FLOOD DESIGN
OF
KHOLONGCHU HYDROELECTRIC PROJECT

Project Report submitted in partial fulfilment of the requirement for the degree of

Bachelor of Technology

in

Civil Engineering

under the Supervision of

Mr. Abhilash Shukla

By

Shubham Singh Guleria(111709)

Rajneesh Gupta(101259)

to

Jaypee University of Information and Technology

Waknaghat, Solan – 173234, Himachal Pradesh

CERTIFICATE

This is to certify that project report entitled "Flood Design Of Kholongchu Hydroelectric Project", submitted by SHUBHAM SINGH GULERIA and RAJNEESH GUPTA in partial fulfillment for the award of degree of Bachelor of Technology in Computer Science & Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Date: 25-5-15

Prof. Dr. Ashok Kumar Gupta

Head of the Department

Supervisor's Name : MR. ABHILASH SHUKLA

Designation : Assistant Professor(Grade -II)

ACKNOWLEDGEMENT

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CHAPTER 1

1. INTRODUCTION

The Royal Government of Bhutan (RGoB) is proposing to harness the country's vast hydro power potential. Hydro power generation has been identified as one of the core area of cooperation between India & Bhutan. In this context, RGoB has assigned the task of investigation and preparation of Detailed Project Report (DPR) of various Hydro Electric Projects to India. The work for the investigation and preparation of DPR of Kholongchu Hydro-Electric Project on Kholongchu, a tributary of Dramengchu (Gongrichu) in Manas river basin has been assigned to Satluj Jal Vidyut Nigam Limited (SJVNL). The following development alternatives for the project have been considered:

i) Diversion Dam at D-3

This alternative envisages the construction of diversion dam across river Kholongchu about 11 km upstream of its confluence with Dramengchu (Gongrichu) at Duksum. The diversion site is located in Trashiyantse District in the North – Eastern part of Bhutan at Latitude 27^{o} 30' 32'' N and Longitude 91^{o} 31' 10'' E. It is proposed to utilize a net head of about 550 m for development of hydro power. The power house is located about 4.5 km downstream of Duksum. The project catchment lies between Latitude 27^{o} 27' 00'' N to 27^{o} 57' 36'' N and Longitude 91^{o} 18' 36'' E to 91^{o} 39' 36'' E. Catchment area upto the diversion site is 1120 sq km, out of which about 15 sq km is snowfed above an elevation of 5000 m.

ii) Diversion Dam at D-7

This alternative envisages the construction of diversion dam across river Kholongchu about 16.5 km upstream of its confluence with Drameng Chu (Gongrichu) at Duksum. The diversion site is located at Latitude 27^{o} 32' 50'' N and Longitude 91^{o} 30' 49'' E. The length of the proposed head race tunnel on the right bank of the river is about 16 km. The power house is located about 4.5 km downstream of Duksum. The total catchment area upto D-7 dam site is 1044 sq km, out of which about 15 sq km is snowfed area. Available net head of about 760 m is proposed to be utilized for hydro – power generation. It is also proposed to consider the possibility of utilizing the water of Chapanangchu, a right bank tributary of Kholongchu River between D-7 and D-3 site. The water of Chapanangchu above elevation 1580 m (±) is proposed to be diverted to head race tunnel through a drop shaft. The catchment area of Chapanangchu at an elevation of 1580 m, from where its water is proposed to be diverted is about 40 sq km. Water availability studies for D-3 dam site have already been cleared by CWC wide letter dated on November 2, 2010. Since another better alternative of dam site at D-7 has now emerged, possibility of utilizing the flows of Chapanangchu as well has been considered and the water availability studies at D-7 and diversion flow of Chapanangchu have also been included in the report.

Following hydrological studies for Kholongchu project have been carried out in this DPR Hydrology Report

- Water availability studies
- Design flood studies

CHAPTER 2

2. RIVER SYSTEM & BASIN CHARACTERISTICS

Kholongchu is a tributary of Dramengchu (Gongrichu), which in turn is a tributary of river Manas. It originates from the snowy range along the northern Bhutan frontier. It generally flows in the southern direction up to the diversion site. The river possesses the marked characteristics of mountain streams i.e. it flows between high rocky mountains confining the channel in a narrow valley, in the upper reaches. As the gradient of the river falls on its exit from the mountainous ranges, the stream rushes tumultuously over beds of large boulders and rock masses. Sisigang Chu, Kongkangchu, Chhodigangchu, Kokturkangchu, Chapanangchu and Dongdichu are its right bank tributaries; whereas Wohmunangchu and Chumduchu joins the river on its left bank. The overall river profile of Kholongchu from source to the diversion site is relatively steep. The length of the river up to the diversion site is about 60.76 km. There are some glaciers and moraine dam glacial lakes in the upper portion of the catchment. The average slope of the river up to the dam site is about 60 m / km.

The main rivers of Bhutan from east to west are Manas, Sankosh, Wang Chu or Raidak, and Torsa. The total length of rivers with tributaries in Bhutan is about 7200 km. The Manas and its tributaries constitute the largest river system in Bhutan, with a total length of about 3200 km. The main Manas or Gong river rises beyond the Great Himalayan range in eastern Bhutan. It enters Bhutan from the Kameng frontier district of Arunachal Pradesh (India) and flows southwest unlike most of the rivers of Bhutan, which usually flow from north northwest to southwest. The Kholong Chu joins river Dramengchu (Gongrichu) at Duksum much upstream of Trashigang. The river bed level near Trashigang is about 606m above mean sea level (MSL) and flows through a bed of boulders. The Lhobrak, or Kuri Chu, the main central tributary of the Manas, is the only tributary that rises north of the Great Himalayas. Trongse Chu (Mangde Chu) then joins river Manas on its right bank and the bed level of the river at its confluence with Trongsachu is about 121 m above MSL. River Manas crosses into India (Assam) near Manas town. Before its confluence with Brahmaputra on its north bank, the river widens with three forks spreading out from near the Bhutan border, creating a wide swath of flood plain.

2.1. The Catchment

Available Topo sheets numbers 78 M/6, 78 M/7, 78 M/8, 78 M/10, 78 M/11 of Survey of India to a scale of 1: 50,000 were utilized for finding the catchment area of Kholongchu up to the diversion site. But it was found that these topo sheets do not cover the upper portion of the catchment and Topo sheet numbers 78 M/5 and 78 M/9 were also required to cover the entire catchment. Since these Topo sheets were not available, the catchment area map of Kholongchu up to the diversion site was obtained using Geographical Information System (GIS) software Earth Resources Data Analysis System ERDAS imagine version 9.1 and Arc GIS 9.2. The catchment area up to the diversion site (D-3) has been estimated as1120 sq km. The catchment falls between latitude 27^{0} 27’ 00” N to 27^{0} 57’ 36” N and Longitude 91^{0} 18’ 36” E to 91^{0} 39’ 36” E. The area of the basin above 5000 m elevation is 14.94 sq km, area above 4500 m is 111.97 sq km and the area between 3000 m to 4500 m elevation is 574.12 sq km. The catchment area at the earlier proposed dam site (D-1) is 1143 sq km as against the value of 1134 sq km, as given in the Bhutan Power System Master Plan, Pre – Feasibility Study Report, Kholongchu – Project, Dec. 93, as estimated by Norconsult. Thus correctness of catchment area worked out using Arc GIS 9.2 has been established as the area worked out for D-1 dam site using the same software is nearly the same as worked out by Norconsult for D-1 dam site in their Pre-Feasibility Study Report. The catchment area plan of Kholongchu up to Diversion site D-3 & D-7 is given in **Figure 2.1.** The catchment area of Chapanangchu at Diversion site is also marked in **Figure 2.1.**

2.2. Hypsometry of the Catchment

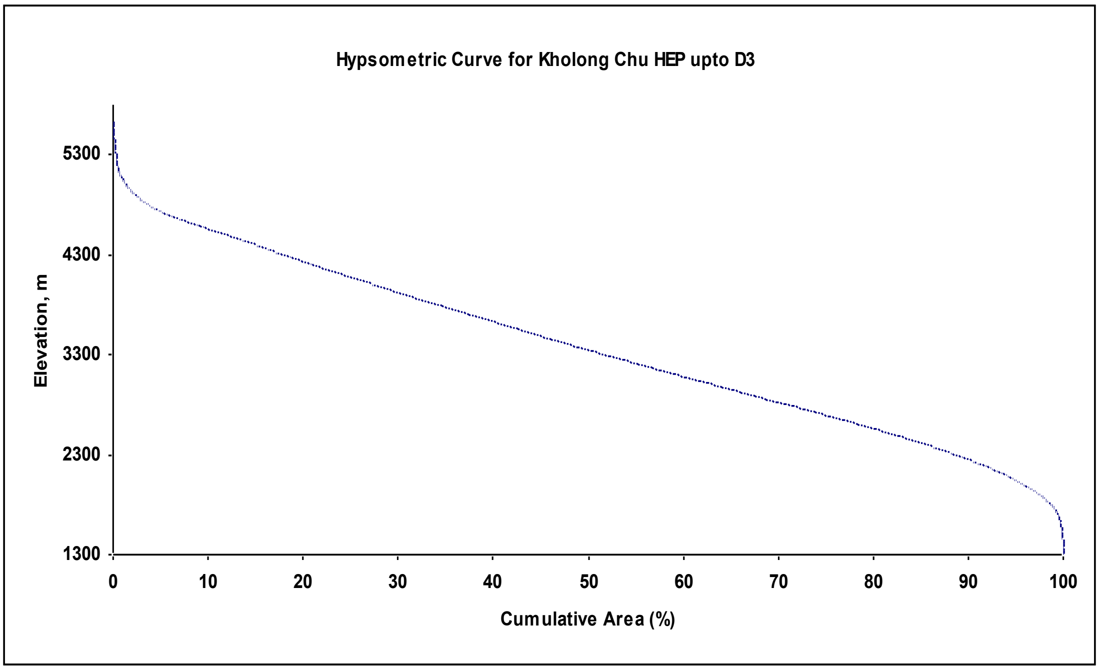
The catchment area up to the Diversion site is the most important feature for the estimation of various hydrological parameters. Since the topo sheets for the entire catchment were not available, the hypsometry of the catchment has been determined using Digital Elevation Model (DEM) and ARCGIS 9.2 software. Information derived from DEM includes: catchment area, average catchment slope and elevation, maximum river length (maximum flow path), equivalent stream slope, and the latitude / longitude of the catchment's centroid. The Hypsometry of the catchment (up to D-3) at contour interval of 100 m has been determined and is as given in **Table 2.1** and plotted in **Figure 2.2.**

Table 2.1: Hypsometry of Kholongchu Catchment

EL (m)	Area above EL (sq km)	% area above EL	Area Between El, (sq km)	Decrease in %
1300	1120.0	100.0		
1400	1119.59	100.0	0.42	0.04
1500	1118.5	99.9	1.09	0.10
1600	1116.64	99.7	1.86	0.17
1700	1113.01	99.4	3.63	0.33
1800	1104.95	98.7	8.06	0.72
1900	1092.1	97.5	12.85	1.16
2000	1071.97	95.7	20.13	1.84
2100	1050.98	93.8	20.99	1.96
2200	1023.51	91.4	27.47	2.61
2300	992.41	88.6	31.1	3.04
2400	957.66	85.5	34.75	3.50
2500	919.38	82.1	38.28	4.00
2600	878.71	78.5	40.67	4.42
2700	836.66	74.7	42.05	4.79
2800	793.17	70.8	43.49	5.20
2900	748.98	66.9	44.19	5.57
3000	706.09	63.0	42.89	5.73
3100	662.8	59.2	43.29	6.13
3200	619.93	55.4	42.87	6.47

3300	577.89	51.6	42.04	6.78
3400	536.35	47.9	41.54	7.19
3500	496.57	44.3	39.78	7.42
3600	458.65	41.0	37.92	7.64
3700	420.11	37.5	38.54	8.40
3800	380.56	34.0	39.55	9.41
3900	341.75	30.5	38.81	10.20
4000	305.81	27.3	35.94	10.52
4100	269.42	24.1	36.39	11.90
4200	232.7	20.8	36.72	13.63
4300	199.47	17.8	33.23	14.28
4400	166.71	14.9	32.76	16.42
4500	131.97	11.8	34.74	20.84
4600	95.52	8.5	36.45	27.62
4700	63.07	5.6	32.45	33.97
4800	39.97	3.6	23.1	36.63
4900	25.36	2.3	14.61	36.55
5000	14.94	1.3	10.42	41.09
5100	7.98	0.7	6.96	46.59
5200	4.34	0.4	3.64	45.61
5300	3.02	0.3	1.32	30.41
5400	1.51	0.1	1.51	50.00
5500	0.48	0.0	1.03	68.21
5600	0.08	0.0	0.4	83.33

Figure 2.2: Hypsometric Curve of Kholongchu Catchment



2.3.Meteorological Aspects

Bhutan has great diversity of climate, perhaps greater than any other area of similar size in the world. While the climate is temperate in the central mountain valley (1535 m to 2155 m), the southern part is tropical, and in general the east of Bhutan is warmer than the west of the country. The central valley of Punakha, Wangdiphodrang, Mongar, Tashigang and Lhuntshi enjoy a semi tropical climate with very cool winters; while Thimpu, Tongsa and Bumthang experience much harsher climate, with heavy monsoon rains in the summer and heavy snow-fall in winter. The monsoon usually arrives by mid June, with the rain falling mainly in the afternoons and evenings. Autumn starts from the end of September or early October and continues up to late November. It is characterized by bright sunny days and some early snowfall at higher elevations. Winter in Bhutan starts from late November and continues till mid March. During winter most parts of the country experience frost and snowfall occurs above elevations of 3000 m.

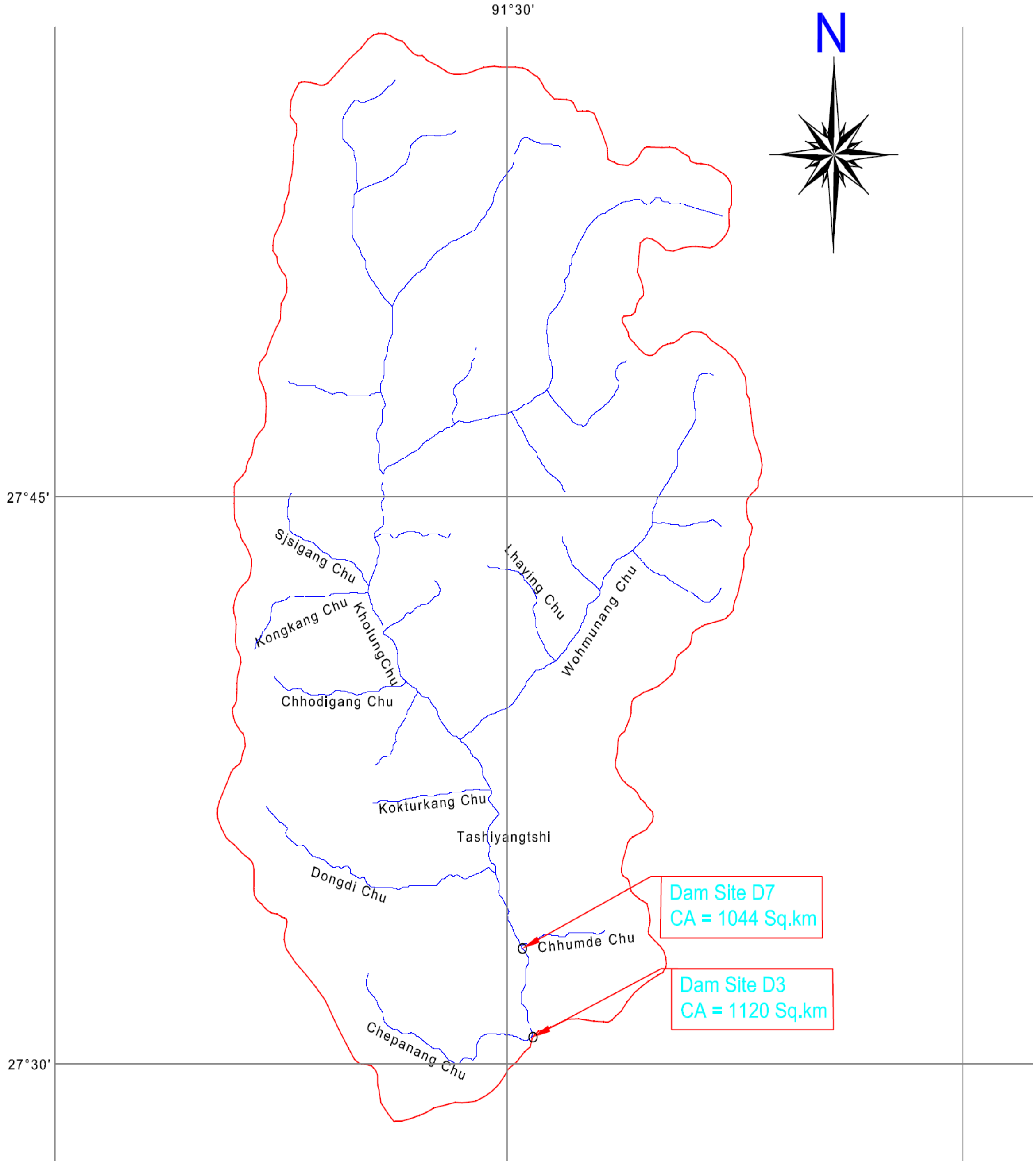
2.3.1. Temperature

Temperatures in the Country vary according to elevation. Temperatures at Thimpu, located at Elevation 2200 m above MSL in west central Bhutan range from 15 ^{0} C to 26 ^{0} C during the monsoon season of June to September, but drop to between about – 4 ^{0} C and 16 ^{0} C in January. Northern parts of the country experience intense cold during winter the minimum temperature goes to about -15 ^{0} C. Most of the central portion of the Country experiences a cool temperate climate year round. I n the south, a hot, humid climate helps to maintain a fairly even temperature range of between 15 ^{0} C to 30 ^{0} C all the year round, although temperature sometimes reach 40 ^{0} C in the valleys during the summer.

2.3.2. **Precipitation**

Distribution of rain in Himalayan mountain regions is extremely complex because of complex orography and no generalizations are possible. The rainfall in Bhutan is dominated by the south - west monsoon, which sweeps in from the Bay of Bengal during the middle of June, is intense during July and August and continues up to September. About 80 to 90 % of the annual rainfall occurs during this period. During the month of October, post-monsoon storms occasionally occur, which only last a few days. During April and May, pre – monsoon showers accompanied by hail storm, generally occur. The November to March period is generally dry and occasional small showers may occur. The northern parts of Bhutan get scanty rainfall and receive precipitation in the form of snow during winter. The plains in general have an average annual rainfall varying from 1500 mm to 2000 mm. The rainfall in inner Himalayas varies with the exposure to the monsoon winds. The Thimpu and Paro Valleys receive about an average rainfall of about 700 mm.

Figure 2.1: Catchment Plan of Kholongchu River Upto Diversion Site D-3 and D-7



CHAPTER 3

3. WATER AVAILABILITY STUDIES

The Royal Government of Bhutan (RGoB) established a network of hydro meteorological stations on various rivers in 1986 and 1991, for the assessment of hydropower potential and to ensure identification of the most promising sites in a systematic manner. At most of the discharge sites, discharge measurements are being made using current meters to measure the velocities. Discharges are calculated by area velocity method. The following hydro meteorological data within and around the basin is available:

3.1. Rainfall Data

Rainfall data at a number of sites in Kholongchu / Dramengchu (Gongrichu) basin is being observed by the Government of Bhutan. Rainfall data for 16 stations within and around the Kholongchu basin is available, out of which only one raingauge site viz. Trashiyangtse falls within the project catchment. Daily rainfall data for the stations available in and around Kholongchu / Dramengchu (Gongrichu) / Mangdechu basins are given in **Table 3.1.**

Table 3.1: List of Rain gauge Stations

S. No.	Station	Location		Altitude (m)	Period
		Latitude	Longitude		
1	Duksum	27	91	950	2000 to 03, 05 to 06
2	Kanglung	27	91	1930	1996 to 2007
3	Sherichu	27	91	705	1995 to 98, 2001, 03 to 05
4	Trashiyangtse	27	91	1830	1990 to 2007
5	Wamrong	27	91	2180	1990 to 2006
6	Yadi	27	91	1580	1990 to 90, 98 to 2006
7	Yallang	27	91	2100	1990 to 99, Aug. 02 to 06
8	Yurung	27	91	1435	1990 to 99, April 03 to 06
9	Chazam	27	91	750	Jan. 1990 to Dec.08
10	Thrimshing	27	91	1580	Jan. 1990 to Dec. 08
11	Dungkhar	27	91	2010	Jan. 1990 to July 07
12	Tangmachu	27	91	1750	Jan. 1990 to July 07

13	Shelgana	27	89	1680	Jan. 1989 to July 07
14	Nobding	27	90	2600	Jan. 1986 to Dec 2006
15	Chendebji	27	90	2660	Nov. 1991 to Dec 2006
16	Phobjekha	27	90	2860	May. 1986 to Dec 2006

A map showing the gauge - discharge and rain gauge sites is enclosed at **Figure 3.1.**

The monthly and annual rainfall values for the above said stations are given in **Tables 3.2 (a)** to **3.2 (p)** and monthly maximum, minimum and mean rainfall variation for each stations are plotted and given in **Figure 3.2 (a) to 3.2 (p).** Rainfall in each station monthly mean value is given **Table 3.2 (q)** and curve also has been plotted is shown in **Figure 3.2 (q).**

