Temperature

The study area is well endowed with temperature-recording stations and Table 3 gives a full coverage of monthly maximum, minimum and mean temperatures for a number of centres.

In the northern part of the catchment, monthly mean temperatures range from 7°C during the winter to about 23°C in summer. In comparison, the southern area is only slightly colder in the winter but significantly cooler in the summer, with means of 6°C and 17°C respectively.

Frosts

It is unlikely that frost has any permanent adverse effect on the native vegetation, which has adapted to very cold conditions (Foley 1945); however, improved pastures species and crops may suffer extreme growth retardation or even death. Areas that are subjected to frost during the winter months have been identified to assist land use planning and to develop specific management practices that will maximise productivity.

Estimating the occurrence of frost from measured screen temperatures has a number of limitations, and the relation between screen temperatures and the incidence of frost on the ground depends on how well the temperature-recording station represents the region. The drainage of cold air into depressions or the placement of windbreaks that impeded the movement of cold air can directly influence the incidence and location of frost, so caution is required when using regional temperature figures to predict local frost damage.

Table 3 – Average maximum, minimum and mean monthly temperatures (°C)

Station	Alt (m)	J	F	M	A	M	J	J	A	S	O	N	D	Year
Bendigo	225													
Maximum		290	28.4	25.3	20.5	15.8	13.3	12.0	13.6	16.2	19.8	23.3	26.5	20.3
Minimum		14.3	14.7	12.5	9.1	6.4	4.5	3.5	4.4	5.9	8.2	10.4	12.6	8.9
Mean		21.7	21.6	18.9	14.8	11.1	8.9	7.8	9.0	11.1	14.0	16.9	19.6	14.6
***Castlemaine**	297													
Maximum		28.5	29.1	25.2	20.4	15.7	13.0	12.0	13.3	15.6	19.3	22.6	26.0	20.1
Minimum		12.5	13.4	10.5	7.3	4.9	2.6	2.3	3.2	4.7	6.4	8.4	10.6	7.2
Mean		20.5	21.3	17.9	13.9	10.3	7.8	7.2	8.3	10.2	12.9	15.5	18.3	13.7
Heathcote	220													
Maximum		28.8	29.3	25.3	20.0	16.2	13.4	12.7	13.6	15.4	19.8	22.7	26.6	20.3
Minimum		13.6	14.2	11.5	8.7	5.9	2.8	3.0	3.5	5.0	6.8	8.8	10.8	7.9
Mean		21.2	21.8	18.4	14.4	11.1	8.1	7.9	8.6	10.2	13.3	15.8	18.7	14.1
Kyneton	509													
Maximum		26.5	24.6	22.5	18.1	13.1	10.9	9.3	11.1	13.8	17.1	20.6	22.8	17.5
Minimum		10.3	10.5	9.2	5.5	3.9	2.9	1.9	2.8	3.4	5.4	6.9	8.6	5.9
Mean		18.4	17.6	15.9	11.8	8.5	6.9	5.6	7.0	8.6	11.3	13.8	15.7	11.7
Rochester	105													
Maximum		30.9	30.7	26.8	21.9	16.8	14.1	13.4	14.8	17.4	21.7	24.8	28.4	21.8
Minimum		14.9	15.8	13.0	9.7	6.6	3.6	3.5	4.5	5.7	8.2	10.1	12.8	9.0
Mean		22.9	23.3	19.9	15.8	11.7	8.9	8.5	9.7	11.6	15.0	17.5	20.6	15.4

* Outside Campaspe River Catchment

Source: Commonwealth Bureau of Meteorology

Improvements in the resolution of thermal imagery from satellites will, in the future, enable meteorologists to provide regional maps showing those areas most susceptible to frost (Kalma *et al* 1983) – an advance on the present system of forecasting the likelihood of frost from sparsely situated ground temperature recorders.

Despite the various, screen temperatures of 2°C provide a reasonable basis for predicting light to moderate frosts at ground level while a screen temperature of 0°C indicates a heavy frost on the ground. Table 4 lists the maximum, minimum and average number of light-moderate and heavy frosts that occur each month at a number of centres throughout the catchment.

As one would except, the incidence of frost in the catchment increases with increasing latitude and elevation. Kyneton, situated on the open basaltic plains, has the lowest mean monthly temperatures and the highest incidence of frost of all the recording centres. Progressively northwards, Castlemaine, Heathcote and Bendigo, all in valley situations and receiving cold air drainage, have a decreasing incidence of frost. Rochester, however, on the open plains where the frequent absence of an insulating cold layer allows the warm air to dissipate into the clear night skies, has a higher incidence of frost than Bendigo.

