the watershed results in significant latitudinal variation even within the valley bottom as is evident from Table 2.4 and Figure 2.3.

On the large scale the Coast and Cascade Mountains cast a rain-shadow over the entire Basin. Annual precipitation totals well in excess of 100 inches are common on the western slopes of the coastal mountains. Some of the driest parts of British Columbia, including the southern Okanagan Valley, lie just

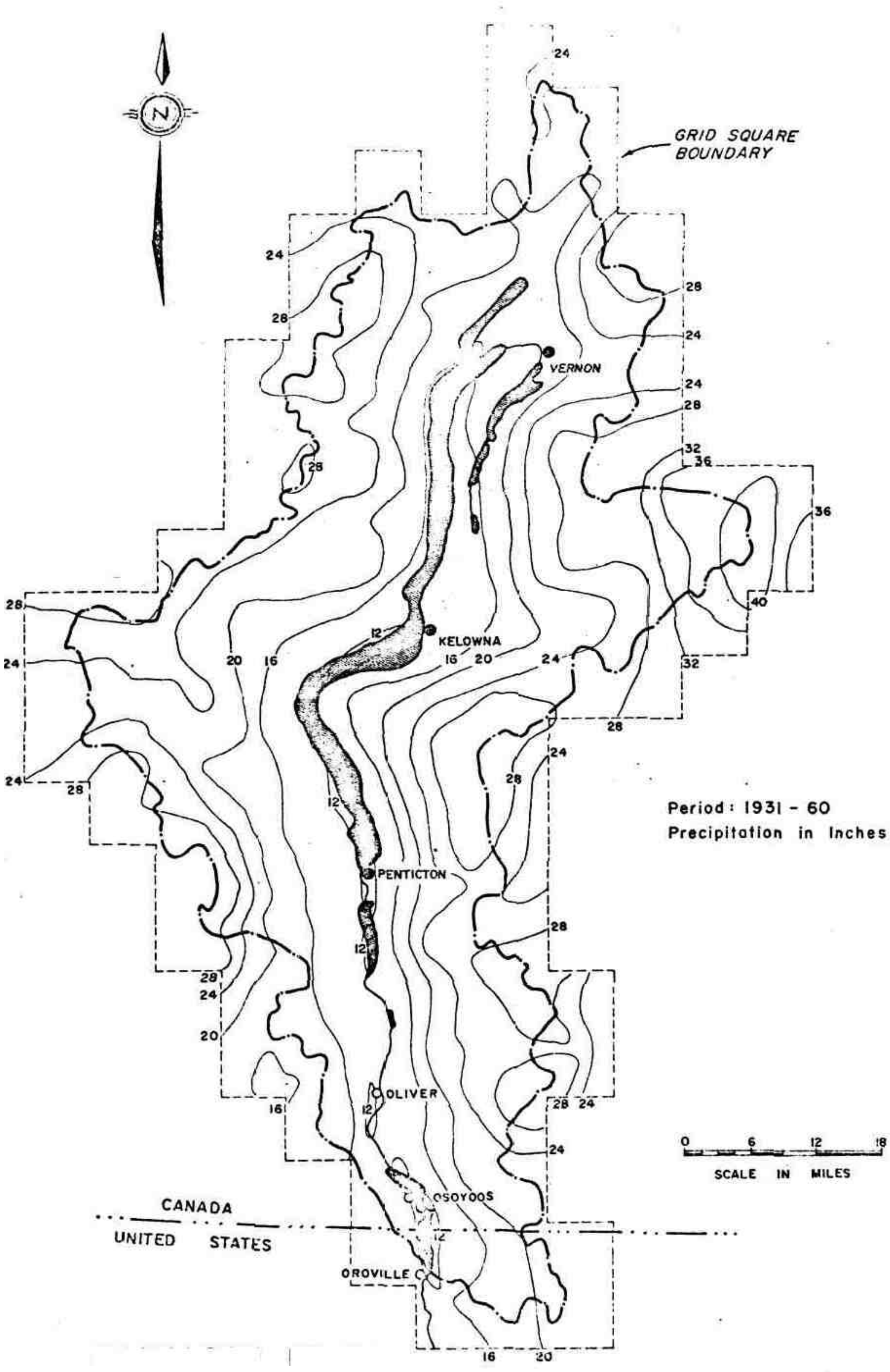
TABLE 2.4

Mean Precipitation Statistics (1941 - 70 Normals)

	Osoyoos	Oliver 2	Penticton A	Kelowna	Vernon	Armstrong	Joe Rich Creek	McCullock
Elevation (ft. above MSL)	1070	997	1121	1160	1383	1200	2870	4100
Mean Annual Precipitation (In.)	13.47 (8)	12.00 (1)	11.66 (1)	12.00 (8)	15.23 (8)	17.63 (2)	22.89 (2)	27.14 (1)
Mean Annual Rainfall (In.)	10.76 (8)	9.39 (1)	9.14 (1)	8.51 (8)	10.95 (8)	12.31 (2)	15.57 (2)	12.63 (1)
Mean Annual Snowfall (In.)	27.1 (8)	26.0 (1)	27.2 (1)	34.9 (8)	42.8 (8)	53.0 (2)	72.7 (2)	145.1 (1)
No. of Days with Measureable Precip.	86 (4)	79 (2)	100 (1)	105 (3)	118 (4)	97 (2)	120 (2)	136 (1)
No. of Days with Measureable Rain	68 (4)	63 (1)	77 (1)	83 (3)	84 (4)	70 (2)	78 (2)	65 (1)
No. of Days with Measureable Snow	19 (4)	19 (2)	28 (1)	22 (3)	33 (4)	27 (2)	46 (2)	74 (1)
Summer Month with Greatest Precip. and Mean Amount	JUNE 1.44 (8)	JUNE 1.25 (1)	JUNE 1.40 (1)	AUGUST 1,03 (8)	JUNE 1.49 (8)	JUNE 1.66 (2)	JUNE 2.49 (2)	JUNE 2.28 (1)
Winter Month with Greatest Precip. and Mean Amount	DECEMBER 1.80 (8)	DECEMBER 1.41 (1)	JANUARY 1.24 (1)	DECEMBER 1.58 (8)	DECEMBER 2.06 (8)	DECEMBER 2.34 (2)	DECEMBER 2.44 (2)	DECEMBER 3.16 (1)
Month with Minimum Precipitation and Mean Amount	SEPTEMBER 0.61 (8)	SEPTEMBER 0.63 (1)	MARCH 0.65 (1)	APRIL 0.64 (8)	MARCH 0.73 (8)	MARCH 0.90 (2)	FEBRUARY 1.42 (2)	APRIL 1.83 (1)

CODE FOR TYPE OF NORMAL

1. 30 years between 1941 and 1970.
2. 25 to 29 years between 1941 and 1970.
3. 20 to 24 years between 1941 and 1970.
4. IS to 19 years between 1941 and 1970.
5. 10 to 14 years between 1941 and 1970.
6. Less than 10 years.
7. Combined data from 2 or more stations.
8. Adjusted to full 30 year period.
9. Estimated.



OKANAGAN BASIN
MEAN ANNUAL PRECIPITATION

Figure 2.3

to the east of these same mountain barriers. This rain-shadow is most strongly felt in the southwestern portions of the Basin. To the north and east the effects of the coastal barrier diminishes and the upslope effects of the Okana-gan Highlands and Monashee Mountains begin to augment precipitation.

On a more local basis individual ridiges and ranges may markedly affect the spatial distribution of precipitation over any given sub-basin. Factors such as elevation, distance from and height of upstream mountain barriers and the cumulative effects of several such barriers all influence the patterns of accumulation of precipitation over the watershed. Models have been developed during the study (see Technical Supplement 2) which relate the spatial distribution of precipitation to such topographic factors.

In the spatial distribution of mean annual precipitation the over-riding influence of elevation is at once evident. Average precipitation at valley bottom is generally between 10 and 15 inches in the south and 15 to 20 inches in the north. By way of contrast the ridges surrounding the watershed receive 25 to 35 inches. In fact some of the higher terrain bordering the basin to the east is estimated to receive a total of 35 to 40 inches annually. These figures reveal not only the direct effect of elevation but also the superimposed increase from the dry southwest to the relatively much wetter northeastern portions of the watershed. The temporal distribution of the mean annual precipitation reflects the influences of neighbouring climatic regions. Both a coastal winter peak and a continental summer peak occur, each of nearly the same intensity. The month by month variations for Vernon are presented in Figure 2.4 as an example. Although many diverse situations occur, these two maxima can be related to the dominant atmospheric circulation patterns during those seasons.

