Queensland Government
Department of Main Roads
Road System & Engineering

WQ30

CLIMATE OF WESTERN QUEENSLAND

Contact: Lex Vanderstaay Phone: (07) 4931 1657 / Ian Reeves Phone: (07) 3834 3089

1 Introduction

This technical note is one of a series on notes regarding road construction issues in the three MR western Districts of Queensland. Details of these notes can be found in the Preface to WQ Technical Notes. This note and its companion notes on soils (WQ32) and geology (WQ31) are more by way of background documents, compared to some of the other notes which are more specific to the physical process of road design and construction.

The climate of the western two-thirds of Queensland is characterised by high summer temperatures and cooler winter temperatures, with some winter frosts particularly, but not exclusively, in the south. Rainfall is typically low and unreliable, generally less than 500mm per annum, seasonal in the north and becoming less seasonal towards the south. Evaporation, as measured by the Australian Standard Pan, is extremely high and typically exceeds rainfall by a factor of 10 or more, the observed range being 2 to 21 at thirteen selected sites.

Location of Sites			
Site	**Latitude Longitude**	**Ht.**	**From***
Normanton	17.67°S, 141.08°E	8m	1872
Mt Isa	20.73°S, 139.48°E	356m	1926
Cloncurry	20.71°S, 140.52°E	200m	1884
Hughenden	20.84°S, 144.20°E	324m	1884
Winton	22.39°S, 143.00°E	182m	1884
Boulia	22.91°S, 139.91°E	156m	1886
Longreach	23.45°S, 144.25°E	191m	1893
Barcaldine	23.55°S, 145.29°E	267m	1886
Birdsville	25.90°S, 139.35°E	46m	1892
Quilpie	26.61°S, 144.26°E	200m	1917
Charleville	26.42°S, 146.22°E	293m	1874
Roma	26.57°S, 148.79°E	299m	1870
Thargomindah	28.00°S, 143.82°E	129m	1949

* Commencement year for most data.

The time base required to make statistically valid estimates of climatic conditions is generally considered to be several centuries, and even then long term changes in climatic conditions cannot be predicted. In Western Queensland the typical time base is only one century. This is insufficient to predict low probability climatic events.

The tables appended to this note (Tables A1 to A6) contain various climate statistics for the above thirteen sites. The statistics have been calculated using data sets which vary in duration from 51 to 128 years. Some variation will occur in the statistics when they are calculated with a data set of different duration to those used for this note.

2 Rainfall

The distribution of rainfall is highly variable. Strong seasonal influences occur in Cloncurry District and the northern half of Barcaldine District. In these areas rainfall occurs mainly in summer, with a seasonal ratio (ratio of summer to winter rainfall) exceeding 3. The southeastern sector of Barcaldine and the eastern half of Roma Districts are in the summer seasonal rainfall zone, with a seasonal ratio of between 1.3 and 3.0. The remaining areas of Barcaldine and Roma Districts (i.e. the western sectors of Barcaldine and Roma) are located in the arid summer zone, with a seasonal ratio in the 1.3 to 3 range. Below approximately 30°S, (i.e. south of Bourke in New South Wales) the seasonal ratio falls below 1.3. An approximately linear reduction in the ratio can be assumed from 3 at Winton to 1.3 at Bourke.

The west is characterised by three trends in its rainfall distribution, these being:

(i) a decrease from the coast towards central Australia,

(ii) a decrease in the seasonal influence on rainfall from North to South, and

(iii) the extremely unreliable and highly variable quantity of rainfall throughout.

Extreme regional rainfall events are generally associated with rain depressions associated with cyclonic activity, while local extreme rainfall events are generally associated with storms.

Rainfall is not easily predictable in Western Queensland, with only the north west having a predictable wet season. In both the central and south west, rainfall is sporadic and far from predictable. Hence the mean annual rainfall is, in some senses, not a good measure of rainfall in any particular year. The normal rainfall regime over most of the west consists of droughts of long duration alternating with floods. This regime better reflects the actual rainfall in the west than a regime of average rainfall with the occasional positive or negative variation from the average.

