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**IPWEA PUBLIC WORKS TRAINING WEEK 2016**

# STORMWATER & DRAINAGE
# RAINFALL INTENSITIES OVER WA – 2013 REVISION

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## 1. INTRODUCTION

Rainfall Intensity-Frequency-Duration (IFD) design rainfall curves represent an important input in the design and investigation of stormwater drainage. Analysis of data from a single station or over a short data timeframe is often highly variable and unreliable for stormwater drainage design. IFD design rainfalls represent a credible and consistent method of estimating the total rainfall depth of a given storm event of specific duration and storm severity. An example of an IFD is shown in the upper part of Figure 3. The lower part shows the equivalent depth-frequency-duration curve (DFD).

Prior to 1982, stormwater design information relied on data collated over short timeframes, with an inadequate coverage of rural areas and some urban areas. The publication of *Australian Rainfall and Runoff: A Guide to Flood Estimation, Volume 1* (1987) represented the first concise, easy to use spatially and temporally consistent rainfall design information available.

Inst. Engrs. Aust. (1987) (ARR87) outlined procedures to derive IFD design rainfall information for a given location by:

i. Assessing the log-normal design rainfalls for 1, 12 and 72 hours for 2 year and 50 year ARI from six master charts;
ii. Applying an appropriate skewness factor for the given location;
iii. Applying short duration factors for durations less than one hour; and
iv. Interpolating and extrapolating rainfall intensities for other ARIs (1 to 100 years) and durations (5 mins to 72 hours).

The 2013 revision of rainfall probabilities by the Bureau of Meteorology (BoM), hereafter referred to as BoM (2013) IFDs, covered 8074 daily monitored rainfall stations (up from 7500) and 2280 continuously monitored rainfall stations (up from 600). The BoM also had access to nearly 30 years additional rainfall data for its design parameters. The new BoM (2013) IFDs use the expanded daily and continuously monitoring rainfall datasets, together with new gridding procedures to provide a greater focus on small urban catchment design.

ARR87 adopted two probabilistic terminologies for design flood estimation, that of an "average recurrence interval" (ARI) for partial time series, and an "annual exceedance probability" (AEP) for annual maxima time series. ARR87 IFDs are expressed as rainfall intensity (in mm/hr) for given ARIs, reflecting the average period between exceedances of a given value. The new 2013 BoM (2013) IFDs are expressed as total rainfall depth (in mm) for given AEPs, reflecting the percentage probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.

Green et al. (2014) presented a comparison between ARR87 IFDs and BoM (2013) IFDs for the Perth and Pilbara-Gascoyne region for the durations and AEPs of the six masters charts (1, 12 and 72 hours for 50% and 2% AEP). Green et al. (2014) calculated a percentage difference for these durations and AEPs across the Perth and Pilbara-Gascoyne regions and Australia-wide.

Davies et al. (2014) compared ARR87 and BoM (2013) IFDs at 43 locations across Western Australia, and performs annual maxima frequency analysis of daily rainfall data for Perth, Busselton and Port Hedland to understand the potential effects of the 30 years of additional data record on either decreasing or increasing AEP. Davies et al. (2014) tentatively stated that the period 1987 to 2013 had altered the statistics of the updated data series, however, it was difficult to discern the extent to which the additional data, or the application of new methods, had resulted in changes to IFDs.

This paper expands on Davies et al. (2014) by assessing BoM-generated ARR87 and BoM (2013) IFDs for 215 local government areas and significant towns and cities within Western Australia, allowing differences in rainfall intensities for be more clearly understood. This paper should assist IPWEA members in ensuring they are using the latest information and highlight local authorities with under and over design.

## 2. DIFFERENCES ACROSS WESTERN AUSTRALIA (GREEN ET. AL., 2014)

Green *et al.* (2014) presented an Australia-wide graphical representation of the percentage change in IFDs across Australia for a 2% AEP event of 1 hour duration. Figure 1 shows Australia-wide mapping of this relationship from Green *et al.* (2014).

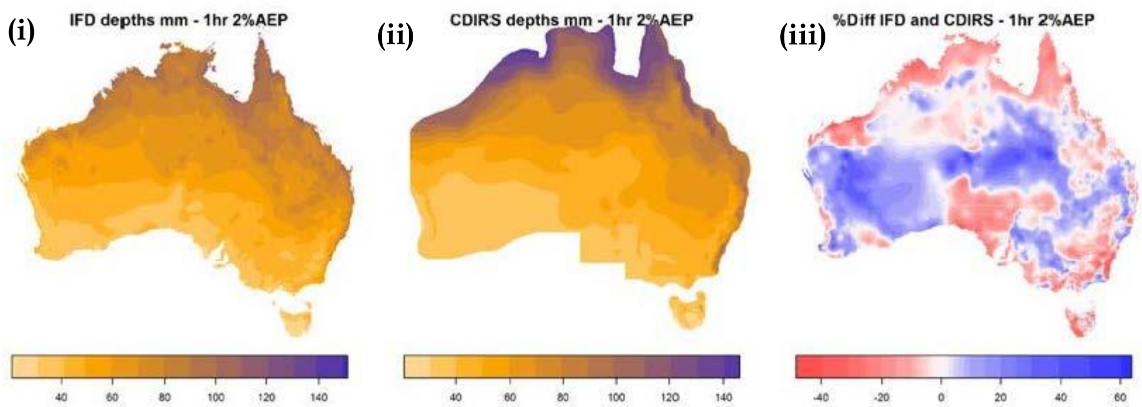


**Figure 1: (i) BoM (2013) IFD; (ii) ARR87 IFD; and (iii) Percentage difference for 2% AEP and 1hr duration (Green et al., 2014)**

Green *et al.* (2014) used a red-to-blue colour scale to map negative-to-positive changes in IFDs, as shown in Figure 1 (iii). The general trend for Western Australia suggested that rainfall depths in inland areas increased from 1987, whereas coastal strips in the South-West and coastal areas in the North decreased from 1987 rainfall depths. The noticeable exceptions were the Busselton area in the South-West and Geraldton to Coral Bay in the North-West.

In general, the trend suggested that inland areas, where rainfall monitoring stations are more widely dispersed, were underestimated by ARR87 IFDs, whereas coastal areas, where rainfall monitoring stations are much more numerous, were over-estimated by ARR87 IFDs.