In winter either December or January is normally the month of heaviest precipitation. At most locations this is also the annual peak. During that season a predominantly southwesterly flow of Pacific air streams overhead. Occluded maritime weather systems are directed across the coastal barrier to the interior. The moist maritime air aloft releases precipitation which may fall through residual cool interior air masses in the form of snow, or, if warmer maritime air has scoured out the valley, rain may fall at lower elevations even in mid-winter. An additional contribution to winter precipitations comes from disturbances within colder airmasses, most commonly moving along the Arctic front.

In summer June is normally wetter than its neighbouring months. Much of this precipitation is the result of heavy showers triggered by the passage of weak frontal disturbances. Expansion of the Pacific anticyclone towards the Gulf of Alaska results in predominant northwesterly winds over much of B.C. during summer months. Thus, unstable air masses move in from the northwest following frontal passages. Strong heating from the warmed land surface releases this instability in the form of convective showers or thunderstorms.

During the early summer migratory, non-frontal "cold lows" occasionally pass through southern B.C. from the northwest, west or southwest. Such storms may produce periods of several days of gloomy. Showery weather, sometimes with significant periods of heavy rainfall, before moving to the east of the region.

Spring and the period from mid-summer to fall mark the low points on the distribution of annual precipitation. Either March or April is normally the month of least precipitation, and, over much of the basin, is also the driest month of the year. The exception is the southern tip of the watershed, where September is the driest month. The fall minimum is less pronounced elsewhere and may consist of a mid-summer plus a late fall dip in the curve (for example, **see** Figure 2.4).

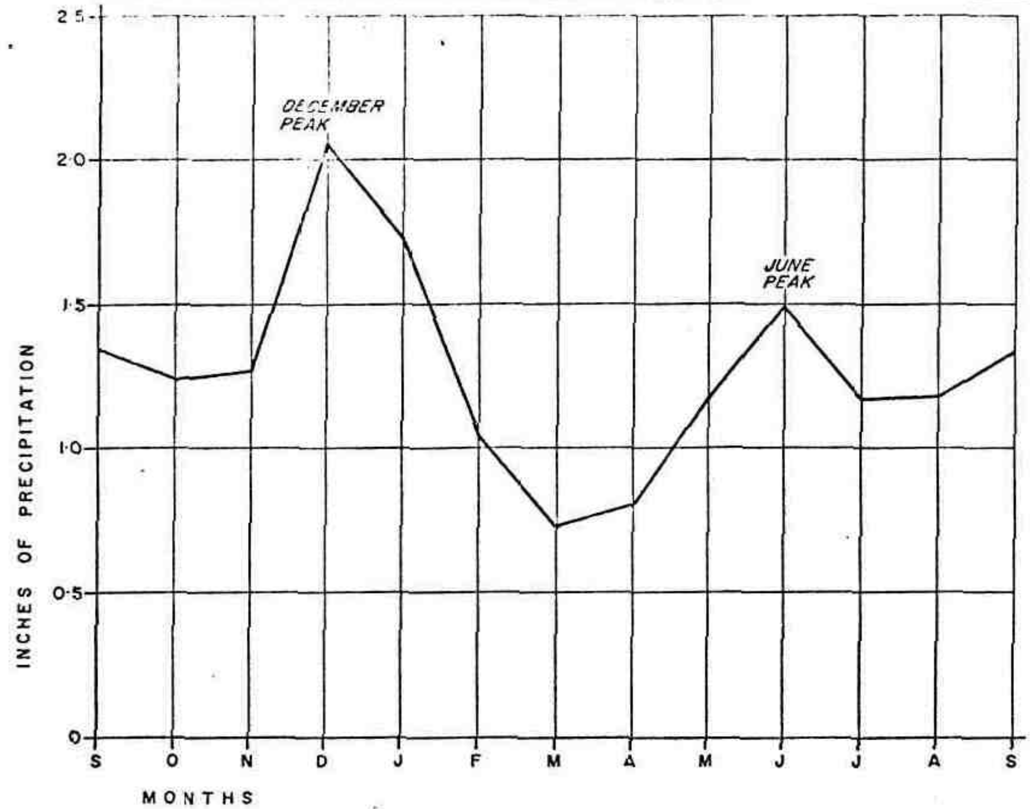
Table 2.4 summarizes much of the preceding discussion and shows clearly some interesting aspects of the north-south gradients along the valley as well as the marked changes up the slopes to the east. Most striking is the increase in snowfall amounts from a low of 25 to 30 inches south of Penticton to 45 to 55 inches north of Vernon even though station elevations increase only slightly. Similarly, the number of days with measurable snowfall increases from about 20 in the south to about 30 north of Penticton. Data for McCulloch (4,100 feet elevation) reveal the even more dramatic effects of elevation. It snows on an average of 74 days per year there, resulting in 145 inches of snowfall.

2.1.3 Snow Courses

The Okanagan River is a typical interior river which receives the major portion of its runoff during April to July inclusive from snow melt within the 4,000 to 7,000 foot elevation band outlined in Figure 2.6. This snow accumulates during the winter months increasing in density and usually in depth until it reaches the "ripened" stage near the end of April on into May.

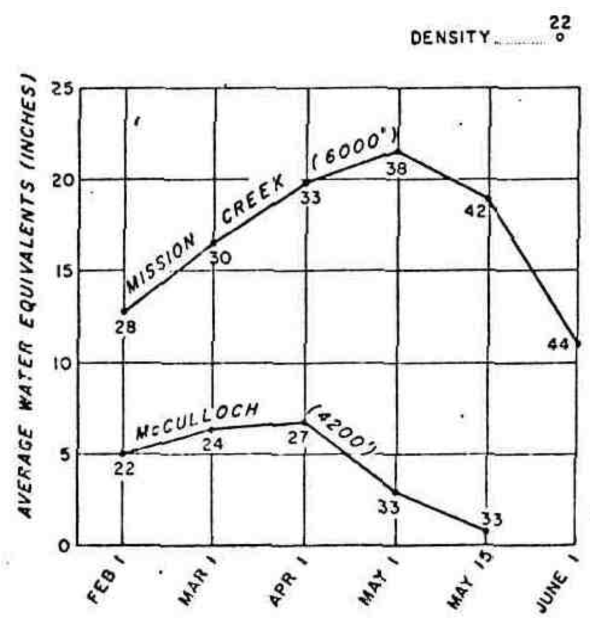
The average water equivalent in inches for two typical snow courses namely Mission Creek and McCulloch are shown in Figure 2.6 for the period February through June.

At the 6,000 foot level as represented by the Mission Creek course very little of the winter's accumulated snow pack (November through to March) melts while at the lower elevations at or below 4,000 feet as indicated by the McCulloch sampling winter temperature variations can result in early melt.



