Rainfall Monitoring in the Gammon Ranges

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Summary: Little is known about the variability of rainfall with altitude in the semi-arid regions of Australia. As a result, a long term rainfall monitoring program was established in the Gammon Ranges in 1988, as part of the Scientific Expedition Group's Gammon Ranges Scientific Project. The project will continue until 1998 and is expected to provide valuable information to organisations such as the Department of Transport, the Engineering and Water Supply Department and the Electricity Trust of South Australia. As part of the project, rainfall is continuously recorded on the Gammon Plateau, as well as two other locations in the Gammon Ranges National Park. The pluviometer on the Gammon Plateau was installed in September 1988 and is located at an elevation of approximately 930 m. This makes it the highest official rain gauge in the Flinders Ranges. The other two pluviometers were installed in April 1990 and August 1991 at elevations of 540 m and 650 m respectively. The rainfall records obtained at the Gammon Plateau were compared with those at several stations in the adjacent Windy Creek / Emu Creek catchments. A comparison of the average annual rainfall and the average number of rain days per year showed that both values increased with altitude. In addition, the average annual rainfalls recorded were significantly greater than the climatic average rainfalls provided by the Bureau of Meteorology. A comparison of average summer and winter rainfalls showed little correlation between average rainfall and elevation during the summer months, which is indicative of localised thunderstorm activity, triggered primarily by cold fronts. During winter, on the other hand, there was a marked increase in average rainfall with altitude. This is because winter rainfalls are characterised by low intensity events triggered by orographic lifting.

1. PROJECT BACKGROUND

This project arose out of curiosity - how did the Gammon Plateau support such a dense growth of vegetation in a low rainfall area? This curiosity was heightened by an experience in which extremely heavy rain in the ranges was observed to be confined almost entirely to the ranges.

It was soon recognised that the only way to find out exactly how much rain actually falls in the ranges would be to establish a long term rainfall monitoring project. It was also recognised that this could provide a different and valuable opportunity for the Scientific Expedition Group (SEG) to assist in the training of young people in field science activities. From this rather humble start, and with the help of many people and organisations, this project has now grown into a significant, broad environmental monitoring exercise, which will provide valuable information to organisations such as the National Parks and Wildlife Service (NPWS), the Department of Transport, the Department of the Environment and Natural Resources (DENR), and the Electricity Trust of South Australia (ETSA). In addition, the project provides training and wilderness experience for expeditioners of all ages.

On 11th September 1988, the project was officially commenced with the "turning on" of the pluviometer on the Gammon Plateau. The project was dedicated to the memory of Louise Grandfield, a SEG member and leader on Expedition Freeling Plateau in 1986, who devoted much of her short career to caring for the Flinders Ranges. Tragically, Louise was killed in a car accident on a field trip to the Flinders just one month after the Freeling expedition.

2. PROJECT DESCRIPTION

The Gammon Range in the far northern Flinders Ranges (Figure 1) consists of a deeply dissected quartzite plateau with steep gorges and spectacular cliffs. The area covered by the SEG project is towards the western end of the Gammon Range, and is reached from an access track which turns east from the Mt Serle-to-Yankaninna Road into the Gammon Ranges National Park. This area was selected because it is less popular than the eastern part of the park, which means that the scientific experiments are less likely to be disturbed and the data collection trip is in an area of near wilderness, which adds to the experience for participants.

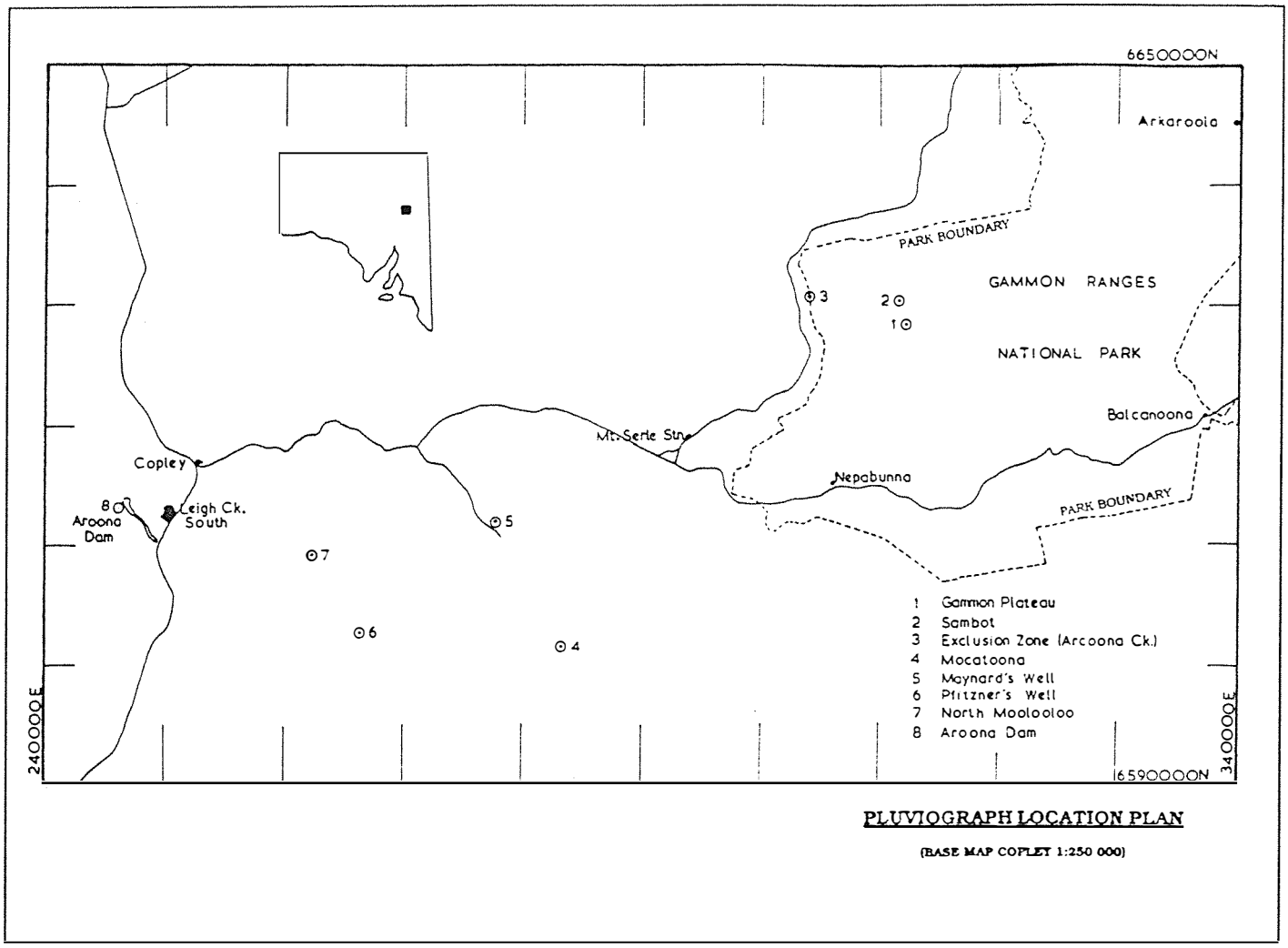


Figure 1: Location Plan

The project was designed as a long term monitoring exercise, and it is intended that it will continue for at least 10 years (i.e. until 1998). With this in mind, the program is being developed gradually and kept within the resources available. Regular visits to the various sites are important, and a schedule has been drawn up which provides for 5 visits per year. A "window" of time is allowed for each trip, and the leader of a trip is expected to arrange his / her itinerary to fit within this "window".