Figure 3.2 (a): Maximum, Minimum and Mean Rainfall at Duksum

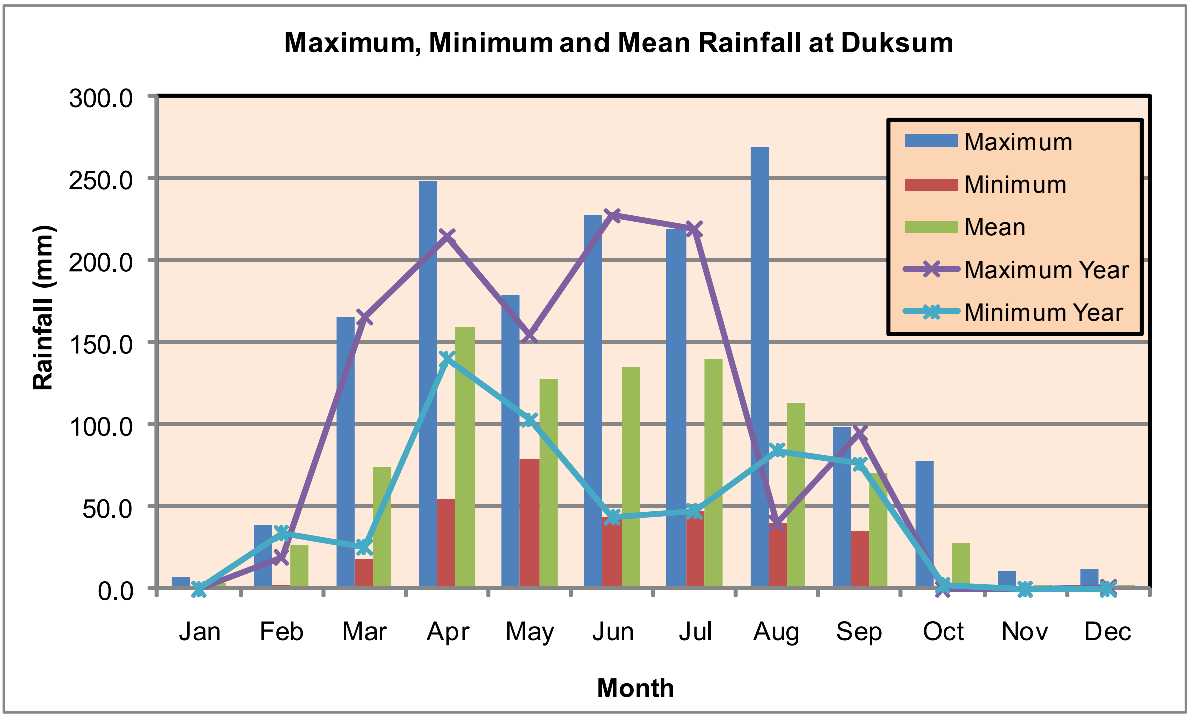


Figure 3.2 (b): Maximum, Minimum and Mean Rainfall at Kanglung

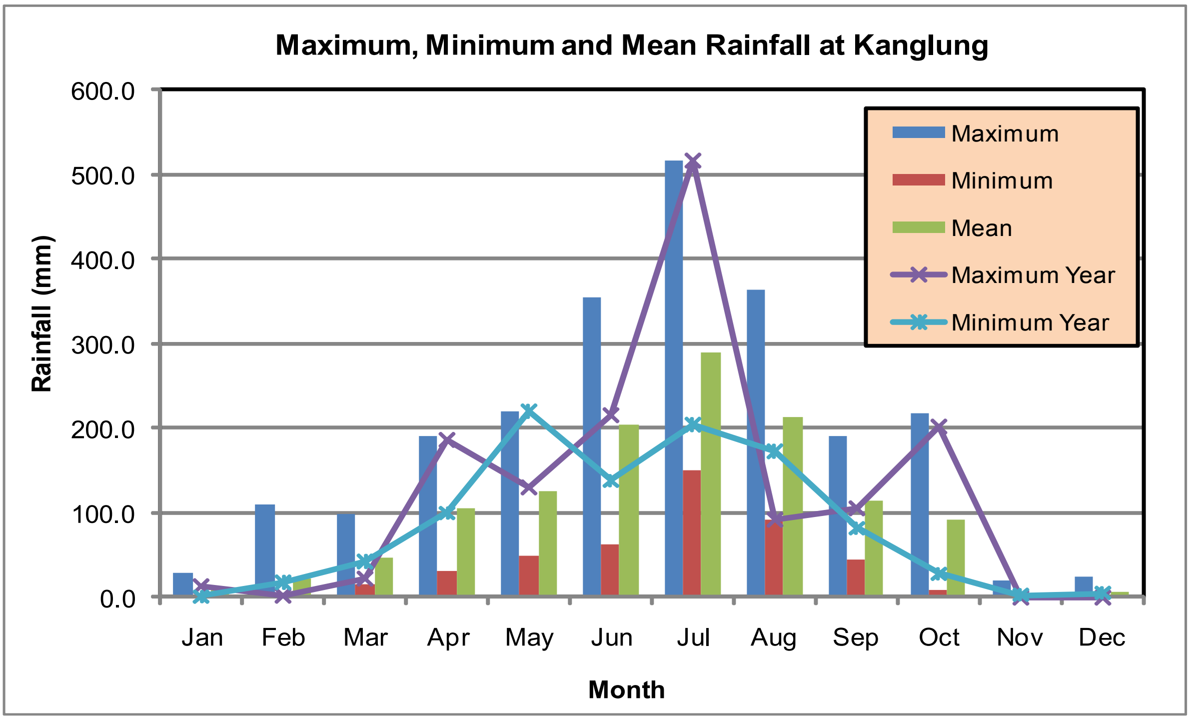


Figure 3.2 (c): Maximum, Minimum and Mean Rainfall at Sherichu

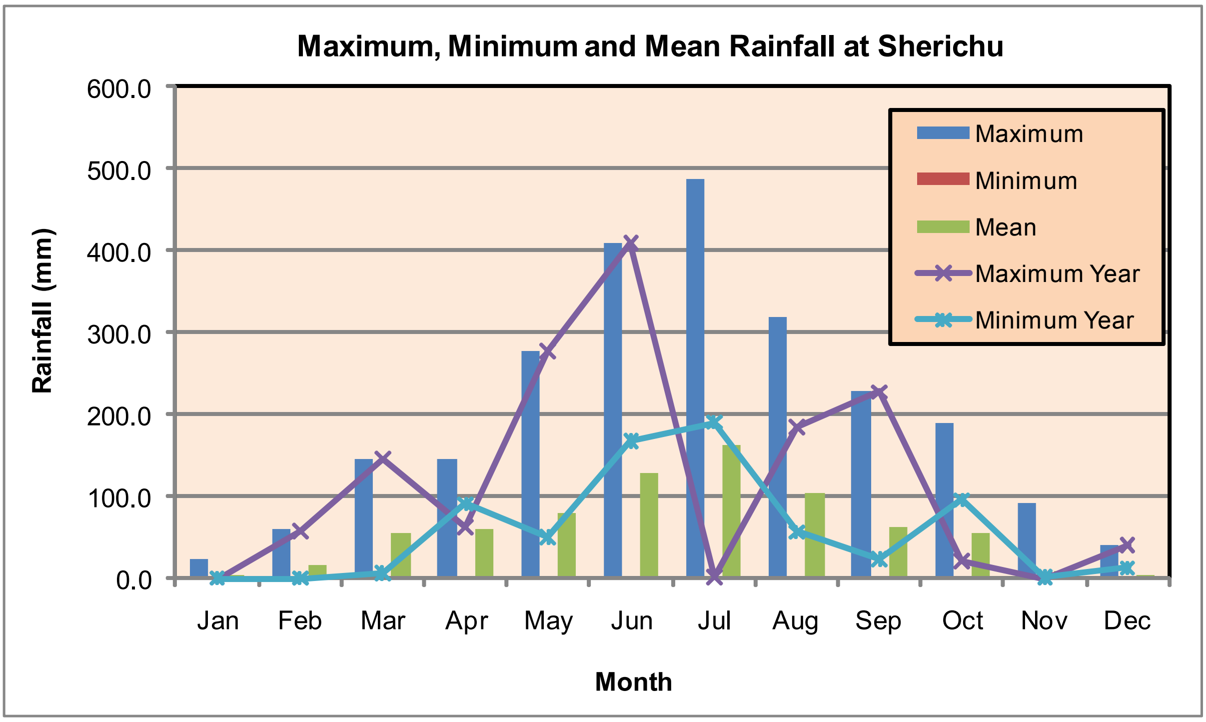


Figure 3.2 (d): Maximum, Minimum and Mean Rainfall at Trashiyantse

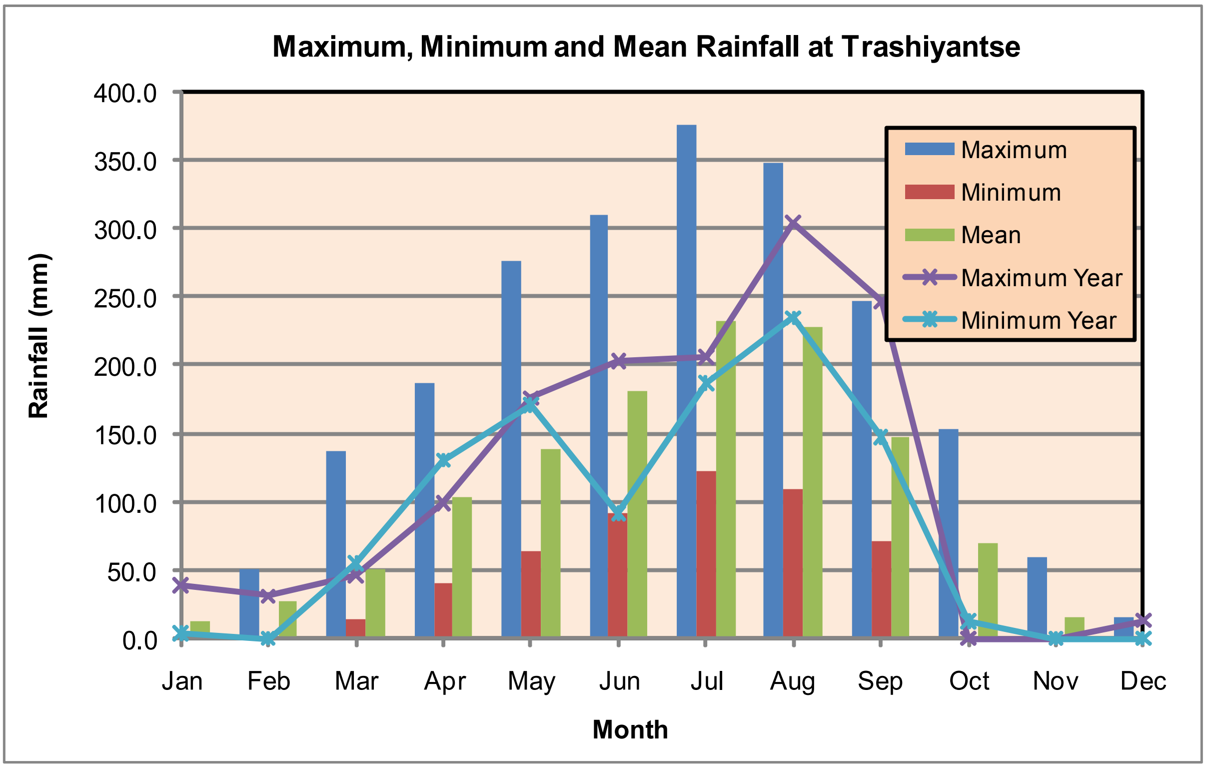


Figure 3.2 (e): Maximum, Minimum and Mean Rainfall at Wamrong

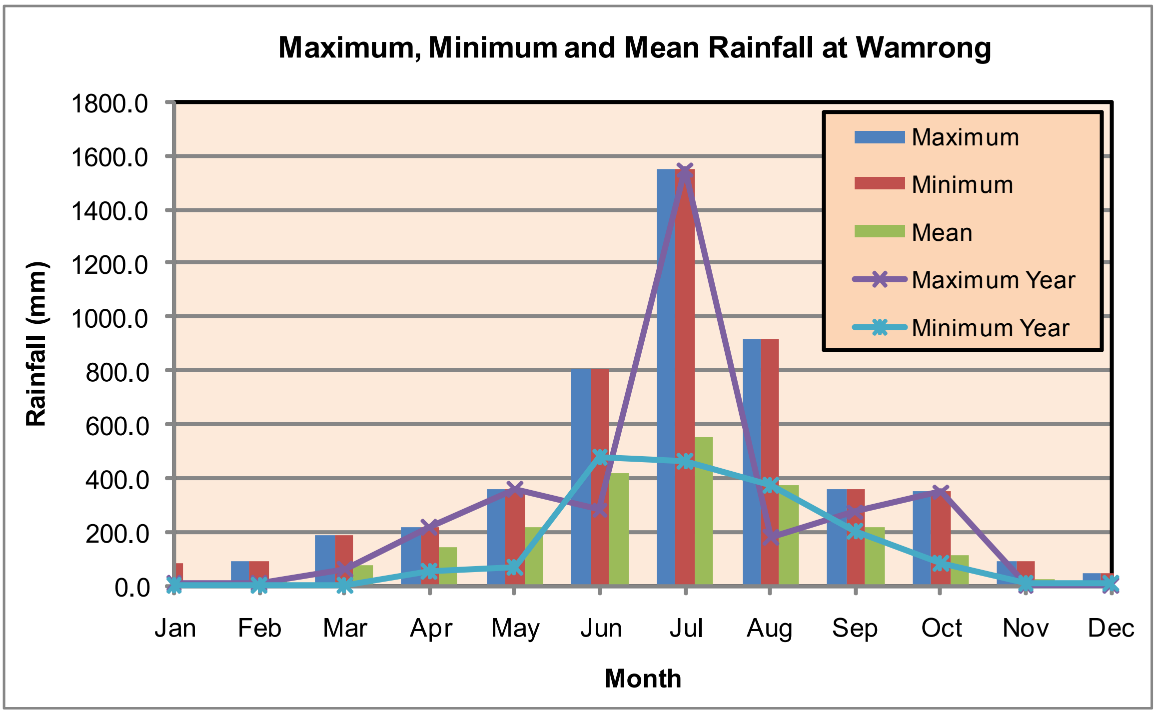


Figure 3.2 (f): Maximum, Minimum and Mean Rainfall at Yadi

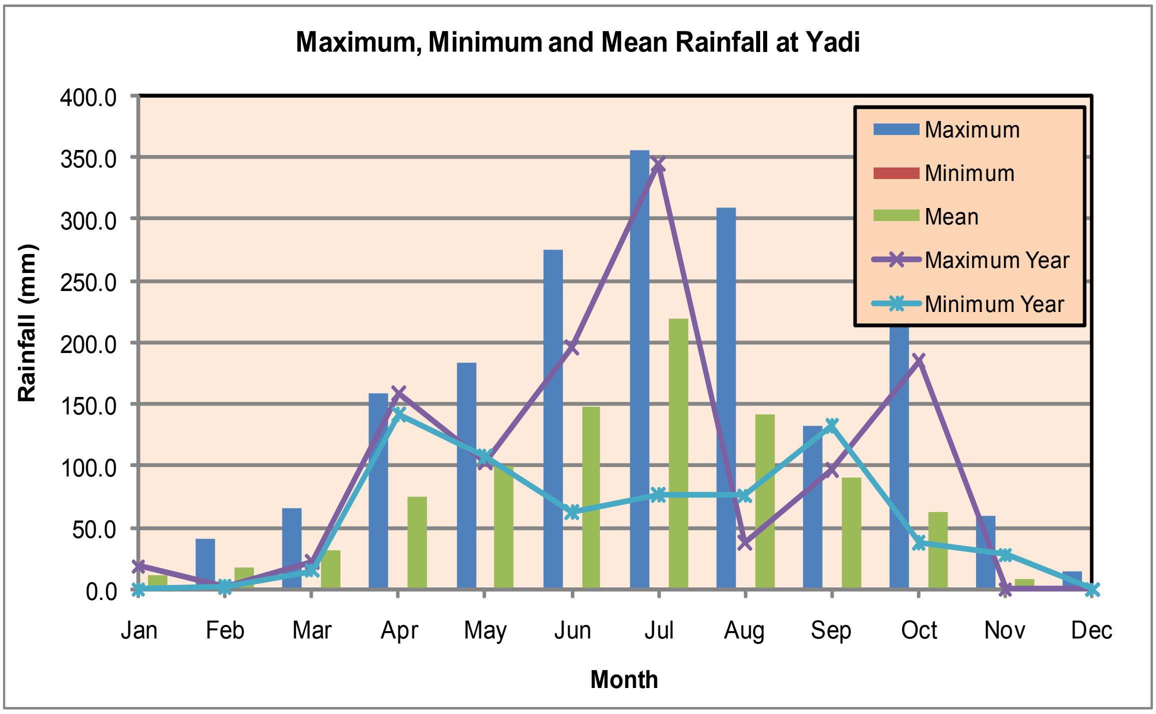


Figure 3.2 (g): Maximum, Minimum and Mean Rainfall at Yallang

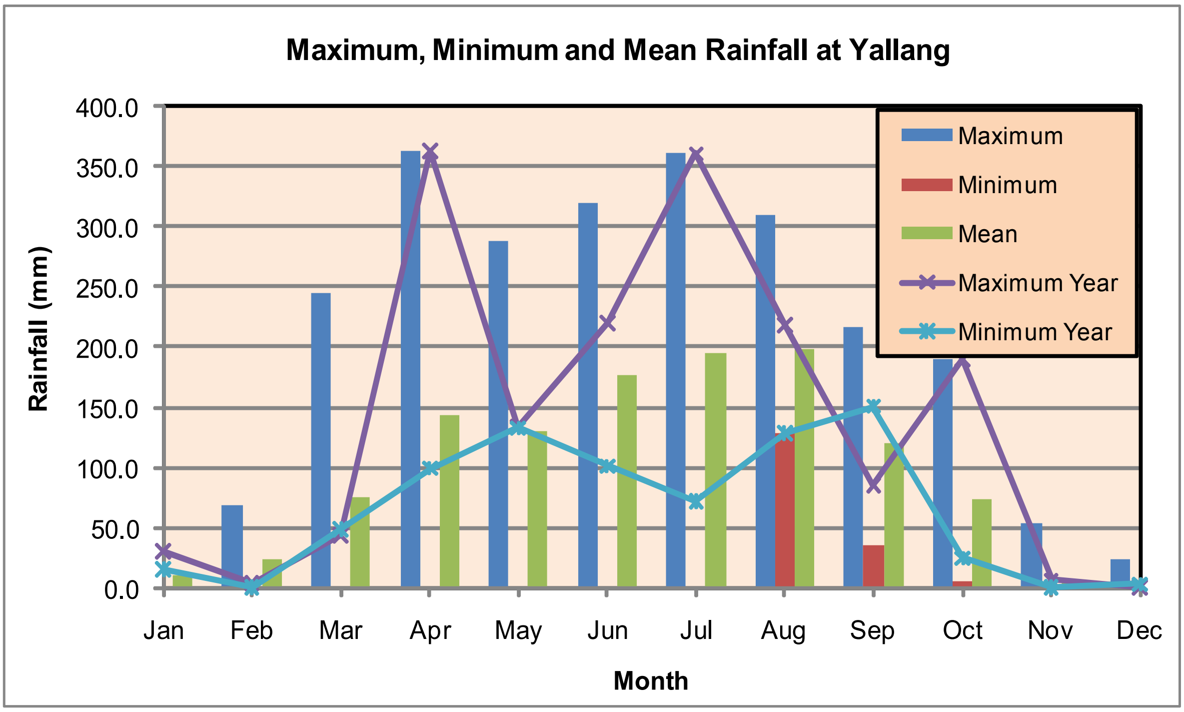


Figure 3.2 (h): Maximum, Minimum and Mean Rainfall at Yurung

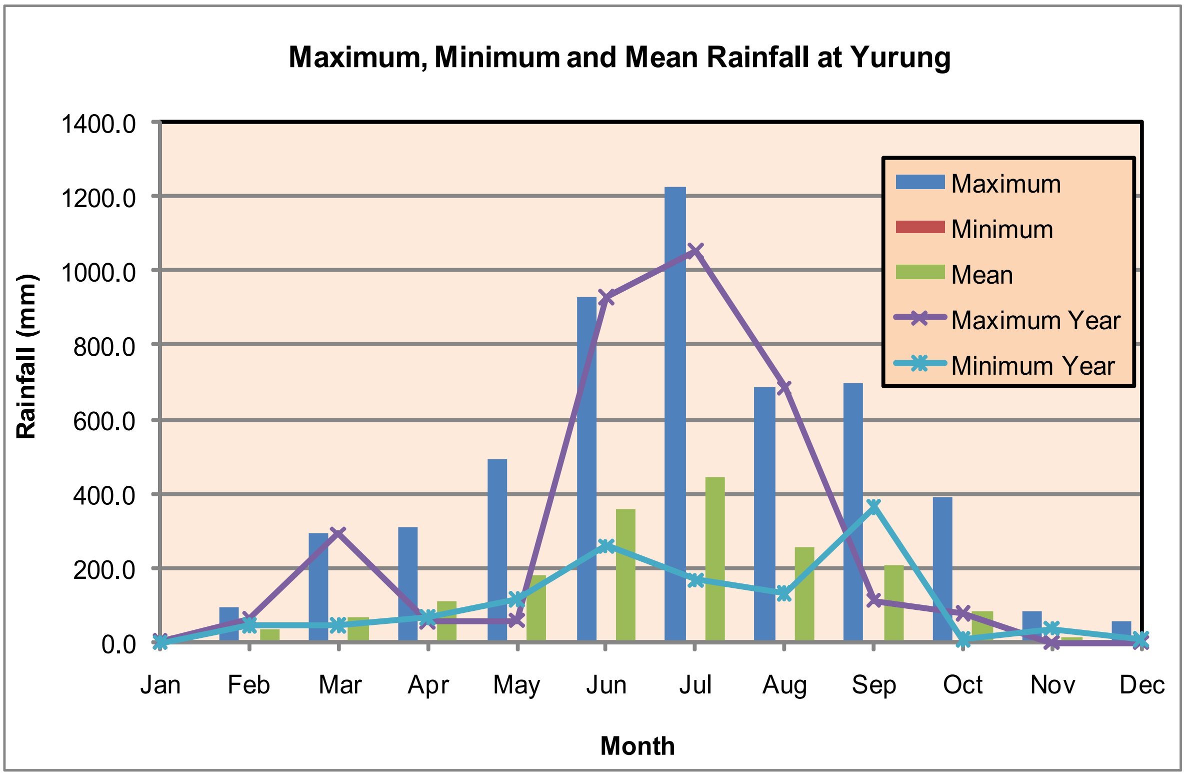


Figure 3.2 (i): Maximum, Minimum and Mean Rainfall at Chazam

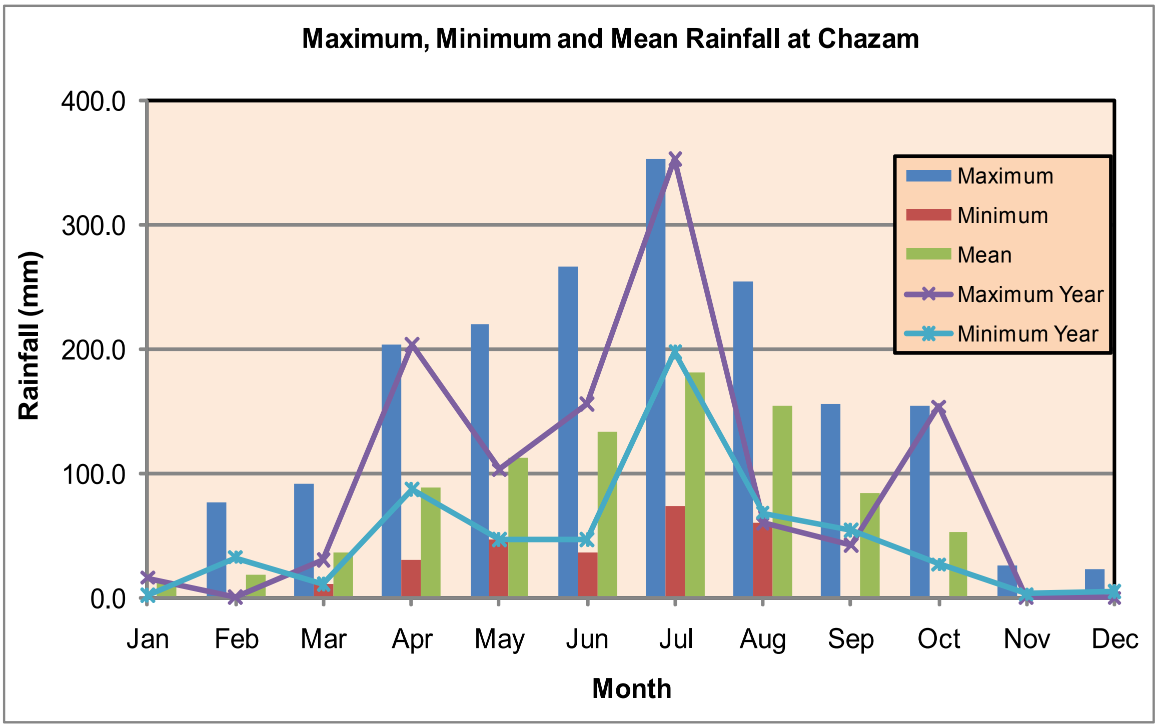


Figure 3.2 (j): Maximum, Minimum and Mean Rainfall at Thrimshing

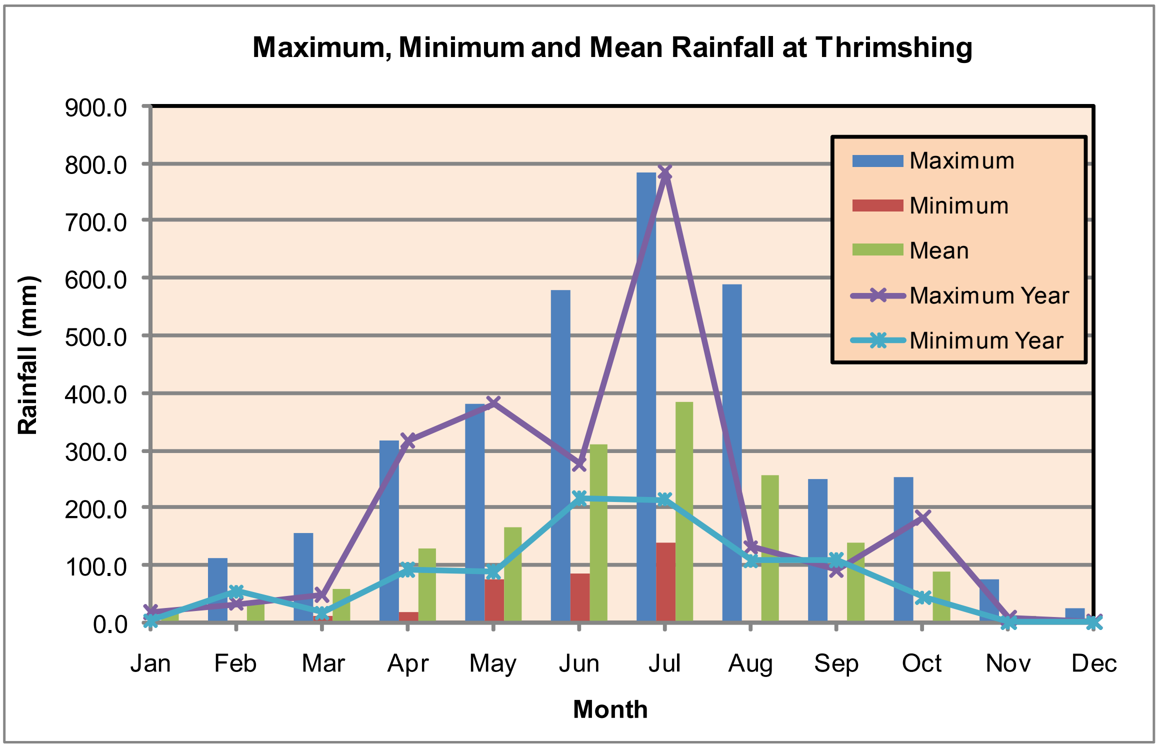


Figure 3.2 (k): Maximum, Minimum and Mean Rainfall at Dungkhar

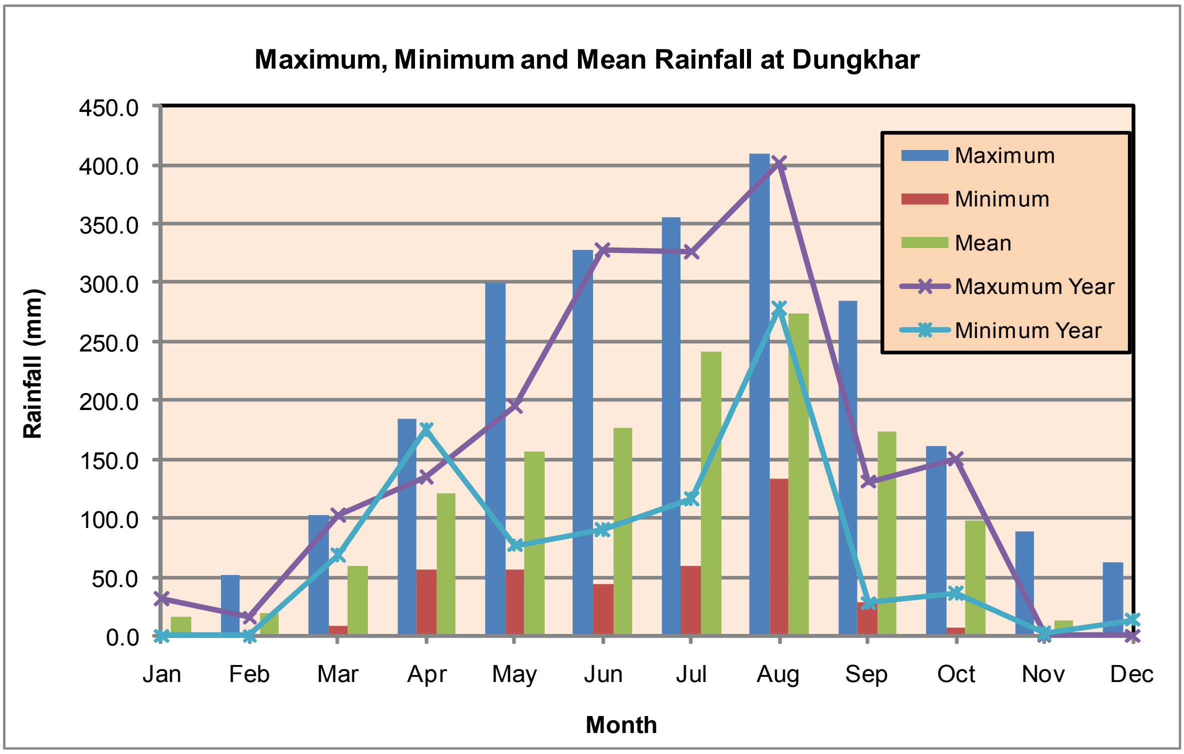


Figure 3.2 (l): Maximum, Minimum and Mean Rainfall at Tangmachu

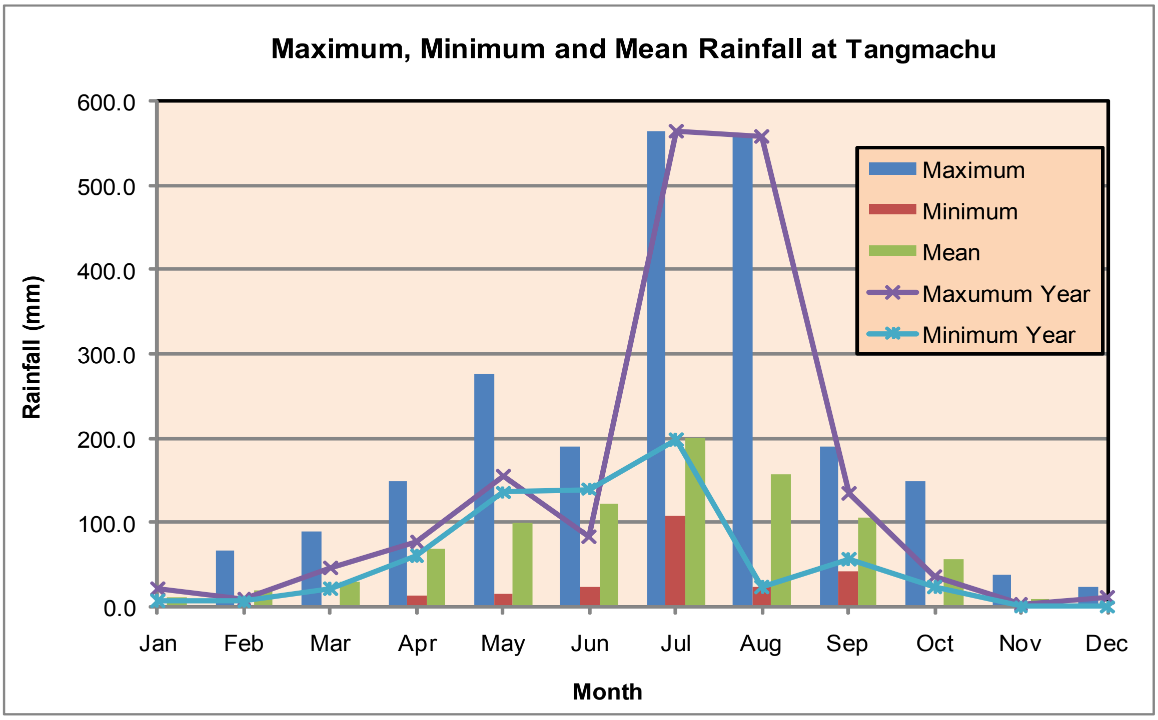


Figure 3.2 (m): Maximum, Minimum and Mean Rainfall at Shelgana

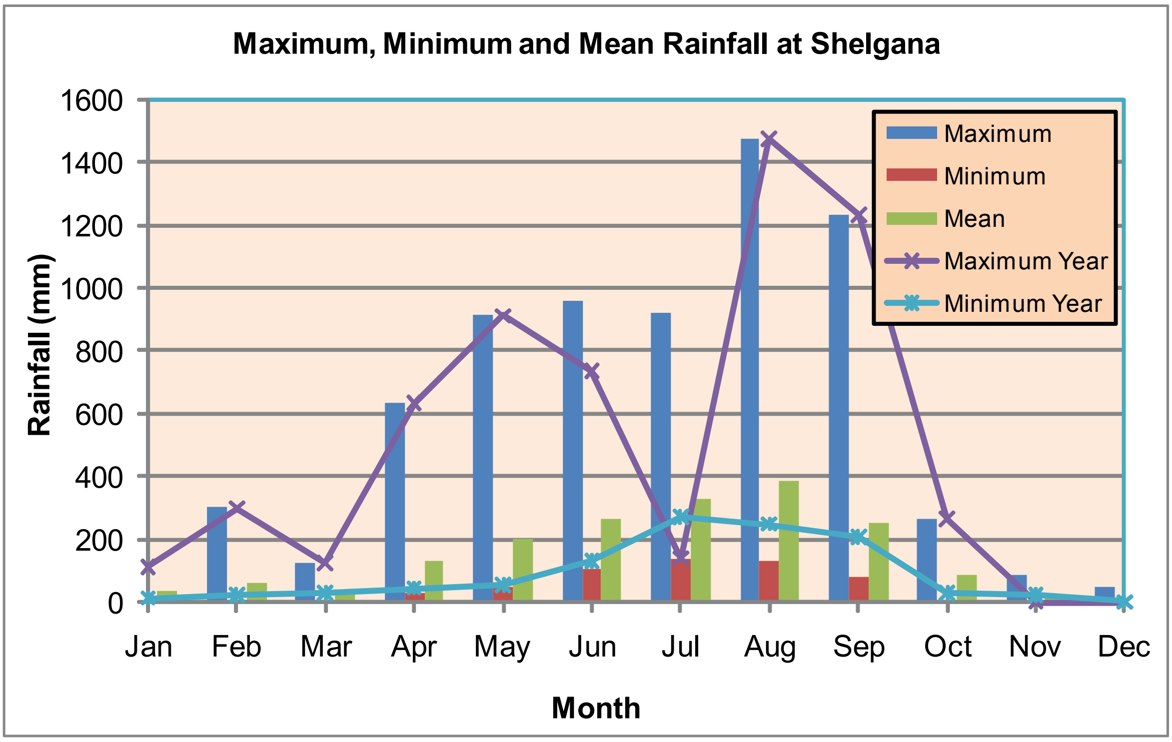


Figure 3.2 (n): Maximum, Minimum and Mean Rainfall at Nobding

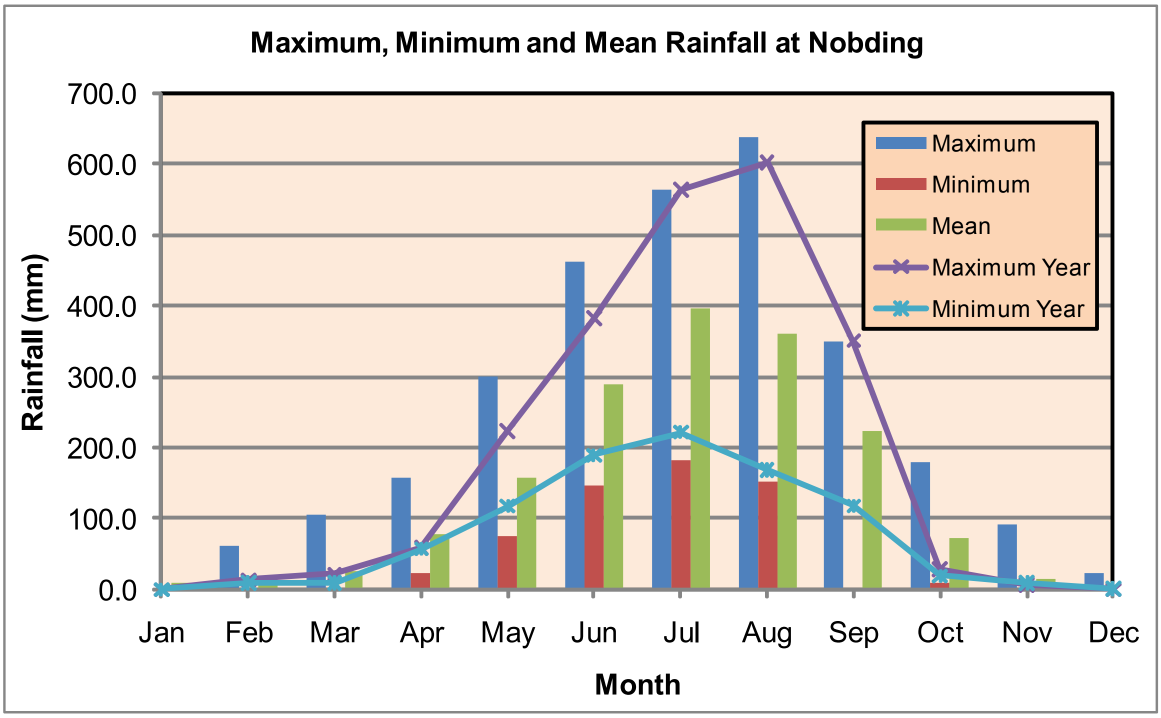


Figure 3.2 (o): Maximum, Minimum and Mean Rainfall at Chendebji

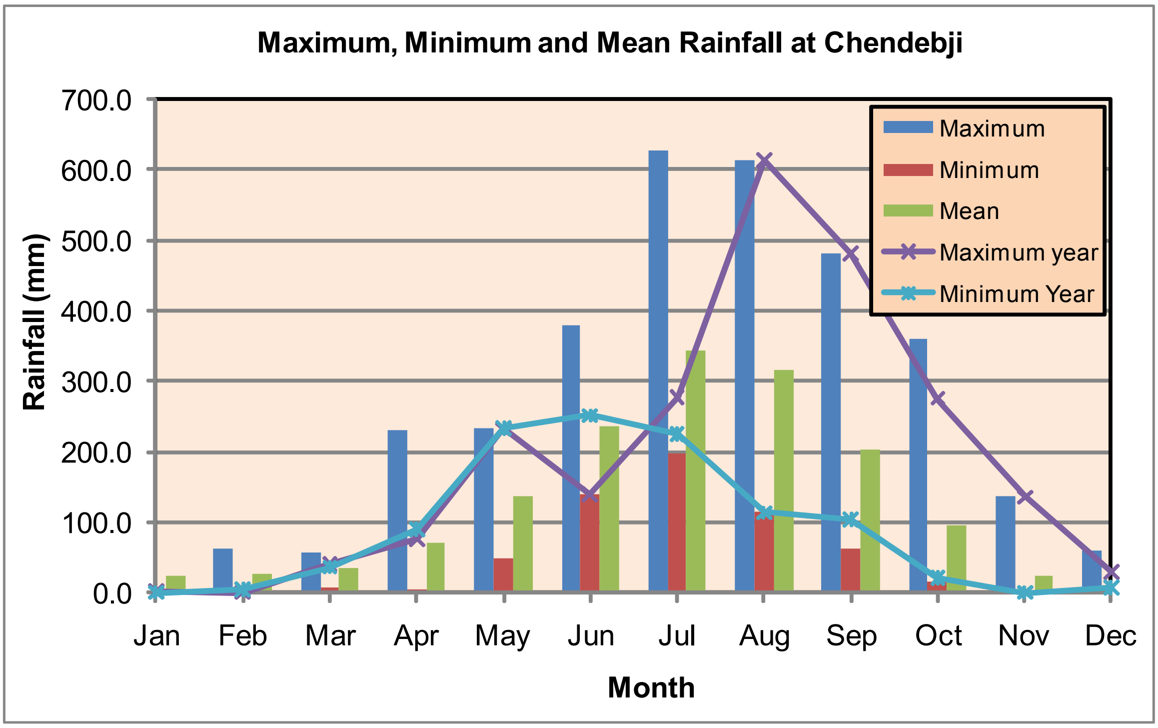


Figure 3.2 (p): Maximum, Minimum and Mean Rainfall at Phobjekha

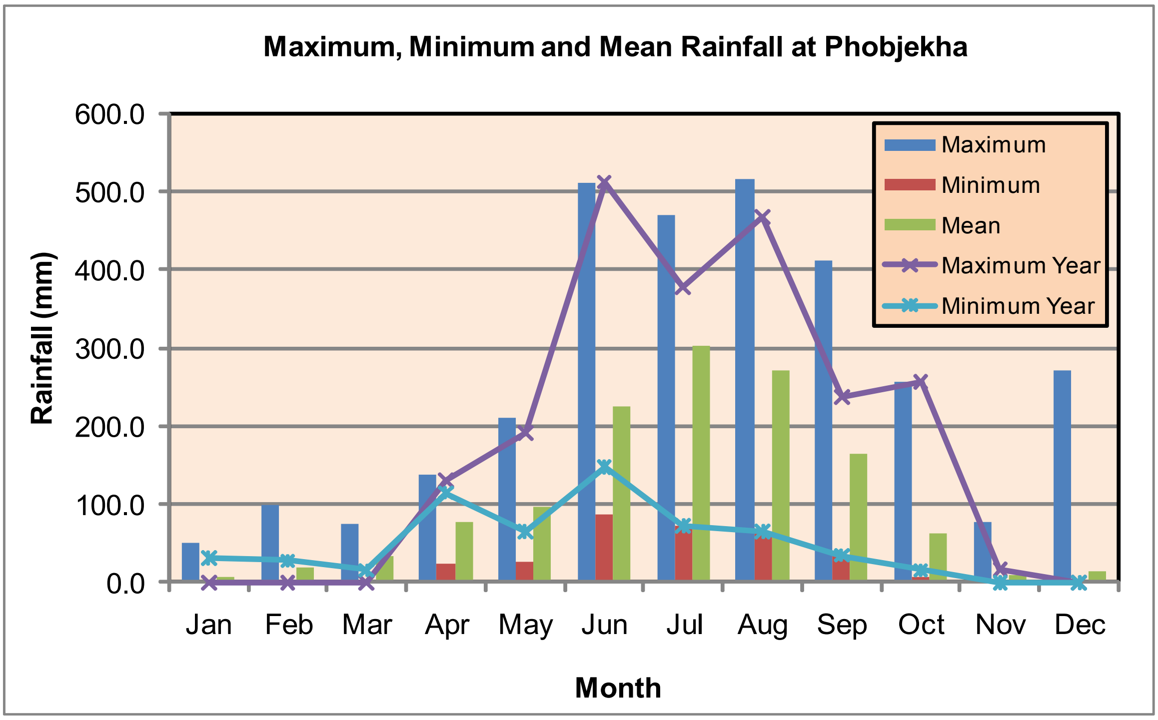
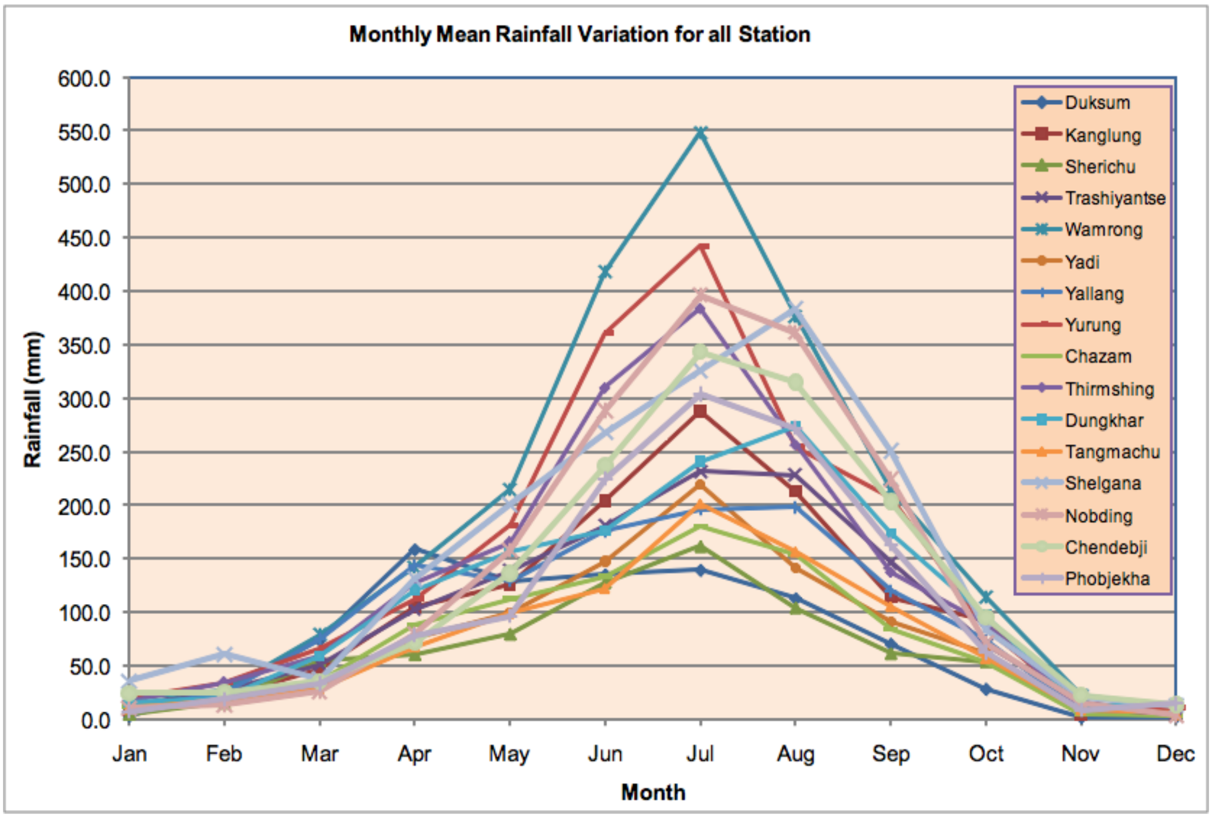


Figure 3.2 (q): Mean Monthly Rainfall Values for Various Raingauge Station



3.2. Gauge and Discharge Data

Daily discharge data available for the sites on Kholongchu / Dramengchu (Gongrichu) is given in **Table 3.3.**

Table 3.3: Available Discharge Data

Sl.No	Site	River	Catchment Area (sq km)	Data Available
1	Lhuntsi	Khomachu	611	Jan 1986 – June 2009
2	Trashiyangtse	Kholongchu	862	Jan 87 – Oct 98
3	Muktirap	Kholongchu	905	Feb 2001 – June 2010
4	Dam Site	Kholongchu	1120	Aug 2009 – May 2010
5	Uzorong	Gongri Chu	8560	Feb 92 – Dec 2009
6	Chazam	Gongrichhu	9085	Feb 1987 – May 2008

In addition, 10 – daily discharges for the following sites in the adjacent river basins have been obtained from the DPR of Mangde Chhu Hydro Electric Project:

Sl.No	Site	River	Catchment Area (sq km)	Data Available
1	Bjizam	Mangde Chhu	1393	April1994 to May 2009
2	Kurjey	Chamkhar Chhu	1350	June 1991 to June 2010
3	Refe	Mangde Chhu	2080	April 1981 to Oct. 1995

3.3.ANALYSIS OF DATA

From the available daily discharges of Kholongchu at Trashiyantse, 10-daily average discharges were computed and 10-daily discharges for the period Jan. 1987 to Oct 1998, thus obtained are given in **Table 3.4 (a)**. Similarly from the available daily discharges of Kholongchu at Muktirap, Dramengchu (Gongrichu) at Chazam, Dramengchu (Gongrichu) at Uzorong and Khomachu at Lhuntsi, 10-daily discharges for the period of data available at each site have been computed and are given in **Tables 3.4 (b)** to **3.4 (f).** 10-Daily discharges at Bjijam, Kurjey and Refe are given in **Tables 3.4 (g)** to **3.4 (i)** respectively**.**

3.3.1. Consistency Checks

Before utilizing the data for water availability studies, the following consistency checks were carried out to check the accuracy and consistency of the observed discharges at various sites:

3.3.1.1. Single Mass Curves

Using the available discharge data of River Kholongchu at Muktirap (Catchment area = 905 sq km) and Trashiyantse (Catchment area = 862 sq km) discharge sites, which are close to the proposed dam site, cumulative annual flows at the two sites have been worked out in **Tables 3.5 & 3.6**. Mass curves of cumulative annual flows at the two sites are plotted in **Figures 3.3 & 3.4**. It is seen that the Single Mass Curves for Muktirap and Trashiyangtse are nearly a straight line, indicating that the discharges at these two sites are consistent, Single Mass Curve has also been plotted at proposed dam site using Muktirap & Trashiyantse discharges on the basis of catchment area proportion. Cumulative annual flows at the proposed dam site have been worked out in **Tables 3.7**. Mass curve of cumulative annual flows at dam site is plotted in **Figure 3.5**.

Table 3.5: Annual and Cumulative Yields at Muktirap

Period	Annual flows (MCM)	Cumulative Value
2001-02	1914	1914
2002-03	1809	3723
2003-04	2511	6234
2004-05	2270	8504
2005-06	1986	10490
2006-07	1786	12276
2007-08	2254	14530
2008-09	2096	16626
2009-10	1812	18438

Figure 3.3: Single Mass Curve – Muktirap

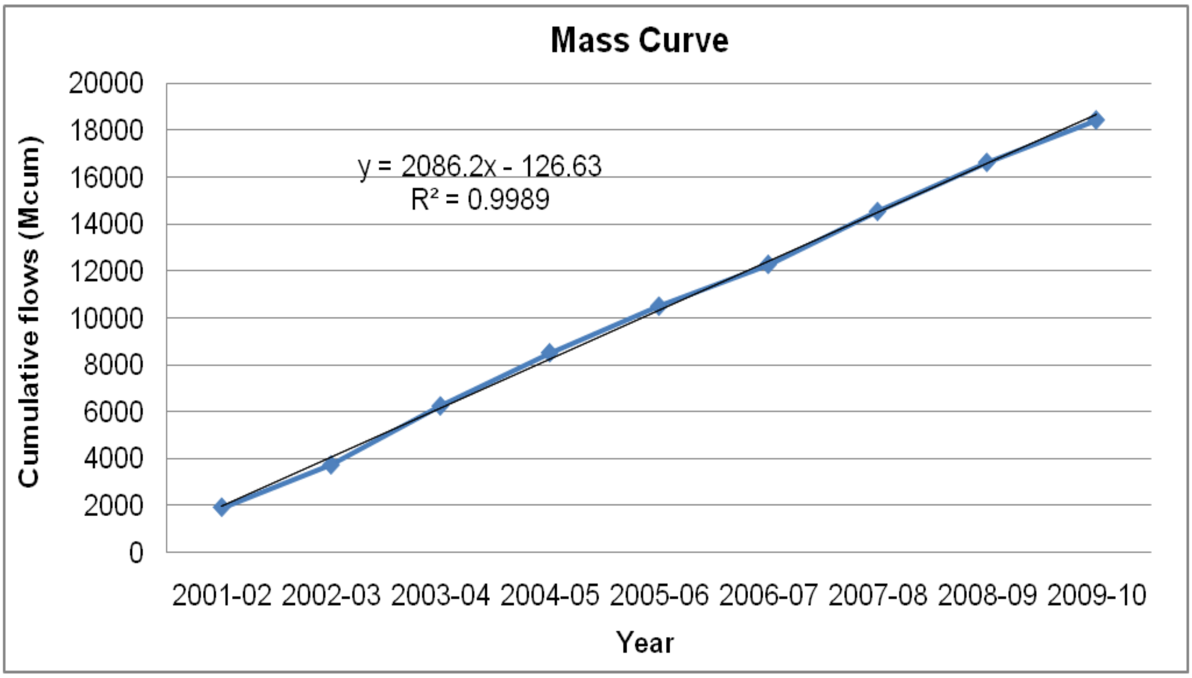


Table 3.6: Annual and Cumulative Yields at Trashiyantse

Period	Annual flows (MCM)	Cumulative Value
1987-88	1733	1733
1988-89	1582	3316
1989-90	1746	5061
1990-91	1940	7001
1991-92	1894	8895
1992-93	1689	10584
1993-94	1989	12573
1994-95	1932	14505
1995-96	2407	16912
1996-97	2570	19482
1997-98	2248	21730

Figure 3.4: Single Mass Curve –Trashiyantse

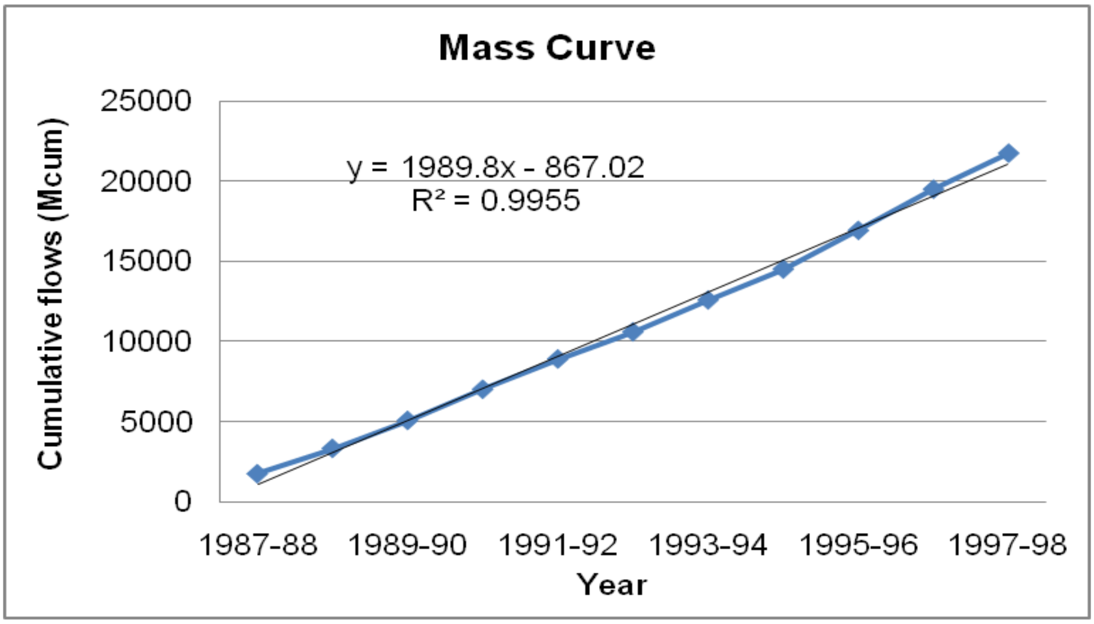
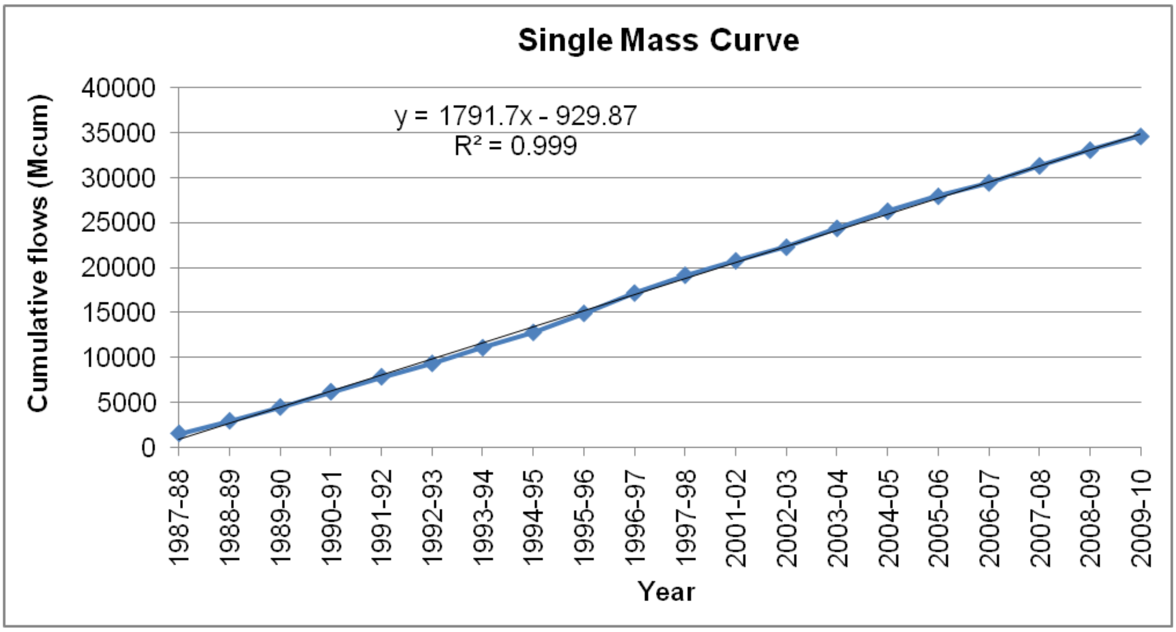


Table 3.7: Annual and Cumulative Yields at Kholongchu Dam Site (D-3)

Period	Annual flows (MCM)	Cumulative Value
1987-88	1528	1528
1988-89	1395	2923
1989-90	1539	4462
1990-91	1710	6172
1991-92	1670	7842
1992-93	1489	9331
1993-94	1753	11085
1994-95	1703	12787
1995-96	2122	14910
1996-97	2266	17176
1997-98	1982	19158
2001-02	1607	20765
2002-03	1519	22284
2003-04	2108	24393
2004-05	1906	26299
2005-06	1668	27967
2006-07	1500	29466
2007-08	1893	31359
2008-09	1760	33119
2009-10	1521	34641

Figure 3.5: Single Mass Curve –Kholongchu Dam Site



3.3.1.2. T –Test for Homogeneity of Data

To check, if the observed discharges at Muktirap and Trashiyangtse are homogeneous, statistical check i.e. t-test has been carried out on the available annual yields at these two sites. The annual yields at the two sites are given in **Table 3.8**. Mean and variance of annual flows at the two sites have been determined in **Table 3.9**. T statistical and t critical values have also been worked out in **Table 3.9**. It is seen that t Stat value is less than t Critical value. It is therefore concluded that the discharge data at these two sites is homogeneous.