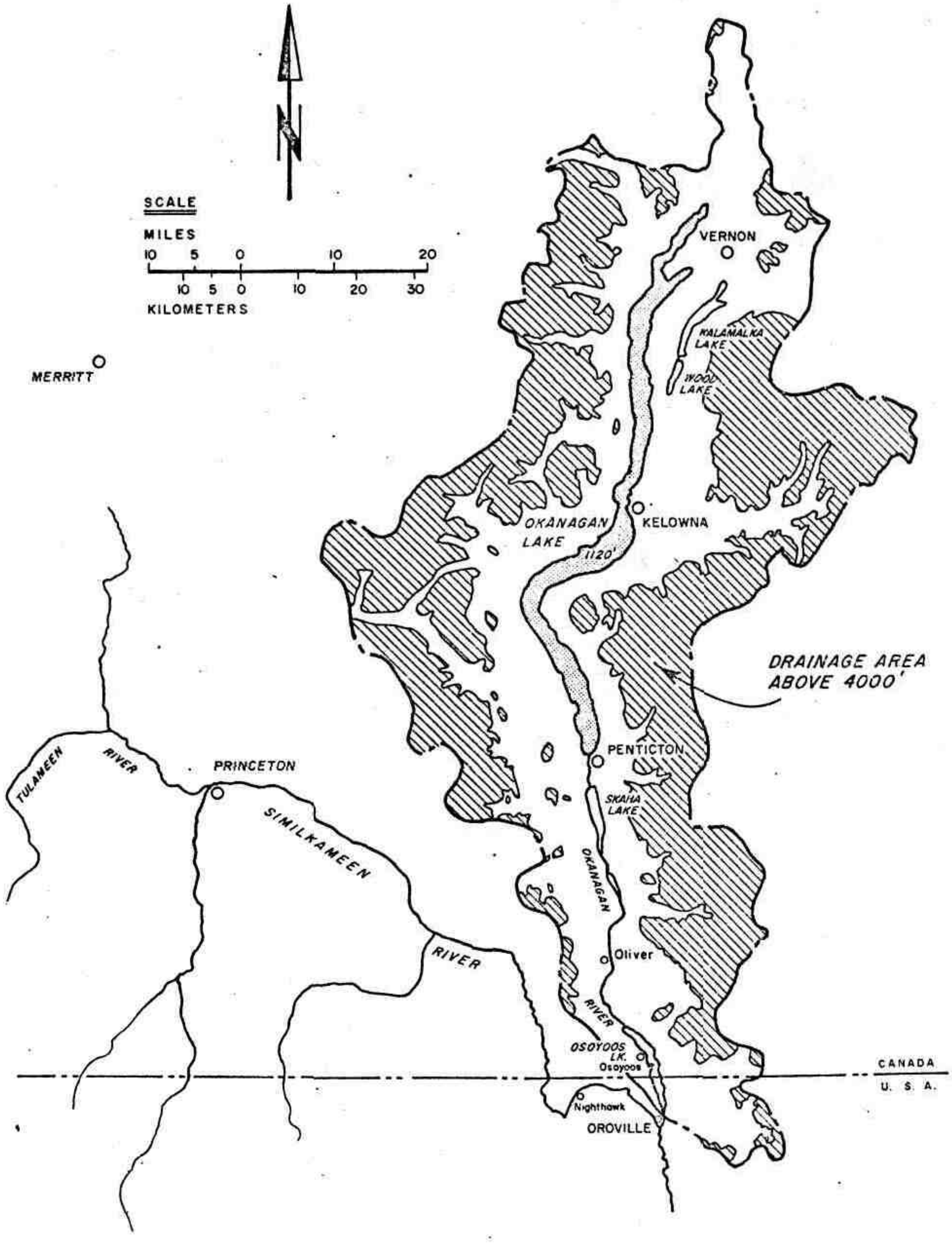
AVERAGE MONTHLY
PRECIPITATION AT VERNON

Figure 2.4



AVERAGE SNOW WATER EQUIVALENTS
MISSION CR. AND McCULLOCH SNOW COURSES
OKANAGAN LAKE BASIN

Figure 2.5



OKANAGAN BASIN NORTH OF OROVILLE
SHOWING UPPER DRAINAGE AREA
ABOVE 4000 FEET ELEVATION

Figure 2.6

Moreover, as indicated in the precipitation analysis there are areas where topography influences the spatial distribution of snowfall such as the rain-shadow area In the southwestern portion of the Basin. There the Trout Creek Course (elevation 4,700 feet) and the Mount Kabau Course (elevation 5,950 feet) have lower water equivalents than would be expected for their elevations.

April 1 mean water equivalents for a number of long-term snow courses have been plotted in Figure 2.7 against their respective elevation while Appendix B. details the fluctuation in snow water equivalents throughout the winter for selected snow courses as determined from snow surveys.

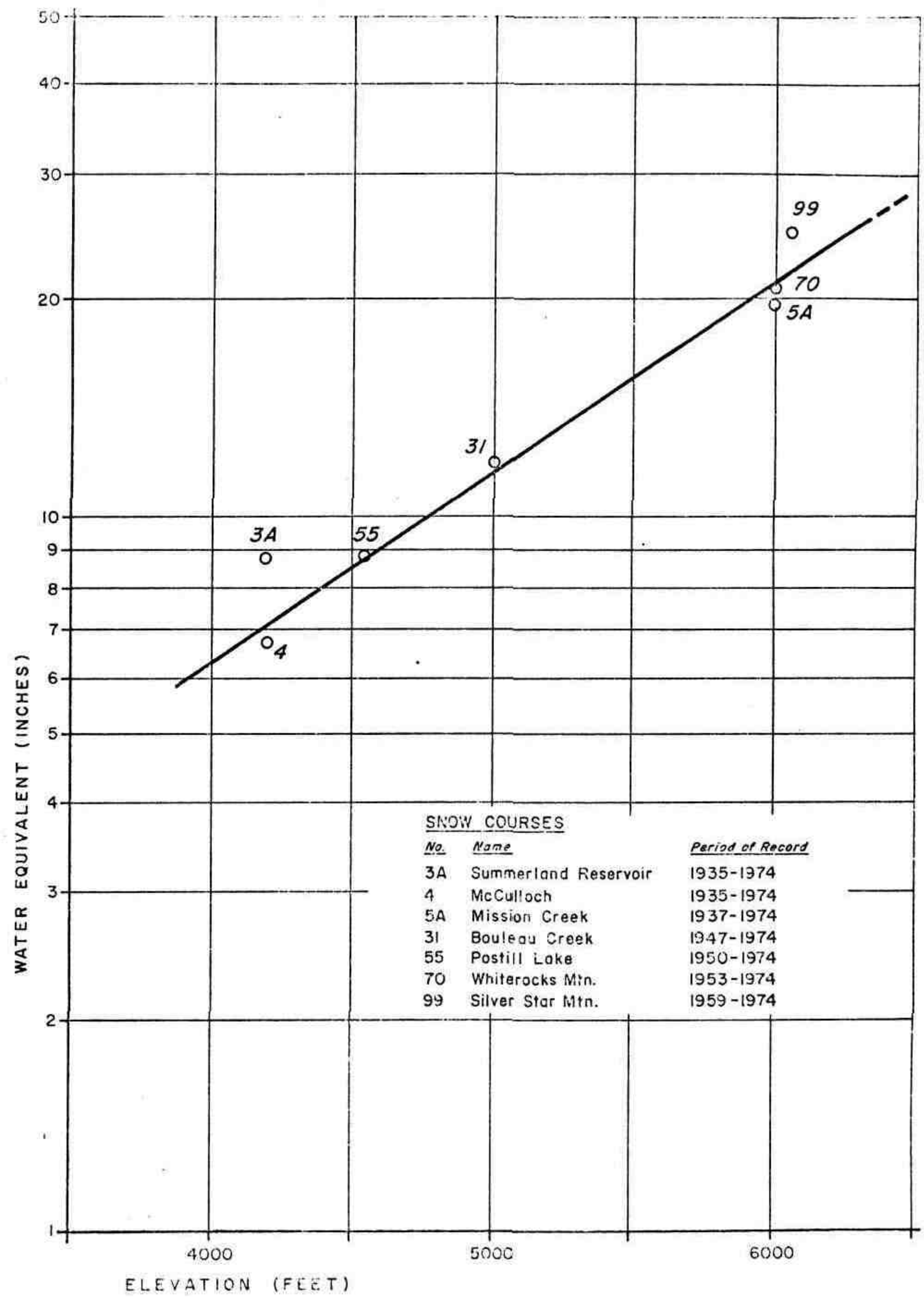
In general, the Valley floor is free of snow by mid March up to elevation 3,500 extending up to the 6,000 foot range by May 1.

2.1.4 Temperature

The temperature regime of the Okanagan Valley is best described as being of the mild continental type. In the valley summers are warm with hot days but cool and sometimes cold nights. Winters, while often cold, are much less extreme than is the case in areas to the north and east, which have more pronounced continental climates. The uplands are considerably cooler than valley sites but do not experience the very low extremes common to more northerly locations with similar mean temperature distributions.