At present the project consists of the following monitoring activities:

- Rainfall monitoring at 3 sites
- Water level & temperature monitoring at 1 site
- Vegetation monitoring at 6 sites
- Stream biology and chemistry monitoring at 2 sites
- Human impact monitoring at 3 sites
- Monitoring rainfall chloride content at 3 sites.
- Monitoring feral animal counts and locations.

3. RAINFALL MONITORING

Prior to the setting up of the project, information on rainfall in the Flinders Ranges was limited to "daily read" raingauges located at homesteads around the foothills. Little is known about the variability of rainfall with height in this semi-arid climate, although orographic effects can cause an increase in rainfall at favourable locations. After 6 years of operation, the project is beginning to show differences between stations which have a rational meteorological basis.

Five rainfall recording stations were set up by the Engineering and Water Supply Department for ETSA to monitor rainfall in the catchments which supply water to Aroona Dam, the main water supply for Leigh Creek South. These stations have been in operation since the early 1980's and provide a basis of comparison for the rainfalls recorded at the Gammon Ranges stations. Because of the random and infrequent nature of the rainfall in this area, it will take many years before sufficient data have been collected to enable an accurate comparison with adjacent stations. However, a general understanding of the differences and similarities is already starting to develop.

The three pluviometers are located (Figure 1):

- on the **Gammon Plateau,** between North Tusk Hill and Four Winds Hill. Grid Reference: 126 281. Station No AW004517 (installed September 1988).
- on the northern flank on North Tusk Hill, close to **Lower Sambot Waterhole**. Grid Reference: 111 302. Station No AW004519 (installed August 1991).
- near the campsite on Arcoona Creek at the western boundary of the Gammon Ranges National Park. Located next to a long term "exclosure" experiment being conducted by the S.A. Department of Primary Industries to investigate the regeneration of native grasses, shrubs and trees when grazing pressures are removed **(Exclusion Zone)**. Grid Reference: 051 307. Station No AW004518 (installed April 1990).

A water level and water temperature recorder has been set up in Arcoona Creek close to the outlet from the gorges, not far from AW004518, Grid Reference: 052 309, Station No AW004520, (Installed June 1993).

The initial rainfall monitoring site, on the Gammon Plateau, is at an elevation of approximately 930 m. This makes it the highest continuously recording rain gauge in South Australia and this site was selected to determine the rainfall on the plateau. The other sites are at approximately 650 m and 540 m elevation and are therefore suitably located to investigate the altitude effect of the ranges on rainfall. All three sites are within the catchment of Arcoona Creek, and with the installation of a stream gauge, a start can be made in relating rainfall to runoff, leading to a better understanding of the water balance and interaction with groundwater. The monitoring program has also included the regular recording of the presence and depth of surface water in two waterholes (Wild Ass Creek and Upper Sambot).

4. REVIEW OF RAINFALL DATA COLLECTION

Rainfall from the Gammon Plateau has been collected continuously since September 1988, and for shorter periods at the other sites. The rainfall was collected by standard Rimco 200 mm tipping bucket raingauges (and 1 similar instrument manufactured by Monitor), and recorded by electronic loggers. Initially, a MACE TRS77 logger was used on the Gammon Plateau. However, this instrument was strictly limited in its range to 90 days, and was replaced in December 1990 by a Cherryville Logger manufactured by System Design Services. The Cherryville loggers are capable of operating unattended for much longer periods.

During the recording period, there have been two equipment failures, from 24-04-89 to 09-07-89 and from 12-12-90 to 20-05-91. During the periods of failure, total rainfall amounts were recorded, but the distribution of the rainfall is not known. The changeover to the new type of logger gave rise to a series of difficulties due to faults in the equipment and inexperience in handling the new loggers. It is believed that the problems have now been overcome.

To date, there have been approximately 30 data recovery trips to the area including several special trips to replace defective components or to upgrade loggers.

Data Loggers were supplied by Systems Design Services (SA), and much assistance in advice, service and materials has been provided by this firm on a cost-recovery (non-profit) basis.

5. DATA HANDLING AND ARCHIVING

The Water Resources Branch (formerly in the Engineering and Water Supply Department) of the Department of the Environment and Natural Resources has provided much help in supplying and installing the original logger, in assisting with the preparations and debriefings for each monitoring trip, and in handling, editing and archiving the data. Editing of the data records has been carried out at the Crystal Brook office, and all data is archived at the Water Resources office (226 2524)

6. DATA EVALUATION

The rainfall records obtained at the Gammon Ranges were compared with those at Aroona Dam, North Moolooloo, Pfitzner's Well, Maynard's Well and Mocatoona in the adjacent Windy Creek and Emu Creek Catchments (Figure 1), which flow into Aroona Dam at Leigh Creek. Rainfall has been recorded at increments of 0.2 mm at these stations over the period of review. While there are other rainfall stations within the Gammon Ranges catchments, these are only read once a day or less frequently. In this preliminary phase of the data analysis, no attempt has been made to analyse the data for time-periods shorter than one day.

Complete records of daily rainfall at Aroona Dam, North Moolooloo, Pfitzner's Well, Maynard's Well, Mocatoona and the Gammon Plateau were available for 1989, 1990, 1992 and 1993. During 1991, no records were available for North Moolooloo and Pfitzner's Well from October to December, for Mocatoona from July to December and for the Gammon Plateau from January to April. It should be noted that no comparison was made with stations to the east of the Gammon Ranges, such as Arkaroola and Balcanoona, as there are substantial gaps in the data at these stations over the period considered.

Complete records of monthly rainfall at Sambot Waterhole and the Exclusion Zone were only available for 1993. The pluviometer at the Exclusion Zone was installed in April 1990, but records were unavailable from January to April 1991 and from January to August 1992. The pluviometer at Sambot Waterhole was installed in August 1991, but records were unavailable from July to October 1992.

