

IRRIGATION DEPARTMENT

**HYDROLOGICAL ANNUAL
2013/14**

**Hydrology Division
Irrigation Department
Colombo 07
Sri Lanka**

Hydrological Annual – Irrigation Department
55th year of publication

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FOREWORD

Hydrological Annual is a publication of the Hydrology Division of Irrigation Department. Content of the booklet is extremely useful for the water resources planners and developers, researchers, students and the general public of the country.

First volume of this series was published in 1960, with respect to the water year 1959/60, with the limited data and information available at the time. The content and the presentation of the journal were eventually improved by the staff of Hydrology Division. The Annual of 2013/14 is also presented with some additional features and improvements.

Graphical presentation of spatial variations of annual and seasonal rainfalls is newly added to the rainfall section of this volume. The reader can quickly go through these figures and view the variability and trends of rainfalls in different climatic regions of the island due to the impact of climate change and other natural and manmade phenomena.

Further, an editorial board was appointed to scrutinize the information provided & the technical papers and also to attend the necessary amendments before publication. This will improve the reliability and accuracy of the information provided by the journal.

Part I and II of the journal provide the general information of the river basins and the salient hydrological features of the water year.

Part III of the journal is allocated for the technical papers and research works carried out by the engineers engaged in water related development works.

A severe flood was experienced in the North Central province in December 2014. This is considered as the most severe hydrological hazard faced by the people of this area after the destructive flood in 1957. The paper "Comparison of the 2014 flood with the Devastating flood of 1957" analyses the behavior and the important hydrological features of both floods. This will be particularly useful for hydrological modelers who are in search of historical data.

The history of the Hydrology Division goes beyond 1950s up to the period of its establishment as a specialized branch of the Irrigation Department. The last paper is a reorganization proposal prepared by Eng. Shirley J. Bocks, the first officer in charge of Hydrology Branch, to present to his employer, then Director of Irrigation. The content of this document is still valid and useful in future development of the water resources development sector of the country. I hope this document will be interested to the present officers in government service who are responsible for restructuring of state organizations in order to provide better services to the nation.

Eng. Ms. P. Hettiarachchi,
Director of Irrigation (Hydrology)

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PART I

- **Terminology and Abbreviations**
- **Conversion Factors**
- **River Basin Map and Drainage Area**
- **Hydrometric Stations**

TERMINOLOGY AND ABBREVIATIONS USED IN PUBLICATION

Flood Hydrograph	-	A plot of discharge against time.
Annual Flood Peak	-	Highest value of discharge for the year indicated by the hydrograph
Maximum Flood Peak	-	Maximum observed flood peak during the period of observation.
Average Annual Rainfall	-	Arithmetic mean of annual rainfall values for the period of observation.
Rainfall Intensity	-	Cumulative depth of rainfall during a particular duration.
Annual Runoff	-	The total volume of water measured at a particular point for the year.
Average Annual Runoff	-	Arithmetic mean of annual run-off for the period of observation.
Annual Yield	-	Annual yield is the volume of water available to the tank from its own catchment (without diversions) during the year.
Specific Yield	-	$\frac{\text{Yield (MCM)}}{\text{Catchment Area (Sq.Kms)}}$
Duty	-	Duty is the irrigation requirement (issued from the sluice) during a cultivation season for one hectare $\text{Duty (meters)} = \frac{\text{Sluice Issue (ha.m)}}{\text{Area Cultivated (ha)}}$
Evaporation	-	The transfer of water into the atmosphere from a free water surface.
Potential Evapotranspiration	-	The evapotranspiration from vegetal cover and from soil surface when the root zone is saturated.

CONVERSION FACTORS

Length

Imperial		Metric / SI
1 inch	= 1/12 foot	0.0254 m
1 foot	= 1/3 yard	0.3048 m
1 yard	= 3 feet	0.9144 m
1 Engineering chain	= 100 feet	30.48 m
1 mile	= 52.8 chains = 5280 feet	1609 m

Area

Imperial		Metric / SI
1 square foot	= 144 square inches	0.0929 m ²
1 acre	= 43,560 ft ²	4,047 m ² = 0.4047 ha
2.47 acres		1 ha
1 square mile	= 640 acres	259 ha = 2.59 km ²

Volume & Discharge

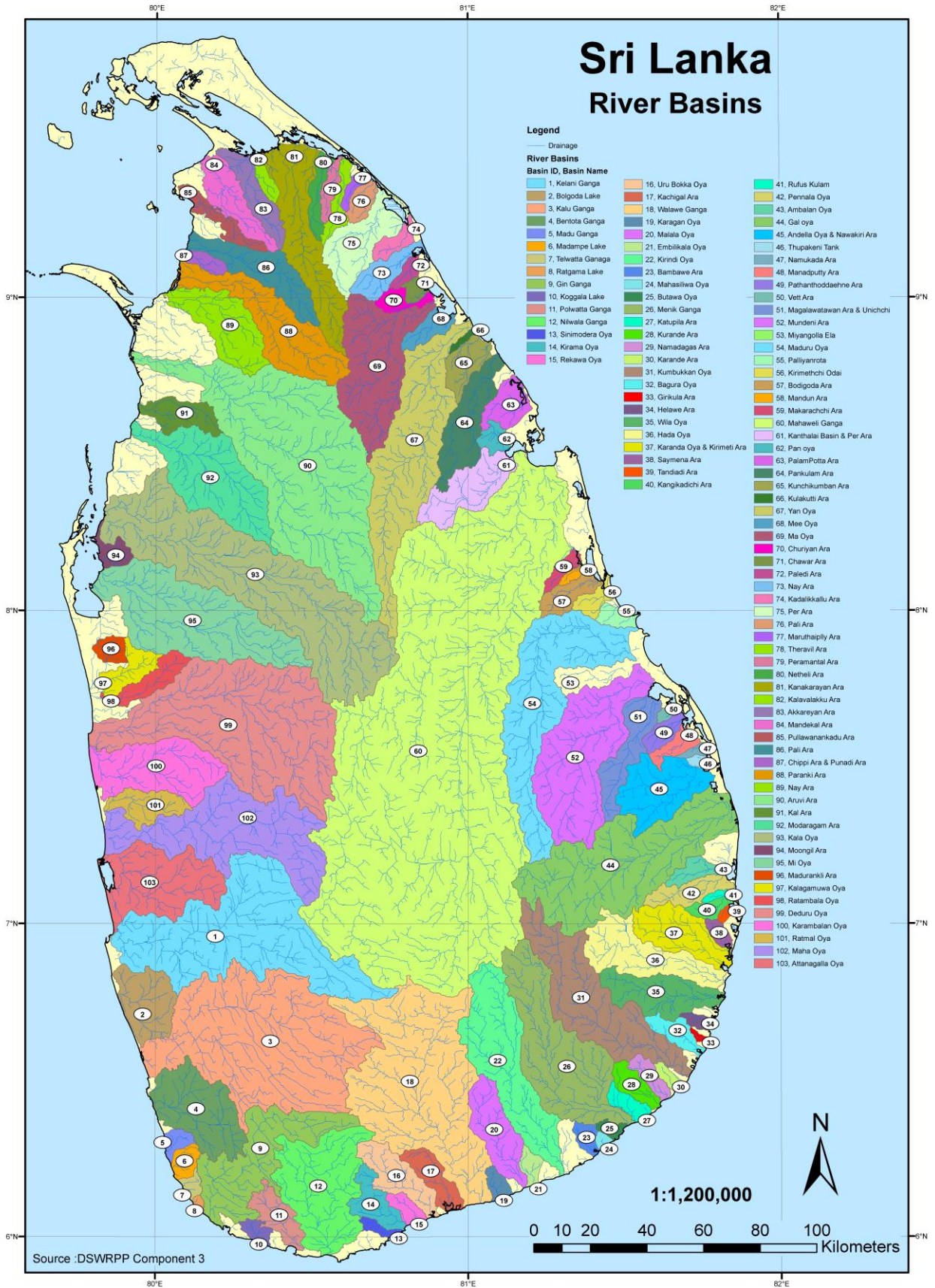
Imperial		Metric / SI
1 cubic foot per second (cusec)		28.317 l/s
1 cusec during 1 day	= 1.983 acre.ft	2,446.57 m ³
1 acre.foot		1,234 m ³
1 acre.foot/day		14.28 l/s = 1234 m ³ /d
1 acre.inch	= 3.630 ft ³	102.8 m ³

Map scales

Imperial		Metric / SI
1 inch : 10 feet		1 : 120
1 inch : 20 feet		1 : 240
1 inch : 66 feet		1 : 792
1 inch : 132 feet		1 : 1,584
1 inch : 264 feet		1 : 3,168
1 inch : 528 feet		1 : 6,336
1 inch : 1 mile		1 : 63,360

Weight

Imperial		Metric / SI
1 pound		0.4536 kg
2.24 pound		1 kg
1 ton		1,016 kg
2,240 pounds		1 Metric Ton = 1000 kg
1 bushel (paddy)		22.88 kg
1 bushel/acre		56.5 kg/ha



RIVER BASINS OF SRI LANKA

	River Name	Drainage Area Sq.kms	River Name	Drainage Area Sq.kms
1	Kelani Ganga	2340	41 Rufus Kulam	27
2	Bolgoda Ganga	396	42 Pannel Oya	195
3	Kalu Ganga	2839	43 Ambalan Oya	112
4	Bentara Ganga	667	44 Gal Oya	1911
5	Madu Ganga	69	45 Andella Oya	534
6	Madampe Ganga	90	46 Tumpun Keni	18
7	Telwatta Ganga	41	47 Namakada Aru	12
8	Ratgama Lake	13	48 Mandipattu Aru	90
9	Gin Ganga	915	49 Pathantoppu Aru	101
10	Koggala Ganga	55	50 Vett Aru	22
11	Polwatta Ganga	232	51 Magalavatavan Aru	304
12	Nilwala Ganga	1043	52 Mundeni Aru	1373
13	Sinimodara Oya	35	53 Miyangolla Ela	228
14	Kirama Oya	183	54 Maduru Oya	1439
15	Rekawa Oya	70	55 Pulliyanpota Aru	87
16	Urubokka Oya	373	56 Kirimechchi Odai	89
17	Kachigal Ara	208	57 Bodigolla Aru	132
18	Walawe Ganga	2424	58 Mandan Aru	26
19	Karagan Oya	60	59 Makarachchi Aru	59
20	Malala Oya	409	60 Mahaweli Ganga	10266
21	Embilikala Oya	69	61 Kantalai Aru	437
22	Kirindi Oya	1156	62 Palampotta Aru	97
23	Bambawe Ara	66	63 Panna Oya	164
24	Mahaseelawa Oya	13	64 Pankulam Aru	377
25	Buthawa Oya	37	65 Kunchikumban Aru	245
26	Menik Ganga	1301	66 Palakutta Aru	8
27	Katupila Ara	111	67 Yan Oya	1518
28	Kurunda Ara	99	68 Mee Oya	89
29	Nabadagas Ara	110	69 Ma Oya	1042
30	Karambe Ara	54	70 Churiya Aru	105
31	Kumbukkan Oya	1227	71 Chavar Aru	35
32	Bagura Oya	93	72 Palladi Aru	66
33	Girikula Oya	14	73 Manal Aru	194
34	Helawa Ara	38	74 Kodalikallu Aru	92
35	Wila Oya	472	75 Per Aru	392
36	Heda Oya	615	76 Pali Aru	70
37	Karanda Oya	425	77 Maruthapillay Ary	36
38	Seman Aru	72	78 Thervil Aru	104
39	Tandiadi Aru	20	79 Piramanthal Aru	91
40	Kangikadichi Aru	78	80 Methali Aru	114

81	Kanakarayan Aru	604
82	Kalwalappu Aru	68
83	Akkarayan Aru	244
84	Mandekal Aru	208
85	Pallavarayan Kaddu Aru	311
86	Pali Aru	451
87	Chappi Aru	79
88	Parangi Aru	770
89	Nay Aru	717
90	Aruvi Aru	3291
91	Kal Aru	210
92	Moderagama Aru	1001
93	Kala Oya	2526
94	Moongil Aru	78
95	Mee Oya	1555
96	Madurankuli Aru	128
97	Kalagamune Oya	169
98	Rathambala Oya	244
99	Deduru Oya	2622
100	Karambala Oya	693
101	Ratmal Oya	341
102	Maha Oya	1470
103	Attanagalu Oya	811
	Area of Jaffna Peninsula including Vadamarachchi Lagoon, but excluding islands of Kayts , Kartivu	1018
	Residual area comprising largely, coastal zones intervening between adjacent river basins of Sri Lanka	5049
	Total	65591

Source: Water Resources Planning Project under component 03 of DSWRPP- 2013

HYDROMETRIC STATIONS FOR 2013/14
(According to River Basin)

Name of Station	River Basin	Coordinates	Catchment Area (Sq.Km)
1. Norwood	Kelani Ganga	(6°50'22", 80°36'42")	97
2. Kithulgala	Kelani Ganga	(6°59'26", 80°24'44")	83
3. Dearaniyagala	Kalani Ganga	(6°55'28", 80°20'16")	183
4. Holombuwa	Kelani Ganga	(6°56'13", 80°27'42")	155
5. Glencourse	Kelani Ganga	(6°58'28", 80°10'58")	1463
6. Hanwella	Kelani Ganga	(6°54'34", 80°04'46")	1782
7. Ratnapura	Kalu Ganga	(6°40'42", 80°23'39")	603
8. Ellagawa	Kalu Ganga	(6°43'55", 80°12'36")	1393
9. Millakanda	Kalu Ganga	(6°37'56", 80°11'23")	780
10. Putupaula	Kalu Ganga	(6°36'06", 80°03'26")	2598
11. Baddegama	Gin Ganga	(6°10'33", 80°10'27")	681
12. Tawalama	Gin Ganga	(6°20'31", 80°19'49")	377
13. Pitabeddara	Nilwala Ganga	(6°12'45", 80°28'34")	333
14. Wellawaya	Kirindi Oya	(6°42'35", 81°06'40")	172
15. Tanamalwila	Kirindi Oya	(6°27'39", 81°07'32")	749
16. Kataragama	Menik Ganga	(6°24'56", 81°19'51")	787
17. Siyambalanduwa	Heda Oya	(6°54'18", 81°32'36")	295
18. Padiyatalawa	Maduru Oya	(7°23'01", 81°11'31")	159
19. Calidonia	Mahaweli Ganga	(6°54'07", 80°41'52")	148
20. Demodara	Mahaweli Ganga	(6°56'12", 81°02'03")	78
21. Nawalapitiya	Mahaweli Ganga	(7°02'51", 80°32'04")	176
22. Peradeniya	Mahaweli Ganga	(7°15'39", 80°35'26")	1168
23. Laggala Pallegama	Mahaweli Ganga	(7°34'02", 80°49'52")	129
24. Galgamuwa	Mee Oya	(7°58'07", 80°15'34")	299
25. Chilaw	Deduru Oya	(7°36'01", 79°48'57")	2610
26. Badalgama	Maha Oya	(7°18'00", 79°58'47")	1360
27. Dunamale	Attanagalu Oya	(7°06'56", 80°04'50")	153

PART II

- **Rainfall**
- **Variation of Rainfall**
- **Rainfall Intensities**
- **Evaporation and Evapotranspiration**
- **Stream Flow Data**
- **Runoff / Rainfall Ratio**
- **Flood Hydrographs**

RAINFALL

MONTHLY RAINFALL AT PRINCIPAL STATIONS

(in mm)

Upper line : Current year 2013/14

Lower line : Long-term average from 1970/71 to 2012/13

Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	NEM Total	SWM Total	Annual Total
1 Anuradhapura	125	196	105	160	45	3	346	180	1	0	60	266	634	853	1488
	245	243	198	82	53	71	161	75	15	29	31	68	893	378	1271
2 Badulla	171	201	232	73	40	65	119	213	3	16	65	132	783	547	1330
	236	270	269	185	89	100	191	103	34	65	70	124	1148	586	1734
3 Bandarawela	214	151	126	74	21	18	298	221	22	6	56	127	604	731	1335
	245	247	186	114	67	100	172	105	51	61	57	135	958	581	1539
4 Batticaloa	24	199	271	274	73	22	1	174	0	0	83	22	863	280	1143
	171	350	411	243	130	75	56	38	33	34	39	74	1379	272	1652
5 Colombo	140	205	32	86	19	145	255	83	239	35	255	313	627	1180	1807
	337	336	149	70	68	115	245	319	202	124	104	220	1075	1214	2289
6 Galle	292	287	93	61	43	68	159	185	247	65	445	311	843	1412	2255
	313	303	177	87	63	94	226	285	201	155	151	247	1037	1265	2302
7 Hambantota	53	148	60	2	0	98	14	76	21	6	45	44	361	205	566
	127	213	121	67	42	57	94	82	51	35	51	73	627	385	1012
8. Jaffna	82	162	87	93	23	0	8	81	8	2	109	36	447	243	690
	244	366	263	76	37	35	65	49	19	29	47	64	1020	274	1294
9 Katugastota	258	113	84	73	33	8	240	121	115	77	97	257	569	907	1475
	270	295	190	102	71	89	191	134	135	129	101	138	1017	829	1846
10 Katunayaka	165	194	35	26	2	130	193	163	146	111	318	124	551	1054	1606
	361	312	126	52	67	119	217	283	160	89	94	192	1037	1035	2072
11 Kurunegala	297	190	32	30	5	63	576	160	75	53	167	293	617	1324	1942
	354	318	141	70	74	137	266	183	144	103	86	148	1093	930	2024

MONTHLY RAINFALL AT PRINCIPAL STATIONS

(in mm)

Upper line : Current year 2013/14

Lower line : Long-term average from 1970/71 to 2012/13

Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	NEM Total	SWM Total	Annual Total
12. Mahailuppallama	229	190	70	134	10	0	323	195	2	0	26	243	633	789	1422
	252	263	192	85	74	71	174	85	16	31	34	89	938	430	1367
13. Mannar	41	239	132	53	10	2	25	91	0	0	102	109	478	328	805
	167	262	202	50	45	44	90	46	8	14	9	47	771	214	984
14. Monaragala * (2009/10 to 2012/13)	175	189	181	77	62	30	68	120	1	93	139	88	714	507	1221
	199	235	193	187	127	145	208	124	17	36	94	78	1087	557	1643
15. Nuwara Eliya	177	162	67	48	8	47	145	151	173	80	122	187	508	859	1367
	237	228	185	119	64	68	136	167	189	179	144	169	900	983	1884
16. Polonnaruwa * (2009/10 to 2012/13)	39	143	228	270	62	5	58	138	0	0	51	101	748	349	1096
	393	351	411	296	198	108	150	75	0	49	65	63	1758	402	2159
17. Potuvil * (1985/86 to 2012/13)	133	195	362	277	72	47	1	50	8	8	6	27	1085	100	1186
	126	261	300	307	136	79	81	41	11	17	23	57	1207	229	1436
18. Puttalam	122	288	43	97	9	35	208	85	15	0	66	110	595	485	1080
	228	250	130	52	41	66	166	94	32	23	17	66	767	398	1165
19. Ratmalana	325	172	22	57	45	101	245	81	200	73	267	238	721	1104	1825
	362	361	165	73	69	115	269	323	200	127	117	243	1145	1279	2424
20. Ratnapura	361	335	41	293	77	139	420	226	579	233	619	589	1247	2666	3914
	446	374	223	120	142	212	361	448	419	300	279	380	1517	2188	3705
21. Trincomalee	35	177	190	164	83	5	2	57	5	25	120	108	654	317	971
	211	359	339	140	91	46	55	59	30	59	79	118	1186	399	1585
22. Vavuniya	195	160	78	264	18	2	154	250	0	8	55	118	717	587	1304
	227	276	247	87	69	57	135	68	19	46	50	97	962	414	1376

Note :- * Denotes Long term average less than specified above.

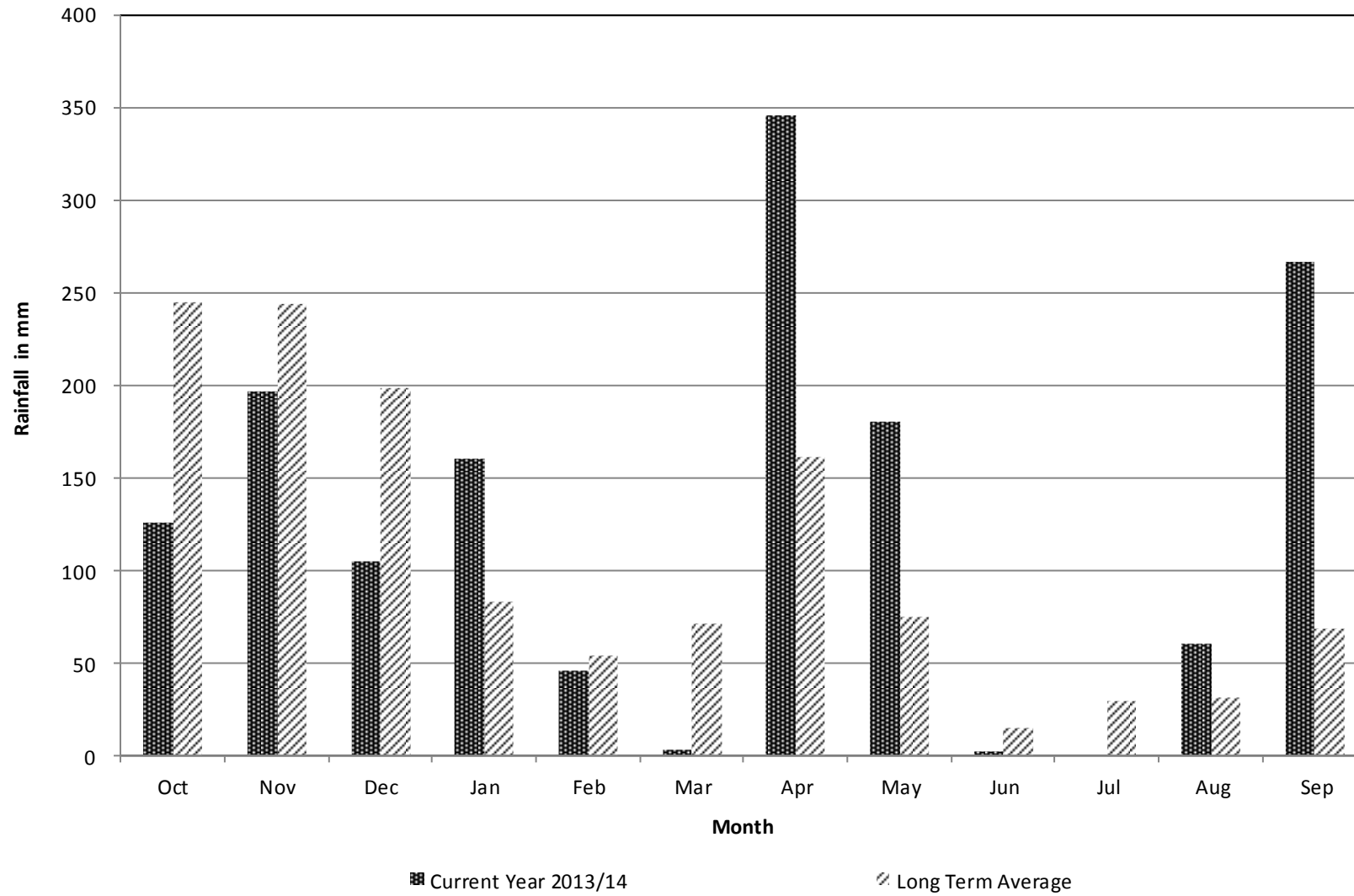
NEM denotes North - East Monsoon, SWM denotes South - West Monsoon

VARIATION OF RAINFALL

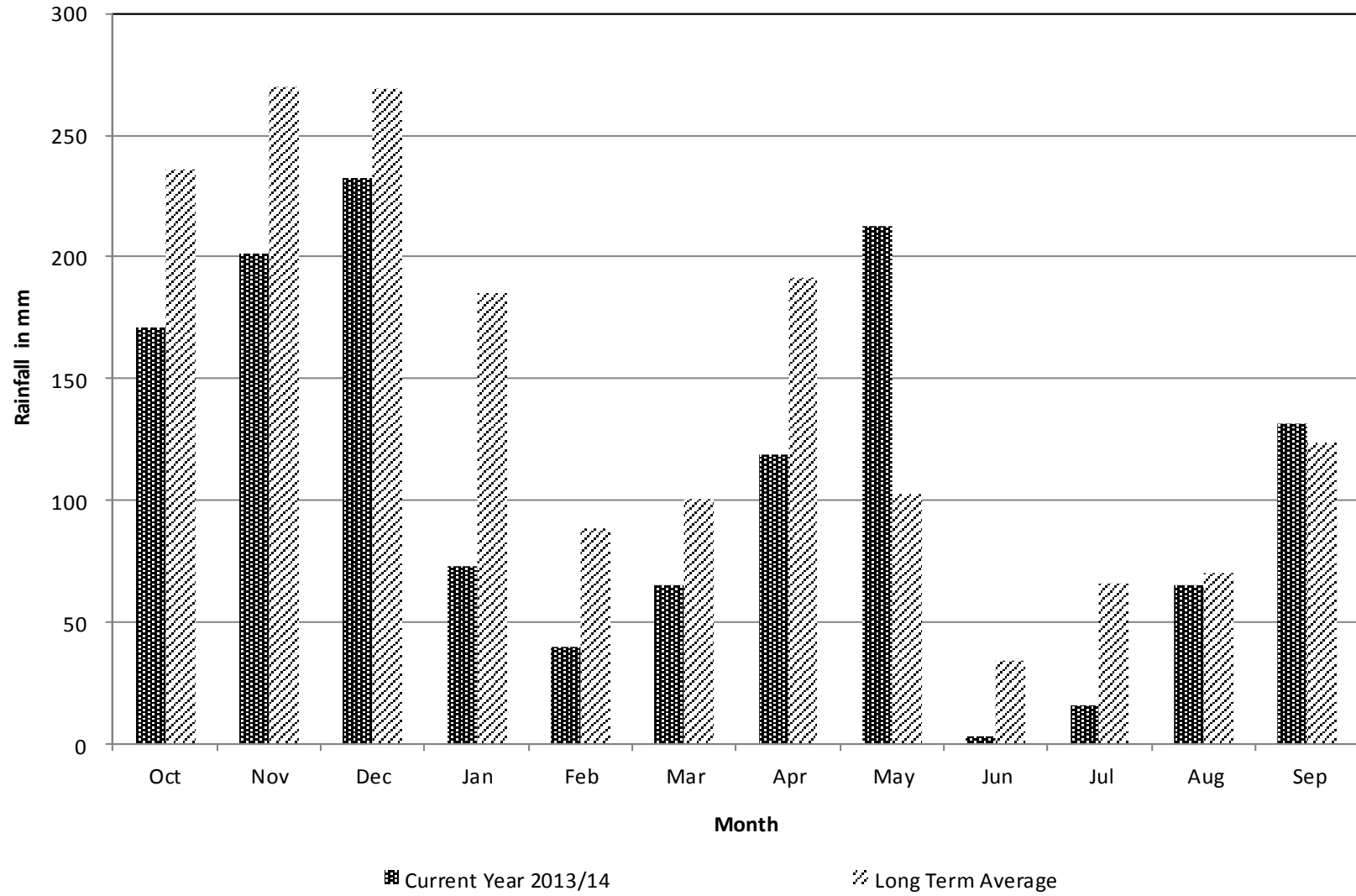
- **Temporal variation at each station**
- **Spatial variation for each month/ average month**

