

Comparison between Rainfall IFD in ARR (1987) and BoM (2013) for Western Australia

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Abstract

The Paper compares rainfall IFDs published in Australian Rainfall & Runoff (ARR, 87) with 2013 Bureau of Meteorology publication for various locations throughout Western Australia, for AEP down to 1% and storm duration up to 72 hours.

The 2013 IFDs shows considerably lower rainfall intensity in the Pilbara across all AEPs and durations, and large increases in rainfall intensity in other areas of WA (as around Busselton in the South West). Annual maximum analysis of daily rainfall data for single stations suggests that the increase (decrease) may be partially attributed to the occurrence (non-occurrence) of relatively high rainfall totals in years since ARR87.

1. INTRODUCTION

The frequency analysis of rainfall data is an important part of hydrological design procedures and is used as input to the design of a wide range of hydraulic structures and associated risks of overtopping or failure in both rural and urban areas.

Rainfall intensity-frequency-duration (IFD) design rainfall curves were derived throughout Australia by the Bureau of Meteorology (BoM) in a project commencing in 1982 and completed in 1986 for ARR87. That Project provided IFD data for Annual Exceedence Probabilities (AEPs) down to the 1% level (alternatively reported in terms of average recurrence interval (ARI) up to 100 years), for durations from 5 min to 72 hrs.

No comprehensive revision to the IFD data for Australia was made until the 2013 BoM publication at <http://www.arr.org.au/>, and <http://www.bom.gov.au/water/designRainfalls/ifd/index.shtml>. These are referred to here as 2013 IFD, or similar notation.

This paper presents an overview of the increases or decreases between ARR87 rainfall IFDs and 2013 revision spatially across WA.

Methodology for ARR87 included annual maxima data series analysis, and conversion to partial duration series using factors similar to those of Miller *et al.* (1973). ARR87 IFDs were based largely on daily read data and focused on the design of structures on large rural catchments and therefore durations less than 5 minutes were not considered necessary.

The 2013 IFD revision uses the greatly expanded network of rainfall stations for both daily and continuous data. Advanced statistical techniques are used together with new gridding procedures and a greater focus on small urban catchment design with IFD estimates down to 1 min (Green *et al* 2012).

Green *et al* (2012) explain that both annual maxima and partial duration series were analyzed but that for more frequent events the annual maxima series was used with conversion factors for the 50% and 20% annual exceedance probability (AEP).

The 2013 IFDs are part of a larger suite of design flood estimation inputs currently being revised through the ARR research project, to be released progressively over the next 2 years. The BoM website states that until all components of ARR are revised, the new IFDs can only be used in specific circumstances and refers to guidance provided by Engineers Australia.

The purpose of this Paper is to draw attention to the differences between IFDs presented in ARR87 compared to 2013 IFD for Western Australia.

2. WA COMPARISON: ALL DURATIONS, ALL AEPS

Figure 1 shows a map of Western Australia with generalized results for all AEP and durations of the differences between the ARR87 and 2013 IFDs. Note that ARR87 minimum duration is 5 minutes, whereas 2013 IFD is 1 minute so that no comparison is possible for less than 5 minutes.

Figure 1 shows in colour coding the following:

- In Red – areas of WA which have a large increase in rainfall intensity for all duration and AEP;
- In Orange, Pink, Yellow and Light Green – intermediate or mixed result with some decreases and some increases in rainfall intensity;
- In Green – a distinct decrease in rainfall intensity across almost all AEP and durations.

For example, large intensity increases are evident in the South West around Bunbury, Busselton and Augusta. Examples of locations with a large rainfall intensity decrease are the Darling Scarp from Pinjarra to Harvey, South Coast between Pemberton and Albany and the Pilbara from Exmouth, Onslow, Karratha to Port Hedland and inland to Tom Price.

Figure 1 notes that the maximum increase in rainfall intensity is 52% at Yallingup in the South West for 1% AEP 1 hr duration, and the largest decrease in rainfall intensity is 48% at Karratha in the Pilbara for 1% AEP 2 hr duration.