A summary of the monthly rainfalls and number of rain days per month is given in Appendix A.

6.1 Annual Data:

In order to obtain a meaningful comparison between the various stations, it was decided to average the data for 1989, 1990, 1992 and 1993, as complete records were available for these years.

The average annual rainfall as well as the elevations of the various rainfall stations is shown in Figure 2. It was decided to use the point elevation at the rainfall station, rather than the general elevation surrounding the station, as it is uncertain whether using the general elevation gives a better representation of actual events. Figure 2 shows that at lower altitudes (i.e. Aroona Dam, North Moolooloo and Pfitzner's Well) there is no significant relationship between height and average annual rainfall. However, at higher elevations, there is a definite increase in average annual rainfall with altitude. A similar trend can be observed when looking at the number of rain days (Figure 3).

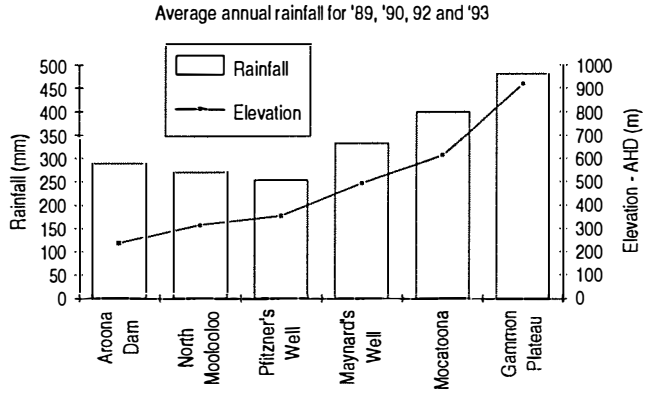


Figure 2: Average Annual Rainfall

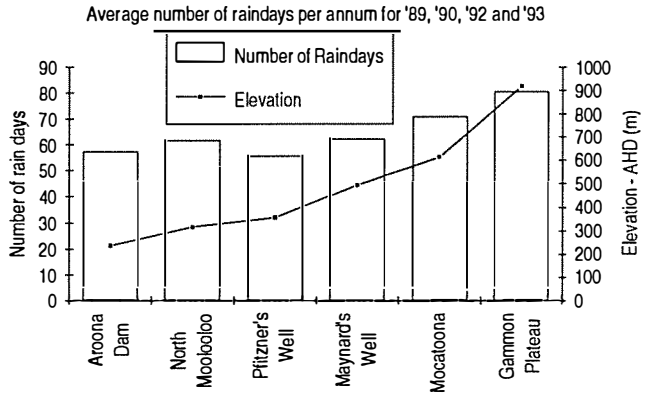


Figure 3: Average Number of Rain Days per Year

A comparison of the average annual rainfalls with the climatic average rainfalls provided by the Bureau of Meteorology (BOM) (Figure 4) indicates that the mean values given by the Bureau of Meteorology are consistently lower than the actual mean values, especially at increased altitude. However, it is difficult to get a true indication of the average rainfall from the short record considered here, as the rainfalls obtained may be biased by large events.

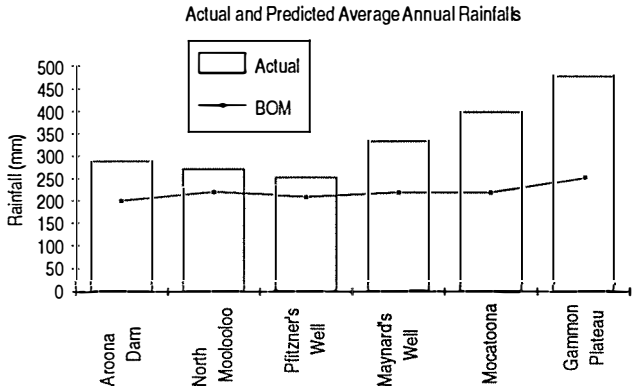


Figure 4: Comparison of Actual Average Rainfall with that Given by the Bureau of Meteorology

A comparison of the annual rainfall and the total number of rain days for 1993 for the three sites in the gammon ranges (Figures 5 and 6) shows that they follow the trends suggested by comparing the Gammon Plateau with the sites in the Emu Creek / Windy Creek catchment. There is a definite increase in annual rainfall and the total number of rain days with altitude.

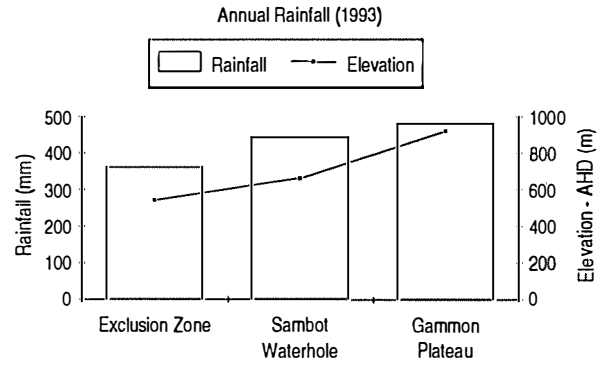


Figure 5: Annual Rainfall in the Gammon Ranges (1993)

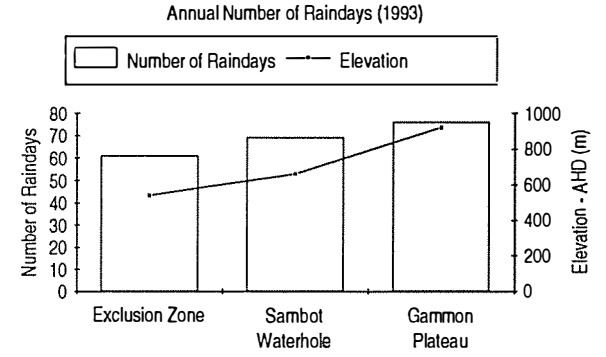


Figure 6: Annual Number of Rain Days in the Gammon Ranges (1993)

Figures 7 and 8 indicate that the total annual rainfall and the annual number of rain days in the Gammon Ranges are comparable to those at locations in the Windy Creek / Emu Creek catchment at similar altitudes.