An analysis of 110 years of rainfall data for Winton indicated that 45% of the years had less than 80% of mean annual rainfall, 28% had between 80% and 120% of the mean, and 27% had more than 120% of the mean. Given the distribution of annual rainfall at any one site, it becomes critical to note which “average” is used to define rainfall. The two most common measures are *median rainfall* i.e. the 50 percentile rainfall of available records, and *mean rainfall* i.e. the $\{\Sigma(\text{annual rainfall})\}/(\text{number of years})$. Rainfall statistics for thirteen sites in Western Queensland are summarised in Tables A1 and A2.

The prediction of future rainfall for the west is currently generally based on the Southern Oscillation Index (SOI) and in such predictions the “average” used is the median rainfall.

In section 10 of this note, the significance of “wet” and “dry” periods is described from the point of view of road construction. Thus a “wet” period is described as a period in which rainfall exceeds a nominated quantity over a nominated time. Given the significance of such events, the mean annual occurrence of such events is tabulated in Table A3 of the appendix.

3 Southern Oscillation Index (SOI)

The Southern Oscillation Index is a function of the air pressure variation between Tahiti and Darwin and has been strongly correlated with rainfall patterns in Western Queensland. When the SOI is strongly negative (SOI < -10 for an extended period), termed an El Niño event, the probability of rainfall significantly decreases. The degree of decrease has been correlated with the magnitude of the SOI. The net effect on Western Queensland is that the position of the 500mm isohyte is typically moved east to run along the top of the ranges along the eastern Queensland coast. During strongly positive SOI periods (SOI > 10 for an extended period), La Niña events, the converse applies and the 500mm isohyte tends to be displaced by up to 800km west of its median position. It should be noted that the position of the standard isohytes is the mean position and may be considered to correspond with an SOI of approximately zero. Median annual isohytes are shown on Figure 1.

Generally the SOI is used to predict rainfall probability for the forthcoming 2 to 4 months. These predictions are based on both the magnitude of the SOI and whether the SOI is rising, steady or falling. The SOI climate estimates are generally given in terms of a probability of exceeding median rainfall over a defined period. Such predictions are generally issued monthly but, for some areas, it has been observed that the timing as well as the magnitude of the SOI is critical, thus a high SOI in April / May will be a better indicator for winter - spring rains than a September - October SOI for summer rains. The critical time for the SOI predictions varies from area to area, therefore reference should always be made to published maps of median rainfall predictions. Such maps are now routinely published weekly in most newspapers, and are also available on the Internet (see Bibliography for details). These maps give only the probability of exceeding median rainfall, and no guarantees can be given.

4 Temperature

The distribution of temperature across eastern Australia is characterised by two trends:

(i) a broad reduction of mean temperature from north to south, and

(ii) a cooling coastal effect which is most prominent along the east coast.

In Western Queensland only the first factor is significant. The mean summer maximum of Western Queensland is generally in the 36° to 40° range. The summer minima are similarly distributed, with most of the area in the 21° to 24° range. The prevalence of temperatures above 38° decreases from north to south.

In winter a greater range is observed, as summarised in the following table. The prevalence of frosts also increases from north to south.

Winter Temperatures		
Area	Average temp	Average min temp
South of 25°S	18° to 21°	3° to 6°
22°S to 25°S	21° to 25°	6° to 9°
18°S to 22°S	24° to 27°	9° to 12°
North of 18°S	27° to 30°	12° to 15°

Unlike rainfall, the average temperature parameters generally provide realistic average parameters. Table A4 in the appendix contains a summary of temperature statistics.

5 Solar Radiation

The average level of solar radiation is a useful aggregate climatic parameter. It includes both the extent of solar radiation, which is a function of latitude, and the degree of cloud cover. Because of the combined effect of these parameters, the central west area north of the tropic of Capricorn to just north of Cloncurry has the highest level of average incoming solar radiation at typically $600 mWhcm^{-2}$. North and east of this area, the more frequent cloud cover reduces the average, while south of this zone the latitude reduces the level. The level of incoming solar radiation is a major determinate of the rate at which bitumen oxidises, although this parameter is not a direct input into the accepted model of bitumen deterioration.