In considering the Australia-wide view, Green et. al. (2014) had suggested that the differences between ARR87 and BoM (2013) IFDs reflected both a change in the methods adopted and an increase in the rainfall data available.

## 3. DATA AND METHODS ADOPTED FOR CALCULATING IFDS

Centroids of each local government area (LGA) in Western Australia, with the exception of the Shire of the Cocos (*Cocos Islands*) and the Shire of Christmas Island (*Christmas Island*), were generated in 2016 by JDA using Landgate's Shared Land Information Platform (SLIP) dataset of local government authorities and formatted in ESRI's ArcMaps.

Centroids were estimated where the LGA boundary encompassed more than one area, such as the City of Perth and the City of Fremantle, and for LGAs containing coastal islands, such as the City of Cockburn. Centroids were used to provide a general overview of each LGA. For coastal LGAs, development and urbanisation occurs predominantly along the coast, and centroids of these LGAs may not accurate represent these significant towns and cities. Centroids were therefore also estimated for significant city and town areas.

In total, this represented 138 LGAs and 77 significant towns and cities datasets: 215 in total.

The Easting-Northing-Zone coordinates of each dataset were inputted in the BoM's Rainfall IFD Data System to derive ARR87 and BoM (2013) IFDs. Note that ARR87 duration range is 5 minutes to 72 hours, whereas, the BoM (2013) IFD range is 1 minute to 168 hours (7 days). Comparison between ARR87 and BoM (2013) were made across 5 minute to 72 hours range for comparable durations.

ARR87 IFDs (expressed as rainfall intensity) were converted to total rainfall depths (mm) for all comparable durations.

ARR87 ARIs were expressed as a function of the AEP vs. ARI relationship using the following formula:

$$\mathrm{ARI} = -\frac{1}{\ln(1 - \mathrm{AEP})}$$

**Table 1: ARI vs. AEP Relationship**

| **ARI/EY-AEP Relationship** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **BoM (2013) AEPs, as % probability** | 1 EY | 50% | 20% | 10% | 5% | 2% | 1% |
| **ARI, in years (Reciprocal of AEP)** | 1 | 2 | 5 | 10 | 20 | 50 | 100 |
| **ARI, in years (Formula-derived)** | 1 | 1.44 | 4.48 | 9.49 | 19.5 | 49.5 | 99.5 |

The general conversion from ARI or EY to AEP as the reciprocal of ARI or EY does not apply for 20% and 50% AEP, as shown in Table 1.  A 50% AEP is equivalent to a 1.44 year ARI and a 20% AEP is equivalent to a 4.48 year ARI.

Design rainfalls for ARIs of 1 year to 10 year were plotted for each duration, and an interpolated rainfall depth was derived for a 1.44 year ARI and a 4.48 year ARI. Table 2 shows the ARI or EY vs. AEP relationship used to compare ARR87 and BoM (2013) IFDs in this paper.

**Table 2: ARI-AEP Conversion**

| **ARI/EY-AEP Conversion** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **BoM (2013) AEPs, as % probability** | 1 EY | 50% | 20% | 10% | 5% | 2% | 1% |
| **ARR87 ARIs, in years (adjusted)** | 1 | 1.44 | 4.48 | 10 | 20 | 50 | 100 |

The percentage change between ARR87 and BoM (2013) IFDs was calculated across comparable durations and AEPs using the following formula:

$$\text{Percentage change (\%)} = \frac{\text{BoM(2013) IFD} - \text{ARR87 IFD}}{\text{ARR87 IFD}} \text{ x } 100$$

where a positive % change reflects an increase in design rainfall depths between 1987 and 2013, and a negative % change reflects a decrease in design rainfall depths between 1987 and 2013.

## 4. WA COMPARISON: ALL AEPS, 24 HOUR DURATION

This paper uses a red-to-green colour scale to map increases-to-decreases from ARR87 to BoM (2013) IFDs across Western Australia. All AEPs and all durations were mapped across mainland Western Australia

Table 3 summarises the results from all durations (5 mins to 72 hrs) and all AEPs (1 EY to 1% AEP). The assessed trend across Western Australia is consistent with Australia-wide mapping in Green *et al.* (2014), with IFD rainfall depths in inland areas increasing from ARR87, and coastal strips in the South-West and coastal areas in the North decreasing from ARR87.

**Table 3: Results summary of centroid analysis of percentage difference between ARR87 and BoM (2013) IFDs – all durations**

| AEP | Results Summary |
|---|---|
| **1 EY** | • General increase across Western Australia<br>• Trend increases in magnitude for longer durations.<br>• Increases across durations 5 mins to 2 hours mostly along the North-West coast, and small areas around Perth and the South-West.<br>• General increase across all durations inland of Meekatharra;<br>• Small decreases for lower durations in northern and southern coastal LGAs. |
| **50% AEP** | • General increase inland of Meekatharra.<br>• Decreases for some coastal LGAs in North-West and locations around Perth and the South-West<br>• Most increases within +5 to +15% range.<br>• Shire of Meekatharra have the most significant increases across all durations |
| **20% AEP** | • General decrease across Perth and surrounding LGAs; extending to some locations in the South-West.<br>• General increase inland of Meekatharra and LGAs around Shark Bay and Port Hedland; slight decreases up to duration of 3 hours. |
| **10% AEP** | • Similar trend to 20% AEP; general decrease across Perth and surrounding areas, and general increase inland of Meekatharra.<br>• Shire of Meekatharra exhibited the most significant change from + 35% at smaller durations tending to small decreases (> -5%) at longer durations. |
| **5% AEP** | • Exhibits similar trend to 20% and 10% AEPs.<br>• Most differences across the coast from Geraldton to Denmark were within ± 5% |
| **2% and 1% AEP** | • Variable changes across all durations.<br>• Some inland LGAs with significant increases at shorter durations tended to significant decreases at longer durations.<br>• Most coastal LGAs exhibit significant decreases at shorter durations tending to significant increases at longer durations.<br>• Perth and surrounding LGAs exhibit a general negative trend across most durations. |

Figure 2 shows the percentage difference across Western Australia for all AEPs of 24 hour duration. This shows the non-uniformity of changes to ARR87 IFDs across Western Australia, with general decreases across Perth and surrounding areas; general increases across inland Western Australia, with outliers such as Shire of Ngaanyatjarraku and the Shire of Ashburton.