Table 3.8: Annual Yields at Trashiyantse & Muktirap

Year	Muktirap		Chazam	
	Annual Yield (mm)	Cumulative	Annual Yield (mm)	Cumulative
2001	2177	2177	1272	1272
2002	1980	4157	1011	2105
2001	2711	7090	1217	1521
2004	2505	9595	1270	4791
2005	2207	11802	961	5754
2006	1966	11769	725	6479
2007	2417	16206	818	7117

Trashiyantse		Muktirap	
Period	Annual Yield (mm)	Period	Annual Yield (mm)
1987-88	2011	2001-02	2115
1988-89	1836	2002-03	1999
1989-90	2025	2003-04	2774
1990-91	2250	2004-05	2508
1991-92	2197	2005-06	2195
1992-93	1959	2006-07	1973
1993-94	2307	2007-08	2490
1994-95	2241	2008-09	2316
1995-96	2792	2009-10	2002
1996-97	2982		
1997-98	2608		

Table 3.9: T-Test - Two Samples Assuming Unequal Variances

Year	Trashiyantse		Chazam	
	Annual Yield (mm)	Cumulative	Annual Yield (mm)	Cumulative
1988	1747	1747	956	956
1989	2085	3831	1190	2146
1990	2170	6002	1617	3763
1991	2244	8245	1376	5139
1992	1950	10195	942	6081
1993	2285	12480	937	7018
1994	2184	14664	896	7914
1995	2797	17461	1071	8985
1996	3052	20513	956	9941
1997	2656	23169	872	10813

Mean	2291.703019	2263.749642
Variance	130881.8637	78044.94555
Observations	11	9
Hypothesized Mean Difference	0	
df	18	
t Stat	0.194902321	
P(T<=t) one-tail	0.423826216	
t Critical one-tail	1.734063592	
P(T<=t) two-tail	0.847652431	
t Critical two-tail	2.100922037	

3.3.1.3.Double Mass Curve

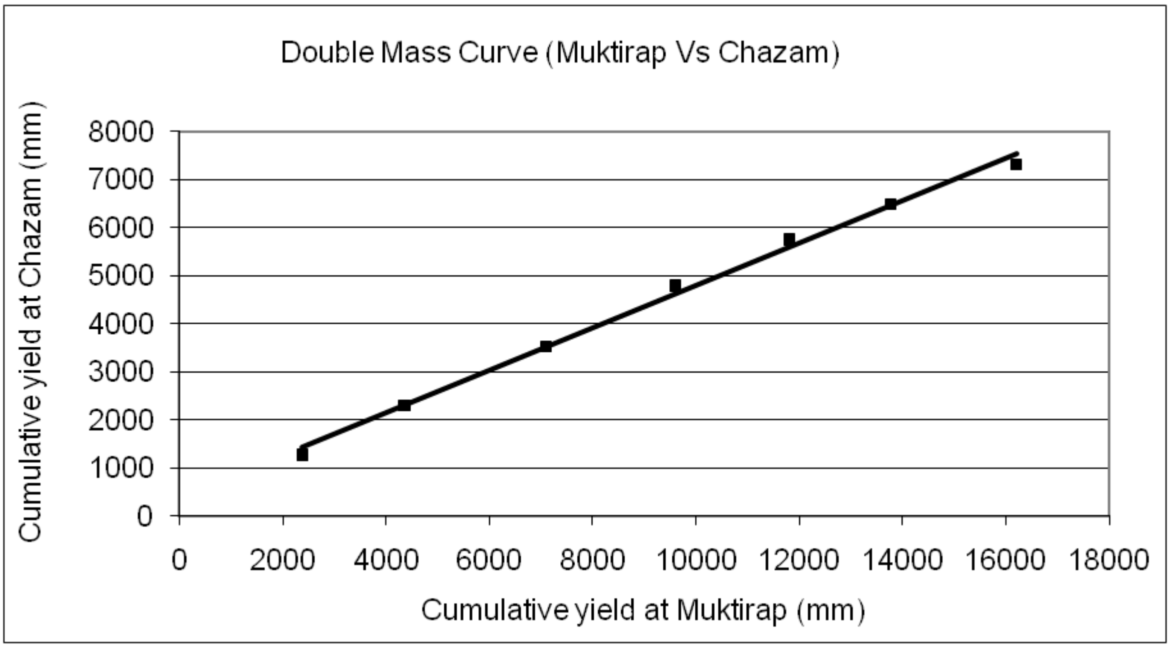
a) Muktirap and Chazam Discharges

Using the concurrent period annual flows of Kholongchu at Muktirap and Dramengchu (Gongrichu) at Chazam, cumulative annual flows at the two sites have been worked out in **Table 3.10**. Double mass curve between the cumulative flows at the two sites is plotted in **Figure 3.6**. It is seen that the double mass is nearly a straight line, indicating that the discharges at the two sites are consistent.

Table 3.10: Annual and Cumulative Yields at Muktirap and Chazam

Year	Muktirap		Lhuntsi	
	Annual Yield (mm)	Cumulative	Annual Yield (mm)	Cumulative
2001	2377	2377	2230	2230
2002	1980	4357	2094	4324
2003	2733	7090	2267	6591
2004	2505	9595	2025	8616
2005	2207	11802	1911	10528
2006	1966	13769	1943	12471
2007	2437	16206	2164	14634
2008	2324	18529	2164	16798

Figure 3.6: Double Mass Curve of Muktirap and Chazam



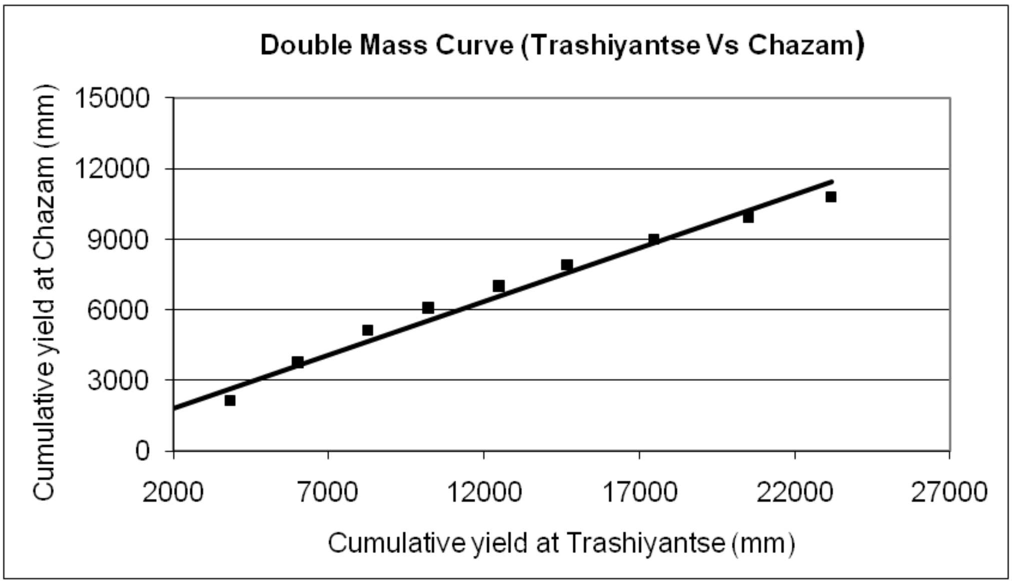
b) Trashiyantse and Chazam Discharges

Using the concurrent period annual flows of Kholongchu at Trashiyantse and Dramengchu (Gongrichu) at Chazam, cumulative annual flows at the two sites have been worked out in **Table 3.11**. Double mass curve between the cumulative flows at the two sites is plotted in **Figure 3.7**. It is seen that the double mass is nearly a straight line, indicating that the discharges at the two sites are consistent.

Table 3.11: Annual and Cumulative Yields at Trashiyantse and Chazam

Year	Trashiyantse		Uzorong	
	Annual Yield (mm)	Cumulative	Annual Yield (mm)	Cumulative
1993	2285	4249	1239	1239
1994	2184	6433	997	2236
1995	2797	9231	1329	3565
1996	3052	12283	1139	4704
1997	2656	14939	1189	5892

Figure 3.7: Double Mass Curve of Trashiyantse and Chazam



Similarly cumulative annual discharges for the common period for the sites in adjacent basin have also been worked out for Khoma River at Lhuntsi & Muktirap, Dramengchu (Gongrichu) at Uzorong & Trashiyangtse, Chamkharchu at Kurjey & Muktirap and Mangdechu at Bjizam & Muktirap. The annual and cumulative annual values for the concurrent period data of these sites are given in **Tables 3.12** to **3.14** and the plots of corresponding double mass curves are given in **Figures 3.8** to **3.11.**

Table 3.12: Annual and Cumulative Yields at Muktirap and Lhuntsi

Year	Muktirap		Lhuntsi	
	Annual Yield (mm)	Cumulative	Annual Yield (mm)	Cumulative
2001	2377	2377	2230	2230
2002	1980	4357	2094	4324
2003	2733	7090	2267	6591
2004	2505	9595	2025	8616
2005	2207	11802	1911	10528
2006	1966	13769	1943	12471
2007	2437	16206	2164	14634
2008	2324	18529	2164	16798

Figure 3.8: Double Mass Curve of Muktirap and Lhuntsi

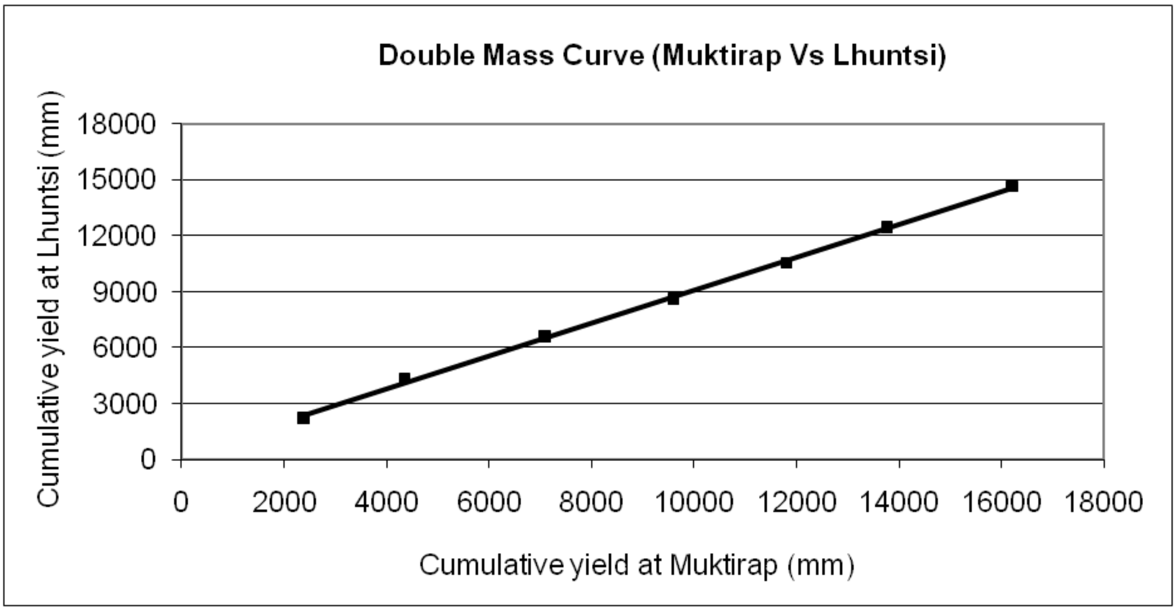


Table 3.13: Annual and Cumulative Yields at Trashiyantse and Uzorong

Year	Trashiyantse		Uzorong	
	Annual Yield (mm)	Cumulative	Annual Yield (mm)	Cumulative
1993	2285	4249	1239	1239
1994	2184	6433	997	2236
1995	2797	9231	1329	3565
1996	3052	12283	1139	4704
1997	2656	14939	1189	5892

Figure 3.9: Double Mass Curve of Trashiyantse and Uzorong

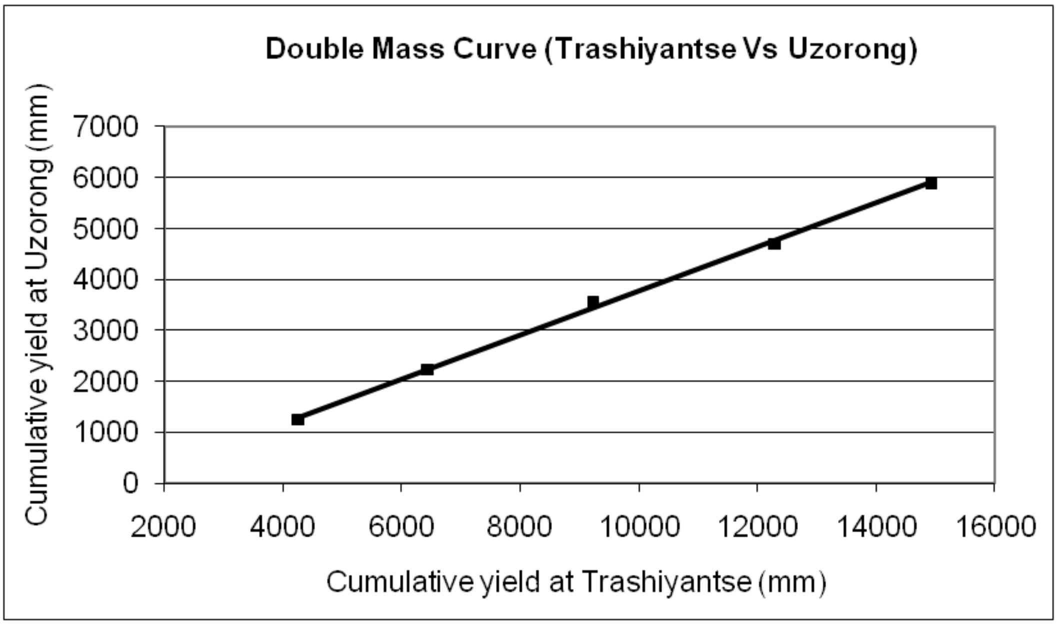


Table 3.14: Annual and Cumulative Yields at Muktirap, Kurjey and Bjizam

Year	Muktirap		Kurjey		Bjizam	
	Annual Yield (mm)	Cumula-tive	Annual Yield (mm)	Cumula-tive	Annual Yield (mm)	Cumula-tive
2001	2377	2377	1160	1160	1461	1461
2002	1980	4357	1151	2312	1293	2754
2003	2733	7090	1263	3575	1544	4298
2004	2505	9595	1304	4880	1523	5821
2005	2207	11802	1177	6056	1368	7189
2006	1966	13769	1179	7235	1269	8457
2007	2437	16206	1204	8440	1363	9820

Figure 4.10: Double Mass Curve of Muktirap and Kurjey

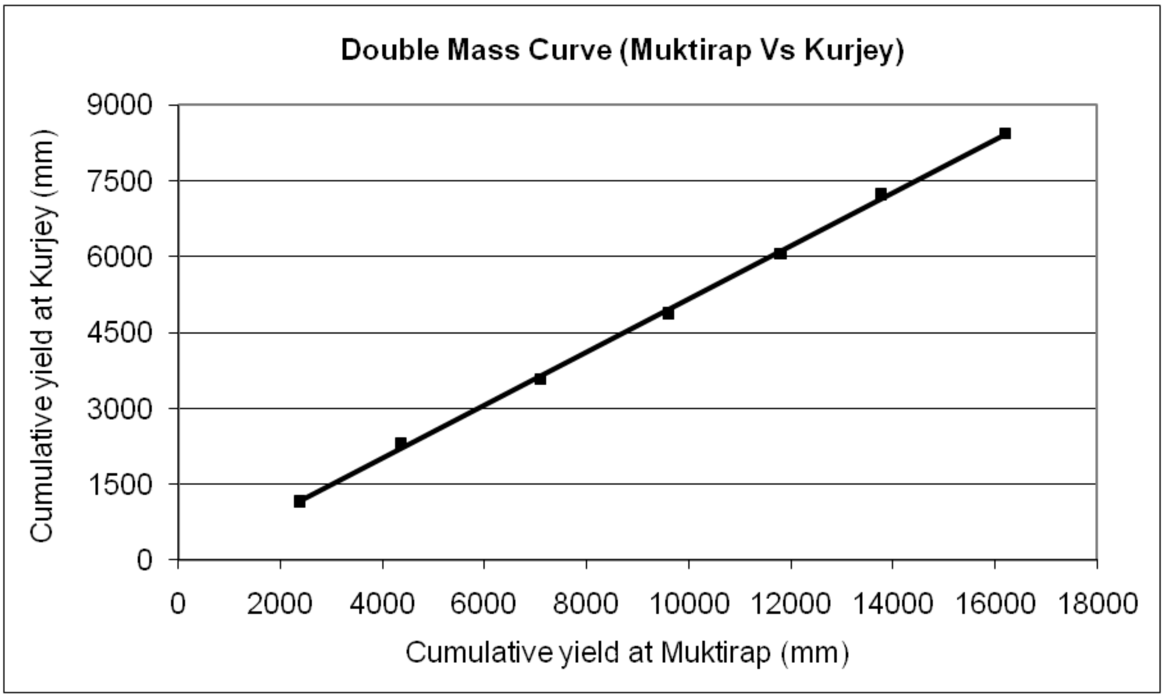
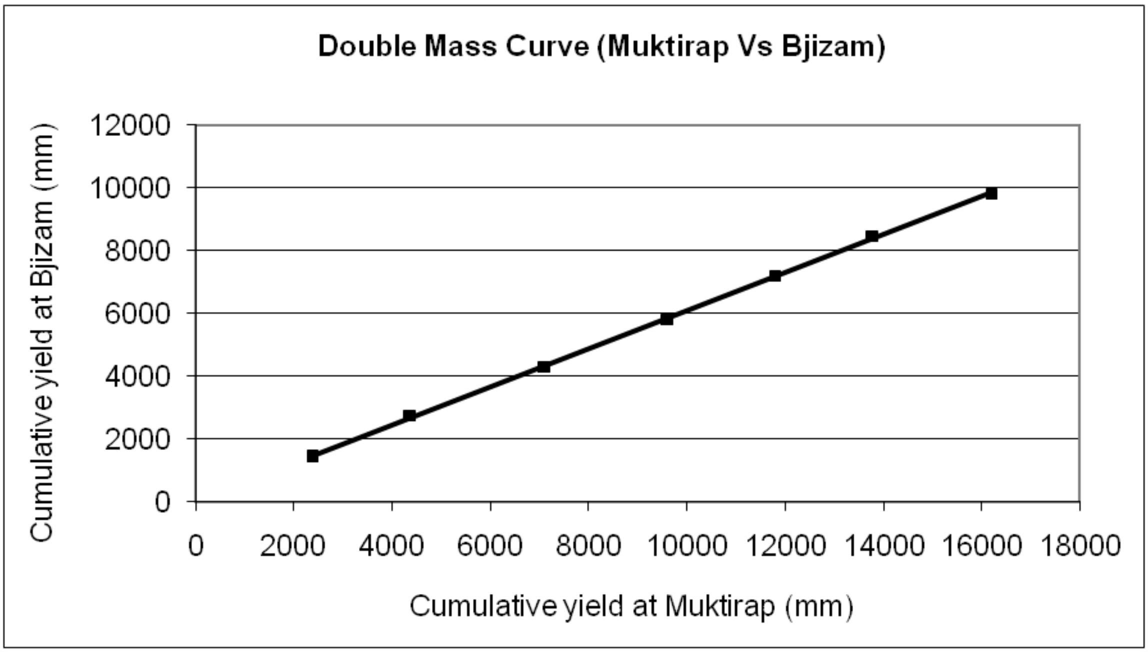


Figure 3.11: Double Mass Curve of Muktirap and Bjizam



Since the double mass curves for the above sites are nearly straight lines, the discharges at Lhuntsi, Uzorong, Kurjey and Bjizam in the adjacent basins are consistent with the discharges at Muktirap and Trashiyantse.

3.3.1.4.Correlation of Discharges

10-Daily discharges at Chazam, Lhuntsi, Kurjey and Bjizam have been correlated with the 10-daily discharges for the concurrent period at Muktirap. The plots of 10-daily discharges at Muktirap with Chazam, Lhuntsi, Kurjey and Bjizam are given in **Figures 3.12 to 3.15** respectively.

Figure 3.12: Correlation of Chazam & Muktirap Discharges

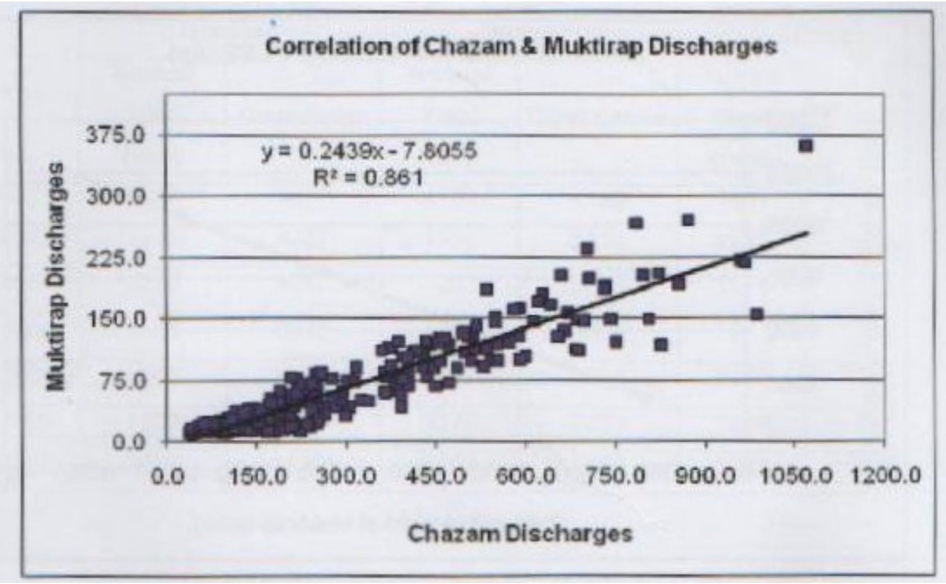


Figure 3.13: Correlation of Lhuntsi & Muktirap Discharges

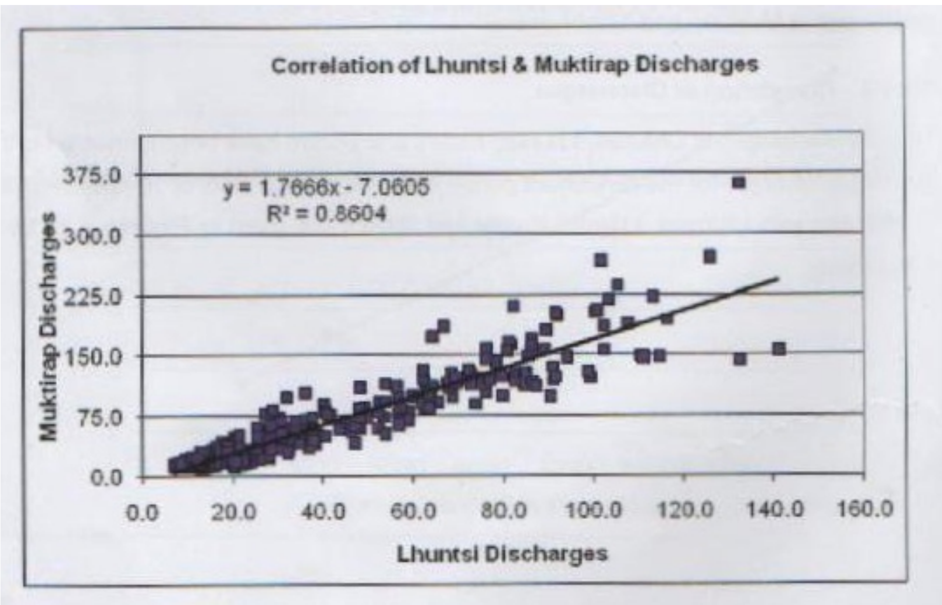


Figure 3.14: Correlation of Kurjey & Muktirap Discharges

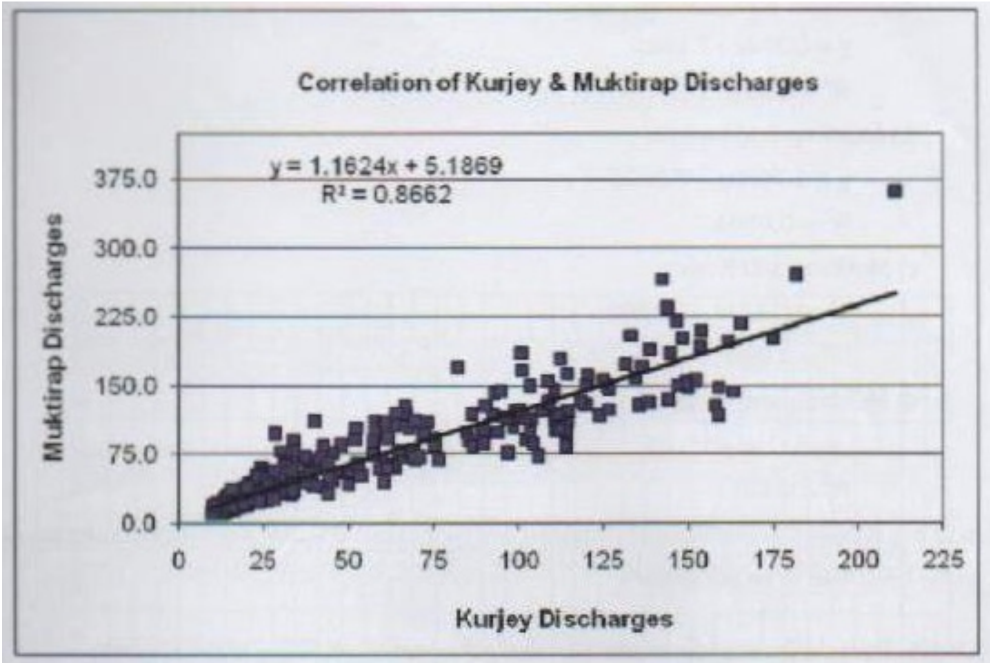
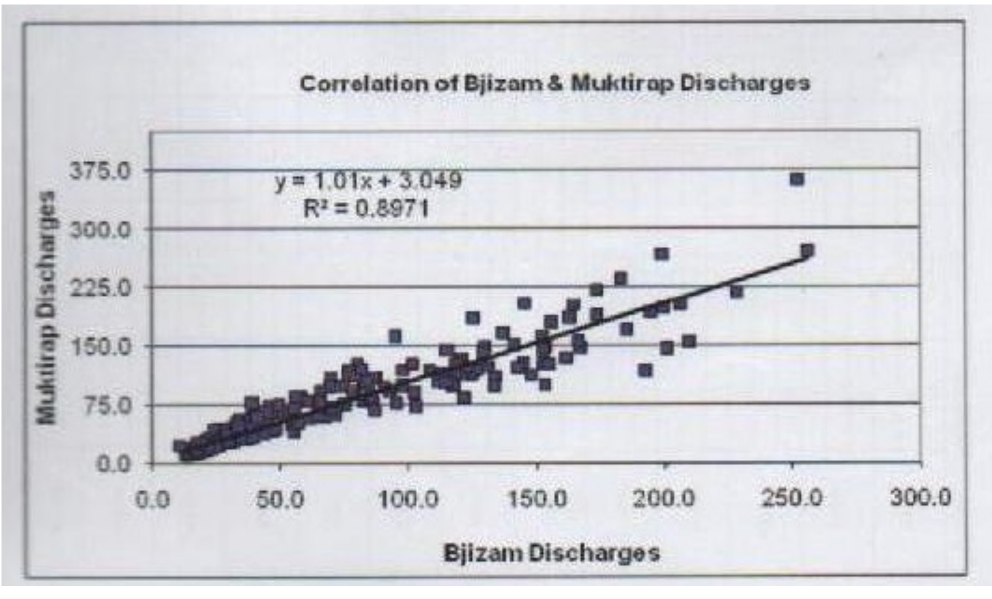


Figure 3.15: Correlation of Bjizam & Muktirap Discharges



The following relations of 10-daily discharges at these sites have been obtained:

a) Muktirap and Chazam

$y = 0.244x - 7.8055$

$R^2 = 0.861$

b) Muktirap and Lhuntsi

$y = 1.7666x – 7.0605$

$R^2 = 0.8604$

c) Muktirap and Kurjey

$y = 1.1624x + 5.1869$

$R^2 = 0.8662$

d) Muktirap and Bjizam

$y =1.01x + 1.049$

$R^2 = 0.8971$

Since the correlation coefficients obtained are more than 0.8, the discharges at these sites can be assumed to be consistent.

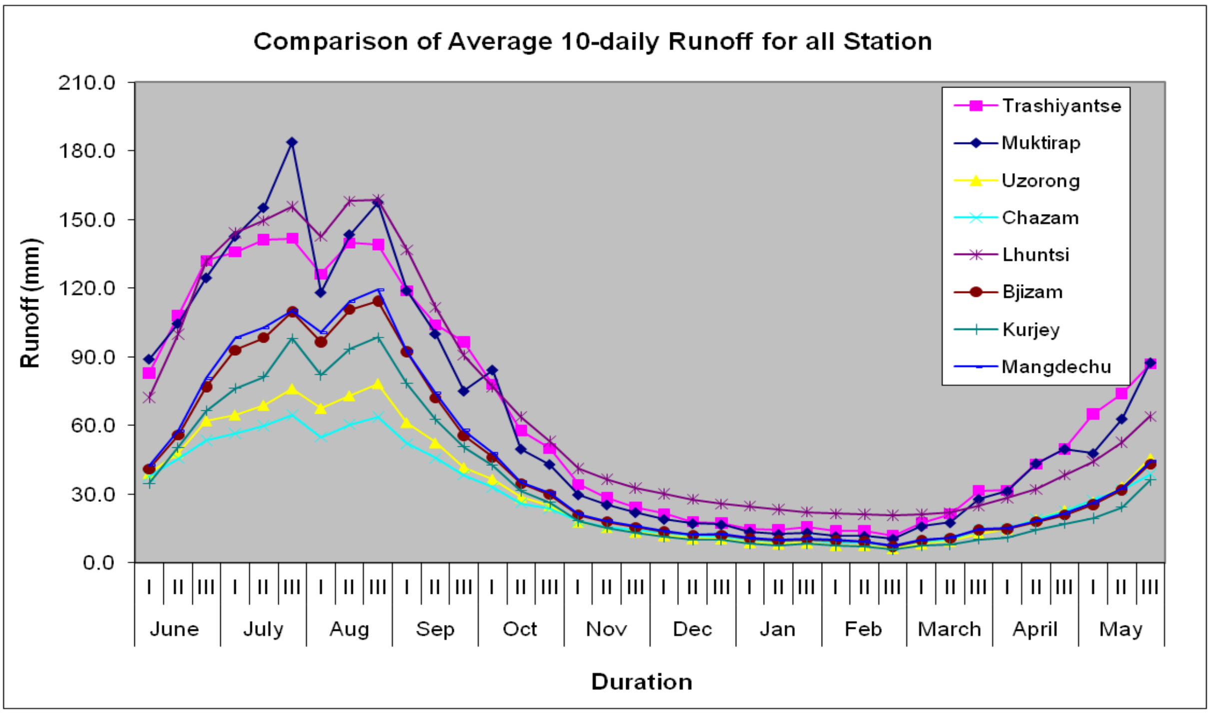
3.3.1.5.Comparison of Average 10 - Daily Runoff

From the available data at various sites, 10-daily average runoff at each site has been worked out and the values thus obtained are given in **Table 3.15** and plotted in **Figure 3.16.**

Table 3.15: Comparison of 10-daily Average Runoff at Various Stations

Month	10-daily	Average 10 - daily Runoff (mm)							
		Trashiyantse	**Muktirap**	**Uzorong**	**Chazam**	**Lhuntsi**	**Bjizam**	**Kurjey**	**Mangdechu**
June	I	82.8	89.0	39.2	37.9	72.3	41.0	34.8	42.5
	II	108.0	104.6	48.2	45.6	99.9	55.8	50.4	57.7
	III	132.2	124.5	62.1	53.5	131.7	77.0	66.5	80.8
July	I	135.9	142.6	64.7	56.6	144.1	92.9	76.2	98.3
	II	141.2	155.1	68.9	60.0	149.6	98.4	81.3	102.8
	III	141.8	183.7	76.2	64.7	155.6	109.7	98.0	110.2
Aug	I	126.1	118.1	67.6	54.9	142.7	96.6	82.1	100.7
	II	139.8	143.4	73.1	60.5	158.1	110.7	93.5	114.3
	III	139.0	157.5	78.4	63.8	158.8	114.5	98.5	119.5
Sep	I	118.9	118.9	61.4	52.2	136.8	92.2	78.3	92.4
	II	104.0	100.0	52.5	45.8	111.5	72.1	62.6	74.1
	III	96.5	75.1	41.7	38.3	90.7	55.7	50.6	57.9
Oct	I	78.0	84.3	36.7	33.0	76.8	46.2	42.6	47.8
	II	57.8	49.8	28.6	26.0	64.0	34.6	31.4	35.2
	III	50.0	43.1	25.1	23.7	53.1	29.8	26.4	30.6
Nov	I	34.2	29.8	18.0	18.3	41.2	20.9	18.3	21.3
	II	28.5	25.5	15.7	15.8	36.5	17.9	15.4	18.3
	III	24.3	22.1	13.5	14.2	32.7	15.5	13.3	15.9
Dec	I	21.5	19.1	12.0	13.0	30.1	13.5	11.4	13.9
	II	18.0	17.3	10.8	11.7	27.7	12.1	10.1	12.4
	III	17.3	16.8	10.6	11.5	25.8	12.2	10.0	12.5
Jan	I	14.7	13.6	8.9	10.2	24.7	10.5	8.5	10.8
	II	14.4	12.6	8.4	9.4	23.2	9.7	7.7	9.9
	III	15.7	13.3	8.8	10.1	22.3	10.3	8.5	10.6
Feb	I	14.1	11.7	7.7	8.9	21.5	9.8	7.5	10.0
	II	14.1	11.8	7.8	8.9	21.2	9.2	7.3	9.5
	III	11.8	10.6	6.3	7.2	20.8	7.2	5.7	7.4
March	I	17.3	16.0	8.4	9.4	21.2	9.8	7.4	10.0
	II	21.3	17.6	9.6	10.2	21.9	10.8	7.8	11.1
	III	31.6	27.9	12.7	14.4	24.8	14.3	10.3	14.7
April	I	31.7	31.4	14.9	15.0	28.2	14.8	11.1	15.2
	II	43.2	43.5	19.0	19.2	32.1	17.9	14.5	18.4
	III	49.7	49.8	23.1	22.4	38.4	20.9	17.1	21.5
May	I	65.1	47.9	26.7	27.5	44.4	25.5	19.4	26.2
	II	73.9	62.9	33.3	31.8	52.8	31.8	24.3	32.6
	III	86.9	87.5	45.7	38.8	64.0	43.2	36.1	44.4
Annual Runoff (mm)		**2301**	**2278**	**1146**	**1044**	**2401**	**1465**	**1245**	**1511**

Figure 3.16: Comparison of Average 10-daily Runoff for all Station



From the graph it is seen that 10-daily runoff at Muktirap, Trasiyantse and Lhuntsi are very high as compared to the runoff at other four sites. It is thus concluded that the observed discharges at Muktirap, Trashiyantse and Lhuntsi are on the higher side.