6 Wind

Other than the far northern section of Western Queensland (i.e. Gulf coastal area) wind is not influenced by coastal effects. Wind measurements from the four main meteorological stations in the west are summarised in Table A6.

7 Thornthwaite Index

The Thornthwaite Equation is a climatic equation which estimates the potential evapotranspiration based on monthly climate data. The Thornthwaite index (Ti) is a function of potential evapotranspiration (Ep); soil moisture deficiency (d); and drainage (D) which is the difference between rainfall and evapotranspiration.

$$Ti = (100D - 60d)/Ep$$

The equation is one of the simpler equations which can be used to estimate this parameter. Although other equations are potentially more rigorous, they rely on the availability of more detailed data inputs, rendering their calculation on a regional basis unrealistic.

The Thornthwaite Index may be calculated on a regional basis and has been correlated with soil moisture suction in road subgrades. The index is valid only in situations where a water table is located deeper than approximately 10m.

In Western Queensland the index varies from -10 immediately west of the Great Dividing Range to -40 in the far southwest.

8 Evaporation

The rate of evaporation is generally measured as the rate water evaporates from an open, water filled pan of standard dimensions (Australian Standard Pan), and recorded as mm of evaporation per day. This could be considered the maximum amount of evaporation from a drying pavement, however water may also infiltrate into lower layers thus significantly further increasing the apparent “evaporation”. An evaporation of 1mm corresponds to a the loss of 1litre (or 1kg) of water per square metre. Average monthly evaporation figures are included in Table A5. Pan evaporation figures are used in the calculation of the Thornthwaite Equation.

Since water is a significant input to road construction it is critical that some estimate of the likely loss of water via evaporation can be made.

The following equation gives a method of estimating evaporation losses from a moist surface based on a method of prediction of the rate of evaporation from a fresh exposed concrete surface. This estimate is based on humidity, material temperature, air temperature and wind speed.

$$Ev = (0.055+0.014V) [(0.617+ 0.063P)^2 - 0.9*e\text{^} \{-6.03 +1.33 \ln(H)+ T*0.114 H.^{-0.14}\}]$$

Where Ev = evaporation rate in l/m^2; H = ambient relative humidity in %; T = ambient air temperature in C°; P = surface pavement temperature in C°; V = wind speed in km/h; and e = 2.7183.

As a example, at an air temperature of 35°, a pavement temperature of 35° and a wind speed of 30km/h, an evaporation loss of 10 l/m^2 will occur in 3 to 4 hours. For a 150mm thick pavement layer with an OMC of 12%, such a loss will reduce the moisture content by 2% (or 17% of OMC). This calculation ignores other losses e.g. infiltration of moisture into the underlying pavement or subgrade layers.

9 Extreme Events

Extreme weather events which can occur in Western Queensland include extreme rain, both flood and drought, extreme wind, and extreme temperature. Extremely high rainfall events tend to be associated with rain depressions following cyclones.

10 Climate Parameters and Road Construction

Rainfall

The most critical climatic parameter for road construction is rainfall. Analysis of historical construction records and indices of pavement performance suggests that rainfall equal to or exceeding the following figures may directly affect both short and long term pavement serviceability. These influences have been designated W1 to W3 for the wetting influence and D1 to D3 for the drying influences. The most critical timing of these influences in the road construction process is discussed in other notes in this series.

Critical Rainfall Events	
Wetting Influences	**Drying Influences**
Greater than 100mm in 4 weeks (W1)	Less than 10mm in 4 weeks (D1)
Greater than 200mm in 8 weeks (W2)	Less than 20mm in 8 weeks (D2)
Greater than 300mm in 16 weeks (W3)	Less than 40mm in 16 weeks (D3)

The distributions of these influences at selected western locations is detailed in Table A3. This table shows the average number of days per year each condition occurs, and the number of times the nominated conditions occur per year, both based on 51 years of data. The data shows that there are significant differences that could be expected to produce different road performance between the various sites. Using Normanton and the W1 event as an example, W1 conditions occur for an average of 81.9 days per year, with on average 2.4 W1 events annually. Typically this actually occurs (for Normanton) as one W1 event of several months duration early in the year, followed by one or two short duration events at other times. The usual distribution of events is not shown in Table A3.

