



Rainfall Intensity ARI & AEP and Stormwater Detention

Rev 0, Created 10 September 2021

The Australian Rainfall and Runoff (ARR) guide to flood estimation, by Institution of Engineers, 2001, provided the methodology, equations, and a comprehensive series of maps to obtain the rainfall intensity for a given average recurrence interval (ARI) and storm duration.

Stormwater detention is a method used to restrict the discharge from a site being developed to a pre-determined rate by utilising an orifice and water storage. A method known as "The Swinburne Method" published by Dr Donald Phillips and Bruce Bowditch in 2006 is implemented in Structural Toolkit. This method calculates storage volumes, orifice size and permissible site discharge (PSD) utilising the rainfall intensities derived from an ARI and time of concentration for the site and catchment. ARR 2001 is used to determine the intensities for varying storm durations to find the maximum, or peak requirement.

Australian Rainfall and Runoff was revised in 2019 and is available for download in pdf format from the government website. In this guidebook, design rainfalls (rather than rainfall intensities) are defined as a probabilistic estimate of the likelihood of a specific rainfall depth being recorded at a particular location for a defined duration and is classified by an Annual Exceedance Probability (AEP) (Rainfall Estimation, Chapter 3.2). The data associated with design rainfalls is available via the Bureau of Meteorology website (Rainfall Estimate, Chapter 3.9.1) and can be converted to design rainfall intensities.

The glossary webpage on the Bureau of Meteorology also defines the AEP as "*The probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.*" *The relationship between AEP and ARI is defined as:*

AEP = 1-exp(-1/ARI) which results in the following:

ARI (years)	AEP (%)
1	63.2%
2	39.3%
5	18.1%
10	9.5%
20	4.9%
50	2%
100	1%

ARIs of greater than 10 years are very closely approximated by the reciprocal of the AEP.

The Intensity–Frequency–Duration (IFD) data available from the Bureau of Meteorology (known as the Rainfall Data System - 2016) has been added to the Structural Toolkit V5.5 release.

The Bureau of Meteorology website states rainfall:

"The 2016 design rainfalls are based on a more extensive database, with more than 30 years of additional rainfall records and inclusion of data from an additional 2300 (sites) collected by organisations across Australia. By combining contemporary statistical analyses and techniques with this expanded rainfall database, the 2016 design rainfalls provide more accurate estimates for Australia. In addition, the 2016 design rainfalls provide better estimates of the 2% and 1% annual exceedance probability (AEP) design rainfalls than the interim 2013 design rainfalls.

Note: The 2016 design rainfalls replace both the ARR87 design rainfalls and the interim 2013 design rainfalls. "

This guide aims to show the methodology to establish the parameters to derive the previous ARI method and the new AEP method using downloadable data from the Bureau of Meteorology.



Website links

The ARR 2019 guideline: : <http://arr.ga.gov.au/arr-guideline>

Bureau of Meteorology website: <http://www.bom.gov.au/water/designRainfalls/>

Intensity-Frequency-Duration data: <http://www.bom.gov.au/water/designRainfalls/revise-ifd/>

Bureau of Meteorology explanation of ARI vs AEP: <http://www.bom.gov.au/water/designRainfalls/ifd-arr87/glossary.shtml>

Rainfall intensity by Average Recurrence Interval (ARI)

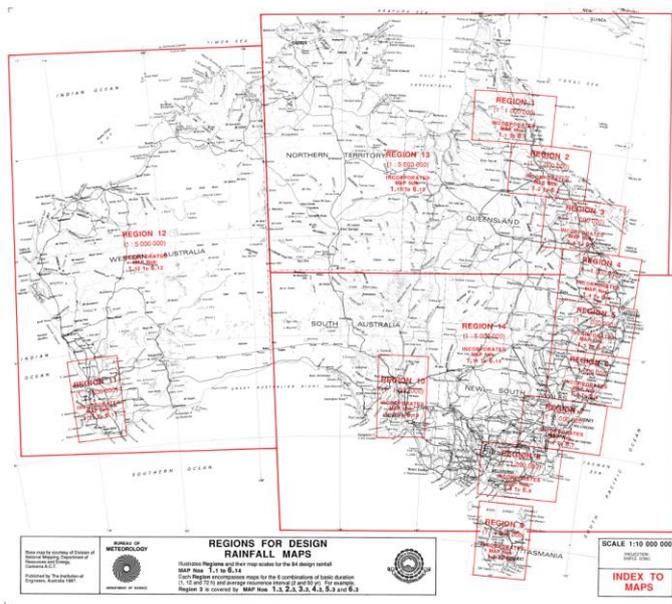
The rainfall intensity depends on the average recurrence interval (ARI) (ie. 1 in 100 years) and the duration of the storm event. Less frequent events result in higher intensities whilst longer rainfall durations result in lower intensities.