Temporal variation at each station

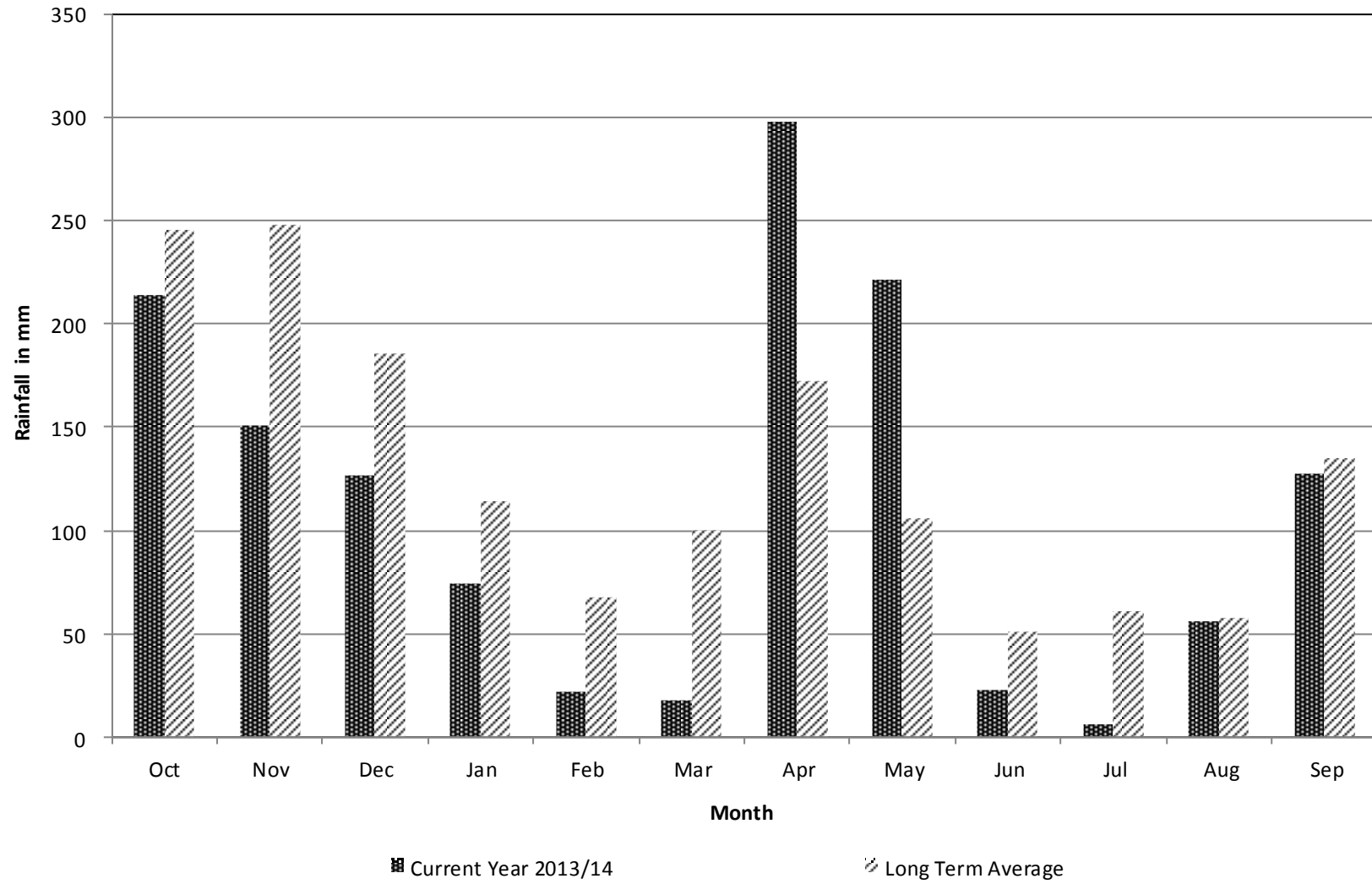
Variation of Rainfall at Anuradhapura



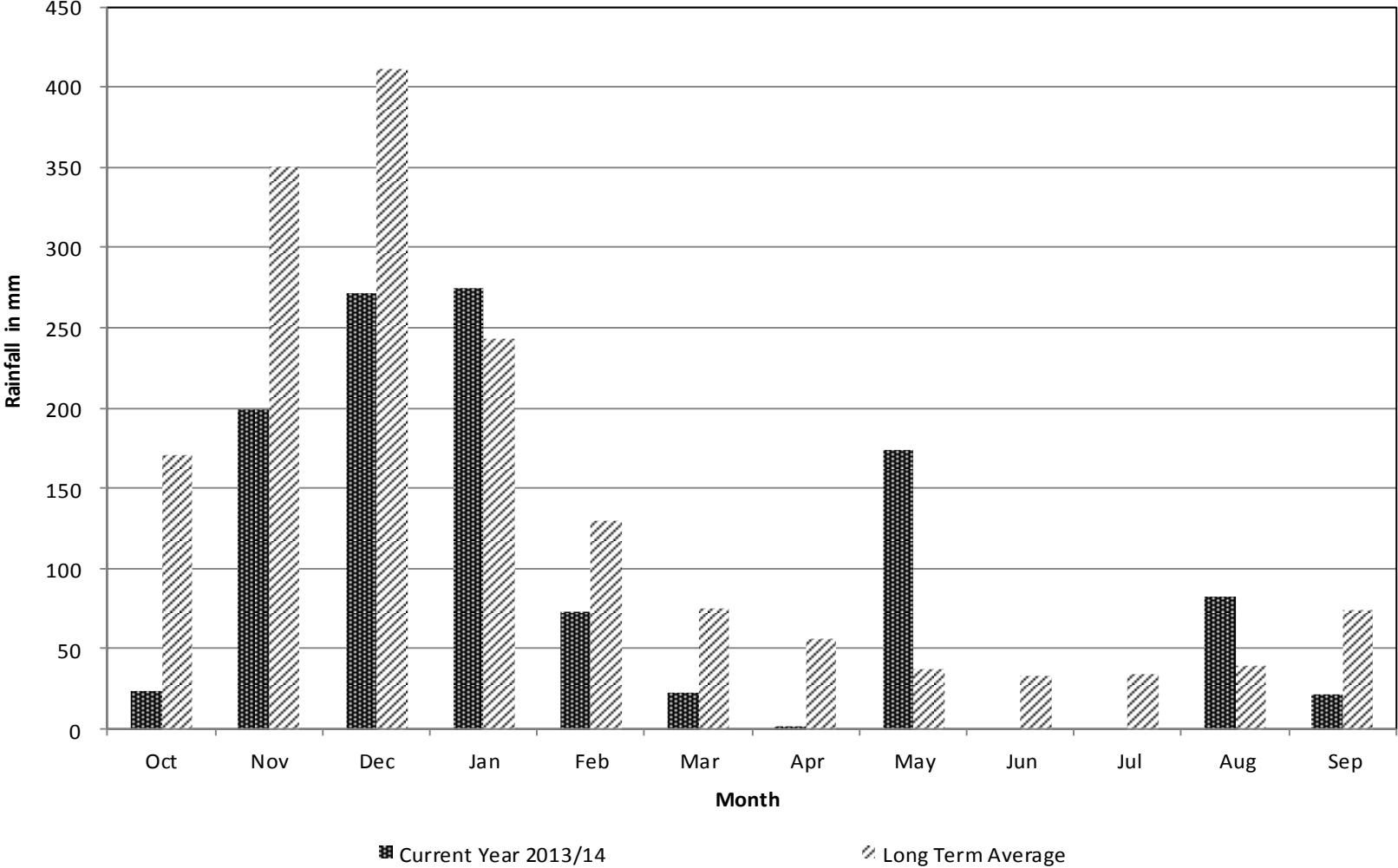
Variation of Rainfall at Badulla



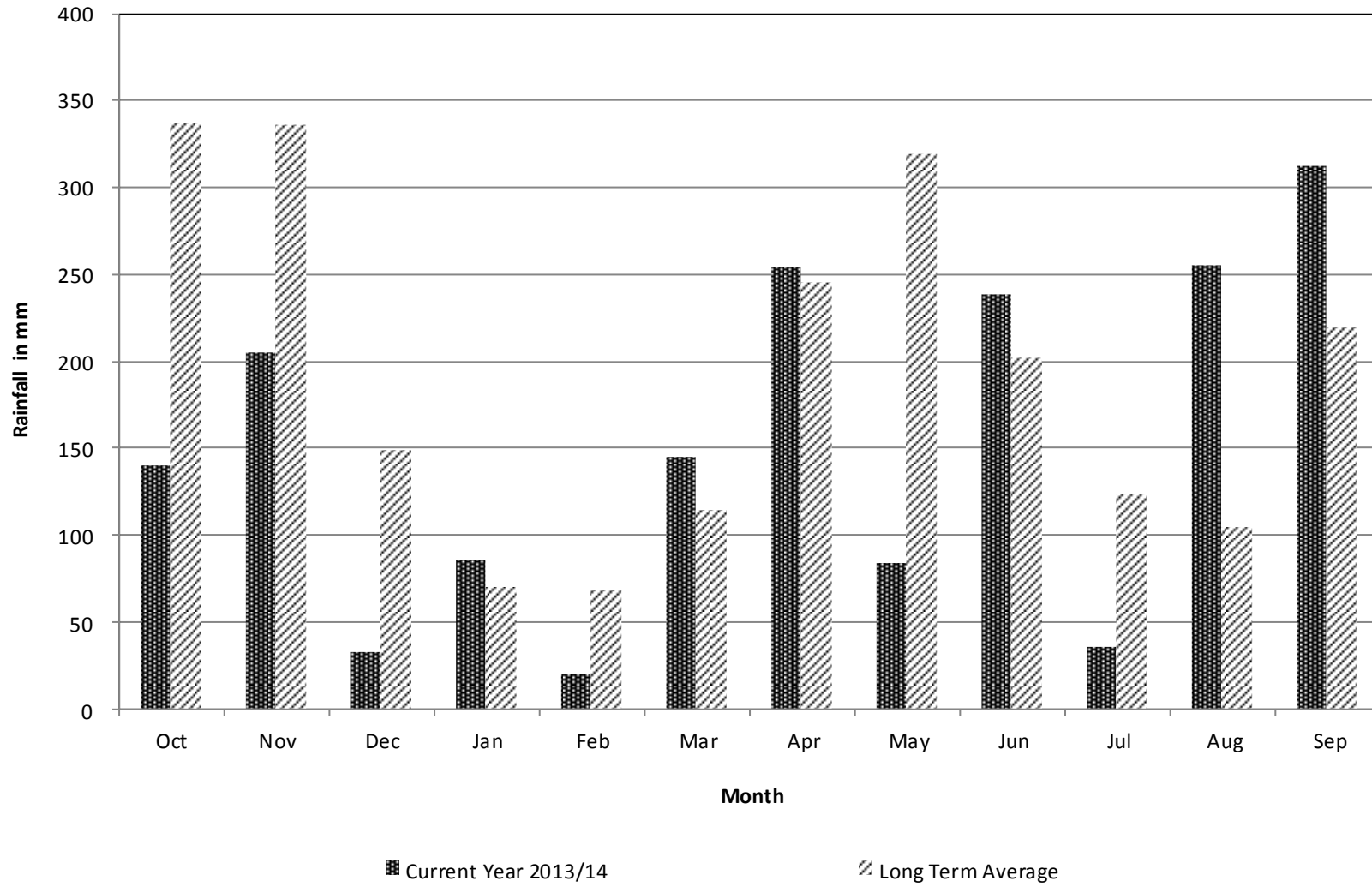
Variation of Rainfall at Bandarawela



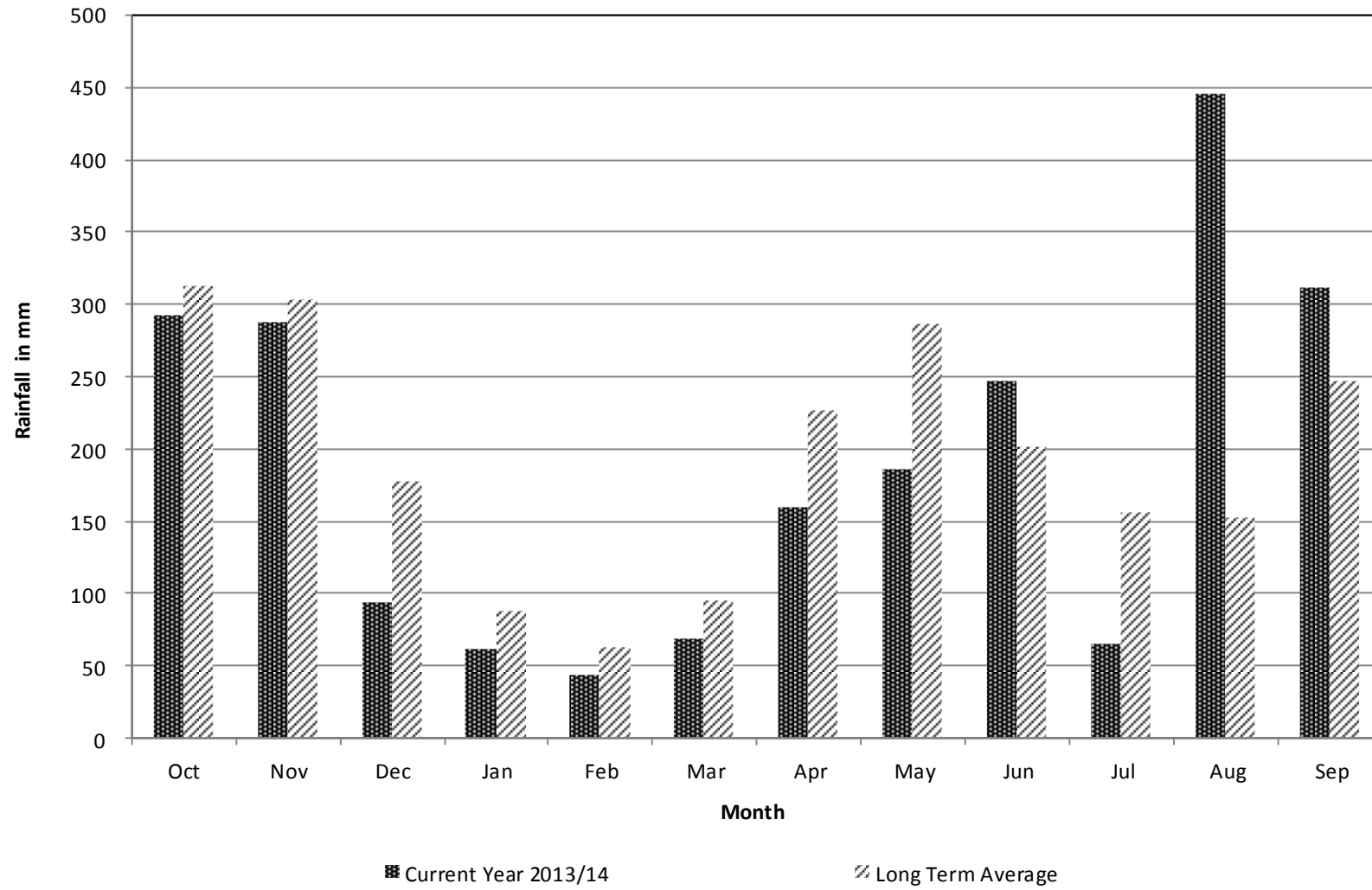
Variation of Rainfall at Batticaloa



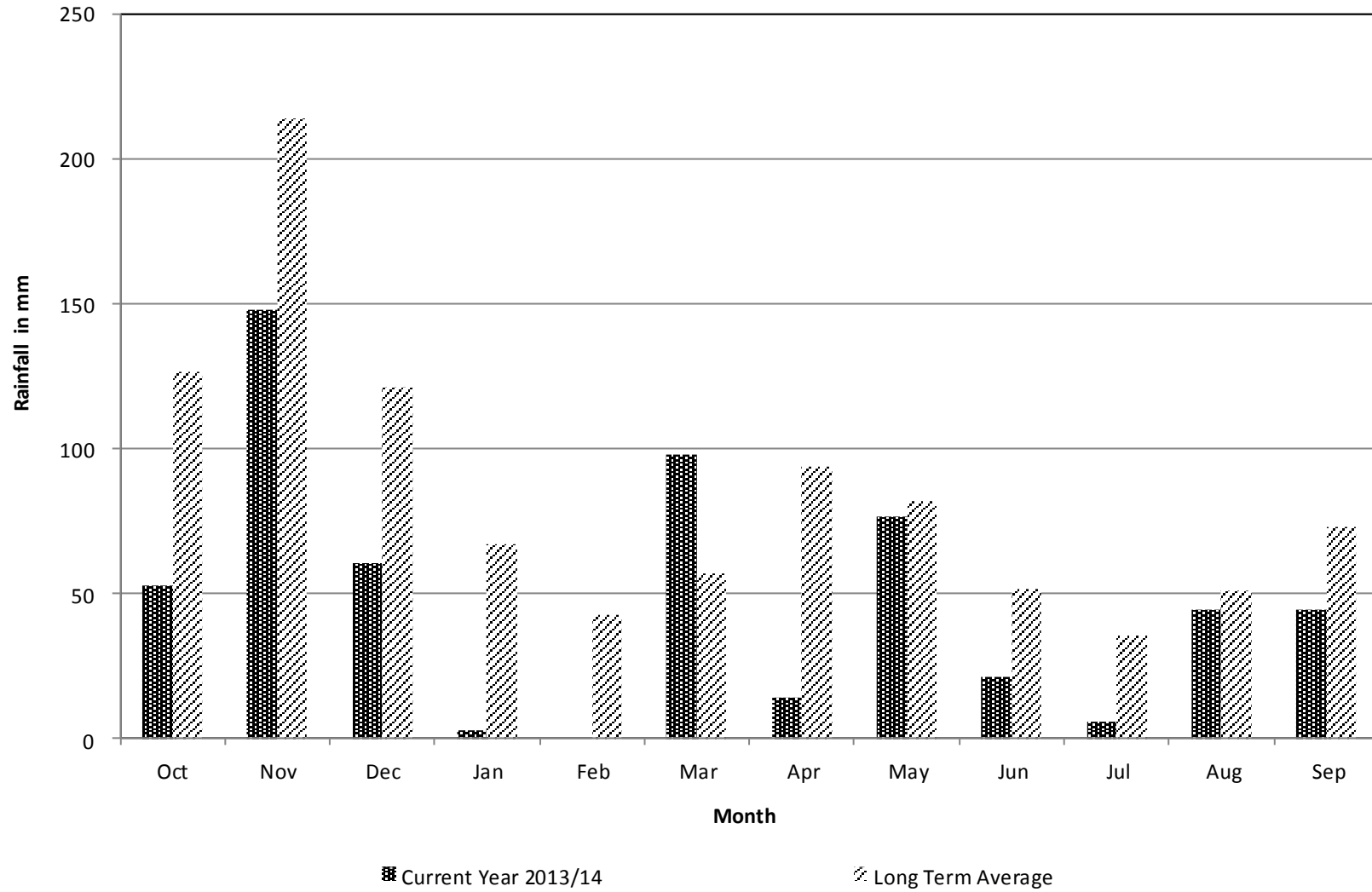
Variation of Rainfall at Colombo



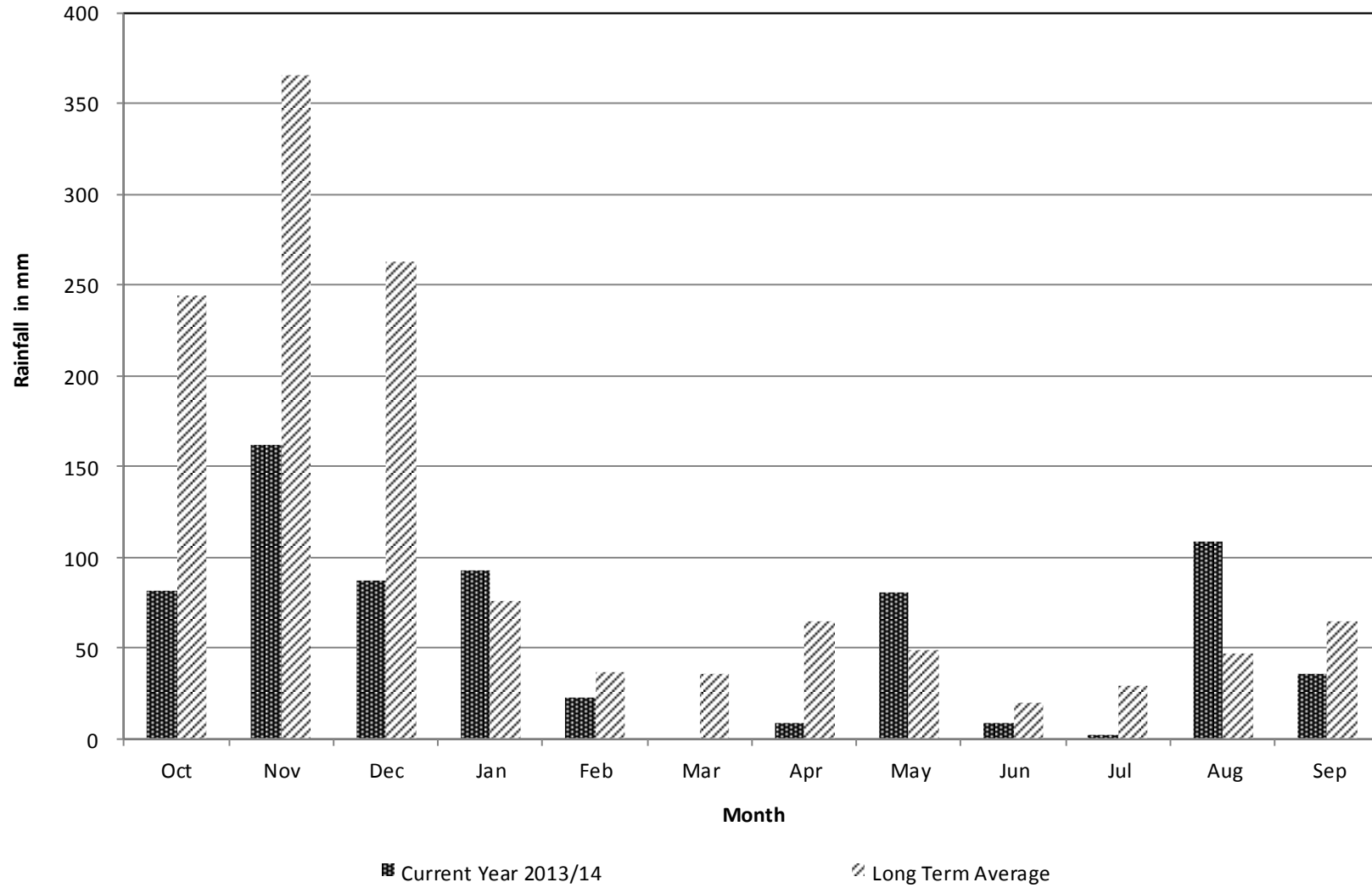
Variation of Rainfall at Galle



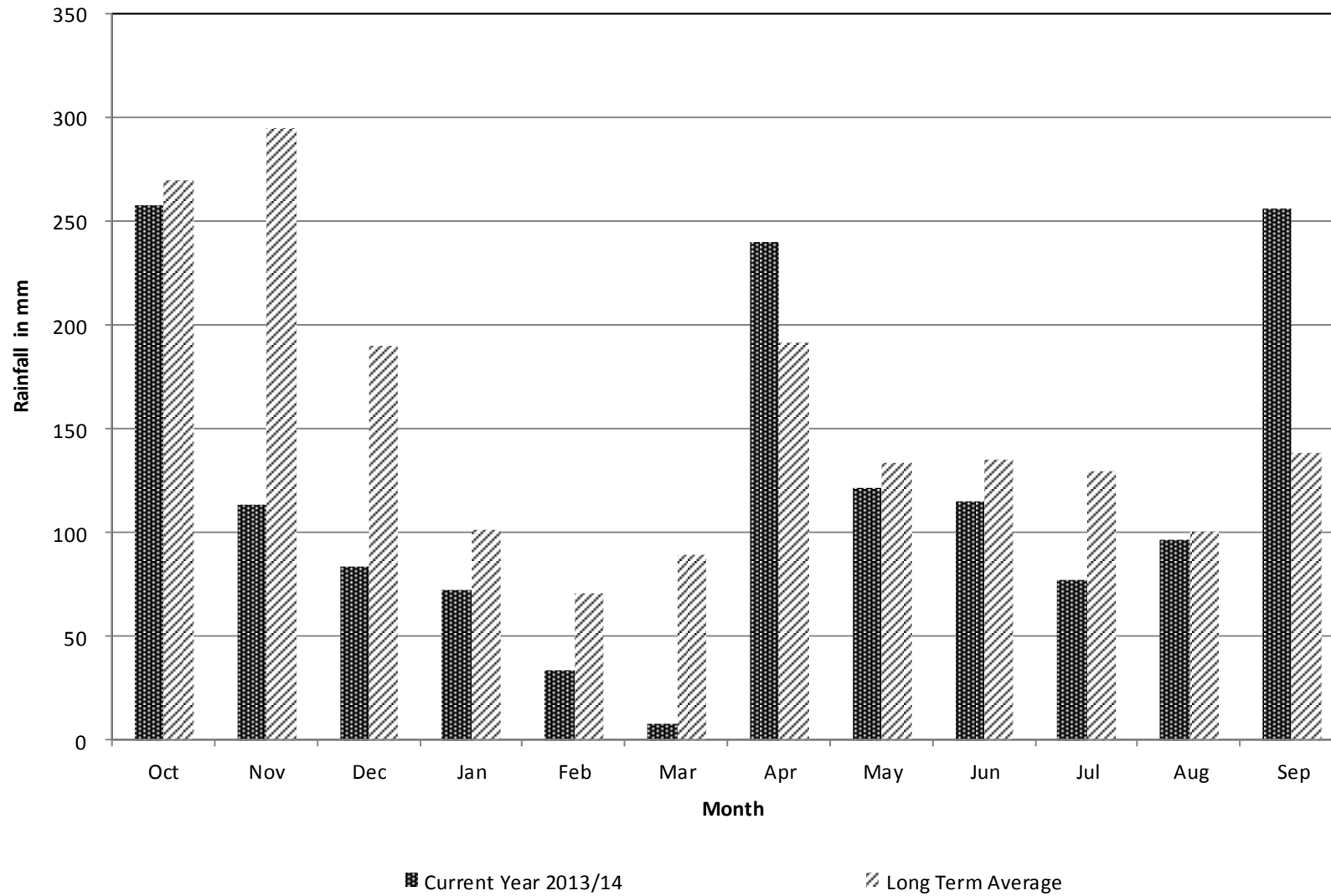
Variation of Rainfall at Hambanthota



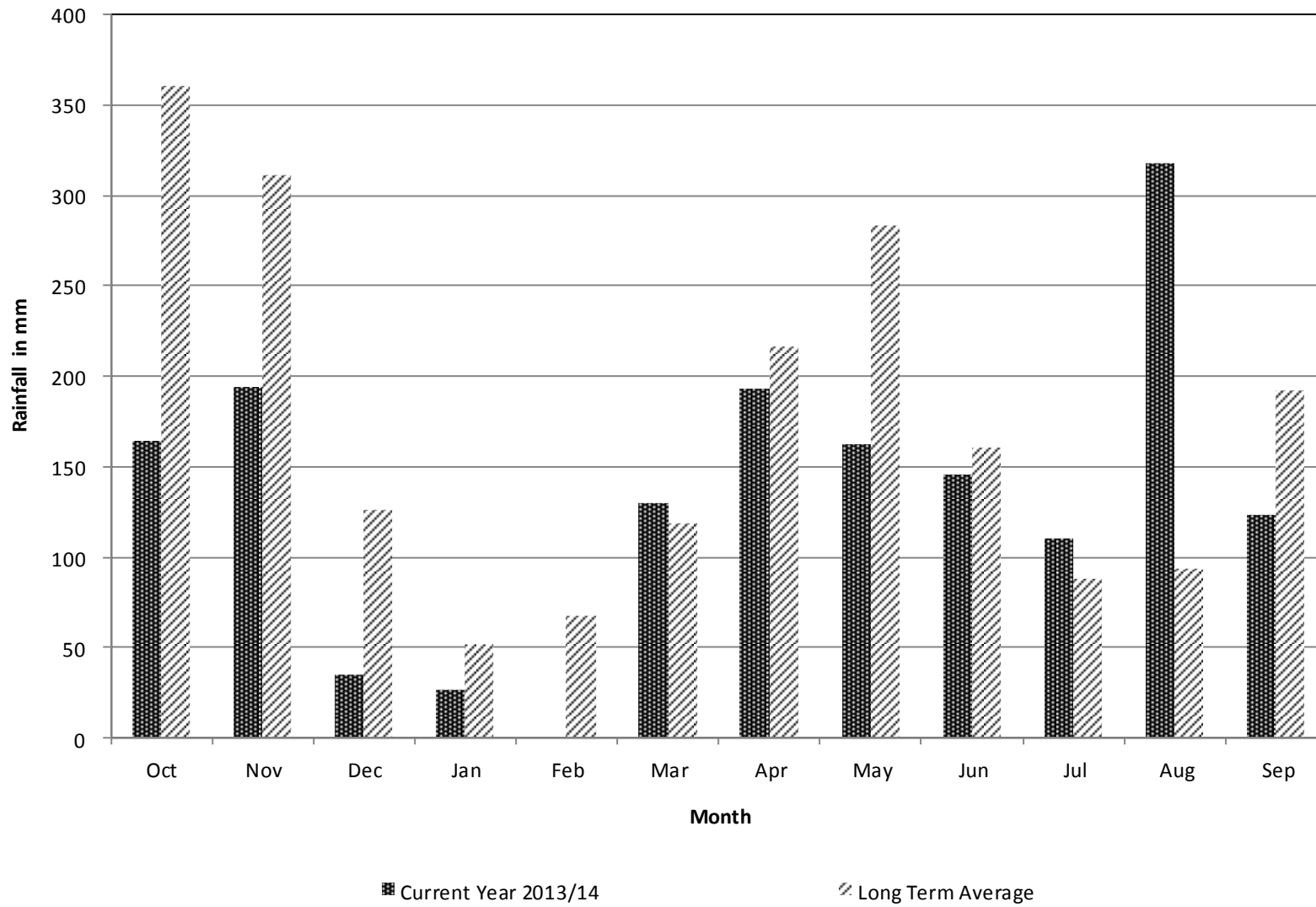
Variation of Rainfall at Jaffna



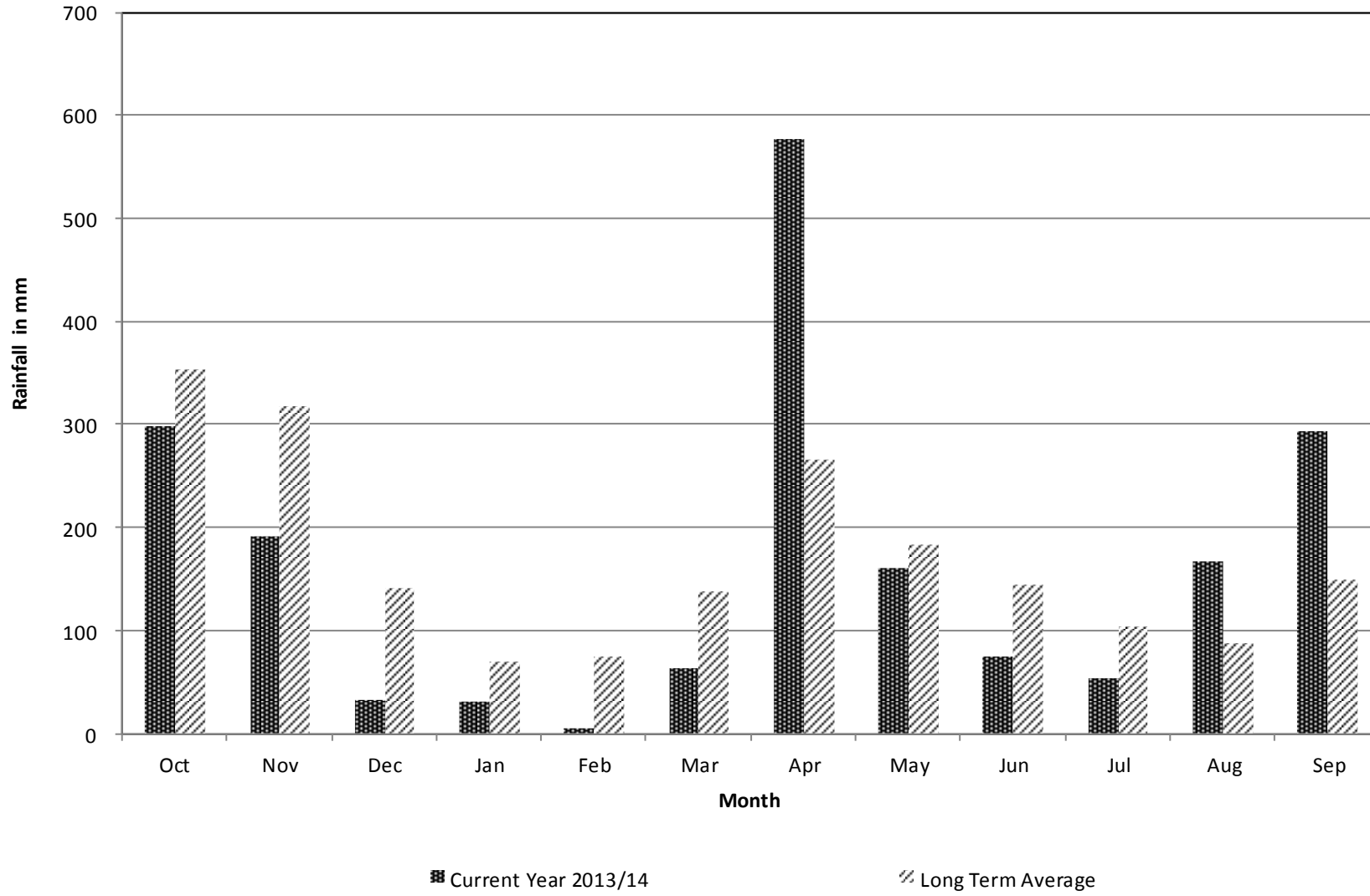
Variation of Rainfall at Katugasthota



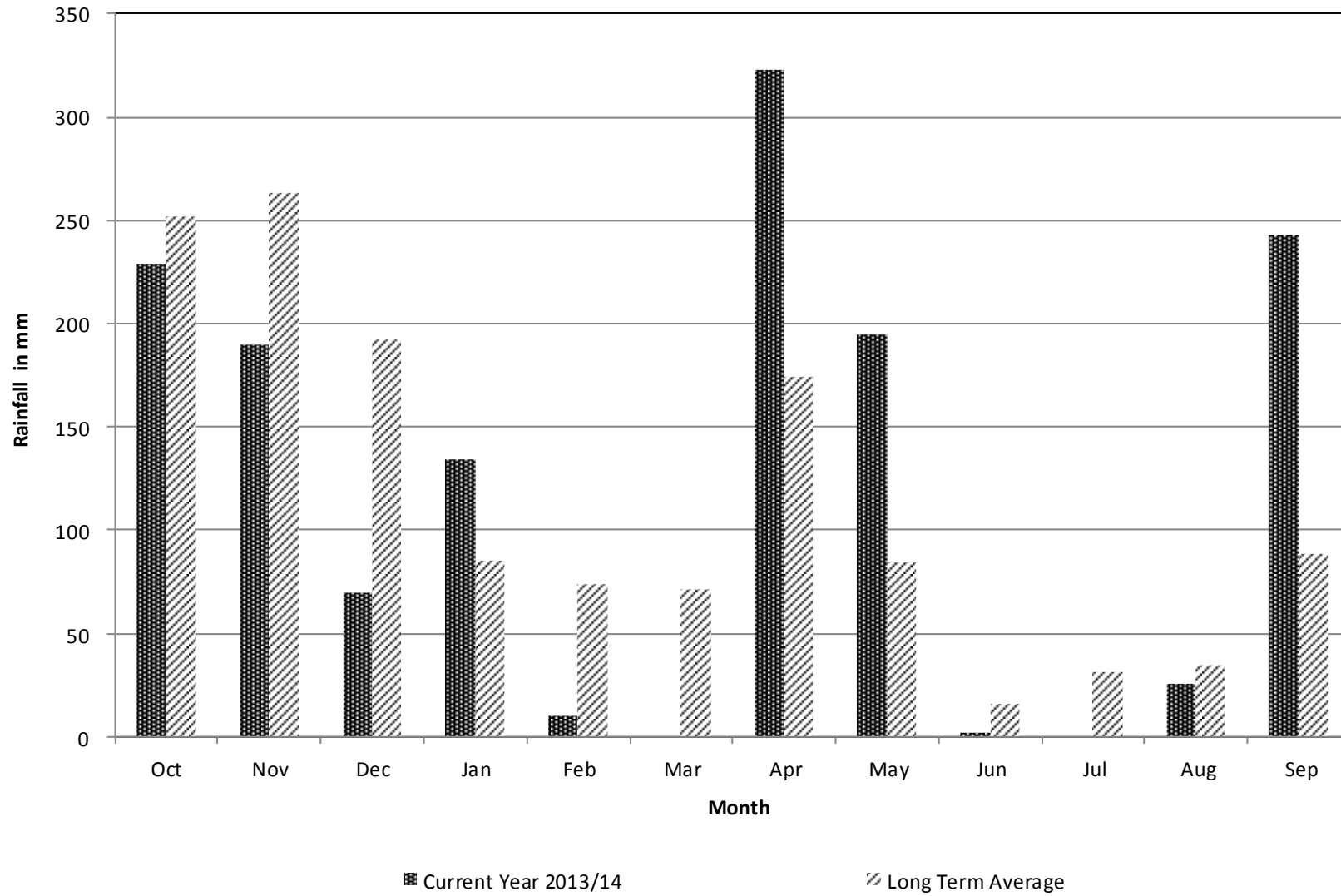
Variation of Rainfall at Katunayaka



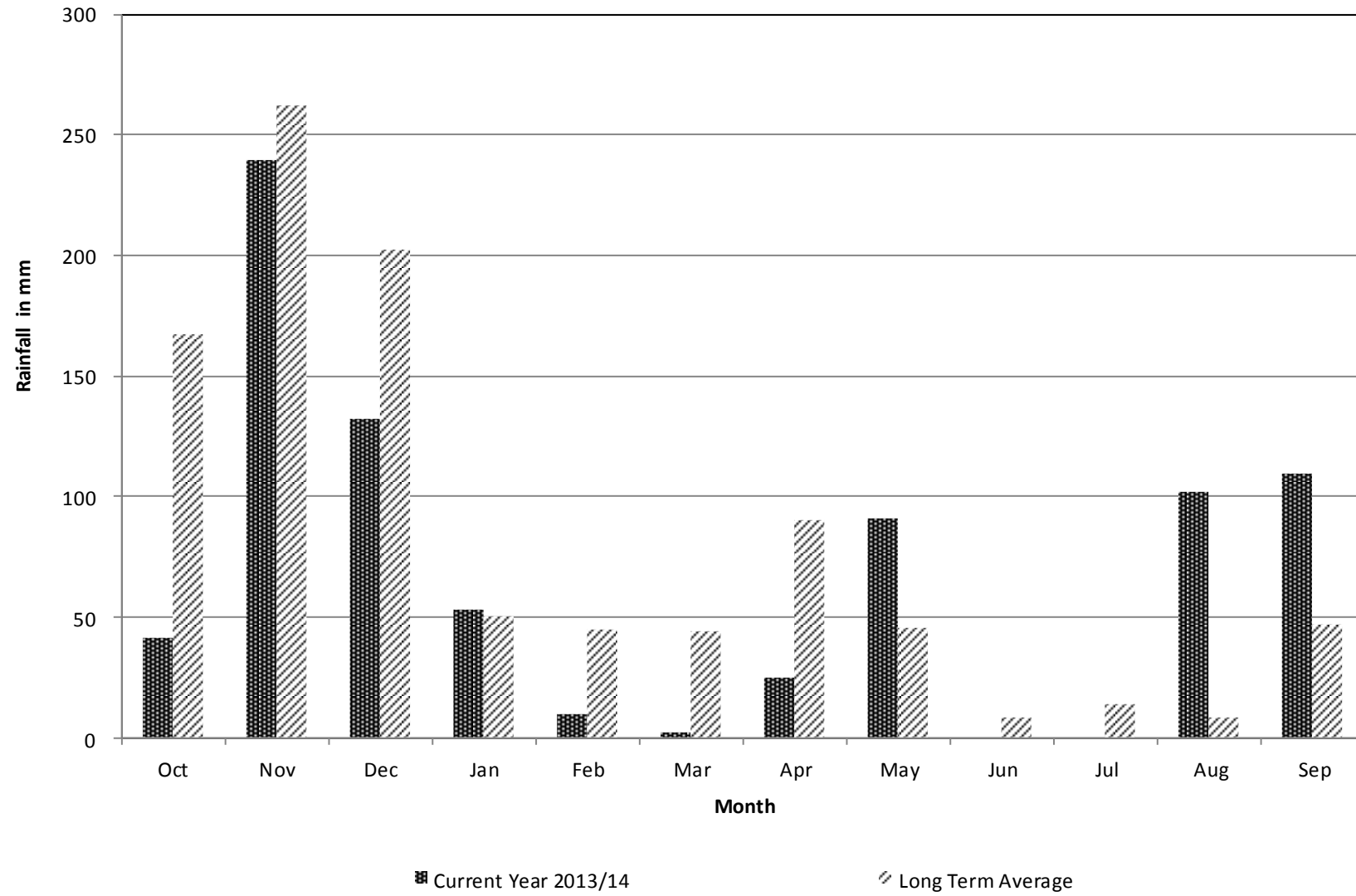
Variation of Rainfall at Kurunegala



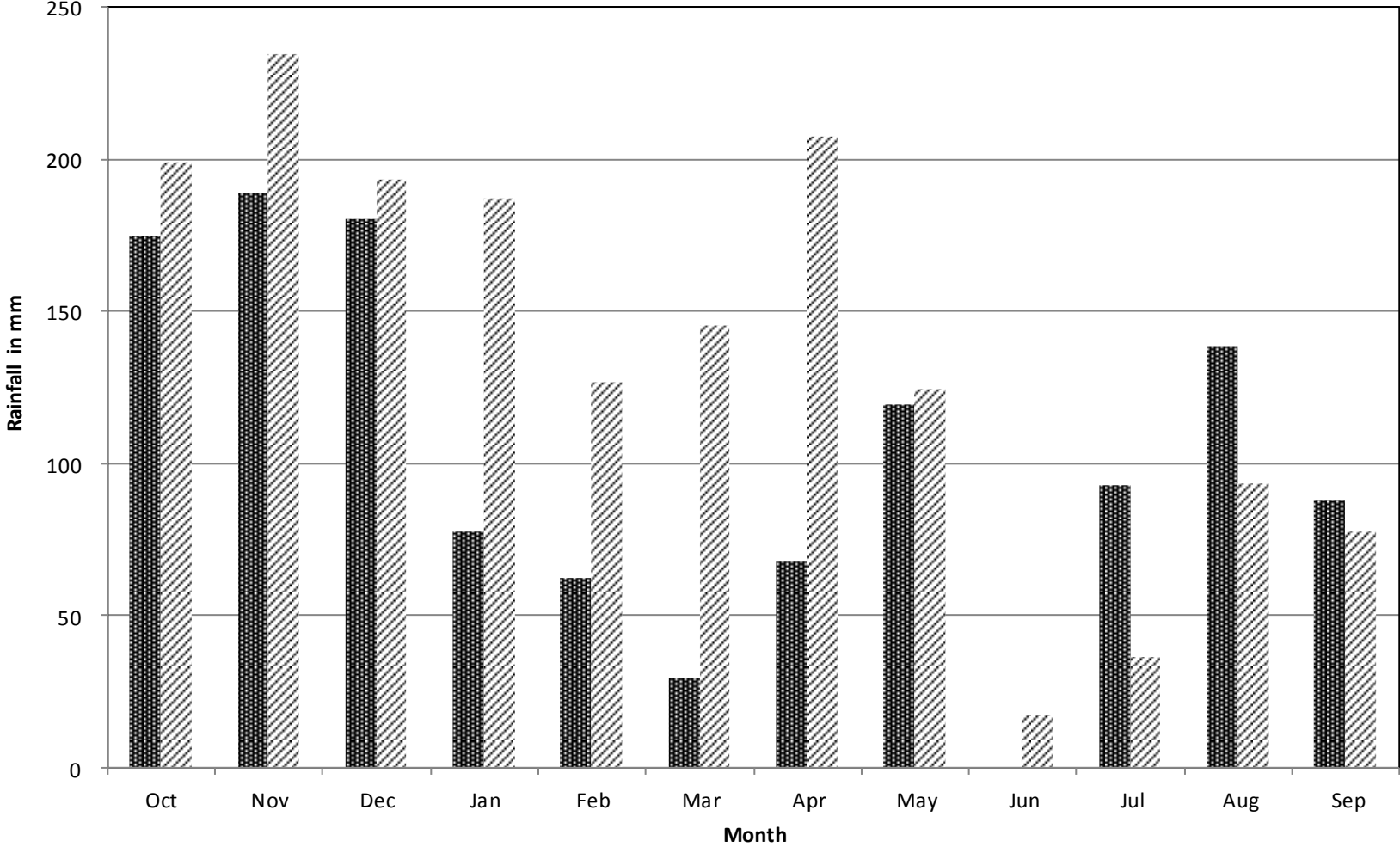
Variation of Rainfall at Mahalluppallama