3.3.1.6.Comparison of Rainfall & Runoff

From the available daily discharges, annual and average annual runoffs at various sites have been computed and given in **Table 3.16.**

Table 3.16: Annual and Average Annual Runoff at Various Sites

Year	Trashiyantse	Muktirap	Uzorong	Chazam	Lhuntsi	Bjizam	Kurjey	Mangdechu
1986-87					2242			
1987-88	2021			1050	2630			
1988-89	1850			1058	2527			
1989-90	2033			1201	2776			
1990-91	2256			1713	2813			
1991-92	2204			1195	2898	1660	1400	1711
1992-93	1967		1239	924	2546	1248	1059	1292
1993-94	2318		997	982	2791	1270	1094	1310
1994-95	2256		1329	883	2280	1273	1065	1319
1995-96	2803		1139	1069	2652	1586	1292	1632
1996-97	2995		1189	935	2569	1577	1391	1625
1997-98	2610		1202	874	2298	1403	1256	1444
1998-99			1092	1060	2720	1795	1450	1856
1999-2000			1226	807	2583	1529	1354	1584
2000-01			1243	963	2764	1613	1290	1668
2001-02		2127	999	1247	2230	1426	1168	1474
2002-03		2010	1303	1004	2094	1316	1177	1362
2003-04		2783	1325	1288	2267	1598	1275	1647
2004-05		2518	1071	1305	2025	1486	1311	1534
2005-06		2211	904	818	1911	1349	1177	1395
2006-07		1984	1096	748	1943	1289	1191	1330
2007-08		2517	1064	804	2164			
2008-09		2340	1014		2164			
1009-10		2015			1798			
Mean	**2301**	**2278**	**1143**	**1044**	**2403**	**1464**	**1247**	**1511**

Though rainfall data for only one station within the catchment is available, yet it is seen that the rainfall at various stations within or around the catchment varies from 882 mm to 2186 mm, Considering a runoff factor of 0.7, rainfall for a runoff of 2296 mm at Muktirap would be about 3280 mm, which for the entire catchment of river Kholongchu up to Muktirap appears improbable. In view of this, it is felt that the observed discharges at Muktirap are on the higher side. Similarly the discharges at Trashiyangtse and Lhuntsi appear to be on the higher side. Whereas the observed discharges at Chazam, Uzorong, Kurjey, Bjijam and Mangdechu dam site appear to be in order.

3.3.1.7.Conclusions Derived from Consistency Checks

From the consistency checks carried out on the observed data at various sites, the following conclusions may be derived:

i) The discharges at various sites are consistent and follow nearly the same trend.

ii) The discharges at Muktirap and Trashiyangtse are homogeneous

iii) Though the observed discharges at Muktirap and Trashiyangtse are consistent and homogeneous, yet they appear to be on the higher side, when compared with the likely catchment rainfall or with the discharges at other sites within the basin or adjacent basin.

iv) Similarly the observed discharges of Khomachu at Lhuntsi appear to be on the higher side.

3.4.PREPARATION OF FLOW SERIES

Muktirap and Trashiyangtse discharge sites (catchment areas 905 sq km and 862 sq km respectively) are nearly 10 km upstream of the diversion site (D-3) and the catchment areas at the Diversion site and these sites are comparable. It would, therefore, be desirable to use the discharge data of Muktirap and Trashiyangtse for the water availability studies for the project. But it is found that the observed annual runoff at these sites is very high, when compared with the runoff at other sites within the basin or with the sites in the adjacent basin. The runoff at these sites also appears to be high when compared with the likely catchment rainfall up to the discharge sites.

Though Chazam and Uzorong discharge sites fall in the same basin and the discharges at these sites appear to be compatible with rainfall, but the catchment areas at these sites is about 8 times the catchment area at the project site. Hence the catchment characteristics of Uzorong or Chazam would be quite different and these sites would have different hydro-meteorological characteristics. Hence it would also not be desirable to use the discharge series at these sites for developing the flow series at the proposed dam site.

In view of the above, it is proposed to develop the 10-daily discharge series at the diversion site by converting the observed discharges at Trashiyangtse and Muktirap to the dam site in catchment area proportion and then applying a suitable reduction factor to the flow series thus obtained, to make it compatible with the likely catchment rainfall.

3.4.1.Estimation of Average Annual Runoff from Catchment Rainfall

Average annual rainfall for various stations within and around the catchment of Kholongchu HEP has been utilized for estimating the average annual runoff for the project. The catchment up to the project site has been divided into elevation zones of 100 m intervals up to an elevation of 3,000 m, and then from 3,000 m to 4,600 m and the balance catchment above 4,600 m. From the hypsometry of the catchment, catchment areas intercepted for each zone have been determined. Corresponding rainfall values for various elevations have been taken from the average annual rainfall values of the respective rain gauge stations at those elevations. Multiplying the rainfall value for each zone with the corresponding catchment area of the zone, average annual runoff for each zone in MCM has been found out. The sum of average annual runoff for all the elevation zones gives the annual average runoff in MCM for the whole catchment up to the project site, which works out as 1759.3 MCM (1571 mm). The computations for average annual runoff from catchment rainfall are given in **Table 3.17.**

3.4.2. Development of Flow Series at the Dam Site

Since Kholongchu HEP is a run- of - the river project, it would be desirable to develop 10 daily flow series for planning the project features. As already mentioned in Para 3.2, available discharge data of River Kholongchu at Trashiyangtse and Muktirap discharge sites, which are located near the project site and have comparable catchment areas, have been utilised for estimating the discharge series at the dam site. Discharge data at Trashiyangtse is available for the period January 1987 to October 1998, whereas the data for the period February 2001 to June 2010 is available at Muktirap. Following procedure has been adopted for estimating the 10-daily discharge series at the dam site:

S.No	Year	Yield (MCM)	Depandability (%)	Corrosponding Year	Corrosponding Yield (MCM)
1	1987-88	1537	4.76	1996-97	2276
2	1988-89	1406	9.52	1995-96	2132
3	1989-90	1545	14.29	2003-04	2115
4	1990-91	1714	19.05	1997-98	1983
5	1991-92	1676	23.81	2004-05	1913
6	1992-93	1495	28.57	2007-08	1913
7	1993-94	1762	33.33	2008-09	1778
8	1994-95	1714	38.10	1993-94	1762
9	1995-96	2132	42.86	1990-91	1714
10	1996-97	2276	47.62	1994-95	1714
11	1997-98	1983	**52.38**	**2005-06**	**1680**
12	2001-02	1617	57.14	1991-92	1676
13	2002-03	1527	61.90	2001-02	1617
14	2003-04	2116	66.67	1989-90	1545
15	2004-05	1913	71.43	1987-88	1537
16	2005-06	1680	76.19	2009-10	1531
17	2006-07	1509	80.95	2002-03	1527
18	2007-08	1914	85.71	2006-07	1508
19	2008-09	1778	**90.48**	**1992-93**	**1495**
20	2009-10	1531	95.24	1988-89	1406

i) 10 - Daily discharges at Trashiyangtse have been converted to the dam site (D-3) in catchment area proportion.

ii) 10-Daily discharges at Muktirap have also been converted to the dam site (D-3) in catchment area proportion.

iii) The combined 10-daily discharge series thus obtained at the dam site (D-3) for the period January 1987 to October 1998 and February 2001 to June 2010 is given in **Table 3.18**.

S.No	Site	Dependable Flows (MCM)	
		90%	50%
1	D-3	1495	1680
2	D-7	1392	1565
3	Chapanangchu diversion	54	61
4	D-7 + Chapanangchu diversion	1446	1626

iv) From the 10 -daily discharge series at the dam site (D-3) as obtained above in step (iii), average annual runoff in cumecs and annual runoff in MCM and mm have been worked out for each year in **Table 3.18**. Average annual runoff for the whole series has been worked out as 2591 MCM (2314 mm).

v) The discharge series obtained in step (iv) above and arranged in water year (June to May) for the period 1987 - 88 to 2009 -10, is given in **Table 3.19**. Average annual runoff for this series works out as 2553 MCM (2279 mm).

vi) Average annual runoff as worked out on the basis of rainfall data in **Table 3.17** is 1759.3 MCM (1571 mm).

vii) Reduction factor to estimate the flow series at the dam site (D-3) has been worked out by dividing the average annual runoff at the dam site obtained from rainfall data with the average annual runoff obtained by conversion of observed discharges at Trashiyangtse & Muktirap to dam site in catchment area proportion. The reduction factor thus works out as 0.679 (1571 / 2314).

viii) Hence a reduction factor of 0.679 has been applied to the discharge series at the dam site (D-3) for the period 1987- 88 to 2009- 10, obtained by increasing the observed discharges at Trashiyangtse and Muktirap in catchment area proportion (**Table 3.19).** The estimated discharge series thus obtained for the period 1987- 88 to 2009 - 10 is given in **Table 3.20.**

ix) For estimating the discharge series at D-7 dam site, the discharges obtained at D-3 dam site have been reduced in the catchment area proportion. The discharge series at the proposed D-7 dam site thus obtained is given in **Table 3.21**.

x) It is also proposed to consider the possibility of diverting water of Chapanangchu above elevation 1580 m (±) to head race tunnel through a drop shaft. The catchment area of Chapanangchu above elevation 1580 m works out as 40 sq km. The flow series for Chapanangchu at the diversion site has been obtained in **Table 3.22** by reducing the flows at D-3 site in catchment area proportion. The combined flow series for D-7 dam site and Chapanangchu diversion is given in **Table 3.23**.

3.5. DEPENDABLE DISCHARGES

Annual flows for Kholongchu project site (D-3) for the period 1987-88 to 2009-10 have been computed from the 10-daily flows obtained in **Table 3.20**. The annual flows thus derived have been arranged in descending order. The following equation developed by Weibull has been used for estimating the percentage dependable flows:

$$D = (m / (N+1)) \times 100$$

Where, D = % age dependability

m = Rank of annual flow in descending order

N = Number of years of data

Dependable flows have been estimated in **Table 3.23**

Table 3.23: Estimation of Dependable Flows for D-3 Dam site

Similarly 90% and 50% dependable annual flows have been worked out for D-7, Chapanangchu diversion and D-7 plus Chapanangchu diversion. The 90% and 50% dependable flows for the above alternatives, which correspond to the years 1992 - 93 and 2005 - 06 re-

Type of Structure	Flood Prescription
CWC: criteria for pick up weir	According to the importance and level conditions, a flood of 50 to 100 years return period should be adopted
IS: 6966 (1989): Criteria for hydraulic design of barrages & weirs	For purpose of design of items other than free board, a design of 50 years may normally suffice. In such cases, where risks and hazards are involved, a review of this criteria based on site conditions may be necessary. For designing the free board, a minimum of 500 years return period flood or the Standard Project Flood (SPF) may be desirable.
IS 11223 (1985): Guidelines for determining spillway capacity	Spillways of small dams with gross storage between 0.5 and 10 MCM and hydraulic head between 7.5 and 12 m are to be designed to safely pass the 100 year flood. Intermediate dams with gross storage capacity between 10 and 60 MCM and hydraulic head between 12 and 30 m are to be designed for safely pass the Standard Project Flood (SPF). Large dams with gross storage capacity greater than 60 MCM & hydraulic head greater than 30 m are to be designed to safely pass the Probable maximum Flood (PMF).

spectively, are given below in **Table 3.24.**

Table 3.24: 90 % and 50 % Dependable Flows

S.No	Site	Dependable Flows (MCM)	
		90%	50%
1	D-3	1495	1680
2	D-7	1392	1565
3	Chapanangchu diversion	54	61
4	D-7 + Chapanangchu diversion	1446	1626

The 10 - daily discharges during the 90% dependable year of 1992-93 for various alternatives are given below in **Table 3.25.**

Table 3.25: 90 % Dependable Year Flows

Year (1992-93)		10-Daily Discharges (cumecs)			
		D-3	D-7	Chapanang Chu Diversion	D-7 + Chapanang Chu Diversion
June	I	58.0	54.0	2.1	56.1
	II	67.3	62.7	2.4	65.1
	III	108.6	101.1	3.9	105.1
July	I	79.7	74.2	2.9	77.1
	II	79.6	74.1	2.9	77.0
	III	100.7	93.8	3.6	97.5
August	I	96.2	89.6	3.5	93.1
	II	84.0	78.3	3.0	81.3
	III	93.0	86.6	3.4	89.9
September	I	74.3	69.2	2.7	71.9
	II	79.8	74.3	2.9	77.2
	III	54.8	51.0	2.0	53.0
October	I	62.1	57.9	2.2	60.1
	II	53.9	50.2	2.0	52.2
	III	39.2	36.5	1.4	38.0
	I	29.3	27.3	1.1	28.4

November	II	26.4	24.5	1.0	25.5
	III	27.0	25.1	1.0	26.1
December	I	25.5	23.7	0.9	24.7
	II	15.4	14.4	0.6	14.9
	III	13.2	12.3	0.5	12.8
January	I	13.5	12.6	0.5	13.1
	II	16.3	15.2	0.6	15.7
	III	19.3	17.9	0.7	18.6
February	I	19.1	17.8	0.7	18.5
	II	20.0	18.7	0.7	19.4
	III	21.3	19.9	0.8	20.6
March	I	21.2	19.8	0.8	20.5
	II	19.5	18.2	0.7	18.9
	III	20.1	18.7	0.7	19.4
April	I	24.6	22.9	0.9	23.8
	II	31.0	28.9	1.1	30.0
	III	35.5	33.0	1.3	34.3
May	I	53.8	50.1	1.9	52.0
	II	56.8	52.9	2.1	54.9
	III	59.6	55.5	2.2	57.6

CHAPTER 4

4. DESIGN FLOOD

4.1.General

Design flood studies are essential for proper planning & functioning of water resource projects. If the selected design flood is too high, it results in a conservative & unnecessary costly structure; while adoption of a low design flood may result in the loss of the structure itself, causing untold misery to the people downstream, in addition to the damage to the structure and valuable properties.

4.2.Design Flood Criteria

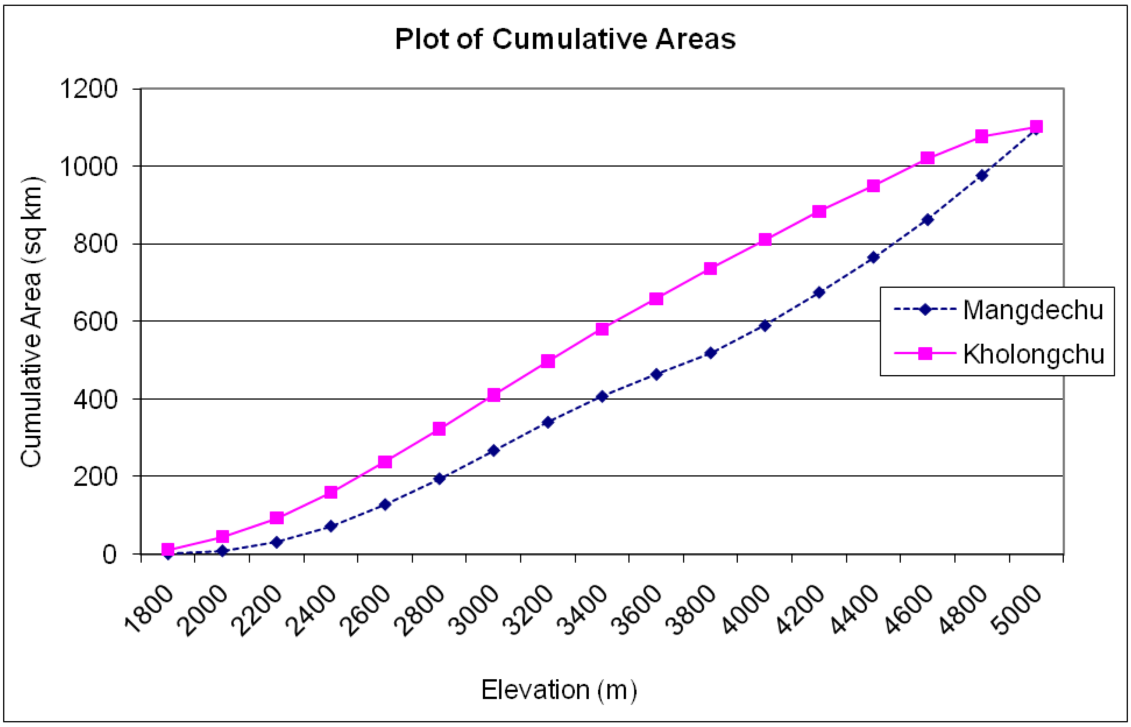
The standards and guidelines for the prescription of the appropriate design flood given by CWC & Bureau of Indian Standards (BIS) are summarized in **Table 4.1**

Table 4.1: Design Flood Prescription Criteria

Type of Structure	Flood Prescription
CWC: criteria for pick up weir	According to the importance and level conditions, a flood of 50 to 100 years return period should be adopted
IS: 6966 (1989): Criteria for hydraulic design of barrages & weirs	For purpose of design of items other than free board, a design of 50 years may normally suffice. In such cases, where risks and hazards are involved, a review of this criteria based on site conditions may be necessary. For designing the free board, a minimum of 500 years return period flood or the Standard Project Flood (SPF) may be desirable.
IS 11223 (1985): Guidelines for determining spillway capacity	Spillways of small dams with gross storage between 0.5 and 10 MCM and hydraulic head between 7.5 and 12 m are to be designed to safely pass the 100 year flood. Intermediate dams with gross storage capacity between 10 and 60 MCM and hydraulic head between 12 and 30 m are to be designed for safely pass the Standard Project Flood (SPF). Large dams with gross storage capacity greater than 60 MCM & hydraulic head greater than 30 m are to be designed to safely pass the Probable maximum Flood (PMF).

Since the height of the dam is more than 30 m, Kholongchu HEP is designed to safely pass the probable maximum flood.

4.3.Design Flood Approach



Following approaches are adopted for the estimation of design flood:

i) Hydro-meteorological approach

ii) Probabilistic Approach Using Frequency Analysis

4.3.1.Hydro meteorological Approach

a) Synthetic Unit Hydrograph

Since short duration gauge, discharge and rainfall data for any discharge site for Kholongchu or other rivers in the vicinity having similar hydro-meteorological characteristics, is not available, derivation of unit hydrograph based on the observed hydro-meteorological data is not possible. Hence design flood for the project has been worked out based on synthetic unit hydrograph derived using Clark's model and Dimensionless unit hydrograph.

b)Clark's Model for Synthetic U.G.

Clark's model uses "Time – Area Histogram" of the catchment for the development of an Instantaneous Unit Hydrograph (IUH). It is assumed that the rainfall excess first undergoes pure translation and then attenuation. The Clark's method expresses the unit hydrograph in terms of two parameters viz time of concentration (Tc) and storage attenuation constant (R) representing the rate of with drawl of water from the storage in the basin and channel system. R can be estimated by dividing the flow at the point of inflection on the recession side of the direct surface runoff hydrograph by the rate of change of discharge at that time. The method is based on the concept of Instantaneous Unit Hydrograph (IUH), which translates incremental runoff from sub-areas within a basin to the dam site according to their travel time and then routes this runoff through a linear reservoir in order to account for the storage effect of the basin and river channels.

c)Dimensionless Unit Hydrograph

If unit hydrograph for a basin having similar hydro-meteorological characteristics has been developed, it can be utilized to find out the unit hydrograph for an ungauged basin, by reducing it to a dimensionless hydrograph. To construct a dimensionless unit hydrograph from a unit hydrograph, its time scale in hours is first reduced by dividing the time ordinates by factor "lag plus semi duration". Then discharge ordinates of the unit hydrograph (in cumecs) are reduced by multiplying them by a factor equal to "lag plus semi duration" divided by the total direct runoff of the unit hydrograph in cumec hours. Such a double adjustment of time and unit hydrograph ordinates of the U.G. eliminates the effects of basin size, area pattern and duration of effective rainfall. A unit hydrograph for the ungauged area can be obtained directly from this dimensionless U.G. by multiplying the time ordinates by the appropriate value of lag and discharge ordinates by runoff volume of 1 cm rainfall excess in unit duration.

4.3.2.Probabilistic Approach Using Frequency Analysis

In this approach frequency analysis of the annual instant peak discharges at the dam site obtained from the observed annual peak discharges of Kholongchu at Muktirap and Trashiyantse has been carried out, using appropriate distribution. Since annual peak discharges are determined from observed daily discharges, an appropriate multiplication factor is applied to the annual observed flood peaks based on daily observed discharges, to account for the missing instantaneous peak discharge values.

4.4. HYDRO-METEOROLOGICAL APPROACH

4.4.1.Clark's Method

It is seen that design flood for Mangdechu HEP, which also falls in Manas basin and has similar rainfed catchment area has been examined and approved by CWC. In view of this, the Mangdechu and Kholongchu basins were compared to check the hydro-meteorological similarity of the two basins.

4.4.1.1.Comparison of Hypsometry

Hypsometry of rainfed catchment of Mangdechu and Kholongchu catchment elevation interval of 200 m is given in **Table 4.2.** From this cumulative area at 200 m interval have been worked out and plotted in **Figure 4.1.** It is seen that the cumulative catchment area graph for different elevation ranges are of similar nature, indicating that the two catchments are hydro-meteorologically similar.

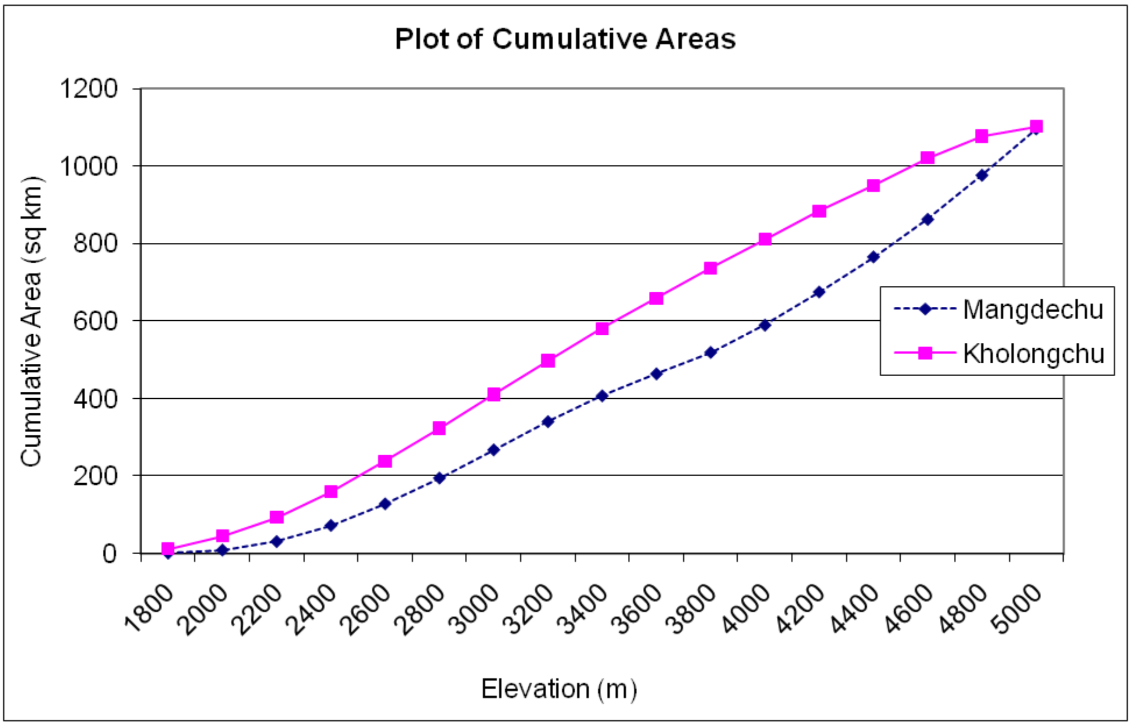
4.4.1.2.Equivalent Elevations

Equivalent elevations of the two catchments have also been determined by multiplying the incremental areas with the average elevation and then dividing the sum by the respective catchment area **(Table 4.2).** The equivalent elevation for the Kholongchu and Mangdechu thus work out as 3353 m and 3750 m respectively. Since the two values do not differ much, these catchments can be considered as hydro-meteorologically similar.

Table 4.2: Estimation of Equivalent Elevation

Elevation Increment	Average Elevation	Incremental Area		Incr Area * Avg Elevation	
		Mangdechu	Kholongchu	Mangdechu	Kholongchu
1400-1600	1500	0	2.95	0	4425
1600-1800	1700	0.7	11.69	1190	19873
1800-2000	1900	7.98	32.98	15162	62662
2000-2200	2100	21.89	48.46	45969	101766
2200-2400	2300	41.71	65.85	95933	151455
2400-2600	2500	55.76	78.95	139400	197375
2600-2800	2700	66.52	85.54	179604	230958
2800-3000	2900	72.84	87.08	211236	252532
3000-3200	3100	72.94	86.16	226114	267096
3200-3400	3300	66.63	83.58	219879	275814
3400-3600	3500	56.84	77.7	198940	271950
3600-3800	3700	55.28	78.09	204536	288933
3800-4000	3900	70.55	74.75	275145	291525
4000-4200	4100	85.61	73.11	351001	299751
4200-4400	4300	90.55	65.99	389365	283757
4400-4600	4500	96.99	71.19	436455	320355
4600-4800	4700	114.01	55.55	535847	261085
4800-5000	4900	119.56	25.03	585844	122647
Sum		1096.36	1104.65	4111620	3703959
		Equivalent Elevation (m)		3750	3353

Figure 4.1: Plot of Cumulative Areas



4.4.1.3.Comparison of Hydrographs

10-daily discharges for the common period (2001 to 2007) at Muktirap and Mangdechu have been plotted in **Figures 4.2 (a) to 4.2 (g)**. The flows for the entire common period at the two sites have also been plotted in **Figure 4.2 (h)**. It is seen that the plots follow a similar trend, which also indicates that the two sites are hydro-Meteorologically similar.

Figure 4.2 (a): Comparison of Discharges (2001)

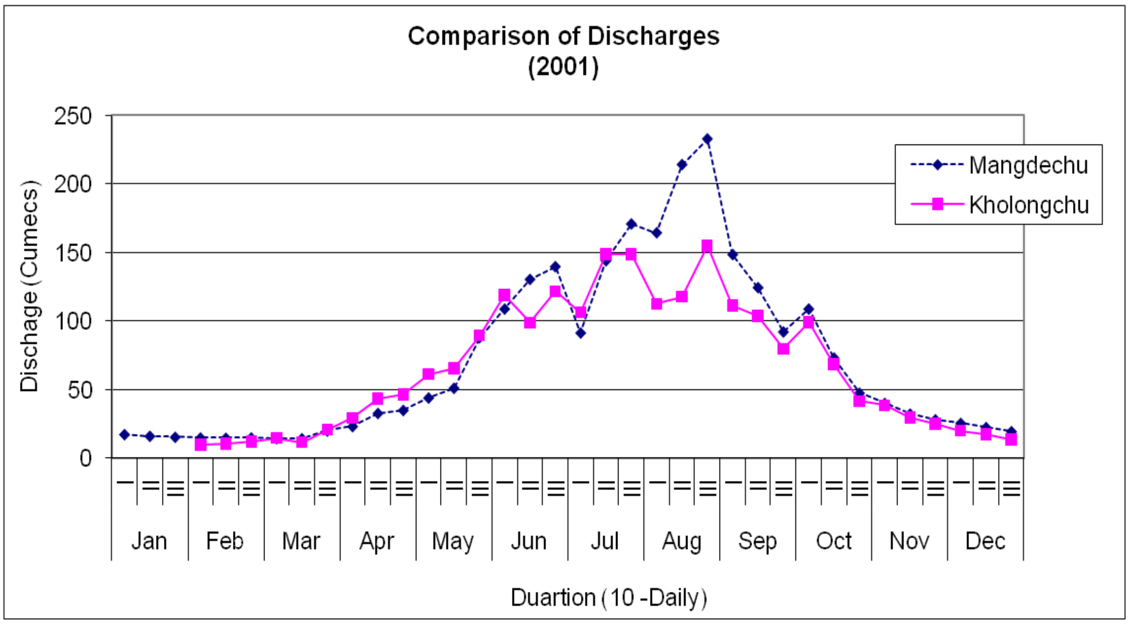


Figure 4.2 (b): Comparison of Discharges (2002)

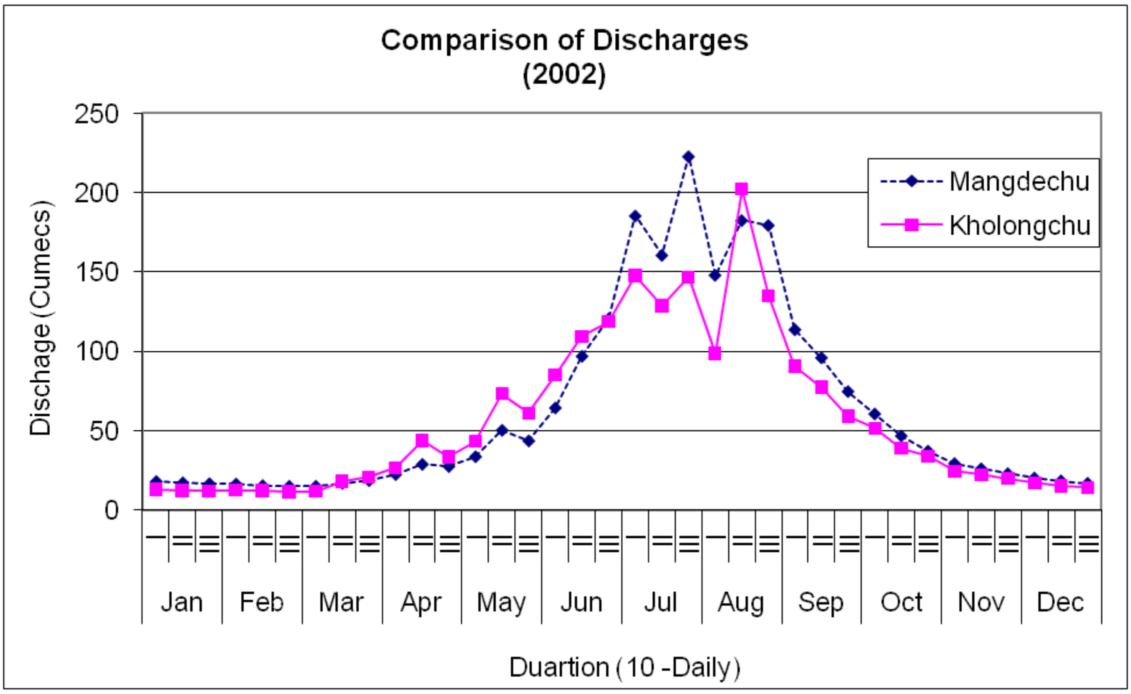


Figure 4.2 (c): Comparison of Discharges (2003)

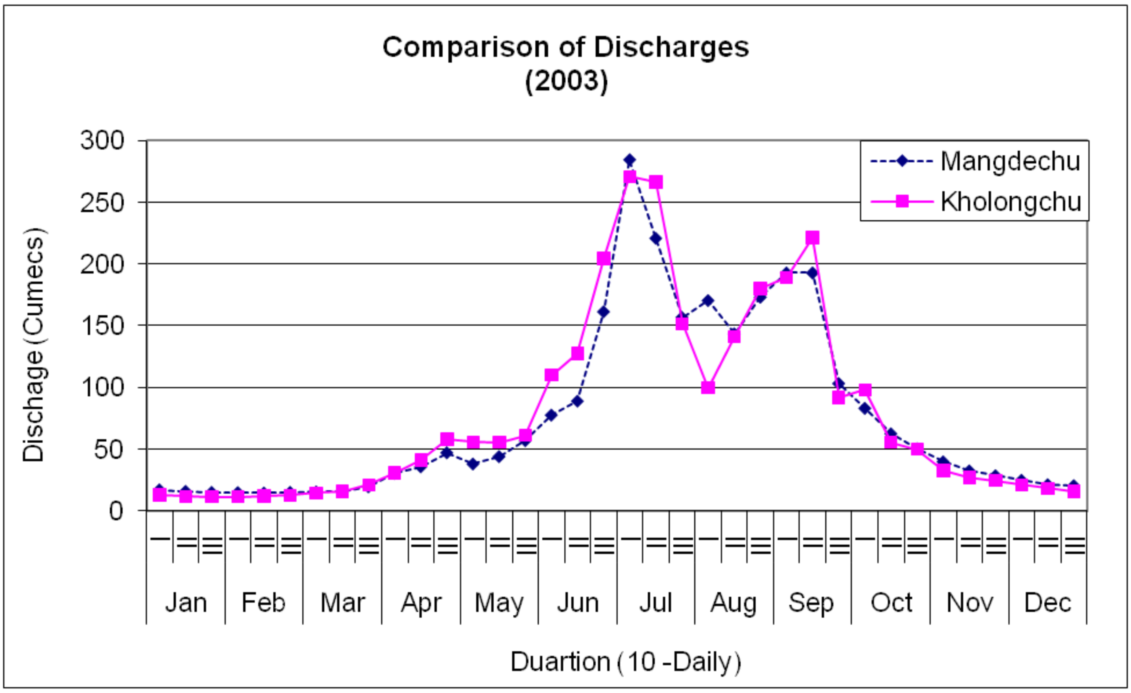


Figure 4.2 (d): Comparison of Discharges (2004)

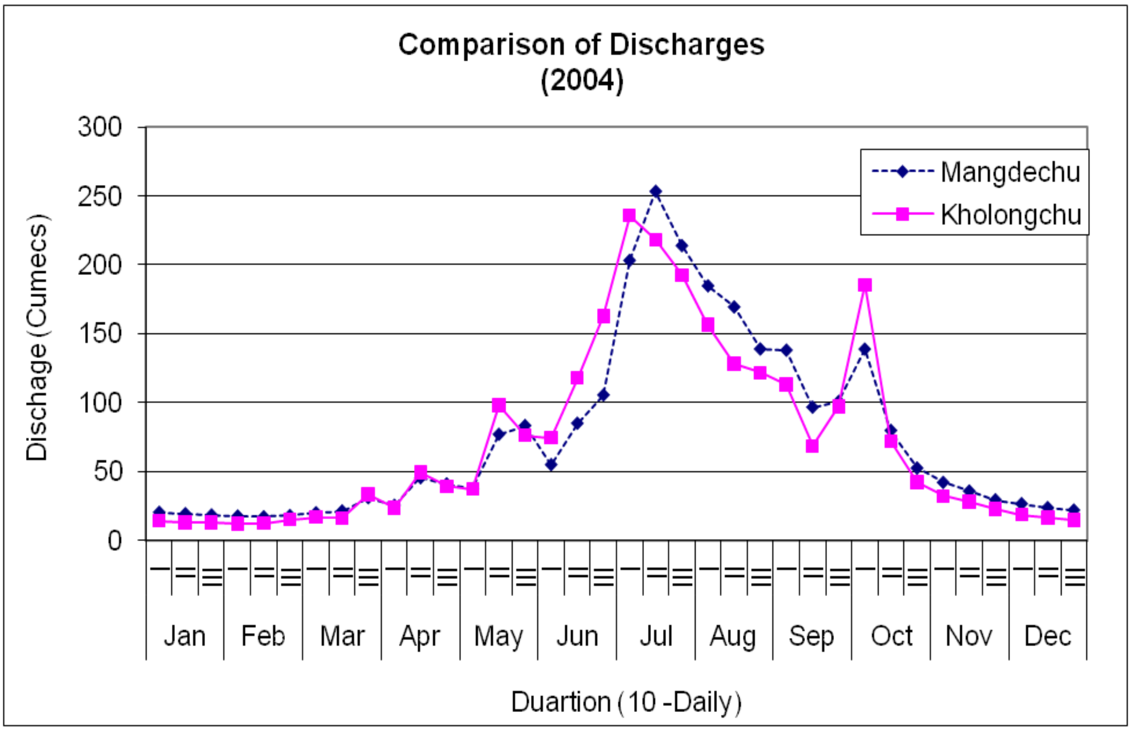


Figure 4.2 (e): Comparison of Discharges (2005)

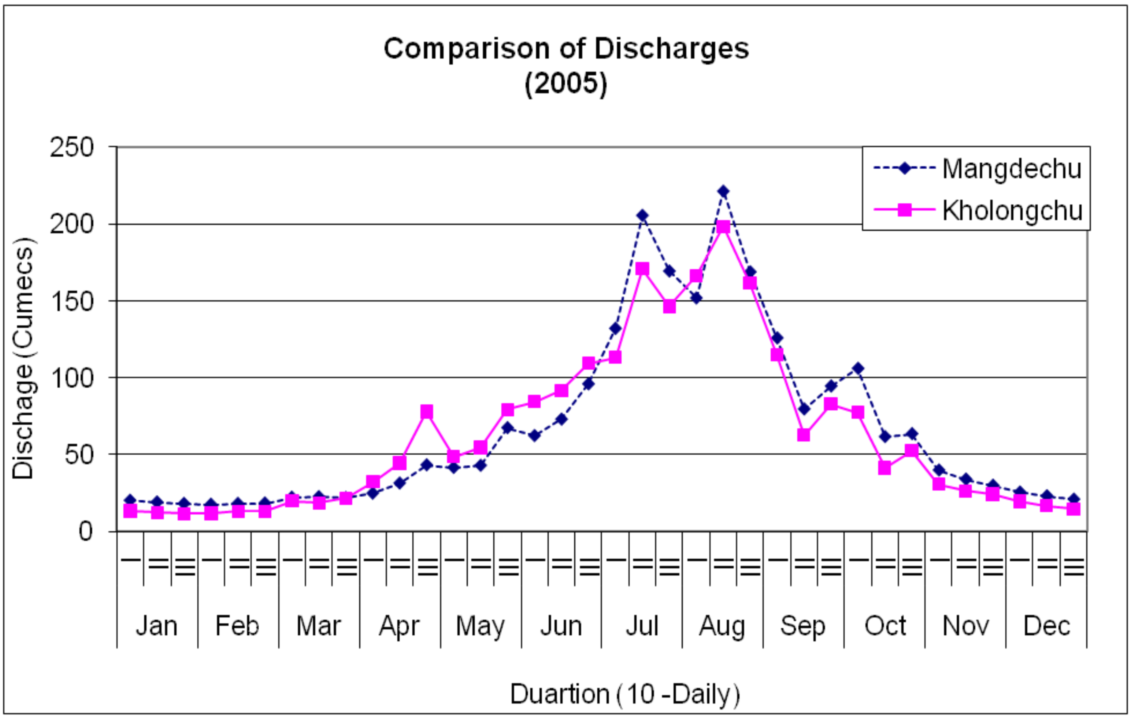


Figure 4.2 (f): Comparison of Discharges (2006)

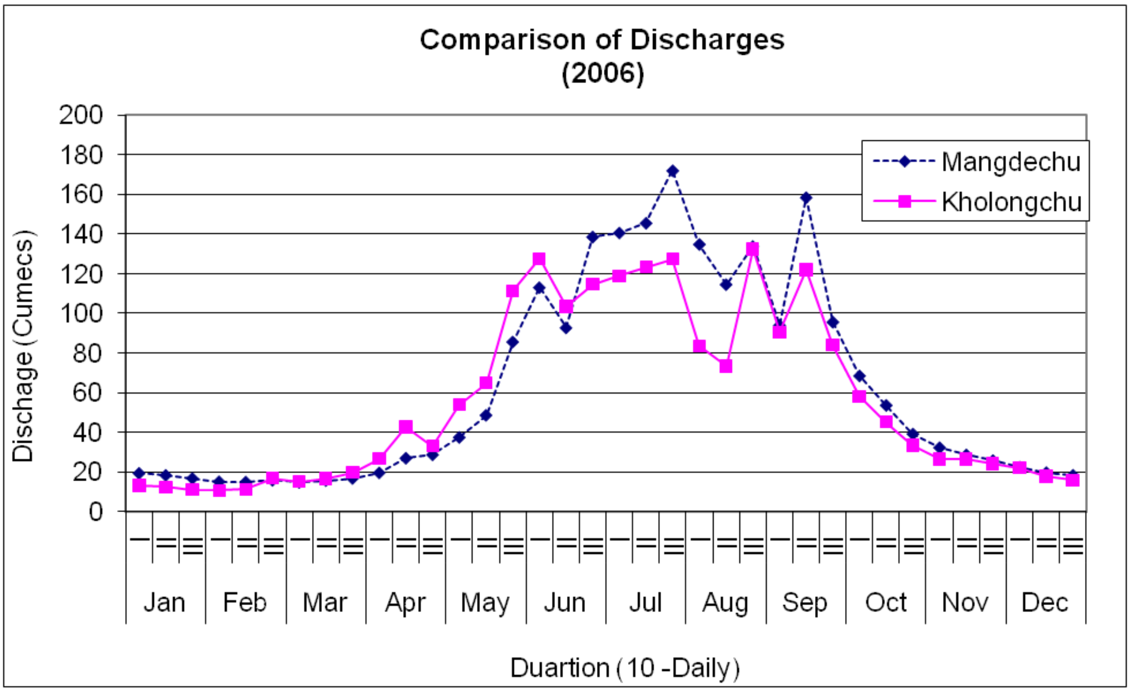


Figure 4.2 (g): Comparison of Discharges (2007)