Tables 1 to 3 present rainfall intensity differences between 1987 and 2013 for Perth, Busselton and Port Hedland for all AEP and durations calculated as:

$$\text{Percentage difference} = (2013(\text{BoM}) - \text{ARR87}) \times 100 \div \text{ARR87}.$$

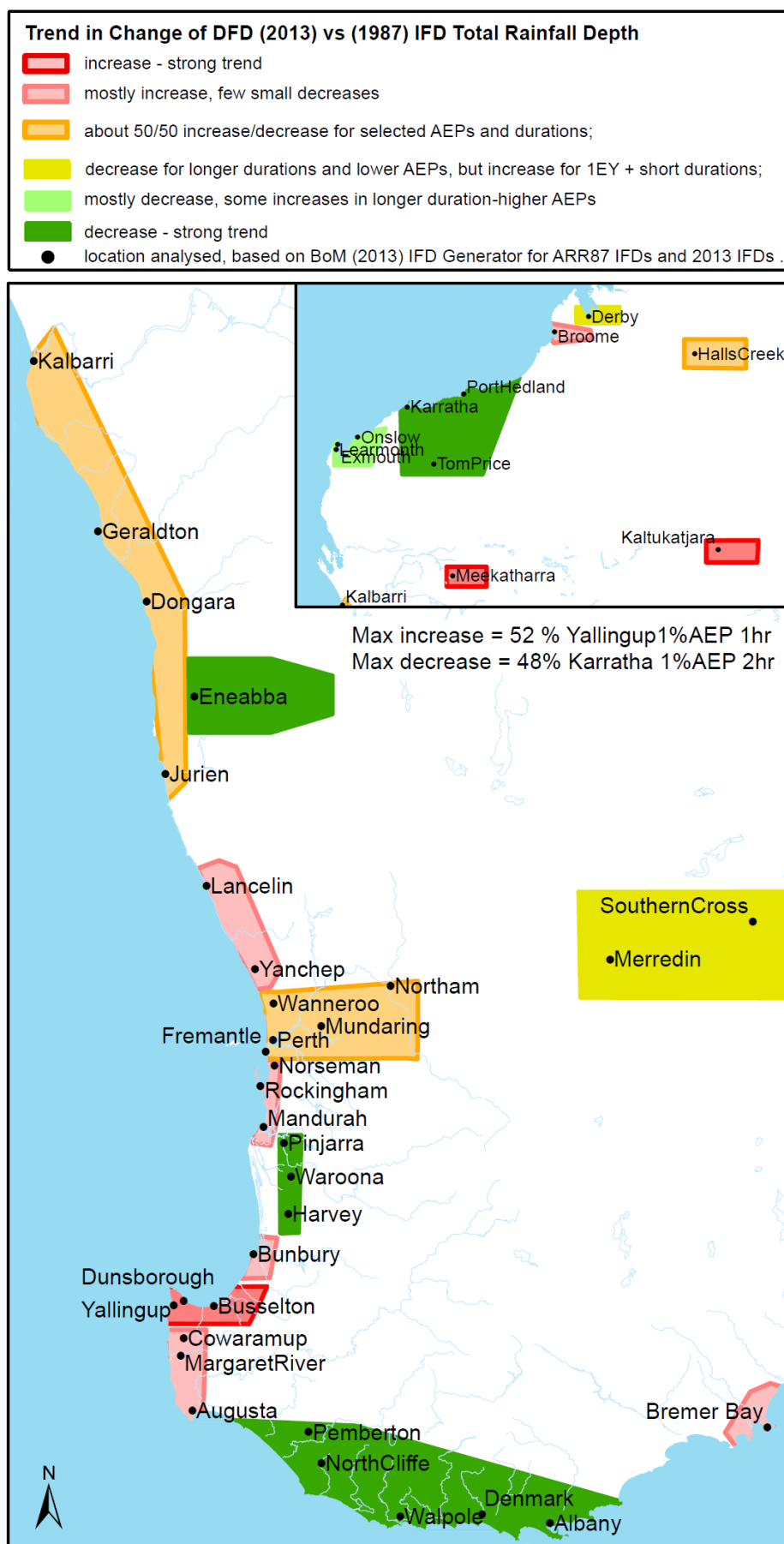


Figure 1: Spatial trends for differences between the ARR87 and BoM (2013) IFDs for all AEPs and durations.