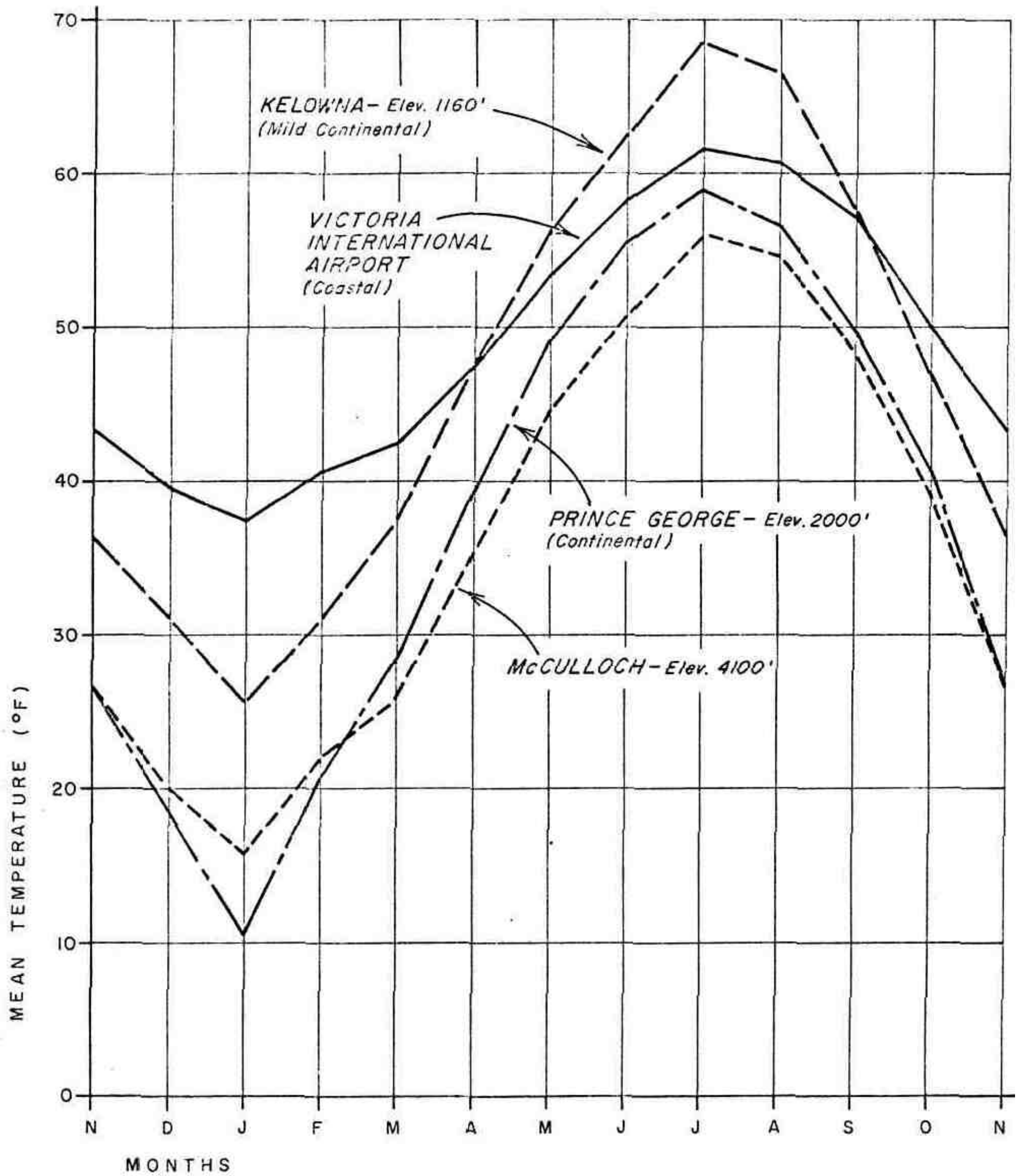
The variation of mean monthly temperatures in several distinct British Columbia regions are displayed in Figure 2.8. Kelowna and McCulloch are representative of the Okanagan Valley and Okanagan Highlands, respectively. -Victoria and Prince George represent the coastal and continental extremes for comparison with the Okanagan curves. The increase in annual range from Victoria (24.2°F) to Kelowna (42.8°F) is the result of much milder winters on the coast coupled with warmer summers in the Okanagan Valley. The strong control Of elevation is evident in Figure 2.8. McCulloch (4,100 feet) has a mean annual temperature slightly below that of Prince George, which is located almost 300 miles to the north at just over 2,000 feet in elevation. Summers are slightly cooler at McCulloch but winters are less severe than those at Prince George (absolute minima of -43°F and -58°F respectively).

Mean daily maximum temperatures in the Okanagan cover a wider annual range than do the mean temperatures depicted In Figure 2.8. This is due to the larger daily range in summer. In Kelowna, mean maximum temperatures vary from 31.4°F in January to 82.4°F in July (i.e. a spread of 51.0°F). Thus, about one-third of mid-summer days are tropical in nature (maximum temperature • 86°F) and thaws occur at valley bottom on about half of days in January, at the coldest time of year.



SNOW COURSE WATER EQUIVALENT (APR 1st)
VERSUS ELEVATION, OKANAGAN LAKE BASIN

Figure 2.7



VARIATION OF MEAN MONTHLY TEMPERATURES
AT 4 SELECTED STATIONS IN B.C.

Figure 2.8

Table 2.5 illustrates the gradual decrease in temperature from south to north along the valley bottom and the more sharply declining temperatures encountered on the steeply rising terrain to the east. Mean annual temperatures near 50°F at valley bottom just north of the U.S. border rank among the highest in Canada. These values slowly drop to about 47 degrees near Okanagan Lake and to 45 degrees in northern sections of the valley. Joe Rich Creek (2,870 feet) averages less than 40°F and McCulloch (4,100 feet) only 36.6°F. Similar trends are apparent in most other parameters listed in Table 2.5.

Absolute extremes of temperature are strongly dependent on the local measurement site. In general terms, valley locations have all exceeded 100 degrees. A high of 111°F was recorded at a site in Oliver with an elevation of 997 feet. Even upland stations have recorded values close to 100 degrees. At the opposite end of the scale absolute minimum readings vary from the range of -15 to -25 degrees in the south to values in the range of -30 to -45 degrees in the north. A minimum of -47°F has been reported at Joe Rich Creek. These values indicate the wide range of temperatures possible over the Okanagan Watershed.

The lowest minima and spells of coldest weather are brought by invasions of continental arctic air. This cold dense air frequently spills across the Rockies into the Central Interior of British Columbia, but much less frequently reaches the more protected Okanagan region. When it does its route can normally be followed as it plunges southward across the central plateau and along the Fraser River. It then pushes eastward up the tributary system of the Thompson, finally being deflected southward by the barrier of the Monashee Mountains into the Okanagan Valley. The hottest spells in summer occur when a southerly circulation brings hot, dry continental tropical air into the region from the sun-baked plateaus of the western United States.

2.1.5 Wind

Surface winds in the Okanagan Basin are controlled by three major factors. These include the large-scale wind patterns in the atmosphere above the area, the configurations of regional and local topography and the presence of large lakes in the valley. These factors often interact in complex ways, although the overiding influence of the north-south orientation of the main va11ey on mean winds is very evident. The lake-land thermal contrast is also prominent in the diurinal variations of wind near larger lakes.

Mean atmospheric circulation at ridge top elevations goes through a well marked annual cycle as discussed earlier in connection with the mean precipitation regime. Winter southwesterlies are strongest, averaging 15 to 20 miles per hour. Northwesterly winds are dominant in summer but with average speeds

<u>Table 2.5</u>

<u>Mean Temperature for Selected Stations in Okanagan Basin (1941-1970 Normals)</u>

	Osoyoos	Oliver	Penticton A	Kelowna	Vernon	Armstrong	Joe Rich Creek	McCulloch
Elevation (ft. above MSL)	1070	1000	1121	1160	1383	1200	2870	4100
Mean Daily Temp. for the Year	49.7 (4)	48.2 (1)	47.9 (1)	47.2 (3)	46.9 (4)	44.7 (1)	39.7 (3)	36.6 (1)
Mean Daily Maximum Temp.	58.8 (4)	60.0 (1)	58.2 (1)	57.1 (3)	55.8 (4)	56.2 (1)	52.5 (3)	49.1 (1)
Mean Daily Minimum Temp.	40.5 (4)	36.4 (1)	37.5 (1)	37.2 (3)	36.9 (4)	33.2 (1)	26.8 (3)	24.0 (1)
Greatest Temp.	101	109	105	102	104	105	98	98
Lowest Temp.	-14	-23	-17	-24	-31	-44	-47	-43
# of Years of Record	17	34	30	62	45	56	23	34
# of Days with Frost	114 (4)	146 (1)	130 (1)	137 (3)	139 (4)	169 (2)	227 (3)	257 (2)
Mean July Temp.	71.8 (4)	69.6 (1)	68.2 (1)	68.5 (3)	68.3 (4)	66.6 (1)	58.9 (3)	56.0 (1)
Mean January Temp.	27.0 (4)	25.6 (1)	26.7 (1)	25.7 (3)	21.2 (4)	20.4 (1)	17.2 (3)	16.0 (1)
Mean Annual Range	44.8 (4)	44.0 (1)	41.5 (1)	42.8 (3)	47.1 (4)	46.2 (1)	41.7 (3)	40.0 (1)

All temperatures in °F

<u>CODE FOR TYPE OF NORMAL</u>

1. 30 years between 1941 and 1970.
2. 25 to 29 years between 1941 and 1970.
3. 20 to 24 years between 1941 and 1970.
4. 15 to 19 years between 1941 and 1970.
5. 10 to 14 years between 1941 and 1970.
6. Less than 10 years.
7. Combined data from 2 or more stations.
8. Adjusted to full 30 year period.
9. Estimated.

of only 8 to 12 miles per hour. Mean winds during the transitional spring and fall periods are westerly with speeds midway between the two extremes.