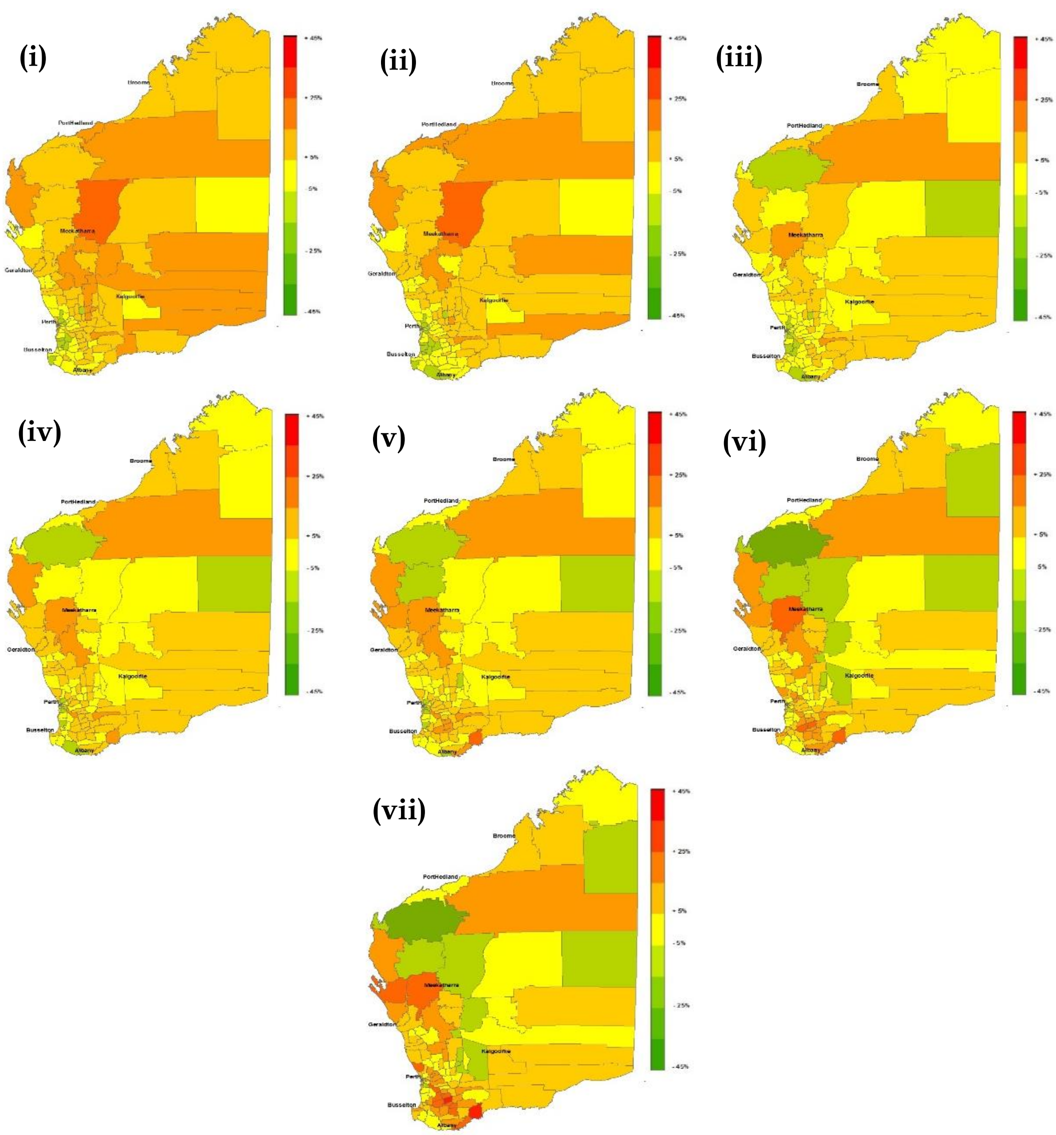


**Figure 2: Percentage difference across Western Australia between ARR87 and BoM (2013) IFDs for (i) 1 EY; (ii) 50% AEP; (iii) 20% AEP; (iv) 10% AEP; (v) 5% AEP; (vi) 2% AEP; and (vii) 1% AEP of 24 hours duration.**

## 5. CITY OF PERTH COMPARISON: 1% AEP, ALL DURATIONS

An assessment was conducted for the City of Perth for a fixed 1% AEP across all durations (Figure 3). This included City of Perth Rainfall Intensity Charts (*Design and Construction Note Book 200*) and a single location's coordinates within the City of Perth to derive ARR87 and BoM (2013) IFDs for a 1% AEP (100 year ARI) design rainfall event.