The Australian Rainfall and Runoff (ARR) A guide to Flood estimation, 2001, Volumes 1 and 2, is used to derive the intensity. Equations, outlined in Volume 1, Book 2, Cl A.3 utilise a set of parameters obtained from graphs/maps published as part of the ARR (on a CD).

The maps can be used to derive the predicted intensities anywhere throughout Australia and are in sub-maps within the region folder on the CD.

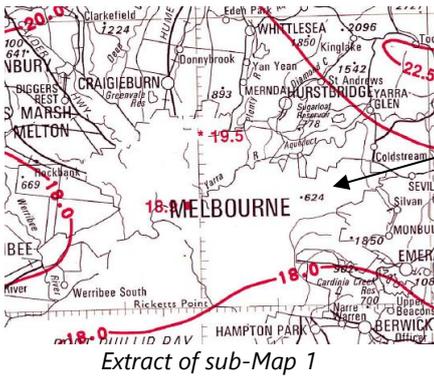
The following example is for Nunawading, an eastern suburb of Melbourne.

From the ARR VOL2, open the index to determine the region then go to the Maps folder for the identified region



Region index

Go to the folder to get the values from the individual maps.



Nunawading is close to station 624.

The following parameters were obtained for Nunawading from the specified sub-maps.

2 Year ARI

1 hour (2i_1) =	19.0mm/hr	(sub-Map 1)
12 hour (${}^2i_{12}$) =	4.5mm/hr	(sub-Map 2)
72 hour (${}^2i_{72}$) =	1.4mm/hr	(sub-Map 3)

50 Year ARI

1 hour (${}^{50}i_1$) =	37.6mm/hr	(sub-Map 4)
12 hour (${}^{50}i_{12}$) =	7.45mm/hr	(sub-Map 5)
72 hour (${}^{50}i_{72}$) =	2.40mm/hr	(sub-Map 6)

Geographical Factors

Map 7 has the skews split into 3 areas (7a-West Australia, 7b-NT and Queensland, 7c - south-eastern states)
Map 8 and 9 contain the F2 and F50 parameters.

Skewness (G) =	0.35	(Map 7)
Factor (F2) =	42.7	(Map 8 - Geographical factor for obtaining 6-minute duration intensities, ARI = 2 years)
Factor (F50) =	15.0	(Map 9 - Geographical factor for obtaining 6-minute duration intensities, ARI = 50 years)

Creating a Custom ARI in the [Rainfall Intensity (ARI)] module

With the new Rainfall Intensity (ARI) V5.02 module, a custom ARI can be created. Open the Rainfall Intensity (ARI) and select the [Custom] tab.

Using the maps within the ARR 2006 publication, obtain the three parameters for the 2 year ARI (${}^2i_1, {}^2i_{12}, {}^2i_{72}$) and 50 year ARI (${}^{50}i_1, {}^{50}i_{12}, {}^{50}i_{72}$); and the three geographical factors (G, F2 and F50).

Enter the City name, latitude and longitude, then press [Save Custom ARI...] to save the data as a .xml file for later use in the Stormwater Detention module.



Rainfall intensity by Average Exceedance Probability (AEP)

The Average Recurrence Interval (ARI) is replaced by Average Exceedance Probability (AEP) in the 2019 version of ARR (ie. 1% AEP replaces 1 in 100 year ARI). Using the Bureau of Meteorology IFD data, a 7-coefficient natural log polynomial regression is used to derive a depth of rainfall for a specific AEP and duration.

$$\text{DepthP} = e^{(C0 + C1 \ln(T) + C2 \ln(T)^2 + C3 \ln(T)^3 + C4 \ln(T)^4 + C5 \ln(T)^5 + C6 \ln(T)^6)} \text{ (in mm)}$$