Variation of Rainfall at Mannar



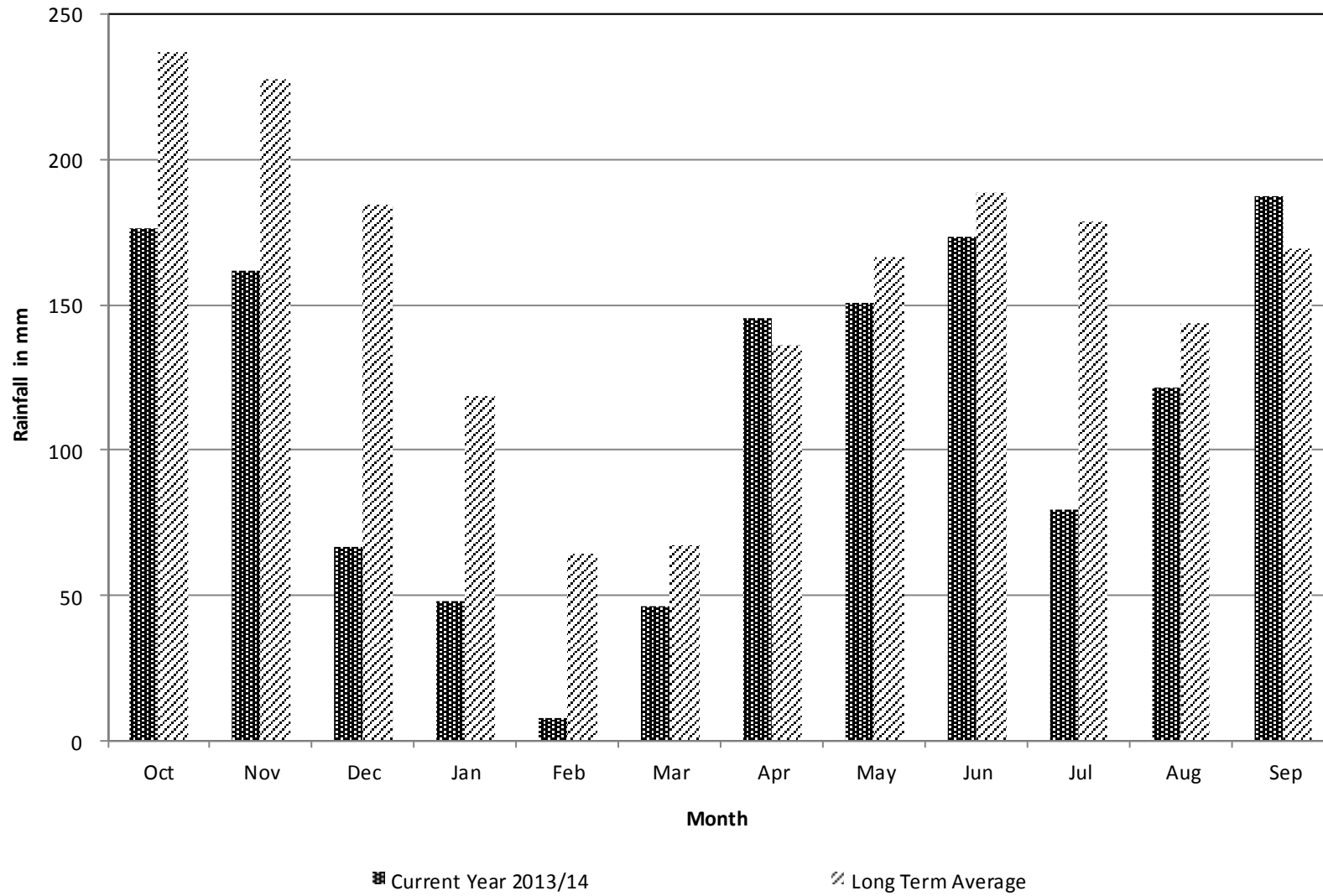
Variation of Rainfall at Monaragala



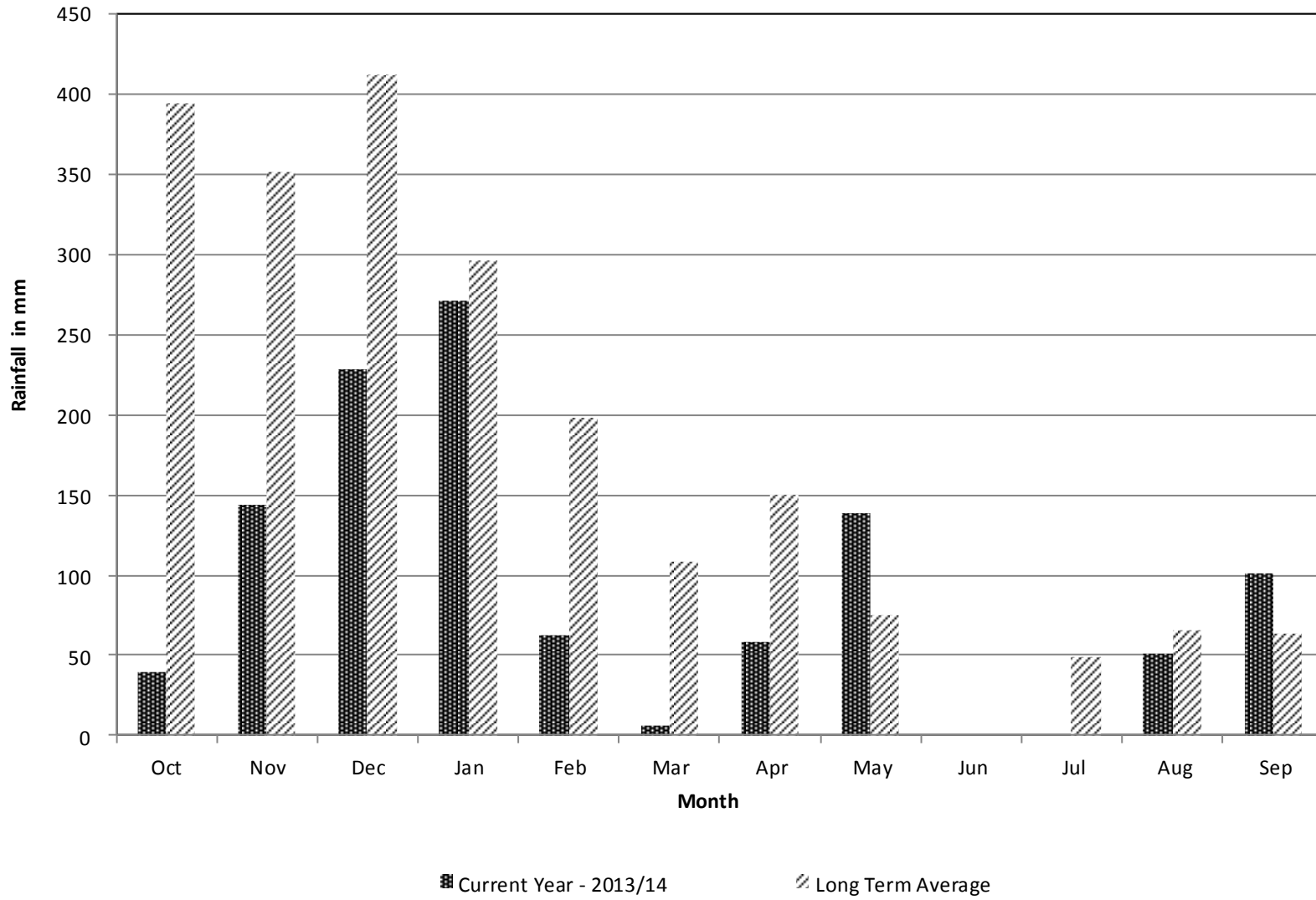
■ Current Year - 2013/14

▨ Long Term Average

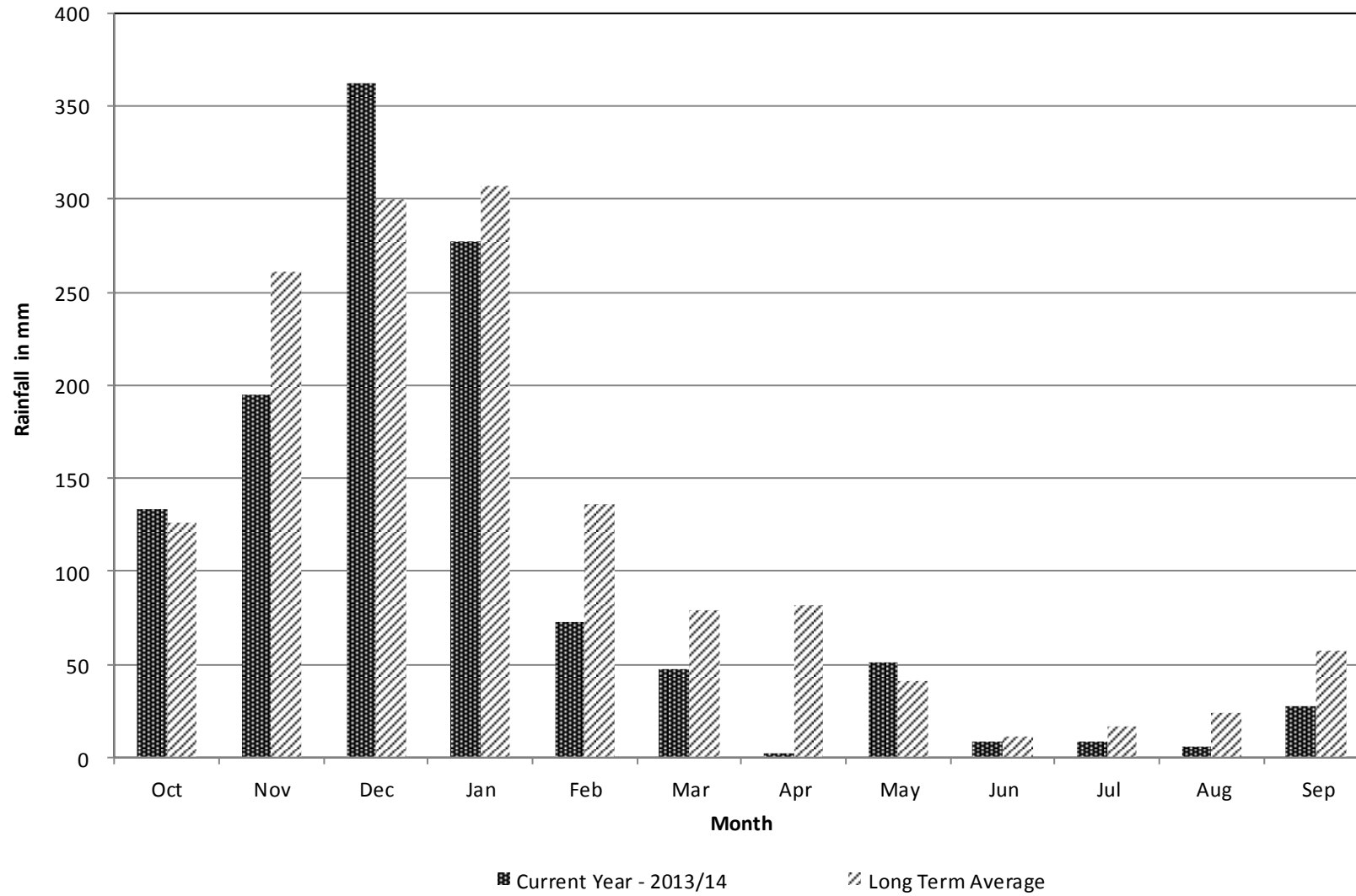
Variation of Rainfall at Nuwara Eliya



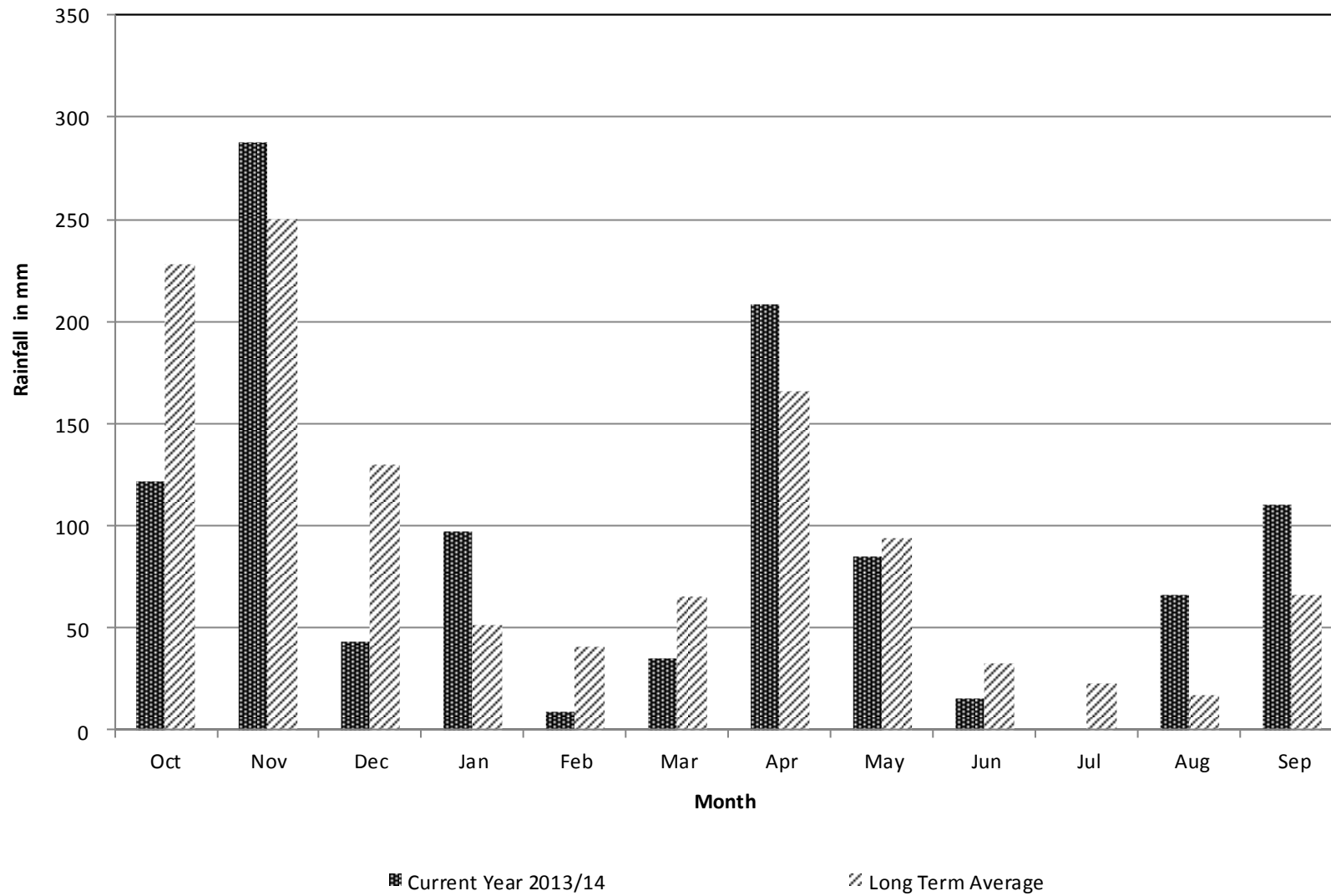
Variation of Rainfall at Polonnaruwa



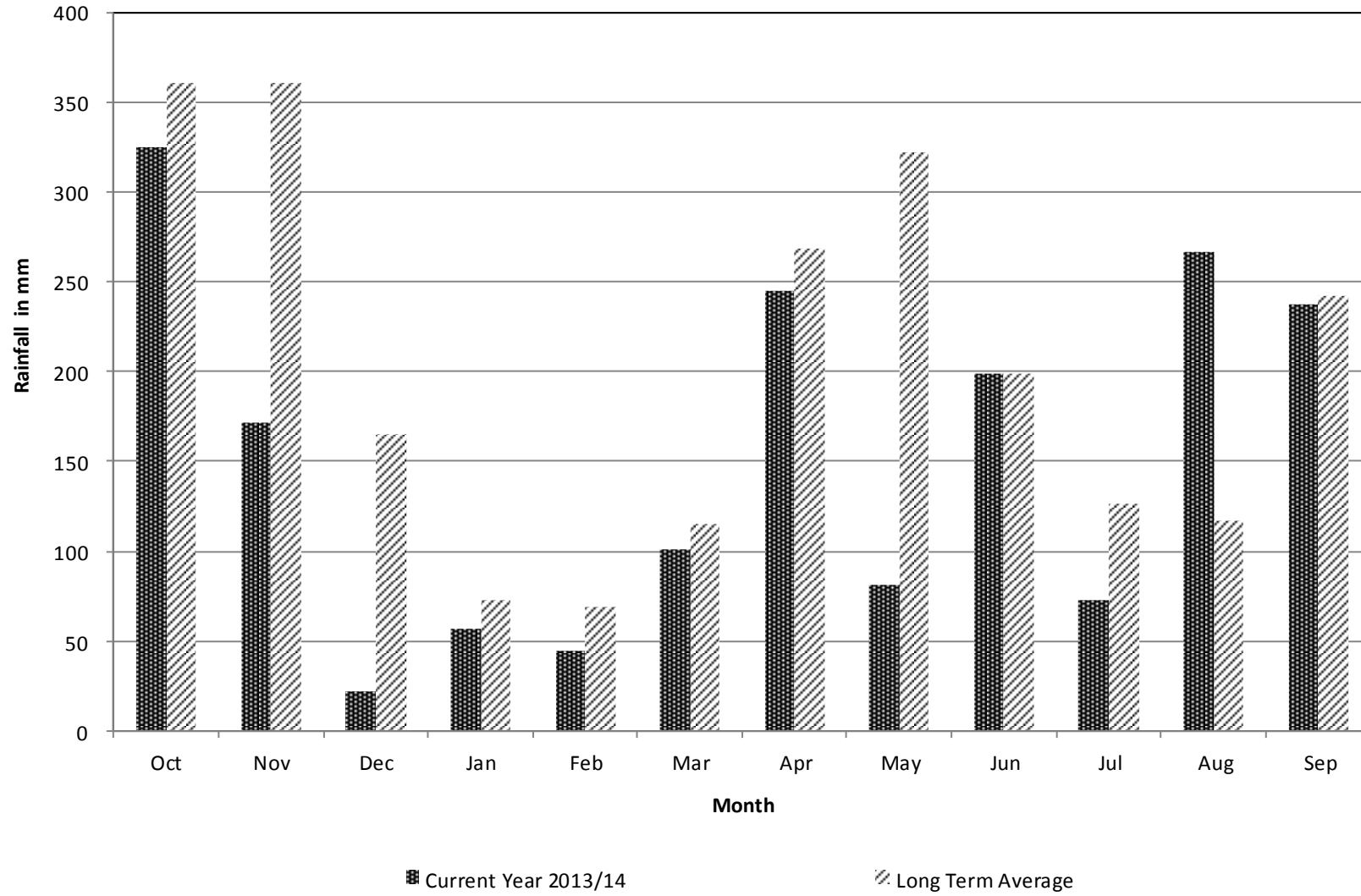
Variation of Rainfall at Potuvil



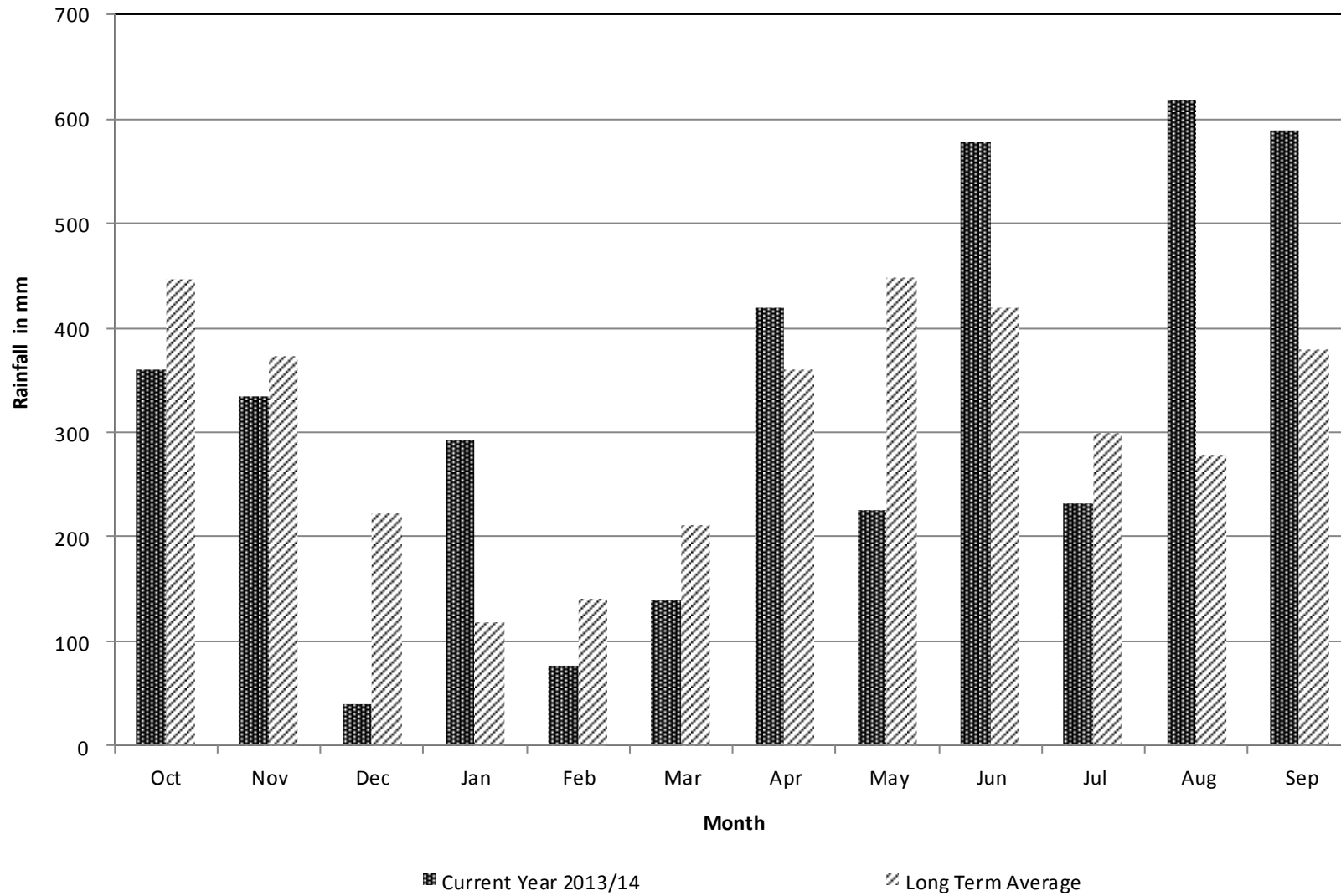
Variation of Rainfall at Puttalam



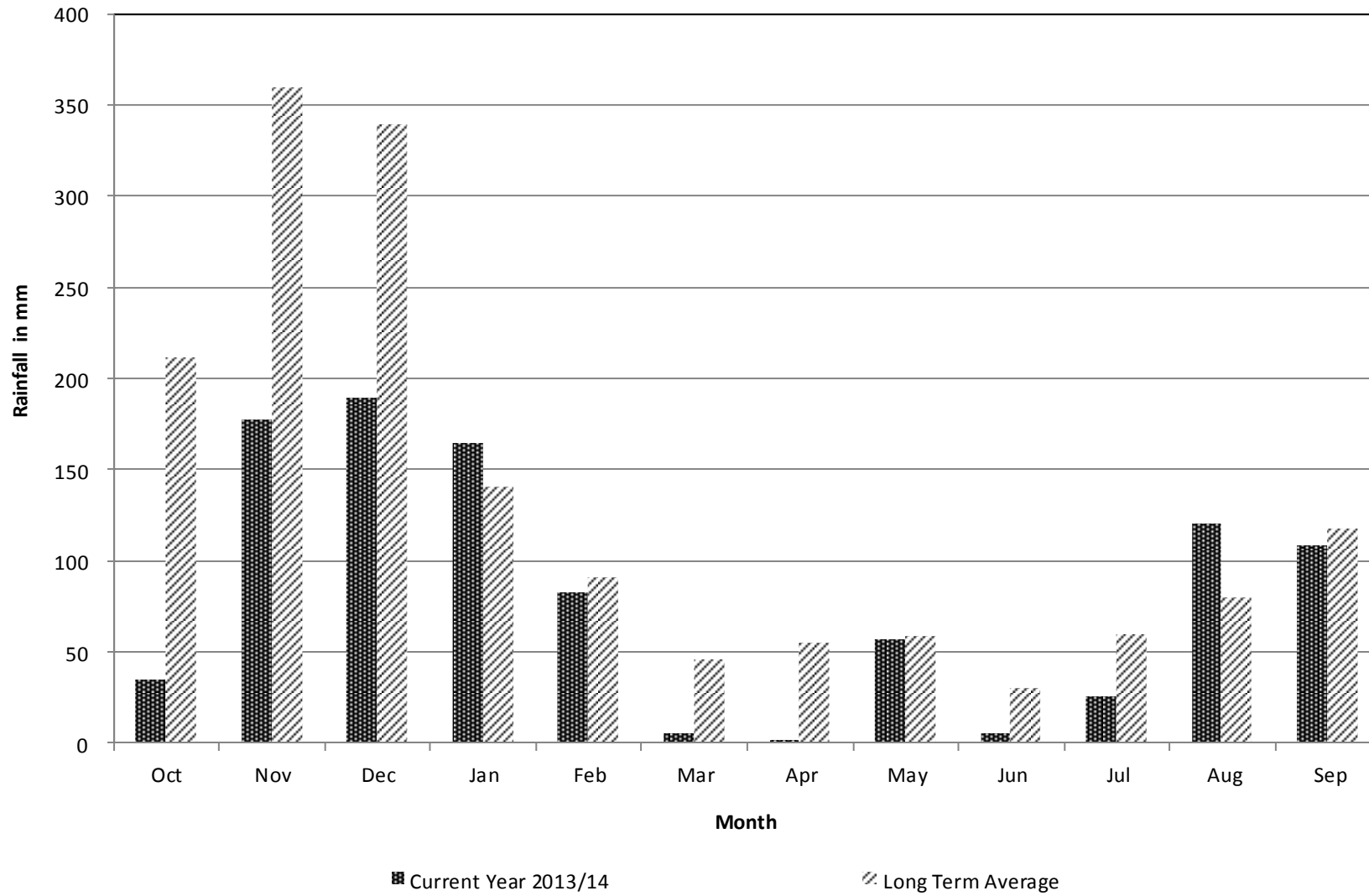
Variation of Rainfall at Ratmalana



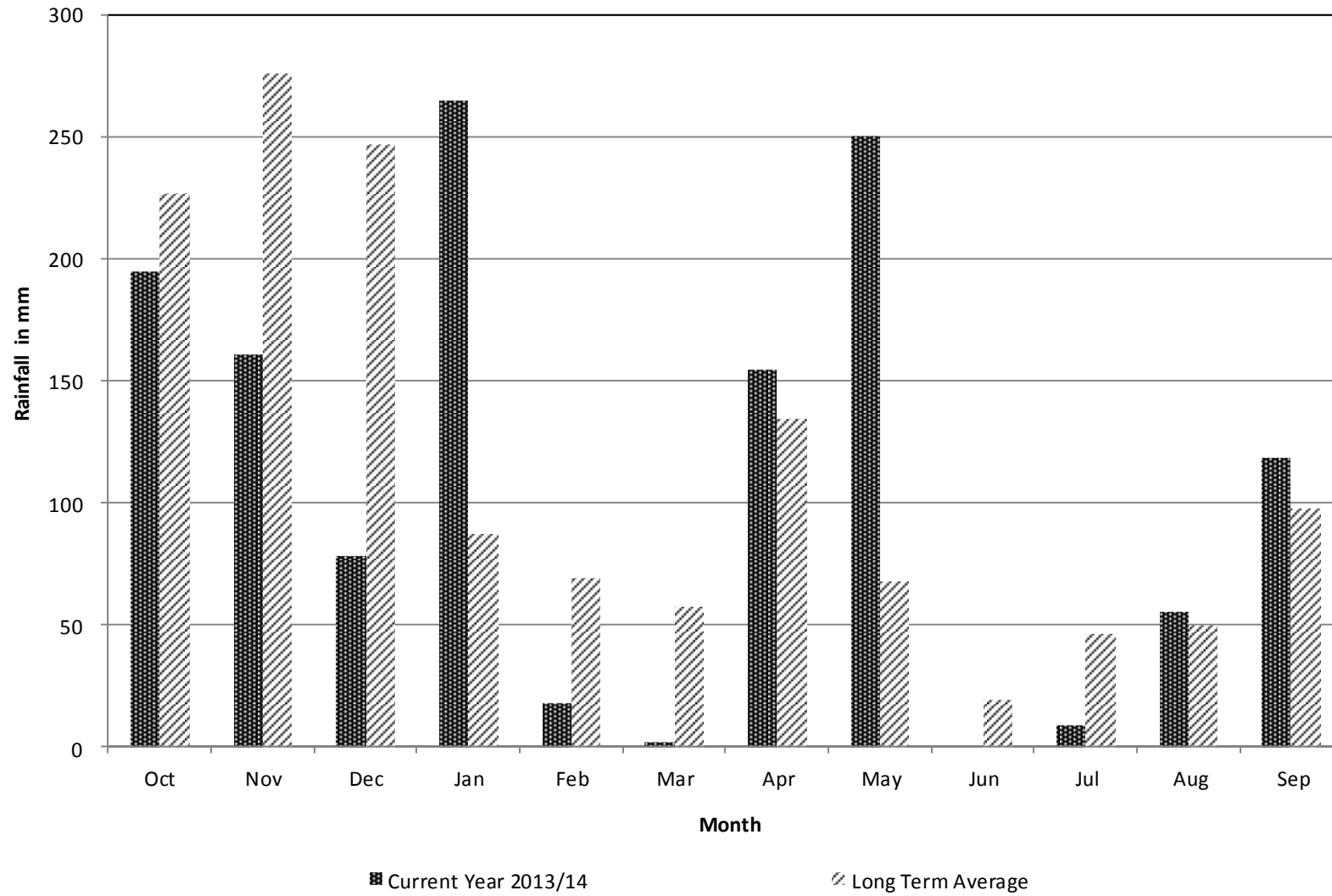
Variation of Rainfall at Ratnapura



Variation of Rainfall at Trincomalee

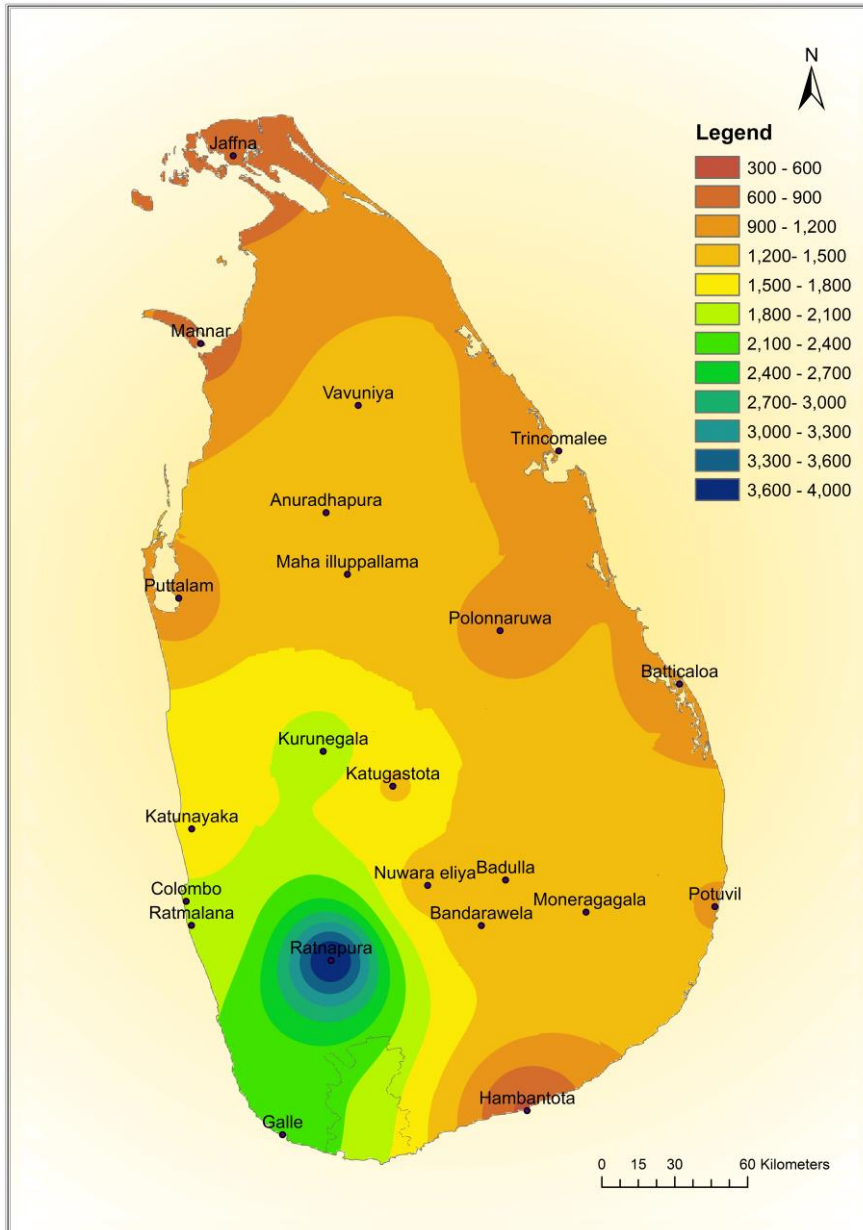


Variation of Rainfall at Vauniya

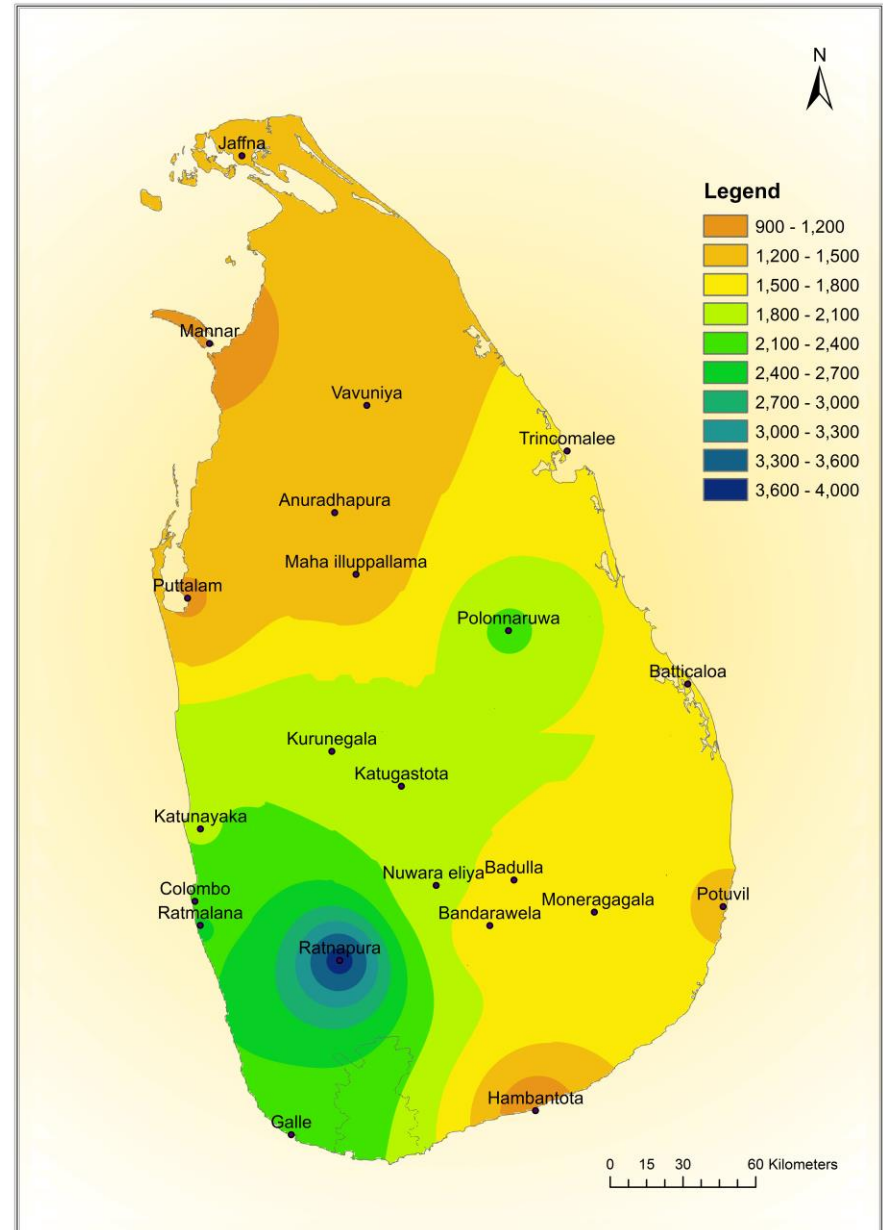


Spatial variation for each month/ average month

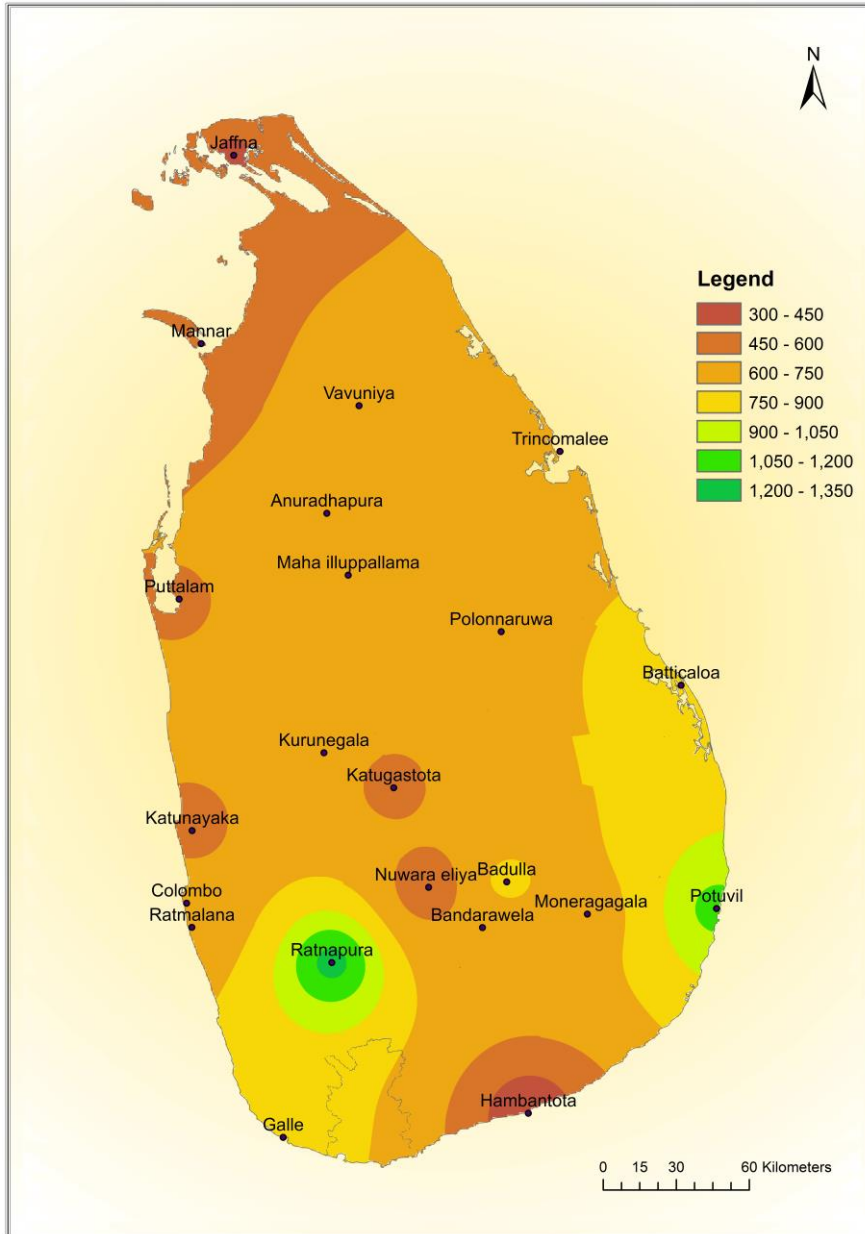
Annual Rainfall Distribution – Current year 2013/14