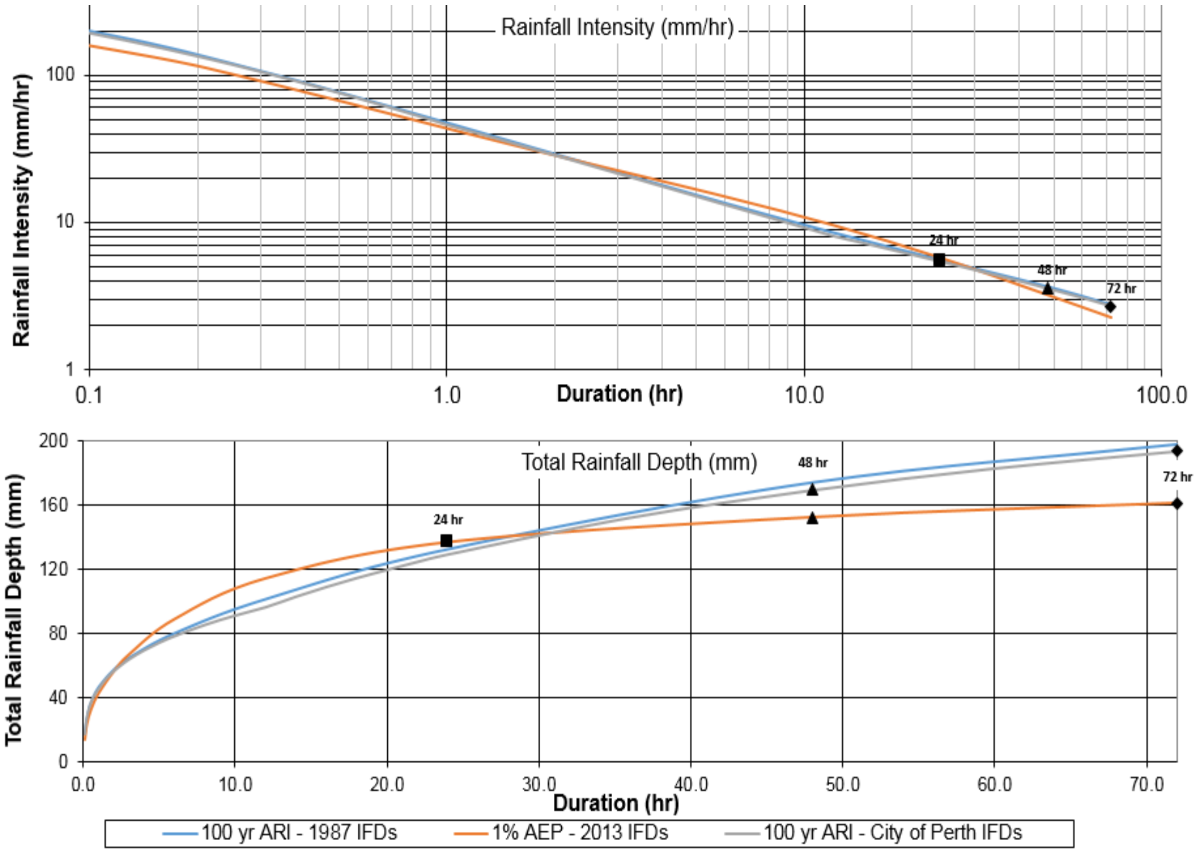


**Figure 3: Design Rainfalls for the City of Perth – 1% AEP**

Figure 3 shows IFD data for a 1% AEP event in the City of Perth as both *Rainfall Intensity* (mm/hr) and *Total Rainfall Depth* (mm). The *Rainfall Intensity* IFD curve, as generally presented on a logarithmic scale, shows no significant variation between ARR87 and BoM (2013) IFDs. The *Total Rainfall Depth* IFD curve, on a linear scale, shows rainfall depths increasing by a maximum of 20 mm for 1% AEP events between 6 hours and 30 hours duration, and progressively decreasing for longer durations, with a 30 to 35 mm decrease from both the City of Perth and ARR87 design rainfall depths, for a 72 hour duration event.

Note that Figure 3 does not apply to the whole Perth Metropolitan area; only the City of Perth LGA. Figure 4 shows results for 1% AEP for 1 hour and 24 hour durations for the various local governments in the Perth Metro area. This shows that variation in rainfall depths for a 1% AEP rainfall event in the City of Perth is largely reflective of changes across the Perth Metro area.

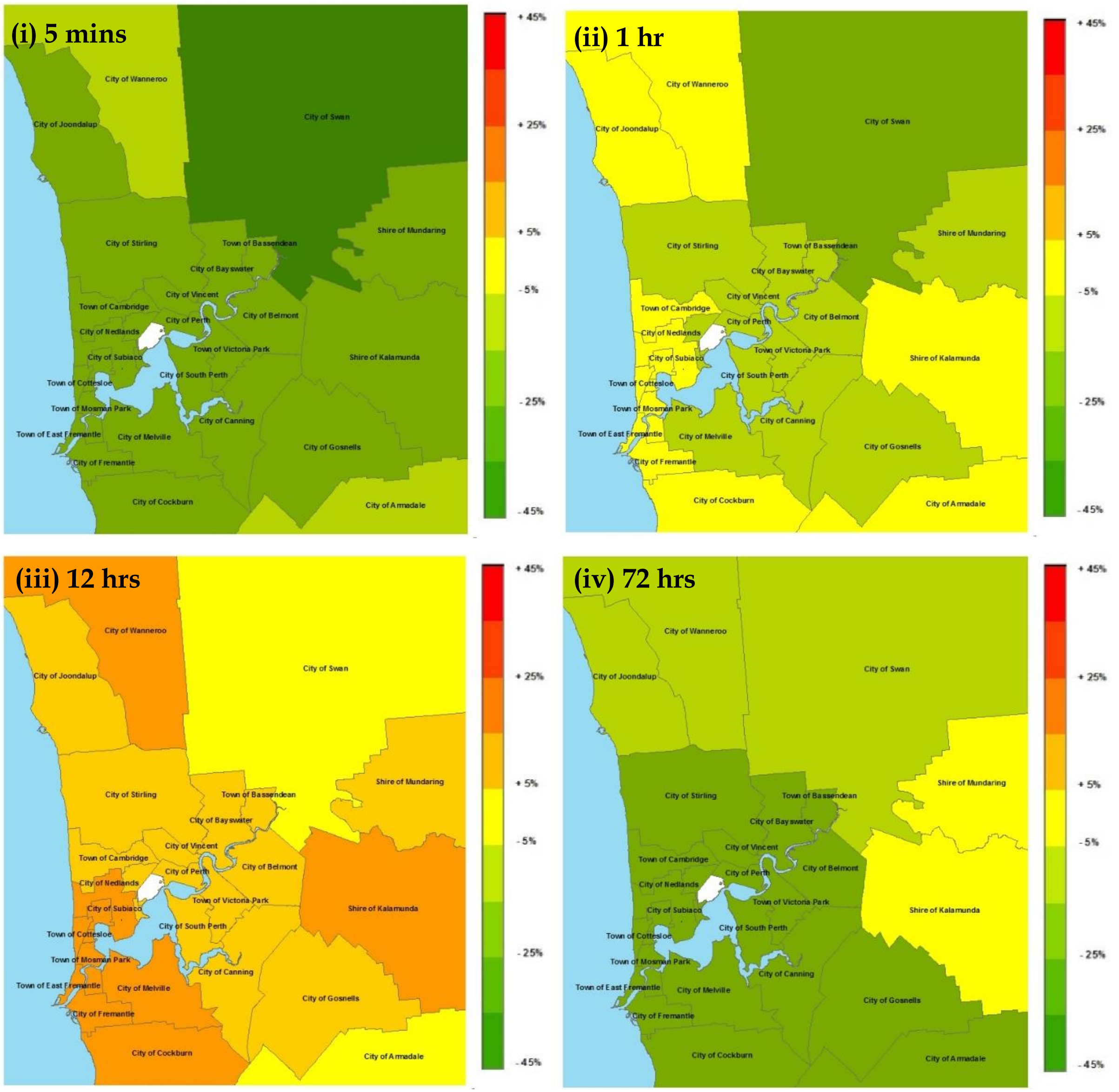


**Figure 4: Percentage difference across Perth Metro area for 1% AEP rainfall event of durations: (i) 5 mins, (ii) 1 hour, (iii) 12 hours; and (iv) 72 hours.**