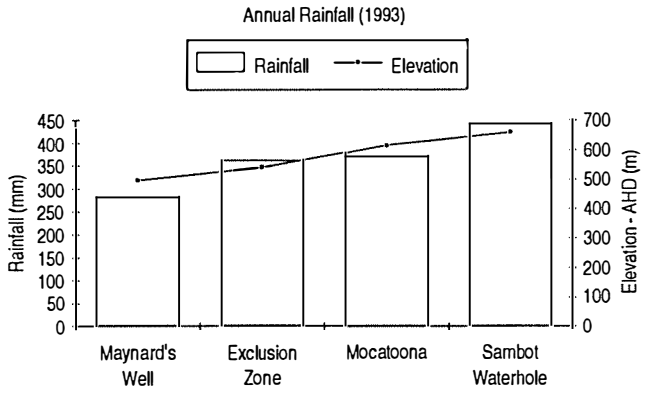


Figure 7: Annual Number of Rain Days in the Gammon Ranges and Locations at Comparable Elevations in the Emu Creek / Windy Creek Catchment (1993)

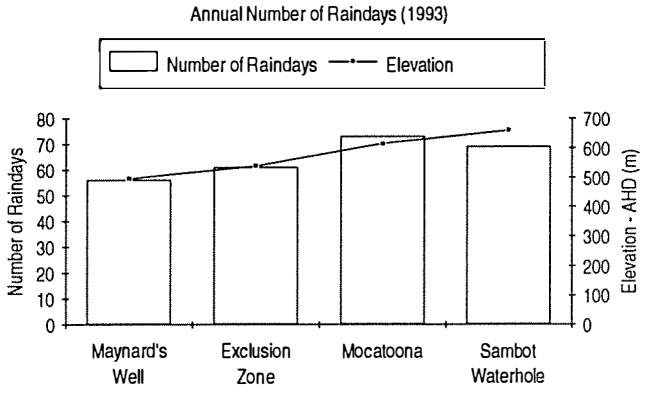


Figure 8: Annual Number of Rain Days in the Gammon Ranges and Locations at Comparable Elevations in the Emu Creek / Windy Creek Catchment (1993)

6.2 Seasonal Data:

A better comparison between the rainfall at the various stations can be obtained by separating winter and summer rainfalls, as the rainfall mechanisms are quite different at different times of the year.

In winter, the air is usually cool and does not hold much moisture. Orographic lifting is likely to be a trigger for rainfall (Curran, 1994), primarily resulting in showers and drizzle (Figure 9). Consequently, one would expect little variation in rainfall at the sites with low altitude (i.e. Aroona Dam, North Mooloolloo and Pfitzner's Well), but a marked increase in rainfall with altitude at the sites where orographic lifting plays a major role (i.e. Maynard's Well, Mocatoona and especially the Gammon Plateau). This phenomenon can be clearly illustrated by looking at the spatial distribution of daily rainfall for some of the winter events (Figures 10 to 13).

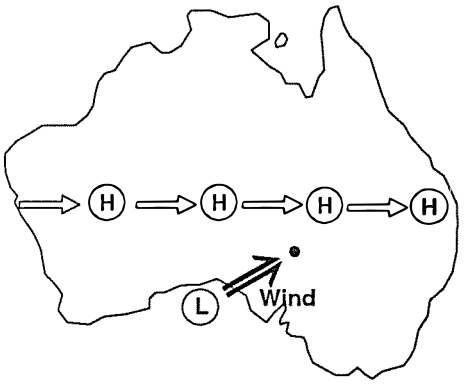


Figure 9: Typical Winter Rainfall Mechanism

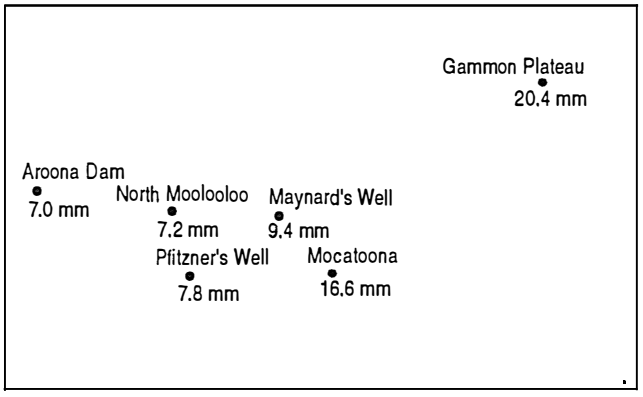


Figure 10: Rainfall Distribution (10-07-1989)

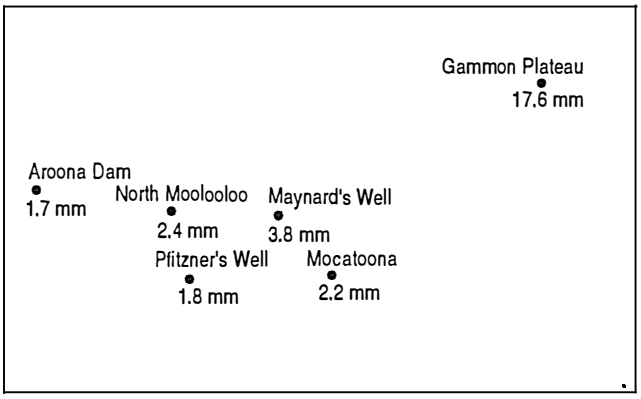


Figure 11: Rainfall Distribution (01-07-1990)

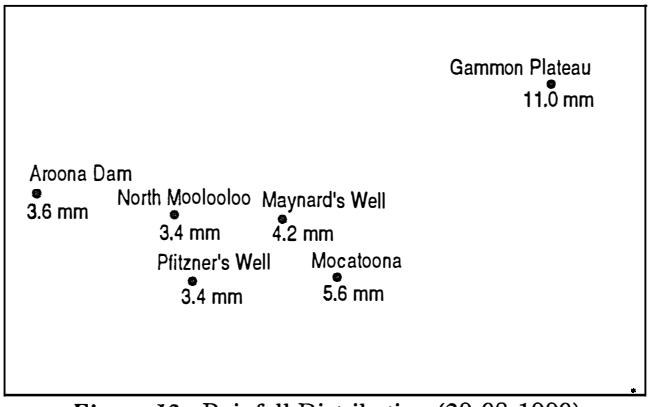


Figure 12: Rainfall Distribution (29-08-1990)

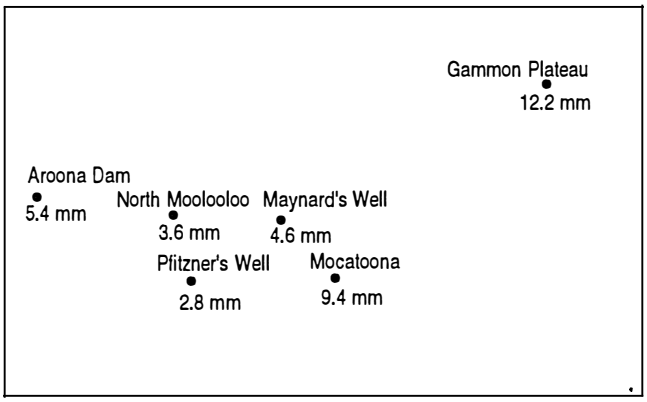


Figure 13: Rainfall Distribution (11-06-1993)

In summer, the air is usually warm and holds a lot of moisture. Summer rainfalls are usually shorter, more localised and more intense (Curran, 1994). Orographic lifting can be a trigger for these thunderstorms, but other triggers such as cold fronts are more likely and result in more intense rainfalls (Figure 14). As a result, one would not expect an increase in rainfall with altitude, but randomly centred localised events. This phenomenon can be clearly illustrated by looking at the spatial distribution of daily rainfall for some of the summer events (Figures 15 to 19).