These atmospheric winds are channeled by the terrain and interact with local circulations produced by heating and cooling to create the winds that are observed at ground level. As one would expect, winds blowing up and down the main north-south valley strongly dominate the statistics. This is particularly well illustrated by the mean annual wind rose for Penticton Airport (Figure 2.9). North and south winds are equally common and if south-southeast and north-northwest directions are included almost 70% of hours with winds are accounted for. The generally sheltered position of locations at the bottom of a deep valley is illustrated by the relatively high percentage of calms (21%). These reach their peak frequency during September and October when stagnant high pressure patterns dominate the weather.

The mean annual regime presented in Figure 2.9 is in reality composed of two well marked and opposite seasonal patterns. Table 2.6 presents month by month statistics which clarify these seasonal differences. In summer the upper air circulation is from the northwest. The sun-baked land surface is warmer than the deep lakes with their relatively slower response to the seasonal warm-up. Thus the situation favours a well defined lake-breeze circulation in which air rises over the warm land, sinks over the cooler water and flows from north to south at Penticton. In fact, over 60% of hours with winds are accounted, for when frequencies from the north and northwest are added. Such winds tend to diminish to near calm after sunset with the cutoff of the solar energy required to drive the circulation.

In winter a stronger upper circulation flows from the southwest. In addition, the land surface is now cooler than the generally open waters of Okanagan Lake, a situation which favours a land breeze or southerly winds at Penticton. Thus, during winter the frequency of south or south-southeast winds climbs to 60% of hours with wind while the comparable frequency of northerly winds drops to nearly 10%. Mean speeds reach their peak at this time of year attaining 15 to 18 miles per hour.

Although Penticton has been singled out in the above discussion, the overall wind regime will be similar at most valley bottom locations near Okanagan Lake. At locations somewhat removed from the lake the overall up and down valley winds will still dominate the mean wind regime: however, the lake-breeze circulation may be replaced by local drainage winds coming down the steep side-slopes into the main valley. In a typical case, the slopes west of Okanagan Lake cool rapidly after sunset. A thin layer of relatively denser air cooled by contact then gravitates down the drainage pattern much as would

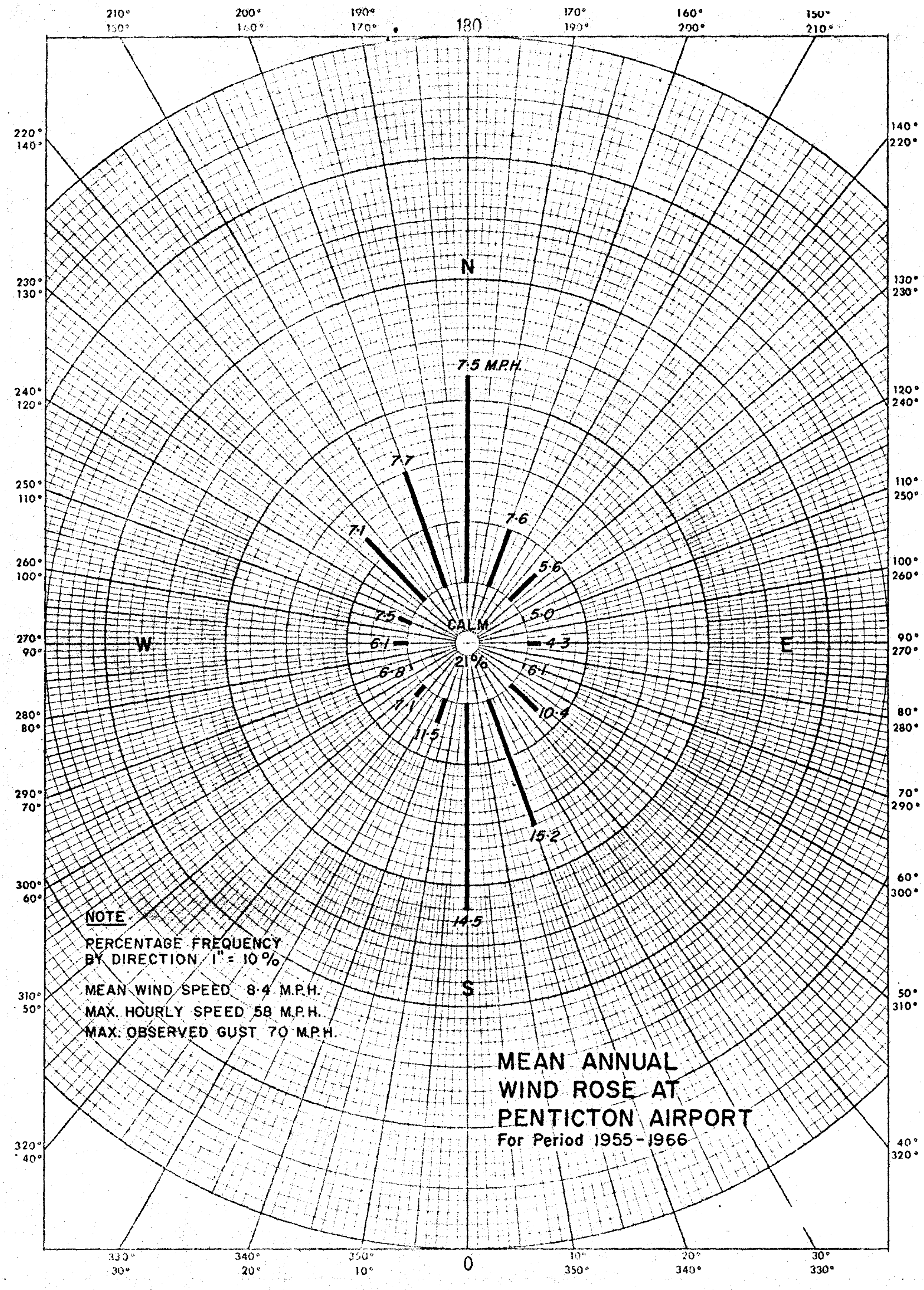

N
S
E
W
7·5 M.P.H.
7·7
7·1
7·6
5·6
5·0
4·3
6·1
10·4
15·2
14·5
11·5
7·1
6·8
6·1
7·5
CALM
21%
NOTE
PERCENTAGE FREQUENCY BY DIRECTION 1" = 10%
MEAN WIND SPEED 8·4 M.P.H.
MAX. HOURLY SPEED 58 M.P.H.
MAX. OBSERVED GUST 70 M.P.H.
MEAN ANNUAL WIND ROSE AT PENTICTON AIRPORT
For Period 1955-1966