## 6. TRENDS – SOUTH-WEST WA, (1 EY and 1% AEP)

A trend analysis was conducted across LGAs and significant towns and cities in South-West WA for all AEPs.

Figures 5 and 6 show generalised results for 1 EY and 1% AEP for all durations.

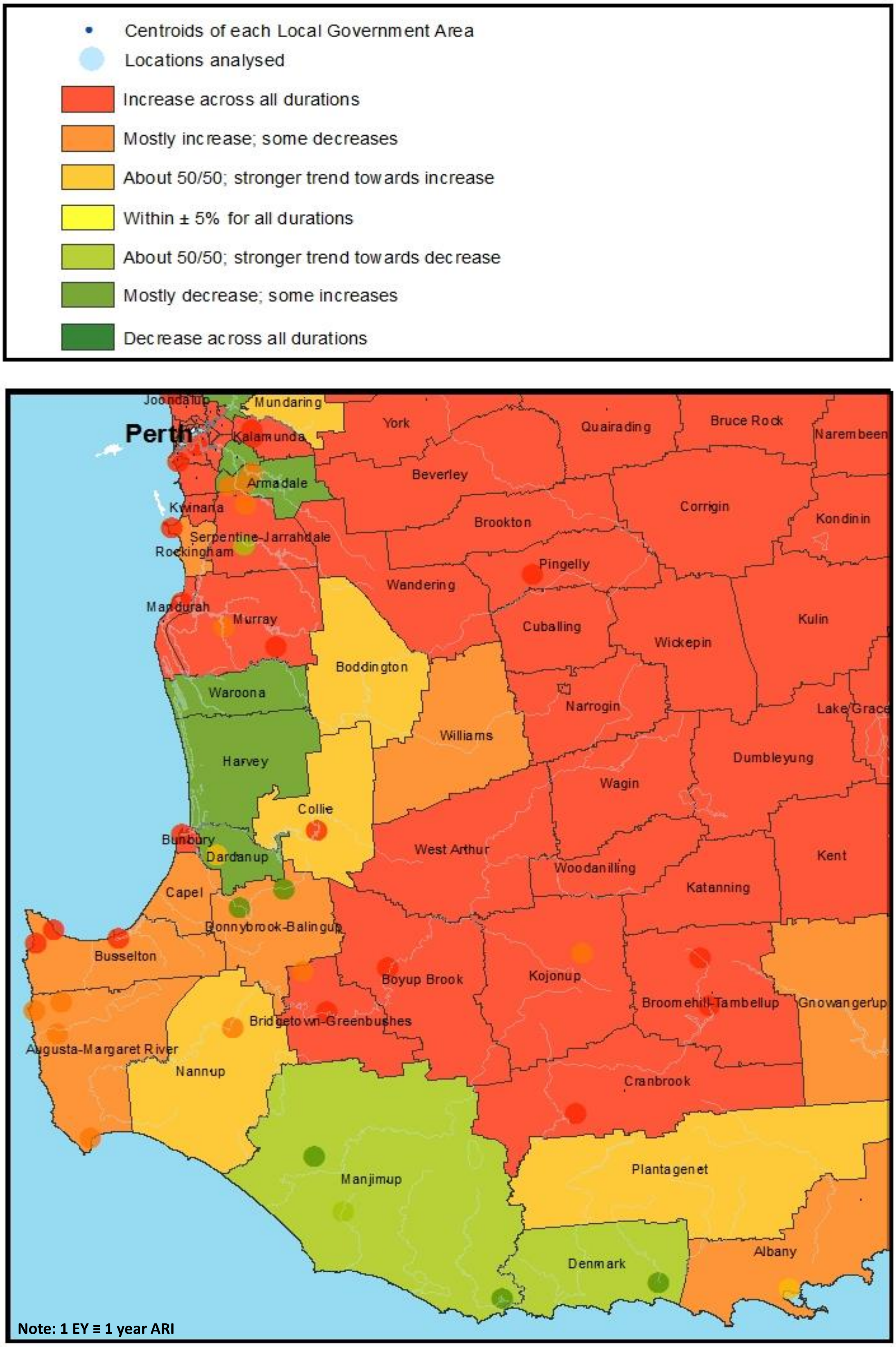


**Figure 5: 1 EY trend of change between ARR87 and BoM (2013) IFDs for all durations – South-West WA**

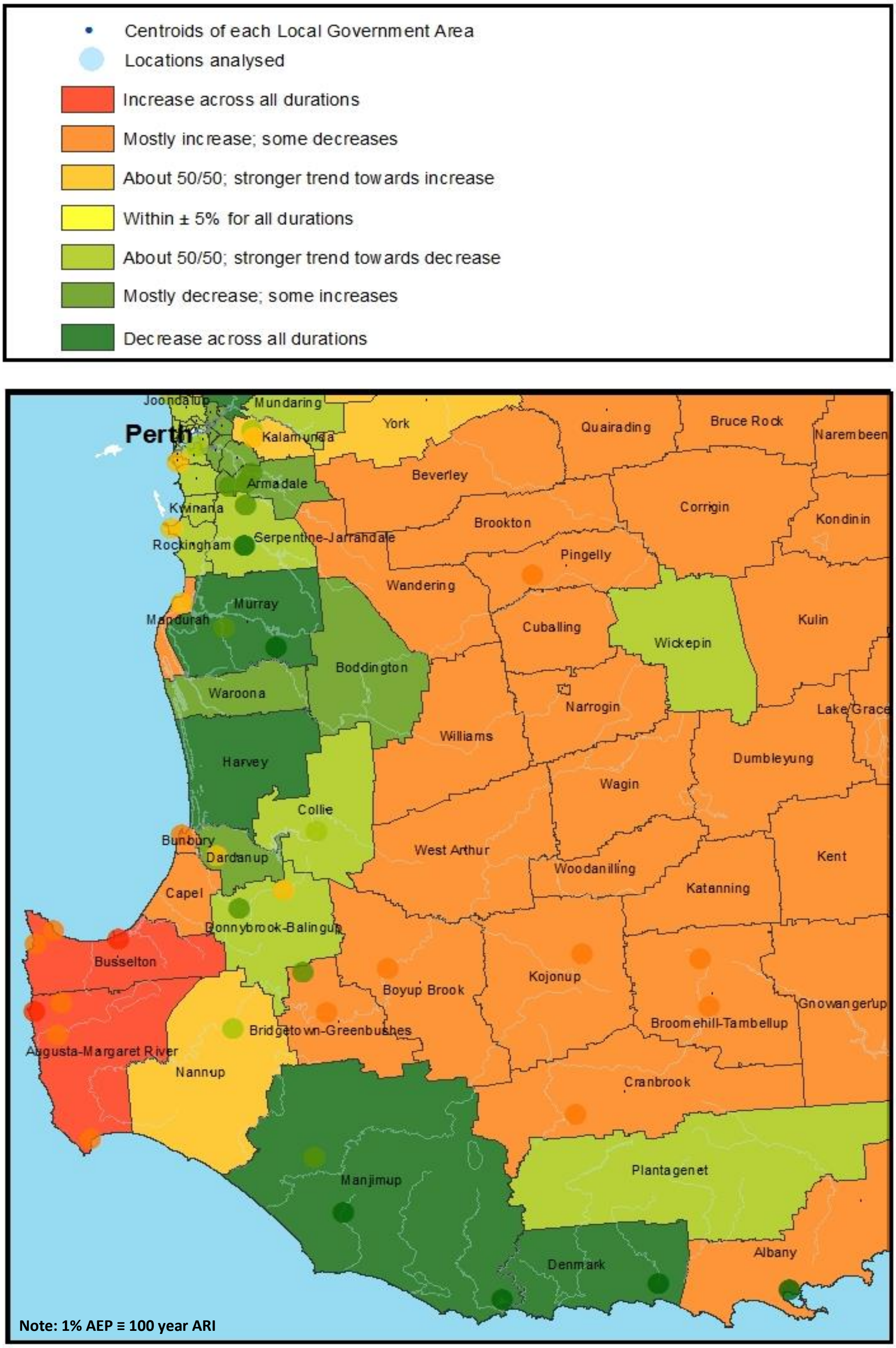


**Figure 6: 1% AEP trend of change between ARR87 and BoM (2013) IFDs for all durations – South-West WA**

Figures 5 and 6 show that IFDs derived from LGA centroid coordinates are not wholly reflective of significant towns and cities located within the local government areas. This is particularly noticeable in locations with larger urbanisation such as Albany, Dunsborough and Yallingup, where the coloured circle for the location differs from the LGA. For example, Albany is coloured dark-green in Figure 6, whereas the LGA, City of Albany, is coloured orange.

In general, inland LGAs show a gradually increase trend, with the exception of the Shire of Wickepen, for 1 EY and 1% AEP. Coastal LGAs suggest a decrease trend from 1 EY to 1% AEP, particularly from Perth to Harvey.

The denser populated South-West areas from the City of Bunbury to the Shire of Nannup show an increase trend for both 1 EY and 1% AEP, with significant towns and cities for 1% AEP in Figure 6 differing noticeably from LGA centroid design rainfalls.

## 7. COMPARISON – SIGNIFICANT TOWNS AND CITIES TO LGA CENTROIDS

LGA centroids were generally in close proximity to significant towns and cities.