Table 1 Perth - Differences between ARR87 and 2013 (BoM) revised IFD – all durations & selected AEPs

DURATION	1 EY/1yr ARI	10% AEP/10yr ARI	5% AEP/20yr ARI	2% AEP/50yr ARI	1% AEP/100yr ARI
5Mins	16.7%	-4.2%	-8.5%	-14.2%	-17.7%
10Mins	14.2%	-2.9%	-6.2%	-11.4%	-15.2%
30Mins	10.7%	-0.4%	-3.4%	-6.5%	-8.9%
1Hr	9.5%	0.3%	-1.5%	-3.5%	-5.0%
2Hrs	9.4%	2.2%	1.4%	1.6%	1.6%
3Hrs	8.7%	3.7%	4.2%	5.3%	6.3%
6Hrs	8.2%	6.2%	7.9%	11.4%	14.0%
12Hrs	7.3%	6.4%	8.3%	11.9%	15.1%
24Hrs	6.0%	2.6%	3.1%	4.1%	5.1%
48Hrs	7.4%	-2.7%	-5.3%	-8.7%	-11.3%
72Hrs	11.5%	-3.5%	-8.1%	-13.7%	-17.7%

Table 2 Busselton - Differences between ARR87 and 2013 (BoM) revised IFD – all durations & selected AEPs

DURATION	1 EY/1yr ARI	10% AEP/10yr ARI	5% AEP/20yr ARI	2% AEP/50yr ARI	1% AEP/100yr ARI
5Mins	40.8%	17.1%	12.1%	5.4%	1.0%
10Mins	34.7%	19.2%	15.0%	9.5%	5.2%
30Mins	29.3%	24.4%	23.3%	21.0%	19.1%
1Hr	26.4%	25.9%	26.2%	26.6%	26.5%
2Hrs	24.3%	26.7%	28.5%	30.0%	31.5%
3Hrs	22.3%	26.6%	28.7%	31.5%	32.7%
6Hrs	19.0%	25.5%	28.0%	30.9%	33.2%
12Hrs	13.8%	21.8%	24.6%	27.4%	29.4%
24Hrs	7.4%	15.5%	17.7%	20.1%	21.6%
48Hrs	2.0%	8.1%	9.3%	10.6%	10.9%
72Hrs	2.3%	5.1%	5.6%	5.9%	5.3%

Table 3 Port Hedland - Differences between ARR87 and 2013 (BoM) revised IFD – all durations & selected AEPs

DURATION	1 EY/1yr ARI	10% AEP/10yr ARI	5% AEP/20yr ARI	2% AEP/50yr ARI	1% AEP/100yr ARI
5Mins	-20.6%	-29.2%	-31.1%	-32.4%	-33.4%
10Mins	-11.9%	-21.8%	-24.0%	-26.4%	-28.0%
30Mins	-10.7%	-25.0%	-28.1%	-31.1%	-32.9%
1Hr	-11.8%	-28.0%	-31.2%	-34.2%	-36.4%
2Hrs	-10.2%	-27.3%	-30.6%	-33.7%	-35.6%
3Hrs	-7.5%	-24.7%	-28.1%	-31.1%	-33.0%
6Hrs	0.0%	-17.2%	-20.4%	-23.7%	-25.8%
12Hrs	7.5%	-8.3%	-11.8%	-15.2%	-17.7%
24Hrs	11.5%	-3.8%	-7.7%	-11.5%	-14.0%
48Hrs	11.6%	-6.0%	-10.8%	-15.3%	-18.0%
72Hrs	12.6%	-8.4%	-14.1%	-19.3%	-21.9%

3. SINGLE STATION DAILY RAINFALL ANNUAL MAXIMA ANALYSIS

To understand potential effects of the additional period of data record on either increasing or decreasing AEP (without determining the magnitude), single station daily rainfall annual maxima analysis was performed.

The Log Pearson III (LPIII) distribution (utilised in ARR87) was fitted to annual maxima daily rainfall data for several locations in WA, in separate analyses using data up to 1986 and a full dataset to 2013. Differences between the analyses are summarized below.

The general extreme value (GEV) distribution was used by Green *et al* (2012) for the 2013 IFDs, and the LPIII distribution is used here for illustration only as a preliminary analysis. The 2013 IFDs are based on updated statistical methods, regional gridding procedures, expansion of rainfall data sites and increased record period compared to ARR87 (Green *et al*, 2012), therefore the magnitude of any increase or decrease illustrated in this section has not been examined.

The graphical analyses use the unbiased plotting position (Cunnane, 1978).