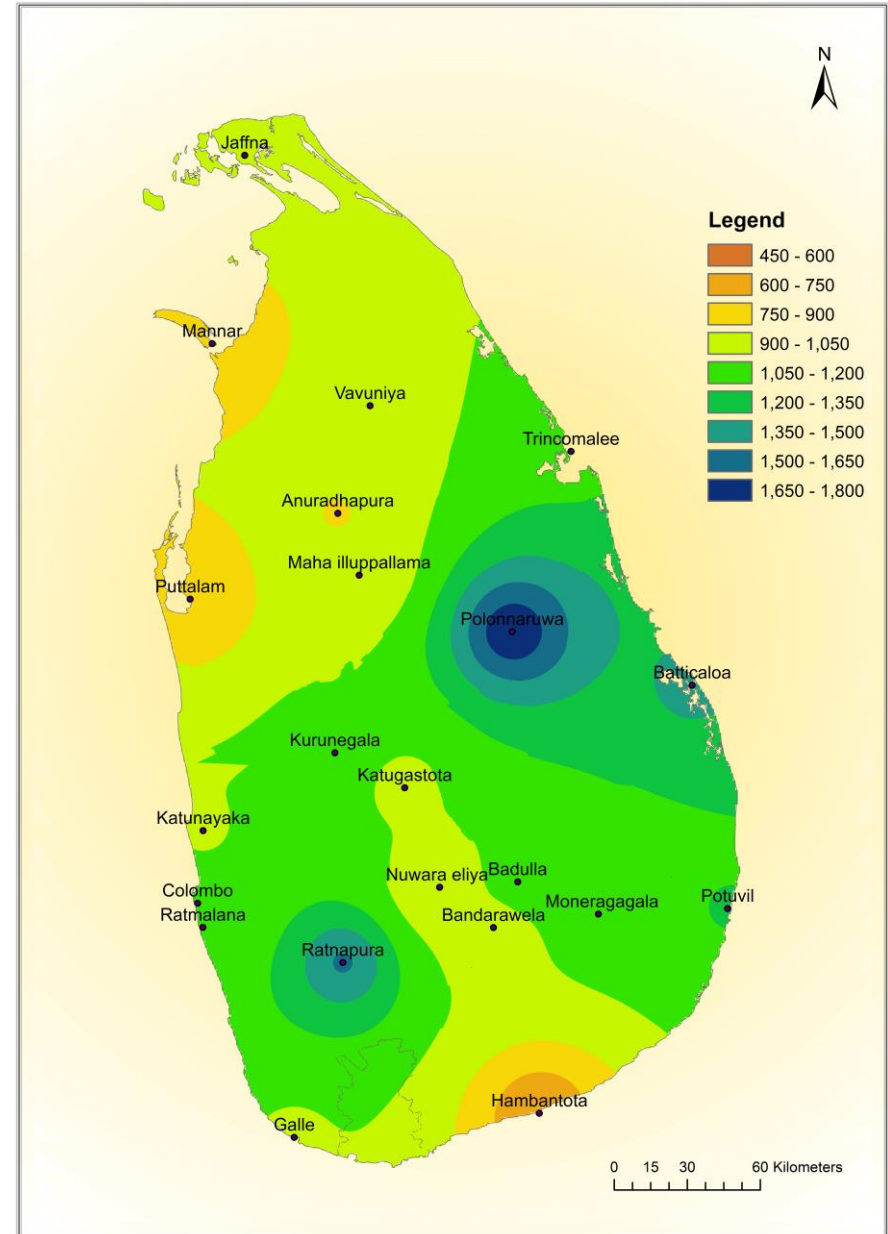
Annual Rainfall Distribution – Long Term Average



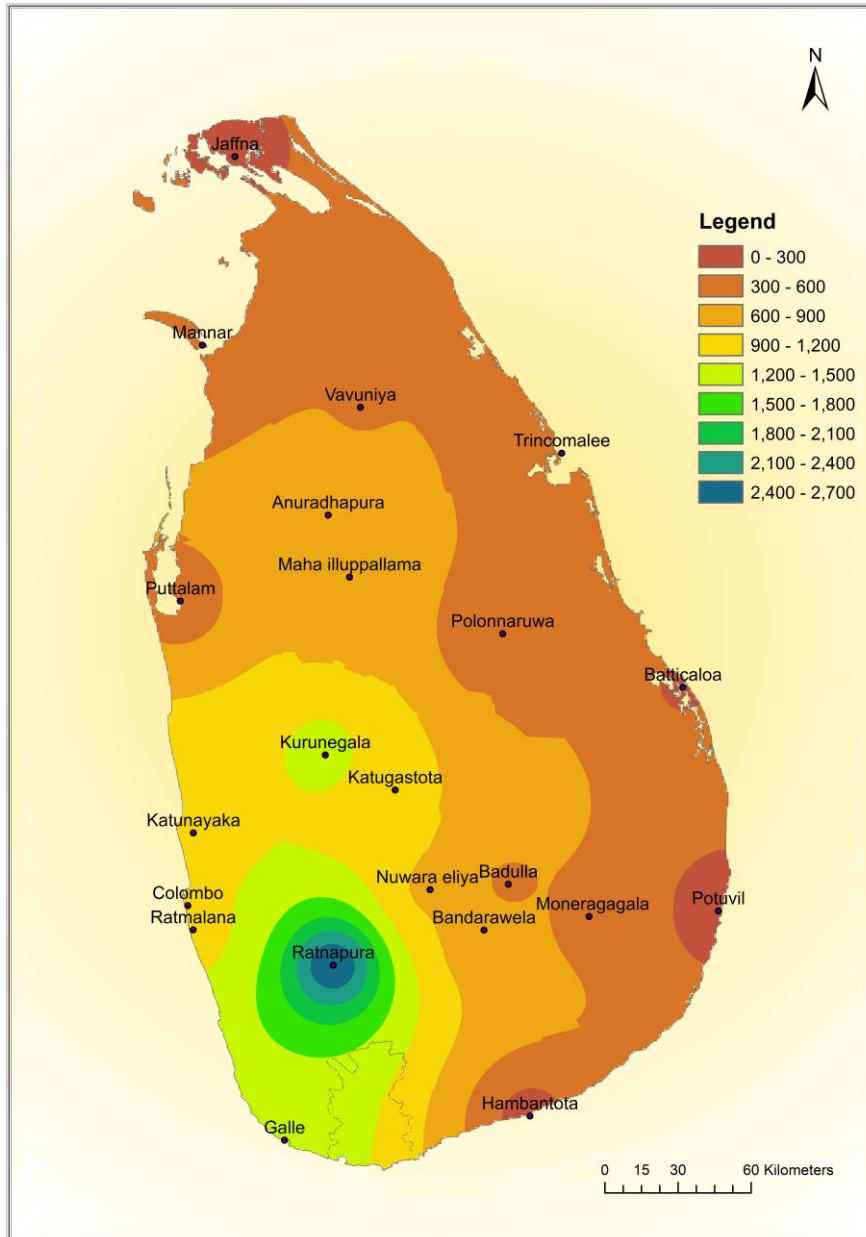
NEM Rainfall Distribution – Current year 2013/14



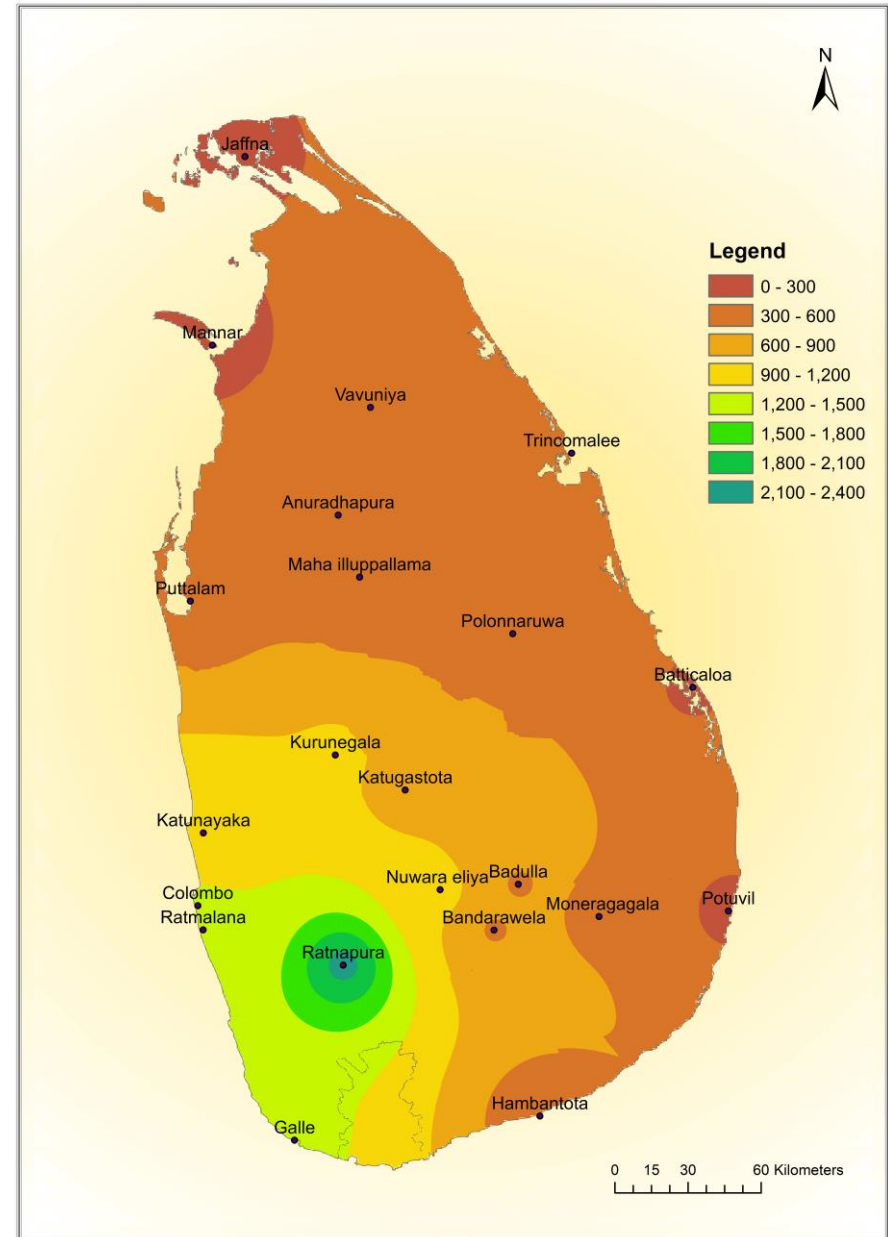
NEM Rainfall Distribution – Long Term Average



SWM Rainfall Distribution – Current year 2013/14



SWM Rainfall Distribution – Long Term Average



RAINFALL INTENSITIES

RAINFALL INTENSITY ANALYSIS
WATER YEAR 2013/14
(MAXIMUM DEPTH OF RAINFALL in mm)

Station	Duration in Hours							
	3	6	12	24	48	72	96	120
Badalgama	123	135	160	161	230	232	234	236
Baddegama	83	95	102	102	126	160	216	217
Calidoniya	50	58	89	96	129	134	138	174
Deraniyagala	125	149	169	169	222	301	321	326
Dolabodakanda	38	71	73	73	131	165	175	202
Dunamale	126	152	152	152	256	258	260	261
Galgamuwa	106	108	108	108	171	181	221	282
Giriulla	152	191	239	250	263	265	265	265
Glencourse	122	146	189	190	280	299	300	300
Hanwella	78	92	138	140	218	255	285	289
Holombuwa	122	132	133	133	160	234	297	297
Horowpathana	61	73	119	124	143	169	174	235
Karandagolla	118	118	118	118	181	183	185	213
Kithulgala	108	136	171	172	209	222	223	269
Kuda Oya	74	74	74	74	83	93	117	146
Laggala - Pallegama	153	181	181	181	181	362	410	414
Nakkala	85	85	85	85	112	133	160	181
Peradeniya	64	69	91	103	123	145	147	147
Pitabeddara	67	71	73	73	121	155	158	186
Putupaula	66	68	68	73	122	175	180	180
Ranugalla	203	216	216	216	244	244	244	244
Siyambalanduwa	99	99	99	99	99	99	99	192
Thaldena	64	91	91	91	91	182	200	212
Thanamalwila	95	97	97	97	133	133	133	133
Thawalama	109	117	122	128	249	335	348	351
Urawa	80	80	80	80	115	149	167	175
Wellawaya	146	146	146	146	175	184	186	186

**EVAPORATION
AND
EVAPOTRANSPIRATION**

MONTHLY PAN EVAPORATION FOR THE WATER YEAR 2013/14

(in mm)

Name of Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total		
													NEM	SWM	Annual
Agalawatta	94.0	89.5	69.8	90.8	101.3	125.8	88.7	78.1	67.3	65.6	71.9	90.5	571.2	462.1	1033.3
Badalgama	82.7	80.4	85.4	92.2	116.9	118.3	94.4	94.6	86.2	94.0	76.8	81.4	575.9	527.3	1103.2
Bandarawela	99.2	89.0	49.9	74.4	100.8	93.6	102.6	73.5	105.3	137.3	103.2	114.0	506.9	635.9	1142.9
Bombuwela	102.3	90.0	87.4	93.9	101.8	120.6	97.2	101.6	97.5	93.6	97.1	99.9	596.0	587.0	1183.0
Colombo	104.2	91.8	105.4	116.6	118.2	129.3	126.9	108.2	106.2	115.0	107.9	106.8	665.4	671.0	1336.3
Dunamale	95.9	89.9	91.2	118.9	124.4	136.7	105.4	78.2	74.9	74.6	75.2	89.4	657.0	497.6	1154.6
Galgamuwa	116.8	76.0	65.0	81.6	112.3	155.6	123.5	115.8	125.1	133.6	136.9	125.0	607.4	760.0	1367.4
Giradurukotte	15.5	86.7	60.1	53.6	88.2	93.3	-1	105.1	140.7	160.0	143.5	145.2	397.4	-1	-1
Horowapathana	166.0	82.0	82.6	69.1	80.9	115.5	128.1	138.3	184.4	194.1	166.1	165.4	596.0	976.4	1572.5
Kurunegala	84.9	69.9	68.5	102.3	124.3	152.2	111.3	100.8	96.9	107.9	97.7	97.5	602.2	612.0	1214.2
Mahailuppallama	122.8	70.8	52.4	62.3	88.2	139.2	113.7	109.4	130.8	150.7	133.0	144.6	535.6	782.2	1317.8
Padiyathalawa	151.5	91.6	56.8	61.0	101.3	122.1	142.8	117.9	182.8	199.8	152.2	166.4	584.2	962.0	1546.2
Palugasdamana	174.3	97.7	79.1	-1	110.7	135.3	157.7	157.5	191.7	209.2	183.2	169.5	-1	1068.8	-1
Puttlam	136.4	75.3	67.9	83.4	113.4	167.7	135.3	128.0	150.9	165.2	158.4	142.5	644.1	880.4	1524.5
Rathnapura	71.0	75.6	69.8	85.6	98.3	107.3	69.3	64.8	74.4	81.3	55.8	66.6	507.4	412.2	919.7
Sevanagala	13.6	103.8	88.0	122.1	141.1	174.3	126.9	120.6	168.6	195.0	158.7	150.9	643.0	920.7	1563.7
Seetha Eliya	-1	-1	-1	-1	-1	-1	-1	-1	-1	87.4	88.4	57.3	-1	-1	-1
Talgahagoda	87.4	85.7	77.7	94.0	119.0	168.0	129.7	103.3	95.6	104.8	88.9	89.9	631.8	612.2	1244.0

Note :- Missing data is denoted by -1

NEM denotes North - East Monsoon, SWM denotes South - West Monsoon

**OPEN WATER EVAPORATION (E_o) & POTENTIAL EVAPOTRANSPIRATION FOR
REFERENCE CROP (E_{To})**

For the Calendar Year : 2014
Weather Station : Agalawatta
Latitude : 15.00 North
Altitude : 65.5 m

Month	Temp. Avg. °C	Humidity Avg. %	Sunshine hrs	Wind Speed km/day	E _o mm	E _{To} mm
Jan	27.21	77.03	4.97	0.46	105	78
Feb	24.69	69.82	7.25	0.50	132	95
Mar	28.17	67.63	5.99	0.46	149	112
Apr	27.33	70.78	5.25	0.44	149	104
May	28.04	78.55	4.01	0.50	141	107
Jun	26.29	83.28	3.76	0.55	133	101
Jul	25.45	74.34	4.97	0.56	142	106
Aug	26.70	82.08	3.89	0.44	132	101
Sep	26.36	76.65	5.14	0.49	138	103
Oct	27.08	83.19	4.01	0.38	113	86
Nov	25.96	81.82	3.13	0.33	91	67
Dec	25.97	78.73	2.98	0.34	82	59
Annual	26.60	76.99	4.61	0.46	1505	1119

**OPEN WATER EVAPORATION (E_o) & POTENTIAL EVAPOTRANSPIRATION FOR
REFERENCE CROP (E_{To})**

For the Calendar Year : 2014
Weather Station : Padiyathalawa
Latitude : 8.00 North
Altitude : 35 m

Month	Temp. Avg. °C	Humidity Avg. %	Sunshine hrs	Wind Speed km/day	E _o mm	E _{To} mm
Jan	21.62	72.23	3.21	0.28	96	70
Feb	19.84	53.18	6.93	0.32	130	89
Mar	23.41	55.32	7.49	0.45	159	116
Apr	24.85	53.73	7.97	0.57	173	127
May	25.74	64.42	6.40	0.46	154	114
Jun	25.54	52.30	7.83	0.91	172	131
Jul	27.71	47.87	7.05	1.22	182	146
Aug	26.23	57.00	7.26	0.85	173	133
Sep	25.17	56.93	7.90	1.14	177	133
Oct	24.45	69.42	6.03	0.38	140	103
Nov	21.64	71.97	2.67	0.25	93	67
Dec	21.83	79.32	2.31	0.22	86	62
Annual	24.00	61.14	6.09	0.59	1735	1292

OPEN WATER EVAPORATION (E_o) & POTENTIAL EVAPOTRANSPIRATION FOR REFERENCE CROP (E_{To})

For the Calendar Year : 2014
Weather Station : Palugasdammana
Latitude : 8.00 North
Altitude : 52 m

Month	Temp. Avg. °C	Humidity Avg. %	Sunshine hrs	Wind Speed km/day	E _o mm	E _{To} mm
Jan	25.62	90.84	3.60	4.90	112	76
Feb	24.86	91.25	6.54	4.69	143	92
Mar	27.47	91.06	6.58	5.62	172	111
Apr	29.13	87.47	7.30	0.83	170	129
May	29.08	84.97	6.72	1.23	167	99
Jun	30.73	71.83	6.94	4.81	241	90
Jul	30.58	67.19	6.66	32.13	572	307
Aug	30.23	72.71	5.95	21.31	405	243
Sep	29.63	73.53	7.30	19.21	377	230
Oct	27.68	84.32	5.37	7.56	187	128
Nov	26.15	90.37	2.54	3.01	104	76
Dec	25.89	91.10	1.58	4.18	95	68
Annual	28.09	83.05	5.59	9.12	2746	1649

STREAM FLOW DATA

STREAM FLOW DATA - WATER YEAR 2013/14

Upper line : Runoff in MCM

Lower line : Rainfall in mm

Name of station & River Basin	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annul Runoff & Annual Rainfall 2013/14	Long-term Average of Annual Runoff & Rainfall up to 2012/13		Peak Flood for 2013/14 & Observed Maximum Flood Peak up to 2012/13		
														value	**	cumecs	Time	Date
1 Badalgama R.B. 102	85.80	125.65	20.86	1.13	0.92	4.32	18.74	71.45	73.53	14.50	65.60	33.74	516.24	1280.60	48	491.04	8:00pm	03.06.2014
	343.5	222.5	46.8	28.4	58.8	83.7	307.8	221.9	319.8	134.7	318.1	291.1	2377.1	2335.0		1982.16	12:00mn	24.09.1971
2 Baddegama R.B. 9	145.57	272.30	149.17	111.22	100.11	103.32	134.32	135.50	302.32	111.34	264.36	181.56	2011.09	2395.12	7	349.11	7:00am	05.06.2014
	344.0	429.7	154.7	121.9	95.6	126.8	287.7	235.0	343.8	132.3	399.5	412.5	3083.5	3470.1		573.43	4:00pm	03.06.2008
3 Calidonia R.B. 60	15.73	14.49	16.04	9.50	6.10	6.72	6.74	9.23	22.84	13.40	19.00	10.54	150.33	214.14	29	178.48	3:00pm	12.06.2014
	111.1	156.1	82.0	83.5	28.1	80.0	192.9	136.0	331.7	152.1	155.6	131.1	1640.0	2066.9		172.28	9:00am	10.01.1986
4 Chilaw R.B. 99	208.28	183.83	168.76	192.33	168.66	204.63	193.72	278.03	184.00	187.50	189.87	188.38	2347.99	2416.98	23	-1	-1	-1
	232.3	192.4	53.0	37.3	5.2	25.2	381.2	150.1	67.8	29.8	168.3	227.3	1569.9	2050.5		1520.00	1:00pm	05.01.1990
5 Demodara R.B. 60	2.09	1.12	0.75	0.79	0.10	0.10	0.63	2.38	0.12	0.00	0.43	0.79	9.30	67.10	22	30.87	5:00pm	30.10.2013
	301.9	183.0	176.8	99.6	27.3	32.0	254.6	255.4	8.4	1.3	52.2	165.0	1557.4	1953.9		-1	-1	-1
6 Deraniyagala R.B. 1	43.54	33.33	16.82	11.15	5.89	7.29	13.45	24.22	91.89	40.79	102.29	60.87	451.53	608.39	57	368.00	8:00pm	12.06.2014
	344.5	466.4	58.2	187.2	71.8	101.2	324.3	297.8	621.7	328.7	658.7	816.0	4276.5	5108.8		2313.00	9:00am	31.05.1985
7 Dunamale R.B. 103	17.58	34.58	10.95	3.01	0.06	4.18	19.53	20.91	23.12	7.40	17.41	18.07	176.80	199.91	8	44.21	3:00am	04.06.2014
	326.6	393.2	64.6	86.0	56.2	238.9	498.4	278.3	340.9	183.3	340.8	329.7	3136.8	3378.7		58.66	11:00pm	31.05.2008
8 Ellagawa R.B. 3	134.25	192.23	193.65	72.07	36.26	41.60	64.69	76.27	599.61	116.78	303.27	136.61	1967.29	3404.21	56	1215.00	12:00mn	04.06.2014
	363.2	365.3	111.3	199.5	65.7	111.8	339.5	274.9	471.6	207.3	425.3	357.5	3292.7	3738.7		2620.00	4:00am	19.05.2003
9 Galgamuwa R.B.95	0.77	1.15	0.93	0.97	0.49	0.46	4.50	24.70	1.56	1.77	2.32	1.49	41.11	45.16	21	92.26	10:00pm	04.05.2014
	150.6	217.2	40.8	120.2	14.1	18.6	368.3	215.2	9.0	0.4	113.6	256.6	1524.6	1229.8		159.25	1:00pm	19.11.2006
10 Glencourse R.B. 1	240.59	270.04	134.15	76.39	49.26	55.21	99.33	141.67	330.08	200.35	423.12	281.03	2301.22	3953.94	65	898.50	6:00pm	03.06.2014
	359.4	321.7	43.2	100.5	70.5	100.4	321.4	212.4	527.7	250.7	504.8	458.8	3271.5	3620.9		3500.00	10:00am	04.06.1989

Note :- Missing data is denoted by -1 , ** Denotes period of records

STREAM FLOW DATA - WATER YEAR 2013/14

Upper line : Runoff in MCM
Lower line : Rainfall in mm

Name of station & River Basin	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annul Runoff & Annual Rainfall 2013/14	Long-term Average of Annual Runoff & Rainfall up to 2012/13		Peak Flood for 2013/14 & Observed Maximum Flood Peak up to 2012/13		
														value	**	cumecs	Time	Date
11 Hanwella R.B. 1	188.96	278.17	68.01	50.62	43.22	44.42	73.24	99.47	421.89	128.40	515.16	254.88	2166.44	4217.07	38	1117.40	7:00pm	03.06.2014
	358.7	335.8	44.8	97.7	62.4	105.6	327.5	208.1	525.8	236.7	469.9	435.7	3208.7	3722.1		2745.58	8:00am	05.06.1989
12 Holombuwa R.B. 1	10.20	13.73	3.91	1.27	0.90	0.99	3.57	8.30	12.61	4.69	19.92	16.27	96.36	263.91	49	131.98	9:00am	09.08.2014
	334.5	395.0	15.4	69.0	119.8	84.8	299.8	206.3	327.0	174.4	432.8	440.9	2899.7	3063.7		644.47	7:00am	03.06.1989
13 Kataragama R.B. 26	10.49	13.48	12.27	10.81	8.20	8.83	9.53	9.63	9.90	9.32	9.74	9.28	121.47	220.03	68	220.79	7:00am	25.11.2013
	121.5	290.5	91.9	67.3	15.4	28.6	76.5	84.6	1.5	1.2	29.8	34.1	842.9	1554.5		1365.00	1:00pm	25.12.1957
14 Kitulagala R.B. 1	111.10	91.85	67.64	42.58	27.91	17.65	15.29	17.84	84.96	92.45	148.45	101.01	818.73	1160.85	65	790.68	7:00pm	12.06.2014
	291.1	158.3	74.0	115.4	30.4	65.9	343.9	108.8	667.1	327.6	418.6	292.0	2893.1	3467.2		2157.00	5:15pm	30.05.1989
15 Laggala-Pallegama R.B. 60	4.12	16.02	45.93	33.58	12.37	11.58	7.17	21.63	5.02	2.85	2.83	5.13	168.23	208.25	24	155.23	5:00pm	03.05.2014
	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		1797.02	12:00mn	17.12.2012
16 Millakanda R.B. 3	96.88	176.48	84.87	58.22	37.91	45.81	77.40	111.49	461.72	80.54	220.24	124.06	1575.62	2160.54	23	869.92	9:00am	04.06.2014
	382.1	470.3	252.2	208.2	113.0	163.2	437.5	369.1	562.0	258.4	495.3	404.3	4115.7	4251.8		1320.45	12:00mn	01.06.2008
17 Nawalapitiya R.B. 60	40.06	21.56	13.20	10.41	5.58	5.23	8.79	11.52	73.87	55.62	81.18	43.45	370.47	492.29	25	687.27	7:00pm	12.06.2013
	414.7	225.5	68.3	127.6	33.5	96.4	279.3	137.8	764.8	560.2	480.7	379.1	3567.9	3691.7		360.20	4:00am	28.06.1993
18 Norwood R.B. 1	7.24	9.24	11.95	5.78	2.30	1.85	8.38	9.49	17.58	8.11	10.06	5.68	97.66	134.24	28	86.00	12:00nn	12.06.2014
	167.8	173.5	100.1	122.7	35.9	51.9	317.9	108.3	326.3	140.9	157.6	141.8	1844.7	2627.0		180.98	6:00pm	13.05.2013
19 Padiyatalawa R.B. 54	0.28	1.19	8.64	8.57	3.52	2.03	1.23	3.14	0.21	0.00	0.23	0.10	29.14	149.76	29	51.73	7:00pm	16.01.2014
	221.5	261.7	193.7	146.8	105.3	70.9	26.3	222.7	0.7	0.0	169.0	144.6	1562.9	2116.6		784.16	10:00pm	02.02.2011

Note :-Missing data is denoted by -1, ** Denotes period of records

STREAM FLOW DATA - WATER YEAR 2013/14

Upper line : Runoff in MCM

Lower line : Rainfall in mm

Name of station & River Basin	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annul Runoff & Annual Rainfall 2013/14	Long-term Average of Annual Runoff & Rainfall up to 2012/13		Peak Flood for 2013/14 & Observed Maximum Flood Peak up to 2012/13		
														value	**	cumecs	Time	Date
20 Peradeniya R.B. 60	185.94	151.74	106.88	79.62	53.29	45.92	37.19	48.54	160.97	201.44	286.65	137.69	1495.87	1806.21	65	567.45	12:00am	12.06.2014
	338.7	230.0	140.8	109.3	37.8	53.5	256.1	129.4	421.6	323.4	304.9	278.9	2624.4	2933.2		5097.71	2:30am	15.08.1947
21 Pitabeddara R.B. 12	43.03	111.25	88.76	60.67	25.41	22.51	27.22	27.86	70.87	31.79	42.08	34.53	585.97	509.19	40	570.25	1:00pm	03.06.2014
	264.0	464.4	203.1	168.0	97.6	90.9	171.6	228.9	251.5	117.8	198.6	203.6	2460.1	3073.0		2187.46	12:00nn	31.05.2008
22 Putupaula R.B. 3	252.53	395.04	228.02	198.71	147.89	183.18	204.45	219.38	749.94	182.23	435.91	231.66	3428.94	6173.26	69	1009.11	12:00nn	05.06.2014
	372.4	386.7	154.2	184.3	80.9	129.3	373.4	333.6	543.0	223.0	455.2	376.0	3612.0	3179.8		2829.00	9:30am	16.08.1947
23 Ratnapura R.B. 3	66.08	103.46	51.03	45.44	16.70	23.93	35.11	36.34	229.71	57.40	109.23	59.17	833.60	1073.56	7	557.15	6:00pm	04.06.2014
	362.7	409.3	123.9	199.8	67.5	107.2	299.2	205.6	431.2	195.8	365.3	358.8	3126.3	3103.9		814.10	12:00nn	31.05.1989
24 Siyambalanduwa R.B. 36	1.42	2.46	6.73	0.79	0.02	0.00	0.00	4.04	0.42	0.08	0.37	0.00	16.33	140.93	22	92.88	1:00am	01.05.2014
	169.4	159.6	201.9	104.1	58.8	39.6	58.5	124.5	8.7	92.2	127.0	157.8	1301.8	1727.4		889.27	4:00pm	12.01.2007
25 Thanamalwila R.B. 22	5.86	44.88	31.26	20.90	5.77	4.44	12.52	15.59	0.66	0.02	0.19	1.82	143.90	257.67	26	172.73	9:00pm	26.11.2013
	192.7	282.3	116.0	156.1	17.8	31.3	250.2	116.2	4.9	0.6	12.9	119.2	1300.2	1603.0		824.70	3:00am	24.11.2012
26 Thawalama R.B. 9	59.97	120.26	88.44	57.55	25.70	34.31	59.67	62.61	148.33	53.30	104.79	94.03	908.96	1091.09	40	466.92	7:00pm	03.06.2014
	310.0	474.2	278.7	228.2	98.7	181.8	367.6	316.7	469.5	155.5	355.6	451.1	3687.6	3927.8		1066.40	1:00pm	10.10.1976
27 Wellawaya R.B. 22	6.73	12.27	7.19	4.50	0.98	0.83	5.02	14.08	1.43	0.05	1.19	1.89	56.17	113.09	25	200.59	8:00pm	30.10.2013
	213.4	248.5	110.7	191.6	22.7	32.9	371.8	186.6	3.7	0.7	29.4	198.2	1610.1	2060.5		634.50	8:00pm	21.10.2012

Note :- ** Denotes period of records

RUNOFF RAINFALL RATIOS

RUNOFF RAINFALL RATIOS - 2013/14

Name of River Basin	Station	Annual Rainfall (mm)	Annual Runoff (mm)	Runoff / Rainfall Ratio %
Kelani Ganga	Norwood	1845	1007	55
Kelani Ganga	Kithulgala	2893	2138	74
Kelani Ganga	Deraniyagala	4277	2467	58
Kelani Ganga	Holombuwa	2900	622	21
Kelani Ganga	Glencourse	3272	1573	48
Kelani Ganga	Hanwella	3209	1216	38
Kalu Ganga	Ratnapura	3126	1382	44
Kalu Ganga	Ellagawa	3293	1412	43
Kalu Ganga	Millakanda	4116	2019	49
Kalu Ganga	Putupaula	3612	1318	37
Gin Ganga	Thawalama	3688	2411	65
Nilwala Ganga	Pitabeddara	2460	1554	63
Kirindi Oya	Wellawaya	1610	327	20
Kirindi Oya	Thanamalwila	1300	192	15
Maduru Oya	Padiyathalawa	1563	183	12
Badulu Oya	Demodara	1557	120	8
Mahaweli Ganga	Peradeniya	2624	1280	49
Mahaweli Ganga	Nawalapitiya	3568	2105	59
Deduru Oya	Chilaw	1570	900	57
Maha Oya	Badalgama	2377	380	16
Attanagalu Oya	Dunamale	3137	1157	37

MONTHLY FLOW IN MAJOR RIVERS

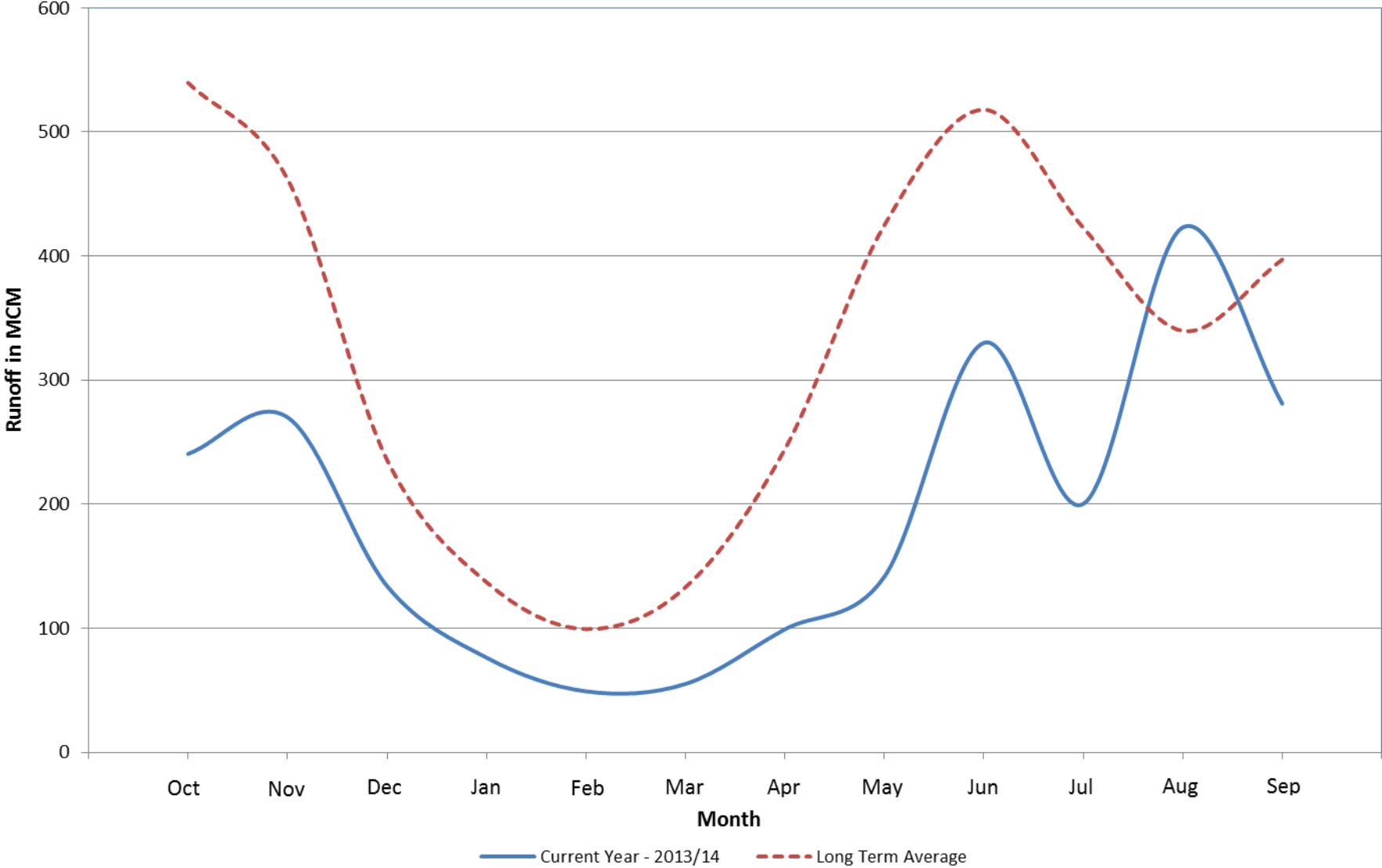
MONTHLY FLOW IN MAJOR RIVERS (in MCM)