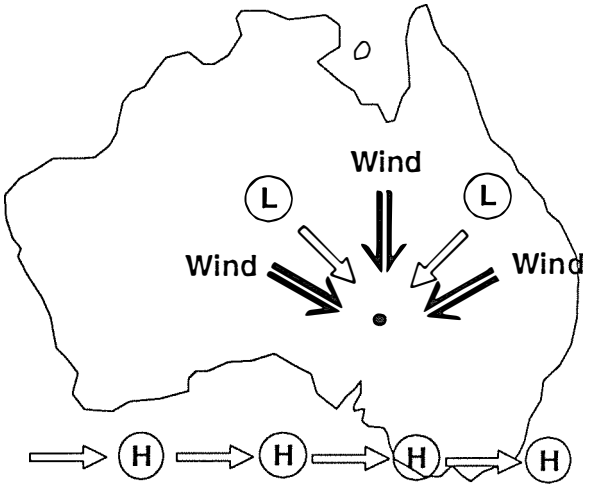


Figure 14: Typical Summer Rainfall Mechanism

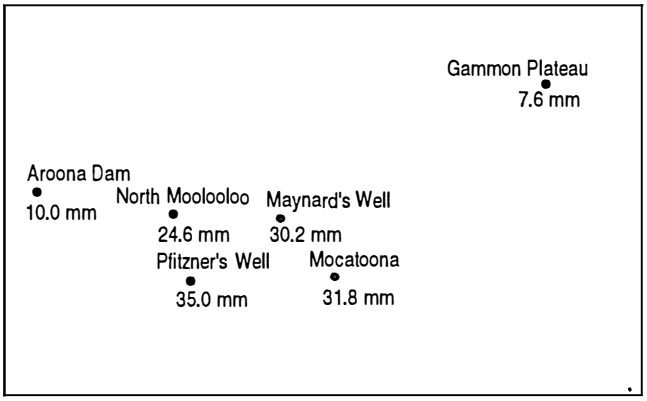


Figure 15: Rainfall Distribution (25-12-1988)

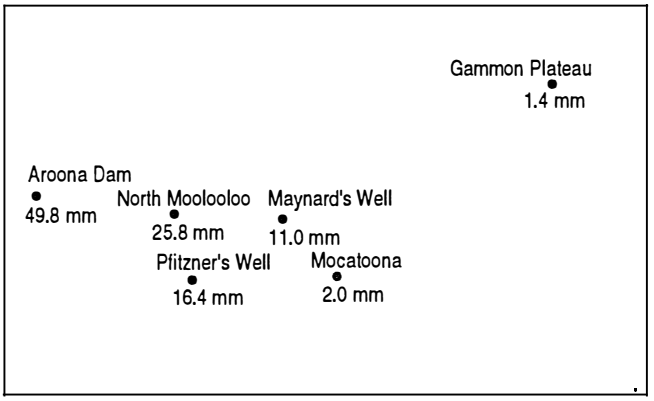


Figure 16: Rainfall Distribution (25-11-1989)

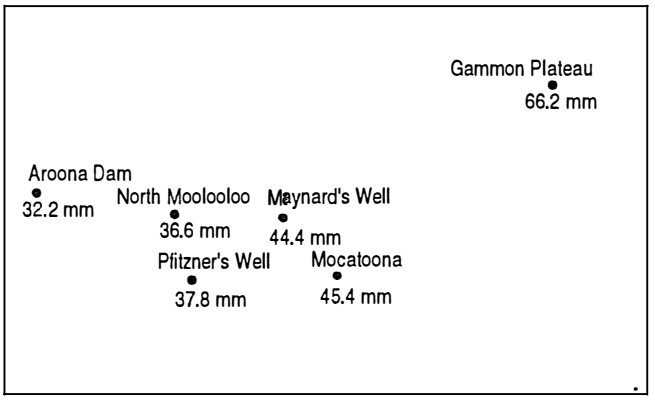


Figure 17: Rainfall Distribution (10-01-1990)

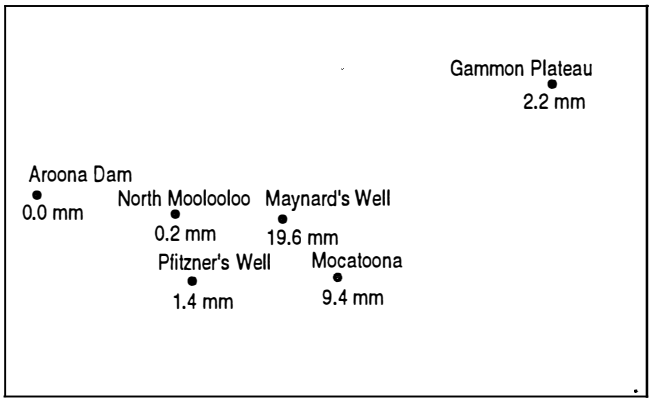


Figure 18: Rainfall Distribution (23-02-1990)

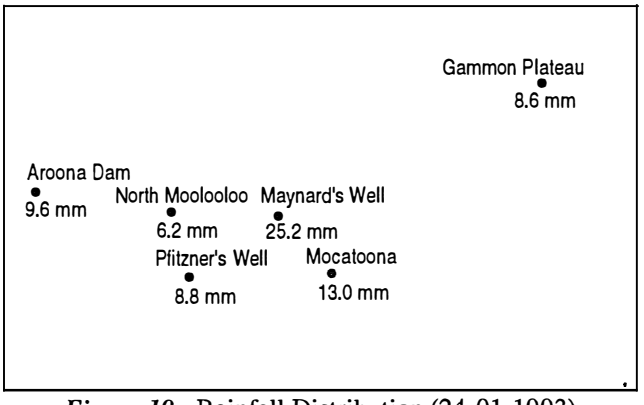


Figure 19: Rainfall Distribution (24-01-1993)

A comparison of the average monthly rainfall in the winter months (May, June, July and August) with that in the summer months (November, December, January, February) for the catchment of interest (Figure 20) shows that:

- In winter, there is little variation in rainfall at the sites with low altitude (i.e. Aroona Dam, North Moolooloo and Pfitzner's Well). However, there is a marked increase in rainfall with height at the locations where orographic lifting takes place (i.e. Maynard's Well, Mocatoona and the Gammon Plateau).
- In summer, there is still more rainfall at higher altitudes, but the variation in rainfall between the various sites is not great. The orographic effect appears to be far less dominant in the summer months.
- The rainfall is consistently greater in the winter months, but more so at higher altitudes.