Bunbury, Busselton and Albany, as significant population centres in the South-West, were located sufficiently away from the centroid coordinates, to suggest that a more detailed assessment was required.

Tables 4 to 10 show the percentage change between ARR87 and BoM (2013) IFDs for each duration and AEP for these three locations and their respective local government area.

**Table 4: City of Bunbury - differences between ARR87 and BoM (2013) IFDs - all durations and AEPs**

| Comparison of AR&R87 IFD and BOM (2013) IFD | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Duration* | Diff 1AEP/1yr | *Diff 0.5AEP/1.44yr* | *Diff 0.2AEP/4.48yr* | *Diff 0.1AEP/10yr* | *Diff 0.05AEP/20yr* | *Diff 0.02AEP/50yr* | *Diff 0.01 AEP/100yr ARI* |
| **5Mins** | 19.6% | 14.1% | 4.3% | 1.8% | -2.4% | -6.5% | -9.3% |
| **10Mins** | 16.4% | 11.5% | 4.5% | 2.9% | -0.2% | -2.9% | -5.3% |
| **30Mins** | 11.3% | 7.4% | 6.0% | 7.0% | 6.8% | 6.5% | 6.3% |
| **1Hr** | 8.9% | 5.5% | 6.1% | 8.4% | 9.5% | 10.6% | 11.5% |
| **2Hrs** | 7.4% | 3.9% | 6.1% | 9.8% | 11.3% | 13.6% | 15.4% |
| **3Hrs** | 6.4% | 3.5% | 6.1% | 10.0% | 12.0% | 14.7% | 16.7% |
| **6Hrs** | 5.4% | 2.8% | 6.7% | 10.7% | 13.1% | 16.1% | 18.4% |
| **12Hrs** | 4.0% | 1.6% | 5.6% | 9.7% | 11.9% | 14.6% | 16.2% |
| **24Hrs** | 1.9% | -0.7% | 2.5% | 5.8% | 7.3% | 9.1% | 10.0% |
| **48Hrs** | 1.3% | -2.0% | -1.3% | 0.5% | 0.8% | 0.8% | 0.5% |
| **72Hrs** | 3.8% | -0.2% | -1.4% | -0.7% | -1.6% | -3.2% | -4.0% |