Upper line : Current year 2013/14

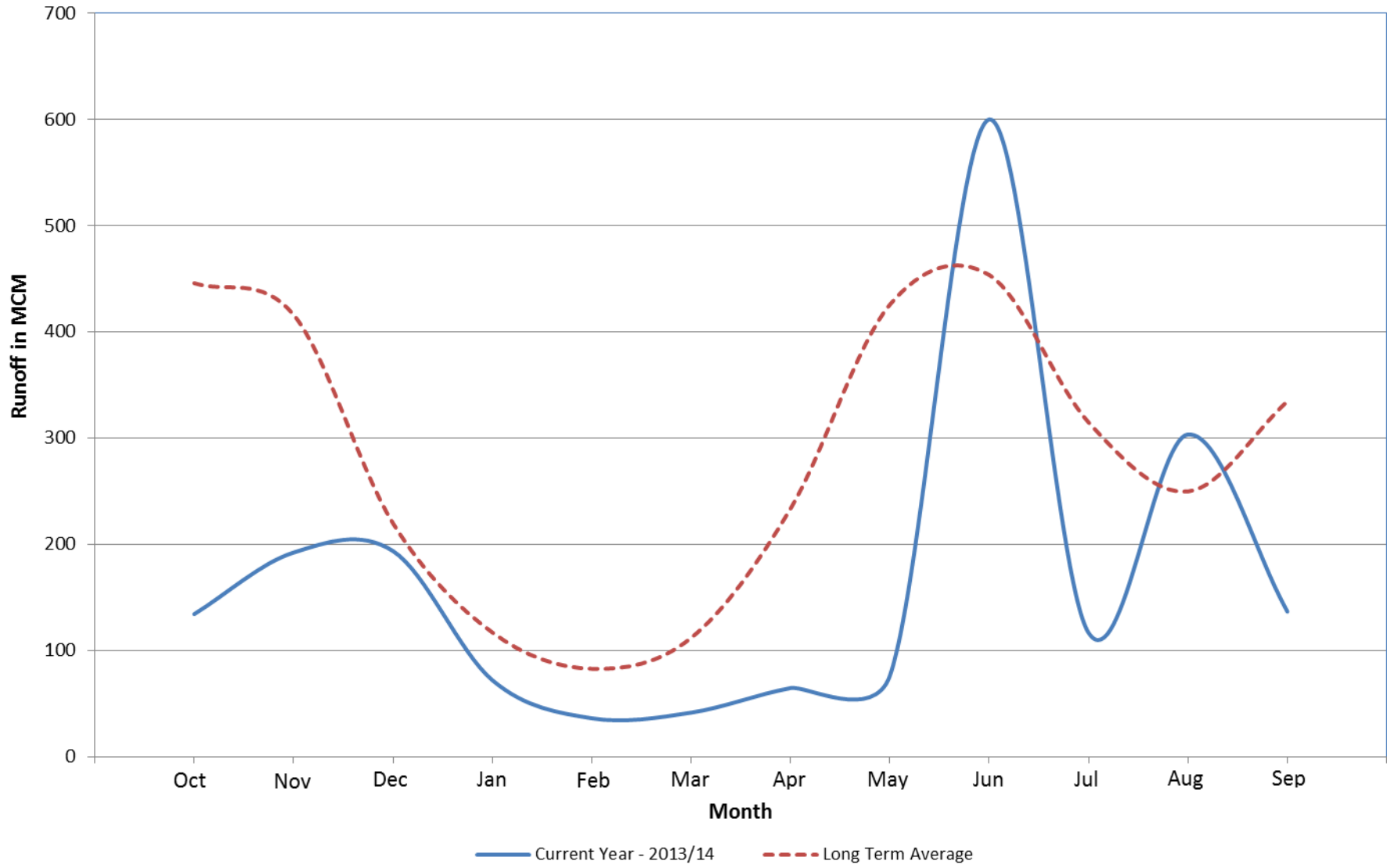
Lower line : Long-term average

Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Kelani Ganga at Glencourse	240.59	270.04	134.15	76.39	49.26	55.21	99.33	141.67	330.08	200.35	423.12	281.03	2301.22
	539.64	461.90	235.77	137.19	99.44	133.10	244.43	424.89	517.94	422.80	339.68	397.15	3953.94
Kalu Ganga at Ellagawa	134.25	192.23	193.65	72.07	36.26	41.60	64.69	76.27	599.61	116.78	303.27	136.61	1967.29
	445.70	415.90	219.78	117.03	82.83	111.91	233.41	425.44	453.32	314.65	249.71	334.53	3404.21
Kalu Ganga at Putupaula	252.53	395.04	228.02	198.71	147.89	183.18	204.45	219.38	749.94	182.23	435.91	231.66	3428.94
	812.78	730.51	452.31	279.56	205.33	265.39	422.24	730.14	785.26	525.07	420.61	544.06	6173.26
Nilwala Ganga at Pitabeddara	43.03	111.25	88.76	60.67	25.41	22.51	27.22	27.86	70.87	31.79	42.08	34.53	585.97
	51.61	76.18	57.20	30.07	21.76	24.77	38.06	73.53	49.03	30.93	22.27	33.80	509.19
Kirindi Oya at Tanamalwila	5.86	44.88	31.26	20.90	5.77	4.44	12.52	15.59	0.66	0.02	0.19	1.82	143.90
	18.98	56.55	45.66	23.04	15.32	20.85	40.20	25.67	5.28	2.25	1.55	2.32	257.67
Deduru Oya at Chilaw	208.28	183.83	168.76	192.33	168.66	204.63	193.72	278.03	184.00	187.50	189.87	188.38	2347.99
	237.92	327.36	223.83	182.84	167.11	179.77	190.56	207.78	182.26	174.89	171.47	171.19	2416.98

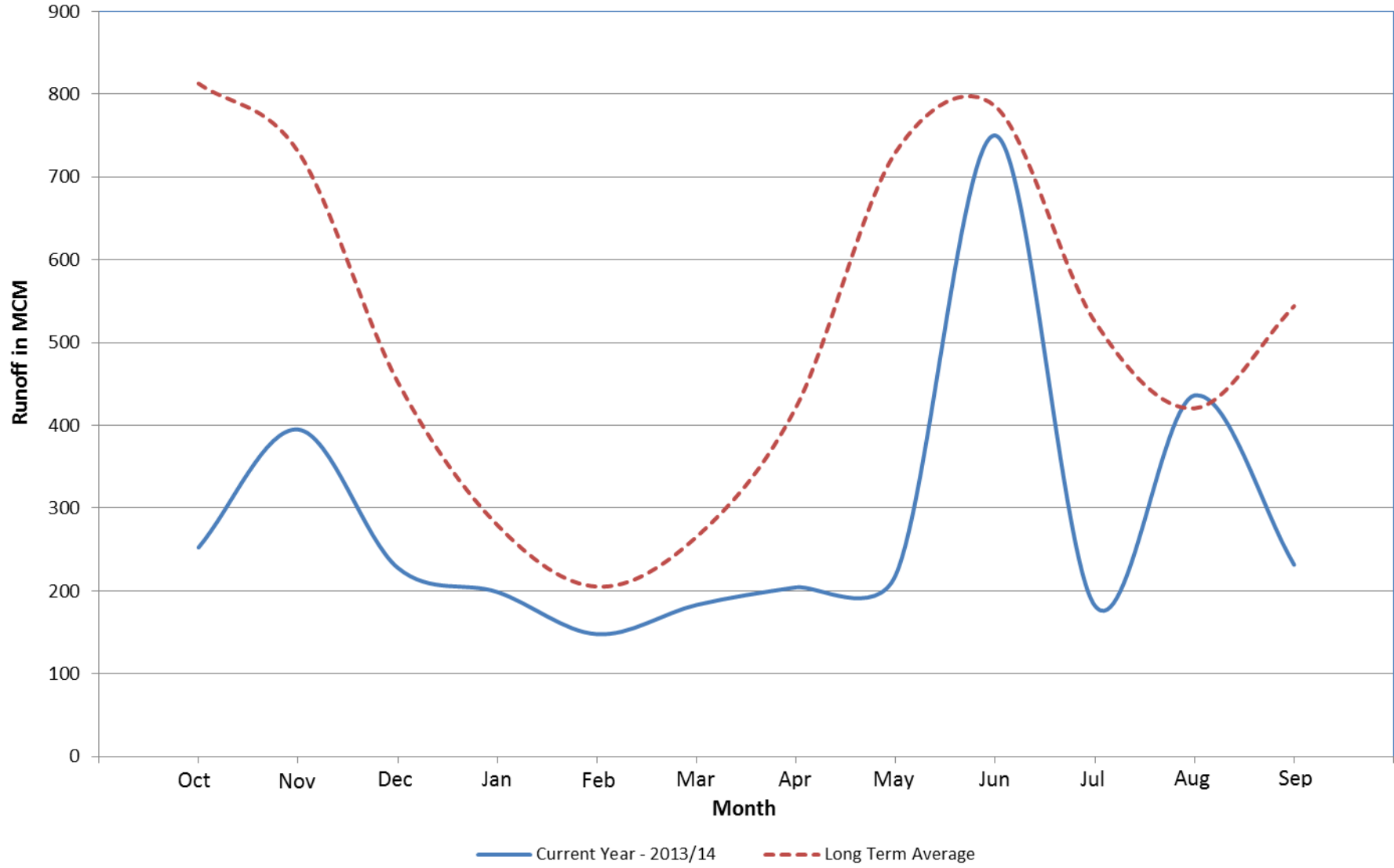
KELANI GANGA AT GLENCOURSE



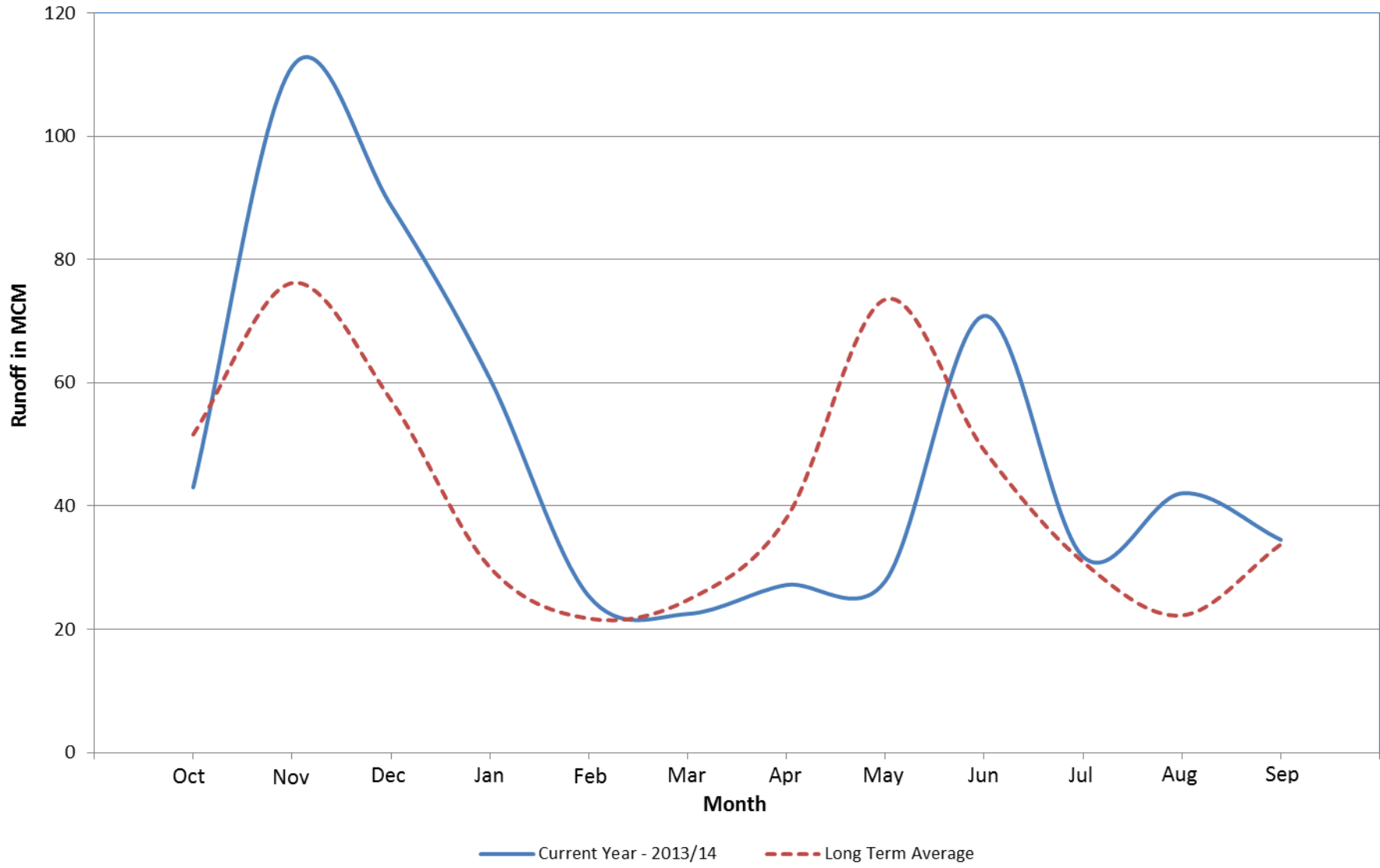
KALU GANGA AT ELLAGAWA



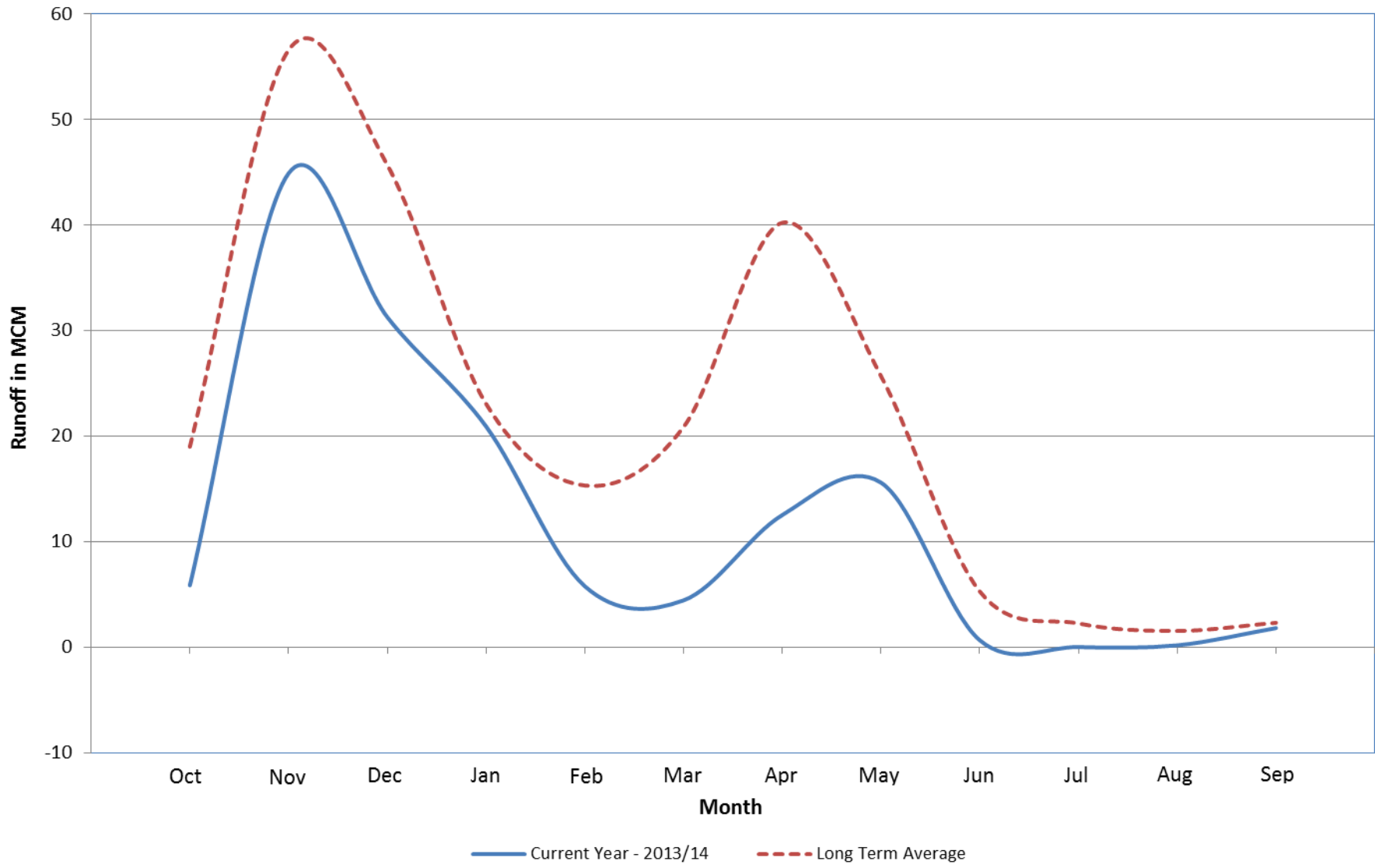
KALU GANGA AT PUTUPAULA



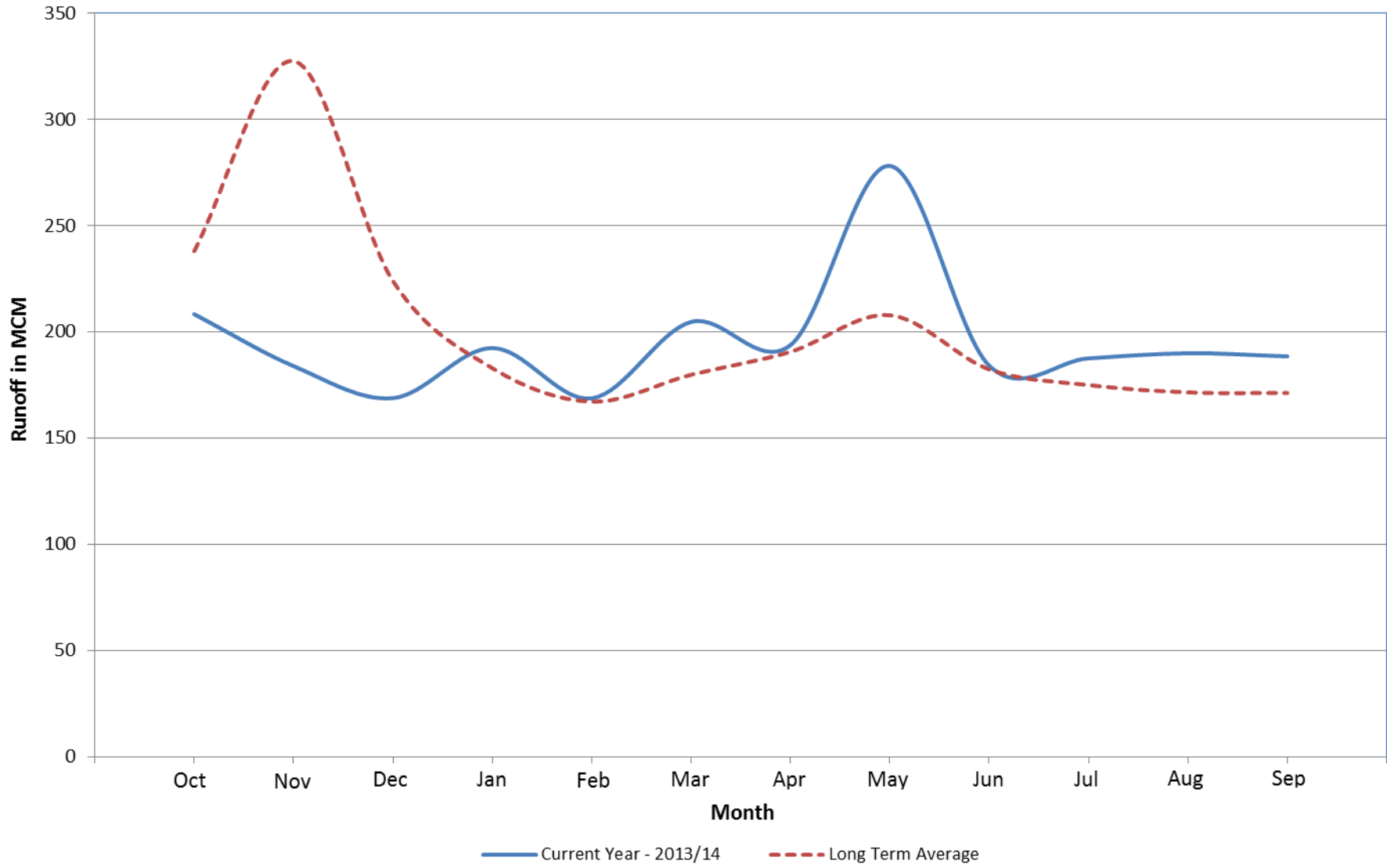
NILWALA GANGA AT PITABEDDARA



KIRINDI OYA AT TANAMALWILA

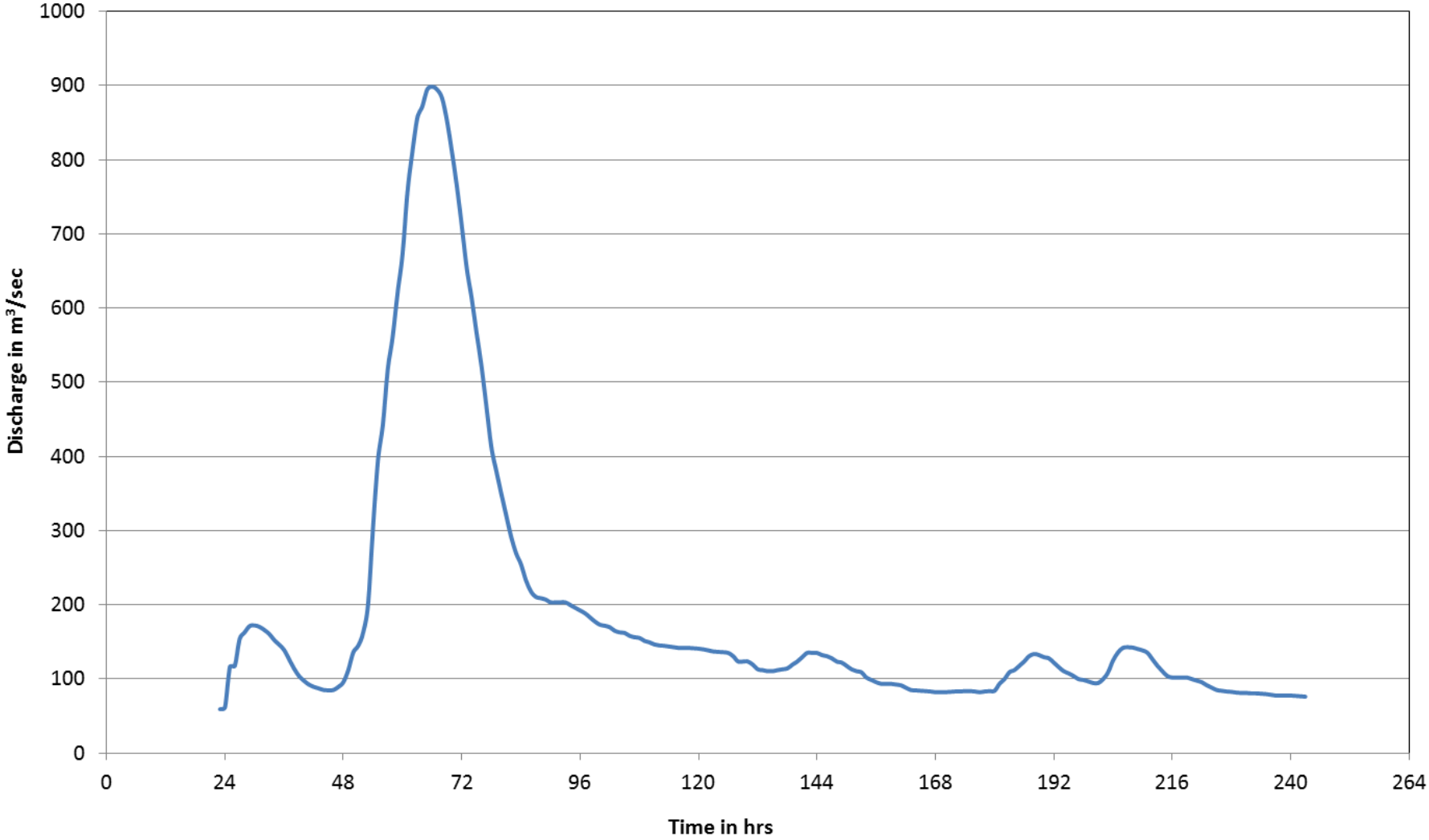


DEDURU OYA AT CHILAW



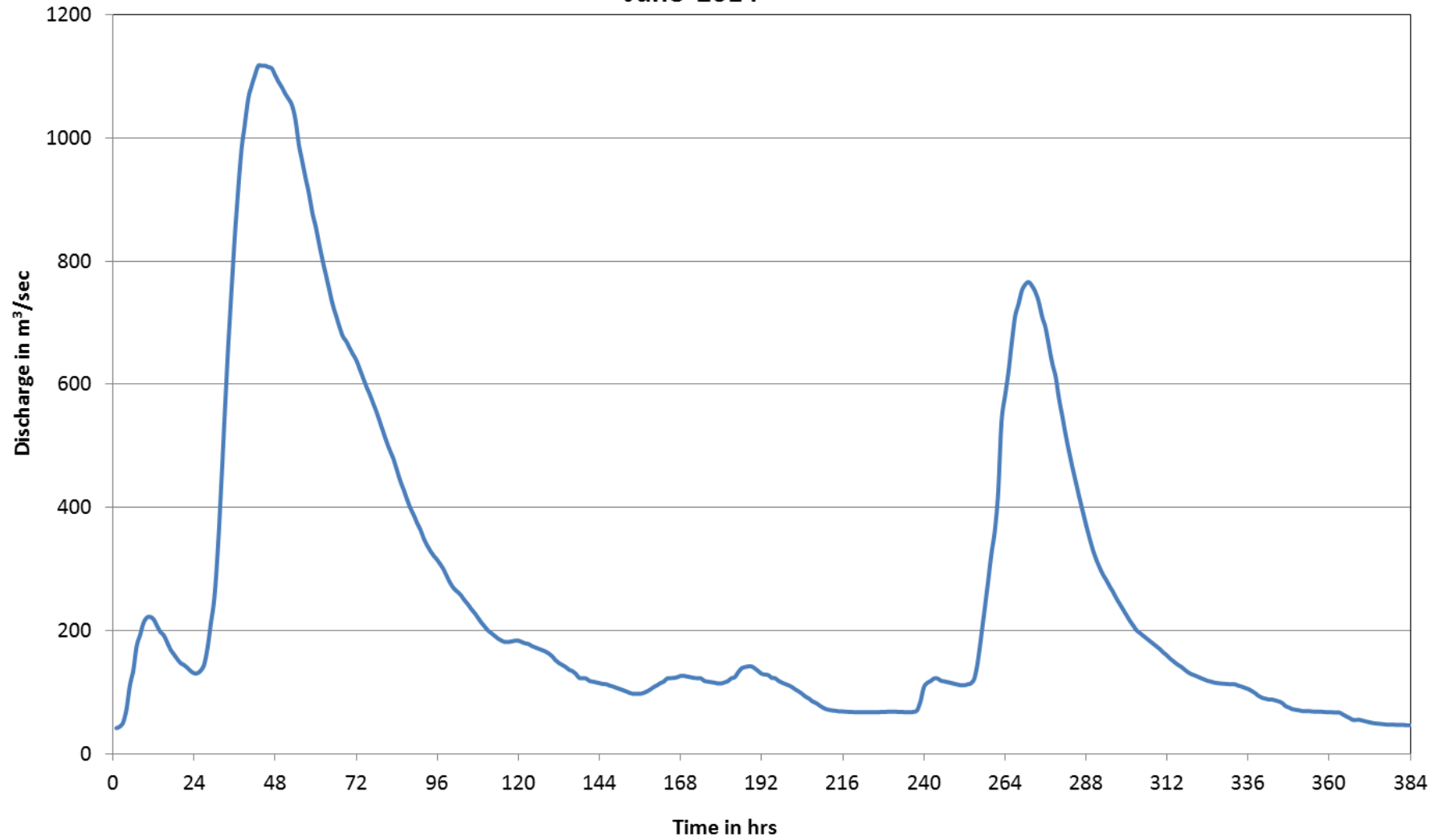
FLOOD HYDROGRAPHS

**Maximum Flood During 2013/14
Kelani Ganga at Glencourse
June 2014**



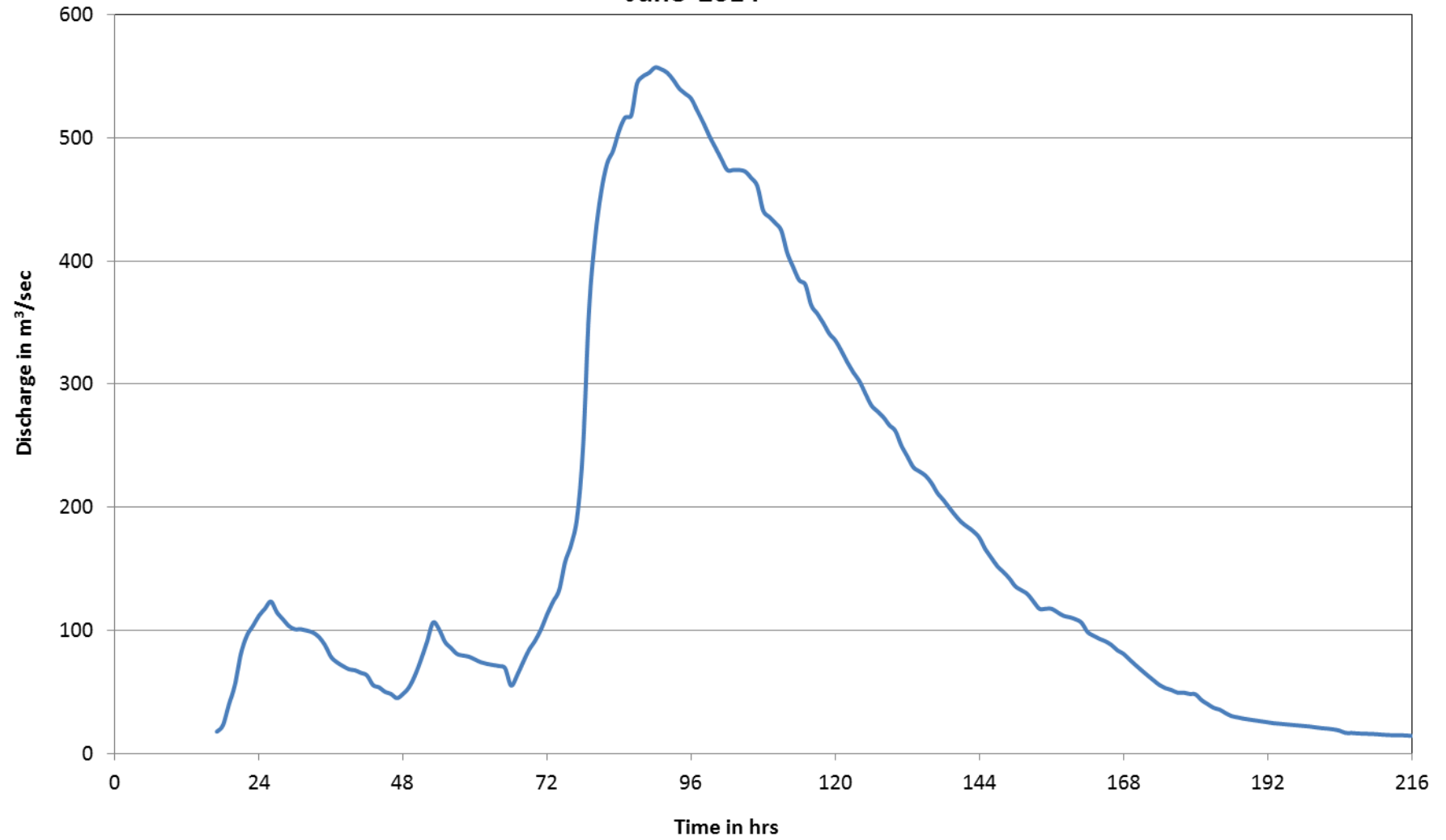
* Initial time - 11:00pm on 1st June 2014

**Maximum Flood During 2013/14
Kelani Ganga at Hanwella
June 2014**



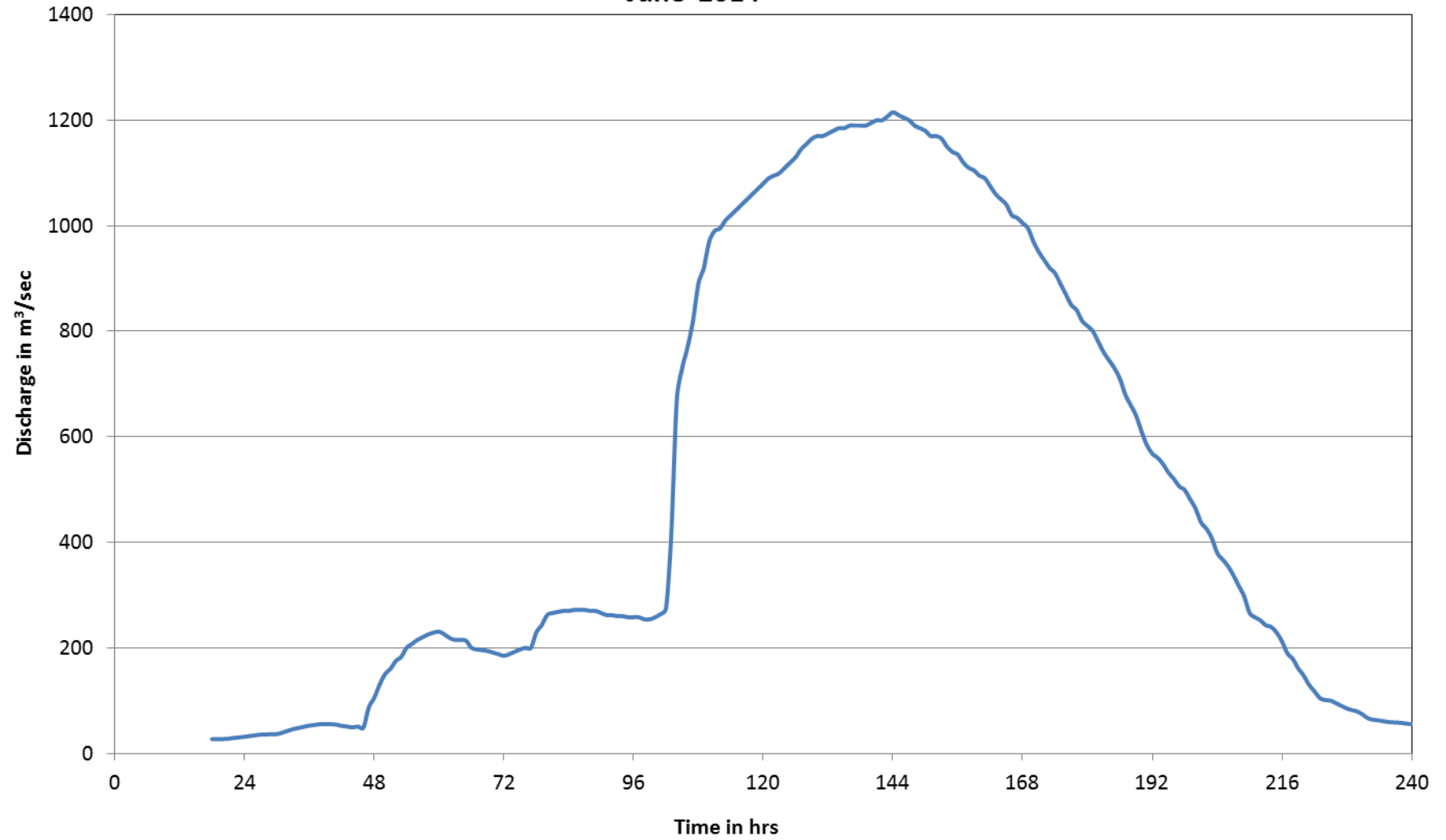
* Initial time - 1:00am on 2nd June 2014

Maximum Flood During 2013/14
Kalu Ganga at Ratnapura
June 2014



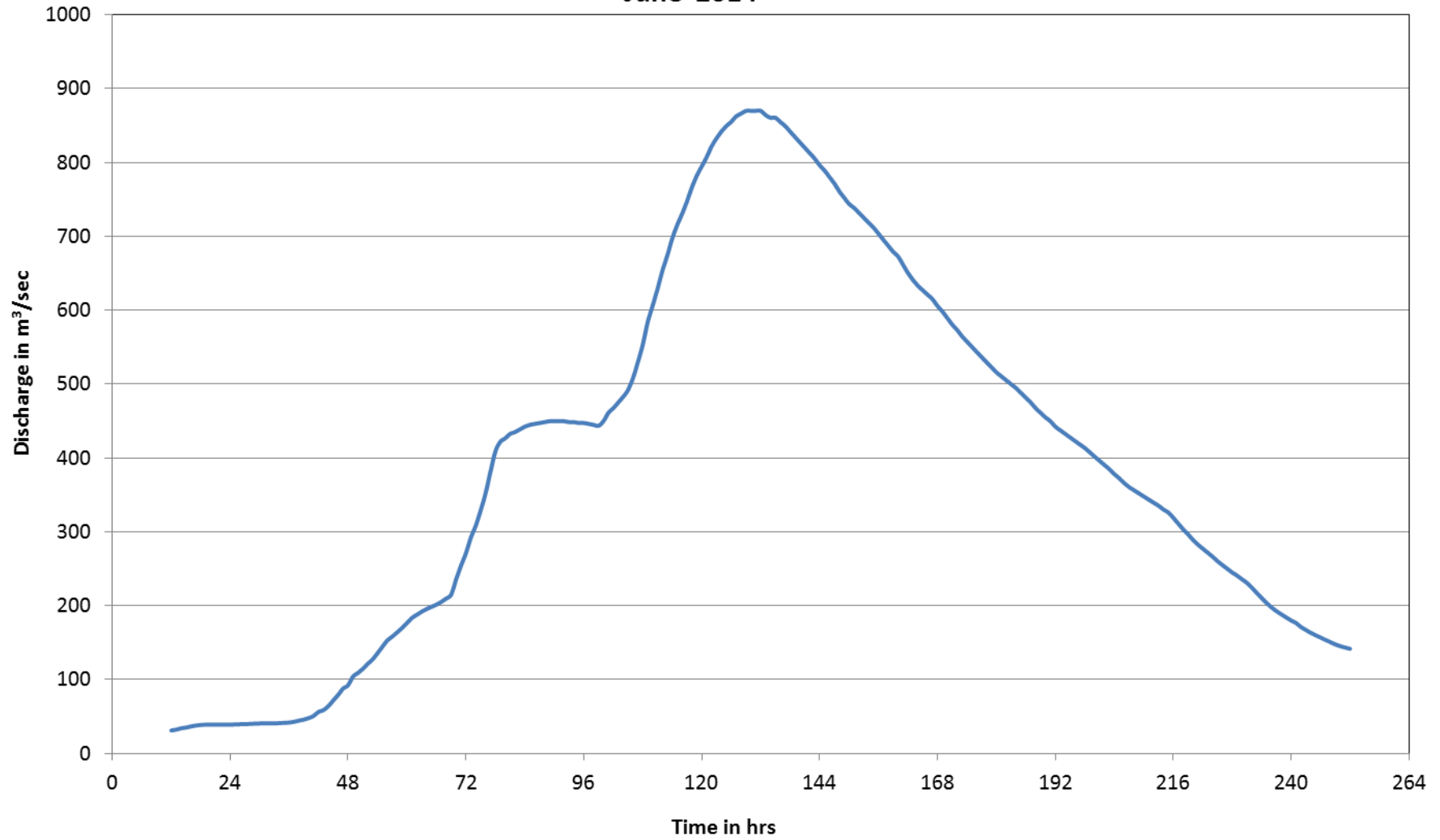
* Initial time - 5:00pm on 1st June 2014