Temperature

Temperature is also critical in several areas of road construction, particularly in relation to sealing practice where it directly affects application rates, proportion of cutter and early performance. Both minimum and maximum temperatures are the basic inputs in bitumen durability calculations using Oliver's method (Oliver 1999). OH&S considerations also become critical for field work during extreme temperature events. Temperature statistics are included in Table A4 in the appendix.

11 Author

This note was written by A.G.B. Vanderstaay, Regional Advisor Technical Services (Central Queensland).

12 Bibliography & Further Data

Bureau of Meteorology 1988: *Climatic Atlas of Australia*. Department of Administrative Services. Canberra.

Oliver, J. 1999: *The performance of sprayed seals*. ARRB Research report. ARR 326.

Thornthwaite, C.W. 1948: *An Approach towards a Rational Classification of Climate*. Geological Review. Vol 38, Pp 55-94.

Climate data for particular sites may be obtained through the Bureau of Meteorology, PO Box 413, Brisbane 4001, phone (07) 3239 8739.

Two web sites are of particular interest:-

www.dnr.qld.gov.au/longpadk, and

http://www.bom.gov.au/silo.

These sites contain selected climate data as well as analyses of past, current and predicted future climatic conditions.

14 Appendix

The following tables and maps are included in the appendix.

Table A1. Annual Rainfall Statistics.

Table A2. Monthly Mean Rainfall and Wet Days.

Table A3. Distribution of Wetting and Drying Influences.

Table A4. Temperature Statistics.

Table A5. Evaporation Statistics.

Table A6. Wind Statistics.

Map 1. Median Annual Isohyets.

Location	Lowest Annual	10% Lowest	Median	Mean	10% Highest	Highest Annual	Highest Daily	Av. No wet days
Normanton	382	526	912	1,336	1,885	2,001	299	56.4
Mt Isa	109	194	377	406	634	921	158	44.6
Cloncurry	178	232	433	440	730	1,122	326	37.3
Hughenden	136	252	483	454	774	1,079	160	42.3
Winton	88	195	359	399	669	1,086	186	39.2
Boulia	60	107	214	244	507	704	209	29.2
Longreach	165	220	403	421	717	1,059	202	39.8
Barcaldine	181	245	454	476	825	1,102	177	49.9
Birdsville	23	53.2	153	161	312	468	155	22.3
Quilpie	82	138	308	346	572	831	186	39.5
Charleville	176	265	472	474	800	958	161	51.1
Roma	242	376	581	588	856	988	174	57.2
Thargomindah	72	153	291	291	519	661	152	26.1