Figure 2.9

Table 2.6

Wind Direction and Velocities at Penticton Airport

Penticton (A), British Columbia

Period 1955-66													Height of Anemometer 93'
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year	
Percentage Frequency														
N	8	12	13	18	22	22	27	27	24	13	10	7	17	N
NNE	2	3	4	5	6	7	9	9	7	4	4	2	5	NNE
NE	2	2	2	3	4	5	5	5	4	3	2	1	3	NE
ENE	*	*	*	*	*	1	*	*	1	1	*	*	*	ENE
E	*	*	*	1	1	1	1	1	1	1	*	*	1	E
ESE	*	*	*	*	*	*	*	*	*	*	*	*	*	ESE
SE	5	4	4	3	3	2	2	1	2	3	3	4	3	SE
SSE	22	17	12	9	7	6	3	4	5	10	16	24	11	SSE
S	28	24	21	14	11	8	7	7	7	18	26	31	17	S
SSW	3	3	3	2	1	2	1	1	1	3	5	4	2	SSW
SW	1	1	2	2	2	2	1	1	1	1	1	1	1	SW
WSW	*	*	*	1	1	1	*	1	*	*	*	*	*	WSW
W	*	*	1	2	2	2	1	1	1	1	1	*	1	W
WNW	1	1	1	1	1	1	1	1	1	1	1	1	1	WNW
NW	6	6	6	7	7	8	8	7	7	6	5	5	7	NW
NNW	6	9	9	10	12	10	14	13	13	8	6	4	10	NNW
Calm	16	18	22	22	20	22	20	21	25	27	20	16	21	Calm
Average Wind Speed in Miles Per Hour														
N	7.8	7.8	7.4	7.9	7.8	7.7	7.6	7.6	7.6	6.6	7.0	6.8	7.5	N
NNE	7.8	8.2	6.8	8.8	8.1	8.4	8.4	8.0	7.5	6.1	6.6	6.6	7.6	NNE
NE	6.1	5.0	5.4	6.4	6.2	5.7	6.4	6.6	5.2	4.0	5.3	4.9	5.6	NE
ENE	5.9	3.7	4.8	5.8	6.0	5.1	5.2	5.0	5.4	3.4	4.8	4.6	5.0	ENE
E	3.5	5.7	4.0	4.7	4.9	4.3	4.6	4.2	4.1	3.6	5.8	4.1	4.3	E
ESE	5.3	6.4	5.7	8.8	5.0	5.5	5.8	5.3	5.7	4.5	6.8	7.8	6.1	ESE
SE	14.2	12.6	10.8	9.0	8.1	7.7	7.2	8.7	9.1	10.5	13.1	13.9	10.4	SE
SSE	17.9	17.0	15.3	15.0	14.5	14.2	12.3	12.5	13.7	15.6	17.1	17.7	15.2	SSE
S	15.9	15.5	15.3	13.6	12.4	12.0	11.2	11.4	13.8	16.9	17.2	18.5	14.5	S
SSW	13.5	12.1	11.4	9.2	8.5	9.2	9.5	7.6	11.1	14.3	15.9	15.2	11.5	SSW
SW	8.1	6.1	6.7	7.5	7.1	6.5	7.2	5.6	6.3	9.4	8.5	6.7	7.1	SW
WSW	4.5	5.7	6.5	8.2	8.5	8.9	8.4	6.2	7.2	6.4	5.6	5.4	6.8	WSW
W	5.5	5.2	6.4	8.1	7.6	7.1	6.8	5.5	6.1	5.5	5.2	4.3	6.1	W
WNW	9.7	7.6	7.9	8.7	7.2	8.0	7.0	6.5	6.4	5.6	7.0	7.8	7.5	WNW
NW	8.8	7.5	7.0	6.9	6.4	6.2	6.4	6.2	6.6	6.6	8.3	8.7	7.1	NW
NNW	8.6	8.5	7.3	7.9	7.8	7.6	7.4	7.1	7.6	7.2	7.8	7.2	7.7	NNW
All Directions														
	11.5	10.0	8.5	7.5	7.0	6.5	6.3	6.2	6.3	7.9	10.6	12.2	8.4	

Maximum Observed Hourly Speed 58 S
Maximum Observed Gust Speed 70
Probable Maximum Gust for
Maximum Hourly Speed 81

Station Information

Airport is located 3 miles south of town in a north-south valley. There are mountains 3 miles to the east and 1 mile to the west.

Table 2.7

Mean Humidity, Cloud and Sunshine at Okanagan Valley Stations

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Mean Relative Humidity (%) (Penticton A)	81	76	67	57	56	55	49	54	61	69	77	83	
Mean Mixing Ratio (gr/lb) (Penticton A)	18	22	23	30	39	49	53	55	46	36	26	23	
Mean Cloud Amount (tenths) (Penticton A)	8.3	7.4	6.6	6.1	6.0	6.6	3.9	4.3	4.8	6.3	7.7	8.3	6.4
Mean hours of Bright Sunshine (Summerland CDA)	47	82	140	196	240	242	313	282	201	131	57	41	1972

flowing water. As the lower valley bottom fills with the cool air the brief, gusty surge of katabatic wind gives way to the calm within the cool air itself. In such areas a more gentle circulation moves up the warmed tributary valleys by day.

Winds in the uplands are less strongly dominated by topography than those In the deeply Indented valleys and therefore are more free to follow atmospheric circulations. However, the frictlonal effect of the forest highlands produces surface wind speeds much reduced from those in the free atmosphere and not greatly different from those in the valley. Isolated peaks or more exposed upland areas are noticeably more windy.

2.1.6 Humidity, Cloud and Sunshine

The Okanagan region is characterized by cool humid air and cloudy skies in winter and by dry air with bright skies in summer. Mean humidity and cloud data for Penticton Airport and mean sunshine data for Summerland CDA are summarized in Table 2.7.

The mean annual number of hours of bright sunshine in the Okanagan Valley falls short of the more than 2,000 hours recorded in several other areas of the Province, including Victoria, the dry belt of the Thompson River Valley and the Peace River area near the Alberta border. Nevertheless the differences are hot large and in comparison with many coastal areas the Okanagan can be considered to be a sunny region.

During the winter months mean relative humidities linger in the high seventies or low eighties with only slight diurnal variation. Such relative humidities are only slightly below comparable coastal values: however, due to lower air temperatures, the actual vapour content of the air (as revealed by the mean mixing ratios in Table 2.7 is only two-thirds of that measured on the coast.

From November through February the Okanagan is as cloudy and sunless as the coast even though precipitation amounts are far smaller. Low stratiform clouds frequently cover the sky and in their absence sunshine Is often prevented by mid-level clouds of Pacific origin moving overhead in the southwesterly air currents.

During the summer air masses over the Okanagan are markedly drier. Mean relative humidities drop from winter values of 80% to 50%. (On the coast, values of 75 to 80% persist through the summer). A much more pronounced diurnal cycle becomes established with early morning averages of 75% and afternoon values near 40%. Despite low relative humidities and due to higher interior temperatures, the absolute vapour content of the air is 80 to 90% of that on the coast during summer.

A marked decrease in mean cloud cover occurs between June and July. Following June, which is a month of heavy precipitation, the frequency of overcast or nearly overcast skies (8-10/10) drops from near 50% to only 30% while the frequency of scattered clouds (0-2/10) does the reverse. Mean cloud cover is at its minimum in the early morning hours of July, August and September. During summer afternoons cumulus clouds, rare in winter, normally form. These frequently develop to the heavy cumulus stage particularly over upland regions. Further development to the thunderstorm stage is related to the heat of the season as revealed by the July peak In the mean number of days with thunder at Penticton (4.2 days out of 14.7 for the year). These showers are normally brief and the sky does not remain heavily clouded for long as is evidenced by a mean cloud total in July of only 3.9 (out of 10.0) which is among the lowest recorded in British Columbia.

2.1.7 Evaporation and Evapotranspiration

In the following discussion evaporation refers to water loss to the atmosphere from a free water surface such as a lake or a pond. Evapotranspiration includes all water transferred to the atmosphere as vapour from a given area, either directly from water and land surfaces or through plant transpiration. In an arid area such as the Okanagan Basin the atmospheric demand for water vapour commonly outstrips the supply of water to land surfaces and to plants. Thus, substantial differences often exist between mean evaporation and mean evapotranspiration from any given area. Each of these two phenomena are discussed below along with their spatial and temporal distributions over the Okanagan watershed.

Evaporation from a free water surface is dependent upon the surface temperature of the water and on the demand of the atmosphere for its vapour. In turn the atmospheric demand is primarily a function of the moisture content of the air and the surface wind speed. Thus, warm water, dry air and strong winds result in rapid evaporation. Evapotranspiration involves not only atmospheric demand but also the added complexities of surface characteristics, plant physiology and water limitation.

Direct measurement of either of the above quantities over natural surfaces has largely defied practical solution. Therefore, a variety of methods of estimation, mostly of an empirical nature, have been developed. Water loss from evaporation pans or smaller evaporimeters may be used as indices of natural evaporation or evapotranspiration. In the widely used Thornthwaite method the potential evapotranspiration (i.e. water loss assuming an adequate moisture supply) is first computed using a statistical relationship to mean monthly air temperatures. Actual evapotranspiration is then obtained by introduction of precipitation and soil moisture values through a set of water-budgeting rules.