Potential Evapotranspiration

Potential evapotranspiration is an estimate of the amount of moisture that a fully vegetated area can lose by evaporation and transpiration when soil moisture is not limiting. It is approximately 80% of the evaporation from a free water surface. Insufficient evaporimeter data are available within the catchment, therefore approximations using Leeper's (1950) modification of Thornthwaite's formula have been used. Figures 4, 5, 6 and 7 show the calculated potential evapotranspiration, plotted against rainfall, for several centres.

Throughout the catchment, during the summer the potential evapotranspiration exceeds the rainfall and pastures dry off in December or earlier, depending on the rooting depth and the ability of the soil to store moisture during the wetter months.

Assuming 100 mm of rain can be stored within the pasture root zone (approximately 0.6 m) of most soils, any extra rainfall will either run off or percolate into the subsoil and parent material. Thus some idea of the water that may be available to supply streams can be obtained. Obviously this is a generalisation, since: heavy storms will result in run-off regardless of the amount of soil moisture; some soils will store more than 100 mm of rain, but other will store considerably less; and some shallow-rooted pasture species may not have the rooting depth to utilise 100 mm of stored soil moisture, whereas deep-rooted eucalypt forest may use far in excess of 100 mm.

Figures 4 –7 do not represent accurate soil-water budgets; they only provide a means of comparing different climatic areas in terms of available soil moisture for plant growth and periods of potential water un-off.

In the southern part of the catchment (Figures 4 and 5), the growing season – when rainfall exceeds potential evapotranspiration – extends from March/April to October/November and 100 mm of water could be stored in the soil from June to November, with the potential of 280+ mm in excess for run-off or deep percolation to the groundwaters. Bendigo (Figure 6) has a much reduced growing season, April-October, with 100 mm of water being stored in the soil from July to September, and only 45 mm of moisture available for run-off or deep percolation.

At Rochester (Figure 7) in the north, the growing season only extends from May to September, and it is unlikely that 100 mm of moisture would be stored in the soil; run-off into the creeks and rivers is uncommon.

Table 4 – Frost Data

Station	Years of records °C	Number of days of frost occurrence per month																									
		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Nov		Dec		Year	
		<0	<2.2	<0	<2.2	<0	<2.2	<0	<2.2	<0	<2.2	<0	<2.2	<0	<2.2	<0	<2.2	<0	<2.2	<0	<2.2	<0	<2.2	<0	<2.2	<0	<2.2
Bendigo																											
Maximum	25 (1957-81)	-	-	-	-	-	-	-	1	2	6	10	20	6	17	5	13	1	7	1	2	-	1	-	-	25	67
Minimum	25 (1957-81)	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	2	-	-	-	-	-	-	-	-	0	6
Average	35 (1935-45; 1957-81)	-	-	-	-	-	-	-	-	0	2	2	7	3	10	1	7	-	3	-	-	-	-	-	-	6	29
Castlemaine*																											
Maximum	16 (1966-81)	-	-	-	-	-	1	4	9	12	17	21	23	17	24	12	17	10	15	3	10	2	6	-	1	81	123
Minimum	16 (1966-81)	-	-	-	-	-	-	-	-	-	3	2	6	1	6	2	6	-	3	-	1	-	-	-	-	5	25
Average	26 (1935-45; 1966-81)	-	-	-	-	-	-	1	3	3	9	8	14	9	16	6	12	3	8	1	5	-	2	-	1	31	70
Heathcote																											
Maximum	6 (1969-75)	-	-	-	-	-	2	1	2	3	9	15	22	10	19	8	13	7	10	2	9	-	3	-	-	46	80
Minimum	6(1969-75)	-	-	-	-	-	-	-	-	-	3	2	9	4	6	2	7	-	3	-	1	-	-	-	-	8	29
Average	6 (1969-75)	-	-	-	-	-	-	-	1	1	5	7	13	6	14	5	10	3	7	1	4	-	1	-	-	23	55
Kyneton																											
Maximum	10 (1957-66)	-	-	-	-	1	4	4	10	9	15	11	19	11	21	8	19	10	19	3	9	3	5	-	4	60	125
Minimum	10 (1957-66)	-	-	-	-	-	-	-	1	-	3	2	6	5	10	2	9	1	5	-	-	-	1	-	-	10	35
Average	20 (1935-45; 1957-66)	-	-	-	-	-	1	-	5	5	9	7	13	8	14	5	13	4	11	1	5	1	3	-	2	32	74
Rochester																											
Maximum	11 (1965-75)	-	-	-	-	-	-	-	3	2	7	11	19	6	17	3	11	3	10	1	3	-	1	-	-	26	71
Minimum	11 (1965-75)	-	-	-	-	-	-	-	-	-	-	-	5	1	4	-	2	-	1	-	-	-	-	-	-	1	12
Average	11 (1965-75)	-	-	-	-	-	-	-	-	-	3	3	10	4	11	2	7	1	4	-	1	-	-	-	-	10	36