The above results are in agreement with the theory discussed earlier.

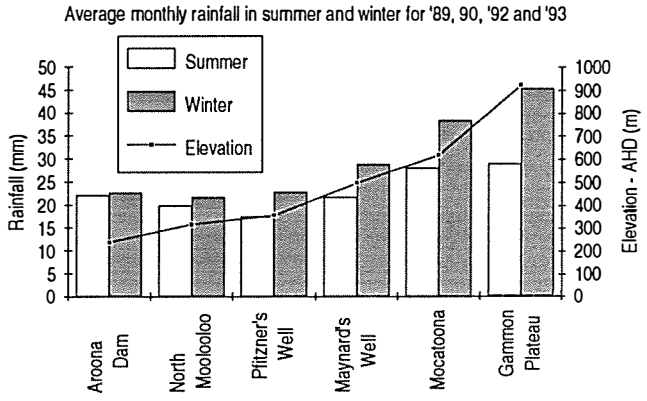


Figure 20: Average Monthly Winter and Summer Rainfalls

A comparison of the average number of rain days per month in the winter months (May, June, July and August) with those in the summer months (November, December, January, February) for the catchment of interest (Figure 21) shows that:

- In winter, there is little variation in the number of rain days at the sites with low altitude (i.e. Aroona Dam, North Moolooloo and Pfitzner's Well). However, there is a definite increase in the number of rain days with height at the locations where orographic lifting takes place (i.e. Maynard's Well, Mocatoona and the Gammon Plateau).
- In summer, there is little variation in the number of rain days per month between the various sites. This indicates that the orographic effect appears to be far less dominant in the summer months.
- The number of rain days is significantly greater in the winter months, suggesting a greater number of rainfall events at lower intensity.

The above results are in agreement with the theory discussed earlier.

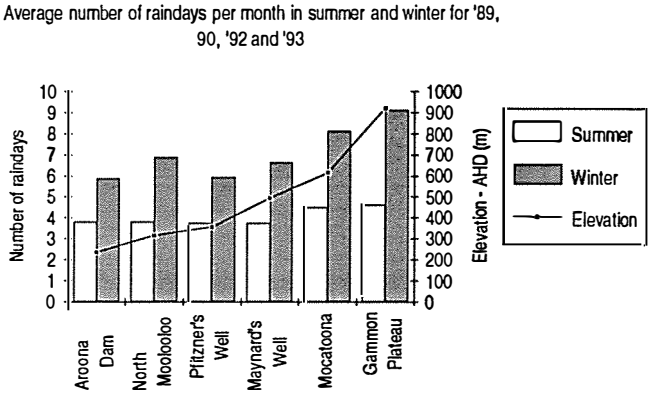


Figure 21: Average Number of Rain Days per Month in Winter and Summer

7. CONCLUSIONS

This paper summarises the status of the Gammon Ranges rainfall project, and includes some preliminary data and analysis. After six years of operation, the project is beginning to show rational, meteorological differences in total rainfall and the number of raindays between various rainfall stations in and around the Gammon Ranges. The comparison of the average annual rainfall and the average number of rain days per year showed that both values increased with altitude. In addition, the average annual rainfalls recorded were significantly greater than the climatic average rainfalls provided by the Bureau of Meteorology. A comparison of average summer and winter rainfalls showed little correlation between average rainfall and elevation during the summer months, which is indicative of localised thunderstorm activity, triggered primarily by cold fronts. During winter, on the other hand, there was a marked increase in average rainfall with altitude. This is because winter rainfalls are characterised by low intensity events triggered by orographic lifting.

8. REFERENCES

Curran, Elizabeth (1994), Climate and Consultancy, Bureau of Meteorology, Regional Office, South Australia, Personal Communication.

APPENDIX A - MONTHLY RAINFALLS AND RAIN DAYS

A1. Monthly Rainfalls (mm)

1989	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Exclusion Zone	Sambot W/Hole	Total
January	0.0	1.4	2.2	3.0	15.2	3.6			25.4
February	0.4	0.0	0.0	0.0	0.0	0.0			0.4
March	210.2	180.4	159.8	217.0	209.0	372.2			1348.6
April	17.8	8.6	19.2	13.0	13.6	29.2			101.4
May	37.8	31.8	52.2	56.6	44.4	40.0			262.8
June	24.4	17.0	27.2	22.0	26.6	39.0			156.2
July	41.4	32.8	43.2	64.2	76.8	84.6			343.0
August	0.0	0.8	1.2	0.2	1.8	3.8			7.8
September	1.8	8.4	3.6	3.6	8.4	5.2			31.0
October	7.4	10.8	14.2	15.6	24.4	16.2			88.6
November	63.2	39.2	41.8	25.8	26.6	11.2			207.8
December	13.4	18.2	15.8	16.8	13.6	25.8			103.6
Total	417.8	349.4	380.4	437.8	460.4	630.8	0.0	0.0	2676.6

1990	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Exclusion Zone	Sambot W/Hole	Total
January	54.0	54.2	49.6	86.4	61.4	82.0			387.6
February	0.4	10.8	4.8	1.6	19.6	5.6			42.8
March	3.4	9.0	5.0	9.0	19.6	7.2			53.2
April	30.2	37.6	43.4	56.8	28.2	30.0			226.2
May	33.0	33.2	30.4	49.6	53.0	95.1	59.0		353.3
June	7.2	12.4	13.6	18.4	31.4	40.0	11.4		134.4
July	21.4	21.0	28.6	30.8	56.2	68.6	31.0		257.6
August	7.6	6.2	8.0	10.2	19.0	20.2	12.0		83.2
September	19.4	15.8	13.8	10.2	17.2	7.2	4.0		87.6
October	2.4	7.2	3.4	9.8	6.6	10.8	11.2		51.4
November	1.0	0.8	2.0	2.6	0.8	0.6	0.2		8.0
December	8.6	8.2	5.0	5.0	13.8	16.2	1.8		58.6
Total	188.6	216.4	207.6	290.4	326.8	383.5	130.6	0.0	1743.9