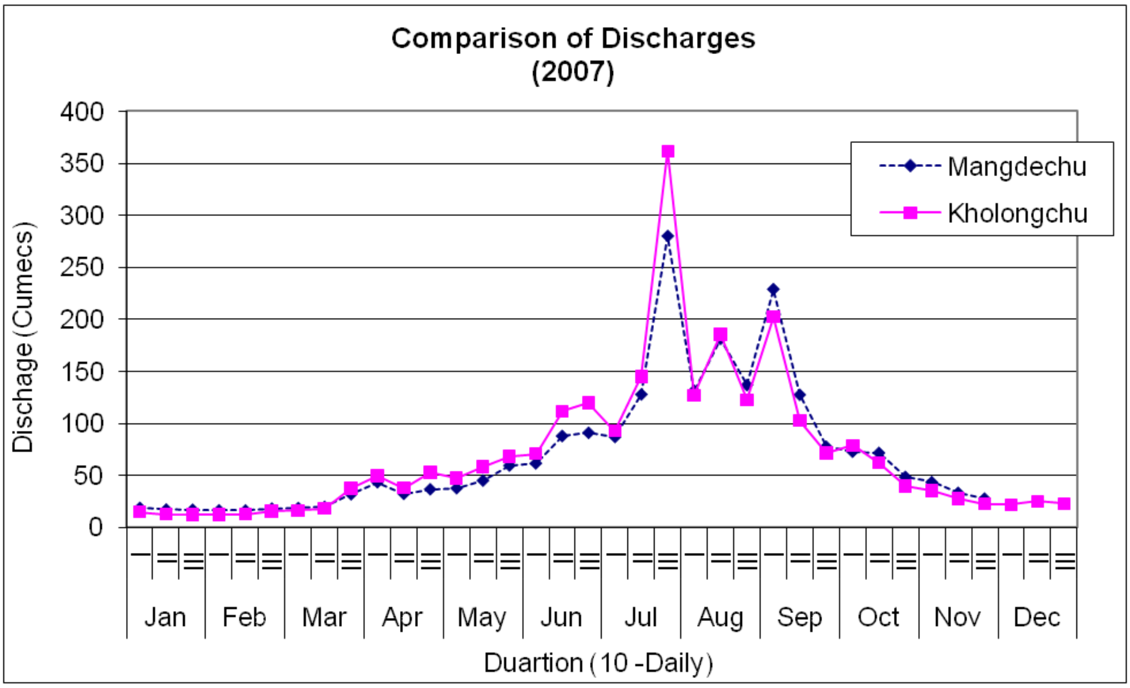
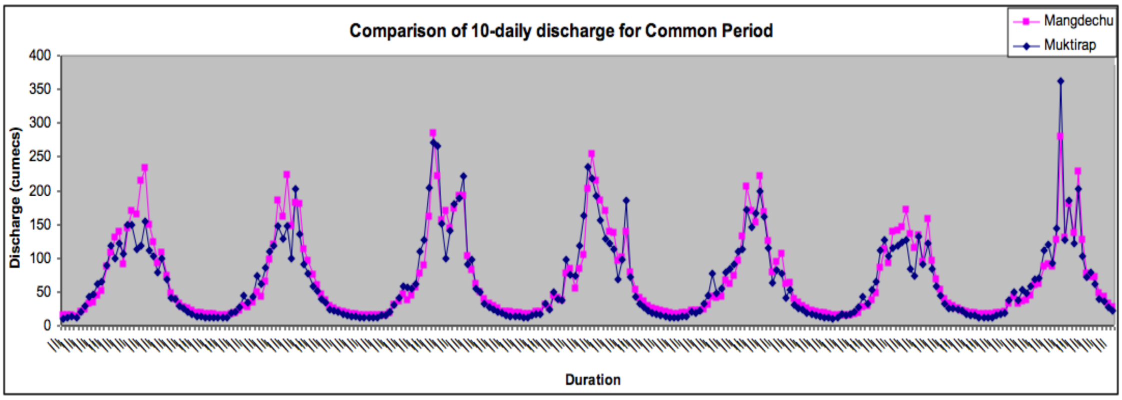


Figure 4.2 (h): Comparison of 10-Daily Discharges for the Common Period



4.4.1.4.Time of Concentration

From the hypsometry of Kholongchu catchment, the elevation difference (H) between the source of Kholongchu river and dam site has been found to be 3480 m (5000-1520 m). The length of the river from the source to D-7 dam site works out as 57.01 km. The time of concentration has been found out by the following formulae:

a) California Equation

$Tc = (0.87 * L^3 / H)^{0.385}$

Where,

Tc	=	Translation time in hr
L	=	Stream length in m
H	=	Difference in elevation in m

Hence Tc = (0.87 * 57010^3 / 3480) ^0.385 = 4.38 hours

b) Kirpich Equation

$Tc = 0.0195 * L^{0.77} * S^{-0.385}$

Where,

Tc	=	Translation time in minutes
L	=	Stream length in m
S	=	Average bed slope

Hence Tc = 0.0195 * 57010 ^0.77 * 0.06^ -0.385 = 4.38 hours

c) Kerby's Equation

Tc = (6.56 LN / (3 * S) ^0.5) ^0.467

Where,

Tc	=	Translation time in minutes
L	=	Stream length in m
S	=	Average bed slope
N	=	Roughness Constant (0.65 assumed)

Hence Tc = (6.65 * 57010 * 0.65 / (3 * 0.06) ^0.5) ^0.467 = 6.28 hours

d) Subzone 2a Report

$T_m = t_p + t_r / 2$

t_p = 2.164 * q_p ^-0.94

q_p = 2.272 * (L * Lc / S)^-0.409

Where,

T_m = Time from the start of rise to the peak of the U.G (hr)

t_p = Time from the centre of effective rainfall duration to U.G peak (hr)

t_r = 1 hr Unit rainfall duration (hr)

q_p = Q_p / A (cumecs per sq km)

Q_p = Peak discharge of unit hydrograph (cumecs)

The following values of L, H and S for the Kholongchu catchment have been determined from the catchment plan:

L = 57.01 km

H = 3480 m

Considering the length of the river between various elevations, the equivalent slope of the river (S) has been worked out as 37.96 m/km. The computations are given in **Table 4.3.**

Table 4.3: Equivalent Slope

S. No.	Elevation	Length	Length of each segment, km	Height above datum, m	Di+Di-1	Li(Di+Di-1)
1	1520	0.00	0.00	0	0	0.00
2	1540	816.46	0.82	20	20	16.33
3	1560	1213.06	0.40	40	60	23.80
4	1590	2788.19	1.58	70	110	173.26
5	1600	3006.49	0.22	80	150	32.75
6	1640	4441.59	1.44	120	200	287.02
7	1680	6366.92	1.93	160	280	539.09
8	1700	6914.70	0.55	180	340	186.24
9	1720	7462.47	0.55	200	380	208.15
10	1751	8421.24	0.96	231	431	413.23
11	1760	9543.29	1.12	240	471	528.49
12	1791	12501.36	2.96	271	511	1511.57
13	1800	13233.48	0.73	280	551	403.40
14	1840	14105.36	0.87	320	600	523.13
15	1880	15132.63	1.03	360	680	698.54
16	1900	15887.00	0.75	380	740	558.23
17	1920	16641.37	0.75	400	780	588.41
18	1960	23155.95	6.51	440	840	5472.24
19	2000	25116.72	1.96	480	920	1803.91
20	2019	25393.74	0.28	499	979	271.20
21	2040	26493.84	1.10	520	1019	1121.01
22	2100	27742.61	1.25	580	1100	1373.65
23	2140	28575.12	0.83	620	1200	999.01
24	2406	31418.42	2.84	886	1506	4282.01
25	2656	34261.72	2.84	1136	2022	5749.15
26	2922	37105.02	2.84	1402	2538	7216.30
27	3156	39948.32	2.84	1636	3038	8637.95
28	3403	42791.62	2.84	1883	3519	10005.57
29	3530	45634.92	2.84	2010	3893	11068.97
30	3730	48478.22	2.84	2210	4220	11998.73
31	3980	51321.52	2.84	2460	4670	13278.21
32	4420	54164.82	2.84	2900	5360	15240.09

33	5004	57008.12	2.84	3484	6384	18151.63
			57.01		sum	123361.26
Hence the Equivalent Slope, S						37.96 m / km

q_p = 2.272 * (57.01 * 28.4 / 37.96) ^ -0.409 = 0.4895 cumecs / sq km

t_p = 2.164 * 0.4895 ^ -0.94 = 4.24 hours

Tm = 4.24 + 0.5 = 4.74 hours

Methodology	**Tc (hrs)**
By California Equation	4.38
By Kirpich Equation	4.38
By Kerby's Equation	6.28
By Subzone 2a Report	4.74
Average	5.33

It is seen that the time of concentration varies from 4.38 hours to 6.28 hours and the average value of time of concentration comes to 5.33 hours. Time to peak of the U.G has therefore been considered as 5 hours.

4.4.1.5.Isochronal Map

Using GIS software ERDAS imagine version 9.1 and Arc GIS 9.2, catchment plan of river Kho-longchu up to D-7 dam site showing the main river and its tributaries and sub – tributaries was prepared and is given in **Figure 4.3.** Considering the time to peak of the unit hydrograph as 5 hours, isochrones at 1 hour time interval have been drawn in **Figure 4.3** and the area between various isochrones was determined and the values of incremental catchment area and cumulative catchment areas between various isochrones are given in **Table 4.4.**

Figure 4.3: Catchment Plan of Showing Isochrones

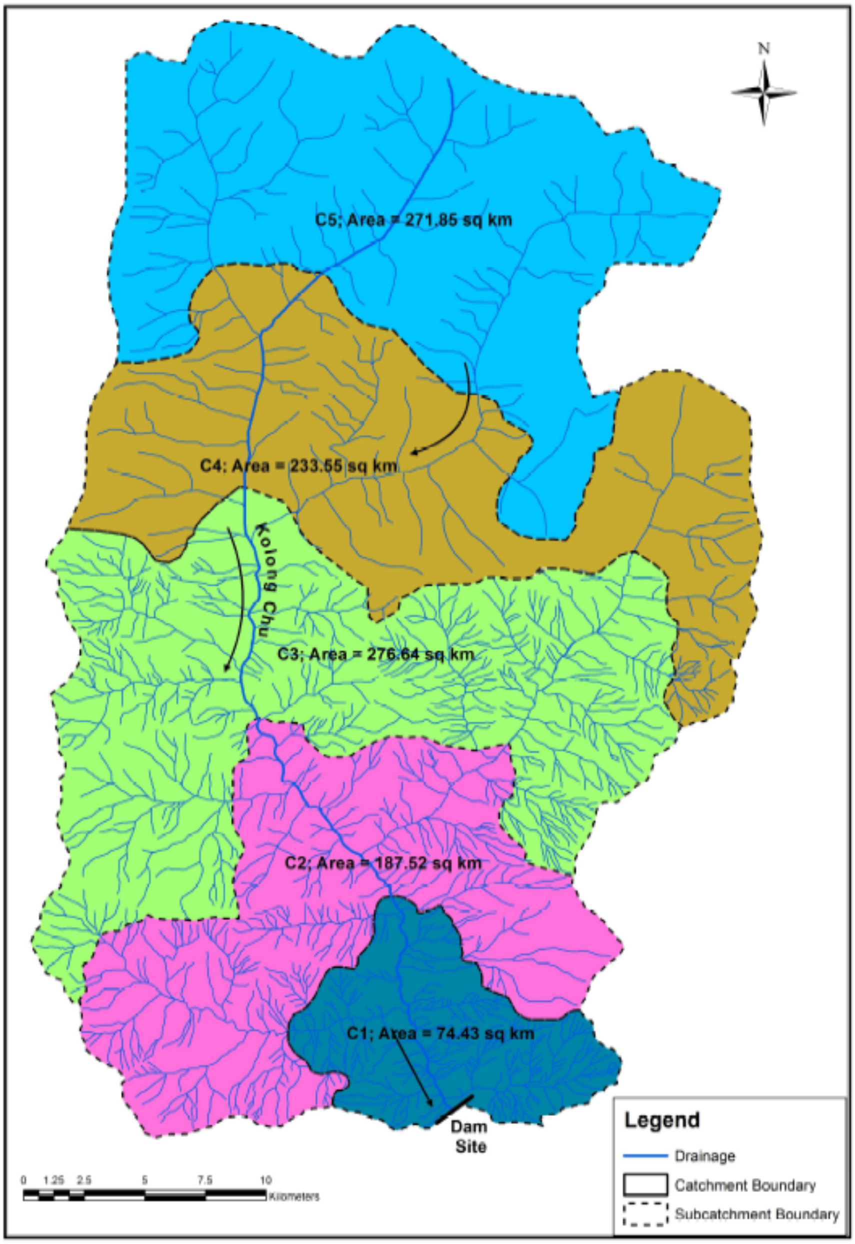


Table 4.4: Incremental & Cumulative Areas between Various Isochrones

S. No.	Isochrones	Incremental Area (sq km)	Cumulative Area (sq km)
1	Dam site - A1	74.43	74.43
2	A1 - A2	187.52	261.95
3	A2 - A3	276.64	538.59
4	A3 - A4	233.55	772.14
5	A4 - A5	256.85	1028.99

4.4.1.6.Development of UG by Clark's Method

Assuming unit duration of the unit hydrograph as 1 hour, the incremental areas of the time area curve of the catchment were converted to runoff in cumecs due to 1 cm rainfall excess in 1 hour as follows:

$$I_i = \frac{1 \times A_i \times 10^6}{100 \times 3600} = 2.78 A_i \text{cumecs}$$

Where,

I_i is the runoff from incremental catchment Ai due to 1 cm of rainfall excess in 1 hour.

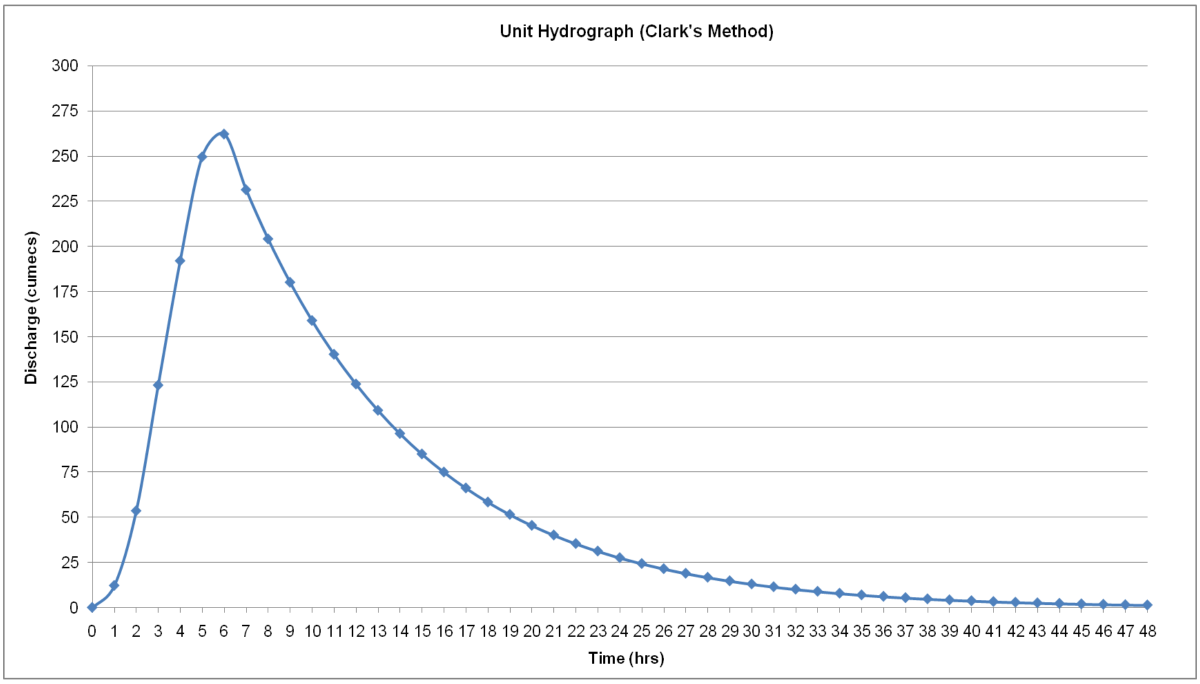
A_i is the incremental catchment area of each segment of the catchment, divided into Tc hour segments.

The incremental runoff from sub-areas within the Kholongchu catchment is then routed to the dam site through a linear reservoir in order to account for the storage effect of the basin and river channels, using two parameters viz time of concentration and the storage attenuation constant R. The time of concentration for the Kholongchu catchment has been estimated as 5 hours and in the absence of any observed flood hydrograph at Kholongchu dam site, the value of R adopted for Mangdechu basin has been considered for Kholongchu basin also, as the two catchments were found to be hydro-meteorologically similar. R value of 8.001 hrs estimated for Mangdechu catchment has also been adopted for Kholongchu catchment. Using these values of Tc and R, the ordinates of instantaneous and synthetic unit hydrograph for Kholongchu have been worked out and given in **Table 4.5** and the unit hydrograph is plotted in **Figure 4.4.**

Table 4.5: Development of Instantaneous Unit Hydrograph

Time (hrs)	Cumulative Area (sq km)	Incremental Area (a) (sq km)	I = 2.78 * a / Delta t (cumecs)	(Oi) (cumecs)	1 - hr Unit Hyd (cumecs / cm)
0	0	0	0	0	0
1	74.43	74.43	206.9	24.3	12
2	261.95	187.52	521.3	82.8	54
3	538.59	276.64	769.1	163.5	123
4	772.14	233.55	649.3	220.7	192
5	1029.0	256.9	714.0	278.7	250
6				245.9	262
7				217.0	231
8				191.5	204
9				168.9	180
10				149.1	159
11				131.5	140
12				116.1	124
13				102.4	109
14				90.4	96
15				79.7	85
16				70.4	75
17				62.1	66
18				54.8	58
19				48.3	52
20				42.6	45
21				37.6	40
22				33.2	35
23				29.3	31
24				25.9	28
25				22.8	24
26				20.1	21
27				17.8	19
28				15.7	17
29				13.8	15
30				12.2	13
31				10.8	11
32				9.5	10
33				8.4	9
34				7.4	8
35				6.5	7
36				5.8	6
37				5.1	5
38				4.5	5
39				4.0	4
40				3.5	4
41				3.1	3
42				2.7	3
43				2.4	3
44				2.1	2
45				1.9	2
46				1.6	2
47				1.5	2
48				1.3	1

Figure 4.4: Unit Hydrograph by Clark's Method



4.4.1.7.Design Strom

India Meteorological Department (IMD) was requested to supply the design storm value for the Kholongchu HEP by SJVNL vide their letter no SJVN/ (ID/CD)/Bhutan HEPS – 880 dated 07.12.2009. Officers of SJVNL and EIPL were persuing with IMD to supply the design storm values. IMD vide their letter dated 10.9.2010 have intimated that due to non-availability of the data of big storms for the project area in Bhutan, it is not possible to give the design storm value for the project. However, IMD is trying to get the data for big storm from Bhutan and their regional office in north-east and after getting the data, design storm value could be given by them.

However, for Mangdechu HEP in Bhutan, having rainfed catchment area of 1096 sq km, which is more or less the same as that of Kholongchu HEP (1029 sq km), the values of Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) given by IMD are given in **Table 4.6.**

Table 4.6: Design Storm Values Given by IMD

Duration	SPS (cm)	PMP (cm)
1 – Day	36.1	46.9
2 – Day	55.9	72.7
3 – Day	73.4	95.4

Since the two catchments have similar catchment area and hydro-meteorological characteristics, the above design strom values have been adopted for Kholongchu HEP also.

4.4.1.8.Temporal Distribution

Since short duration rainfall data is not yet available, the temporal distribution of rainfall for 1-day storm given by IMD for Mangdechu HEP (**Table 4.7**) has been adopted.

Table 4.7: Temporal Distribution Given by IMD

Time (Hrs)	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48
%.age Distribution (24 Hrs)	0	34	55	67	76	84	91	96	100								
%.age Distribution (48 Hrs)	0	30	41	50	57	63	69	74	79	83	87	90	93	95	97	99	100

Time distribution of 1-day storm given by IMD is plotted in **Figure 4.5** and hourly percent temporal values read from the plot. The percentage distribution of 12-hour storm for various time periods has been estimated by dividing the percentage temporal distribution of 24-hour storm by 0.76. Hourly percent temporal distribution values for 24 - hour and 12-hour storms are given in **Table 4.8**.

Figure 4.5: Temporal Distribution Given by IMD

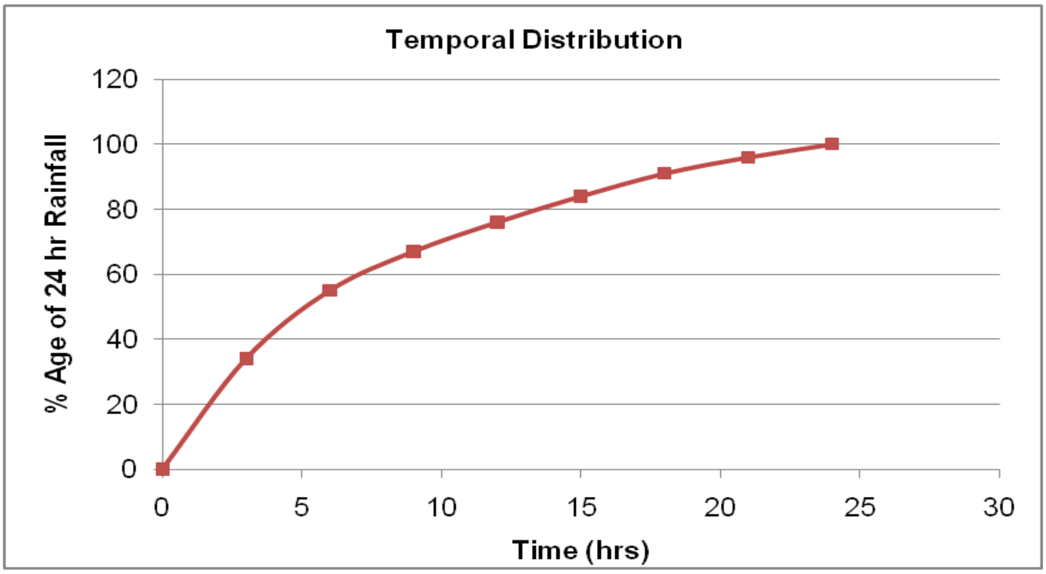


Table 4.8: Temporal Distribution of 24 hr and 12 hr Storm

Time (Hrs)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
%.age Distribution (24 Hrs)	0	12	23	34	43	49	55	60	64	67	70	73	76	79	82	84	87	89	91	93	95	97	98	99	100
%.age Distribution (12 Hrs)	0	16	30	45	57	64	72	79	84	88	92	96	100												

Since the base width of the unit hydrograph is more than 24 hours, 2 day PMP of 72.7 cm, as given by IMD has been considered. The first day PMP is 46.9 cm hence second day PMP works out to 25.8 cm (72.7 cm - 46.9 cm). First day and second day PMP values have been split in to two bells of 12 hours each; the first bell being 76 % and the second bell 24% of the day's value. Using the temporal distribution of 12-hours storm, hourly values of the four bells of the 12-hour's storm have been worked out. The computations are given in **Table 4.9 (a)**.

4.4.1.9. Design Loss Rate

It is assumed that at the time of occurrence of design storm, the soil is nearly saturated. Design loss rate of 0.24 cm / hour as suggested in Subzone 2(a) Report for North Brahmaputra Basin has been adopted and hourly rainfall excess values computed in **Table 4.9 (a).**

4.4.1.10. Base Flow

The design base flow for the catchments of North Brahmaputra basin was arrived in the flood estimation report after studying 237 flood events. Design base flow of 0.05 cumecs per sq. km. of the catchment area has been recommended. Adopting a flow rate of 0.05 cumecs / sq. km, base flow works out as 51 cumecs.

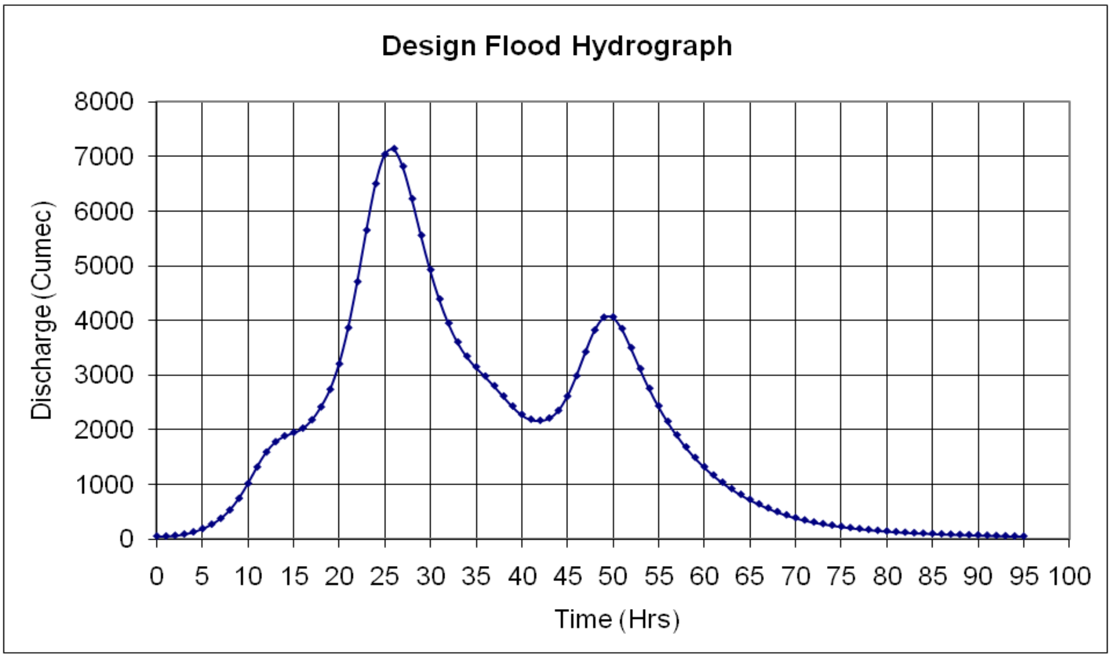
4.4.1.11. Convolution of Design Storm with U.G

The effective rainfall values obtained above are applied to 1 hour unit hydrograph ordinates. The effective rainfall ordinates are arranged against the ordinates of the UG in such a way that the maximum value of rainfall is placed against the peak value of the UG, the next lower rainfall values are arranged against the next lower values of the UG in appropriate order. The order of the effective rainfall values thus obtained is reversed to get the critical sequence.

To obtain the critical value of the design flood, the two bells comprising 76% of the first day and second day storm were combined. The combined storm of these two bells worked out to 55.25 cm (35.64 cm + 19.61 cm), which is more than 24 hour PMP value of 53.94 cm (46.9 cm * 1.15). As per guidelines issued by CWC the combined values of two adjacent 12 hour bells should not exceed the 24 hour PMP value. Hence the arrangement of bells was suitably modified for the estimation of design flood

The first rainfall excess value is multiplied with each of the UG ordinate to obtain the corresponding direct runoff ordinates. The computation is repeated with the remaining rainfall excess values & the direct surface runoff derived from each successive rainfall excess is lagged by 1 hour. The total direct surface runoff for various time periods is added to get the direct surface runoff hydrograph. The base flow is then added to each of the direct surface runoff hydrograph ordinate, to get the values of design flood hydrograph (Probable Maximum Flood) ordinates. The detailed computations are given in **Table 4.9 (a)** to **4.9 (b)**. It is seen that the peak value of the Design Flood is estimated as 7136 cumecs. The Design Flood Hydrograph thus obtained is plotted in **Figure 4.6**.

Figure 4.6: Design Flood Hydrograph (From Clark's U.G)



India Meteorological Department (IMD) has been requested to supply the Standard Project Storm (SPS) & Probable Maximum Storm (PMS) values for the project. The design flood studies would be reviewed after the receipt of design storm values from IMD.

4.4.2.Dimensionless Unit Hydrograph Approach

Since Mangdechu and Kholongchu catchment were found to be hydrologically similar and have nearly equal rainfed areas, the unit hydrograph approved by CWC for Mangdechu HEP has been used for developing the unit hydrograph at Kholongchu dam site. The following procedure has been adopted to develop the unit hydrograph at Kholongchu dam site from the approved UG at Mangdechu dam site.

i. The UG at Mangdechu dam site is converted to dimensionless form by dividing the time ordinates by Tm and discharge ordinates by the runoff in cumecs due to 1 cm rainfall excess over the rainfed catchment up to Mangdechu dam site (V) divided by time to peak of the U.G.

Where,

Tm = Time from the start of rise to the peak of the U.G (hr)

V = Volume due to 1 cm rainfall over the catchment area in sqkm (cumecs)

ii. V for Mangdechu rainfed catchment was determined as follows:

$$V = \frac{1 \times A \times 10^6}{100 \times 3600} \text{ cumecs}$$

= 2.78 X 1096

V = 3046.88 cumecs

And time to peak for Mangdechu HEP is 8 hour. Hence the Mangdechu dam site UG ordinates were divided by 380.86 i.e. (3046.88/8) to get the dimensionless U.G ordinates.

iii. The time of concentration for Kholongchu catchment has been worked out in para 4.2.1.4 and time to peak of 5 hours has been adopted. V for Kholongchu catchment works out as 2860.62 i.e. (2.78 X 1029) cumecs.

iv. The time ordinates of dimensionless U.G were multiplied by 5 and discharge ordinates by 2860.62/5 to obtain the U.G. ordinates for Kholongchu dam site.

The computations are given in **Tables 4.10 and 4.11 (a) to 4.11 (b)** and the unit hydrograph developed for Kholongchu dam site from dimensionless U.G is given in **Figure 4.7.**

The UG is convoluted with the PMP to get the direct surface runoff hydrograph ordinates and by adding the base flow, the design flood for Kholongchu dam site has been estimated as 8750 cumecs. The design flood hydrograph is plotted in **Figure 4.8.**

Table 4.10: Derivation of Dimensionless Unit Hydrograph

Mangdechu data			
Tm	=	8.00	hrs
A	=	1096	sq km
V	=	3046.88	cumecs
Kholongchu data			
Tm	=	5.00	hrs
A	=	1029	sq km
V	=	2860.62	cumecs

Mangdechu				Kholongchu			
Time (ti) (hrs)	UG ordinates (Qi) (cumecs)	ti / Tm	Qi * Tm / V	Time (hrs)	UG Ordinates	Time (hrs)	1 hr UG Ordinates
0	0	0	0	0	0	0	0
1	11.2	0.13	0.03	0.6	16.8	1	41
2	41.6	0.25	0.11	1.3	62.5	2	137
3	83.7	0.38	0.22	1.9	125.7	3	255
4	131.8	0.50	0.35	2.5	198.0	4	338
5	179.1	0.63	0.47	3.1	269.0	5	362
6	216	0.75	0.57	3.8	324.5	6	312
7	237.6	0.88	0.62	4.4	356.9	7	255
8	241.3	1.00	0.63	5.0	362.5	8	208
9	224.1	1.13	0.59	5.6	336.6	9	168
10	197.7	1.25	0.52	6.3	297.0	10	138
11	174.5	1.38	0.46	6.9	262.1	11	113
12	153.9	1.50	0.40	7.5	231.2	12	93
13	135.8	1.63	0.36	8.1	204.0	13	77
14	119.9	1.75	0.31	8.8	180.1	14	63
15	105.8	1.88	0.28	9.4	158.9	15	52
16	93.3	2.00	0.24	10.0	140.2	16	44
17	82.3	2.13	0.22	10.6	123.6	17	37
18	72.7	2.25	0.19	11.3	109.2	18	30
19	64.1	2.38	0.17	11.9	96.3	19	24
20	56.6	2.50	0.15	12.5	85.0	20	19
21	49.9	2.63	0.13	13.1	75.0	21	16
22	44	2.75	0.12	13.8	66.1	22	14
23	38.9	2.88	0.10	14.4	58.4	23	12
24	34.3	3.00	0.09	15.0	51.5	24	11
25	30.3	3.13	0.08	15.6	45.5	25	9
26	26.7	3.25	0.07	16.3	40.1	26	8
27	23.6	3.38	0.06	16.9	35.5	27	7
28	20.8	3.50	0.05	17.5	31.2	28	6
29	18.3	3.63	0.05	18.1	27.5	29	4
30	16.2	3.75	0.04	18.8	24.3	30	2
31	14.3	3.88	0.04	19.4	21.5	31	0
32	12.6	4.00	0.03	20.0	18.9		
33	11.1	4.13	0.03	20.6	16.7		
34	9.8	4.25	0.03	21.3	14.7		

Figure 4.7: Dimensionless Unit Hydrograph

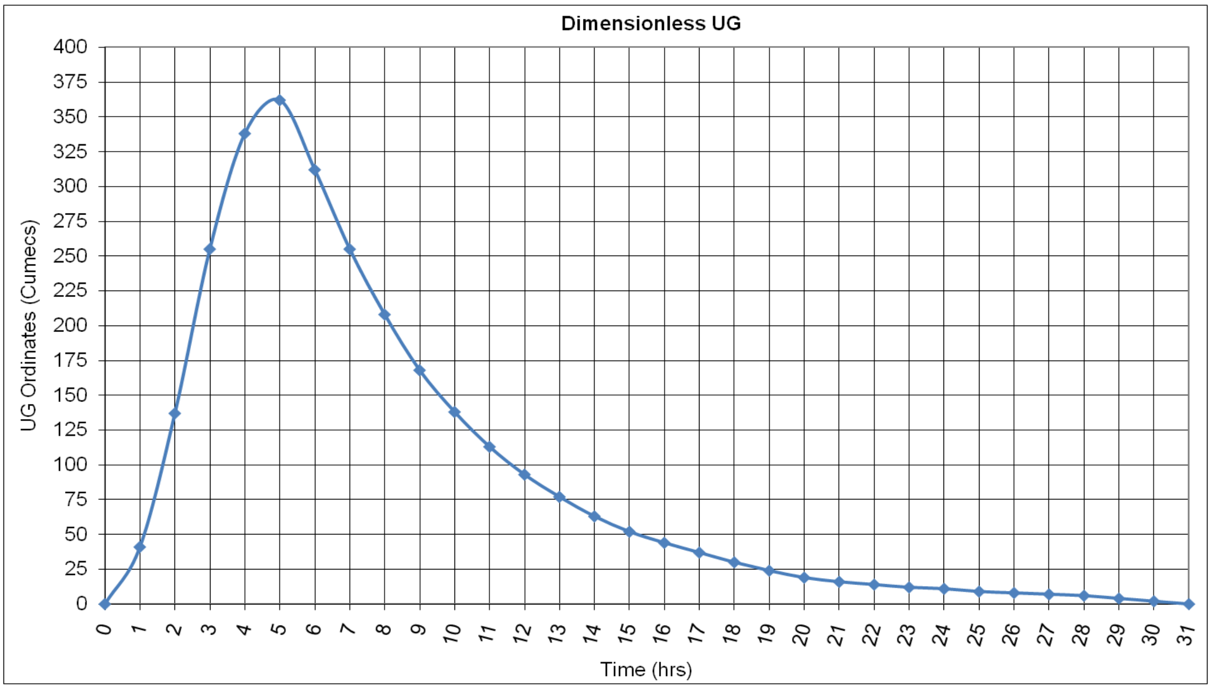
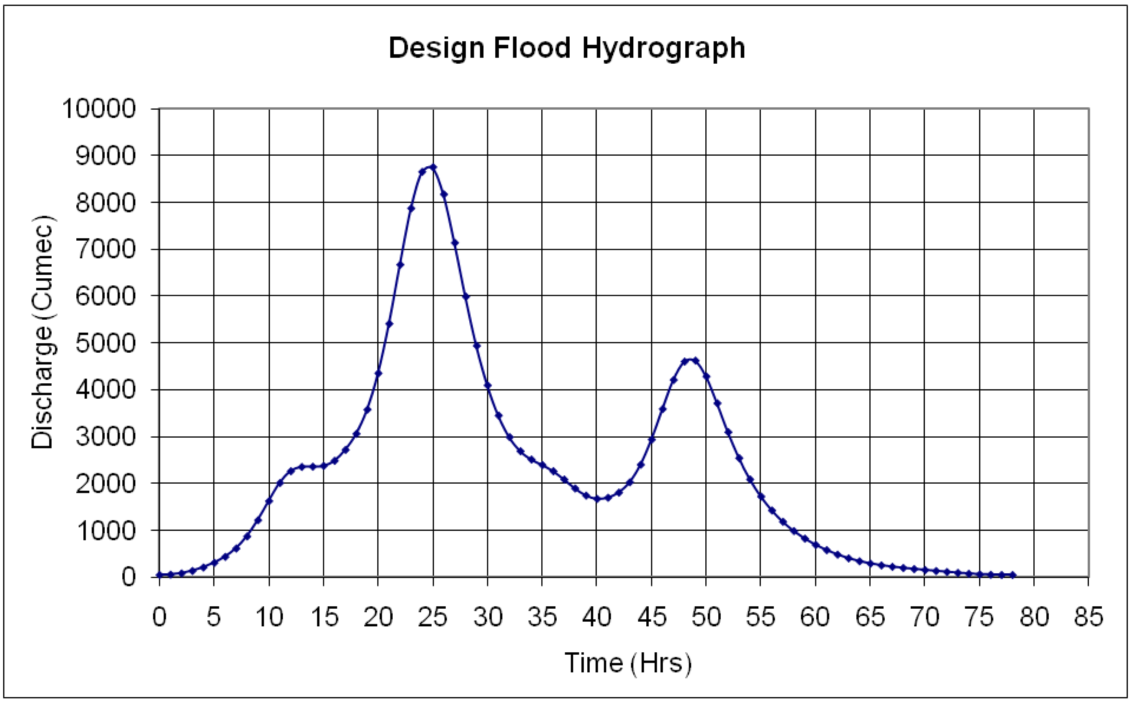


Figure 4.8: Design Flood Hydrograph (From Dimensionless U.G)



4.5.FLOOD FREQUENCY STUDIES

Daily discharge data for Trashiyantse and Muktirap are available from Jan 1987 to Oct 1998 and Feb. 2001 to Oct 2009 respectively. From this data observed annual peak discharge values have been found out at both the sites. These values are transferred to the dam site based on catchment areas at the two sites and at the dam site using Dicken's formula. The annual peak flood values thus obtained for the period 1987-1998 and 2001 - 2009 are given in **Table 4.12**. Since these values are based on daily data, the annual peak discharge values have been increased by 20% to account for the missing instantaneous peak discharges. The annual peak values and instantaneous peak values thus obtained are given in **Table 4.12**.