Table A1 Annual Rainfall Statistics

Location		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Normanton	Rain	253	229	161	40	96	65	48	68	159	43	45	127
	Wet Days	14.2	13.6	9.6	3.1	4.4	2.8	2.2	2.8	6.6	2.5	4.5	9.0
Mt Isa	Rain	98	83	69	14	18	6	6	3	7	20	27	57
	Wet Days	7.5	7.2	4.9	1.5	1.5	0.6	0.7	0.6	0.7	2.9	3.6	5.6
Cloncurry	Rain	111	102	72	15	15	6	6	3	6	17	30	59
	Wet Days	8.1	7.6	5.2	1.6	1.4	0.5	0.7	0.5	0.9	3.9	3.8	5.7
Hughenden	Rain	116	86	47	29	21	16	11	12	3	24	41	47
	Wet Days	7.6	6.4	4.1	2.0	1.8	1.4	1.3	1.0	0.5	2.6	4.5	5.0
Winton	Rain	80	85	54	22	25	11	13	6	6	18	25	51
	Wet Days	6.8	6.2	4.2	2.2	1.9	0.9	1.0	1.1	1.2	2.8	3.3	4.9
Boulia	Rain	52	48	34	12	17	6	10	5	6	15	14	25
	Wet Days	5.1	4.3	3.0	1.5	1.8	1.0	1.1	1.0	1.2	2.5	2.4	3.1
Longreach	Rain	77	73	59	37	28	13	18	10	7	23	23	54
	Wet Days	6.2	5.8	4.2	2.5	2.2	1.4	2.0	1.5	1.4	3.1	3.4	5.1
Barcaldine	Rain	87	77	58	39	34	16	21	15	12	28	30	58
	Wet Days	7.3	6.8	4.8	2.8	2.7	1.8	2.6	1.9	1.9	3.8	4.3	6.2
Birdsville	Rain	29	24	21	8	11	8	13	6	3	13	11	15
	Wet Days	2.9	2.2	1.7	1.4	2.0	1.6	1.6	1.1	1.0	2.3	2.1	2.2
Quilpie	Rain	57	50	47	25	30	16	17	11	12	23	27	31
	Wet Days	5.0	4.2	3.9	2.4	2.9	2.5	2.6	1.8	1.9	3.3	3.7	3.9
Charleville	Rain	73	69	59	34	33	20	26	17	20	38	38	47
	Wet Days	6.8	5.4	4.7	3.2	3.3	2.8	3.1	2.5	2.8	4.9	4.7	5.8
Roma	Rain	83	78	57	33	40	28	37	26	23	57	55	71
	Wet Days	7.0	6.2	4.6	3.2	3.8	2.8	3.7	3.3	3.3	5.7	5.8	6.2
Thargomindah	Rain	48	33	37	19	24	17	19	13	12	18	26	24
	Wet Days	3.7	3.2	3.3	1.9	2.8	2.4	2.8	2.4	2.1	3.3	3.3	2.9

Table A2 Monthly Mean Rainfall and Wet Days

Location	Wetting Influences						Drying Influences					
	W1		W2		W3		D1		D2		D3	
	Days	Event	Days	Event	Days	Event	Days	Event	Days	Event	Days	Event
Normanton	81.9	2.4	90.5	1.3	129.9	1.1	176.5	1.9	196.8	1.2	236.2	1.0
Mt Isa	33.8	1.5	24.7	0.8	34.3	0.6	178.5	3.5	204.3	1.9	242.3	1.1
Cloncurry	40.8	1.5	35.1	0.9	54.5	0.7	177.5	3.2	199.7	2.0	241.2	1.1
Hughenden	40.5	1.8	34.0	1.1	52.6	0.8	186.9	3.5	218.6	1.8	252.1	1.2
Winton	32.2	1.4	23.8	0.6	31.5	0.5	183.4	3.8	215.8	2.1	253.3	1.4
Boulia	13.9	0.7	2.7	0.1	0.2	0.04	223.7	3.7	268.7	3.1	312.3	1.8
Longreach	31.1	1.5	21.3	0.7	32.5	0.5	198.2	4.2	236.3	2.2	276.2	1.1
Barcaldine	35.9	1.9	22.0	0.7	36.5	0.7	222.7	4.1	257.7	1.9	295.7	1.0
Birdsville	4.7	0.3	1.1	0.02	2.0	0.02	112.8	3.4	134.7	2.3	164.8	1.4
Quilpie	18.3	0.9	13.2	0.3	18.1	0.3	203.3	4.7	234.2	2.5	274.6	1.4
Charleville	30.3	1.6	21.8	0.8	35.0	0.8	244.2	4.7	284.5	2.2	323.3	1.0
Roma	42.6	2.2	29.4	1.1	50.1	1.3	279.7	4.0	316.2	1.8	245.2	0.6
Thargomindah	12.6	0.5	6.3	0.2	8.4	0.10	190.5	4.5	221.4	2.7	266.6	1.4

Days = average days per year event will occur,
Events = average no of events per year.
Based on 51 years data from 01Jan 1949 to 31 Dec1999.
W1 >100mm in 4 weeks; W2 >200mm in 8 weeks; W3 >300mm in 16 weeks;
D1 = <10mm in 4 weeks; D2 = <20mm in 8 weeks; D3 = <40mm in 16 weeks.