**Maximum Flood During 2013/14
Kalu Ganga at Ellagawa
June 2014**



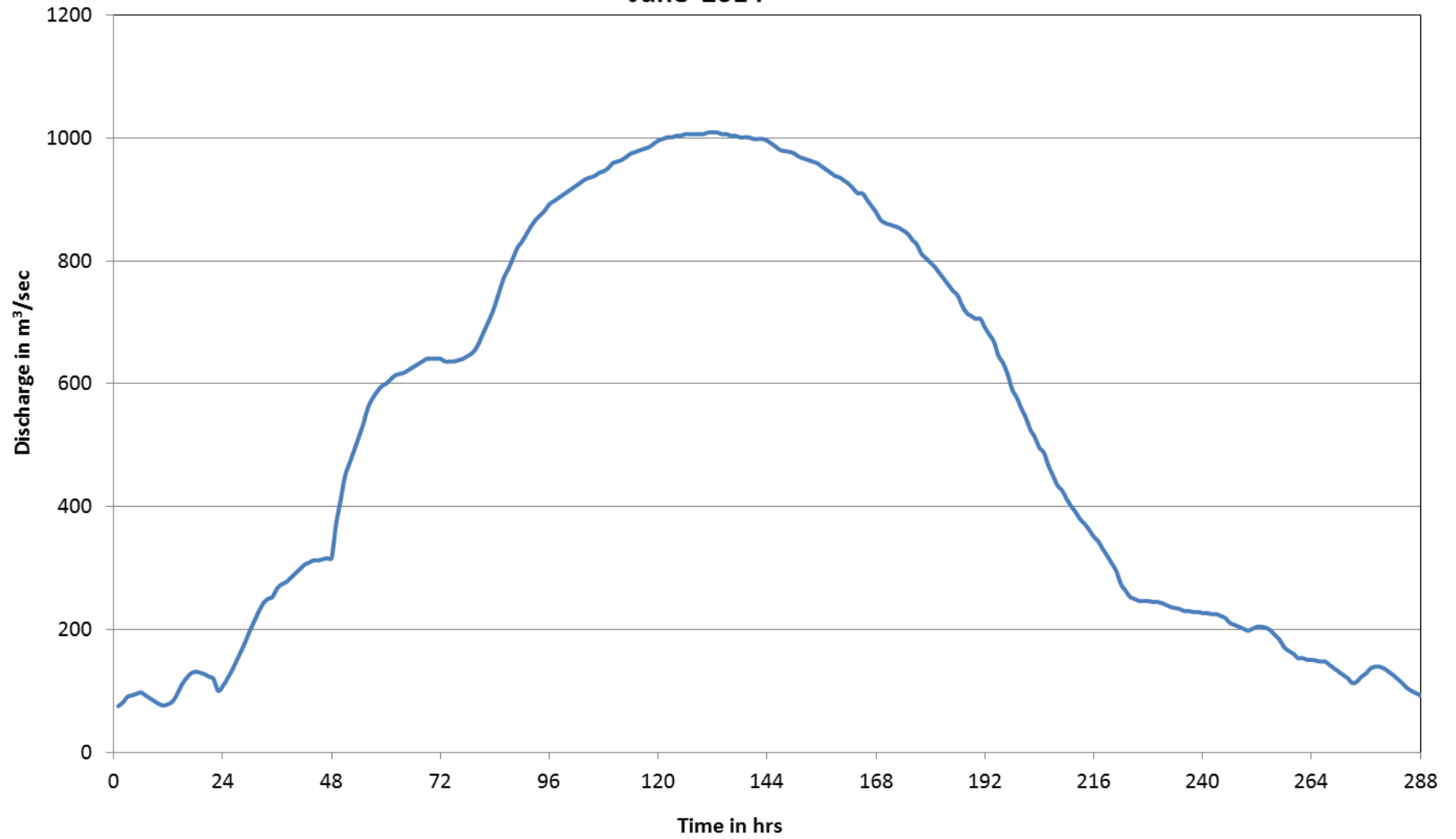
* Initial time - 6:00pm on 30th May 2014

**Maximum Flood During 2013/14
Kalu Ganga at Millakanda
June 2014**



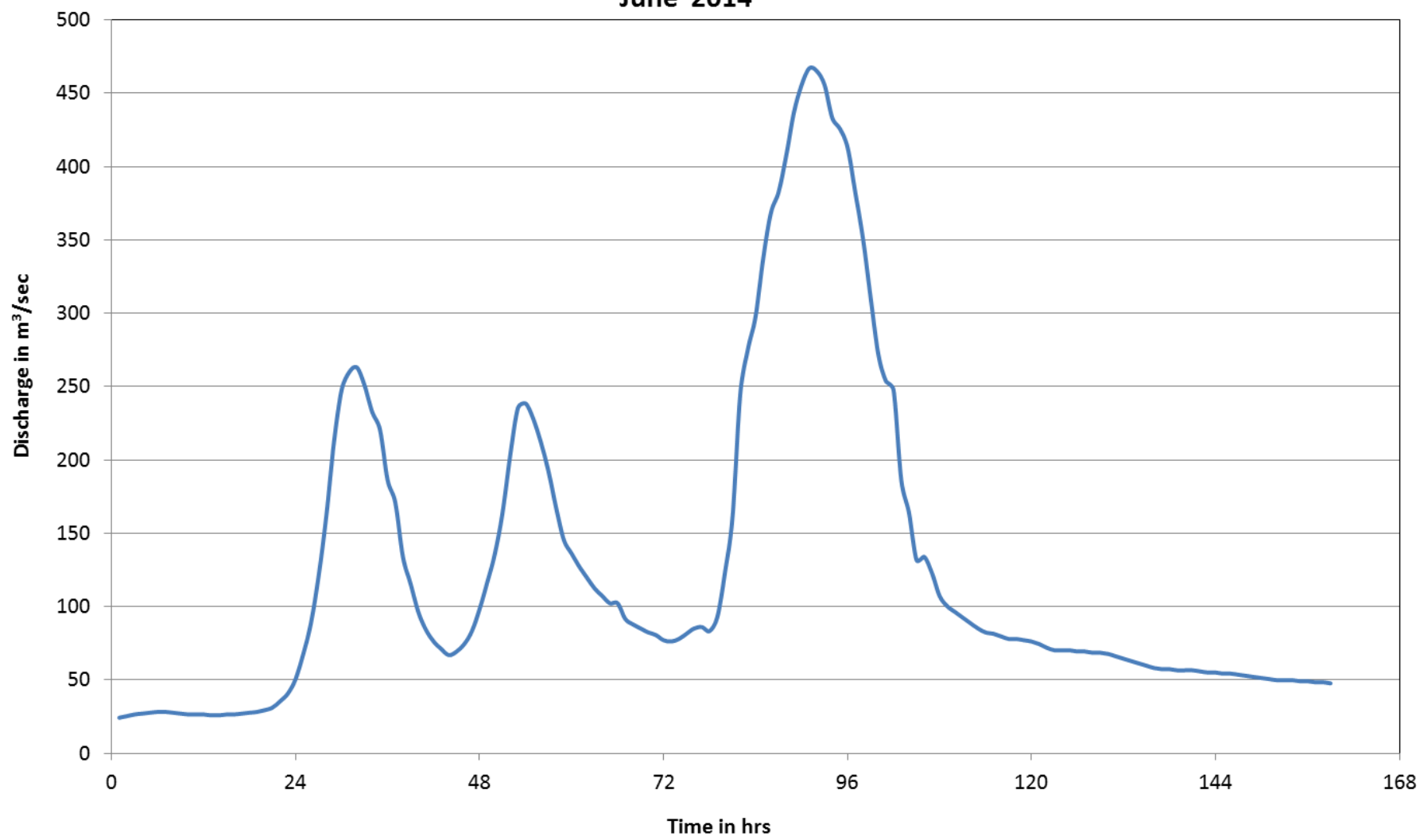
* Initial time - 12:00nn on 30th May 2014

**Maximum Flood During 2013/14
Kalu Ganga at Putupaula
June 2014**



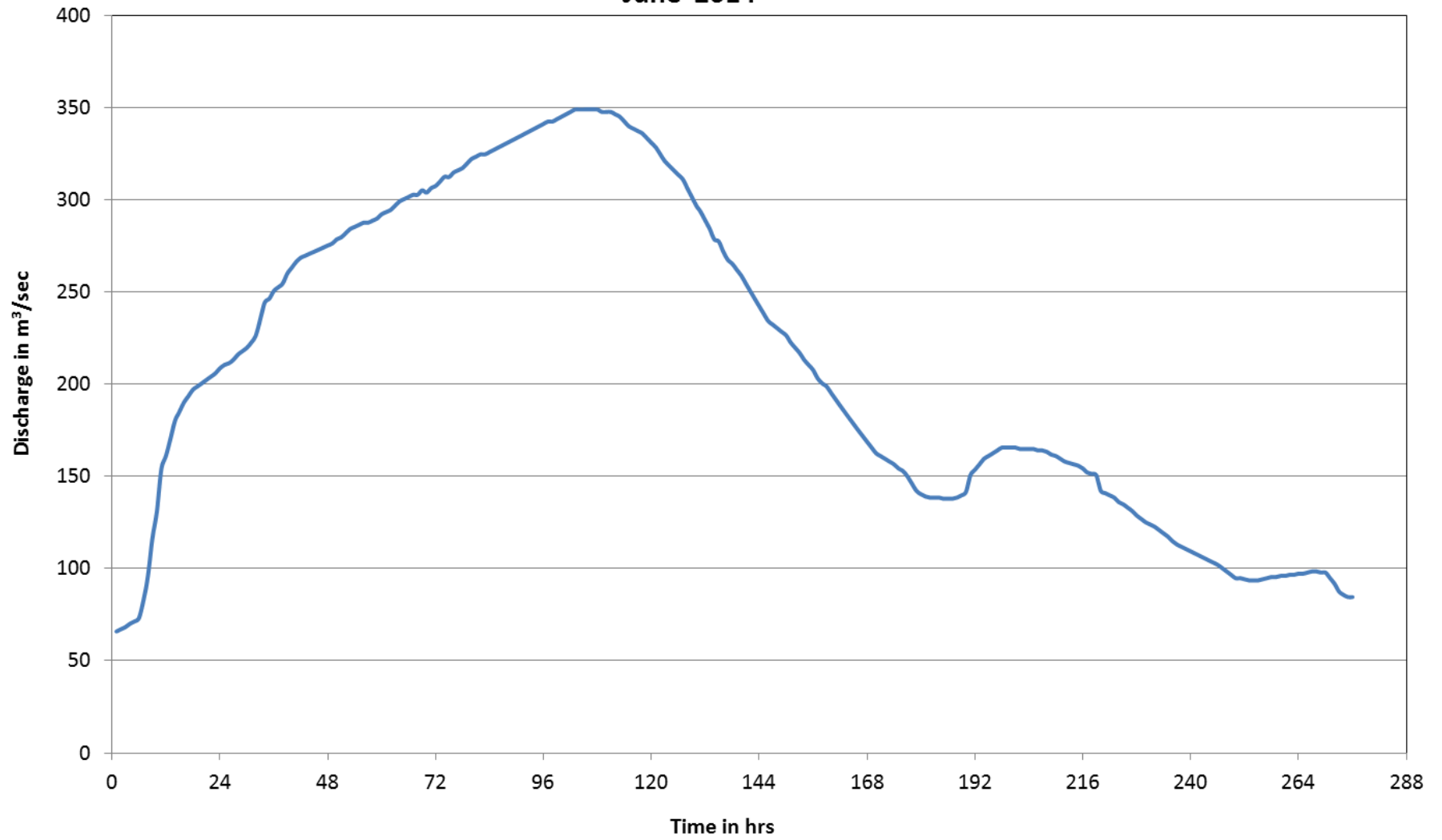
* Initial time - 1:00am on 31st May 2014

**Maximum Flood During 2013/14
Gin Ganga at Thawalama
June 2014**



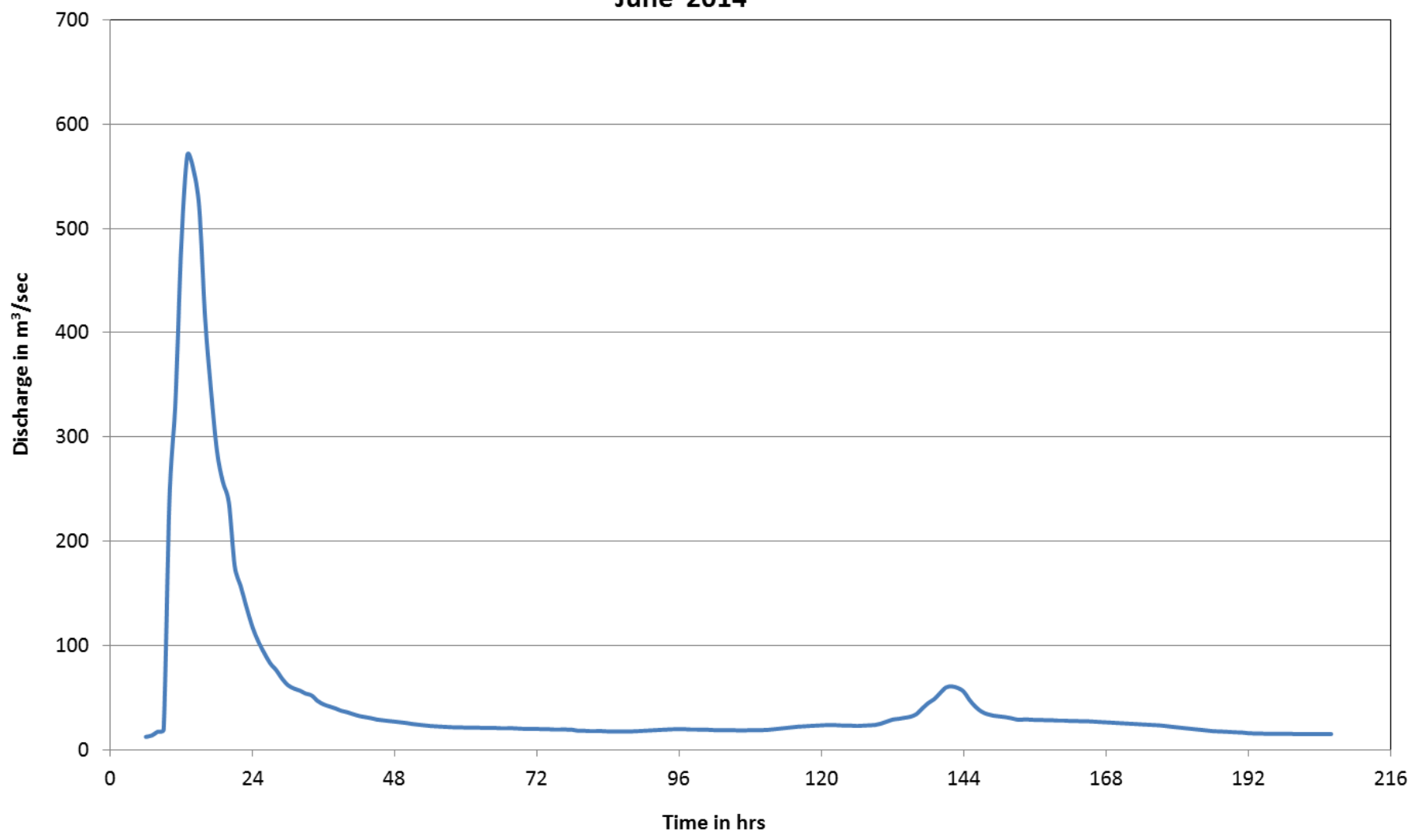
* Initial time - 1:00am on 31st May 2014

**Maximum Flood During 2013/14
Gin Ganga at Baddegama
June 2014**



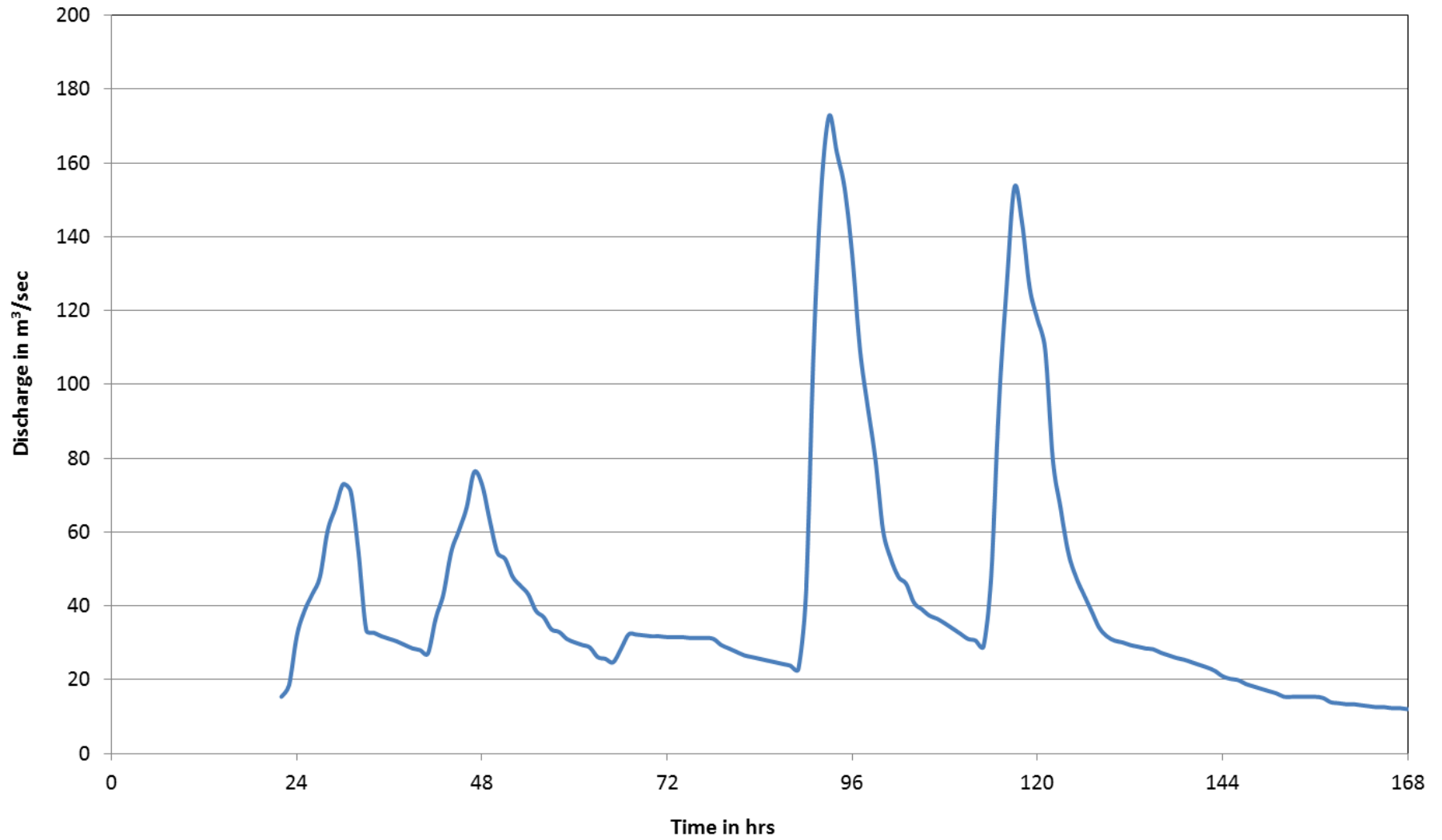
* Initial time - 1:00am on 1st June 2014

**Maximum Flood During 2013/14
Nilwala Ganga at Pitabeddara
June 2014**



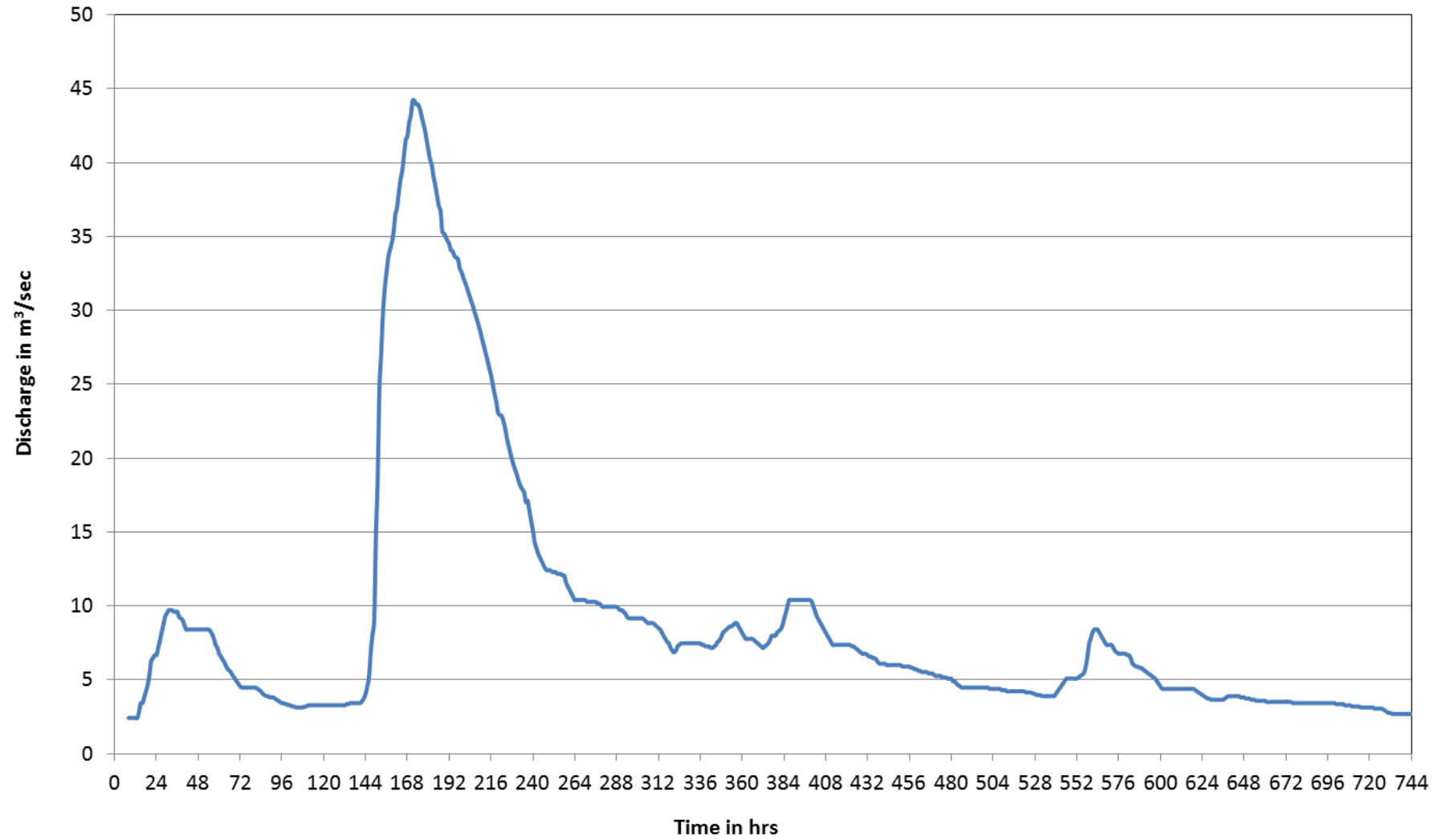
* Initial time - 6:00am on 03rd June

**Maximum Flood During 2013/14
Kirindi Oya at Thanamalwila
Nov 2013**



* Initial time - 10:00pm on 23rd Nov 2013

**Maximum Flood During 2013/14
Aththanagalu Oya at Dunamale
June 2014**



* Initial time - 8:00am on 28th May 2014

PART III

- **Comparison of 2014 December Flood with the Devastating Flood of 1957.**
- **Hydrology in the Service of the People of Ceylon**

**Comparison of 2014 December
Flood with the Devastating Flood
of 1957**

Comparison of 2014 December Flood with the Devastating Flood of 1957

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Abstract

Extreme weather conditions are supposed to have repetitive nature. Particularly severe floods associated with heavy rainfalls follow this nature and it is possible to analyze with statistical methods. Therefore, the statistical terms such as return period, recurrence interval etc. have become familiar not only among the professionals but also among general public.

Most common question arisen after a severe flood is the return period associated with the amount of rainfall received or a peak discharge. Therefore it is worthwhile to analyze such events comparing with the similar events occurred previously. The author wishes to compare the hydrological aspects of the recent flood with the devastating flood of 1957 which is supposed as the most severe hydrological hazard ever experienced by the country. The 1957 flood which was centered in the North-Eastern plains of the country claimed 171 human lives and invaluable properties including entire irrigation system of the North – Central Province.

The December 2014 flood seems comparable to the 1957 flood with respect to the temporal and spatial distribution of rainfalls. However, it is somewhat lower concerning the magnitudes of rainfalls and stream flows and far below with respect to damages. The outcome of this study will be useful in understanding the nature of hydrological hazards and taking precautions for minimizing the loss of lives and property damages in future hazards.

Keywords: Floods, Recent, Historical, Hydrological Aspects

1. Introduction

Out of various natural hazards, hydrological hazards (Floods and landslides associated with heavy rainfalls) are the most common and destructive events in Sri Lanka. That seems to take place every year and sometimes several events a year. The seasonal distribution of hydrological hazards shows two peaks; one from South-West monsoon period (From May to Sept.) and the other from North-East monsoon period (from Dec. to Feb.).

Spatial distribution of floods is also associated with the two monsoon seasons. Wet-Zone Rivers (Nilwala, Gin, Kalu, Kelani, Aththanagalu Oya and Maha Oya) are affected by the South – West monsoon while the other areas are mostly influenced by the North –East monsoon. The Mahaweli upper catchment receives high rainfalls from both monsoons. Generally, Mahaweli floods become more severe when it happens in the North- East monsoon period since the entire catchment receives heavy rains as

experienced during the recent (Dec. 2014) flood.

2. Floods in 2014 December

According to above, the flood occurred in 2014 December can be categorized as a flood influenced by the North-East monsoon which mostly affects the dry zone of the country. Vast area of the island (22 administrative districts out of 25) was affected and heavy damages were experienced. Wet Zone rivers mentioned above, except the Maha Oya situated at the margin, were escaped from flooding. The Mahaweli, Maduru Oya, Yan Oya, Malwathu Oya, Kala Oya, Mee Oya and Deduru Oya basins were severely affected. More prominent features of this flood were the vast area inundated and the longer period of inundation. That is mainly due to the longer storm duration and the flat landscape.

3. Historical Events of Similar Nature

Before rush into the hydrological parameters of recent flood (Dec. 2014), it is worthwhile to review the literature available with respect to the historical floods of similar nature. Since beginning of 20th Century, major floods that affected extensive areas of the country appear to have occurred in 1902, 1913, 1925, 1931, 1940, 1947, 1957, 1963 and 1978. This type of floods occurs when the surface runoff due to heavy rains exceeds the bank full capacity of the rivers. Spilling of reservoirs and breaching of dams can also contribute when it occurs in the agricultural zones such as Anuradapura, Pollonnaruwa etc.

1957 flood appears to have similar characteristics with the recent flood with respect to duration and spatial distribution of rainfalls. From the next chapter onwards, I would like to discuss some important facts found from the various sources for better understanding the hydrological aspects of the recent flood, which is vital for preparing for future hazards.

4. Vital information found from the literature

Heavy floods are normally associated with intense rains. However, the initial hydrological conditions of the catchments also influence to the scale of flood.

The literature gives very clear picture regarding the onset of 1957 flood.

“By the end of November 1957, the majority of irrigation tanks of the dry zone was spilling over or was near full capacity. In early December rainfall was concentrated mainly on the North Eastern parts of the dry zone” [2].

A significant portion of rain water is absorbed by the reservoirs, vegetation, soil etc. and the remaining contributes to surface runoff causing floods. At the above occasion the detention capacities of reservoirs were minimal and the soils were in saturate condition due to previous rains. Secondly it was in the mid of November when the highest rainfalls from North-East monsoon are expected. In such a situation the hydrologists and the disaster management agencies should be in optimum vigilance and

preparedness. There was no such evidence found from the literature.

The same report says *“From about 17th of the December the Zone of highest rainfall expanded gradually from a core area in the North-East to encompass the entire Northern Plains, and the Northern Segment of the central Highlands”.*

That means the entire Mahaweli catchment had received heavy rainfalls during this occasion. In such a situation hydrologists and engineers responsible for flood management should be capable to analyze the situation and forecast the flood.

The report again says *“The torrential rainfall that led to flooding began on 23rd December, and continued unabated until 26th”.*

According to that the authorities has had sufficient time to warn the people and taking precautions if the situation was clearly understood. If so, most of the deaths (reported as 171) could have been avoided. During the flood, the daily rainfall at some locations had reported over 400mm. Such rainfalls are extremely rare and should be given utmost attention.

“According to the annual reports of the government agents, extensive areas in Anuradapura, Pollonnaruwa, Vavunia, Mannar and Puttlam districts were submerged at some places up to 30 feet or more. Localized floods were experienced in the other parts of the country, excluding Southern Region. Apart from the floods, landslides were reported in Kurunegala, Matale, Kandy, Nuwara Eliya and Badulla.

Reported number of deaths at the incident was 171 and about 65000 houses were either partially or totally damaged. Irrigation Department reported serious damage to 35 major Irrigation works and minor damage to 53 others in addition to breaching of more than 1300 village tanks. Exclusive damage to roads, bridges and railways were also reported.

According to above the authorities had failed to take precautions (prediction, early warning, preparedness etc.) before the flood. However, they were struggling throughout the flood period to control the situation, save the life and minimize the damage. After the flood they had taken immediate actions to restore the irrigation system and other infrastructure facilities to save the economy of the country.

The following excerpt from an article prepared by an Irrigation Engineer involved in the situation gives an idea about the gravity of the event.

“From 20th of December 1957, heavy rains were experienced in the North Central Province. I noticed that the Nuwarawewa was spilling and certain sections of the bund tended to show signs of creep. Those were sand bagged and weighted so as to drain excess moisture. All the city tanks were then full and overflowing. Heavy rains continued and by 22nd December the Mannankattiya tank situated close to Huruluwewa with a water head of 18 feet and irrigating 1800 acres had breached. Closer to the city, the Nachchaduwa tank was overflowing dangerously” [1]

The engineers had faced very complicated situations due to breaching and overflowing of the several reservoirs in cascade systems of irrigation works. This is a very common situation in the most of agricultural districts in the country. Breach of one dam causes to damage several others. This type of situations cannot be handled without having predefined operation rules. Secondly it is necessary to have sufficient number of hydrometric stations at crucial points with reliable communication system.

Due to lack of preparedness and essential resources, the engineers had to face very difficult situations throughout the period. The flood experienced that time was far beyond their capacity of control.

However with sudden decisions and enduring effort they were able to protect some of the reservoirs. Their experience during the flood is very important in planning flood control works in future. The sections they used to cut open the reservoirs, the channels excavated to bypass flood flows without entering to downstream tanks etc. can be taken for further investigation. Information provided by the paper [1] such as access roads to critical areas during the flood, durations of inundation, interruption to essential services and public utilities will also be useful in planning the flood control works.

If a similar rainfall is experienced nowadays the damage would be much higher due to the developments taken place and the increased population. Further it is more dangerous due to the large number of reservoirs constructed under the Mahaweli project. These reservoirs

are managed by several organizations under the different Ministries. Proper coordination among those organizations should be ensured to minimize flood hazards. Already 'Mahaweli Water Panel' has been established with the participation of all related organizations to take decisions related to water allocation among sub systems. A similar arrangement can be made to control the floods in the Mahaweli River System.

5. Comparison of the recent flood (December 2014) with the devastating Flood in 1957

5.1. Rainfall

According to above reports, the majority of irrigation tanks in the dry zone was spilling or at full capacity at the onset of 1957 flood. In contrast to that, the tank storages were in low positions up to end of November 2014 and no significant rainfalls recorded up to 16th December.

Similar to December 1957, the recent rainfall also mainly concentrated on the North Eastern plains of the Dry Zone. Fairly high rainfall (94 mm) was observed on 17th December at Manampitiya hydrometric station on the middle reach of the Mahaweli River. Same station recorded 206.6 and 220 mm rainfalls on two consecutive days, 19th and 20th December. This rainfall was somewhat under estimated since it was counted for two days (daily rainfalls are recorded at fixed time intervals, normally at 8 am). Intensity of the rain was such that, 385.4 mm rain had fallen within 21 hrs from 11 pm of 19th Dec. to 08 pm of the following day. This rainfall continued on 21st Dec. making the three day total as high as 514.7 mm (**Annex I**). This is the maximum rainfall recorded during the flood period.

Manampitiya is not far from Habarana where highest rainfall was recorded during the 1957 flood. The highest three day rainfall received this time (514.7 mm) is much less than the same parameter recorded (1240.28 mm) during the 1957 flood [2]. However this figure (three day rainfall at Habarana) is a little doubtful and not proved by any other source of data. According to the records of the Department of Meteorology, the highest three-day rainfall (in December 1957)

recorded at Vavunia was 543.4 mm (**Annex II**).

In both events, the rainfall had originated in the North-East, gradually expanded to the entire Northern Plains, and the Northern Segment of the central hills. According to past records on 1957 flood, the torrential rainfall that led to severe floods had begun on 23rd December and continued up to 26th [2]. In 2004 also the highest and widely spread rainfalls had been recorded during the 24th and 25th December. Even though the severity of the event is less, the behavior of the weather in 2014 shows high correlation with the previous (1957) event.

Out of all affected river basins in the recent flood, the Mahaweli catchment recorded the highest rainfalls. Rainfalls collected from 14 stations (distributed fairly well over the catchment) are used for the calculation. Maximum 3-day rainfalls over 400 mm had been observed at Manampitiya (514.7 mm), Laggala Pallegama (428.1mm) and Bowatenna (431.2mm) rainfall stations (**Annex III**).

The Deduru Oya catchment also recorded average rainfall over 100 mm on two consecutive days (129.8 mm on 24th and 108.4 on 25th). The total inflow to Deduru Oya reservoir was computed as 267 MCM for two days. This is nearly the 3.5 times of the capacity of the reservoir. The spillway released the maximum flow of 1200 cumecs inundating the downstream area causing severe floods.

Apart from above, the catchments of Maha Oya, Mee Oya, Malwathu Oya, Heda Oya, Maduru Oya and Kirindi Oya had recorded high rainfalls on 24th and 25th December.

Out of the rainfall stations maintained by Meteorological Department, Polonnaruwa had recorded maximum 3-day rainfall of 446.8 mm. Batalloa, Mahalluppallama and Mulative stations had experienced 3-day rainfalls of 355.9 mm, 312.4 mm and 383.2 mm respectively.

Station rainfalls of the recent flood (Dec. 2014) and 1957 flood are given in Table 1. All stations have recorded slightly lower rainfalls (total of the flood period) in 2014 when compare to 1957.

Table 1 : Comparison of daily rainfalls (in mm) during 1957 and 2014 floods.

River Basin	Mahaweli River						Malwathu Oya	
	Peradeniya		Manampitiya		Nawalapitiya		Anuradapura	
Date/Year	1957	2014	1957	2014	1957	2014	1957	2014
Dec. 17	17.5	23.7	44.2	94	0	35	53.3	39.8
Dec. 18	11.9	27.3	19.56	2.2	18	25.2	5.5	1.3
Dec. 19	77.4	30.5	142.24	206.6	2.5	38.4	36.8	162.5
Dec. 20	16.2	28.2	77.47	220	96.5	33.3	62.9	34.6
Dec. 21	20.3	9.7	76.71	88.1	8.8	35	22.1	72.8
Dec. 22	36.8	43.6	37.34	54.2	13.4	32.2	0	9
Dec. 23	53.5	20.6	65.53	24.6	4.8	35.8	33	31.3
Dec. 24	116.8	106.7	183.13	61.9	14.4	57.1	206.5	35.8
Dec. 25	103.3	105.7	104.65	61.9	74.1	110	219.7	62.8
Dec.26	41.6	2.8	51.31	0	152.3	0	9.1	3.1
Dec.27	65.2	66.1	38.61	5.3	46.2	25	39.3	69.5
Total mm	560.5	465.5	840.75	818.2	431.0	427.0	688.2	522.5

Table 2: Maximum Rainfalls during 1957 and 2014 floods with respect to different durations

Station	Peradeniya		Manampitiya		Nawalapitiya		Anuradapura	
	1957	2014	1957	2014	1957	2014	1957	2014
One Day Max.	116.8	106.7	183.13	220	152.2	110	219.7	162.5
Two Day Max.	220.1	212.4	287.78	426.6	226.4	167.1	426.2	197.1
Three Day Max.	273.6	233.0	353.31	514.7	272.6	202.9	459.2	269.9
Four Day Max.	326.9	276.6	404.62	568.9	310.6	235.1	474.6	294
Five Day Max.	380.4	286.3	467.36	610.9	325	270.1	507.6	328.6

Same rainfalls were used to compute the maximum rainfalls over longer durations and tabulated (Table 2) for the convenience of comparison. All rainfall stations except Manampitiya show lower values in 2014 flood when compare to 1957. However at Manampitiya on the Mahaweli lower reach has received higher rainfalls, this time, with respect to all durations.

5.2 Maximum Water Levels Reached, and the durations of Inundation

Irrigation Department maintains 35 hydrometric stations on major rivers throughout the island. Some of the stations were inundated during the flood disturbing continuous recording of water levels. However they had managed to record the peak levels and the approximate times of peak discharges (**Annex IV**). Salient features derived from the hydrographs of all 35 stations are summarized in Table 3.