Table 4.12: Annual Maximum Peaks

S.No	Year	Observed Annual Peaks (cumecs)		Annual Peaks at Damsite D-7 (cumecs)	Peaks increased by 20%
		Trashiyantse	Muktirap		
1	1987	202	-	233	280
2	1988	171	-	198	237
3	1989	182	-	211	253
4	1990	206	-	238	286
5	1991	167	-	194	232
6	1992	147	-	170	204
7	1993	304	-	352	423
8	1994	273	-	316	380
9	1995	359	-	415	499
10	1996	803	-	929	1115
11	1997	435	-	503	604
12	1998	528	-	611	733
13	2001	-	218	243	292
14	2002	-	568	634	761
15	2003	-	415	463	555
16	2004	-	457	510	611
17	2005	-	235	262	314
18	2006	-	193	216	259

19	2007	-	581	648	777
20	2008	-	348	388	466
21	2009	-	643	717	861
Mean				**402**	**483**
Standard Deviation				**210**	**252**

The annual peak values have been subjected to flood frequency analysis using Gumbel's distribution. The floods for various return periods viz 50, 100, 500, 1000 and 10000 years have been worked out.

Since the peak flow series is for a limited period, the 95% upper confidence value floods for various return periods have also been estimated. The values of the floods for various return periods are given in **Table 4.13.**

Table 4.13: Summary of Frequency Analysis by Gumbel's Distribution

Summary of flood peaks by frequency Analysis (cumecs)							
Return Period T (years)	10	25	50	100	500	1000	10000
K	1.613	2.499	3.157	3.810	5.318	5.967	8.120
Peak Flood (cumecs)	889	1112	1278	1442	1822	1986	2528
95% Upper Confidence Peak Flood (cumecs)	1152	1472	1710	1947	2495	2731	3516

Keeping in view the availability of limited period flow series, 10,000 year flood of 3516 cumecs may be considered as design flood based on flood frequency approach.

4.6.BASED ON MANGDECHU DESIGN FLOOD

Mangdechu HEP having a rainfed catchment area of 1096 sq km also lies in Manas River basin. As explained in Para 4.4.2, both Mangdechu and Kholongchu HE projects have similar hydro -meteorological characteristics and almost equal catchment areas. CWC has recently approved a design flood (PMF) of 6900 cumecs for Mangdechu HEP. Reducing this flood using Dicken's equation, the design flood for Kholongchu HEP has been estimated below,

Design Flood at Kholongchu Dam Site (D-7) = 6900 * (1029/1096) ^0.75

= 6581 cumecs

CONCLUSIONS AND RECOMMENDATIONS

Since both Kholongchu and Mangdechu have nearly equal catchment areas and the catchments are hydro -meteorologically similar, the design flood approved by CWC for Mangdechu has also been considered for the estimation of design flood for Kholongchu. The values of design flood obtained by using different approaches are given below in **Table 4.14**.

Table 4.14: Summary of Design Flood Results

S.No	Method	Design Flood (cumecs)
1	Clark's Approach	7136
2	Dimensionless UG	8750
3	Flood Frequency Analysis	3516
4	Based on Design Flood Approved by CWC for Mangdechu HEP	6581

Since observed flood hydrograph / hydrographs were not available for estimating the R value for Kholongchu dam site and being hydro-meteorologically similar to Mangdechu catchment, the R value estimated for Mangdechu project has been adopted for estimating the unit hydrograph using Clark’s approach for Kholongchu project. In view of these conservative value of design flood of 8,750 cumecs obtained from Dimensionless UG is recommended for adoption.

SCOPE FOR FUTURE WORK

- Sedimentation Studies
- Glof Studies
- Site Investigation and Analysis

APPENDICES

Table 3.2 (a): Monthly Rainfall at Duksum (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1990	2.2	41.8	41.4	127.2	88.0	145.8	150.7	131.8	113.8	78.1	0.0	0.0	921
1991	61.8	25.2	31.3	58.4	77.3	193.4	210.5	169.2	83.6	22.2	8.0	10.6	952
1992	3.0	41.6	50.0	29.8	153.4	167.2	205.4	181.0	85.2	38.6	0.0	5.8	961
1993	29.4	26.5	54.4	68.0	78.2	113.9	296.6	153.4	88.7	29.8	1.6	0.0	941
1994	38.2	29.8	50.2	66.8	58.0	136.8	233.4	157.8	131.1	25.6	7.2	1.8	937
1995	15.0	36.7	43.6	67.8	156.0	132.6	268.7	79.2	51.2	6.0	59.6	10.6	927
1996	26.4	0.0	25.5	15.2	134.8	193.2	314.2	90.8	100.4	2.2	0.0	0.0	903
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1998	0.0	0.0	0.6	23.7	45.6	227.0	355.9	219.4	64.4	57.5	0.0	0.0	994
1999	2.0	0.0	15.4	55.7	142.8	169.9	173.7	201.2	68.5	161.7	0.2	0.0	991
2000	1.2	15.2	32.4	45.0	84.1	274.9	184.5	308.5	96.6	0.0	0.2	0.0	1043
2001	0.8	19.8	19.6	112.5	183.4	84.4	122.2	111.3	77.2	46.8	0.2	3.4	782
2002	0.3	0.5	10.8	81.7	83.1	155.7	282.7	244.6	127.8	34.5	19.2	9.4	1050
2003	6.6	21.5	55.9	85.3	76.9	197.3	300.1	96.5	109.9	121.8	2.4	14.3	1089
2004	18.7	1.6	22.7	158.7	103.1	195.6	345.0	38.0	96.7	185.5	0.1	0.0	1166
2005	0.0	36.4	66.5	141.7	122.2	56.1	205.0	151.6	123.4	215.0	6.8	0.0	1125
2006	0.0	2.4	15.3	141.4	107.2	62.7	76.9	76.1	132.2	37.8	28.0	0.0	680
Avg	12.1	17.6	31.5	75.2	99.7	147.4	219.1	141.8	91.2	62.5	7.9	3.3	966
Max	61.8	41.8	66.5	158.7	183.4	274.9	355.9	308.5	132.2	215.0	59.6	14.3	1166
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	680

Table 3.2 (b): Monthly Rainfall at Kanglung (mm)

Monthly Rainfall at Kanglung (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1996	27.6	4.8	31.5	29.8	158.0	211.2	343.7	204.6	128.4	110.2	0.0	0.0	1250
1997	14.4	27.8	86.7	58.2	176.8	353.2	150.6	224.3	137.0	18.6	0.0	21.8	1269
1998	0.7	13.4	99.3	87.5	49.1	178.3	314.4	242.7	115.3	52.2	0.7	0.0	1154
1999	12.8	0.0	27.2	60.9	137.4	172.9	254.0	282.0	67.3	150.8	2.8	0.0	1168
2000	9.0	19.8	20.5	68.0	93.9	297.2	284.3	364.1	117.2	8.2	1.0	2.8	1286
2001	0.7	17.1	42.3	99.5	219.1	137.7	203.8	172.1	81.6	27.7	2.5	5.0	1009
2002	3.1	3.7	39.2	140.9	155.4	185.2	366.4	263.1	131.3	23.2	18.6	23.2	1353
2003	7.0	33.6	71.2	134.4	68.1	293.8	221.0	103.7	43.3	125.8	0.6	15.8	1118
2004	13.5	2.0	22.4	185.9	129.4	214.9	516.0	91.3	104.5	202.2	0.0	0.0	1482
2005	7.9	22.2	62.0	190.3	114.3	63.0	279.0	202.7	141.6	216.9	0.0	4.6	1305
2006	0.0	4.0	14.8	140.8	146.2	124.0	220.2	190.8	109.6	41.2	19.4	5.8	1017
2007	7.0	108.8	45.2	65.4	58.2	212.4	303.2	214.2	191.0	127.8	6.4	0.0	1340
Avg	8.6	21.4	46.9	105.1	125.5	203.7	288.1	213.0	114.0	92.1	4.3	6.6	1229
Max	27.6	108.8	99.3	190.3	219.1	353.2	516.0	364.1	191.0	216.9	19.4	23.2	1482
Min	0.0	0.0	14.8	29.8	49.1	63.0	150.6	91.3	43.3	8.2	0.0	0.0	1009

Table 3.2 (c): Monthly Rainfall at Sherichu (mm)

Monthly Rainfall at Sherichu (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1995	0.0	0.0	141.0	145.0	58.0	160.7	151.4	285.6	153.6	0.0	91.7	0.0	1187
1996	23.4	12.6	125.2	17.0	149.3	161.6	315.1	106.8	109.1	98.3	0.0	0.0	1118
1997	0.0	57.3	146.2	61.7	277.1	408.7	2.0	184.0	227.5	20.5	0.0	40.4	1425
1998	0.0	0.4	114.5	69.8	33.7	106.4	450.4	319.3	29.8	28.5	0.0	0.0	1153
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2001	0.0	36.0	5.4	0.0	107.8	37.3	0.0	0.0	21.4	43.8	0.0	0.0	
2002	0.0	0.0	0.0	6.9	8.6	42.3	0.0	0.0	0.0	0.0	0.0	0.0	
2003	0.0	0.0	6.0	90.9	51.0	167.8	190.7	56.4	22.9	95.8	2.0	12.8	696
2004	19.4	3.6	22.5	145.5	91.0	291.3	486.4	55.5	35.5	118.9	0.0	0.0	1270
2005	10.7	61.1	46.5	129.4	100.3	32.4	181.5	140.6	77.0	188.8	3.4	0.0	972
Avg	4.9	15.5	55.2	60.6	79.7	128.0	161.6	104.4	61.5	54.1	8.8	4.8	1117
Max	23.4	61.1	146.2	145.5	277.1	408.7	486.4	319.3	227.5	188.8	91.7	40.4	1425
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	696

Table 3.2 (d): Monthly Rainfall at Trashiyangtse (mm)

Monthly Rainfall at Tashiyangtse (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1990	5.6	19.4	14.5	122.6	106.6	185.3	212.2	189.4	175.6	150.2	0.0	0.0	1181
1991	38.8	31.0	46.0	99.3	175.8	202.8	205.4	303.4	246.0	0.0	0.0	13.3	1362
1992	8.6	24.4	63.2	124.2	126.4	138.2	259.0	185.4	112.2	63.0	0.0	8.3	1113
1993	22.6	40.0	58.3	91.8	159.6	194.8	213.2	173.0	146.2	35.5	10.0	7.5	1153
1994	38.6	12.9	137.4	109.8	100.7	124.6	254.8	236.2	134.4	25.3	32.9	14.5	1222
1995	24.5	50.7	29.6	104.3	63.2	174.8	262.5	267.4	152.9	6.2	59.2	15.4	1211
1996	27.0	44.0	23.2	40.5	275.7	206.8	239.2	226.6	111.4	149.0	12.8	3.0	1359
1997	8.0	29.2	44.2	71.3	125.5	213.3	287.2	298.9	176.4	30.1	14.9	10.8	1310
1998	5.0	24.4	66.9	40.0	71.1	238.6	269.1	310.0	105.0	95.8	5.4	2.6	1234
1999	8.0	0.0	15.2	55.5	204.6	187.6	213.5	277.8	197.2	153.8	8.6	7.6	1329
2000	2.6	23.8	49.8	108.4	206.8	255.0	221.4	196.4	167.4	16.4	23.6	0.0	1272
2001	4.6	34.4	46.0	186.3	118.3	127.8	222.6	197.2	126.4	64.2	19.0	6.4	1153
2002	3.8	0.0	55.4	130.2	170.4	92.1	186.5	234.5	147.2	13.0	0.0	0.0	1033
2003	6.5	42.3	75.8	122.4	81.0	309.7	122.4	108.8	71.2	94.0	20.0	11.5	1066
2004	14.8	6.8	16.2	125.6	85.4	193.0	273.1	183.2	99.4	139.6	0.0	0.0	1137
2005	11.0	38.6	98.2	95.6	157.8	102.4	167.6	210.2	213.4	124.1	28.0	0.0	1247
2006	0.0	17.0	53.9	104.8	165.1	116.5	185.4	347.3	74.1	28.3	38.7	7.1	1138
2007	4.9	50.1	30.5	120.0	103.6	187.4	375.5	162.0	185.2	75.4	13.2	0.0	1308
Avg	13.1	27.2	51.4	102.9	138.8	180.6	231.7	228.2	146.8	70.2	15.9	6.0	**1213**
Max	38.8	50.7	137.4	186.3	275.7	309.7	375.5	347.3	246.0	153.8	59.2	15.4	1362
Min	0.0	0.0	14.5	40.0	63.2	92.1	122.4	108.8	71.2	0.0	0.0	0.0	1033

Table 3.2 (e): Monthly Rainfall at Wamrong (mm)

Monthly Rainfall at Wamrong (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1990	28.1	87.6	88.1	167.4	259.0	569.8	385.6	251.6	255.4	71.4	0.0	0.0	2164
1991	80.5	44.2	66.2	185.1	215.7	320.0	402.5	264.3	188.8	115.4	92.0	42.5	2017
1992	20.9	77.0	86.4	199.8	259.7	367.2	455.0	303.0	283.7	157.2	80.0	0.0	2290
1993	33.0	27.3	42.2	133.1	336.6	471.0	359.1	505.2	303.8	56.6	1.4	0.0	2269
1994	39.8	32.1	86.0	195.7	249.9	354.4	406.0	357.2	243.0	98.2	60.0	40.0	2162
1995	27.0	67.2	28.0	142.4	210.5	390.7	563.2	368.0	358.5	78.3	83.2	0.0	2317
1996	43.8	10.3	60.0	26.4	257.7	466.1	783.3	376.8	246.4	151.6	0.0	1.0	2423
1997	20.2	52.4	149.5	105.8	130.3	459.0	328.6	393.7	324.0	13.2	21.5	24.8	2023
1998	2.0	28.6	189.8	115.2	73.9	682.0	717.6	618.2	93.4	46.2	0.0	0.0	2567
1999	0.0	0.0	38.4	122.8	344.8	262.5	491.2	287.4	123.0	273.8	6.4	0.0	1950
2000	10.0	0.0	53.6	57.8	134.9	807.2	409.7	915.0	206.6	9.0	4.8	0.0	2609
2001	0.0	0.0	0.0	54.9	69.3	477.4	465.1	372.4	203.6	84.3	8.7	8.2	1744
2002	5.1	1.2	36.0	171.4	157.0	232.0	537.1	216.5	156.7	17.5	0.0	25.1	1556
2003	4.0	14.6	92.4	193.6	86.3	341.7	663.7	273.3	164.4	207.2	10.4	19.6	2071
2004	7.3	6.8	59.9	216.4	357.2	281.1	1545.9	182.2	273.4	347.6	0.0	3.4	3281
2005	8.4	4.4	104.2	116.4	294.8	0.0	520.6	420.0	215.8	213.7	0.0	0.0	1898
2006	0.0	2.0	156.6	212.6	211.0	619.0	290.0	301.2	0.0	10.0	10.0	10.0	1822
Avg	19.4	26.8	78.7	142.2	214.6	417.7	548.5	376.8	214.1	114.8	22.3	10.3	2186
Max	80.5	87.6	189.8	216.4	357.2	807.2	1545.9	915.0	358.5	347.6	92.0	42.5	3281
Min	0.0	0.0	0.0	26.4	69.3	0.0	290.0	182.2	0.0	9.0	0.0	0.0	1556

Table 3.2 (f): Monthly Rainfall at Yadi (mm)

Monthly Rainfall at Yadi (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1990	2.2	41.8	41.4	127.2	88.0	145.8	150.7	131.8	113.8	78.1	0.0	0.0	921
1991	61.8	25.2	31.3	58.4	77.3	193.4	210.5	169.2	83.6	22.2	8.0	10.6	952
1992	3.0	41.6	50.0	29.8	153.4	167.2	205.4	181.0	85.2	38.6	0.0	5.8	961
1993	29.4	26.5	54.4	68.0	78.2	113.9	296.6	153.4	88.7	29.8	1.6	0.0	941
1994	38.2	29.8	50.2	66.8	58.0	136.8	233.4	157.8	131.1	25.6	7.2	1.8	937
1995	15.0	36.7	43.6	67.8	156.0	132.6	268.7	79.2	51.2	6.0	59.6	10.6	927
1996	26.4	0.0	25.5	15.2	134.8	193.2	314.2	90.8	100.4	2.2	0.0	0.0	903
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1998	0.0	0.0	0.6	23.7	45.6	227.0	355.9	219.4	64.4	57.5	0.0	0.0	994
1999	2.0	0.0	15.4	55.7	142.8	169.9	173.7	201.2	68.5	161.7	0.2	0.0	991
2000	1.2	15.2	32.4	45.0	84.1	274.9	184.5	308.5	96.6	0.0	0.2	0.0	1043
2001	0.8	19.8	19.6	112.5	183.4	84.4	122.2	111.3	77.2	46.8	0.2	3.4	782
2002	0.3	0.5	10.8	81.7	83.1	155.7	282.7	244.6	127.8	34.5	19.2	9.4	1050
2003	6.6	21.5	55.9	85.3	76.9	197.3	300.1	96.5	109.9	121.8	2.4	14.3	1089
2004	18.7	1.6	22.7	158.7	103.1	195.6	345.0	38.0	96.7	185.5	0.1	0.0	1166
2005	0.0	36.4	66.5	141.7	122.2	56.1	205.0	151.6	123.4	215.0	6.8	0.0	1125
2006	0.0	2.4	15.3	141.4	107.2	62.7	76.9	76.1	132.2	37.8	28.0	0.0	680
Avg	12.1	17.6	31.5	75.2	99.7	147.4	219.1	141.8	91.2	62.5	7.9	3.3	966
Max	61.8	41.8	66.5	158.7	183.4	274.9	355.9	308.5	132.2	215.0	59.6	14.3	1166
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	680

Table 3.2 (g): Monthly Rainfall at Yallang (mm)

Monthly Rainfall at Yallang (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1990	0.0	68.0	71.0	171.4	117.6	238.4	292.9	153.2	128.0	126.0	4.6	0.0	1371
1991	35.8	47.5	101.0	107.4	218.6	212.1	209.1	309.1	136.8	64.6	0.0	9.1	1451
1992	0.8	37.2	78.3	98.4	91.3	184.9	272.8	187.4	98.5	74.1	3.4	10.2	1137
1993	27.1	3.0	71.1	149.3	177.4	232.6	109.4	133.2	216.6	39.5	3.7	4.3	1167
1994	25.0	0.0	139.4	115.2	96.8	254.0	168.8	165.0	35.6	7.9	3.7	5.2	1017
1995	0.0	65.9	43.7	128.2	127.7	193.5	308.7	250.2	151.2	62.2	53.9	14.6	1400
1996	29.2	0.0	48.9	167.0	288.0	138.8	253.5	232.9	81.4	80.7	0.0	0.0	1320
1997	0.0	17.6	175.7	64.1	140.7	319.6	233.0	262.6	163.2	5.4	0.0	10.8	1393
1998	8.2	11.2	116.2	113.2	38.1	193.9	298.2	200.0	156.5	112.4	0.0	0.0	1248
1999	0.0	0.0	13.0	150.4	172.0	135.8	196.3	259.1	110.4	144.4	18.8	23.6	1224
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	197.7	102.1	46.1	0.0	7.0	
2001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	197.7	102.1	46.1	0.0	0.0	
2002	15.2	1.0	48.7	99.3	132.8	101.2	71.6	128.1	150.8	24.8	0.0	3.2	777
2003	10.0	29.5	38.0	348.8	65.0	185.4	231.4	170.4	84.2	89.0	3.2	12.0	1267
2004	30.5	3.4	44.0	363.3	134.1	220.4	360.4	218.0	85.4	190.2	6.6	0.0	1656
2005	8.2	60.4	244.6	160.1	245.0	119.0	200.8	132.8	151.4	113.2	0.0	0.0	1436
2006	0.0	63.6	35.2	208.0	156.4	259.8	120.8	172.4	82.0	29.6	32.6	0.0	1160
Avg	11.2	24.0	74.6	143.8	129.5	175.8	195.7	198.2	119.8	73.9	7.7	5.9	1268
Max	35.8	68.0	244.6	363.3	288.0	319.6	360.4	309.1	216.6	190.2	53.9	23.6	1656
min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	128.1	35.6	5.4	0.0	0.0	777

Table 3.2 (h): Monthly Rainfall at Yurung (mm)

Monthly Rainfall at Yurung (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1990	22.4	73.4	68.2	198.0	170.2	549.1	297.3	399.0	451.0	211.2	0.0	0.0	2440
1991	65.5	34.0	52.0	92.6	335.0	458.0	551.0	356.2	159.4	1.0	0.0	22.8	2128
1992	7.4	64.1	70.0	198.8	202.2	306.4	430.2	391.2	253.8	97.0	75.0	56.2	2152
1993	70.5	91.2	45.6	131.8	292.2	610.4	328.2	352.2	422.8	62.4	17.6	6.4	2431
1994	8.7	36.5	93.0	102.8	215.5	337.0	421.8	315.8	133.2	39.1	11.3	0.6	1715
1995	96.6	48.0	27.2	61.8	252.0	448.6	580.8	450.8	697.6	4.6	82.8	45.2	2796
1996	30.8	3.6	78.0	17.6	372.1	523.4	713.9	208.6	141.6	128.0	0.0	0.0	2218
1997	9.2	30.0	146.0	77.2	0.0	726.2	130.2	243.2	194.6	13.8	0.0	28.0	1598
1998	2.6	64.6	291.6	58.2	58.6	930.2	1051.8	684.6	112.6	77.3	0.0	0.0	3332
1999	0.0	0.0	18.0	217.4	366.0	95.1	431.8	205.6	43.0	131.5	0.0	0.0	1508
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	149.0	125.0	5.0	9.0	0.0	
2001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2002	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2003	0.0	0.0	0.0	190.5	114.9	326.0	587.0	70.0	81.9	29.8	0.0	12.1	1412
2004	0.0	0.0	103.0	311.0	493.3	428.8	1223.0	76.9	168.0	264.4	0.0	3.0	3071
2005	24.4	94.1	90.2	187.3	99.4	130.0	606.5	292.2	164.0	391.0	0.0	0.0	2079
2006	0.0	45.0	45.0	66.0	116.3	259.1	167.2	131.0	363.0	10.0	37.1	8.0	1248
Avg	19.9	34.4	66.3	112.4	181.6	360.5	442.4	254.5	206.6	86.2	13.7	10.7	2152
Max	96.6	94.1	291.6	311.0	493.3	930.2	1223.0	684.6	697.6	391.0	82.8	56.2	3332
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1248

Table 3.2 (i): Monthly Rainfall at Chazam (mm)

Monthly Rainfall at Chazam (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1990	3.1	34.4	23.1	88.8	86.1	136.6	150.3	104.4	117.0	139.3	0.0	0.0	883
1991	50.8	22.7	28.9	93.5	157.1	202.2	191.8	253.6	102.8	61.3	0.0	8.0	1173
1992	2.4	32.5	11.2	87.0	46.6	46.6	197.4	68.4	54.4	26.8	3.0	4.6	581
1993	25.8	27.4	31.6	86.2	125.2	148.4	73.8	149.6	87.6	2.0	0.0	0.0	758
1994	30.4	21.2	54.4	59.8	220.6	122.6	134.6	107.8	54.6	18.8	14.6	3.8	843
1995	13.0	26.0	15.4	75.9	61.2	136.3	259.5	221.6	155.2	4.0	26.4	9.2	1004
1996	23.2	7.6	27.6	33.4	176.8	127.2	260.3	160.2	65.8	73.4	0.0	0.0	956
1997	10.4	10.0	70.4	39.9	101.3	218.2	116.0	188.2	69.7	6.8	0.0	22.6	854
1998	1.8	4.8	91.7	31.1	87.2	111.7	219.2	164.8	115.0	40.2	0.0	0.0	868
1999	8.6	0.0	23.3	50.6	99.6	138.3	201.6	194.8	71.0	104.0	6.8	0.0	899
2000	2.0	15.8	25.4	50.6	133.8	266.6	137.2	237.8	144.6	1.0	0.0	0.0	1015
2001	1.0	16.0	24.2	90.8	139.9	49.4	128.8	127.4	84.4	35.4	1.0	2.6	701
2002	0.0	0.6	28.7	105.6	103.8	118.2	182.1	183.5	93.6	10.7	15.4	1.0	843
2003	8.3	23.7	35.9	130.1	62.3	137.2	155.8	63.4	45.0	88.4	8.6	8.2	767
2004	16.2	1.0	30.5	203.7	103.0	156.1	352.8	59.6	42.7	153.8	1.0	0.0	1120
2005	5.8	18.8	57.0	138.4	176.9	36.9	216.9	135.1	93.3	136.8	1.6	0.0	1018
2006	0.0	9.8	12.8	147.4	129.0	117.9	97.6	81.6	75.4	23.2	8.0	1.4	704
2007	0.0	77.4	16.5	41.7	75.1	145.7	209.1	227.8	124.0	89.8	13.6	0.0	1021
2008	28.6	10.1	76.9	128.5	53.5	123.5	145.6	191.1	0.0	0.0	0.0	0.0	758
Avg	12.2	18.9	36.1	88.6	112.6	133.7	180.5	153.7	84.0	53.5	5.3	3.2	882
Max	50.8	77.4	91.7	203.7	220.6	266.6	352.8	253.6	155.2	153.8	26.4	22.6	1173
Min	0.0	0.0	11.2	31.1	46.6	36.9	73.8	59.6	0.0	0.0	0.0	0.0	581

Table 3.2 (j): Monthly Rainfall at Thrimshing (mm)

Monthly Rainfall at Thrimshing (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1990	22.7	70.7	67.9	179.1	182.8	389.8	317.4	0.0	242.2	229.6	0.0	10.6	1713
1991	70.4	31.0	44.0	69.0	217.0	439.4	345.6	374.0	224.4	90.0	1.2	11.6	1918
1992	3.0	53.5	16.8	92.9	88.8	215.2	214.2	107.3	109.1	43.5	0.0	0.0	944
1993	48.4	12.6	41.0	123.7	284.9	421.5	292.4	250.8	102.1	31.6	3.0	0.0	1612
1994	35.8	24.6	69.6	82.8	182.2	267.4	137.4	268.1	37.0	15.4	0.0	0.4	1121
1995	17.2	109.5	23.8	153.8	160.2	313.2	459.7	347.1	250.2	28.2	73.6	3.8	1940
1996	31.0	7.6	53.7	17.0	272.4	316.6	617.5	243.8	142.8	111.9	0.4	0.4	1815
1997	10.2	30.7	127.6	81.6	107.7	323.6	174.5	270.4	210.2	18.0	0.2	24.6	1379
1998	0.0	22.2	157.2	65.6	74.8	556.2	573.9	427.6	85.4	84.2	1.4	0.0	2049
1999	0.0	0.0	33.2	120.8	249.0	215.0	309.2	313.2	56.9	197.8	5.0	0.0	1500
2000	11.0	10.3	57.0	59.9	116.8	577.8	291.6	589.7	192.6	33.0	8.2	0.0	1948
2001	3.0	14.4	10.8	128.8	153.2	154.8	291.8	191.2	102.2	37.6	11.0	5.8	1105
2002	2.0	4.0	43.2	128.0	93.6	186.0	487.4	150.2	143.2	12.2	24.2	13.4	1287
2003	7.0	49.0	65.0	203.4	106.1	269.8	543.2	231.9	92.8	155.8	3.4	9.1	1737
2004	18.8	33.0	48.2	316.7	382.4	275.0	785.1	130.6	90.3	183.6	7.8	1.8	2273
2005	8.6	32.6	72.7	156.1	139.0	84.3	437.3	156.9	104.9	252.1	7.2	0.0	1452
2006	4.9	29.0	66.9	148.1	112.6	329.8	177.5	123.7	196.8	19.0	33.8	1.2	1243
2007	0.8	113.1	31.4	177.8	124.7	391.6	591.0	185.6	226.7	160.0	15.0	0.0	2018
2008	38.6	10.6	82.4	119.6	101.2	161.5	255.8	512.4	0.0	0.0	0.0	0.0	1282
Avg	17.5	34.7	58.5	127.6	165.8	309.9	384.3	256.6	137.4	89.7	10.3	4.4	1597
Max	70.4	113.1	157.2	316.7	382.4	577.8	785.1	589.7	250.2	252.1	73.6	24.6	2273
min	0.0	0.0	10.8	17.0	74.8	84.3	137.4	0.0	0.0	0.0	0.0	0.0	944

Table 3.2 (k): Monthly Rainfall at Dungkhar (mm)

Monthly Rainfall at Dungkhar (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1990	0.0	26.0	76.7	104.7	100.5	189.8	276.4	273.8	284.0	143.0	0.0	8.0	1483
1991	45.0	10.0	92.0	183.8	300.6	248.8	280.2	339.4	222.6	44.6	2.0	11.2	1780
1992	5.0	41.6	19.4	148.6	89.4	128.1	295.6	268.2	161.4	125.8	0.0	0.0	1283
1993	37.0	14.0	72.0	104.0	200.2	213.2	77.0	409.8	247.4	146.4	0.0	0.0	1521
1994	40.0	28.6	96.2	108.6	243.2	319.0	347.2	269.8	110.6	56.8	13.0	0.0	1633
1995	0.0	20.0	19.0	86.2	114.9	258.2	328.4	282.0	219.6	83.5	88.0	40.1	1540
1996	41.6	27.4	78.9	97.3	282.8	178.8	355.8	333.2	193.6	139.1	46.0	0.0	1775
1997	17.0	8.0	67.0	86.2	234.5	241.2	269.5	274.4	193.8	56.9	6.0	62.0	1517
1998	31.4	15.4	102.4	134.4	194.8	327.8	325.8	402.0	130.8	149.8	0.0	0.0	1815
1999	1.0	0.0	8.9	100.2	80.3	111.6	279.5	281.7	146.0	153.0	13.8	1.0	1177
2000	9.0	27.8	65.5	130.3	116.4	170.5	270.5	385.8	192.2	7.4	6.6	29.0	1411
2001	0.0	0.0	53.7	55.8	231.6	113.0	109.0	162.2	102.4	71.3	9.0	27.7	936
2002	0.0	0.0	68.1	175.4	76.8	90.5	116.2	278.4	27.8	36.0	2.2	13.6	885
2003	19.1	29.9	28.1	109.9	85.6	156.8	246.7	164.4	209.8	57.4	2.2	17.0	1127
2004	13.2	12.8	53.3	133.5	55.6	156.1	156.7	132.7	168.7	160.5	0.0	0.0	1043
2005	8.2	29.1	95.0	116.7	164.0	101.0	59.5	148.4	144.9	150.6	14.9	0.0	1032
2006	6.6	16.4	53.6	158.6	169.2	44.2	342.2	256.7	199.2	74.2	7.2	17.0	1345
2007	12.4	51.2	16.4	144.4	79.3	131.6	200.4						
Avg	15.9	19.9	59.2	121.0	156.7	176.7	240.9	274.3	173.8	97.4	12.4	13.3	1370.7
Max	45.0	51.2	102.4	183.8	300.6	327.8	355.8	409.8	284.0	160.5	88.0	62.0	1814.6
Min	0.0	0.0	8.9	55.8	55.6	44.2	59.5	132.7	27.8	7.4	0.0	0.0	885.0

Table 3.2 (l): Monthly Rainfall at Tangmachu (mm)

Monthly Rainfall at Tangmachu (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1990	5.6	12.8	18.0	56.6	51.9	143.0	239.0	117.2	86.3	92.6	0.0	0.8	824
1991	42.2	46.8	51.4	35.7	111.8	190.8	168.0	193.4	85.4	0.0	0.0	6.4	932
1992	0.0	3.8	0.0	31.2	51.7	118.9	251.6	126.2	88.7	54.5	0.0	10.4	737
1993	3.1	4.6	12.3	72.7	71.4	112.0	233.8	171.8	189.7	13.7	0.0	2.0	887
1994	26.4	25.8	36.3	42.8	71.0	143.5	123.8	133.0	133.4	34.3	37.8	6.2	814
1995	10.5	34.8	15.5	69.6	52.6	136.4	232.9	144.6	124.0	17.1	6.0	14.5	859
1996	6.7	6.4	21.2	60.4	135.8	139.7	198.9	24.0	55.8	23.4	0.0	0.0	672
1997	21.0	9.0	46.2	77.2	155.5	82.6	564.3	557.9	134.6	35.8	3.6	11.1	1699
1998	0.0	9.0	46.2	75.4	135.8	139.7	218.9	25.2	55.8	23.4	0.0	0.0	729
1999	0.0	0.0	12.1	12.7	117.1	130.8	153.3	140.4	106.0	145.4	13.8	2.7	834
2000	0.8	8.3	21.4	52.7	66.9	118.6	141.2	169.0	154.0	25.4	7.8	0.0	766
2001	6.4	39.5	14.0	63.5	277.1	158.1	219.5	139.9	133.0	77.6	10.0	3.4	1142
2002	9.2	1.0	89.1	91.4	101.7	128.2	142.4	188.0	69.9	43.0	27.4	10.3	902
2003	12.3	30.9	39.7	101.9	44.5	144.0	126.0	86.7	148.4	64.7	14.1	22.8	836
2004	19.0	10.8	36.3	148.9	44.7	85.3	145.7	100.4	83.4	149.0	0.0	0.0	824
2005	16.6	14.9	18.7	95.0	145.5	23.7	163.2	131.1	42.4	145.8	5.2	0.0	802
2006	0.0	8.0	14.7	70.3	136.9	107.0	107.0	210.9	103.0	24.0	31.8	4.3	818
2007	6.0	67.4	30.0	65.1	15.1	101.3	193.5						
Avg	10.3	18.5	29.1	68.0	99.3	122.4	201.3	156.5	105.5	57.0	9.3	5.6	886.9
Max	42.2	67.4	89.1	148.9	277.1	190.8	564.3	557.9	189.7	149.0	37.8	22.8	1698.8
Min	0.0	0.0	0.0	12.7	15.1	23.7	107.0	24.0	42.4	0.0	0.0	0.0	672.3

Table 3.2 (m): Monthly Rainfall at Shelgana (mm)

Monthly Rainfall at Shelgana (mm)													
Date\Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1989	14.2	55.2	49.6	114.7	109.2	192.8	257.9	173.2	141.2	201.9	61.9	45.6	**1417.4**
1990	20.3	53.7	40.0	91.5	133	217.9	395.7	211.5	104.6	73.0	44.2	30.0	**1415.4**
1991	35.7	53.2	52.8	183.0	218.4	494.9	397.3	255.3	113.8	42.0	41.6	24.7	**1912.7**
1992	17.2	68.4	31.8	96.3	114.2	188.1	400.0	350.0	126.6	11.9	2.2	1.6	**1408.3**
1993	113.2	299.9	124.2	634.2	911.7	734.7	140.0	1473.5	1230.9	264.2	0.0	0.0	**5926.5**
1994	302.5	302.5	0.0	372.2	795	956.4	922.5	869.3	584.1	0.0	36.6	0.0	**5141.1**
1995	64.8	108.5	119.1	88.6	81.6	158.2	337.6	303.5	202.8	17.0	90.0	13.0	**1584.7**
1996	30.8	66.4	50.8	59.0	103.3	144.8	240.0	416.1	410.1	82.4	42.8	31.7	**1678.2**
1997	15.0	34.6	22.5	99.0	107.2	197.0	305.1	351.8	144.0	12.0	0.0	33.0	**1321.2**
1998	0.0	0.0	70.2	90.0	50.2	210.0	192.2	321.0	151.0	119.0	8.0	0.0	**1211.6**
1999	1.0	0.0	8.0	156.0	182.5	136.0	358.0	307.0	279.0	185.0	6.0	14.0	**1632.5**
2000	13.0	23.0	28.0	45.5	55.8	132.5	270.7	249.2	206.0	28.0	22.0	1.0	**1074.7**
2001	0.0	4.5	0.0	26.5	146.0	213.0	201.0	341.0	165.5	97.5	0.0	6.0	**1201.0**
2002	8.5	0.0	9.0	81.0	105.5	284.5	306.5	330.0	171.0	49.5	3.0	15.5	**1364.0**
2003	7.0	34.0	9.0	72.0	109.0	261.5	297.3	130.0	146.9	87.0	6.0	14.0	**1173.7**
2004	16.7	2.0	17.0	118.1	174.8	201.0	229.2	246.2	77.7	106.2	0.0	0.0	**1188.9**
2005	17.9	0.0	64.6	41.0	112.2	114.8	355.9	244.8	100.3	117.8	1.4	0.0	**1170.7**
2006	0.0	9.0	13.0	82.4	169.8	104.0	252.0	329.5	162.8	18.4	2.4	0.0	**1143.3**
2007	3.0	41.4	13.0	38.6	135.2	149.0	337.8						
Average	35.8	60.9	38.0	131.0	200.8	268.0	326.1	383.5	251.0	84.0	20.5	12.8	1812.5
Max	302.5	302.5	124.2	634.2	911.7	956.4	922.5	1473.5	1230.9	264.2	90	45.6	5926.5
Min	0	0	0	26.5	50.2	104	140	130	77.7	0	0	0	1074.7

Table 3.2 (n): Monthly Rainfall at Nobding (mm)

Monthly Rainfall at Nobding (mm)													
Date \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1986	5.0	0.0	0.0	89.0	82.0	347.0	527.0	212.6	132.7	74.0	0.0	0.0	**1469.3**
1987	0.0	0.0	51.0	157.0	179.0	448.0	493.0	151.3	0.0	80.0	0.0	0.0	**1559.3**
1988	0.0	5.0	11.0	101.6	129.6	206.0	424.7	475.5	239.5	10.0	18.0	10.0	**1630.9**
1989	4.8	37.2	43.1	39.8	128.0	346.4	398.0	247.0	340.6	83.6	14.2	0.0	**1682.7**
1990	0.0	16.3	38.4	123.2	151.0	260.0	453.6	278.1	292.8	70.4	6.8	0.0	**1690.6**
1991	43.0	15.6	36.6	66.2	83.7	328.0	359.7	638.6	273.1	8.4	7.2	0.0	**1860.1**
1992	7.2	0.0	7.5	73.8	266.2	276.8	408.9	380.7	275.4	84.2	0.0	11.6	**1792.3**
1993	24.6	0.0	23.6	68.8	180.8	202.6	241.6	503.6	294.0	160.3	14.8	2.4	**1717.1**
1994	15.6	28.4	39.4	126.0	246.6	358.0	387.0	421.9	142.8	21.8	10.6	0.0	**1798.1**
1995	38.0	30.4	17.6	41.6	189.8	313.4	508.6	277.8	146.5	47.4	87.6	11.6	**1710.3**
1996	0.0	4.1	15.8	23.0	148.8	236.4	387.0	351.4	325.6	66.0	6.7	0.0	**1564.8**
1997	5.0	7.0	20.0	50.6	98.2	227.4	432.7	413.4	318.8	11.0	1.4	5.8	**1591.3**
1998	0.0	0.0	7.2	91.0	96.0	308.0	415.0	463.0	160.0	94.0	5.0	0.0	**1639.2**
1999	0.0	0.0	7.0	119.0	291.0	237.0	300.0	464.0	259.0	179.0	10.0	0.0	**1866.0**
2000	0.0	13.8	22.0	59.0	223.0	382.0	564.0	603.0	351.0	28.0	7.0	0.0	**2252.8**
2001	0.0	0.0	106.2	82.0	299.5	461.0	455.0	322.5	218.0	125.0	90.4	24.0	**2183.6**
2002	30.0	42.9	30.0	106.0	130.0	271.5	487.5	352.0	272.0	61.5	0.0	3.0	**1786.4**
2003	16.2	61.0	16.0	78.8	95.0	305.2	460.8	419.8	312.4	121.6	17.8	11.5	**1916.1**
2004	13.2	10.5	13.8	59.3	102.2	202.1	182.0	216.7	118.6	75.4	6.8	0.0	**1000.6**
2005	16.6	12.7	37.3	51.7	76.0	147.2	210.0	228.0	121.5	72.8	10.6	0.0	**984.4**
2006	0.0	9.0	8.8	57.0	117.5	189.3	221.9	168.2	118.2	19.0	9.6	1.0	**919.5**
Average	10.4	14.0	26.3	79.3	157.8	288.3	396.1	361.4	224.4	71.1	15.5	3.9	1648.3
Max	43.0	61.0	106.2	157.0	299.5	461.0	564.0	638.6	351.0	179.0	90.4	24.0	2252.8
Min	0.0	0.0	0.0	23.0	76.0	147.2	182.0	151.3	0.0	8.4	0.0	0.0	919.5