1991	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Exclusion Zone	Sambot W/Hole	Total
January	19.6	32.8	44.2	21.6	18.2				136.4
February	0.0	0.0	0.0	0.0	0.0				0.0
March	11.8	5.6	12.6	8.8	17.6				56.4
April	0.0	0.0	0.0	0.0	0.8				0.8
May	0.2	0.2	0.4	2.4	1.0	0.0	0.0		4.2
June	32.8	34.4	39.4	33.4	40.0	53.0	37.6		270.6
July	18.0	17.0	22.0	21.0		40.6	36.2		154.8
August	10.6	12.4	13.0	17.4		15.2	9.2		77.8
September	3.6	2.8	3.0	1.0		8.8	1.6		20.8
October	0.0			1.2		0.2	0.0	0.0	1.4
November	23.0			24.2		30.2	24.4	27.8	129.6
December	1.2			0.0		1.6	0.4	0.0	3.2
Total	120.8	105.2	134.6	131.0	77.6	149.6	109.4	27.8	856.0

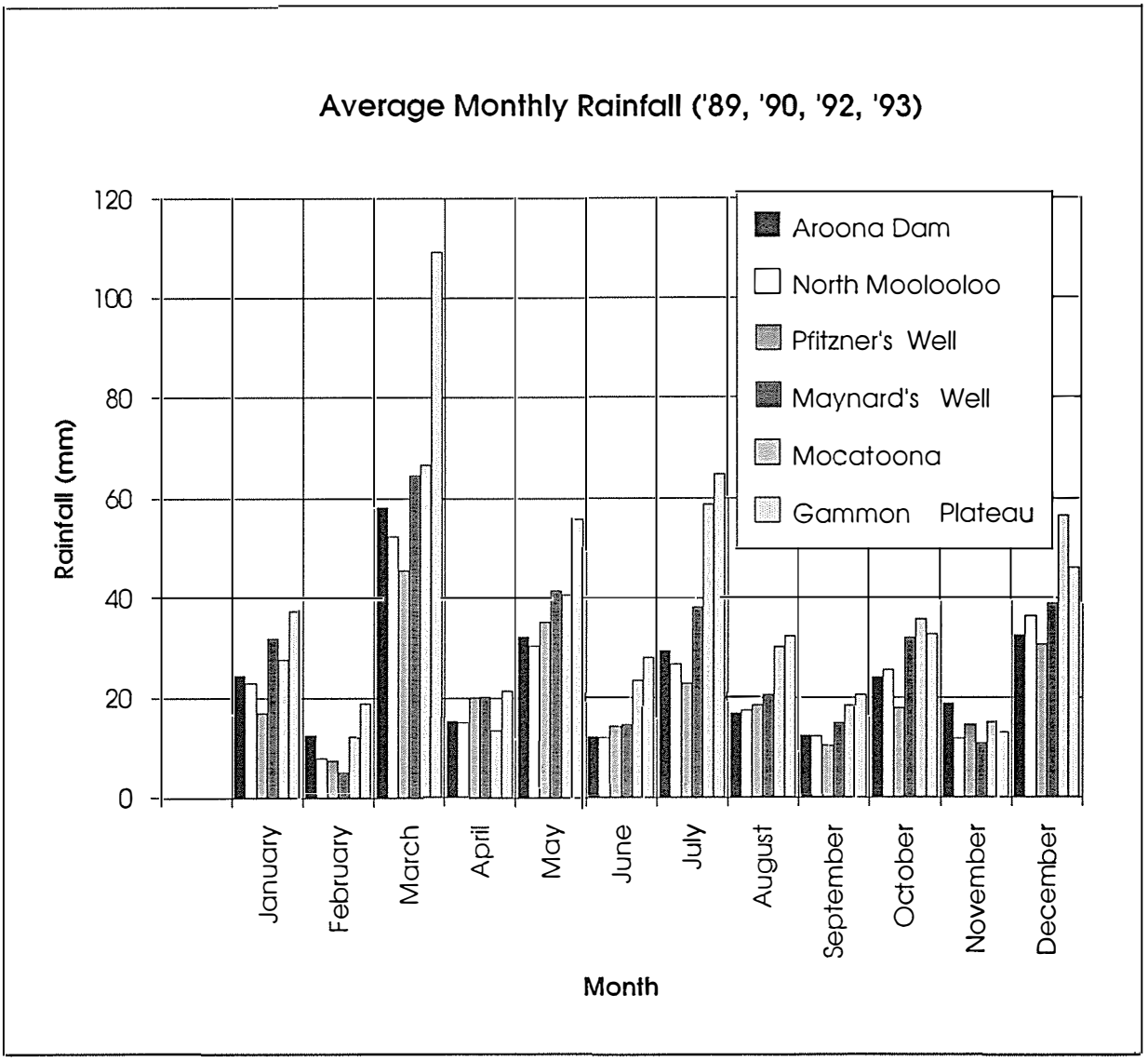
1992	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Exclusion Zone	Sambot W/Hole	Total
January	2.6	0.4	0.2	1.2	4.2	1.8		1.2	11.6
February	47.4	18.6	17.2	17.4	14.0	42.8		34.0	191.4
March	15.0	15.4	17.0	29.4	34.0	48.5		56.1	215.4
April	12.8	13.8	17.8	11.2	12.2	25.8		20.6	114.2
May	47.6	42.2	53.4	44.6	52.4	60.7		58.3	359.2
June	5.6	6.8	8.6	6.8	13.8	9.2		6.6	57.4
July	6.6	2.4	4.0	3.4	9.4	5.0			30.8
August	56.4	58.4	65.2	62.8	78.2	81.7			402.7
September	24.6	22.2	24.4	39.8	40.6	49.2	28.0		228.8
October	39.6	42.0	53.8	49.2	62.4	45.8	35.0		327.8
November	5.8	4.0	6.6	9.2	15.2	27.2	18.6	28.6	115.2
December	72.2	57.2	46.8	48.0	103.2	30.8	34.6	27.8	420.6
Total	336.2	283.4	315.0	323.0	439.6	428.5	116.2	233.2	2475.1

1993	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Exclusion Zone	Sambot W/Hole	Total
January	41.2	36.2	16.0	37.2	30.2	62.2	48.6	74.8	346.4
February	1.2	1.6	7.4	0.6	15.0	27.4	6.0	16.0	75.2
March	4.0	5.0	0.8	3.0	4.0	9.0	4.2	3.4	33.4
April	0.0	0.0	0.0	0.2	0.0	0.8	0.2	0.2	1.4
May	10.8	14.8	5.2	15.2	13.0	28.0	23.2	25.0	135.2
June	11.2	11.6	7.8	11.2	22.4	24.2	10.6	17.0	116.0
July	48.0	50.6	16.0	54.2	92.8	101.0	73.2	84.0	519.8
August	3.6	4.8	0.0	9.4	22.0	23.6	17.8	21.4	102.6
September	3.6	2.4	0.0	6.4	7.6	21.0	14.6	19.4	75.0
October	47.2	42.4	0.4	53.4	49.8	58.2	47.8	57.4	356.6
November	5.4	3.6	8.0	6.0	18.0	13.4	9.0	13.4	76.8
December	35.8	61.8	55.2	85.6	95.4	111.4	106.2	110.2	661.6
Total	212.0	234.8	116.8	282.4	370.2	480.2	361.4	442.2	2500.0