Table A3 Distribution of Wetting and Drying Influences

Site	Lowest recorded temp.	Mean No. of days <0°	Lowest Avg Monthly Minimum	Highest Avg. Monthly Maximum	Mean No of days >40°	Highest recorded temp.
Normanton	6.6	0.0	15.2	36.1	6.7	43.3
Mt Isa	1.1	0.0	10.0	37.7	28.8	44.3
Cloncurry	5.0	0.0	10.3	38.0	20.0	43.4
Hughenden	-2.0	0.3	8.8	37.0	31.4	43.9
Winton	-1.7	0.8	8.0	38.3	31.2	45.6
Boulia	-0.5	0.1	7.4	38.5	44.4	46.1
Longreach	-1.1	0.4	6.9	37.5	26.9	46.1
Barcaldine	-1.6	0.6	7.7	35.8	9.2	44.8
Birdsville	-1.7	0.3	6.6	38.6	43.9	49.5
Quilpie	-2.3	0.5	6.0	36.8	17.9	46.5
Charleville	-4.5	8.3	4.4	36.1	4.3	46.5
Roma	-5.0	10.9	4.1	34.4	5.1	44.5
Thargomindah	-6.5	0.7	15.6	40.2	15.6	47.5

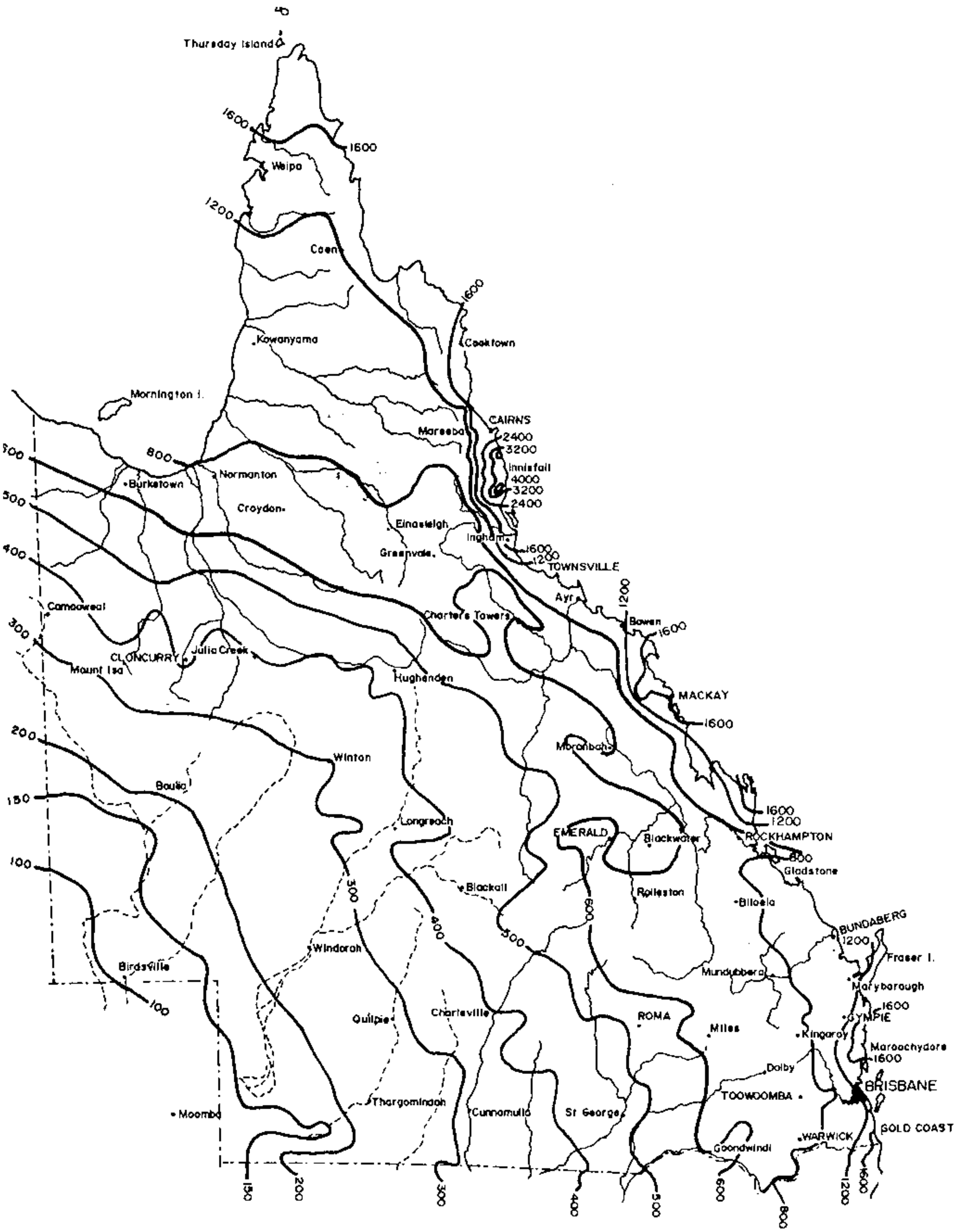
Table A4 Temperature Statistics

Site	Mean Daily evaporation (mm/day) Australian Standard Pan figures												Avg annual days	
	J	F	M	A	M	J	J	A	S	O	N	D	Clear	Cloudy
Normanton	7.5	6.7	6.9	7.8	7.6	7.1	7.4	8.6	9.8	10.5	10.3	8.9	135.4	80.6
Mt Isa	10.1	9.2	8.7	8.1	6.2	5.1	5.3	6.6	8.5	10.3	11.2	11.0	189.7	37.3
Cloncurry	10.1	9.1	8.2	8.1	6.4	5.3	5.5	6.8	8.8	10.5	11.3	11.1	No data available	
Hughenden	7.7	7.1	7.1	6.2	4.7	4.0	4.1	5.2	6.9	8.3	8.8	8.6	180.5	55.9
Winton	10.5	9.2	8.6	7.3	5.3	4.2	4.5	5.7	7.7	9.8	10.9	11.3	189.4	51.2