There are difficulties and limitations involved in the application of either of these or other empirical approaches. Use of the more physically realistic energy budget method is also particularly difficult in an area of sharp dry-wet contrasts such as the Okanagan Valley, due to horizontal energy advection. In advectlon situations heat gained by the air over dry regions is used to increased evapotranspiration over moist areas. This so called "oasis effect" contributes significantly to evapotranspiration over lakes and irrigated agricultural land in the otherwise dry Okanagan Valley invalidating a straightforward budget including computed evapotranspiration based upon the vertical energy flows normally measured.

In Canada and the United States the Class A Evaporation Pan (as described in Appendix A) Is the standard network evaporation instrument. Empirical studies have determined that evaporation from small lakes with negligible heat storage capacity is equivalent to 70 per cent of the pan water loss plus or minus a correction factor dependent upon air temperature, water temperature and wind speed (Kohler, Mordenson, and Fox, 1955). This approach has been used to prepare national maps of mean "lake evaporation" in both the United States and Canada (Kohler, Nordenson and Baker, 1959: Ferguson, 0'Neill and Cork, 1970). (See Appendix A). These national maps depict average conditions over larger areas and since, in Canada at least, they are based upon a sparse network concentrated below 3,500 feet elevation they lack the degree of detail desired in the Okanagan Basin.

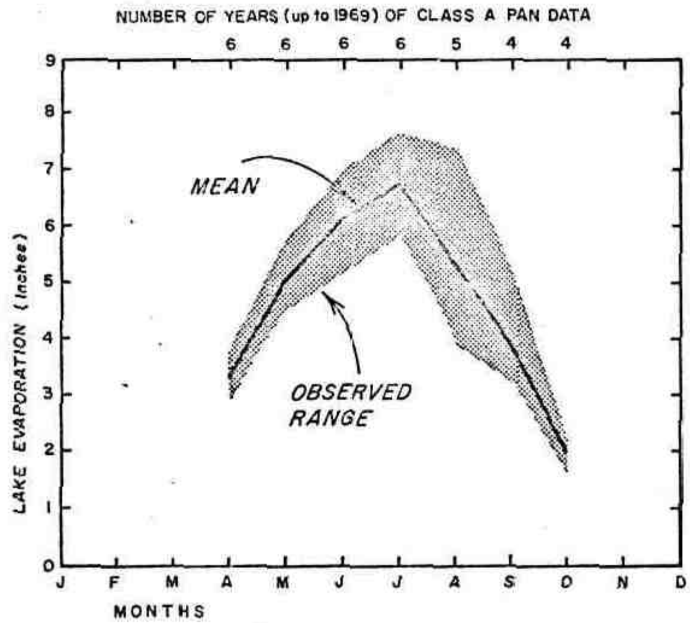
In view of the requirement for estimates of evaporation and evapotranspiration from various sub-basins, elevation bands and terrain types It was necessary to construct a model based upon a synthesis of relevant experimental and theoretical material. Lake evaporation values as obtained from network Class A pan data and their variations with latitude and elevation provided the first step. Such measurements were begun at Summerland Experimental Station (Summerland CDA) in April, 1958. In addition, short periods of record were available from the six additional stations installed during the current study. It was determined that lake evaporation decreases with increasing latitude by six per cent per degree of latitude, using Summerland CDA normal values adjusted to 1,000 feet above sea level as a base. Further, it was found that lake evaporation decreases with increasing elevation at rates dependent on the month but averaging just over five per cent per 1,000 feet for the year, again based upon Summerland CDA normals.

The average annual lake evaporation at Summerland is 34.5 Inches. Mean and extreme monthly values during the ice-free pan measurement season are presented In Figure 2.10. Values below 1.0 inches are estimated from clima-tological data for the months of November through February with a minimum of 0.1 inches in January. A sharp peak of 6.76 inches in July coincides with the peak in the mean daily temperature curve (Figure 2.8).

The spatial distribution of mean annual lake evaporation based upon the model previously described is presented in Figure 2.11. Strongest evaporation occurs at low elevation in the vicinity of Osoyoos Lake, where values as high as 36 Inches are estimated. Decrease with latitude reduces values to 32.5 Inches near the north end of Okanagan Lake. Model estimates as low as the 26 to 27 inch range are given for higher terrain bordering the watershed both to the east and to the west.

The above evaporation estimates are pertinent to small reservoirs and lakes at various elevations and locations within the Okanagan watershed. Of more significant to the general water balance of the area is the amount of evaporation from large lakes and evapotranspiration from a variety of surfaces including natural and agricultural plant communities. For the purpose of mapping mean actual evapotranspiration an empirical model was developed relating mean actual evapotranspiration to mean lake evaporation on a month by month basis. Ratios were determined for each of five cover types which included water at valley bottom (i.e. large lakes), water above 2,000 feet (i.e. small lakes and reservoirs), irrigated land, forested land and open land. Grid square values were then computed based upon the percentage of each cover type within each 5km X 5km square. (Details are given in Technical Supplement II).

The above model incorporates a variety of factors including the reduction of evapotranspiration during seasons of water limitation, the "oasis effect" over irrigated lands and seasonal lags in evaporation from large lakes due to their thermal capacity. Because of these complexities resultant patterns at a resolution of five kilometers show sharp discontinuities near large lakes and at boundaries of Irrigated regions. For this reason the map mean annual evapotranspiration values shown in Figure 2.12 does not Include isolines. In general, however, it can be seen that values estimated by the model are in excess of 30 inches over large lakes, that they decrease to as little as 10 to 15 inches over dry open lands in the south, and that there is a gradual increase in evapotranspiration with elevation in the forested highlands to over 25 inches in several areas. Detailed values of month by