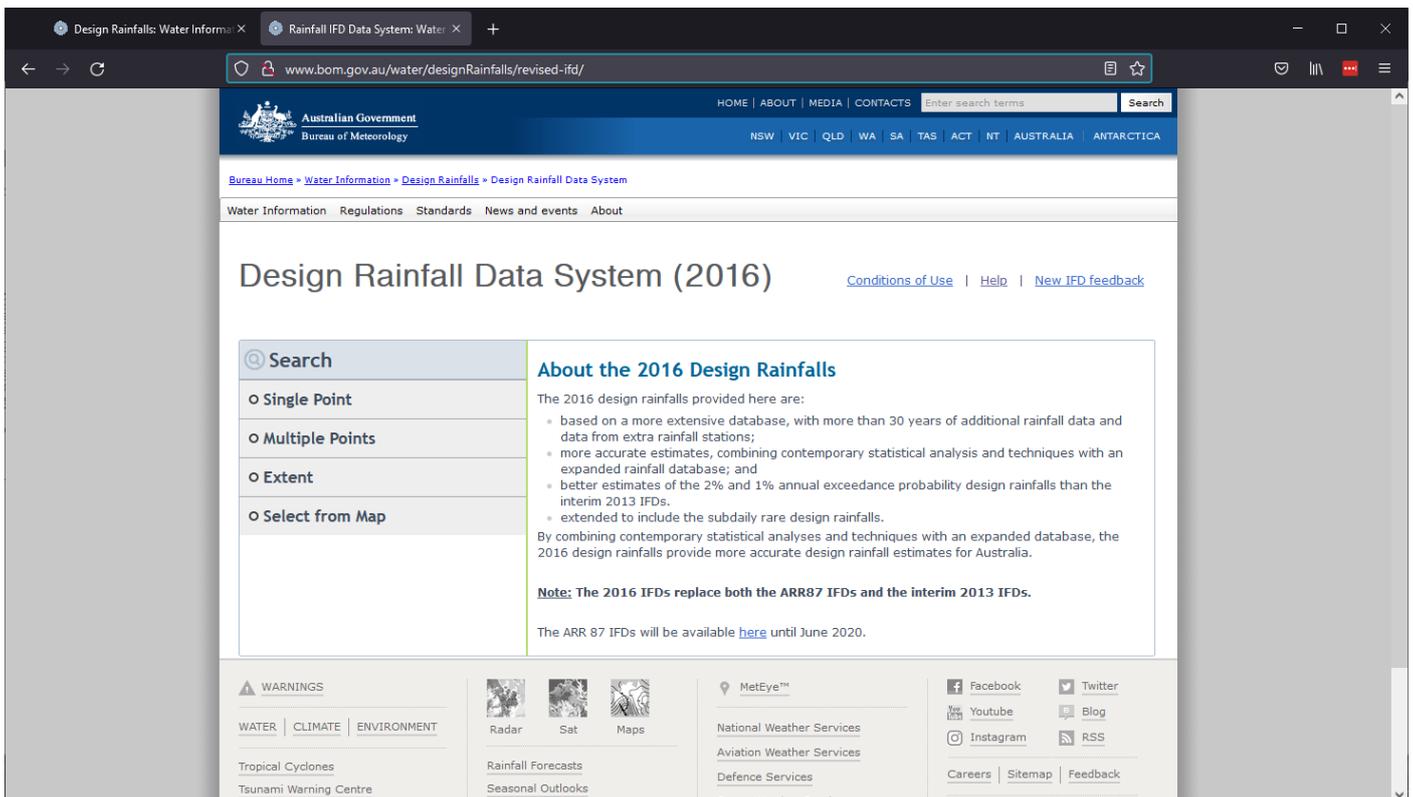
The depth is converted to a rainfall intensity using the following equation:

$$\text{intensity (mm/h)} = \text{depth (mm)} / \text{duration (hours)}$$

The data is obtained by entering latitude and longitude information on the website, and downloading the Rainfall Intensities; or the coefficients file for which you are able to calculate the depth, then convert to intensity.

The following example is for Nunawading, an eastern suburb of Melbourne.

Using your browser, go to the Bureau of Meteorology website <http://www.bom.gov.au/water/designRainfalls/revise-ifd/>





Use "Select from Map" to determine the latitude and longitude.

Design Rainfall Data System (2016)

[Conditions of Use](#) | [Help](#) | [New IFD feedback](#)

lat	lon
-37.827	145.180

Selecting the point on the map places the coordinates in the lower table.

We recommend saving a copy of this to your project documents folder by taking a screen shot (Shift-Windows-S) and selecting the [Window] option.



Alternatively, you can use the Snipping Tool from the windows search bar.