**Table 5: Bunbury - differences between ARR87 and BoM (2013) IFDs - all durations and AEPs**

| Comparison of AR&R87 IFD and BOM (2013) IFD | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Duration* | Diff 1AEP/1yr | *Diff 0.5AEP/1.44yr* | *Diff 0.2AEP/4.48yr* | *Diff 0.1AEP/10yr* | *Diff 0.05AEP/20yr* | *Diff 0.02AEP/50yr* | *Diff 0.01 AEP/100yr ARI* |
| **5Mins** | 22.9% | 15.3% | 6.4% | 2.6% | -0.3% | -5.3% | -7.8% |
| **10Mins** | 19.2% | 13.9% | 6.2% | 4.4% | 1.9% | -1.2% | -3.8% |
| **30Mins** | 13.4% | 9.3% | 8.0% | 8.9% | 8.4% | 8.5% | 8.3% |
| **1Hr** | 10.8% | 7.2% | 7.9% | 10.2% | 11.4% | 12.8% | 14.0% |
| **2Hrs** | 8.9% | 5.5% | 8.4% | 11.9% | 13.6% | 16.3% | 18.0% |
| **3Hrs** | 8.0% | 5.0% | 8.4% | 12.6% | 14.5% | 17.2% | 19.8% |
| **6Hrs** | 6.9% | 4.4% | 8.5% | 13.0% | 15.3% | 18.0% | 20.2% |
| **12Hrs** | 5.5% | 3.3% | 7.6% | 11.8% | 14.0% | 16.6% | 18.4% |
| **24Hrs** | 3.9% | 1.4% | 4.5% | 8.0% | 9.2% | 10.8% | 11.8% |
| **48Hrs** | 3.6% | 0.2% | 0.8% | 2.6% | 2.9% | 2.3% | 2.0% |
| **72Hrs** | 5.5% | 1.4% | 0.4% | 1.2% | 0.5% | -1.1% | -2.7% |

**Table 6: City of Busselton - differences between ARR87 and BoM (2013) IFDs - all durations and AEPs**

| Comparison of AR&R87 IFD and BOM (2013) IFD | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Duration* | Diff 1AEP/1yr | *Diff 0.5AEP/1.44yr* | *Diff 0.2AEP/4.48yr* | *Diff 0.1AEP/10yr* | *Diff 0.05AEP/20yr* | *Diff 0.02AEP/50yr* | *Diff 0.01 AEP/100yr ARI* |
| **5Mins** | 38.6% | 30.0% | 18.8% | 14.2% | 8.9% | 1.6% | -3.2% |
| **10Mins** | 35.7% | 29.0% | 20.6% | 16.9% | 12.1% | 5.6% | 1.7% |
| **30Mins** | 28.5% | 23.9% | 21.7% | 21.8% | 20.1% | 17.5% | 15.2% |
| **1Hr** | 23.8% | 19.7% | 20.3% | 22.4% | 22.3% | 22.3% | 22.4% |
| **2Hrs** | 20.3% | 16.8% | 18.5% | 21.9% | 23.3% | 25.3% | 26.5% |
| **3Hrs** | 18.0% | 14.7% | 17.8% | 21.6% | 23.2% | 25.9% | 27.6% |
| **6Hrs** | 14.3% | 11.6% | 16.2% | 20.8% | 23.1% | 25.8% | 28.5% |
| **12Hrs** | 9.6% | 7.5% | 13.1% | 18.0% | 20.5% | 23.4% | 25.1% |
| **24Hrs** | 3.8% | 2.1% | 7.8% | 12.4% | 14.7% | 16.8% | 18.0% |
| **48Hrs** | -0.8% | -3.0% | 1.7% | 5.4% | 7.0% | 7.9% | 8.5% |
| **72Hrs** | -0.2% | -2.8% | 0.3% | 3.3% | 4.0% | 3.5% | 3.5% |

**Table 7: Busselton - differences between ARR87 and BoM (2013) IFDs - all durations and AEPs**

| Comparison of AR&R87 IFD and BOM (2013) IFD | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Duration* | Diff 1AEP/1yr | *Diff 0.5AEP/1.44yr* | *Diff 0.2AEP/4.48yr* | *Diff 0.1AEP/10yr* | *Diff 0.05AEP/20yr* | *Diff 0.02AEP/50yr* | *Diff 0.01 AEP/100yr ARI* |
| **5Mins** | 40.8% | 32.0% | 21.5% | 17.1% | 12.1% | 5.4% | 1.0% |
| **10Mins** | 34.7% | 29.2% | 22.4% | 19.2% | 15.0% | 9.5% | 5.2% |
| **30Mins** | 29.3% | 25.3% | 23.8% | 24.4% | 23.3% | 21.0% | 19.1% |
| **1Hr** | 26.4% | 23.0% | 23.6% | 25.9% | 26.2% | 26.6% | 26.5% |
| **2Hrs** | 24.3% | 20.8% | 23.0% | 26.7% | 28.5% | 30.0% | 31.5% |
| **3Hrs** | 22.3% | 19.0% | 22.6% | 26.6% | 28.7% | 31.5% | 32.7% |
| **6Hrs** | 19.0% | 16.3% | 20.9% | 25.5% | 28.0% | 30.9% | 33.2% |
| **12Hrs** | 13.8% | 11.6% | 17.0% | 21.8% | 24.6% | 27.4% | 29.4% |
| **24Hrs** | 7.4% | 5.5% | 10.9% | 15.5% | 17.7% | 20.1% | 21.6% |
| **48Hrs** | 2.0% | -0.3% | 4.1% | 8.1% | 9.3% | 10.6% | 10.9% |
| **72Hrs** | 2.3% | -0.5% | 2.4% | 5.1% | 5.6% | 5.9% | 5.3% |