* Outside Catchment

Source: Foley, J. C. (1945); Commonwealth Bureau of Meteorology, 1982

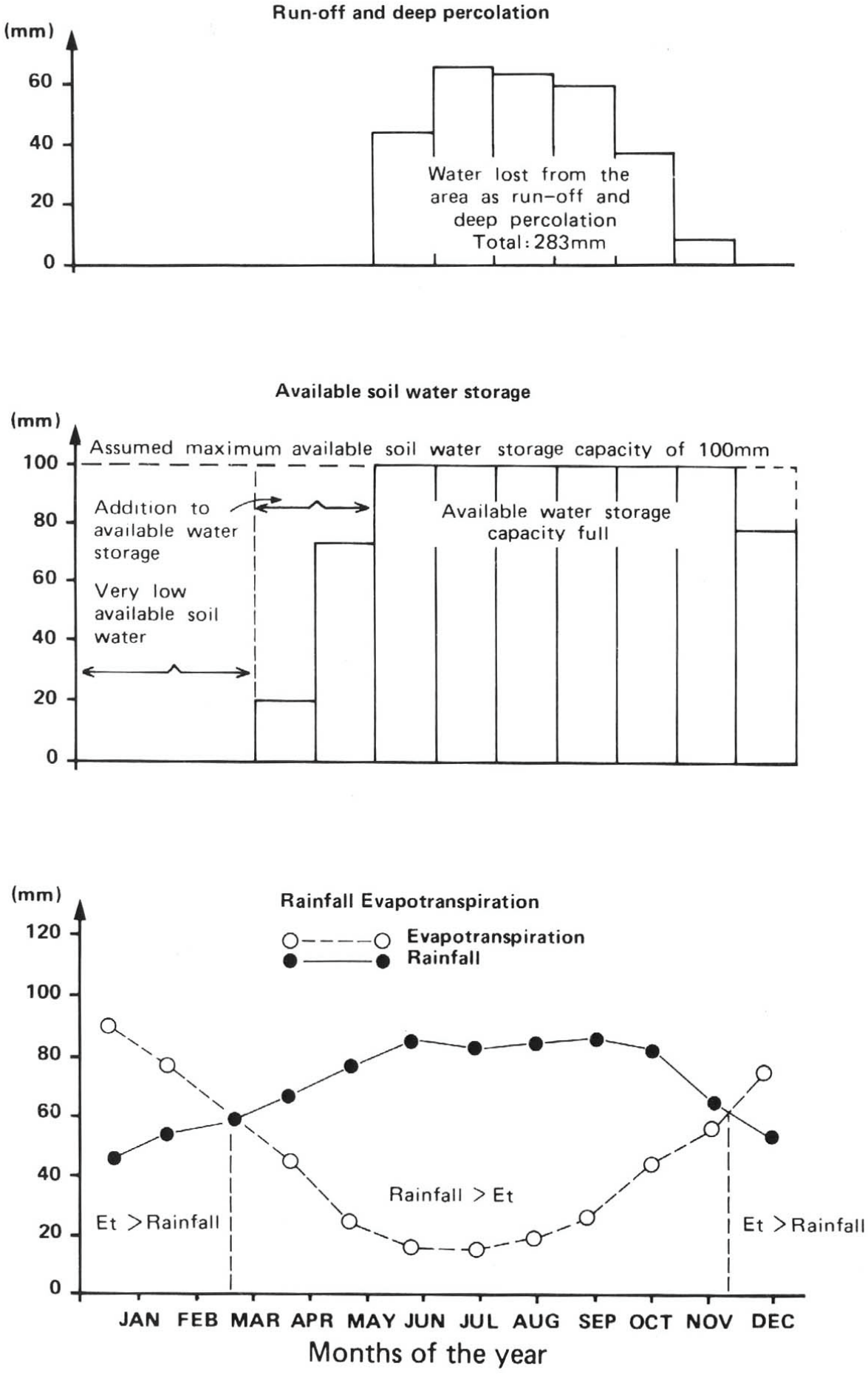

Figure 4 – Water budget for Mount Macedon

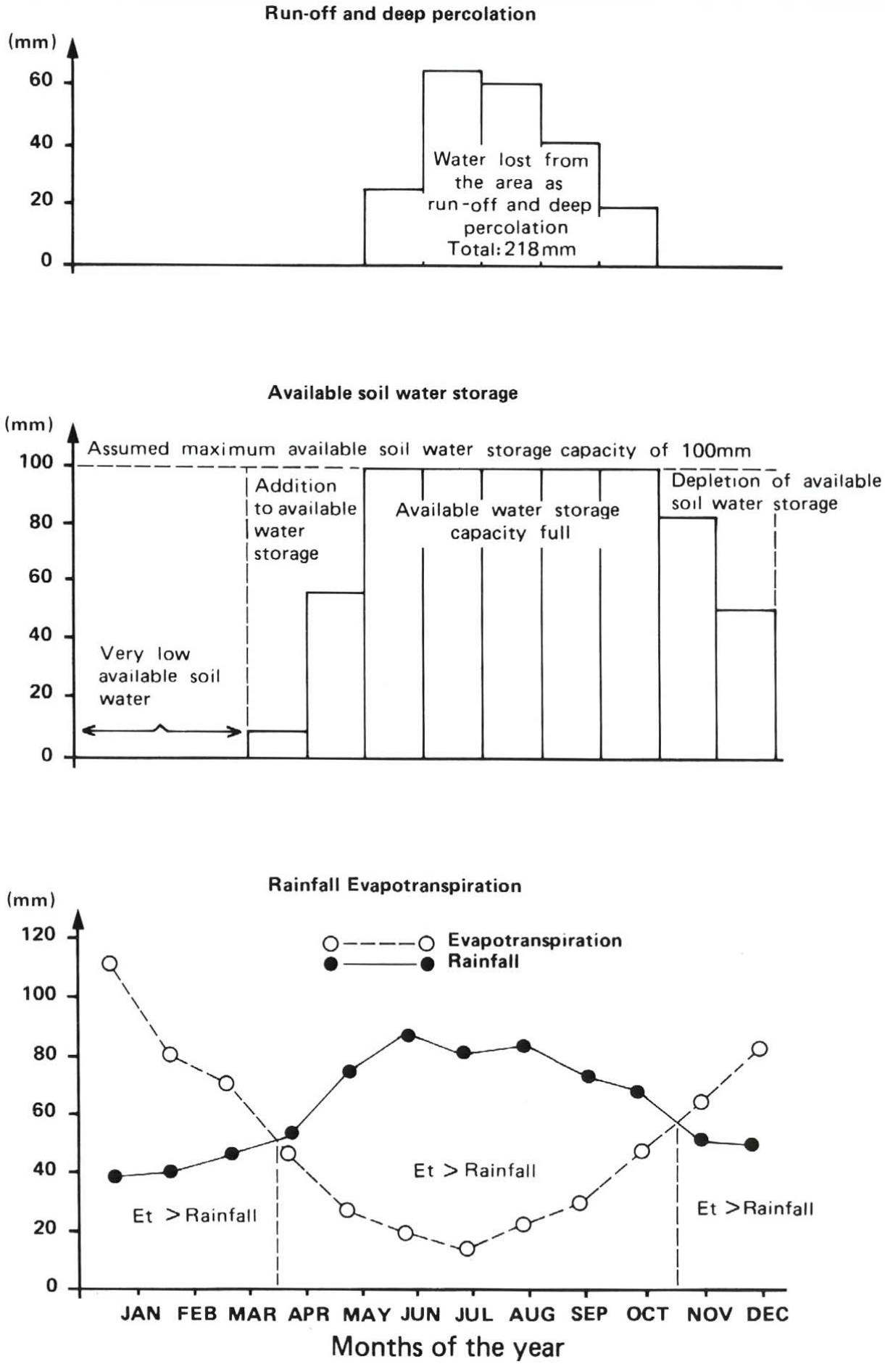

Figure 5 – Water budget for Kyneton

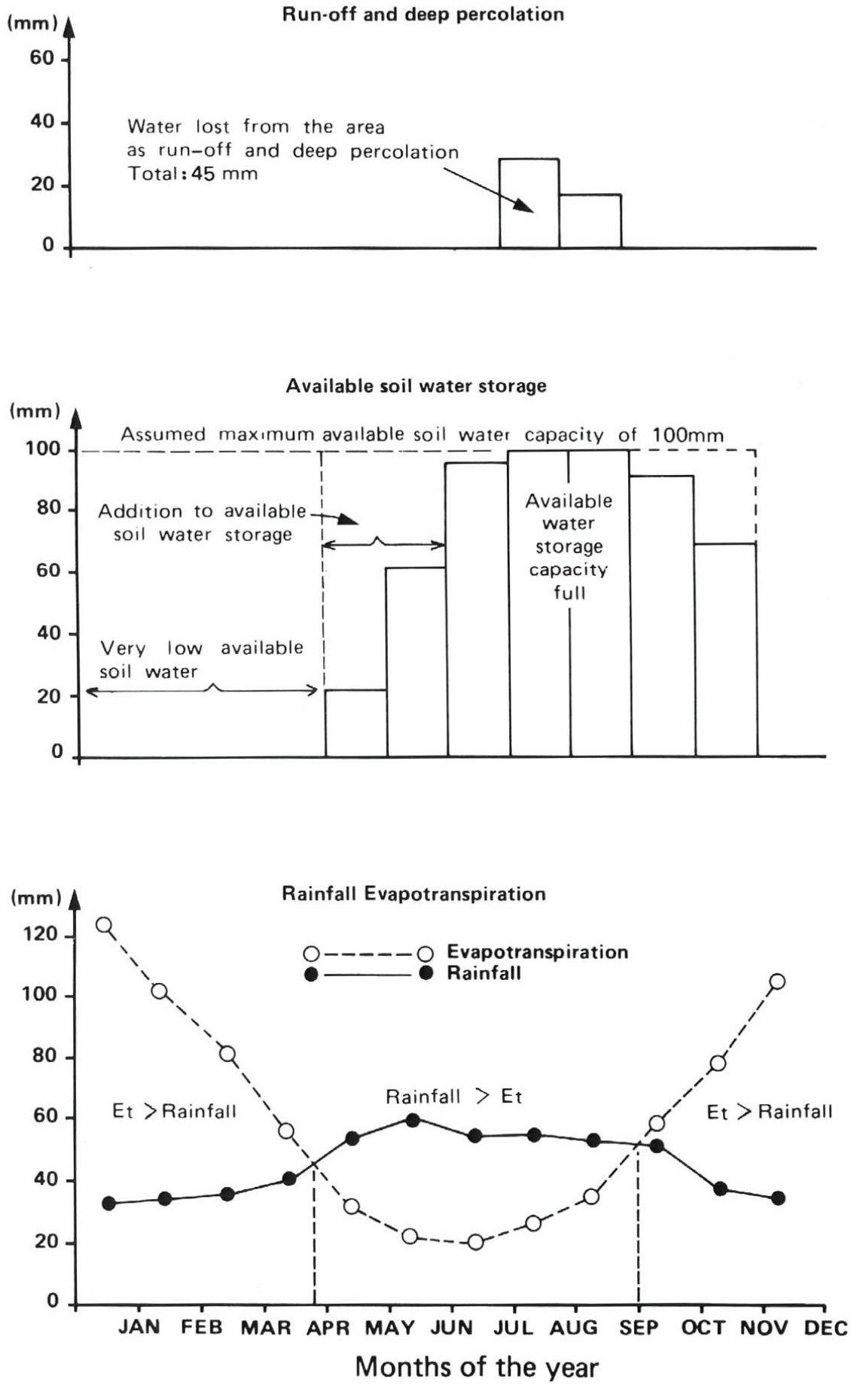

Figure 6 – Water budget for Bendigo

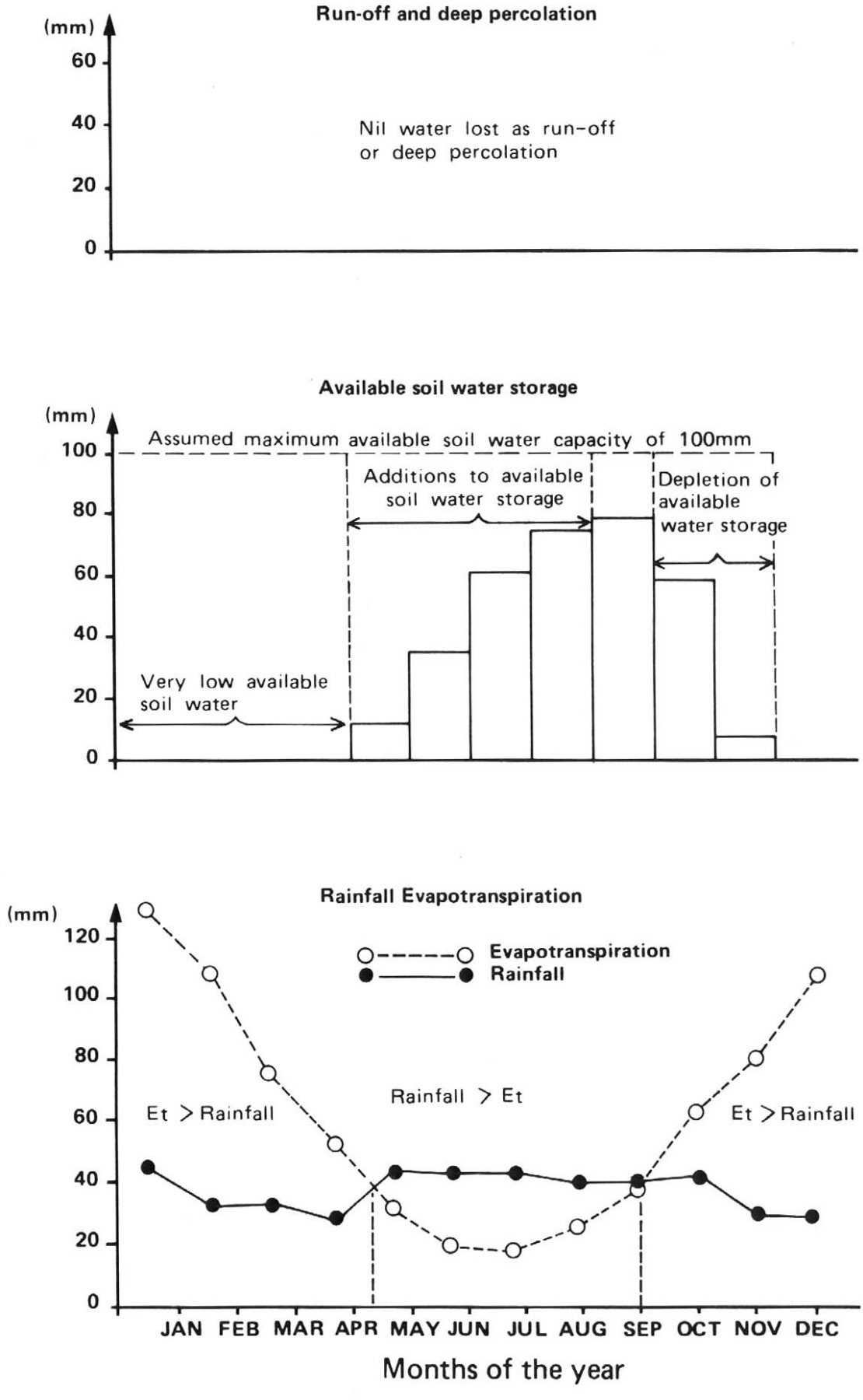

Figure 7 – Water budget for Rochester

Growing Season

The range in ability of plants to grow at low temperatures varies considerably. For example, some temperate grass