Table 3.2 (o): Monthly Rainfall at Chendebji (mm)

Monthly Rainfall at Chendebji (mm)

Date \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1991	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	1.2	59.0	
1992	32.2	37.6	46.2	49.7	60.0	207.7	257.9	251.1	190.4	83.3	57.2	10.4	**1283.7**
1993	51.6	24.5	37.5	63.1	102.4	184.6	225.1	319.8	144.5	35.8	8.8	7.0	**1204.7**
1994	43.9	33.8	31.3	35.0	64.8	278.6	445.4	335.6	174.5	38.2	9.4	10.9	**1501.4**
1995	29.5	50.2	32.7	5.5	54.3	380.3	383.8	260.2	214.3	23.1	72.4	23.4	**1559.7**
1996	30.8	24.2	37.5	25.3	109.9	295.4	337.9	170.9	285.8	123.6	5.6	28.8	**1475.7**
1997	49.4	37.2	38.2	79.7	70.7	232	245.3	311.9	165.5	14.5	49	36.1	**1329.5**
1998	31.2	63.6	56.6	90.9	130.6	203.5	462.9	306.4	96.8	64.5	0.0	0.0	**1507.0**
1999	36.1	50.6	30.5	85.7	212.4	246.4	380.8	428.2	220.5	360.4	13.6	2.0	**2067.2**
2000	24.6	10.7	41.4	47.0	211.5	205.3	256.4	390.5	173.6	17.1	10.5	0.0	**1388.6**
2001	2.4	0.0	41.2	76.9	232.3	140.5	277.6	614.3	481.8	275.8	135.6	30.2	**2308.6**
2002	30.5	29.5	7.3	90.5	234.6	187.9	313.9	433.2	220.1	16.5	1.0	0.0	**1565.0**
2003	6.0	0.0	41.4	231.5	120.1	352.6	196.2	151.9	254.2	65.3	0.0	0.0	**1419.2**
2004	0.0	0.0	16.5	41.4	49.5	249.1	628	245.8	264.6	127	0.0	8.0	**1629.9**
2005	0.0	17.5	36.3	25.0	158.4	139.1	517.1	390.6	63	160.8	0.0	0.0	**1507.8**
2006	0.0	4.0	36.2	90.5	233.3	251.5	224.2	113.6	103.5	21.3	0.0	7.0	**1085.1**
Average	24.5	25.6	35.4	71.2	136.3	237	343.5	314.9	203.5	95.1	22.8	13.9	1523.8
Max	51.6	63.6	56.6	231.5	234.6	380.3	628.0	614.3	481.8	360.4	135.6	59.0	2308.6
Min	0.0	0.0	7.3	5.5	49.5	139.1	196.2	113.6	63.0	14.5	0.0	0.0	1085.1

Table 3.2 (p): Monthly Rainfall at Phobjekha (mm)

Monthly Rainfall at Phobjekha (mm)

Date \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1986	N.A.	N.A.	N.A.	N.A.	27.5	N.A.	N.A.	N.A.	222.0	110.6	5.6	0.0	
1987	0.0	0.0	26.1	N.A.	32.0	271.8	464.7	N.A.	N.A.	N:A.	N.A.	N.A.	
1988	N.A.	N.A.	N.A.	N.A.	N.A.	285	355.9	273.6	67.4	7.5	17.8	0.0	
1989	3.4	70.0	10.0	35.0	N.A.	282.0	N.A.	183.5	227.5	15.0	1.2	0.8	
1990	0.0	24.4	28.0	59.0	90.4	105.6	417.5	177.2	159.6	53.8	0.0	0.0	**1115.5**
1991	5.0	0.0	49.9	45.4	137.6	170.0	200.2	400.0	216.6	20.0	0.0	270.9	**1515.6**
1992	2.4	0.0	15.0	57.1	121.5	190.0	351.0	265.7	63.2	24.0	0.0	0.0	**1089.9**
1993	32.0	28.0	16.0	115.0	64.6	148.0	72.0	65.7	35.0	16.0	0.0	0.0	**592.3**
1994	52.0	15.0	42.0	24.0	62.0	273.1	195.1	299.0	51.0	10.0	3.0	0.0	**1026.2**
1995	5.0	6.0	6.5	55.0	39.0	314.1	329.3	158.4	169.2	6.2	77.0	0.0	**1165.7**
1996	0.0	0.0	36.0	71.0	66.2	295.4	388.9	203.5	300.0	102.1	9.0	0.0	**1472.1**
1997	15.0	34.9	59.6	126.0	109.0	351.0	470.4	515.0	145.0	12.0	0.0	0.0	**1837.9**
1998	0.0	0.0	74.9	139.2	96.0	105.8	461.0	479.7	193.9	31.9	0.0	0.0	**1582.4**
1999	0.0	0.0	0.0	131.0	191.0	512.0	377.4	467.0	237.0	257.0	17.0	0.0	**2189.4**
2000	10.0	14.0	43.0	38.0	129.0	353.1	342.0	410.3	412.1	9.0	24.4	0.0	**1784.9**
2001	0.0	19.8	17.0	99.0	211.5	130.5	163.6	293.0	132.0	117.0	0.0	12.0	**1195.4**
2002	3.0	12.0	56.9	98.4	79.5	163.4	310.2	266.9	137.3	39.3	0.0	5.5	**1172.4**
2003	3.9	98.9	23.6	69.2	66.7	209.3	233.8	160.6	136.2	108.6	4.2	0.0	**1115.0**
2004	10.4	4.6	27.8	89.3	79.1	145.3	236.4	177.5	94.4	121.6	7.4	0.8	**994.6**
2005	0.0	26.0	58.5	60.9	89.7	88.3	220.5	178.8	145.1	144.0	2.3	0.0	**1014.1**
2006	0.0	6.0	45.0	101.7	137.3	98.4	184.4	194.6	127.6	47.2	8.8	3.4	**954.4**
Average	7.5	18.9	33.5	78.6	96.3	224.6	303.9	272.1	163.6	62.6	8.9	14.7	1285.1
Max	52.0	98.9	74.9	139.2	211.5	512.0	470.4	515.0	412.1	257.0	77.0	270.9	2189.4
Min	0.0	0.0	0.0	24.0	27.5	88.3	72.0	65.7	35.0	6.2	0.0	0.0	592.3

Table 3.2 (q): Mean Monthly Rainfall Value at Various Station (mm)

Station/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Duksum	3.0	26.7	74.0	159.0	128.2	135.4	139.7	113.0	70.3	28.2	1.9	2.6
Kanglung	8.6	21.4	46.9	105.1	125.5	203.7	288.1	213.0	114.0	92.1	4.3	6.6
Sherichu	4.9	15.5	55.2	60.6	79.7	128.0	161.6	104.4	61.5	54.1	8.8	4.8
Trashiyantse	13.1	27.2	51.4	102.9	138.8	180.6	231.7	228.2	146.8	70.2	15.9	6.0
Wamrong	19.4	26.8	78.7	142.2	214.6	417.7	548.5	376.8	214.1	114.8	22.3	10.3
Yadi	12.1	17.6	31.5	75.2	99.7	147.4	219.1	141.8	91.2	62.5	7.9	3.3
Yallang	11.2	24.0	74.6	143.8	129.5	175.8	195.7	198.2	119.8	73.9	7.7	5.9
Yurung	19.9	34.4	66.3	112.4	181.6	360.5	442.4	254.5	206.6	86.2	13.7	10.7
Chazam	12.2	18.9	36.1	88.6	112.6	133.7	180.5	153.7	84.0	53.5	5.3	3.2
Thrimshing	17.5	34.7	58.5	127.6	165.8	309.9	384.3	256.6	137.4	89.7	10.3	4.4
Dungkhar	15.9	19.9	59.2	121.0	156.7	176.7	240.9	274.3	173.8	97.4	12.4	13.3
Tangmachu	10.3	18.5	29.1	68.0	99.3	122.4	201.3	156.5	105.5	57.0	9.3	5.6
Shelgana	35.8	60.9	38.0	131.0	200.8	268.0	326.1	383.5	251.0	84.0	20.5	12.8
Nobding	10.4	14.0	26.3	79.3	157.8	288.3	396.1	361.4	224.4	71.1	15.5	3.9
Chendebji	24.5	25.6	35.4	71.2	136.3	237	343.5	314.9	203.5	95.1	22.8	13.9
Phobjekha	7.5	18.9	33.5	78.6	96.3	224.6	303.9	272.1	163.6	62.6	8.9	14.7

Table 3.4 (a): 10-Daily Observed Discharges at Trashiyantse (cumecs)

Year		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Month	10-daily												
Jan	I	10.9	14.0	11.0	12.2	19.2	14.6	15.3	16.0	12.6	15.8	16.2	13.9
	II	9.9	13.0	14.3	11.3	17.9	13.7	18.5	15.2	12.2	14.6	14.8	13.2
	III	11.7	12.0	15.8	11.5	17.8	13.5	21.9	13.3	11.7	13.5	13.8	12.2
Feb	I	12.9	11.5	17.5	11.1	17.5	13.6	21.7	11.3	11.6	13.5	13.9	11.6
	II	12.2	11.5	15.9	11.4	18.9	11.9	22.7	10.6	12.5	12.7	13.7	12.5
	III	13.5	12.0	17.7	10.8	23.4	11.2	24.2	10.0	11.0	13.9	14.1	13.0
March	I	14.1	15.0	24.8	11.0	20.0	15.2	24.1	15.8	15.7	16.2	16.2	15.5
	II	16.5	18.7	22.0	13.6	26.3	20.4	22.2	26.1	21.0	23.6	24.6	15.8
	III	23.7	18.8	32.1	17.8	32.9	42.5	22.8	38.7	37.0	24.2	28.9	19.2
April	I	50.4	35.9	31.4	16.5	44.6	38.3	28.0	45.6	27.8	32.0	23.2	24.3
	II	34.1	39.8	37.3	44.6	42.0	61.9	35.2	37.9	39.2	60.4	36.4	39.3
	III	43.7	43.2	44.6	58.7	43.2	50.0	40.2	47.1	55.4	65.4	45.5	52.5
May	I	42.1	51.4	61.8	55.3	66.5	54.3	61.0	78.3	90.4	74.4	62.8	58.5
	II	62.3	61.0	62.5	83.5	68.2	62.4	64.4	60.6	127.8	82.2	81.6	56.7
	III	64.9	60.0	96.8	77.4	67.2	56.6	67.6	85.0	81.3	100.1	87.3	87.5
June	I	79.3	62.6	70.9	103.7	84.1	65.7	83.9	75.8	105.9	78.0	99.2	86.6
	II	92.7	93.6	105.4	96.7	108.8	76.4	97.7	91.0	194.0	69.5	159.8	106.4
	III	93.5	73.0	98.5	107.2	115.6	123.2	108.5	159.9	186.2	213.8	171.2	247.0
July	I	104.4	111.5	111.3	115.3	141.3	90.4	106.0	112.0	185.0	208.2	205.8	319.1
	II	100.9	100.4	107.9	146.1	127.4	90.3	111.9	79.1	180.1	318.7	186.4	191.7
	III	130.3	118.8	93.7	121.6	102.8	114.3	102.8	143.3	145.8	201.2	140.4	173.1
August	I	121.0	97.0	94.4	86.7	133.7	109.2	211.2	115.3	141.3	149.7	124.9	186.1
	II	154.2	99.9	104.3	109.4	121.5	95.3	149.1	116.7	193.5	194.7	195.5	350.3
	III	113.0	125.4	123.7	99.3	117.1	105.4	130.3	150.5	172.0	158.1	92.0	216.6
September	I	115.6	93.8	102.1	98.7	112.7	84.3	109.6	109.5	120.0	213.9	144.4	179.2
	II	88.3	62.2	105.1	96.2	99.2	90.5	84.0	114.3	107.5	123.1	170.8	80.2
	III	67.3	64.7	100.2	96.2	95.4	62.1	99.1	84.0	126.3	120.7	143.1	74.7
October	I	63.5	47.9	77.0	108.2	76.3	70.5	79.0	78.6	69.1	115.3	70.3	53.1
	II	49.8	33.0	53.7	80.7	59.9	61.2	77.1	47.3	65.9	56.2	49.4	81.0
	III	48.9	28.0	42.5	52.5	45.4	44.5	57.6	38.8	46.4	58.8	36.0	70.2
November	I	37.7	21.6	39.4	41.0	35.6	33.2	33.7	29.8	33.5	40.3	29.4	39.9
	II	27.4	17.4	36.3	33.4	28.6	29.9	28.4	22.4	32.2	31.2	25.5	28.4
	III	22.5	14.7	28.8	28.1	22.7	30.6	24.0	20.4	23.4	29.0	23.1	24.3
December	I	19.2	13.5	22.2	25.4	20.1	28.9	23.6	19.1	21.0	23.0	20.0	21.4
	II	16.4	11.8	15.5	22.3	17.8	17.5	21.9	17.4	18.8	20.3	17.9	18.0
	III	15.2	10.3	13.5	20.2	16.2	15.0	19.3	12.4	17.4	17.6	15.3	15.7

Table 3.4 (b): 10-Daily Observed Discharges at Muktirap (cumecs)

Month	10 - daily	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
January	I	14.3	13.2	12.9	14.2	13.5	13.3	15.0	17.7	15.3	13.3
	II	13.2	12.4	11.7	13.1	12.4	12.4	12.7	16.8	15.3	12.1
	III	12.7	12.2	11.5	13.0	11.6	11.2	12.4	16.2	15.0	10.9
February	I	12.2	12.6	11.6	12.2	11.8	10.7	12.2	15.5	13.1	10.2
	II	10.7	12.4	12.1	12.4	13.2	11.2	12.6	15.0	12.1	10.1
	III	12.0	11.7	12.8	14.9	13.1	17.0	15.6	15.6	13.6	10.6
March	I	14.6	11.9	14.6	16.8	19.9	15.2	16.4	17.2	20.1	18.4
	II	11.7	18.3	15.7	16.3	18.6	16.7	18.2	22.7	21.0	18.7
	III	20.8	20.9	21.1	33.4	21.7	19.8	37.6	30.2	18.1	36.5
April	I	29.4	26.8	30.9	23.6	32.3	26.8	49.5	31.7	34.4	39.5
	II	43.4	43.9	41.2	49.1	44.7	42.8	37.9	50.5	46.7	53.2
	III	46.5	33.5	58.1	39.1	77.9	33.1	52.7	67.8	50.3	56.9
May	I	61.2	43.4	55.8	37.1	48.8	53.9	47.6	63.9	44.5	56.4
	II	65.7	73.4	55.6	97.9	54.6	64.9	58.5	69.2	40.5	78.7
	III	89.5	61.1	61.3	76.2	79.3	111.4	68.4	72.8	155.2	64.2
June	I	118.9	85.0	110.0	74.5	84.4	127.5	70.9	103.5	64.5	103.7
	II	98.8	109.6	127.6	117.7	91.8	103.4	111.7	172.9	52.2	109.5
	III	121.7	118.8	204.4	162.9	109.4	114.7	120.0	131.9	89.9	169.6
July	I	106.2	147.8	270.7	235.5	113.3	118.9	92.9	114.6	144.1	
	II	148.8	128.8	266.3	218.2	170.9	123.4	145.0	158.8	102.0	
	III	148.9	146.9	151.4	192.6	146.6	127.4	361.7	143.3	155.8	
August	I	112.5	98.8	99.8	156.4	166.4	83.7	127.2	117.7	150.9	
	II	117.7	202.3	141.2	128.1	198.3	73.3	185.6	155.7	149.4	
	III	154.9	134.9	180.1	121.6	161.5	132.4	122.6	210.0	131.6	
September	I	111.3	90.6	189.1	112.9	115.0	90.5	202.3	122.8	86.2	
	II	103.8	77.5	221.1	68.3	62.8	122.0	102.5	84.6	100.3	
	III	79.7	59.2	91.6	97.2	82.9	83.9	71.7	72.2	69.4	
October	I	99.0	51.6	98.0	185.4	77.4	58.1	78.9	59.7	86.4	
	II	68.7	39.0	55.4	72.0	41.5	45.3	62.1	41.0	44.4	
	III	41.7	34.0	50.0	42.3	52.5	33.4	39.6	43.6	32.2	
November	I	38.7	24.7	32.6	32.0	30.8	26.6	35.3	34.6	26.1	
	II	29.8	22.4	27.2	28.0	26.4	26.6	27.8	28.5	23.3	
	III	25.1	19.9	24.5	22.8	24.3	24.1	22.6	24.4	20.6	
December	I	20.1	17.2	21.2	18.6	19.6	22.2	21.7	21.5	18.4	
	II	17.6	15.2	18.4	16.4	16.9	17.8	25.1	19.1	16.3	
	III	13.5	14.3	15.8	14.7	14.8	15.9	22.8	17.6	14.5	

Table 3.4 (c): 10-Daily Observed Discharges at Chazam (cumecs)

Month	10 - daily	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
January	I		101.5	103.1	125.8	228.8	101.6	95.7	93.4	74.1	103.3	95.6	84.0	82.1	83.1	114.1	108.7	96.7	158.9	223.8	46.2	71.4	54.9
	II		97.5	114.5	121.5	215.3	94.0	92.9	92.0	75.4	96.2	89.8	78.9	76.9	74.8	106.1	98.6	85.2	142.4	179.0	43.5	62.8	49.5
	III		92.7	136.1	119.2	209.0	90.9	91.4	90.3	74.0	90.9	85.7	73.0	75.9	71.8	106.1	90.5	78.9	132.6	171.1	41.6	64.1	45.8
February	I	96.0	89.7	140.3	114.1	209.1	89.2	97.2	92.0	76.0	89.3	84.1	65.7	70.2	68.0	104.4	92.7	89.3	97.5	166.2	36.5	62.6	41.4
	II	92.7	89.2	137.1	111.3	213.7	84.8	98.4	89.9	77.8	87.4	84.5	68.2	68.0	65.0	96.2	90.4	81.8	99.0	171.1	37.8	67.1	38.8
	III	94.9	89.7	146.2	109.7	225.2	83.1	89.7	79.9	74.9	87.2	80.6	78.5	67.3	60.6	102.0	90.7	93.0	101.5	170.4	43.6	69.8	37.6
March	I	94.4	90.7	165.6	107.9	177.7	102.3	91.7	92.5	84.0	99.5	95.1	81.6	65.3	67.4	100.0	82.8	87.1	121.3	211.2	39.1	74.3	43.5
	II	110.5	99.2	163.5	116.4	201.9	110.3	96.4	121.7	88.8	128.0	144.2	84.8	66.9	70.0	74.5	98.5	93.1	111.3	208.1	41.7	80.1	61.8
	III	134.5	106.3	196.0	142.2	220.0	206.0	97.1	179.4	113.3	147.6	142.4	116.2	74.3	94.9	125.0	121.3	107.0	205.4	235.7	52.1	113.9	92.2
April	I	230.3	173.2	207.5	139.7	290.5	181.5	111.0	222.8	89.7	165.1	115.6	120.3	97.7	200.6	176.2	155.1	152.6	153.8	156.5	124.7	188.8	86.1
	II	159.5	188.3	229.8	233.3	354.0	258.6	113.7	189.3	143.4	180.8	140.9	171.4	109.0	170.1	280.0	264.7	197.0	337.3	213.7	187.1	156.4	126.1
	III	217.0	202.1	298.9	311.5	378.6	228.2	129.0	251.8	205.7	199.1	167.1	262.3	177.0	240.5	284.1	262.9	292.3	242.1	276.5	139.8	218.2	175.1
May	I	211.8	285.0	369.8	442.4	532.4	260.6	317.9	359.7	368.5	258.0	240.7	311.7	187.5	228.6	383.3	283.6	240.0	189.6	224.6	197.1	173.3	212.6
	II	334.6	334.1	345.6	632.4	447.0	303.5	361.7	327.1	516.4	364.8	300.2	240.1	158.6	286.6	389.2	382.9	250.5	456.7	275.8	228.9	218.1	194.4
	III	357.6	331.4	587.4	583.8	474.7	266.6	335.4	368.9	408.0	322.0	306.6	342.7	328.7	373.6	486.1	363.4	293.7	394.2	367.2	418.5	249.8	184.8
June	I	417.2	317.1	437.8	823.5	478.0	302.5	430.7	381.3	423.0	295.1	340.9	329.5	246.7	350.2	550.7	404.4	424.9	302.3	370.7	504.0	227.7	
	II	465.1	459.5	708.0	851.7	711.3	335.6	449.7	492.4	566.7	282.0	412.0	396.2	311.5	425.2	542.5	499.6	510.9	471.7	427.2	393.3	359.9	
	III	488.2	381.4	552.6	895.1	663.4	580.7	520.0	505.8	527.6	546.7	485.5	758.4	494.2	494.7	750.5	512.1	823.3	590.7	412.7	371.7	454.8	
July	I	533.6	561.8	610.3	894.1	729.0	432.5	516.8	396.8	780.2	542.6	564.4	935.9	451.8	524.8	431.3	687.2	872.8	703.5	514.0	440.5	374.4	
	II	550.4	581.4	614.6	1040.0	792.3	513.1	434.2	372.7	645.7	680.9	528.9	718.8	431.9	626.3	741.7	588.2	785.0	968.1	620.4	465.5	548.3	
	III	640.6	630.8	554.1	880.5	619.4	611.1	443.7	457.3	549.3	515.6	407.9	622.0	528.6	475.8	807.2	698.4	548.3	856.4	613.2	456.1	1070.6	
August	I	619.2	547.8	530.7	762.1	779.7	629.4	662.2	424.5	570.0	497.1	451.8	665.1	392.1	630.9	682.3	553.5	590.1	670.3	642.7	364.4	463.9	
	II	672.1	586.7	573.4	743.2	787.9	525.2	583.2	452.1	782.7	549.0	659.4	987.2	532.0	570.5	827.8	796.8	517.6	653.7	707.5	315.2	534.5	
	III	567.1	813.3	621.2	746.9	685.0	569.9	543.8	568.0	582.7	451.1	402.1	779.6	648.1	457.9	986.8	665.3	628.4	572.4	580.7	495.6	433.0	
September	I	704.5	514.4	555.0	684.2	687.5	436.9	515.1	439.3	493.2	511.7	445.3	645.6	614.6	515.0	687.7	446.2	732.8	534.1	377.1	316.2	660.5	
	II	552.8	369.1	610.6	705.4	558.9	422.1	395.9	471.3	450.5	434.7	443.3	421.8	445.2	421.6	600.6	387.3	958.7	448.9	218.9	387.2	403.7	
	III	511.1	336.7	571.0	724.6	505.0	307.4	376.7	312.2	544.5	414.6	387.5	371.5	295.5	325.0	436.1	366.0	529.2	403.6	248.7	257.2	242.4	
October	I	384.2	270.7	437.0	702.2	391.4	288.2	326.2	277.2	340.7	377.6	275.3	263.0	0.0	236.0	552.9	291.9	508.1	731.8	217.1	209.0	207.5	
	II	255.3	202.8	314.4	624.4	326.3	354.7	232.9	209.0	286.2	264.7	205.6	253.6	0.0	186.7	404.6	252.5	391.2	471.4	145.0	171.1	188.9	
	III	246.1	178.6	253.1	452.8	245.3	248.5	217.8	165.8	241.0	225.9	173.1	271.6	0.0	167.5	305.8	200.3	324.9	391.8	174.7	140.7	134.6	
November	I	195.0	150.9	229.2	378.7	213.7	196.2	178.2	146.4	193.9	209.6	144.5	176.3	181.8	134.1	248.7	170.1	245.6	298.5	103.5	108.6	126.5	
	II	164.0	141.9	201.0	343.0	188.4	151.0	159.7	137.1	180.4	177.7	129.8	153.4	152.4	123.4	186.1	146.7	206.5	254.0	88.4	103.9	107.8	
	III	148.0	133.6	182.8	311.7	157.7	108.8	139.6	127.0	161.7	167.9	122.2	139.0	135.5	108.5	143.9	127.7	211.2	250.0	82.5	93.3	76.3	
December	I	133.9	132.1	159.6	288.1	140.4	114.4	139.7	119.6	116.5	133.7	110.1	126.2	113.1	91.6	136.6	118.2	214.2	238.4	73.4	92.1	75.7	
	II	123.2	121.8	148.5	259.7	125.0	101.5	126.0	100.1	103.1	117.3	96.8	118.3	99.3	82.9	126.1	108.1	187.9	216.7	61.4	83.8	66.4	
	III	110.0	110.0	136.1	243.4	110.4	83.1	103.7	87.0	96.4	100.8	82.6	94.9	90.1	77.9	114.5	101.0	170.4	196.4	56.6	75.1	61.6	

Table 3.4 (d): 10-Daily discharges at Uzorong (cumecs)

Year / Month	10-daily	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Jan	I		89.8	98.4	85.1	118.6	73.6	61.5	80.3	85.4	86.8	84.3	86.5	99.1	106.3	92.6	86.2	68.6	103.2
	II		89.9	96.1	82.7	115.3	64.1	57.6	74.5	77.9	80.1	80.5	80.2	93.8	97.9	87.4	74.2	62.3	100.9
	III		89.3	89.8	81.8	111.4	58.0	52.5	69.3	72.4	80.0	78.8	74.7	92.8	91.9	81.8	71.8	56.7	97.2
Feb	I		89.4	86.1	81.9	104.8	52.8	49.3	65.7	70.9	80.4	74.4	73.1	86.6	89.7	77.2	71.3	53.0	92.2
	II		97.0	83.7	85.6	102.1	59.5	51.0	62.8	66.8	82.9	70.9	73.6	84.6	98.8	77.5	73.7	50.1	88.6
	III	78.6	94.3	81.9	80.1	102.4	61.6	52.2	62.0	59.4	81.5	67.8	73.0	90.4	94.0	93.9	89.5	50.1	98.6
March	I	96.5	91.3	80.3	93.9	110.8	72.6	52.3	60.5	68.3	80.1	65.2	75.6	99.4	130.6	82.2	85.9	55.8	118.1
	II	109.6	94.5	107.2	97.3	141.0	134.6	54.2	68.1	75.3	76.4	86.8	77.6	103.3	125.6	90.4	91.0	82.3	113.8
	III	232.8	90.8	114.3	156.9	137.1	122.0	86.7	68.6	98.9	98.9	98.9	98.8	164.8	137.4	101.8	149.3	116.6	109.4
April	I	189.8	104.8	226.2	138.8	154.9	101.4	95.9	92.7	248.5	127.9	126.4	149.7	124.8	168.8	135.8	218.7	120.9	178.8
	II	288.1	156.8	212.4	168.3	216.1	146.0	160.4	109.5	186.1	171.2	186.8	190.1	271.3	237.7	198.3	177.1	203.6	213.6
	III	240.0	174.7	260.7	220.5	249.4	158.8	216.1	215.9	232.7	204.0	189.5	282.7	220.2	311.2	163.3	248.8	293.4	247.4
May	I	245.6	337.6	292.0	304.9	279.3	286.2	309.2	193.4	273.3	284.4	215.5	258.1	208.3	258.7	237.5	211.7	319.7	223.0
	II	288.1	395.8	304.3	757.5	369.8	394.4	239.3	160.1	341.1	277.5	316.1	249.8	466.1	300.2	265.3	248.9	334.7	188.7
	III	208.6	400.6	328.6	657.0	322.1	409.1	307.4	420.4	509.2	411.0	277.0	334.8	395.1	389.0	449.2	289.9	330.0	766.4
June	I	295.0	528.6	297.0	469.5	291.7	455.8	328.5	264.8	494.7	487.8	332.5	478.5	319.4	397.4	537.5	281.3	398.6	331.5
	II	360.6	584.3	470.3	670.3	285.8	615.3	417.4	339.5	562.4	564.7	455.3	553.9	553.9	434.0	416.4	414.4	587.5	306.9
	III	706.2	683.6	499.0	603.0	632.0	742.4	811.0	557.3	681.6	734.2	498.1	901.9	799.6	424.5	424.9	478.2	521.7	379.2
July	I	508.1	548.4	403.8	876.4	596.4	877.5	1051.8	560.6	588.0	389.4	669.0	1073.6	882.6	479.2	474.3	416.3	595.8	547.1
	II	619.5	623.2	336.1	740.8	815.4	829.0	858.3	536.5	713.8	769.6	560.7	946.7	1129.9	613.4	501.3	601.1	683.3	410.8
	III	677.1	584.3	518.1	661.9	598.1	575.1	754.7	675.6	711.7	772.4	649.2	646.8	956.7	607.6	505.7	1079.5	760.9	612.8
August	I	703.8	1045.7	633.8	677.6	594.5	725.5	774.0	512.6	978.4	606.1	546.8	580.9	839.2	664.7	394.4	636.7	485.9	647.9
	II	678.8	807.6	552.4	746.1	701.9	943.6	1110.7	736.4	829.7	883.8	663.0	614.2	722.2	725.2	339.9	713.9	582.8	676.2
	III	722.2	726.9	671.7	735.4	564.9	560.7	875.2	1026.7	686.4	1184.0	671.3	707.3	619.5	648.3	507.1	543.1	610.1	643.4
Septembe r	I	463.8	705.7	557.7	630.8	589.6	620.8	733.3	857.4	753.9	652.1	462.9	715.3	548.7	473.2	370.0	797.3	592.9	418.3
	II	534.1	586.0	556.5	519.7	456.1	645.0	424.1	577.5	653.6	564.6	427.8	884.1	382.6	326.0	451.6	529.0	419.6	425.3
	III	351.8	508.3	369.1	665.7	479.9	513.6	363.9	340.8	425.6	405.9	381.5	513.5	367.3	368.5	345.1	369.6	351.7	315.9
October	I	293.9	382.8	303.1	388.4	425.8	309.6	265.2	362.0	280.1	547.9	289.9	466.4	617.1	347.1	257.1	363.2	290.6	352.0
	II	418.3	317.8	236.2	331.0	274.6	229.0	227.7	375.4	220.8	363.4	227.5	304.4	418.6	227.0	208.5	295.7	209.4	223.3
	III	219.8	239.7	172.3	253.3	251.8	177.8	250.2	281.6	201.6	216.4	187.4	274.0	262.7	278.9	168.0	218.0	251.7	171.4
November	I	175.0	186.6	155.1	204.4	212.4	139.9	170.7	202.8	157.0	189.2	154.5	203.3	208.1	176.1	139.0	186.4	198.4	144.4
	II	138.7	167.7	133.4	193.7	176.2	120.2	143.6	179.8	146.5	150.5	142.0	173.5	180.6	156.7	133.5	156.5	167.8	131.9
	III	127.0	145.4	116.1	147.2	162.9	104.0	107.6	142.7	127.2	130.6	125.1	152.2	158.8	144.2	124.0	132.1	142.7	121.3
December	I	119.7	125.8	105.7	134.2	144.4	89.2	93.1	124.7	107.7	116.5	110.6	133.4	139.4	123.5	112.1	116.3	126.8	112.7
	II	120.2	111.1	98.7	122.7	126.3	81.1	78.5	108.5	99.6	105.2	99.2	119.6	123.5	109.7	96.9	101.8	114.7	102.6
	III	94.0	101.8	91.7	120.6	112.5	65.0	64.6	99.3	89.9	90.2	91.3	108.3	112.2	97.9	88.6	95.2	101.6	95.3

Table 3.4 (e): 10-Daily Discharges at Lhuntsi (cumecs)

Month	10-Daily	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Jan	I	31.3	26.6	17.8	20.4	19.4	20.2	19.6	20.2	22.4	13.9	14.9	15.1	13.9	15.4	16.8	11.7	14.0	12.1	10.0	15.4	13.9	16.0	16.0	22.8
	II	31.3	21.3	16.6	19.6	18.8	19.2	18.9	19.4	21.1	13.4	13.6	14.2	13.8	14.0	15.4	11.1	13.1	11.1	9.0	14.1	14.4	14.8	14.8	21.7
	III	31.3	17.4	15.8	18.0	18.6	18.4	18.1	19.1	20.3	13.0	13.3	14.1	13.0	14.2	14.7	10.9	12.4	10.8	8.6	13.4	13.6	13.6	13.6	21.6
Feb	I	30.9	15.2	15.6	17.4	17.7	17.7	18.5	18.7	20.2	12.2	12.6	14.0	12.1	14.0	14.3	12.5	11.8	9.8	7.8	12.5	12.9	12.9	12.9	20.5
	II	30.6	15.0	15.1	16.8	17.0	17.6	17.2	19.7	19.3	12.3	12.3	13.6	11.8	13.6	14.4	13.7	11.4	9.3	7.3	12.5	12.4	12.8	12.8	20.5
	III	30.6	14.7	14.7	16.8	16.7	18.2	17.0	17.7	18.8	12.4	12.9	13.3	11.2	12.8	13.5	12.9	11.2	8.8	7.1	12.3	13.2	13.1	13.1	20.0
Mar	I	30.4	14.5	14.7	18.0	16.5	17.3	17.5	19.8	18.6	12.7	12.5	13.9	11.3	12.9	13.9	12.9	11.0	8.9	8.0	13.6	13.1	12.9	12.9	22.2
	II	30.4	15.0	15.2	17.2	17.3	19.6	19.4	19.9	20.2	12.7	14.7	18.6	11.7	13.7	13.5	12.0	12.5	8.6	8.8	14.0	12.8	12.2	12.2	19.7
	III	30.4	16.5	15.2	20.3	19.0	21.1	26.4	18.1	21.1	19.3	15.3	19.2	13.1	14.3	13.9	13.1	14.3	9.5	15.5	14.7	13.0	18.7	18.7	20.6
Apr	I	30.2	21.9	20.4	20.7	16.5	26.2	24.8	20.0	25.6	17.1	16.3	18.1	13.4	16.9	26.2	14.6	16.7	12.9	10.9	17.3	13.5	25.2	25.2	28.4
	II	34.9	22.5	22.0	22.2	17.3	24.1	34.0	26.1	26.8	17.1	20.0	18.9	16.2	16.7	25.4	17.7	26.6	19.5	20.2	20.4	20.7	21.4	21.4	33.2
	III	35.8	23.5	23.9	25.5	19.0	26.1	31.5	33.7	28.8	25.4	29.1	20.4	22.7	25.5	33.4	20.2	26.9	28.2	21.4	27.1	24.2	30.7	30.7	37.5
May	I	35.2	24.6	29.3	35.5	30.7	38.1	34.2	38.0	39.9	46.2	37.6	30.1	34.3	23.9	28.3	25.4	25.3	29.9	16.5	31.8	30.4	28.3	28.3	37.9
	II	36.9	34.9	36.9	38.1	48.6	36.7	38.2	50.5	44.6	58.6	41.9	32.5	29.0	28.8	47.7	30.2	30.3	29.7	32.0	29.2	35.1	34.0	34.0	34.9
	III	38.3	41.4	40.1	76.2	52.0	44.9	35.4	47.9	47.7	50.7	35.2	41.8	41.3	59.9	66.2	40.3	31.4	35.6	41.8	40.8	56.4	37.8	37.8	80.8
Jun	I	50.3	51.9	46.4	59.3	30.7	56.9	41.8	62.5	52.8	63.4	40.8	47.3	42.4	44.9	79.6	72.2	49.3	48.4	41.5	48.1	72.8	36.2	36.2	56.9
	II	64.5	72.4	80.2	111.4	48.6	80.4	56.8	63.1	76.8	105.5	43.5	80.5	53.8	83.9	92.1	68.8	67.8	68.5	62.5	52.4	63.1	64.4	64.4	53.8
	III	77.5	88.5	62.5	96.0	52.0	96.5	112.4	85.4	119.0	134.9	108.7	97.3	158.0	117.5	103.8	99.4	91.2	100.9	81.7	64.1	69.7	62.3	62.3	74.0
Jul	I	67.3	92.7	106.3	114.9	118.0	128.6	80.3	84.7	69.8	161.9	118.7	121.0	166.8	116.0	129.4	63.7	114.6	125.9	105.5	72.9	77.1	53.9	53.9	
	II	78.9	92.7	119.3	113.0	159.0	133.1	110.1	98.5	65.7	110.8	167.5	136.9	118.4	87.2	134.0	85.5	98.9	101.8	103.5	86.3	79.6	76.4	76.4	
	III	62.5	129.1	129.3	102.3	126.3	106.1	128.6	102.9	101.0	98.6	131.3	61.2	129.5	138.2	115.9	110.7	111.2	86.5	116.4	94.2	84.5	132.6	132.6	
Aug	I	56.0	138.6	106.8	93.8	90.9	152.9	129.4	161.2	81.0	112.0	111.0	86.6	126.2	97.9	123.7	84.7	90.4	79.8	89.1	81.1	62.6	82.5	82.5	
	II	52.8	124.3	121.1	107.4	119.0	157.1	101.0	174.0	79.0	124.0	104.6	174.5	172.6	134.9	125.3	86.5	100.5	78.4	85.0	92.0	53.5	102.4	102.4	
	III	63.2	125.4	168.0	140.6	97.8	134.1	122.3	137.7	125.4	113.3	96.3	83.3	174.9	130.0	151.1	141.1	91.0	89.6	74.8	86.2	72.3	82.2	82.2	
Sep	I	57.7	129.2	105.9	112.0	90.9	132.1	116.7	105.8	72.6	81.1	126.8	87.4	110.8	121.3	127.8	87.3	63.0	107.8	75.4	67.7	62.1	91.6	91.6	
	II	53.0	112.0	69.1	109.0	119.0	99.6	82.9	81.2	87.1	64.5	93.5	61.1	63.2	84.5	94.9	76.3	56.8	113.3	58.8	37.6	69.6	63.6	63.6	
	III	53.2	78.3	63.2	96.7	97.8	86.9	56.8	65.2	53.1	94.1	76.7	56.0	49.3	62.5	73.4	59.2	48.3	65.6	56.7	28.9	57.2	48.3	48.3	
Oct	I	49.7	53.7	48.7	69.0	90.9	59.5	44.7	66.1	42.5	54.3	65.2	39.9	42.8	55.9	49.4	60.0	38.8	61.4	66.8	40.9	43.8	52.3	52.3	
	II	47.2	39.5	38.8	43.0	119.0	45.3	31.0	59.5	32.4	39.8	41.6	32.5	39.2	49.2	41.8	45.2	32.8	46.4	49.8	35.7	36.2	47.2	47.2	
	III	41.7	39.0	33.5	34.9	97.8	35.2	36.0	45.0	25.0	31.6	34.5	26.0	41.1	38.1	32.8	31.6	26.4	40.5	30.1	35.1	30.9	38.4	38.4	
Nov	I	36.3	29.9	29.8	31.0	33.3	30.9	31.5	33.0	23.7	25.1	28.3	23.0	31.1	31.1	21.2	28.7	21.8	32.5	21.2	27.7	25.5	37.0	37.0	
	II	35.2	26.3	26.8	28.3	29.8	28.0	29.3	29.8	21.5	24.3	25.3	20.7	27.0	26.9	17.5	23.8	20.7	22.8	16.6	24.8	23.3	32.2	32.2	
	III	33.4	24.0	25.2	25.6	26.9	25.7	26.6	27.5	18.3	20.5	22.4	18.8	22.9	23.6	14.6	20.5	19.0	22.8	13.9	22.2	20.6	28.1	28.1	
Dec	I	32.3	22.5	24.2	23.1	25.0	23.9	23.6	26.3	17.1	18.6	19.1	18.3	21.7	21.7	14.7	19.0	17.4	19.6	13.0	18.5	18.6	25.9	25.9	
	II	31.4	20.8	23.0	21.6	22.7	22.1	22.0	25.1	16.3	17.9	17.8	17.8	19.1	20.5	13.9	17.0	15.8	13.7	12.3	14.4	17.0	24.1	24.1	
	III	30.9	18.6	21.3	20.4	21.3	20.8	21.0	23.2	15.0	16.3	16.2	15.1	17.2	19.2	13.1	15.2	15.8	10.5	13.0	13.3	15.4	23.1	23.1	