PERTH

Figure 2 shows increases in rainfall for AEP less than 20%, of up to +11% at 1% AEP, an increase consistent in direction with Table 1, which also shows increases for AEP less than 20% of up to +5.1% at 1% AEP. Figure 2 shows ranks 1, 3, 4 occurred since 1986 (1992, 2001, 1987 respectively).

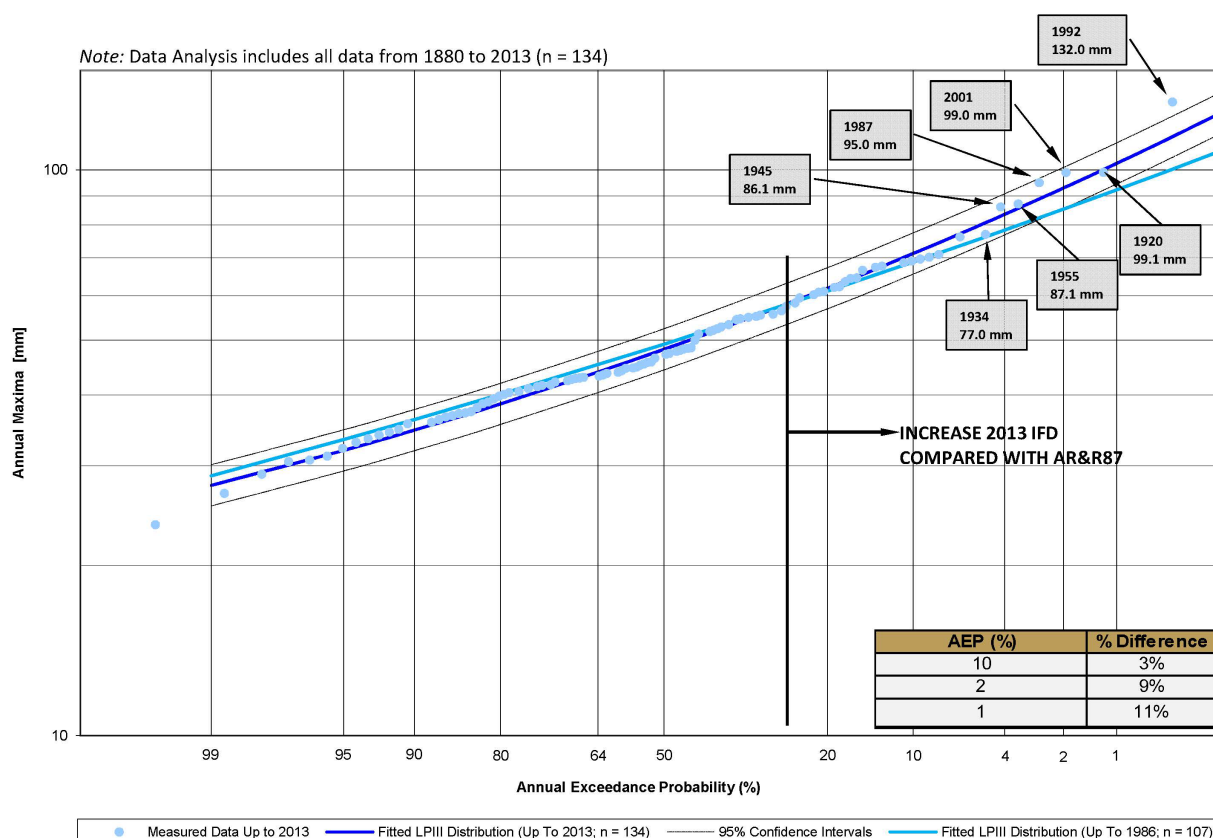


Figure 2: Perth Daily Rainfall – Annual Maxima Frequency Analysis Log Pearson III for 24hrs Storm Duration Comparison

BUSSELTON

Figure 3 shows increases in rainfall for AEP less than 50% of up to +8% at 1% AEP, and increase in direction consistent with Table 2, which also shows increases for AEP less than 10% of up to +21.6% at 1% AEP. Figure 3 shows ranks 1, 5, 6 occurred since 1986 (1991, 2005, 1988 respectively).