NOTE: FROM ATLAS OF CANADA 1967~1970
ATMOSPHERIC ENVIRONMENT SERVICE
ENVIRONMENT CANADA

LAKE EVAPORATION AT SUMMERLAND, B.C.
ZONE 3(b) – WESTERN MOUNTAINS

Figure 2.10

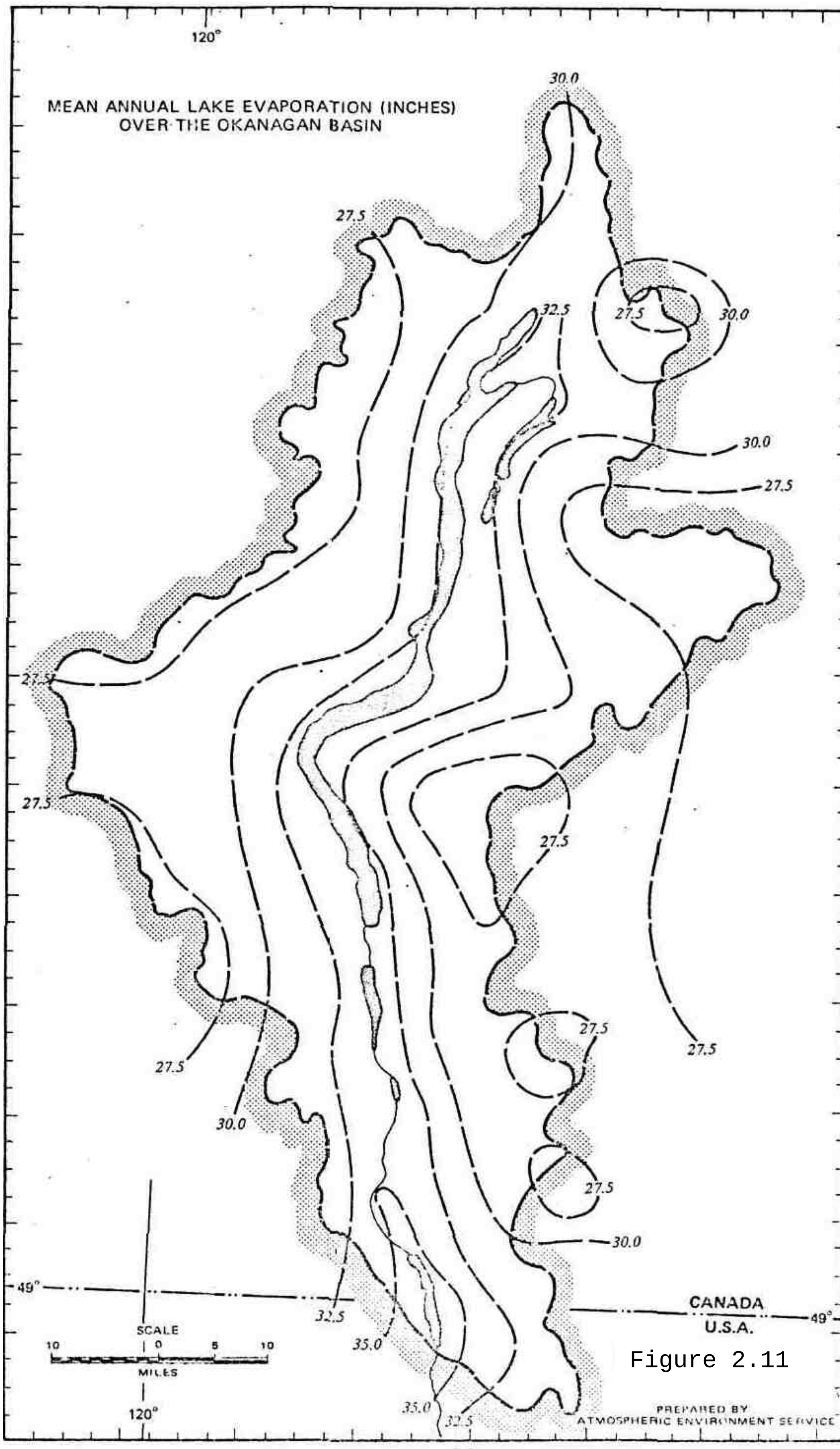

120°
MEAN ANNUAL LAKE EVAPORATION (INCHES)
OVER THE OKANAGAN BASIN
30.0
27.5
32.5
27.5
30.0
30.0
27.5
27.5
27.5
27.5
27.5
27.5
27.5
30.0
27.5
30.0
49°
CANADA
U.S.A.
49°
SCALE
10 0 5 10
MILES
120°
32.5
35.0
35.0
32.5
PREPARED BY
ATMOSPHERIC ENVIRONMENT SERVICE

Figure 2.11

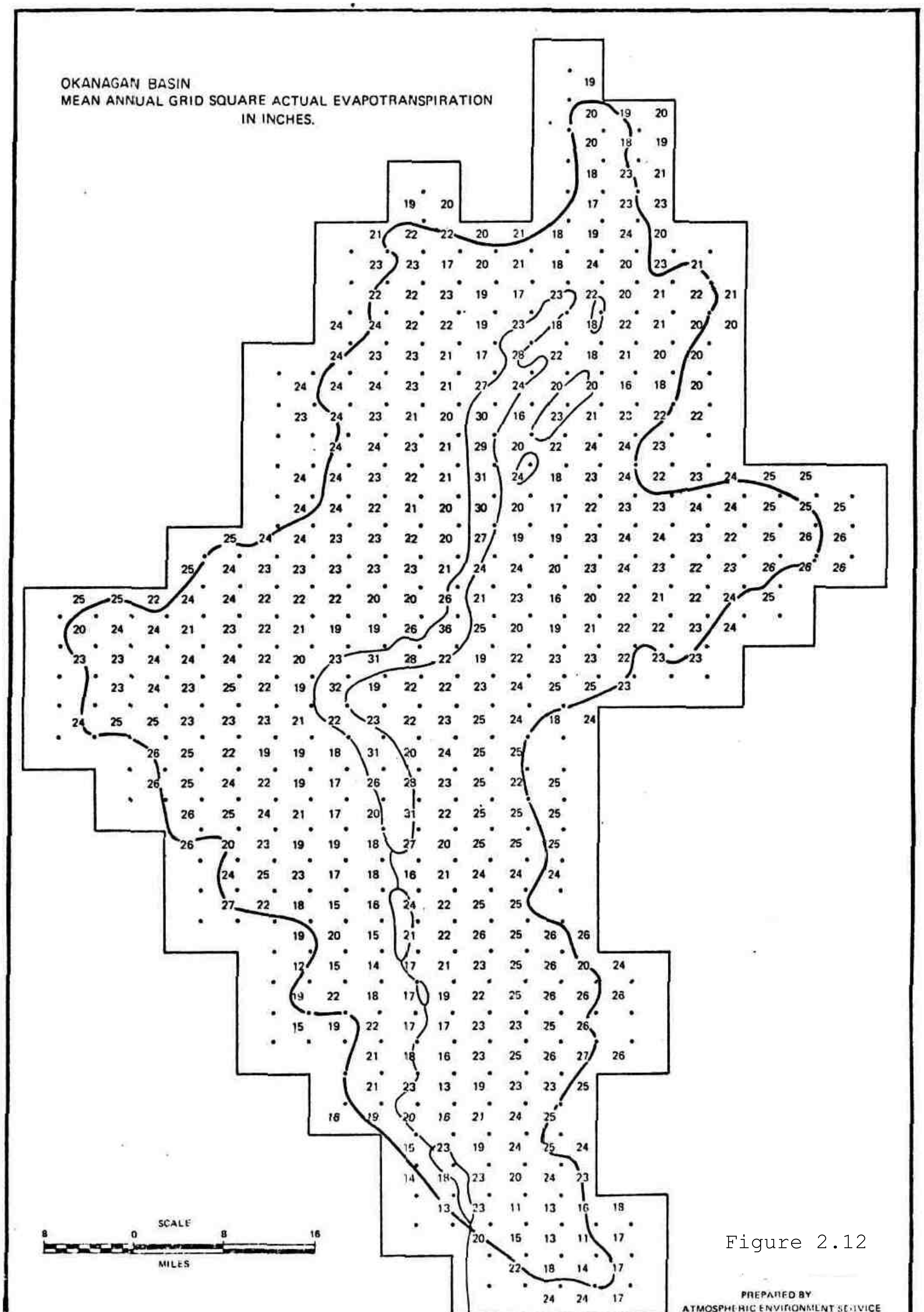


Figure 2.12

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month changes for each type of coyer and location in the watershed are available in Technical Supplement III. Additional information is also available with respect to evaporation in Appendix A of this Technical Supplement.

2.1.8 Storms

As noted throughout this Chapter, the Okanagan Basin has been well endowed with a climate that is generally benign from the point of view of agriculture, recreation and general livability. Its winters are less extreme than those of locations to the north and east; sunshine totals are high due to dry, warm summers. The nornal limitations of water supply in the valley are generally met by provision of irrigation water from higher altitude reservoirs. However, these prevailing conditions do not preclude instances, of severe weather which may be damaging to the economy of the area.

Outbreaks of very cold continental Arctic air occasionally reach the Okanagan Valley, as described in 2.1.3. While the Okanagan is much less likely to undergo long periods of continuous cold than northern Interior centres such as Quesnel and Prince George, occasionally temperatures are severe enough to damage fruit trees. Benches and slopes, which are often protected from the more common inversion frosts, are exposed to the freezing winds associated with such severe Arctic outbreaks. Extreme minimum temperatures as low as -15 to -25°F in southern parts of the Valley and -30 to -45°F in the north have been recorded (see Table 2.6).

Extremes of heat may also prove harmful to plants not adapted to such conditions. In summer months, hot, dry air often extends northward from the desert-like basins of the western plateaux of the United States. Temperatures In excess of 100 degrees Fahrenheit have been recorded at most Okanagan Valley locations (see Table 2.6). As this dry, hot air moves over the surface, it has a desiccating effect on agricultural plants in the area.

During the hot, dry months of July and August, rainfall, when It does come, is most commonly the result of the build-up of large cumulonimbus "thunder" clouds. In extreme cases, hail rather than rain, is produced. Such storms may devastate crops and destroy property in minutes, due to a combination of petting hailstones and strong, gusty winds.

One severe storm on July 29, 1946 swept a path of destruction from Summerland across Lake Okanagan to Okanagan Mission and on to Kelowna, Rutland and Winfield. Damage totalled $1,700,000. Approximately ten percent of all apples, peaches, prunes and apricots, 15 percent of the pear crop and five percent of the crabapples were destroyed. Some hailstones measured over two inches in diameter and weighed over two ounces. Glass in roost homes in the Summerland district was broken by the flying hailstones. Fortunately, storms of this degree of severity are rare. However, the possibility of a repeat performance is always present (for reference see "Meteorology in British Columbia: A Centennial Review" by Thorne K. Won, Atmospheric Environment Service).