species still show some growth activity when the temperature falls below 0°C whereas some tropical plants practically cease growth at temperatures of 10°C. It is generally accepted, however, that plant growth is retarded when ground temperatures fall below 10°C (Trumble 939) and virtually ceases below temperatures of 6°C (Martin and Leonard 1967) – see Figure 8.

Plant growth is also limited by lack of water and the irony of agricultural land use in this study area is that moisture limits it when the temperature is right and *vice versa*. Throughout most of the catchment, plant growth is slow during the winter months, particularly in the north, leaving only the autumn and spring for moderate-maximum growth response.

Wind

The summary of wind data from the Bureau of Meteorology given in Figures 9 and 10 compares morning and afternoon wind direction and wind speed for Bendigo (27 years of records) and Echuca (24 years of records).

Wind direction and wind speed are extremely variable throughout the State; moreover, it is difficult to record and present wind data in a useful format. Most weather stations only estimate wind speed according to the old Beaufort scale at 0900 and 1700 hours. Additional useful information, particularly from an erosion hazard viewpoint, would be the strength and duration of wind gusts, the visibility or quantity of dust in the air, the percentage of time wind comes from specific directions and the corresponding percentages of time wind speed falls within certain categories. Continuous wind-speed recorders provide most of this information, but very few exist within the State.