1994	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Exclusion Zone	Sambot W/Hole	Total
January	0.0	0.0	2.4	3.4	1.2	0.6	11.2	2.0	20.8
February	58.2	75.4	77.0	88.0	85.6	94.2	107.0	109.4	694.8
March	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
April									0.0
May									0.0
June									0.0
July									0.0
August									0.0
September									0.0
October									0.0
November									0.0
December									0.0
Total	58.2	75.4	79.4	91.4	86.8	94.8	118.2	111.4	715.6

Average Monthly Rainfalls ('89, '90, '92, '93)

Average	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Total
January	24.5	23.1	17.0	32.0	27.8	37.4	161.6
February	12.4	7.8	7.4	4.9	12.2	19.0	63.5
March	58.2	52.5	45.7	64.6	66.7	109.2	396.7
April	15.2	15.0	20.1	20.3	13.5	21.5	105.6
May	32.3	30.5	35.3	41.5	40.7	56.0	236.3
June	12.1	12.0	14.3	14.6	23.6	28.1	104.6
July	29.4	26.7	23.0	38.2	58.8	64.8	240.8
August	16.9	17.6	18.6	20.7	30.3	32.3	136.3
September	12.4	12.2	10.5	15.0	18.5	20.7	89.1
October	24.2	25.6	18.0	32.0	35.8	32.8	168.3
November	18.9	11.9	14.6	10.9	15.2	13.1	84.5
December	32.5	36.4	30.7	38.9	56.5	46.1	241.0
Total	288.7	271.0	255.0	333.4	399.3	480.8	2028.0



A2. Number of Rain Days

1989	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Exclusion Zone	Sambot W/Hole	Total
January	0	1	1	1	1	2			6
February	1	0	0	0	0	0			1
March	12	9	10	10	9	13			63
April	4	2	5	6	5	12			34
May	6	8	7	6	8	5			40
June	10	14	9	9	10	7			59
July	13	12	11	13	15	18			82
August	0	2	2	1	3	4			12
September	1	2	2	1	2	3			11
October	3	4	5	5	5	7			29
November	7	8	9	8	8	8			48
December	2	1	2	1	3	2			11
Total	59	63	63	61	69	81	0	0	396

1990	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Exclusion Zone	Sambot W/Hole	Total
January	4	5	4	5	5	7			30
February	2	2	2	2	1	1			10
March	2	2	2	2	2	2			12
April	4	5	6	5	6	7			33
May	5	5	6	6	7	9	6		44
June	6	6	6	7	9	12	6		52
July	12	14	13	11	12	16	13		91
August	3	5	6	6	6	6	12		44
September	3	3	4	4	4	4	4		26
October	5	4	4	4	3	4	4		28
November	1	1	1	1	1	1	1		7
December	2	5	1	3	5	2	4		22
Total	49	57	55	56	61	71	50	0	399

1991	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Exclusion Zone	Sambot W/Hole	Total
January	6	7	9	6	8				36
February	0	0	0	0	0				0
March	2	2	2	1	2				9
April	0	0	0	0	3				3
May	1	1	1	1	1	0	0		5
June	11	10	13	11	12	14	10		81
July	7	9	9	10		16	12		63
August	3	3	4	4		6	3		23
September	3	1	2	2		5	3		16
October	0			2		1	0	0	3
November	7			5		6	6	5	29
December	1			0		2	2	0	5
Total	41	33	40	42	26	50	36	5	273

1992	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Exclusion Zone	Sambot W/Hole	Total
January	1	1	1	1	2	2		1	9
February	5	5	5	3	4	6		6	34
March	1	2	2	2	2	3		2	14
April	6	5	6	6	5	6		6	40
May	7	8	10	9	10	11		10	65
June	4	5	6	6	6	10		8	45
July	3	2	2	3	3	4			17
August	7	8	8	8	10	13			54
September	8	11	8	9	11	13	10		70
October	9	11	10	10	10	8	10		68
November	4	2	6	7	6	6	6	7	44
December	12	10	11	12	12	12	10	11	90
Total	67	70	75	76	81	94	36	51	550

1993	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Exclusion Zone	Sambot W/Hole	Total
January	7	9	5	5	4	8	9	9	56
February	2	2	2	1	9	2	2	2	22
March	3	2	3	2	3	4	4	3	24
April	0	0	0	1	0	2	1	1	5
May	4	5	2	6	6	6	4	7	40
June	3	3	2	3	6	7	5	6	35
July	9	10	5	9	15	12	10	9	79
August	2	3	0	3	4	6	4	6	28
September	5	5	0	7	6	7	4	6	40
October	8	9	1	9	9	7	7	7	57
November	4	3	3	4	5	4	3	4	30
December	7	6	7	6	6	11	8	9	60
Total	54	57	30	56	73	76	61	69	476

1994	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Exclusion Zone	Sambot W/Hole	Total
January	0	0	1	1	2	2	4	3	13
February	4	4	3	4	4	9	7	9	44
March	0	0	0	0	0	0	0	0	0
April									0
May									0
June									0
July									0
August									0
September									0
October									0
November									0
December									0
Total	4	4	4	5	6	11	11	12	57

Average Number of Raindays ('89, '90, '92, '93)

Average	Aroona Dam	North Moolooloo	Pfitzner's Well	Maynard's Well	Mocatoona	Gammon Plateau	Total
January	3.0	4.0	2.8	3.0	3.0	4.8	20.5
February	2.5	2.3	2.3	1.5	3.5	2.3	14.3
March	4.5	3.8	4.3	4.0	4.0	5.5	26.0
April	3.5	3.0	4.3	4.5	4.0	6.8	26.0
May	5.5	6.5	6.3	6.8	7.8	7.8	40.5
June	5.8	7.0	5.8	6.3	7.8	9.0	41.5
July	9.3	9.5	7.8	9.0	11.3	12.5	59.3
August	3.0	4.5	4.0	4.5	5.8	7.3	29.0
September	4.3	5.3	3.5	5.3	5.8	6.8	30.8
October	6.3	7.0	5.0	7.0	6.8	6.5	38.5
November	4.0	3.5	4.8	5.0	5.0	4.8	27.0
December	5.8	5.5	5.3	5.5	6.5	6.8	35.3
Total	57.3	61.8	55.8	62.3	71.0	80.5	388.5