**Table 8: City of Albany - differences between ARR87 and BoM (2013) IFDs - all durations and AEPs**

| Comparison of AR&R87 IFD and BOM (2013) IFD | | | | | | | |
|---|---|---|---|---|---|---|---|
| Duration | Diff 1AEP/1yr | *Diff 0.5AEP/1.44yr* | *Diff 0.2AEP/4.48yr* | *Diff 0.1AEP/10yr* | *Diff 0.05AEP/20yr* | *Diff 0.02AEP/50yr* | *Diff 0.01 AEP/100yr ARI* |
| 5Mins | 12.8% | 7.4% | 1.9% | 0.5% | -2.9% | -5.5% | -7.8% |
| 10Mins | 6.5% | 2.8% | -0.6% | -0.8% | -1.3% | -1.8% | -2.7% |
| 30Mins | 0.0% | -1.8% | 1.1% | 4.9% | 7.0% | 10.1% | 12.2% |
| 1Hr | -2.2% | -3.1% | 2.5% | 7.4% | 10.3% | 13.9% | 16.1% |
| 2Hrs | -0.9% | -1.3% | 4.0% | 8.4% | 11.2% | 13.8% | 15.3% |
| 3Hrs | 0.5% | -0.2% | 5.1% | 9.6% | 10.9% | 13.3% | 14.4% |
| 6Hrs | 3.6% | 2.4% | 6.3% | 10.0% | 11.6% | 13.1% | 14.8% |
| 12Hrs | 5.2% | 4.2% | 7.8% | 11.6% | 13.7% | 16.6% | 18.6% |
| 24Hrs | 5.1% | 4.2% | 8.9% | 14.0% | 17.7% | 22.5% | 25.9% |
| 48Hrs | 3.8% | 2.9% | 9.0% | 15.7% | 20.5% | 27.5% | 32.9% |
| 72Hrs | 5.3% | 4.1% | 8.9% | 15.5% | 19.8% | 26.7% | 32.9% |

**Table 9: Albany - differences between ARR87 and BoM (2013) IFDs - all durations and AEPs**

| Comparison of AR&R87 IFD and BOM (2013) IFD | | | | | | | |
|---|---|---|---|---|---|---|---|
| Duration | Diff 1AEP/1yr | *Diff 0.5AEP/1.44yr* | *Diff 0.2AEP/4.48yr* | *Diff 0.1AEP/10yr* | *Diff 0.05AEP/20yr* | *Diff 0.02AEP/50yr* | *Diff 0.01 AEP/100yr ARI* |
| 5Mins | 11.4% | 3.7% | -6.0% | -9.0% | -12.7% | -16.1% | -18.5% |
| 10Mins | 4.7% | -0.7% | -8.4% | -10.5% | -12.7% | -15.2% | -16.2% |
| 30Mins | -2.3% | -5.1% | -6.9% | -5.9% | -5.4% | -4.7% | -4.0% |
| 1Hr | -2.2% | -5.2% | -5.5% | -3.5% | -2.3% | -1.1% | -0.2% |
| 2Hrs | -2.5% | -5.4% | -5.2% | -3.3% | -2.3% | -0.9% | -0.2% |
| 3Hrs | -2.4% | -5.3% | -5.4% | -3.8% | -3.1% | -2.2% | -1.3% |
| 6Hrs | -2.6% | -5.7% | -6.1% | -4.8% | -4.2% | -3.6% | -3.4% |
| 12Hrs | -1.6% | -4.9% | -6.0% | -4.8% | -4.8% | -4.1% | -3.4% |
| 24Hrs | 2.4% | -1.5% | -4.1% | -3.2% | -3.1% | -2.4% | -1.8% |
| 48Hrs | 10.8% | 5.5% | -0.5% | -0.3% | -0.7% | -1.0% | -0.7% |
| 72Hrs | 15.4% | 9.6% | 1.1% | 0.4% | -1.2% | -1.9% | -2.4% |

For Bunbury, Tables 4 and 5, and Busselton, Tables 6 and 7, the LGA areas are of a relatively small size such that there is not a significant difference between LGA centroids and City Centres. Busselton was approximately +2% to +4% different to the City of Busselton, with four results changing from a small decrease to a small increase. These four changes are not reflected on the state-wide mapping produced with this paper as they fall within the ± 5% threshold. Bunbury was approximately +1% to +3% different to the City of Bunbury, with small decreases tending to small increases.

Albany represented an exception with the LGA centroid reflecting a significant increase for most durations and AEPs and the City Centre IFD reflecting a strong decrease across most durations and AEPs, with exception to 1 EY. The change between Albany and City of Albany ranged from -1% for 1 EY and 5 mins duration to -35% for 1% AEP and 72 hours duration.

## 8. CONCLUSIONS

This paper presents a graphical understanding of the relative difference between ARR87 and BoM (2013) IFD design rainfalls for the centroids of each LGA.

Spatial trends across local government areas in Western Australia were generally non-uniform, and confirmed previous findings of Green et. al. (2014) and Davies et al. (2014) across a more detailed scale.

This paper is intended as a guide only; IFD data from BoM's Rainfall IFD Data System is calculated to a resolution of 0.025 degrees of latitude and longitude, representing a spatial resolution of approximately 2.8 $km^2$. IFD data should be considered on a case-by-case basis

The BoM (2013) IFDs represent Phase 1 of the BoM's Design Rainfall Revision Project, encompassing *Frequent* (1 EY to 10% AEP) and *Infrequent* (10% to 1% AEP) design rainfall events. Phase 2 will incorporate new design rainfalls for *Very Frequent* (12 EY to 1 EY) and *Rare* (1% AEP to 0.05% AEP) design rainfall events. Events which are more frequent than 1 year (1 EY) are expressed as "x Exceedances per year" (EY).

A BoM update of Phase 1 design rainfalls for 2% AEP and 1% AEP for durations longer than one day and the release of Phase 2 design rainfalls is expected in late-2016.

## 9. REFERENCES

Davies, J., Serafini, G., and Green, W. (2014) *Comparison between Rainfall IFD in ARR (1987) and BoM (2013) for Western Australia*. Hydrology & Water Resources Symposium 2014 Perth, Western Australia – Conference Proceedings.

Green, J., Johnson, F., Xuereb, K., Beesley, C., The, C. and Jolly, C. (2014) *Changes to the Intensity-Frequency-Duration (IFD) Design Rainfalls Across Australia*. Hydrology & Water Resources Symposium 2014 Perth, Western Australia – Conference Proceedings.

Institution of Engineers, Australia (1987) (ARR87) *Australian Rainfall and Runoff: A Guide to Flood Estimation,* Vol. 1, Institute of Engineers Australia, Barton, ACT