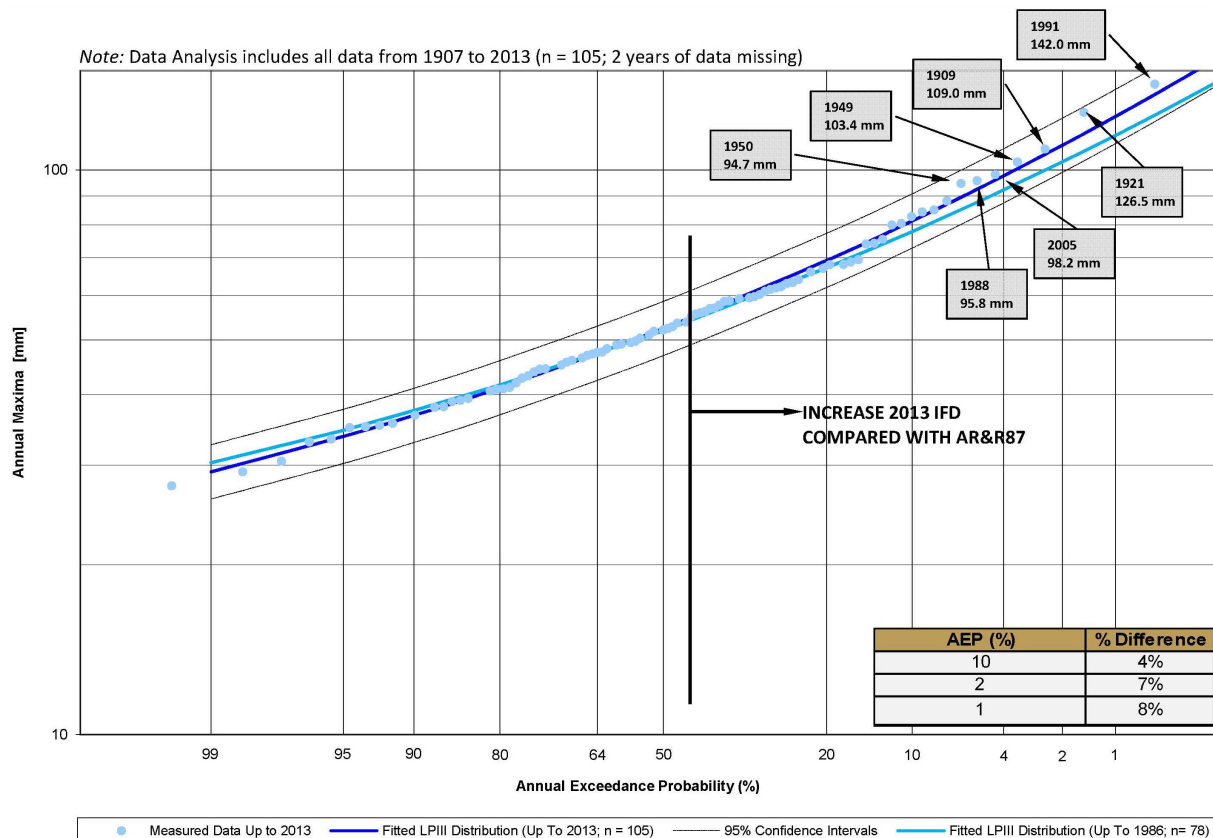


Figure 3: Busseton Daily Rainfall – Annual Maxima Frequency Analysis Log Pearson III for 24hrs Storm Duration Comparison

PORT HEDLAND

Figure 4 shows decreases in rainfall for AEP less than 20% of up to -27% at 1% AEP, a decrease in direction consistent with Table 3, which also shows decreases for AEP less than 50% up to -14% at 1% AEP. Figure 4 shows ranks 3 and 4, which are considerably less than rank 1 (1967), occurred since 1986 (1989 and 2001 respectively).