When you have the co-ordinates, select "Single Point" and enter the coordinates, then [Submit]

Design Rainfall Data System (2016)

[Conditions of Use](#) | [Help](#) | [New IFD feedback](#)

About the 2016 Design Rainfalls

The 2016 design rainfalls provided here are:

- based on a more extensive database, with more than 30 years of additional rainfall data and data from extra rainfall stations;
- more accurate estimates, combining contemporary statistical analysis and techniques with an expanded rainfall database; and
- better estimates of the 2% and 1% annual exceedance probability design rainfalls than the interim 2013 IFDs.
- extended to include the subdaily rare design rainfalls.

By combining contemporary statistical analyses and techniques with an expanded database, the 2016 design rainfalls provide more accurate design rainfall estimates for Australia.

Note: The 2016 IFDs replace both the ARR87 IFDs and the interim 2013 IFDs.

The ARR 87 IFDs will be available [here](#) until June 2020.



A green table with IFD Design Rainfall Depth (mm) will appear. Change the data unit to mm/h to display the orange IFD Design Rainfall Intensity (mm/hr) table and select Coefficients.

Design Rainfall Data System (2016)

Conditions of Use | Help | [New IFD feedback](#)

Analysis - Single Point

Design Rainfalls

- Very Frequent
- IFDs (Frequent and Infrequent)
- Rare

Standard Durations

- 1 - 45 minutes
- 1 - 18 hours
- 24 - 168 hours

Non-Standard Durations

Duration: minutes

Observed Rainfalls

Other Options

- Coefficients**
- Seasonality

Location

Label: Not provided
 Latitude: -37.827 [Nearest grid cell: 37.8375 (S)]
 Longitude: 145.18 [Nearest grid cell: 145.1875 (E)]

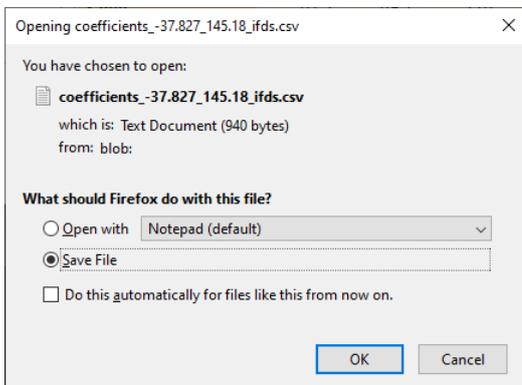
IFD Design Rainfall Intensity (mm/h) Issued: 27 July 2021

Rainfall intensity for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
[FAQ for New ARR probability terminology](#)

Unit: **mm/h**

Duration	Annual Exceedance Probability (AEP)						
	63.2%	50%#	20%*	10%	5%	2%	1%
1 min	95.3	106	143	170	198	238	271
2 min	81.1	89.7	118	139	160	186	207
3 min	72.8	80.7	107	126	145	170	190
4 min	66.6	73.9	98.4	116	134	159	179
5 min	61.5	68.4	91.5	108	126	150	169
10 min	45.7	51.1	68.9	82.2	96.0	116	133
15 min	37.1	41.5	56.1	66.9	78.4	94.9	109
20 min	31.6	35.3	47.7	56.9	66.5	80.4	91.9

Download the csv (comma-separated values file) data file for the intensities and the coefficients and save them to your project documents folder. This file is used to create the custom AEP for use with the Stormwater Detention module.





Creating a Custom AEP in the [Rainfall Intensity (AEP)] module

With the new Rainfall Intensity (AEP) V5.00 released with Structural Toolkit V5.5 module, a custom ARI can be created.

Open the *coefficients* csv data file previously saved in Microsoft Excel.

	A	B	C	D	E	F	G	H	I
1	Copyright Commonwealth of Australia 2016 Bureau of Meteorology (ABN 92 637 533 532)								
2									
3	IFD Design Rainfall Coefficients								
4	Issued: 27-Jul-21								
5	Location Label:								
6	Requester: Latitude -37.827 Longitude 145.18								
7	Nearest g: Latitude 37.8375 (S) Longitude 145.1875 (E)								
8									
9	Coefficient	63.20%	50%	20%	10%	5%	2%	1%	
10	C0	0.462352	0.571134	0.867435	1.040258	1.193363	1.377236	1.506483	
11	C1	0.755883	0.728608	0.668538	0.628552	0.569965	0.460798	0.372726	
12	C2	0.054928	0.084412	0.146912	0.189418	0.25617	0.384041	0.488033	
13	C3	-0.06488	-0.0756	-0.09682	-0.11198	-0.13878	-0.19219	-0.23615	
14	C4	0.014551	0.016152	0.018899	0.02111	0.025923	0.036019	0.044468	
15	C5	-0.00135	-0.00144	-0.00155	-0.00167	-0.00207	-0.00296	-0.00371	
16	C6	4.50E-05	4.65E-05	4.51E-05	4.69E-05	5.93E-05	8.84E-05	0.000114	
17									

Select data and copy into the clipboard using Ctrl-C

Select the coefficient values in Microsoft Excel and use Ctrl-C to copy the data into the clipboard.