Bendigo and Echuca (outside the study area) are separated by only approximately 90 km of open plain, yet the wind data summarised in Figures 9 and 10 show considerable variation. At Bendigo, wind comes predominantly from the south-west quarter in the morning and from the south-west – north-west quarter in the afternoon. Wind speed generally rises in the afternoon, with erosive winds occurring about 25% of the time throughout the year.

At Echuca, wind direction in the morning tends to be from the south- east quarter during the summer and autumn, but more from the west and north-west during the winter-spring period. In the afternoon the wind blow predominantly from the west – north-west. Wins are generally stronger in the afternoon, but the chance of erosive winds occurring during the spring-summer months is only 5-10%.

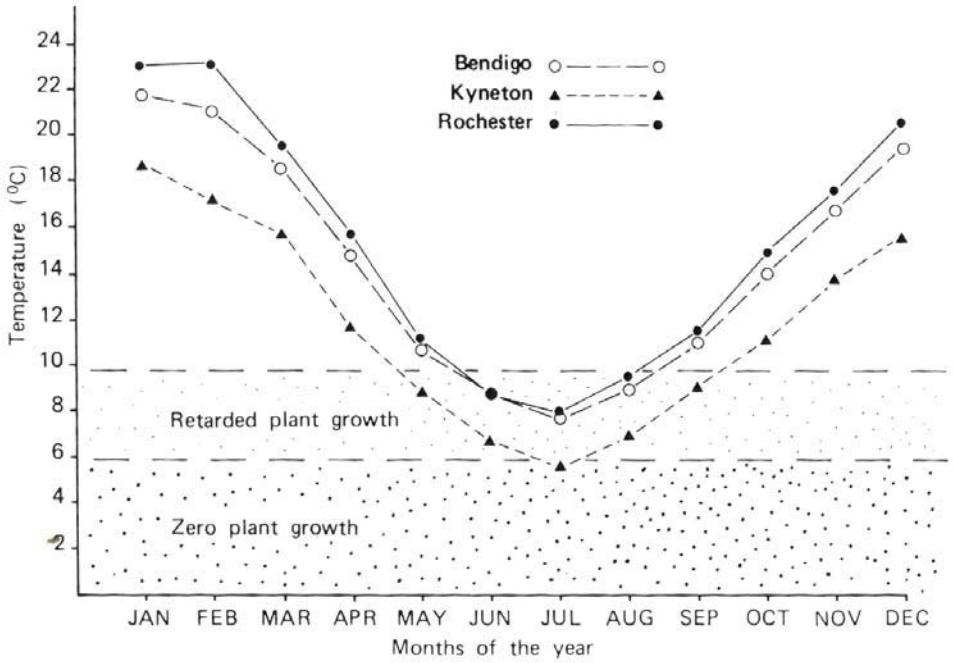

Figure 8 – The average mean monthly temperature for selected towns

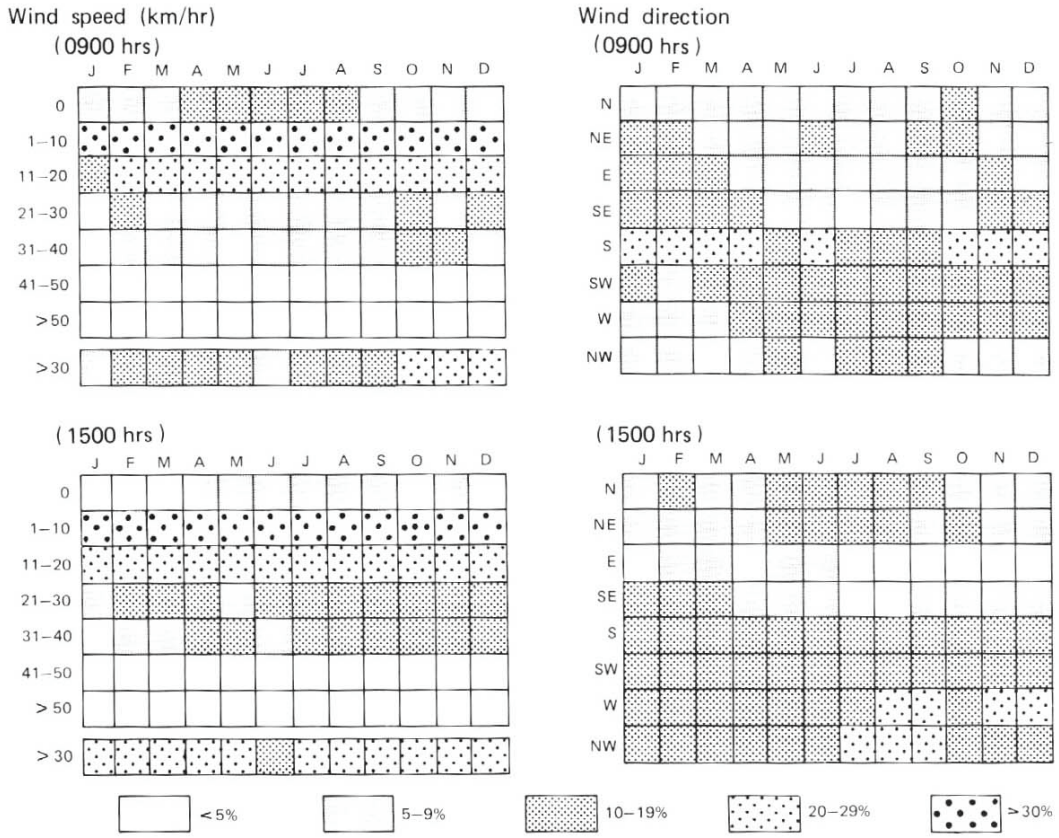

Figure 9 – Monthly probabilities of wind speed and direction for Bendigo

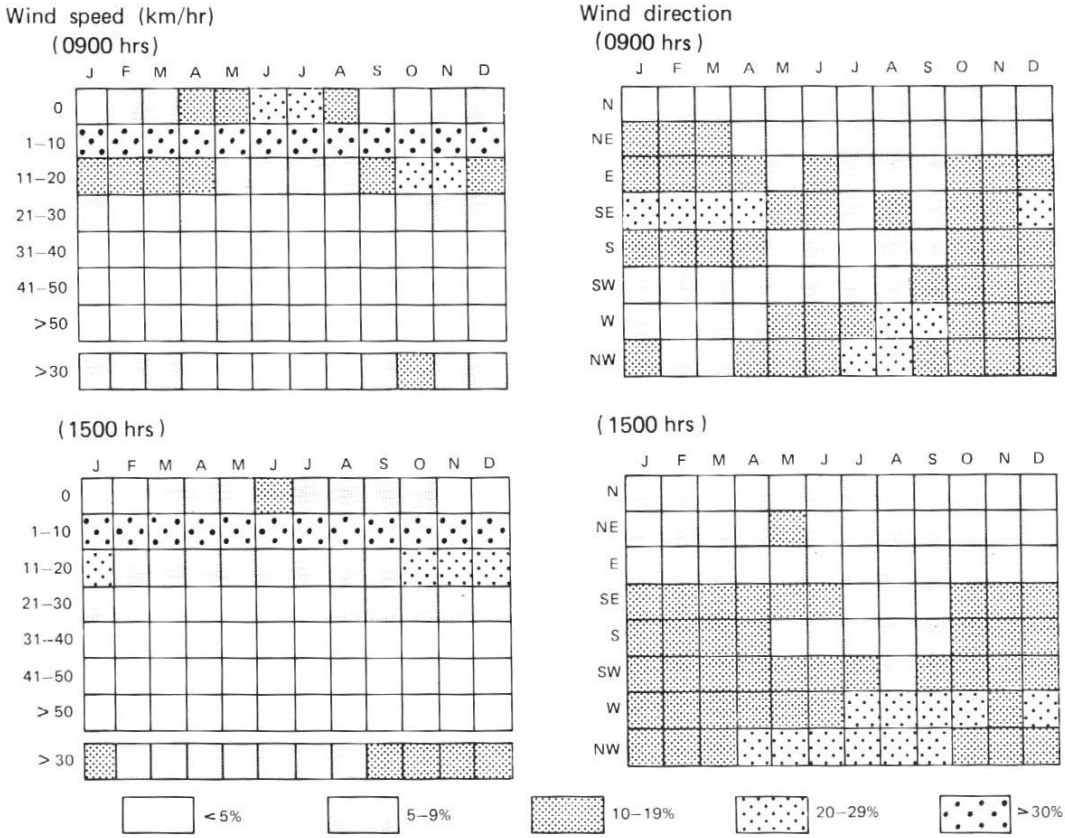

Figure 10 – Monthly probabilities of wind speed and direction for Echuca.