Table 3: Maximum water levels reached (Dec.2014) and classification of floods at different locations

River Basin	Station Name	Unit	Max. Water Level	Major Flood Level	Minor Flood Level	Duration hr	Classification of Flood
Kelani River	Nagalagam st.	ft	4.55	7	5	-	No Flood
	Hanwella	m	7.68	11	8	-	No Flood
	Glencourse	ft	53.6	65	55	-	No Flood
	Holombuwa	ft	20.65	16	11	15	Local Flood
	Deraniyagala	ft	10.1	21	19	-	No Flood
	Kitulgala	m	1.76	5	3	-	No Flood
	Norwood	m	2.56	2.15	2	-	Local Flood
Kalu Ganga	Ratnapura	m	4.3	7.9	6	-	No Flood
	Ellegawa	ft	27.15	40	35	-	No Flood
	Millakanda	m	5.11	7	5.5	-	No Flood
	Putupaula	m	2.62	5	4	-	No Flood
Gin Ganga	Tawalama	ft	12.5	20	15	-	No Flood
	Baddegama	m	3.33	5	4.5	-	No Flood
Nilwala Ganga	Pitabeddara	m	3.34	4.5	3.35	-	No Flood
	Panadugama	m	6.13	6.5	5.5	27	Minor Flood
	Urawa	m	2.4	4	3	-	No Flood
Kirindi Oya	Tanamalwila	m	5.3	5.5	5	6	Minor Flood
	Wellawaya	m	3.4	5.5	5	-	No Flood
	Kuda Oya	ft	17.3	26	25	-	No Flood
Maduru Oya	Padiyatalawa	m	8.08	6	4.5	16	Major Flood
Kumbukkan	Nakkala	ft	15.1	18	13	10	Minor Flood
Heda Oya	Siyambalanda	m	6.46	5	4.5	17	Major Flood
Mahaweli Ganga	Peradeniya	m	8.67	9	7	13	Minor Flood
	Nawalapitiya	m	2.7	4.5	4	-	No Flood
	Weragantota	m	9	8	6	18	Major Flood
	Manampitiya	m	5.08	4	3.9	183	Major Flood
	Taldena	m	5.5	5	4	13	Major Flood
	Laggala	m	4.61	-	-	-	No Flood
	Kelidoniya	m	3.3	-	-	-	No Flood
Yan Oya	Horowpothana	m	8.05	8	7.3	297	Major Flood
Malwathu oya	Tantirimale	m	10.93	8	7.25	224	Major Flood
Mee Oya	Galgamuwa	m	5.81	7	5.94	-	No Flood
Maha Oya	Badalgama	ft	16.6	16	5	33	Major Flood
	Giriulla	m	9.35	6.5	6	21	Major Flood
Attanagalu	Dunamale	m	5.14	5.5	4.4	36	Minor Flood

Station rainfall at Manampitiya during the recent flood was higher than the same

parameter of 1957 (Table 2). However the maximum flood level 5.08 m (37.31 m MSL)

is less than the peak water level in 1957 (38.89 m MSL). The discharge of a river is proportionate to the catchment rainfall which was not known with regards to 1957 flood. Secondly large number of major reservoirs has been constructed in the Mahaweli catchments after the 1957 flood which may cause to reduce the flood levels of the lower basin. Therefore the flood levels of these two events may not be proportionate to the respective rainfalls.

Peak flow rate under the Manampitiya Bridge during 1957 flood had been estimated as 4364 cumec [3]. Same parameter at this time is around 3500 cumec which also lower than the peak flow rate of 1957 flood.

Similarly the peak water level at Horowpothana gauging station during 1957 flood was 11.42m (57.56 m MSL) and the peak flow rate had been estimated as 2251 m³/sec. Peak flood Level this time is 8.05 m (51.56 m MSL) and the corresponding discharge is only 310 cumec. The extremely high discharge in 1957 must be due to the breach of upstream reservoir Hurulu Wewa (67.9 MCM capacity). Discharge beyond 600 cumec has never experienced at Horowpothana after 1957.

6. Statistical Analysis

The 2014 December flood was analyzed statistically using the long term records of annual maximum rainfalls and annual maximum water levels at crucial stations.

Rainfall data for 60 years (from 1954 to 2013) was available for most of the stations while Pothuwil had shorter record from 1983 to 2013. Theoretical distributions of Gumbel EV1 and Pearson Type III were found fairly well fit to the data series of all stations and finally frequency factor method of Pearson distribution was used for rainfall analysis. The summary of the results are presented in Table 4.

summary of the results are presented in Table 4.

Similarly annual maximum water levels at three selected stations on the Mahaweli Ganga (Manampitiya), the Yan Oya (Horowpothana) and the Maduru Oya (Padiyatalawa) were taken for the statistical analysis. Padiyatalawa had the shortest record (30 years from 1984) of water levels. The data series fairly well fit to the Gumbel Distribution (Fig 1).

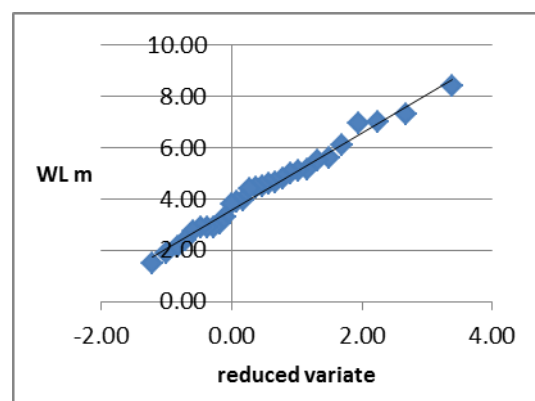


Figure 1 : Statistical analysis of annual Max. WL at Padiyatalawa

Horowpothana data showed some deviations from the theoretical distribution. That is mainly due to the flash floods caused by the breaches of reservoirs in the upper catchment (eg. breach of Huruluwewa in 1957). Therefore unrealistic figures (outliers) were removed from the data series by appropriate methods. Manampitiya data also showed a trend (gradual reduction of annual max. water levels). That may be due to the drastic changes in the catchment taken place due to construction of reservoirs under the Mahaweli project. Therefore only the data recorded for last 30 years were taken for the frequency analysis. The results of frequency analysis of water levels are also tabulated (Table-5).

Table 4 : Return Periods of 1957 and 2014 Rainfalls (daily rainfalls in mm) at different stations

Location of Rainfall Station	Data Period in years	Highest daily RF (mm) in Dec. 1957	Estimated Return Period	Highest daily RF (mm) in Dec. 2014	Estimated Return Period
Anuradapura	60	219.7	200 yr	162.5	25 yr
Badulla	6	217.9	100 yr	195.9	50 yr
Bataloa	60	180.5	5 – 10 yr	147.8	2 – 5 yr
Kurunagala	60	157.9	5 – 10 yr	137.1	2 – 5 yr
Katugastota	60	176.5	25 yr	137.0	10 yr
Mahailluppallama	60	217.1	25 – 50 yr	180.2	10 – 25 yr
Pothuwil	31	-	-	275.8	200 yr

Table 5 : Return periods of 1957 and 2014 floods at three critical locations

Station and River Basin	Data Period yrs	Highest WL (m) recorded in Dec. 1957	Estimated Return Period	Highest WL recorded in Dec. 2014	Estimated Return Period
Padiyatalawa (Maduru Oya)	29	-	-	8.0 m	20 yr
Horrowpotana (Yan Oya)	59	14.1 m	> 200 yr	8.05 m	5 – 10 yr
Manampitiya (Mahaweli Ganga)	30	6.67 m	> 200 yr	5.08 m	10 – 25 yr

It is natural to exaggerate the damages of floods during the period or immediately after a major event due to the hardships and difficulties faced by the people. However the above information reveals that the return periods of the recent floods at Anuradapura

was around 25 years (the return period of 1957 flood was above 100 years). That means there is a possibility of recurring such event (2014 flood) as frequently as 25 years and the area is vulnerable to floods similar to or higher than 1957 flood (200 yr).

7. Damages

Irrigation Department had to face severe crisis during the 1957 flood. Records of Irrigation Department reveal serious damages to 35 major Irrigation works and minor damages to 53 others [1]. Table 6 shows some of major irrigation works which were damaged by the flood and taken for restoration by the Irrigation Department immediately after the flood.

In contrast to that, extensive damages to major irrigation works were not reported in

2014. That may be due to the restoration works taken after 1957 flood, Strengthening of Irrigation Head-works carried out regularly by the authorities and specially the Dam Safety and Water Resources Planning (DSWRP) project implemented recently. However the loss of 17 lives (this was 171 in 1957 flood) due to floods and landslides were reported this time. Extensive damages to crops, houses, roads, bridges and other infrastructure facilities were also reported.

Table 6 : Major Irrigation Works Damaged During 1957 Flood

	District	Schemes
1	Jaffna	Iranamadu tank, Akkarayankulam , Vannerikulam
2	Vavuniya	Mamaduwa tank, Iratperikulam, Muhatankulam, Periyathambanai tank, Pavatkulam, Maniarkulam
3	Mannar	Thachchanamaruthammadu tank, Giant's tank, Akathimuruppu, Periyapandivirichchan Kulam
4	Anuradapura	Kalawewa, Sangilikanadarawa, Maha Madawachchiya, Nachcheduwa tank, Kattiyawa tank, Huruluwewa

5	Kurunegala	Ridibendiela Sch., Mi Oya Diversion Scheme, Palukadawela tank
6	Bataloa	Vakaneri Scheme, Rugam
7	Trinkomalee	Allai Scheme, Kantalai Scheme
9	Kandy	Minipe Scheme
10	Matale	Elahera Scheme

8. Conclusions and Recommendations

There is no doubt the 1957 flood was the most disastrous flood recorded in the North-Eastern part of the country. Fortunately the severity of recent flood was somewhat less than that. Even though complete failures or dam breaches were not much significant, extensive damages to irrigation works were experienced. Therefore, this is high time to revisit the reservoir designs and checking the adequacy of spillway capacities.

The outcome of this study reminds the authorities the necessity of more comprehensive studies in this field for better management of river basins. Hydrological hazard similar to 1957 or even more severe can be expected at any time. Proper understanding of the hydrology of watersheds, preparedness and timely actions can avoid most of the hazards caused by floods.

Defining operation rules for multipurpose reservoirs is a prime requirement of the country. Several large reservoirs came to operation after the Mahaweli Development Project. Those reservoirs are managed by several institutes such as Mahaweli Authority, Ceylon Electricity Board etc. Surplus water from those reservoirs has been diverted to old tanks managed by the Irrigation Department. Proper coordination among those authorities concerning floods

and joint effort with disaster management agencies will be required to minimize the reservoir induced floods in those systems.

Hydrological and hydrodynamic models have been identified as powerful tools in analyzing stream flows in complex river systems. Properly calibrated models will be useful in forecasting river floods. Historical data related to 1957 and 2014 flood events can be used for the calibration of such models.

Reliable and effective system of real time data collection will also be required to use such models in flood warning. Institutional arrangements have to be made to employ competent people, around the clock, for analyzing data and issuing forecasts.

Extreme weather conditions are natural processes which cannot be avoided or controlled by people. But most of the adverse effects can be minimized by preparedness, early warning and timely actions.

References

1. Seneviratna, D.A.V., "A Graphic Account of the Dec. 1957 flood Damage in and around Anuradapura and the Restoration Works that Followed", Hundred Years of the Irrigation Department, Centenary Commemoration Volume, 1900 – 2000.
2. Kingsley Guruge, Floods in Sri Lanka, www.Slideshare.net, Apr 4, 2014.
3. Flood Hydrographs with respect to 1957 Flood, Hydrology Division of the Irrigation Department.

Annex I :

Hourly Rainfalls at Manampitiya Hydrometric Station

Period from 17th Dec. to 24th Dec. 2014

Time \ Date	17	18	19	20	21	22	23	24
10	21.0	0.0	0.0	46.2	0.0	0.0	0.0	14.3
11	16.8	0.0	0.0	30.0	0.0	3.6	0.0	0.0
12	10.6	2.2	0.0	18.5	0.0	2.2	0.0	0.0
13	9.2	0.0	0.0	14.0	0.0	3.4	5.0	0.0
14	2.8	0.0	0.0	8.1	28.0	2.8	4.2	0.0
15	5.0	0.0	0.0	11.5	9.2	2.0	0.0	8.4
16	11.5	0.0	0.0	14.0	0.0	5.6	0.0	0.0
17	0.0	0.0	0.0	10.4	2.0	9.0	4.2	0.0
18	9.2	0.0	0.0	14.6	0.0	0.0	9.5	0.0
19	0.0	0.0	0.0	8.4	0.0	0.0	0.0	0.0
20	2.0	0.0	0.0	3.1	7.0	2.8	2.2	11.2
21	0.0	0.0	0.0	0.0	6.2	0.0	0.0	14.0
22	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	2.8	0.0	21.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	14.0	0.0	8.4	0.0	0.0	2.8
2	0.0	0.0	8.4	0.0	0.0	0.0	0.0	6.2
3	3.1	0.0	16.8	0.0	2.8	0.0	0.0	0.0
4	0.0	0.0	22.4	11.2	7.0	0.0	0.0	3.9
5	0.0	0.0	19.6	4.0	5.6	0.0	0.0	1.1
6	0.0	0.0	30.8	0.0	4.5	0.0	0.0	0.0
7	0.0	0.0	17.4	19.0	0.0	17.2	0.0	0.0
8	0.0	0.0	24.6	7.0	7.0	0.0	0.0	0.0
9	0.0	0.0	31.6	0.0	0.0	0.0	0.0	0.0
Daily RF	94.0	2.2	206.6	220.0	87.7	53.6	25.1	61.9

* Rainfall for 20 hrs from 23 hrs of 19th to 20 hrs of 20th Dec. = 385.4 mm

Annex II :

Rainfall Record with respect to December 1957 (Dept. of Meteorology).

Rainfall Dec. 1957	Anuradhaoura	Batticaloa	Galgamuwa Tank	Kurunegala	Mahaoya	Mannar	Mahailuppallama	Nawalapitiya	Peradeniya	Trincomalee	Vavuniya
1	13.4	68.8	0.0	21.0	125.2	34.0	3.5	5.8	42.6	36.6	13.4
2	0.2	3.5	0.0	3.3	20.3	0.0	1.7	6.6	8.8	3.1	0.5
3	20.5	0.2	7.1	0.7	7.6	0.0	0.7	22.1	0.0	5.3	0.0
4	13.9	1.0	26.6	0.0	1.2	11.4	34.5	9.3	0.0	67.3	5.8
5	4.5	7.6	3.3	0.0	0.0	1.7	0.5	0.0	0.0	6.6	4.8
6	32.0	58.6	11.9	0.0	10.1	46.7	50.2	0.0	0.0	10.9	19.2
7	6.3	22.3	13.9	0.0	15.2	31.5	0.0	0.0	0.0	1.8	5.5
8	0.0	12.9	0.0	2.2	15.2	0.2	0.0	0.0	0.0	0.5	0.7
9	1.2	0.2	0.0	0.0	7.6	7.8	4.3	0.0	0.0	1.3	9.9
10	31.7	69.0	18.7	20.5	96.0	0.2	39.3	20.3	40.6	22.9	15.2
11	3.8	16.7	15.4	0.5	16.5	0.0	33.7	0.2	1.0	10.9	12.1
12	61.4	87.8	13.4	10.6	107.9	0.5	71.6	3.5	5.0	102.1	27.4
13	0.0	0.0	64.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	9.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	4.5	0.0	0.0	1.2	0.0	0.5	0.0	0.0	0.0	0.0
16	10.6	106.6	0.0	0.2	29.2	0.2	7.1	0.0	0.0	3.1	0.0
17	53.3	116.0	65.7	17.2	120.1	7.6	88.3	0.0	17.5	65.8	46.7
18	5.5	12.4	10.4	0.0	34.2	19.2	20.5	18.0	11.9	26.2	4.0
19	36.8	71.6	6.8	37.5	110.4	19.2	29.9	2.5	77.4	96.8	83.8
20	62.9	22.1	15.4	9.3	31.7	24.3	55.1	96.5	16.2	13.0	74.6
21	22.1	99.5	44.2	30.7	99.8	0.2	83.5	8.8	20.3	22.9	1.2
22	0.0	1.5	0.0	3.0	10.1	0.0	1.0	13.4	36.8	0.8	0.0
23	33.0	42.6	67.5	34.0	44.9	12.4	72.9	4.8	53.5	52.1	16.7
24	206.5	180.5	90.9	146.8	174.7	74.9	204.7	14.4	116.8	109.5	175.2
25	219.7	155.1	154.4	157.9	51.3	205.4	217.1	74.1	103.3	49.0	351.5
26	9.1	0.7	44.7	89.4	4.5	86.1	22.3	152.3	41.6	1.3	5.3
27	39.3	5.5	0.0	4.3	2.5	8.6	9.1	46.2	65.2	26.9	23.3
28	2.5	3.3	60.9	3.0	0.0	20.5	8.6	38.0	7.6	16.0	24.6
29	20.3	0.0	28.1	3.5	7.8	6.1	13.9	12.7	14.4	2.3	1.7
30	15.4	8.3	9.3	5.3	3.8	0.0	0.7	1.0	13.7	2.5	3.0
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.8	0.0	0.0	0.0
1 Day Max.	219.7	180.5	154.4	157.9	174.7	205.4	217.1	152.3	116.8	109.5	351.5
2 Day Max.	426.2	335.6	245.3	304.7	226.0	291.5	421.8	226.4	220.1	161.6	526.7
3 Day Max.	459.2	378.2	312.8	394.1	270.9	366.4	494.7	272.6	273.6	210.6	543.4
4 Day Max.	474.6	379.7	357.5	428.1	329.5	378.8	517.0	310.6	326.9	211.9	555.3
5 Day Max.	507.6	479.2	357.5	432.4	396.2	395.5	579.2	325.0	380.4	238.8	579.9
Return Period w.r.t. one day max. RF	200.0	5 - 10		5 - 10		25.0	25 - 50			25	200

Rainfall during Year 2014
Month : December

Basin	Station	16	17	18	19	20	21	22	23	24	25	26	1 Day Max	2 Day max	3 Day Max
Mahaweli Ganga	Kotmale(CEB)	0.0	25.0	15.0	23.0	25.0	5.0	17.0	22.0	60.0	98.0	0.1	98.0	158.0	180.0
	Victoria(CEB)	6.5	59.5	50.2	84.5	25.3	13.3	57.3	29.0	121.8	167.4	8.3	167.4	289.2	318.2
	Randenigala(CEB)	9.8	57.2	21.5	93.7	37.7	14.6	70.7	19.5	69.0	82.4	0.1	93.7	151.4	172.4
	Rantembe(CEB)	16.0	53.0	42.7	130.5	56.7	28.8	114.3	22.0	99.0	139.5	18.4	139.5	238.5	260.5
	Bowatenna(CEB)	23.4	56.2	23.4	98.7	76.4	63.3	48.7	60.9	184.4	185.9	0.2	185.9	370.3	431.2
	Ukuwela(CEB)	1.8	27.0	23.0	41.3	65.0	12.6	40.5	27.6	158.1	106.1	13.1	158.1	264.2	291.8
	U.Kothmale(CEB)	0.0	10.9	18.0	9.5	27.8	1.6	22.7	15.4	42.0	66.4	0.1	66.4	108.4	123.8
	Weraganthota(ID)	29.1	77.5	113.8	96.1	50.3	64.9	85.4	45.2	172.7	149.9	6.2	172.7	322.6	367.8
	Peradeniya(ID)	5.3	23.7	27.3	30.5	28.8	9.7	43.6	20.6	106.7	105.7	2.8	106.7	212.4	233.0
	Nawalapitiya(ID)	4.0	35.0	25.2	38.4	33.3	35.0	32.2	35.8	57.1	110.0	0.0	110.0	167.1	202.9
	Manampitiya(ID)	21.3	94.0	2.2	206.6	220.0	88.1	54.2	24.0	61.9	0.0	0.0	220.0	426.6	514.7
	Laggala (ID)	19.7	55.6	47.9	87.3	63.1	40.7	65.8	72.0	223.5	132.6	14.4	223.5	356.1	428.1
	Taldena(ID)	0.7	44.8	40.4	82.2	36.9	89.8	44.5	23.3	80.3	183.3	12.6	183.3	263.6	286.9
	Calidonia(ID)	0.0	7.4	10.7	18.1	18.0	9.6	20.9	5.6	30.6	67.3	0.0	67.3	97.9	103.5
Catchment Avg.	9.8	44.8	33.0	74.3	54.6	34.1	51.3	30.2	104.8	113.9	5.5				
Kelani Ganga	Castlereigh(CEB)	1.6	8.9	5.9	7.3	32.6	2.0	14.8	23.0	26.5	58.5	4.2	58.5	85.0	108.0
	Norton(CEB)	1.3	6.0	5.5	7.3	23.2	3.0	10.1	9.1	30.7	63.0	0.0	63.0	93.7	102.8
	Maussakelle(CEB)	8.0	9.0	5.2	5.2	22.1	3.3	14.1	8.8	24.0	71.0	3.5	71.0	95.0	103.8
	Canyon(CEB)	0.0	7.2	5.2	8.0	23.0	4.2	12.9	7.5	21.0	71.0	1.5	71.0	92.0	99.5
	Laxapana(CEB)	7.6	4.3	5.5	5.2	26.6	5.3	8.4	16.5	27.5	72.9	1.0	72.9	100.4	116.9
	Norwood(ID)	26.3	10.3	9.2	9.9	7.6	2.0	22.3	10.9	22.2	84.2	0.0	84.2	106.4	117.3
	Kitulgala(ID)	63.5	10.8	5.6	13.0	5.4	5.6	12.0	24.3	19.4	61.4	0.0	63.5	80.8	105.1
	Deraniyagala(ID)	30.8	11.4	5.4	16.2	3.7	3.1	19.9	15.5	14.9	99.3	0.0	99.3	114.2	129.7
	Holombuwa(ID)	0.0	4.6	4.2	16.4	7.0	7.0	10.7	17.3	82.9	147.7	0.0	147.7	230.6	247.9
	Glencourse(ID)	23.2	7.0	16.6	14.3	2.3	11.0	11.5	13.2	14.3	103.5	0.0	103.5	117.8	131.0
	Hanwella(ID)	40.6	3.5	0.6	3.8	1.3	6.0	6.6	10.5	26.0	79.7	0.0	79.7	105.7	116.2
	Colombo(ID)	0.3	0.8	3.1	6.2	0.0	3.6	4.8	26.3	50.1	63.0	0.0	63.0	113.1	139.4
	Colombo(MET)	0.1	0.5	2.5	6.0	0.6		4.3	26.1	52.2	67.8	0.0	67.8	120.0	146.1
	Catchment Avg.	15.6	6.5	5.7	9.1	12.0	4.7	11.7	16.1	31.7	80.2	0.8			

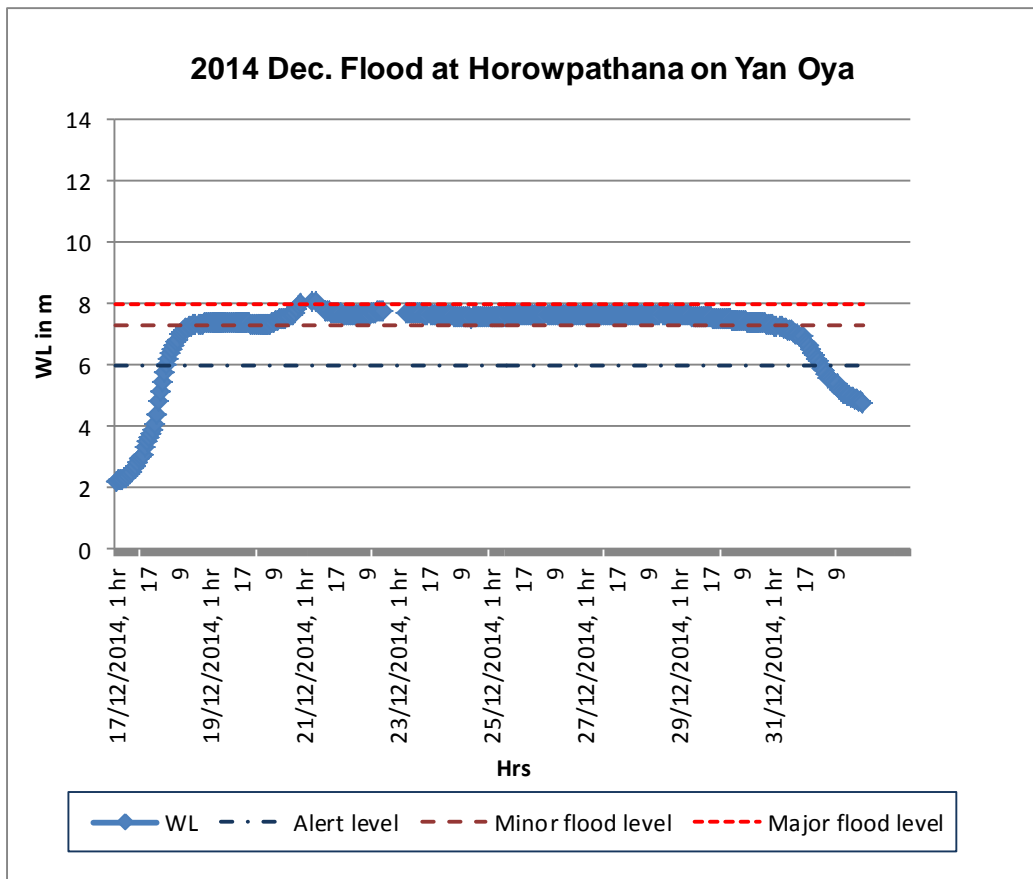
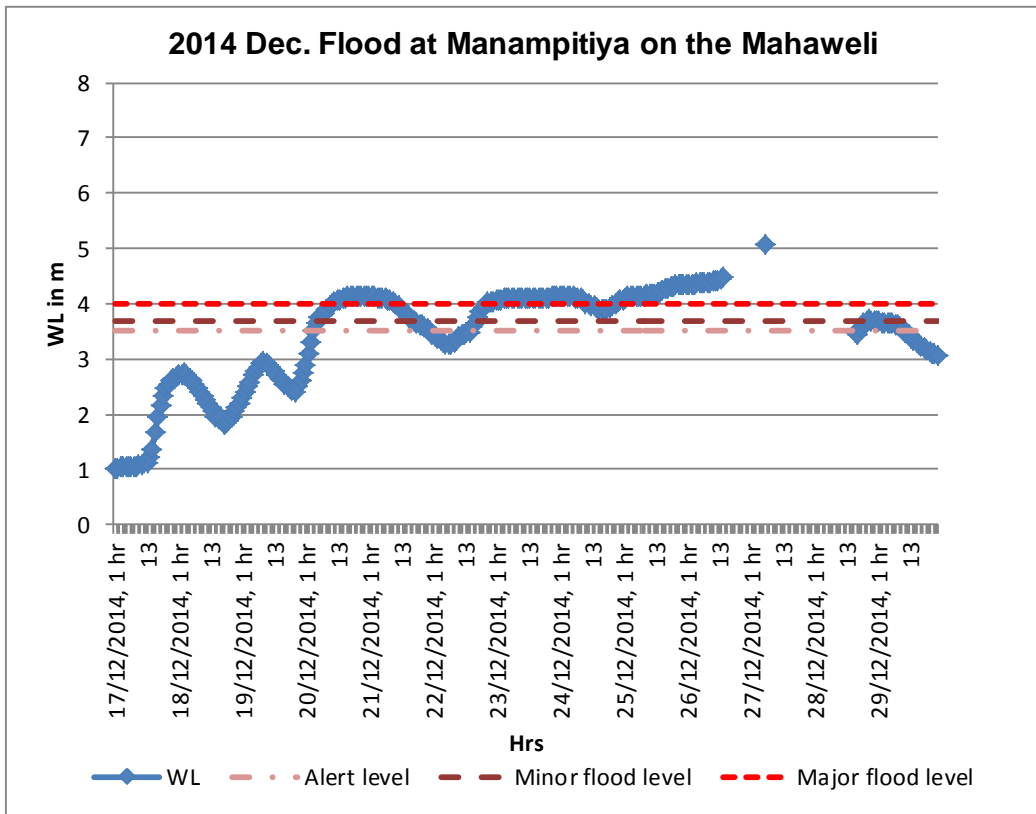
Annex III : Page II

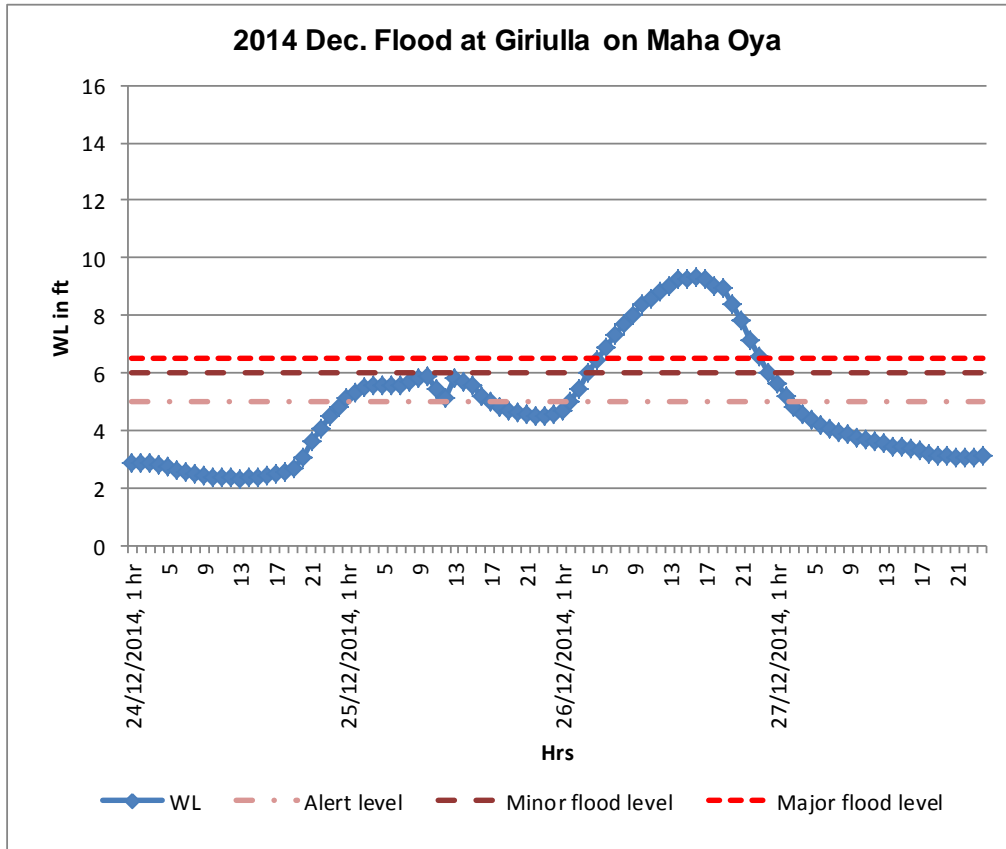
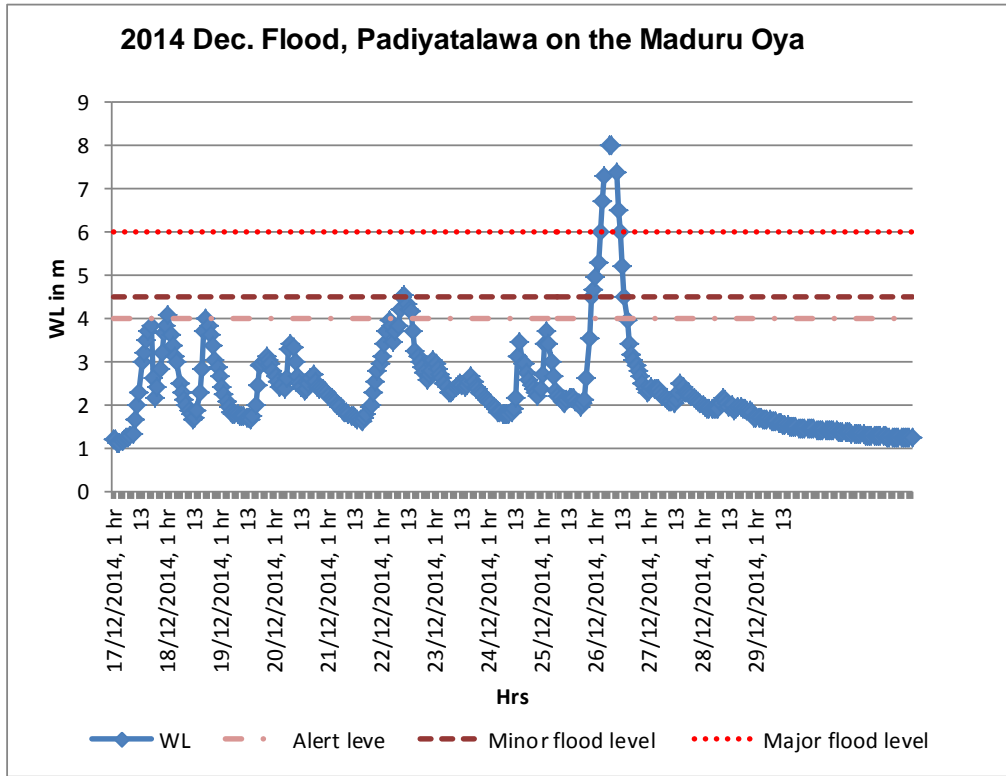
Basin	Station	16	17	18	19	20	21	22	23	24	25	26	1 Day Max	2 Day max	3 Day Max
Kalu Ganga	Ratnapura(MET)	20.9	7.0	3.8	10.5	2.2	4.0	7.0	9.0	20.8	40.2	0.0	40.2	61.0	70.0
	Ratnapura(ID)	28.3	8.1	4.9	2.0	3.0	4.7	6.3	6.4	29.3	51.2	0.0	51.2	80.5	86.9
	Putupaula(ID)	0.0	4.2	6.5	9.3	0.6	0.0	0.6	2.8	9.0	185.3	0.0	185.3	194.3	197.1
	Millakanda(ID)	11.2			2.2	1.2	3.3	4.0	4.0	26.3	145.4	0.0	145.4	171.7	175.7
	Ellagawa(ID)	1.4	4.5	8.7	47.8	2.8	6.7	5.8	7.3	20.8	85.4	1.1	85.4	106.2	113.5
	Kukulegama(CEB)	6.0	4.0	5.0	3.0	5.0	21.0	5.0	3.0	30.0	55.0	0.0	55.0	85.0	88.0
	Catchment Avg.	11.3	5.6	5.8	12.5	2.5	6.6	4.8	5.4	22.7	93.8	0.2			
Gin Ganga	Baddegama (ID)	0.0	2.0	4.2	26.8	0.0	1.2	1.8	3.4	15.9	111.9	0.0	111.9	127.8	131.2
	Tawalama(ID)	5.0	0.0	12.4	87.2	0.6	6.2	6.1	4.7	21.1	11.8	0.0	87.2	99.6	100.2
	Ginganga Avg.	2.5	1.0	8.3	57.0	0.3	3.7	4.0	4.1	18.5	61.9	0.0			
Nilwala Ganga	Panadugama(ID)	0.0	0.3	27.8	5.8	0.0	19.7	9.0	3.4	10.6	68.1	0.0	68.1	78.7	82.1
	Urawa(ID)	1.1	1.4	15.7	16.5	1.4	67.0	9.5	4.0	15.7	42.8	0.0	67.0	76.5	84.9
	Pitabeddara(ID)	0.0	0.0	0.0	9.0	0.0	29.5	7.0	4.2	11.2	67.5	0.0	67.5	78.7	82.9
	Catchment Avg.	0.4	0.6	14.5	10.4	0.5	38.7	8.5	3.9	12.5	59.5	0.0			
Kirindi Oya	Kuda Oya(ID)	0.0	7.8	28.9	39.0	1.1	10.8	11.6	15.0	42.5	110.1	0.0	110.1	152.6	167.6
	Tanamalwila(ID)	0.0	9.3	25.0	27.5	11.7	27.0	6.7	10.4	33.4	112.7	0.8	112.7	146.1	156.5
	Wellawaya(ID)	0.0	11.7	19.0	37.8	8.4	18.2	7.6	14.0	60.7	110.2	0.0	110.2	170.9	184.9
	Catchment Avg.	0.0	9.6	24.3	34.8	7.1	18.7	8.6	13.1	45.5	111.0	0.3			
Maha Oya	Badalgama(ID)	0.0	1.0	4.8	14.8	10.1	11.4	8.1	38.1	110.9	29.5	0.0	110.9	149.0	178.5
	Giriulla(ID)	0.0	4.3	5.9	27.3	17.6	26.3	11.0	24.9	121.0	69.1	0.0	121.0	190.1	215.0
	Catchment Avg.	0.0	2.7	5.4	21.1	13.9	18.9	9.6	31.5	116.0	49.3	0.0			
Attanagalu Oya	Dunamale(ID)	1.8	2.1	17.3	9.5	2.2	39.1	7.2	50.0	96.9	57.6	0.0	96.9	154.5	204.5
	Attanagalla(ID)	0.0	0.0	17.2	8.9	8.9	7.6	8.9	22.9	66.1	106.7	0.0	106.7	172.8	195.7
	Catchment Avg.	0.9	1.1	17.3	9.2	5.6	23.4	8.1	36.5	81.5	82.2	0.0			
Yan Oya	Horowpotana(ID)	5.2	55.9	0.6	74.1				18.6	54.9	90.6	59.2	90.6	149.8	204.7
Heda Oya	Siyambanduwa(ID)	3.1	26.4	54.6	63.0	13.6	16.3	7.4	12.6	84.4	150.2	4.3	150.2	234.6	247.2
Mee Oya	Galgamuwa(ID)	9.9	7.1	2.7	110.5	22.4	47.0	12.0	70.6	26.0	49.9	0.6	110.5	132.9	179.9
Maduru Oya	Padiyatalawa(ID)	24.4	70.4	22.0	64.2	26.0	78.9	56.9	21.2	114.0	118.5	6.7	118.5	232.5	253.7