Open the Rainfall Intensity (AEP) V5.00 module and select the [Custom] tab. Select the top left corner of the data table (cell C0/63.2%) and paste the data using Ctrl-V.

DESIGN RAINFALL INTENSITY V5.00 Notes:

Location

City = Nunawading, VIC Current City = Melbourne, VIC

Latitude = 37.8375 South

Longitude = 145.1875 East

Copy Location AEP...

Custom AEP IFD data

Custom IFD polynomial coefficients from Design Rainfall Data System (2016) by Bureau of Meteorology

	63.20%	50%	20%	10%	5%	2%	1%
C0	0.4623517	0.571134	0.8674352	1.0402583	1.1933627	1.3772361	1.506483
C1	0.7558835	0.7286077	0.6685382	0.628552	0.5699654	0.4607977	0.3727257
C2	0.0549278	0.0844117	0.1469125	0.1894177	0.25617	0.384041	0.488033
C3	-0.0648833	-0.0756003	-0.0968208	-0.111977	-0.1387833	-0.1921939	-0.2361544
C4	0.0145512	0.0161516	0.0188986	0.02111	0.0259226	0.036019	0.0444627
C5	-0.001346	-0.0014407	-0.0015484	-0.0016749	-0.0020726	-0.0029563	-0.0037108
C6	4.503E-05	4.648E-05	4.515E-05	4.69E-05	5.928E-05	8.841E-05	0.0001139

Load Custom AEP...
Save Custom AEP...

Select cell, and paste data into the data area using Ctrl-V

Enter the City name, latitude and longitude, then press [Save Custom AEP...] to save the data as a xml file for later use in the Stormwater Detention module.



Verify the coefficient data values are correct by comparison of the intensities from the Bureau of Meteorology table with the table shown on the [IFD] tab.

Duration	Annual Exceedance Probability (AEP)						
	63.2%	50%#	20%*	10%	5%	2%	1%
1 min	95.3	106	143	170	198	238	271
2 min	81.1	89.7	118	139	160	186	207
3 min	72.8	80.7	107	126	145	170	190
4 min	66.6	73.9	98.4	116	134	159	179
5 min	61.5	68.4	91.5	108	126	150	169
10 min	45.7	51.1	68.9	82.2	96.0	116	133
15 min	37.1	41.5	56.1	66.9	78.4	94.9	109
20 min	31.6	35.3	47.7	56.9	66.5	80.4	91.9

Bureau of Meteorology Rainfall Intensity

Design Rainfall Intensity (mm/hr) for Nunawading, VIC

Duration	Average Exceedance Probability (AEP)						
	63.20%	50%	20%	10%	5%	2%	1%
1 min	95.3	106	143	170	198	238	271
2 min	81.1	89.7	118	139	160	186	207
3 min	72.8	80.7	107	126	145	170	190
4 min	66.6	73.9	98.4	116	134	159	179
5 min	61.5	68.4	91.5	108	126	150	169
10 min	45.7	51.1	68.9	82.2	96.0	116	133
15 min	37.1	41.5	56.1	66.9	78.4	94.9	109
20 min	31.6	35.3	47.7	56.9	66.5	80.4	91.9

AEP Rainfall Intensity

Using the custom ARI and AEP with the Stormwater Detention module

Both the old ARI and new AEP methods for rainfall intensity calculation can be used with the new Stormwater Detention V5.04 design.

Select the [Location] tab and load the desired data from the custom ARI or AEP xml data file created previously using the [Load Custom ARI...] or [Load Custom AEP...].

Select the [OSD Swinburne] tab, and under "Design Criteria", select the Method (A)RI 2001 or A(E)P 2019.

Following input or changing of any design parameters including the Storage method ie. Above, Pipe, Underground, or Custom (which allows a user specific PSD) press [Recalculate...] to design to recalculate the storage volume.