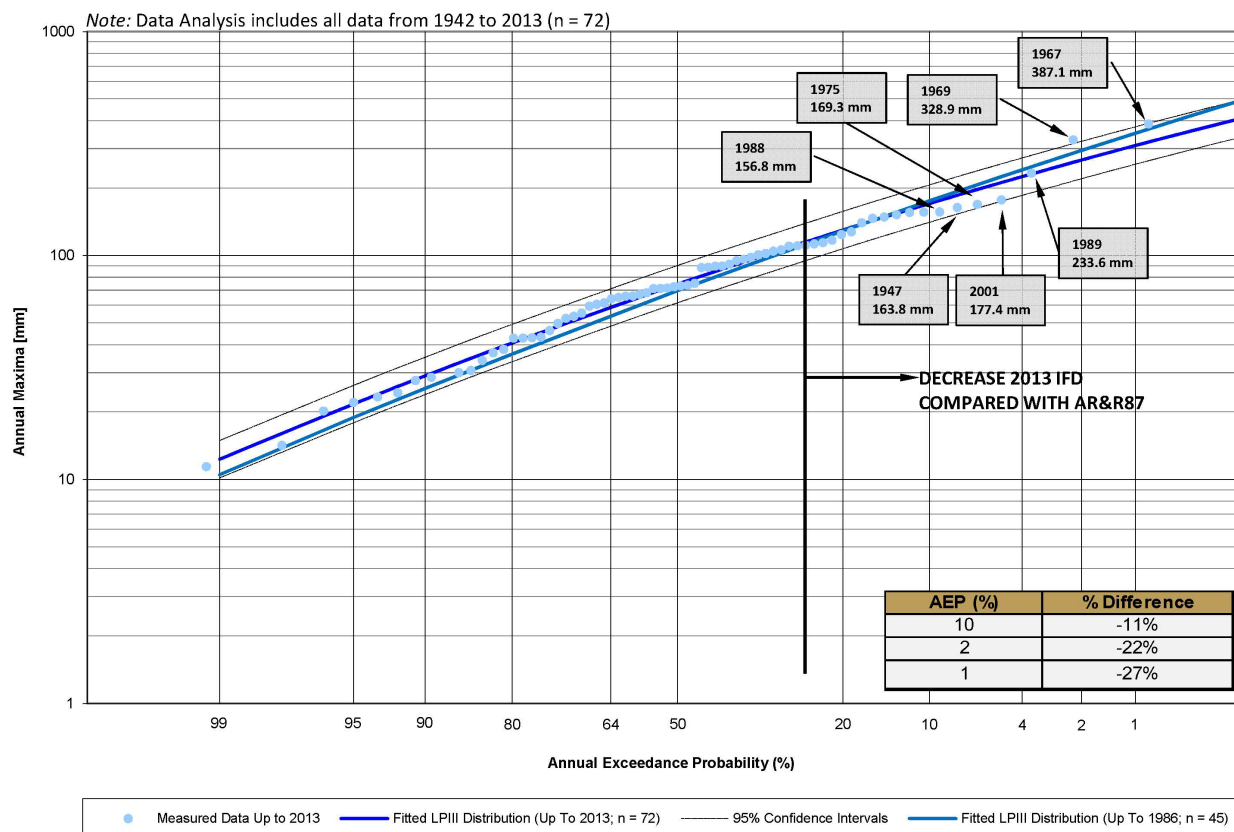


Figure 4: Port Hedland Daily Rainfall – Annual Maxima Frequency Analysis Log Pearson III for 24hrs Storm Duration Comparison

Single station daily rainfall analyses for specific locations in WA give results which are consistent with the changes to the published IFDs between 1987 and 2013, in so far as the occurrence of relatively high rainfalls in the intervening period has resulted in higher predicted intensities, and the non-occurrence of such rainfalls has resulted in a lowering of intensities. The above observations apply only for the daily data analyzed and do not necessarily apply to shorter or longer durations.

Therefore, it can be tentatively stated that the period 1987 to 2013 has altered the statistics of the updated data series to the extent that a fitted LP III distribution suggests different intensities. Green *et al.* (2012) note that in parallel with the expansion of the rainfall database there have been significant advances in statistical methods, gridding procedures and information dissemination techniques which make a revision of the IFD estimates long overdue. It is therefore difficult to separate out the extent to which the additional data, or the application of new methods, has resulted in the changes to the IFDs between 1987 and 2013.

4. CONCLUSIONS

Spatial trends across WA for differences between the ARR (1987) and BoM (2013) IFDs for all AEP and durations have been presented.

The single station analyses of daily data reported in this paper allow for a graphical understanding of the effect of the updated datasets contained in 2013 IFD compared to the 1987 version. In particular, where high rank storms have occurred in the intervening years these have resulted in higher predicted intensities and conversely where such storms have not occurred, lower intensities.

Revised methods of analysis are also responsible in part for the altered IFDs.

Application of the 1987 or the 2013 IFDs should be based on information provided by Engineers Australia and Bureau of Meteorology.

5. REFERENCES

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