Boulia	11.4	9.8	9.0	7.4	5.1	4.1	4.2	5.7	7.7	9.8	10.8	11.8	197.9	44.5
Longreach	11.0	9.4	8.8	7.3	5.2	4.1	4.4	5.7	8.0	10.1	11.6	11.8	183.9	41.0
Barcaldine	9.6	8.5	7.7	6.3	4.5	3.5	3.7	4.9	6.9	8.7	10.1	10.1	175.8	58.2
Birdsville	15.1	13.4	11.0	8.0	5.2	3.8	3.9	5.5	8.1	10.9	12.8	14.9	223.2	41.8
Quilpie	10.2	9.0	7.9	5.9	3.9	2.7	2.9	4.0	5.9	7.9	9.5	10.3	196.5	53.3
Charleville	10.4	9.2	8.1	6.0	3.9	2.9	3.0	4.2	6.1	8.0	9.7	10.6	No data available	
Roma	8.5	7.2	6.5	5.0	3.1	2.4	2.5	3.4	5.1	6.5	7.8	8.5	150.5	67.3
Thargomindah	13.9	12.1	10.0	6.6	2.5	2.7	2.0	5.1	6.5	6.0	13.9	12.1	No data available	

Table A5 Evaporation Statistics

Location	Parameter	Spring		Summer		Autumn		Winter	
		9AM	3PM	9AM	3PM	9AM	3PM	9AM	3PM
Normanton	Dir Speed	N-SE <10	NW 10-30	NW-NE <10	NW 10-30	NE-SE 10-30	SE <10	SE >30	SE <10
Mt Isa	Dir Speed	NW-E-SE 10-30	ALL 10-30	ALL 10-30	S-SE 10-30	E-SE 10-30	E-SE 10-30	E-S 10-30	NE-SE 10-30
Longreach	Dir Speed	N-SE 10-30	ALL 10-30	N-E 10-30	ALL 10-30	NE-E 10-30	E-S 10-30	NE-SE 10-30	ALL 10-30
Charleville	Dir Speed	N 10-30	ALL 10-30	NW-E 10-30	ALL 10-30	N-SE 10-30	E-S 10-30	N-SE 10-30	ALL 10-30
Speed in km/h. Dir = Dominant direction.									

Table A6 Wind Statistics



Map 1 Median Annual Isohyets