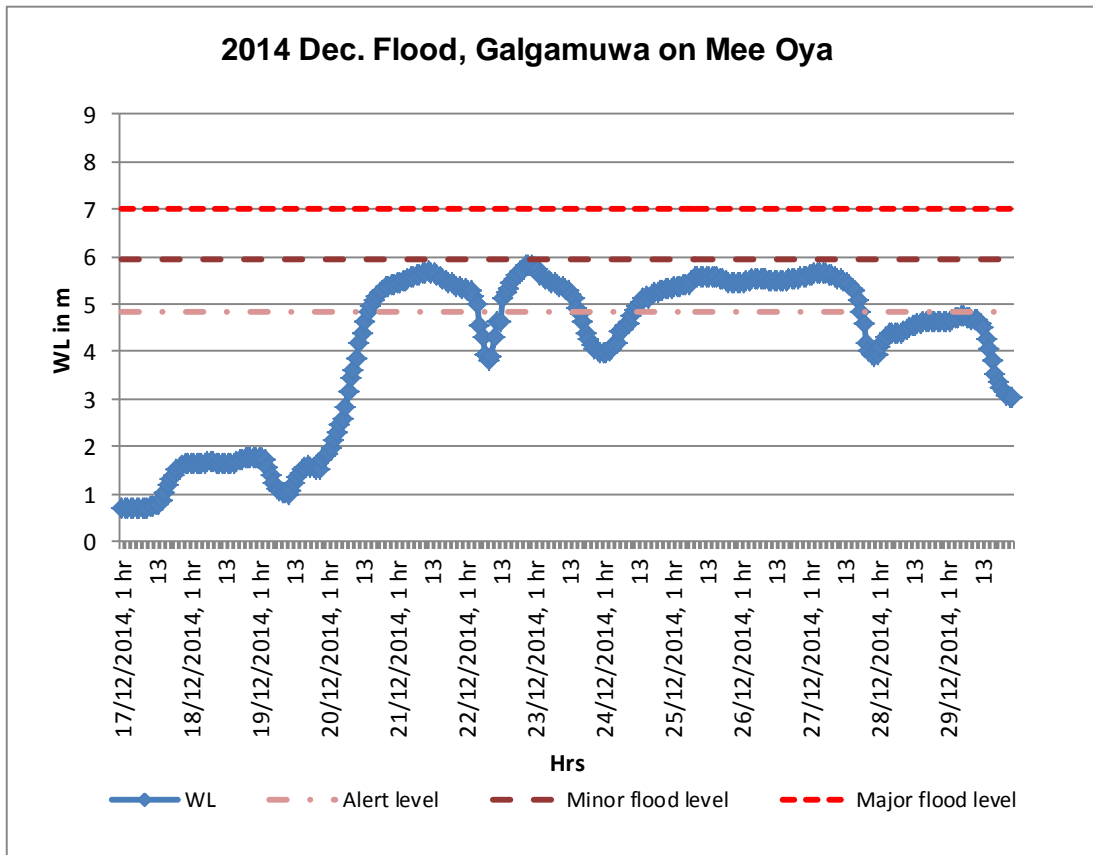
Annex III : Page III

Basin	Station	16	17	18	19	20	21	22	23	24	25	26	1 Day Max	2 Day max	3 Day Max
Malwathu Oya	Tantirimale(ID)	29.1	64.6	64.6	66.1	8.8					16.5	0.6	66.1	130.7	195.3
Kumbukkan Oya	Nakkala(ID)	2.2	31.4	76.2	48.8	12.0	23.4	30.6	35.4	85.4	99.0	0.0	99.0	184.4	219.8
Daduru Oya	Maspotha(ID)	0.0	13.2	6.4	47.0	10.4	28.8	11.5	52.6	67.2	92.7	4.3	92.7	159.9	212.5
	Amunugama(ID)	8.0	30.0	12.5	63.0	34.0	62.0	15.1	30.0	120.0	122.0	38.0	122.0	242.0	280.0
	Athiliwewa(ID)	0.0	10.2	14.0	8.1	6.7	28.0	45.1	10.6	28.3	90.2	79.0	90.2	169.1	197.4
	Ma Eliya(ID)	5.6		36.4	63.0	12.6	84.0						84.0	99.4	159.6
	Daisy Valley(ID)	0.0	26.3	9.9	46.2	12.7	16.8	14.3	27.3	133.3	131.6	0.0	133.3	264.9	292.2
	Diniminithanna(ID)	0.0	46.9	31.6	32.2	48.6	24.1	38.4	39.8	185.6	166.6	5.6	185.6	352.2	392.0
	Catchment Avg.		2.3	25.3	18.5	43.3	20.8	40.6	24.9	32.1	106.9	120.6	25.4		
Principal Stations (Dept. of Meteorology)	Anuradhapura	90.4	39.8	1.3	162.5	34.6	72.8	9.0	31.3	35.8	62.8	3.1	162.5	197.1	269.9
	Badulla	5.1	56.2	30.4	37.3	33.1	39.7	29.2	27.2	54.2	195.9	11.6	195.9	250.1	277.3
	Bandarawela	1.6	26.8	30.2	33.3	21.7	20.5	51.4	24.6	44.3	134.9	2.6	134.9	179.2	203.8
	Bataloa	14.2	22.4	2.9	147.8	142.7	65.4	59.3	31.5	37.1	123.6	101.1	147.8	290.5	355.9
	Colombo	0.1	0.5	2.5	6.0	0.6	3.8	4.3	26.1	52.2	67.8	0.0	67.8	120.0	146.1
	Galle	9.1	22.0	5.6	10.6	0.0	2.2	26.2	1.2	10.5	79.9	0.0	79.9	90.4	91.6
	Hambantota	0.0	17.7	66.9	39.5	3.7	16.7	11.3	11.4	30.5	112.0	0.2	112.0	142.5	153.9
	Jaffna	2.5	25.9	0.0	12.5	1.0	2.4	0.0	15.7	1.5	0.1	0.2	25.9	28.4	38.4
	Monaragala	0.4	18.4	43.6	65.0	13.7	7.5	11.3	29.5	62.2	145.7	1.1	145.7	207.9	237.4
	Katugastota	6.0	24.7	22.9	41.2	19.9	24.8	50.2	24.6	128.3	97.7	2.7	128.3	226.0	250.6
	Katunayaka	0.1	0.2	7.7	6.3	0.5	3.5	5.1	41.4	60.7	27.3	0.0	60.7	102.1	129.4
	Kurunegala	0.3	12.5	8.0	37.9	15.8	42.0	24.0	26.3	137.1	119.3	0.5	137.1	256.4	282.7
	Mahailuppallama	22.2	15.3	0.6	180.2	44.0	88.2	20.8	69.7	30.0	36.6	1.7	180.2	224.2	312.4
	Mannar	2.5	70.6	0.0	35.8	4.1	68.0	16.8	3.1	45.7	4.9	1.8	70.6	84.8	107.9
	Polonnaruwa	26.5	88.7	2.5	148.5	209.9	88.4	44.9	36.6	53.9	121.9	28.3	209.9	358.4	446.8
	Nuwara-Eliya	0.9	24.2	18.6	23.8	28.2	20.9	37.7	17.5	76.7	77.1	0.7	77.1	153.8	171.3
	Potuwil	7.0	47.7	53.1	33.2	36.1	10.2	37.3	25.2	82.2	275.8	16.7	275.8	358.0	383.2
	Puttlam	35.5	15.3	6.8	74.6	9.5	52.4	4.6	29.6	18.9	41.4	0.4	74.6	84.1	136.5
	Ratmalana	0.5	9.8	3.2	8.4	0.5	1.2	2.3	5.9	11.9	54.4	0.0	54.4	66.3	72.2
	Ratnapura	20.9	7.0	3.8	10.5	2.2	4.0	7.0	9.0	20.8	40.2	0.0	40.2	61.0	70.0
	Trincomalee	3.6	58.1	0.1	56.1	92.9	48.8	28.5	2.8	46.5	39.6	38.5	92.9	149.0	197.8
	Vavuniya	40.8	43.2	2.1	18.7	23.2	61.6	13.5	26.6	32.9	23.9	5.9	61.6	84.8	103.5
	Mattala	0.0	10.9	30.4	26.2	2.6	26.5	11.3	9.6	33.8	115.4	0.4	115.4	149.2	158.8
Country	Avg	9.6	21.9	17.6	41.3	23.4	25.6	21.7	21.6	58.6	89.4	6.5			
	Max	90.4	94.0	113.8	206.6	220.0	89.8	114.3	72.0	223.5	275.8	101.1	275.8	426.6	514.7

* Empty Cells denote the data not available







Hydrology in the Service of the People of Ceylon

Hydrology in the Service of the People of Ceylon

by

Shirley J. Bocks, M.A., Cantab., B.Sc., Lond.,

Irrigation Engineer, Hydrology.

SYNOPSIS

The objective in the preparation of this report is to reflect the current organisation and functions of the Hydrology Branch, with emphasis

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tion
Learning history is useful in understanding the present and planning the future. History of Hydrology Division goes up to 1947, the year of its establishment as a branch of Irrigation Department under the Irrigation Engineer in charge Shirley J. Bocks (M.A., Cantab., B.Sc., London, F.R. Met. S). Mr. Bocks, very keen and enthusiastic Engineer, headed the hydrology Branch for 13 years until 1960.

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Mr. Bocks had a very broad vision for the advancement of Hydrological sector of the country and his own work plan for the capacity enhancement of Hydrology Branch. His intension was to address all kinds of requirements of hydrological data and information of the country without confining to the needs of the Irrigation Department. As a self-esteemed and impressive man he struggled to achieve the rights of all categories of employees worked under him, which he considered as an essential requirement to build up successful organization. This paper was a complete re-organization proposal for the Hydrology Division, prepared by Eng. Bocks, in his own words, and presented to his employer, then Director of Irrigation Department.

It is interesting to go through this document and learn the historical background and the original expectations of the forefather of Hydrology Division. This is good time to post-evaluate how much of his expectations were achieved by himself and his successors and how much are still lagging behind after a period of 67 years of its existence. Further, this is useful for us to formulate the future plans and strategies to achieve not only the dream of its founder, Shirley J. Bocks, but also the dreams of the entire nation.

Eng. Ms. P. Hettiarachchi
Director of Irrigation (Hydrology)

2. Hydrology

Hydrology is the science that treats of the occurrence and dis-
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phere. Hydrology therefore deals with

Hydrology in the Service of the People of Ceylon

*By : Shirley J. Bocks,
M.A., Cantab., B.Sc., Lond, F.R. Met.S.,
Irrigation Engineer in Charge,
Hydrology Branch, Irrigation Department, Ceylon, (1947 -1960)*

Synopsis

The objective in the preparation of this report is to reflect the current organization and functions of the Hydrology Branch, with emphasis on limitations that now bear on its activities.

The report concludes with a suggested program of re-organization that would be conducive to maximum utilization of hydrologic information and advice in the ecological development of the country.

1. Introduction

The population of Ceylon is now 7.3 millions. It is increasing at the rate of 13 persons per hour or 114,000 persons per annum. A large population with a high rate of increase imposes a heavy and steadily increasing biotic load on the natural resources of a country. Population-pressure, in a country that is essentially agricultural, occasions a vital need for the maximum development of the natural resources of the country on a basis of sustained yields. Among the most important of the natural resources of Ceylon are water, soil and sunshine. Human life in Ceylon depends chiefly on the paddy plant; paddy makes most exorbitant demands for water, soil and sunshine. Hence the water resources of Ceylon come to be regarded as one of the most important, if not the most important, of the natural assets of this country. On its development on lines of sound ecology, pivots the health and prosperity of the people of this country.

2. Hydrology

Hydrology is the science that treats of occurrence and distribution of water on the surface of the earth and in the lower atmosphere. Hydrology therefore deals directly with the water resources of the country. Water resources may be classified in the following manner.

- (a) Incident precipitation and condensation;
- (b) Surface waters; and
- (c) Ground waters.

Incident precipitation makes the concurrence of two converging sister sciences: hydrology and meteorology. Meteorological activities were commenced in the last century. The ecological value of meteorology could not be overlooked. A Colombo observatory was founded early in this century. The officer in-charge was an "Assistant Superintendent of Surveys, observatory"; the observatory was attached to the Surveyor General's Department. When the value of meteorology was more recognized, there was a "Superintendent of Surveys, Observatory" and the status of the Observatory moved up one notch. Later, there was a "Superintendent, Colombo Observatory" still attached to the Surveyor General. About two years ago, the lien collapsed and there emerged a "Department of Meteorology", divorced from the Surveyor General and free to adjust its activities to meet the converging interests of all Departments of Government and private bodies.

Hydrology treats not only of incident precipitation but also of surface and ground waters available for agriculture and other development. Therefore, from a biotic standpoint, hydrology has a greater bearing on the life and welfare of the people of Ceylon than meteorology. The Hydrology Branch of today is a part of the Irrigation Department in precisely the same way that Colombo Observatory used to be part of the Department of the Surveyor General. In view of an increasing understanding of the role of hydrology in the life and welfare of the people, there will come a time when there will be a separate Department of Hydrology or a Department of Hydrometeorology which will be free to adjust its activities to face squarely all interests in the

ecological development of the country. The writer sincerely hopes that this advancement in hydrology in Ceylon will not be posthumous.

There is another science, parallel to hydrology, pursued by the Government: Mineralogy. The Government Mineralogist is attached the Director of Industries in the same way that the Chief Engineer, Mechanical Branch, Irrigation Department is related to the Director of Irrigation. So if there were a Government Hydrologist attached to the Director of Irrigation, his position would be analogous to the position of the Government Meteorologist relative to the Director of Industries provided that there to correspondence in status, activities and salaries.

3. What Hydrology has to offer

Hydrologic data are of interest to departments of Government engaged in the development of the country when such development pertains, however distantly, to the water resources of the locality of development. A synoptic reflection of role of hydrology in developmental programmers of different types is provided in this table.

Nature of Purpose	Type of data furnished	Interested Bodies
Design of Storage Reservoirs for Irrigation	Report giving daily, monthly and annual yields from catchment, flood hydrographs and hydrograph of design flood.	Irrigation Dep.
Hydro-power	Same as above	Dep. Of Electrical Undertakings
Water Supply	Same as above	Municipalities, Urban Councils
Dry zone cultivation not under Irrigation Schemes	Fluctuations in water table; ground water resources – yields from wells	Department of Agriculture
Diversion Schemes for Irrigation	Minimum and Maximum flows, Hydrograph of medium flood.	Irrigation Dep.
Housing Schemes	Maximum flood-levels	Municipalities, Urban Councils and town councils
Paper Mills, Steel Rolling Factories & similar industrial projects	Report on surface and ground water resources of localities	Dep. Of Industries
Flood-forecasting	Predicting behavior of floods from telegraphed rainfall data.	Municipalities, Urban Councils and town councils & Railway.
Bridges, road and rail works	Maximum flood-level, maximum flow	Dep. Of Public Works, Railway
Sedimentation of reservoirs & sediment flux in streams	Silt sampling data	Gal Oya Development Board, Government Agents, Irrigation Department, Soil Conservation Branch of Dep. Of Agriculture.
Flood Control	Hydrographs and frequency data of floods	Irrigation Department
Reduction in stream pollution	Stream flow habits	Dep. of Medical & Sanitary Services, Municipalities

This table indicates that hydrology can meet the requirements of many interested departments of Government and other bodies, provided the facilities for so doing are made available.

4. What Hydrology Now Offers

The Hydrology Branch is a part of the Irrigation Department. As such, the activities of the Hydrology Branch have a bias towards irrigation. The major part of the data now being gathered is compiled with a view to future schemes of irrigation by diversion and by storage. There is an

almost complete neglect of hydro-power, water supply, flood forecasting and industrial use. The flows down to double falls at Diyaluma on the Haputale Wellawaya road and down the double falls at Dunhinda pass un-gauged although there are excellent gauging weirs already in existence, above the higher of each of these falls. The writer has seen V-notches built into mountain streams in the region of Bandarawela and of Nuwaraeliya but no gauging are been taken. Gaugings taken on some of these streams will indicate the possibility of adequate water supply to these two towns. Laxapana falls on the Muskelliya Oya will form a late stage of the hydro-electric works at Norton Bridge; yet, as far as the writer is aware, the flow down these falls is not being gauged.

Officers of the department of Agriculture come to the Hydrology Branch in quest of data on water tables in the dry zone. The citrus, for example, dies if the water table rises to less than three feet below ground. In regions where the water table rises through a small range, certain plants will thrive. Although such information is vital for plant growth, no data are being compiled. Further, where there are no schemes of irrigation, cultivation in the dry zone will have to depend on ground waters. Investigations in the ability of the soil to supply water for irrigation have a high biotic value. For example, extensive cultivation has been accomplished in California on land irrigated by ground waters; the mean annual rainfall in California is only 27 inches while in the dry zone of Ceylon is two and half times as much. It is a pity that no investigations are being conducted into ground water yields from wells in different areas of the dry zone.

The only flood-forecasting being done by the government is now an incidental function of the department of Meteorology. This Department makes forecasts of flood level on the Kelani from telegraphed rainfall data. The Department had no gauging, except measurement of water level, to go by. Flood-forecasting can be easily done for all significant by the Hydrology Branch. This will be facilitated if hydrology Branch is accommodated in the premises now occupied by the Divisional Irrigation Engineer, Western Division, on the ground floor of the building occupied by the Department of Meteorology. Rainfall data, received in the Department of Meteorology by telephone and by telegraph, will be immediately available to Hydrology Branch, housed in the lower floor of the same building. By methods of flood-synthesis, the hydrograph of the flood past significant towns in the 30-hours following can be predicted on the assumption that no more rainfalls. If rain continues, the prediction will be revised from day to day. This service of flood prediction can be made available to avissawella, Hanwella, Colombo, Gampola, Kandy, Minipe, Kochchikade, Chilaw, Ratnapura, Kalutara, Matara, Gintota, and Ambalantota, all of which are located on rivers of magnitude.

Emphasis has now been placed on the limitations that bear on the functions and activities of the Hydrology Branch in Ceylon. Under these limitations, the service that the Hydrology Branch has been able to offer up to now has been restricted to :-

- (a) Reports on the water available for the design of storage reservoirs;
- (b) Reports on the water available for irrigation by diversions;
- (c) Reports on flood-habits relative to the design of irrigation schemes;
- (d) Reports on the hydro-meteorology of catchments above proposed reservoir sites;
- (e) A statistical analysis of rainfalls in Ceylon, which shows that R inches of rain in part T of a year may be expected to be exceeded N times in hundred years in any given locality in Ceylon;
- (f) A report on Maximum Anticipated Rainfalls in Ceylon; and
- (g) A report on flood flows from Ceylon catchments.

Incidental reports, outside the normal run, include one on Wind Power agriculture in Jaffna Peninsula and another on the Possibility of Hydro-power from Muthu Aiyan Kattu Kulam.

5. A Short History of the Hydrology Branch

In the course of 19th century, Governors of Ceylon and Government Agents showed interest in the repair of breached tanks in the country. An "Irrigation Officer" was appointed late in the century; from this humble beginning, sprang the Irrigation Department today.

Nearly 70 years later, in 1942, under pressure of accumulating data of reservoir replenishment, there was formed a "River Gaugings Sub-division". The objective, at the time was to calculate the replenishment of reservoirs from the data available and thus arrive at the yields

from the catchments above the reservoirs. Nine men were employed at an annual cost of Rs 4,000/- for all nine and one of the duties of an Assistant Irrigation Engineer was to supervise these men.

The writer of this report assumed responsible charge of this River Gaugings Sub-division in 1945. The River Gaugings Sub-division came to be known as the Hydrology Branch. A River gaugings section of the Hydrology Branch was formed with a Technical Assistant in charge of activities of six "Gauge Recorders". The term "gauge recorder" has the weakness that it does not describe the function of the men: they are "river gaugers" –People who gauge the flow in rivers. However, the term, gauge - recorder still persists. The River Gaugings Section worked alongside a Computing Section where eight computers worked under the supervision of a T. A. (Technical Assistant). In England, the term "computer" is applied to a senior draughtsman, who computes quantities. In the Hydrology Branch, it applies to men engaged in computing the replenishment of reservoirs and the flow along streams.

A steady increasing demand for hydrologic data from the Irrigation and other Departments occasioned an uniform increase in personnel, functions, activities and output of the Hydrology Branch. In the year 1951/52, the total cost of hydrological activities, excluding the wages of gauge readers and including the salaries (from Personal Emoluments and from sanctioned estimates), rent allowances, living allowances, hire of boats and the hire of labour for current-metering work is Rs 187,000. This is nearly 47 times the cost of the labour employed in 1942.

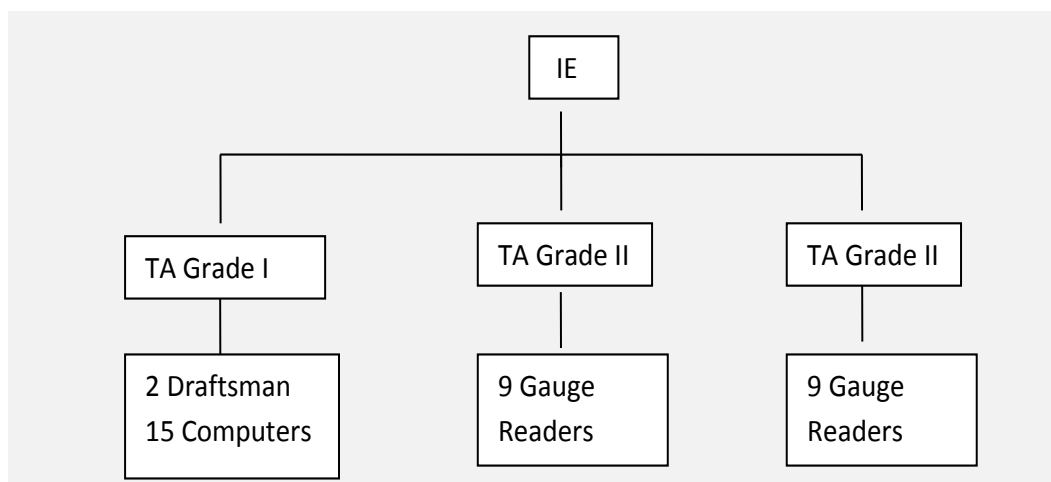
6. Present Organization of the Hydrology Branch

At the end of 1951, the staff of the Hydrology Branch consisted of

One	I. E., Grade II
One	T.A., Grade I,
Two	T. AA, Grade II,
Two	Draftsman,
Eight	Computers,
Seven	Temporary Computers,
Eighteen	Gauge Recorders,
One	Peon.

The clerk dealing with matters pertaining to the Hydrology Branch worked in the office of Divisional Irrigation Engineer, Research & Design; all cases and files pertaining to the Hydrology Branch were retained in the office of the D.I.E.,R.& D. The Hydrology Branch has not been permitted to retain cases pertaining to Hydrology Branch. Although the I.E., Hydrology assumed responsibility for the accuracy of data furnished, he was never allowed to dispatch the data direct to the D.I. or the D.I.E. concerned.

The administrative organization of the Hydrology Branch is conveyed by this diagram.



Of the 15 computers shown above, only 8 hold permanent, monthly-paid and pensionable post of computer. The others are on daily pay. All gauge recorders are on daily pay. There are 320 gauge- readers in Ceylon. These men record the water levels at their respective stations daily and, during floods hourly. These gauge-readers do not come under the direct control the Hydrology Branch; they are controlled by territorial sub-divisional offices although their work is exclusively for the Hydrology Branch. The weakness inherent to this arrangement is apparent.

On January 31, 1952, all temporary computers shall be discontinued and 10 new freshly – appointed, monthly-paid computers shall take their place increasing the total number of computers to 18.

7. Functions of the Personnel comprising the Hydrology Branch

The duties devolving on the personnel on the Hydrology Branch are :-

Designation	Duties
I.E.	<ul style="list-style-type: none"> • Production of technical reports pertaining to the water resources of basins , given catchments and given localities. • Organization and supervision of work done by T.AA. in charge of sections. • Development of techniques for more accurate measurements of stream flow with current-meters, for deeper investigation into the consistency of stream-flow data produced, for research into rainfall/run-off relations, for analysis into the relations between rainstorms and resulting flood-flows and for studies into the yields available from exploited catchments. • Investigation into losses attendant on storage. • Organization and maintenance of evaporation stations over Ceylon. • Organization and supervision of salt sampling stations. • Organization and supervision of silt sampling stations. • Teaching staff methods of flow synthesis, the conversion of observations into finished hydrologic and sediment flux data and methods for investigating into rainfall/evaporation data. • Correspondence & general administration of hydrology Branch.
T.A., Grade I.	<ul style="list-style-type: none"> • In direct charge of computing work involved in the preparation of data pertaining to stream flow, reservoir replenishment' sediment-flux and evaporation. • Is responsible for the accuracy of data produced by computers
T.A. Grade 2	<ul style="list-style-type: none"> • In direct charge of field operations: organization and supervision of river gauging squads, monthly payments, maintenance of current metering and silt sampling squads, surveys of gauging stations with cross sections extending to maximum flood level, preparation of rating curves, establishment of cable-car river gauging stations, surprise inspection of record made by gauge readers (unfortunately under administrative control of S.D.OO.).
Draughtsman	<ul style="list-style-type: none"> • Preparation of Isohyetal maps, hydrological maps, graphs, hydrographs, diagrams; computation of areas of catchments with planimeter.
Computers	<ul style="list-style-type: none"> • Calculation of the amounts of water released from the sluice of tanks, escaping over the spill way, evaporation from the surface of the tank and and the algebraic increase in the amount of water in the reservoir. • Calculation of the flow along streams. • Preparation of tables of day-to-day flows, monthly flows and annual flows. • Computing amount of precipitation on catchments and collection collation with calculated yields. Computations of daily evaporations from incoming records of observations.
Gauge Recorders	<ul style="list-style-type: none"> • River gauging with current meters. • Silt sampling, determination of sediment content of samples by evaporation. • Computation of flows from current meter observations. • Calibration of current meters under supervision of T.A. in charge.

The peon is of general assistance to all members of the Hydrology Branch.

In order to avoid overlap or omission of duties, one of the T.AA Grade 2 is in charge of the Northern halves of the dry zone and of the wet zone; the other is in charge of the southern halves.

8. Salaries and conditions of Service of Personnel of the Hydrology Branch

The stability of an organization and the interests taken in its functions correspond to load and responsibility of the post and the salary paid. It calls for a heroic effort on the part of an officer to continue working with unflagging interest when his promotions are delayed and when his former juniors are promoted over him in seniority. This is precisely what has happened to the I.E. in charge of Hydrology Branch. He works under an inaccurate designation "engineer", when his duties and post are that of "Hydrologist". He is a Master of Arts of the University of Cambridge, a bachelor of Science (1st Class Honours) of the University of London, and a Fellow of the Royal Meteorological Society. The subject he pursued in Cambridge and in London was Pure Mathematics. As such he is well equipped for mathematical investigations in the field of Hydrology. He was sent to the International Engineering Company, San Francisco, in 1948, in order to advise that company on the hydrology of the Kelani Basin. He has been incorrectly designated "Engineer" and has been penalized (by having his promotion from I.E., Grade 2 to I.E. Grade 1 delayed) for being saddled with this inaccurate designation. His colleagues in same seniority in 1948 are now I.EE. in charge of divisions; his time for promotion to the scale of Divisional Engineer is therefore ripe. He has asked the D.I. for the provision of the post of Hydrologist on a scale of Rs 13,200 – 600 – 15,000 which is the scale of a Divisional Engineer and the Govt. Mineralogist. The position of the Hydrologist relative to the D. I., would then be analogous to the post of Govt. Mineralogist in relation to the Director of Industries. When he asked the D.I. for provision of a post Hydrologist, the D.I. replied stating that the matter would receive due consideration when the re-organization of the Department is considered.

The computers of the Hydrology Branch are on a scale of Rs 660 – 42 – Rs 1,668. On this scale, they will never be able to marry and have even one child. Although their posts are permanent and pensionable they are always on the lookout for more remunerative employment.

The gauge-recorders are employed on a temporary casual basis. They can be discontinued with one day's notice. They are paid only Rs 2/- per day on the scale Rs 2/- -/12 – Rs 3/44. They have to be good swimmers and are exposed to dangers from wild animals at their stations. They have to take good care that their boats do not capsize when current metering high flood flows. Those of them who are married have to support a family at their home station and support themselves at their gauging station on less than Rs 3/44 plus living allowance per day. They get no rent allowance. It takes a long time to train a gauge recorder for accurate current metering work. With nothing to hope for their employment, they resign whenever better jobs come their way. In the last six years there have been 70 resignations and 82 appointments. The river gauging sections have been in a state of flux with trained personnel leaving and raw recruits taking their place. At the time of writing 5 of the 18 gauge readers are being trained. The continual loss of trained personnel means that while the cost of Government remains unchanged, the output in current - metering and silt sampling drops. Only the consideration will keep the trained gauge readers permanently in the Hydrology Branch – adequate prospects.

With regard to the Technical Assistants and the Draughts men, there are no comments of the above nature that would be warranted. Each of the two T.A. in charge field activities has to supervise operations over half the area of Ceylon, 13,000 square miles. Each T.A. is allowed 240 miles and 6 days subsistence per month for this duty. One will infer that 13,000 square miles per capita is too large an area for adequate supervision and 240 miles per is too little travelling. A natural solution for full deployment of river gauging will consist of more T.AA and more travelling facilities.

Another weakness in the existing organization is a shortage of academically qualified men who can undertake intricate investigations in the field of hydrology. The T.A. Grade 1 is a Bachelor of Civil Engineering of the University of Mysore. He graduated in 1925 and has five more years of service under Government. All complex technical work is now being done by and

only by I.E. Hydrology. A need for a graduate assistant cannot be overlooked in view of the steadily increasing demand for hydrologic data.

9. A Proposed programme for Re-organization of the Hydrology Branch

The service that the Hydrology Branch can give Departments of Government and other bodies has been described on pages 2 to 5 of this report. The shortcomings that now restrict a full deployment of hydrological activities over the island are:-

- (1) Lack of facilities for gaugings for the development of Hydro-power; the remedy lies in placing the Hydrology Branch in such a position that it can, like the Department of Meteorology, undertake jobs with the full field of ecological development in Ceylon in view.
- (2) Lack of facilities for gaugings for urban and industrial water supply. The Hydrology Branch has all equipment necessary. It can easily discharge this function if administrative provision is made. The requirements can be easily faced if the Hydrology branch were a separate Department, like the Department of Meteorology.
- (3) No gauging of variation of water tables. The remedy again lies in increasing the status of the hydrology Branch and making administrative provision for facing squarely the converging interests of all departments of Government.
- (4) No provision for a service of flood-forecasting. Telegraphed rainfall data are received in the Dep. of Meteorology. The remedy would lie in moving the Hydrology Branch into the premises now occupied by the Divisional Irrigation Engineer, Western Division, on the ground floor of the building housing the Dep. of Meteorology.
- (5) The replacement of incorrect designation, "Irrigation Engineer, Hydrology" by the apt designation "Hydrologist" and the provision of the post Hydrologist on the scale: Rs 13,200 – 600 – 15,000, analogues to the post of a Divisional Irrigation Engineer or Government Mineralogist. The D.I has already proposed in writing that the provision of this post will receive due consideration when the re-organization of the Department is undertaken.
- (6) The appointment of another first class graduate as Assistant hydrologist. This will remedy the present weakness that all highly technical work has to be done by and only by the I.E.
- (7) The Hydrology Branch has no direct control over the 320 gauge readers scattered over the Island, although the gauge readers work exclusively for it. The remedy would lie in the Hydrology Branch taking over all gauge readers in the Island. Payments can be made by money order or personally on receipt of acceptable gauge returns.
- (8) There is a disconcerting disparity in the wages paid to gauge readers in different sub-divisions. Some get Rs 5/- per month and others Rs 2/- per day. If all gauge readers were paid from the Hydrology Branch, uniformity can be introduced.
- (9) At present, payments are made by the Sub-divisional officer, Laboratory in the following manner: cash is handed over to the T.AA. Grade 2, and they proceed all the way from Colombo on a payment circuit visiting their current-metering squads scattered over the Island. They have a large distant to travel by car and on foot without the usual provision of a closed vehicle for the safe transport of government cash. The solution lies in having, say, four T.AA, stationed at Vavuniya, Dambulla, Moneragala and Ratnapura, each having a jurisdiction of $\frac{1}{4}$ of the Island. There will be a shorter distance to travel. These four T.AA may come under the direct control of a third Assistant Hydrologist, who should be an experienced sub-divisional officer and who will be stationed in Colombo. Assisted by clerk and by an accounts clerk, he will make payments to gauge readers by money order on receipt of acceptable gauge returns and will make payments personally, once a month, to all river gauging and silt sampling parties. An objection that may be raised to having 4 T.AA (River Gauging Officers) at Vavunia, Dambulla, Moneragala and Ratnapura is that floods may be expected in the wet zone anywhere between May and October while the majority of the gauge recorders (river gaugers) idling on dry river in the dry zone. The solution to this objection will lie in placing the gauge recorders in the dry zone under the control of the 3rd Assistant Hydrologist and of a T.A. (River Gauging

Officer) Ratnapura during these months. In these months the T.AA (River Gauging Officers) at Vaunia, Dambulla and Moneragala will be engaged in surveys of gauging stations and of river beds, ground water observations and in pumping experiments that determine yields from wells in the dry zone. As the 4 T.AA are to be permanently engaged in hydrological investigations, such service shall be made attractive. They may be given the designation, "River Gauging Officer", and be put on the salary scale of a junior engineer and I.E. Grade 2, Rs 3,360 – 380 – 7680. The Assistant Hydrologist in charge of these River Gauging Officers may be on the scale RS 5,160 - 360 – 12720, (scale of I.E., Grade 2).

- (10) Permanent Computers on the scale of Rs. 660/-42-1,668 have very little to hope for in remuneration. There will be resignations and rash appointments. In educational attainments, they have attained and passed the standard of the J.S.C. examination, the S.S.C. examination and one of them is a matriculate. Now a person with the J.S.C. examination is qualified for selection as an Assistant Clerk. After two years of service in the capacity of Assistant Clerk he is eligible for absorption in the General Clerical Service provided he passes the pertinent examination. Thereafter he is free rise to the top-most ranks of the Clerical Service according to his merit. In the case of Computers the educational qualifications are similar; the work is far more important in view of its relation to the invaluable water resources of the country. The General Clerical Service officers reasonable prospects of remuneration that may be earned by continued meritorious service. It will be fair to extend to the Computers the terms of service now applying to clerks. The following scales of salary and designations may therefore be employed :-

Designation	Scale
Computer Grade III	840 – 72 - 2,434
Computer Grade II	1,440 – 120 - 3480
Computer Grade I	3600 – 180 – 5,040
Computer Special Grade	5,280 – 240 – 6,240.

There should be an examination between the posts of Computer, Grade II an Computer, Grade III. The examination of the General Clerical Service may be made applicable to Computers with minor modification: the paper on Accounts may be suppressed and they will sit instead for papers in elementary mathematics and in Hydrology. Provision may be made for the introduction of graduates directly into the class of Computer Grade I.

- (11) Gauge Recorders, too, may be similarly placed on the scales of the General Clerical Service. Resignations will then cease and trained personnel will be permanently retained. Provision would have to be made for the post of River Gaugers on scales of salary identical with those given above on this page. The designation will be: River Gaugers , Grade III, II, I and Special Grade. They, too, should pass the examination of the General Clerical Service with similar modification. The usual paper in Accounts will be suppressed and they may offer instead papers in elementary mathematics and in River Gaugings. The examination papers relating to elementary mathematics, hydrology and river gaugings may be set by the Hydrologist.
- (12) Each River Gauging Officer (Presently T.AA) will have his own field of activity spreading round his station. According to the present arrangement, the area of authority of each T.A. in charge of River Gaugings extends from Colombo to the east coast. The T. AA. (River Gauging Officers) stationed at Vavuniya, Dammbulla, Monaragala and at Ratnapura will have equipment in this charge. Each of these T.AA will therefore need a Store Keeper to maintain his stores in order when he is on circuit. It will be seen that this suggestions made regarding salaries are not fantastic. The post of Hydrologist is a reasonable proposition on a salary identical with that of the Mineralogist. The River Gauging Officers are T.AA. If they were not in the Hydrology Branch, they can rise to the post of I.E., Grade 2. The salary scales proposed in their case are those of a Junior Assistant Engineer and of an I.E. Grade 2. The salary scales proposed for the three Assistant Hydrologists are those of I.E., Grade I and II; hence they are one notch below that of the Hydrologist. The computers and river gaugers would on the scales of salary of

the General Clerical Service. The draftsmen would remain on the present salary scales applicable to them.

The proposed organization of the Hydrology Branch is exhibited diagrammatically on an attached sheet. Duties and scales of salary have been included in order to make it complete as possible.

10. Conclusion

There have been many objectives in the preparation of this paper. One has been to indicate the importance of hydrology in the ecological development of the country. Another has been to indicate the functions and applications of hydrology possible in such schemes of development. A third objective has been to outline the limitations that now bear on the application of hydrologic data to all converging interests of Government. The fourth objective was to describe the present Hydrology Branch and to present a synoptic survey of its activities. The fifth objective relates to a suggested reorganization of the entire Hydrology Branch that would be conducive to a more complete deployment of its activities in the service of the Government and of the people.

The writer sincerely hopes that these objectives have been attended with reasonable satisfaction in view of the limitation imposed by the size of this report.

The road to survival that Ceylon must tread lies in the maximum utilization of her natural resources on lines of sound ecology. Of her natural resources, water is probably the most important. It furnishes light, power, drinking water and, through the medium of the paddy plant, life for the people of Ceylon.