Table 3.4 (f): 10-Daily Observed Discharges at Kholongchu Dam Site (cumecs)

Year		2009	2010
Month	10-daily		
Jan	I		19.3
	II		18.1
	III		18.3
Feburary	I		68.4
	II		69.2
	III		65.8
March	I		24.5
	II		23.8
	III		44.3
April	I		60.5
	II		67.1
	III		60.5
May	I		68.4
	II		69.2
	III		65.8
June	I	74.7	96.07
	II	67.8	90.49
	III	104.4	132.81
July	I	172.9	131.08
	II	137.3	244.41
	III	178.4	174.17
August	I	179.1	146.7
	II	169.5	162.88
	III	126.3	209.39
September	I	86.8	
	II	105.3	
	III	83.3	
October	I	56.7	
	II	49.1	
	III	37.6	
November	I	34.9	
	II	30.1	
	III	26.1	
December	I	25.2	
	II	24.1	
	III	20.8	

Table 3.4 (g): 10-Daily Discharges at Bjizam (cumecs)

Month	10-daily	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
January	I		20.9	18.9	15.5	15.5	16.7	17.8	15.8	16.3	15.5	18.2	18.1	17.5	17.1		17.1
	II		12.5	17.5	14.6	14.5	15.4	16.6	14.7	15.6	14.3	17.3	17.1	16.6	15.7		16.0
	III		14.9	16.5	13.8	12.9	15.0	15.9	14.0	15.1	13.6	16.5	16.2	15.2	15.5		15.2
February	I		33.4	16.0	13.7	12.8	14.2	15.6	13.6	14.9	13.4	15.8	15.8	13.7	15.0		14.0
	II		22.8	15.6	13.2	13.0	13.6	15.4	13.4	14.0	13.2	15.3	16.3	13.6	14.9		13.3
	III		15.1	16.3	12.7	13.2	13.3	14.1	13.6	13.6	13.7	16.1	16.5	14.3	16.5		15.2
March	I		25.2	17.0	15.2	13.9	12.9	14.7	13.2	13.6	13.9	17.9	19.9	13.4	16.9		19.3
	II		30.4	22.8	21.4	12.9	12.9	15.4	13.1	15.3	14.5	19.1	20.3	14.2	18.0		16.1
	III	18.5	43.0	22.0	19.9	15.3	14.4	20.8	18.2	16.9	17.6	27.9	19.7	15.2	28.9		16.1
April	I	23.0	35.9	23.8	19.0	20.8	17.8	35.2	21.1	20.3	27.4	22.8	22.3	17.7	39.3		23.8
	II	19.4	44.4	32.7	25.5	27.0	23.9	28.5	29.7	26.1	32.2	40.9	28.2	24.4	29.2		32.9
	III	25.0	62.2	39.0	26.4	28.6	34.2	39.5	31.6	24.8	42.5	36.8	38.9	25.9	33.2		37.3
May	I	38.3	82.6	54.0	41.3	47.4	32.0	37.9	39.8	30.4	34.3	33.7	37.4	33.8	34.1		34.9
	II	34.7	116.4	58.6	52.2	48.5	34.2	63.1	46.2	45.4	39.7	69.3	38.6	43.9	40.7		32.6
	III	45.5	102.0	57.4	53.4	51.4	85.9	94.8	79.3	39.4	51.3	75.1	60.7	77.2	53.7		141.8
June	I	40.7	92.0	51.5	72.6	58.7	63.1	90.2	98.1	58.1	69.9	49.5	56.1	101.9	55.6		
	II	55.5	151.4	57.1	107.0	74.7	89.4	124.0	117.5	87.4	80.1	76.5	65.8	83.6	79.2		
	III	72.2	131.1	199.3	122.6	181.4	163.0	147.9	125.9	108.7	145.3	95.1	86.5	124.9	82.0		
July	I	69.1	222.0	180.4	109.3	298.1	133.2	152.4	82.4	167.1	256.2	183.1	119.0	126.7	78.4		
	II	73.0	184.3	235.4	141.5	205.1	142.4	162.5	129.7	144.8	198.9	228.4	185.4	131.1	115.1		
	III	113.0	137.9	171.0	134.9	235.8	160.1	180.3	153.8	200.8	141.2	194.5	152.7	155.0	252.0		
August	I	116.1	133.0	155.4	186.8	225.8	116.1	210.4	148.1	133.5	153.5	166.5	136.9	121.5	118.2		
	II	110.0	173.3	166.1	209.0	408.3	168.9	187.1	192.8	164.6	129.2	152.7	199.6	103.3	163.1		
	III	175.2	143.7	142.3	120.2	215.1	219.2	219.1	209.6	161.7	155.9	125.2	152.2	120.6	123.3		
September	I	96.6	112.6	181.0	158.7	159.5	157.7	205.1	133.8	102.6	173.7	124.4	113.4	84.7	206.1		
	II	103.0	118.3	134.5	129.9	89.6	121.0	133.9	112.1	86.6	173.6	87.1	71.7	142.8	114.8		
	III	72.7	136.2	112.4	109.5	79.6	83.2	90.5	83.1	67.4	93.0	90.8	85.2	86.2	69.9		
October	I	55.7	86.0	97.9	61.4	69.9	72.3	56.1	98.1	54.7	74.9	125.1	95.5	61.8	65.7		
	II	43.6	63.2	59.7	45.2	59.4	68.8	44.2	66.0	42.2	56.3	71.9	55.5	48.4	64.6		
	III	34.3	44.9	52.1	37.0	49.8	56.5	39.5	43.0	33.6	45.4	47.2	57.3	35.4	43.8		
November	I	31.7	35.3	36.1	30.2	35.9	40.1	31.0	36.2	26.5	35.9	37.8	35.9	29.2	39.3		
	II	26.0	33.8	30.3	25.8	31.3	33.9	30.2	29.2	23.5	29.3	32.1	30.5	25.9	30.0		
	III	21.1	28.1	27.6	23.4	27.0	29.5	25.7	25.5	20.8	25.8	26.4	26.9	23.3	25.1		
December	I	19.1	23.9	22.4	21.5	23.1	24.8	21.6	23.1	18.3	22.5	23.8	23.0	20.3	22.2		
	II	17.7	22.1	19.5	19.2	20.4	22.1	19.1	20.4	16.7	19.2	21.3	20.8	17.8	19.4		
	III	16.1	20.6	17.4	17.1	18.1	20.0	17.6	17.7	15.3	18.5	19.7	18.8	16.6	10.8		

Table 3.4 (h): 10-Daily Discharges at Kurjey (cumecs)

Month	10 Daily	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
January	I		10.87	12	11.61	11.76	15.26	14.34	14.74	12.17	14.4	12.71	12	12.81	13.24
	II		10.87	11.62	12.49	11.64	13.09	13.57	13.71	11.43	13.94	1.53	11.33	11.46	12
	III		10.9	11.07	12.34	11.37	12.01	12.9	12.66	11.07	12.84	11.54	11.51	11.75	11.95
February	I		10.56	10.72	10.64	10.9	12.44	13.05	12.72	11.15	12.09	11.43	11.31	11.64	11.92
	II		9.62	11.18	11.08	10.93	11.82	12.48	12.2	10.76	11.13	11.36	10.59	11.36	10.78
	III		9.39	10.28	10.51	10.48	11.25	11.39	11.85	10.78	10.72	11.46	10.32	11.17	10.9
March	I		11.3	9.91	10.48	11.04	10.56	12.34	11.45	10.14	10.73	10.62	10.09	10.93	12.28
	II		12.2	9.58	13.84	13.16	14.06	16.32	11.41	10.54	10.56	10.51	10.23	11.02	12.09
	III		17.69	10.82	14.89	20.82	16.35	14.84	12.68	12.53	13.61	12.38	11.64	11.97	18.75
April	I		16.15	13.99	19.42	15.71	17.79	14.97	16.76	14.12	23.67	15.94	13.7	19.38	15.69
	II		22.88	17.1	17.14	21.25	28.02	16.54	21.26	24.66	20.12	22.07	21.95	26.04	28.35
	III		17.8	23.65	21.37	32.74	30.01	19.86	28.91	24.12	31.21	24.29	20.61	31.25	33.33
May	I	22.13	41.74	35.2	42.79	37.52	29.65	40.07	20.78	29.48	32.49	24.53	25.61	24.9	31.17
	II	25.49	44.01	31.62	71.22	40.54	45.66	36.04	25.3	50.64	35.96	38.3	33.33	50.81	28.44
	III	27.03	40.68	42.92	49.22	46.67	42.23	46.88	66.76	77.03	58.45	33.9	40.73	62.26	45.11
June	I	43.5	35.78	54.73	47.53	68.96	51.78	54.3	46.28	48.36	65.52	67.18	48.04	57.83	57.17
	II	116.4	41.15	73.49	90.57	101.32	75.82	81.06	57.99	69.67	96.16	93.87	73.19	66.76	92.43
	III	85.5	93.53	91.19	90.94	99.6	162.14	116.83	136.28	148.69	112.72	98.84	86.35	133.21	114.58
July	I	149.1	76.58	78.85	68.96	171.04	154.99	134.93	210.97	91.45	118.36	63.69	150.02	182.02	143.93
	II	148.64	111.95	88.47	65.64	136.58	166	154.85	171.99	118.36	122.91	103.39	119.94	142.32	165.53
	III	96.88	126.08	98.71	110.8	107.65	149.63	134.99	186.32	150.39	140.89	126.45	159.06	120.25	153.65
August	I	161.68	129.72	141.22	105.04	124.26	130.75	144.21	161.14	73.69	146.85	110.77	113.95	111.23	151.74
	II	227.25	125.34	123.5	102.34	149.61	136.77	181.6	216.85	155.23	144.84	123.87	148.39	93	135.37
	III	218.07	140.73	121.98	147.54	117.47	125.69	91.89	170.5	190.86	174.52	149.78	144.35	112.47	114.74
September	I	231.92	93.17	102.26	91.56	92.41	147.84	102.8	142.67	151.15	148.86	114.39	102.43	138.73	104.16
	II	131.89	85.83	81.03	98.4	92.16	116.46	89.23	89.75	115.95	107.58	98.59	66.5	146.79	69.66
	III	79.38	57.15	84.04	58.34	136.45	109.51	85.49	76.61	77.52	78.58	69.13	63.47	75.08	72.28
October	I	53.34	46.36	57.06	45.8	61.02	88.89	67.17	59.56	67.87	49.16	85	50.2	61.01	100.84
	II	35.5	43.78	50.38	34.5	50.05	48.08	39.8	51.59	68.93	37.78	60.1	42.73	46.19	65.47
	III	29.67	31.23	36.5	27.31	32.36	42.01	32.47	40.85	52.22	32.4	39.27	32.54	35.41	39.38
November	I	23.89	24.38	27.91	23.44	27.05	33.2	25.85	30.75	36.27	25.97	32.32	26.33	22.26	31.73
	II	20.22	19.65	23.61	19.29	29.94	27.42	22.72	22.11	28.79	23.14	26.29	23.65	18.46	25.07
	III	17.84	16.54	20.64	16.35	21.84	24.85	19.81	20.74	24.51	19.26	22.85	20.53	18.16	22.81
December	I	15.42	15.72	17.38	13.93	17.61	20.65	17.55	18.53	20.49	16.32	20.1	17.73	17.47	19.7
	II	13.89	13.52	15.33	13.53	15.54	17.69	15.9	15.77	17.21	14.97	16.31	15.93	16.02	17.62
	III	13.33	12.33	13.26	11.87	16	15.27	14.17	14	15.97	13.58	13.64	14.13	13.6	16.17

Table 3.4 (i): 10-Daily Discharges at Refe (cumecs)

Month	10 Daily	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-1990	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96
June	I		131.63	94.27	151.56	44.57	108.42	67.96	143.97	157.92	135.98	102.82	108.94	86.12	152.61
	II		128.97	109.27	165.93	71.03	121.95	144.5	265.74	141.48	301.3	136.51	109.18	135.03	342.2
	III		185.97	110.72	213.94	129.9	152.9	111.83	328.11	161.95	168.27	329.27	132.31	243.09	360.83
July	I		219.97		236.11	239.17	178.91	196.82	305.39	177.11	305.66	431.97	208.6	250.59	323.02
	II		162.61	156.73	264.83	219.41	234.57	190.86	336.36	218.26	282.66	505.06	211.43	119.79	343.75
	III		189.3	159.32	274.08	136.23	276.72	226.3	297.32	257.37	223.27	395.78	273.56	124.67	374.6
August	I			124.78	216.69	151.26	225.82	201.72	161.44	229.4	416.68	337.49	515.21	168.65	262.85
	II			131.88	217.42	122.26	233.48	203.6	130.93	270.06	462.8	298.28	744.99	270.43	255.76
	III			147.52	223.37	162.54	188.84	235.53	122.59	184.02	219.33	399.82	1026.12	266.63	219.59
September	I			145.56	228.14	118.31	240.92	156.37	127.57	129.1	296.04	297.75	1189.97	203.66	166.17
	II			169.33	217.82	130.9	175.75	109.46	135	159.75	269.83	310.45	1044.89	166.44	128.89
	III			130.02	161.55	107.2	155.89	95.06	145.42	171.05	150.63	202.13	920.26	117.52	123.53
October	I			81.64	129.64	94.4	112.01	81.99	139.32	205.63	102.42	156.47	727.36	104.6	104.85
	II		106.14	94.46	104.65	95.83	80.65	69.69	98.1	197.62	80.99	150.75	470.47	100.9	87.94
	III		77.89	79.07	75.77	79.66	85.09	61.33	82.09	144.72	90.88	131.12	311.83	97.53	75.63
November	I		51.08	63.48	51.03	50.97	58.06	55.85	80.4	109.13	76.32	85.86	250.25	93.71	
	II		43.64	38.47	42.01	37.17	49.9	51.02	79.9	91.48	62.23	68.89	187.21	80.05	
	III		48.99	36.71	34.86	35.3	45.07	46.64	79.7	78.83	63.45	59.69	135.92	51.23	
December	I		39.6	33.62	28.45	30.7	42.18	43.86	76.9	55.05	53.64	40.71	110.95	41.54	
	II		37.42	31.8	25.22	27.35	39.38	41.84	66.2	47.56	46.99	44.17	100.02	36.45	
	III		34.52	28.27	22.11	24.06	36.29	39.67	59.55	42.18	43.14	48.24	92.64	32.63	
January	I		34.82	34.98	25.29	22.49	33	38.16	53.9	45.75	40.82	35.19	85.72	26.32	
	II		32.93	31.54	27.86	21.47	30.94	36.82	50.2	41.69	37.54	31.23	67.92	24.06	
	III		31.47	26.42		21.42	29.6	35.3	48	38.06	35.43	27.58	38.18	24.79	
February	I		30.27	25.64		23.48	28.49	35.95	47.12	35.75	35.4	26.78	32.56	26.83	
	II		31.69	25.3		24.25	28.12	35.97	50.3	36.69	33.65	30.59	30.66	28.03	
	III		27.93	38.56		23.54	28.77	37.77	49.5	36.18	32.8	30.55	28.64	30.85	
March	I		29.26	53.91		22.86	29.04	42.16	51.85	39.46	30.81	34.29	27.17	29.75	
	II		33.27	32.54		24.47	30.42	41.79	55.99	44.17	38.29	41.06	26.49	28.41	
	III	43.35	31.4	38.09	26.41	28.48	29.9	46.29	53.7	44.97	56.05	46.38	27.73	26.05	
April	I	44.64	37.55	68.75	24.17	39.42	40.44	48.6	49.86	51.3	61.16	47.44	30.02	28.83	
	II	42.48	39.04	72.85	30.87	41.5	41.93	51.99	76.16	49.98	68.85	51.52	31.6	32.16	
	III	52.08	46.59	87.71	39.83	41.07	43.55	54.7	90.71	50.27	61.41	63.48	35.18	34.46	
May	I	91.8	43.92	86.42	37.18	49.9	54.39	57	57.19	83.85	71.12	77.9	38.11	44.73	
	II	83.78	73.26	92.15	40.22	64.99	57.73	52.5	75.54	59.2	76.73	90.19	47.49	119.87	
	III	102.08	89.22	114.02	38.38	74.51	62.84	91.18	101.46	86.47	85.13	99.55	61.06	123.98	

Table 3.17: Estimation of Annual Yield from Rainfall Data

S.No	Station	Rainfall (mm)	Elevation (m)	Catchment area (sq km)	Annual Yield (MCM)
1		1812.5	1400-1600	2.95	5.35
2	Shelgana	1812.5	1600-1800	11.69	21.19
3	Kanglung	1239.5	1800-2000	32.98	40.88
4	Wamrong	2186.0	2000-2200	48.46	105.93
5	Average	1917.2	2200-2400	65.85	126.24
6	Nobding	1648.3	2400-2600	78.95	130.13
7	Chendebji	1523.7	2600-2800	85.54	130.34
8	Phobjekha	1285.1	2800-3000	87.08	111.91
9	Average	1509.4	3000-4600	610.57	921.61
10		1733.8	4600-5600	95.58	165.71
	Total			**1120**	**1759.3**
Annual Yield (m)					**1.571**
Annual Yield (mm)					**1571**

Table 3.18: 10-Daily Discharges of Trashiyangtse & Muktirap Converted to Dam Site (cumecs) - D3

Month (Year →)	10-daily	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
January	I	14.1	18.2	14.3	15.8	24.9	18.9	19.9	20.8	16.4	20.6	21.1	18.1	17.7	16.3	16.0	17.5	16.7	16.5	18.5	21.9	19.0	16.5	18.2
	II	12.9	16.9	18.5	14.6	23.2	17.8	24.0	19.7	15.9	19.0	19.2	17.1	16.4	15.3	14.5	16.2	15.4	15.3	15.8	20.8	18.9	15.0	17.4
	III	15.1	15.6	20.6	14.9	23.1	17.5	28.4	17.3	15.2	17.6	18.0	15.9	15.7	15.1	14.2	16.1	14.3	13.8	15.3	20.0	18.6	13.5	17.1
February	I	16.7	14.9	22.7	14.5	22.8	17.6	28.2	14.6	15.1	17.5	18.1	15.1	15.1	15.6	14.4	15.1	14.6	13.2	15.1	19.2	16.2	12.7	16.8
	II	15.8	14.9	20.6	14.8	24.6	15.4	29.5	13.8	16.3	16.5	17.8	16.2	13.2	15.4	15.0	15.4	16.3	13.9	15.6	18.5	15.0	12.4	16.7
	III	17.6	15.5	23.0	14.0	30.4	14.6	31.4	12.9	14.3	18.1	18.3	16.9	14.8	14.5	15.9	18.5	16.2	21.0	19.3	19.3	16.8	13.1	18.0
March	I	18.3	19.5	32.3	14.3	26.0	19.7	31.3	20.5	20.5	21.1	21.1	20.2	18.0	14.7	18.1	20.8	24.6	18.8	20.3	21.3	24.9	22.8	21.3
	II	21.5	24.3	28.5	17.7	34.1	26.5	28.8	33.9	27.3	30.7	32.0	20.5	14.4	22.6	19.5	20.2	23.0	20.7	22.5	28.1	26.0	23.2	24.8
	III	30.8	24.4	41.7	23.1	42.8	55.3	29.6	50.3	48.1	31.4	37.6	25.0	25.7	25.9	26.1	41.4	26.9	24.5	46.5	37.3	22.4	45.2	34.6
April	I	65.4	46.7	40.8	21.4	57.9	49.7	36.3	59.3	36.2	41.6	30.2	31.6	36.4	33.2	38.2	29.3	39.9	33.2	61.3	39.3	42.6	48.9	41.8
	II	44.3	51.7	48.4	57.9	54.6	80.4	45.7	49.3	51.0	78.4	47.3	51.1	53.7	54.3	51.0	60.8	55.3	52.9	46.9	62.5	57.8	65.8	55.5
	III	56.8	56.2	58.0	76.3	56.2	64.9	52.3	61.2	72.0	85.0	59.1	68.2	57.5	41.5	71.9	48.4	96.4	40.9	65.2	83.9	62.3	70.4	63.8
May	I	54.7	66.8	80.2	71.9	86.5	70.6	79.3	101.7	117.4	96.6	81.6	76.1	75.7	53.7	69.1	45.9	60.3	66.7	58.9	79.0	55.1	69.8	73.5
	II	81.0	79.3	81.2	108.4	88.6	81.1	83.7	78.8	166.0	106.8	106.0	73.7	81.3	90.8	68.9	121.1	67.6	80.4	72.4	85.6	50.1	97.4	88.6
	III	84.3	78.0	125.8	100.6	87.3	73.6	87.8	110.4	105.7	130.1	113.5	113.7	110.7	75.6	75.9	94.4	98.1	137.8	84.6	90.1	192.0	79.4	102.2
June	I	103.0	81.3	92.1	134.7	109.3	85.4	109.1	98.5	137.6	101.4	128.9	112.5	147.2	105.2	136.1	92.2	104.4	157.8	87.8	128.1	79.8	128.3	111.8
	II	120.4	121.6	136.9	125.6	141.3	99.2	127.0	118.3	252.0	90.3	207.6	138.2	122.3	135.6	157.9	145.7	113.6	128.0	138.3	214.0	64.6	135.6	137.9
	III	121.5	94.9	127.9	139.2	150.2	160.0	141.0	207.7	241.9	277.8	222.4	321.0	150.6	147.1	253.0	201.5	135.4	141.9	148.5	163.3	111.2	209.9	175.8
July	I	135.6	144.8	144.6	149.8	183.6	117.5	137.7	145.5	240.4	270.5	267.4	414.6	131.4	182.9	335.0	291.5	140.2	147.2	114.9	141.9	178.3		191.2
	II	131.1	130.4	140.2	189.9	165.5	117.3	145.4	102.8	234.0	414.1	242.2	249.0	184.1	159.4	329.6	270.1	211.5	152.7	179.4	196.5	126.3		193.9
	III	169.3	154.4	121.7	158.0	133.6	148.5	133.6	186.2	189.5	261.4	182.5	224.9	184.3	181.8	187.4	238.3	181.4	157.7	447.6	177.4	192.8		191.1
August	I	157.2	126.0	122.6	112.6	173.7	141.8	274.4	149.8	183.6	194.5	162.3	241.8	139.3	122.2	123.5	193.5	205.9	103.5	157.4	145.6	186.7		162.8
	II	200.3	129.8	135.5	142.2	157.9	123.9	193.8	151.7	251.4	252.9	254.0	455.1	145.6	250.3	174.8	158.6	245.4	90.7	229.7	192.7	184.8		196.2
	III	146.9	162.9	160.7	129.0	152.2	137.0	169.3	195.6	223.5	205.4	119.6	281.5	191.7	166.9	222.9	150.5	199.9	163.8	151.7	259.9	162.9		178.7
September	I	150.2	121.9	132.6	128.3	146.4	109.5	142.5	142.3	155.9	277.9	187.6	232.8	137.8	112.1	234.0	139.7	142.3	112.0	250.4	152.0	106.7		157.9
	II	114.7	80.8	136.6	125.0	128.9	117.6	109.2	148.5	139.7	160.0	222.0	104.3	128.5	95.9	273.6	84.6	77.7	151.0	126.9	104.7	124.1		131.1
	III	87.5	84.0	130.1	125.0	124.0	80.7	128.8	109.1	164.2	156.9	185.9	97.1	98.6	73.3	113.4	120.3	102.6	103.9	88.7	89.4	85.8		111.9
October	I	82.5	62.2	100.0	140.6	99.2	91.6	102.6	102.1	89.7	149.8	91.3	69.0	122.5	63.9	121.3	229.4	95.7	72.0	97.7	73.8	107.0		103.1
	II	64.8	42.9	69.8	104.8	77.9	79.5	100.1	61.4	85.7	73.0	64.2	105.2	85.0	48.3	68.6	89.1	51.3	56.0	76.9	50.7	55.0		71.9
	III	63.5	36.4	55.2	68.2	59.0	57.8	74.8	50.4	60.2	76.4	46.7	91.2	51.6	42.1	61.8	52.3	64.9	41.3	49.1	53.9	39.8		57.0
November	I	49.0	28.1	51.1	53.2	46.2	43.2	43.8	38.8	43.5	52.3	38.2	51.8	47.8	30.5	40.4	39.7	38.1	32.9	43.7	42.8	32.3		42.3
	II	35.5	22.6	47.2	43.4	37.2	38.8	36.9	29.1	41.9	40.5	33.1	36.9	36.9	27.7	33.6	34.7	32.6	32.9	34.4	35.3	28.9		35.2
	III	29.2	19.1	37.4	36.5	29.4	39.7	31.1	26.4	30.4	37.7	30.0	31.5	31.1	24.6	30.3	28.3	30.0	29.8	28.0	30.2	25.5		30.3
December	I	25.0	17.5	28.8	33.0	26.1	37.6	30.6	24.8	27.3	29.9	25.9	27.9	24.8	21.3	26.2	23.0	24.3	27.5	26.9	26.6	22.7		26.6
	II	21.3	15.3	20.1	29.0	23.1	22.8	28.5	22.6	24.4	26.3	23.2	23.3	21.7	18.8	22.8	20.2	20.9	22.0	31.1	23.6	20.1		22.9
	III	19.7	13.4	17.5	26.3	21.1	19.5	25.1	16.1	22.6	22.9	19.9	20.4	16.7	17.7	19.6	18.2	18.3	19.7	28.3	21.7	18.0		20.1
Average Annual Discharge (Cumecs)		71.6	62.0	74.0	77.1	79.7	69.2	81.1	77.6	99.3	108.4	94.3	108.6	76.8	70.3	97.1	89.0	78.4	69.8	86.5	82.5	72.0		82.2
Annual Yield (Mcum)		2258	1956	2335	2431	2513	2183	2559	2446	3133	3419	2975	3425	2423	2218	3061	2805	2472	2202	2729	2602	2270		**2591**
Annual Runoff (mm)		2016	1747	2085	2170	2244	1950	2285	2184	2797	3052	2656	3058	2163	1980	2733	2505	2207	1966	2437	2324	2027		**2314**

Table 3.19: 10-Daily Discharges (Water year wise) at Kholongchu Dam Site D-3 (cumecs) (Based on Observed Discharges at Trashiyantse & Muktirap)

Month (Year →)	10-daily	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	Average
June	I	103.0	81.3	92.1	134.7	109.3	85.4	109.1	98.5	137.6	101.4	128.9	147.2	105.2	136.1	92.2	104.4	157.8	87.8	128.1	79.8	111.0
	II	120.4	121.6	136.9	125.6	141.3	99.2	127.0	118.3	252.0	90.3	207.6	122.3	135.6	157.9	145.7	113.6	128.0	138.3	214.0	64.6	138.0
	III	121.5	94.9	127.9	139.2	150.2	160.0	141.0	207.7	241.9	277.8	222.4	150.6	147.1	253.0	201.5	135.4	141.9	148.5	163.3	111.2	166.9
July	I	135.6	144.8	144.6	149.8	183.6	117.5	137.7	145.5	240.4	270.5	267.4	131.4	182.9	335.0	291.5	140.2	147.2	114.9	141.9	178.3	180.0
	II	131.1	130.4	140.2	189.9	165.5	117.3	145.4	102.8	234.0	414.1	242.2	184.1	159.4	329.6	270.1	211.5	152.7	179.4	196.5	126.3	191.1
	III	169.3	154.4	121.7	158.0	133.6	148.5	133.6	186.2	189.5	261.4	182.5	184.3	181.8	187.4	238.3	181.4	157.7	447.6	177.4	192.8	189.4
August	I	157.2	126.0	122.6	112.6	173.7	141.8	274.4	149.8	183.6	194.5	162.3	139.3	122.2	123.5	193.5	205.9	103.5	157.4	145.6	186.7	158.8
	II	200.3	129.8	135.5	142.2	157.9	123.9	193.8	151.7	251.4	252.9	254.0	145.6	250.3	174.8	158.6	245.4	90.7	229.7	192.7	184.8	183.3
	III	146.9	162.9	160.7	129.0	152.2	137.0	169.3	195.6	223.5	205.4	119.6	191.7	166.9	222.9	150.5	199.9	163.8	151.7	259.9	162.9	173.6
September	I	150.2	121.9	132.6	128.3	146.4	109.5	142.5	142.3	155.9	277.9	187.6	137.8	112.1	234.0	139.7	142.3	112.0	250.4	152.0	106.7	154.1
	II	114.7	80.8	136.6	125.0	128.9	117.6	109.2	148.5	139.7	160.0	222.0	128.5	95.9	273.6	84.6	77.7	151.0	126.9	104.7	124.1	132.5
	III	87.5	84.0	130.1	125.0	124.0	80.7	128.8	109.1	164.2	156.9	185.9	98.6	73.3	113.4	120.3	102.6	103.9	88.7	89.4	85.8	112.6
October	I	82.5	62.2	100.0	140.6	99.2	91.6	102.6	102.1	89.7	149.8	91.3	122.5	63.9	121.3	229.4	95.7	72.0	97.7	73.8	107.0	104.8
	II	64.8	42.9	69.8	104.8	77.9	79.5	100.1	61.4	85.7	73.0	64.2	85.0	48.3	68.6	89.1	51.3	56.0	76.9	50.7	55.0	70.2
	III	63.5	36.4	55.2	68.2	59.0	57.8	74.8	50.4	60.2	76.4	46.7	51.6	42.1	61.8	52.3	64.9	41.3	49.1	53.9	39.8	55.3
November	I	49.0	28.1	51.1	53.2	46.2	43.2	43.8	38.8	43.5	52.3	38.2	47.8	30.5	40.4	39.7	38.1	32.9	43.7	42.8	32.3	41.8
	II	35.5	22.6	47.2	43.4	37.2	38.8	36.9	29.1	41.9	40.5	33.1	36.9	27.7	33.6	34.7	32.6	32.9	34.4	35.3	28.9	35.2
	III	29.2	19.1	37.4	36.5	29.4	39.7	31.1	26.4	30.4	37.7	30.0	31.1	24.6	30.3	28.3	30.0	29.8	28.0	30.2	25.5	30.2
December	I	25.0	17.5	28.8	33.0	26.1	37.6	30.6	24.8	27.3	29.9	25.9	24.8	21.3	26.2	23.0	24.3	27.5	26.9	26.6	22.7	26.5
	II	21.3	15.3	20.1	29.0	23.1	22.8	28.5	22.6	24.4	26.3	23.2	21.7	18.8	22.8	20.2	20.9	22.0	31.1	23.6	20.1	22.9
	III	19.7	13.4	17.5	26.3	21.1	19.5	25.1	16.1	22.6	22.9	19.9	16.7	17.7	19.6	18.2	18.3	19.7	28.3	21.7	18.0	20.1
January	I	18.2	14.3	15.8	24.9	18.9	19.9	20.8	16.4	20.6	21.1	18.1	16.3	16.0	17.5	16.7	16.5	18.5	21.9	19.0	16.5	18.4
	II	16.9	18.5	14.6	23.2	17.8	24.0	19.7	15.9	19.0	19.2	17.1	15.3	14.5	16.2	15.4	15.3	15.8	20.8	18.9	15.0	17.7
	III	15.6	20.6	14.9	23.1	17.5	28.4	17.3	15.2	17.6	18.0	15.9	15.1	14.2	16.1	14.3	13.8	15.3	20.0	18.6	13.5	17.2
February	I	14.9	22.7	14.5	22.8	17.6	28.2	14.6	15.1	17.5	18.1	15.1	15.6	14.4	15.1	14.6	13.2	15.1	19.2	16.2	12.7	16.9
	II	14.9	20.6	14.8	24.6	15.4	29.5	13.8	16.3	16.5	17.8	16.2	15.4	15.0	15.4	16.3	13.9	15.6	18.5	15.0	12.4	16.9
	III	15.5	23.0	14.0	30.4	14.6	31.4	12.9	14.3	18.1	18.3	16.9	14.5	15.9	18.5	16.2	21.0	19.3	19.3	16.8	13.1	18.2
March	I	19.5	32.3	14.3	26.0	19.7	31.3	20.5	20.5	21.1	21.1	20.2	14.7	18.1	20.8	24.6	18.8	20.3	21.3	24.9	22.8	21.6
	II	24.3	28.5	17.7	34.1	26.5	28.8	33.9	27.3	30.7	32.0	20.5	22.6	19.5	20.2	23.0	20.7	22.5	28.1	26.0	23.2	25.5
	III	24.4	41.7	23.1	42.8	55.3	29.6	50.3	48.1	31.4	37.6	25.0	25.9	26.1	41.4	26.9	24.5	46.5	37.3	22.4	45.2	35.3
April	I	46.7	40.8	21.4	57.9	49.7	36.3	59.3	36.2	41.6	30.2	31.6	33.2	38.2	29.3	39.9	33.2	61.3	39.3	42.6	48.9	40.9
	II	51.7	48.4	57.9	54.6	80.4	45.7	49.3	51.0	78.4	47.3	51.1	54.3	51.0	60.8	55.3	52.9	46.9	62.5	57.8	65.8	56.2
	III	56.2	58.0	76.3	56.2	64.9	52.3	61.2	72.0	85.0	59.1	68.2	41.5	71.9	48.4	96.4	40.9	65.2	83.9	62.3	70.4	64.5
May	I	66.8	80.2	71.9	86.5	70.6	79.3	101.7	117.4	96.6	81.6	76.1	53.7	69.1	45.9	60.3	66.7	58.9	79.0	55.1	69.8	74.4
	II	79.3	81.2	108.4	88.6	81.1	83.7	78.8	166.0	106.8	106.0	73.7	90.8	68.9	121.1	67.6	80.4	72.4	85.6	50.1	97.4	89.4
	III	78.0	125.8	100.6	87.3	73.6	87.8	110.4	105.7	130.1	113.5	113.7	75.6	75.9	94.4	98.1	137.8	84.6	90.1	192.0	79.4	102.7
Average Annual Discharge (Cumecs)		71.4	65.2	71.9	79.9	78.0	69.6	81.9	79.6	99.2	105.9	92.6	75.1	71.0	98.5	89.1	78.0	70.1	88.4	82.3	71.1	80.9
Annual Yield (Mcum)		2252	2056	2268	2520	2461	2195	2584	2510	3127	3340	2921	2369	2239	3107	2809	2458	2210	2789	2594	2242	**2553**
Annual Runoff (mm)		2011	1836	2025	2250	2197	1959	2307	2241	2792	2982	2608	2115	1999	2774	2508	2195	1973	2490	2316	2002	**2279**

Table 3.20: 10-Daily Discharges Estimated at D-3 Dam Site (cumecs)

Year / Month	10-daily	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	Average
June	I	69.9	55.2	62.5	91.4	74.2	58.0	74.0	66.9	93.4	68.8	87.4	99.9	71.4	92.4	62.5	70.9	107.0	59.6	86.9	54.1	75.3
	II	81.7	82.5	92.9	85.2	95.9	67.3	86.2	80.3	171.0	61.2	140.9	83.0	92.0	107.1	98.9	77.1	86.8	93.8	145.2	43.9	93.6
	III	82.5	64.4	86.8	94.5	101.9	108.6	95.7	140.9	164.2	188.5	150.9	102.2	99.8	171.6	136.8	91.8	96.3	100.8	110.8	75.5	113.2
July	I	92.0	98.3	98.1	101.6	124.6	79.7	93.4	98.8	163.1	183.5	181.4	89.2	124.1	227.3	197.8	95.1	99.9	78.0	96.3	121.0	122.2
	II	88.9	88.5	95.1	128.8	112.3	79.6	98.7	69.7	158.8	281.0	164.3	124.9	108.2	223.7	183.2	143.5	103.6	121.7	133.3	85.7	129.7
	III	114.9	104.7	82.6	107.2	90.6	100.7	90.6	126.4	128.6	177.4	123.8	125.0	123.3	127.1	161.7	123.1	107.0	303.7	120.4	130.8	128.5
August	I	106.7	85.5	83.2	76.4	117.9	96.2	186.2	101.7	124.6	132.0	110.1	94.5	82.9	83.8	131.3	139.7	70.3	106.8	98.8	126.7	107.8
	II	135.9	88.1	92.0	96.5	107.1	84.0	131.5	102.9	170.6	171.6	172.3	98.8	169.8	118.6	107.6	166.5	61.6	155.9	130.7	125.4	124.4
	III	99.6	110.6	109.1	87.5	103.2	93.0	114.9	132.7	151.7	139.3	81.1	130.1	113.2	151.3	102.1	135.7	111.2	103.0	176.3	110.5	117.8
September	I	101.9	82.7	90.0	87.0	99.4	74.3	96.7	96.5	105.8	188.6	127.3	93.5	76.1	158.8	94.8	96.6	76.0	169.9	103.1	72.4	104.6
	II	77.9	54.8	92.7	84.8	87.4	79.8	74.1	100.7	94.8	108.6	150.6	87.2	65.1	185.7	57.4	52.7	102.5	86.1	71.0	84.2	89.9
	III	59.4	57.0	88.3	84.8	84.1	54.8	87.4	74.1	111.4	106.5	126.1	66.9	49.7	77.0	81.6	69.6	70.5	60.2	60.7	58.2	76.4
October	I	56.0	42.2	67.9	95.4	67.3	62.1	69.6	69.3	60.9	101.7	62.0	83.1	43.3	82.3	155.7	65.0	48.8	66.3	50.1	72.6	71.1
	II	43.9	29.1	47.4	71.1	52.8	53.9	68.0	41.7	58.1	49.5	43.6	57.7	32.7	46.6	60.5	34.8	38.0	52.2	34.4	37.3	47.7
	III	43.1	24.7	37.5	46.3	40.0	39.2	50.8	34.2	40.9	51.8	31.7	35.0	28.6	42.0	35.5	44.1	28.0	33.3	36.6	27.0	37.5
November	I	33.2	19.1	34.7	36.1	31.3	29.3	29.7	26.3	29.5	35.5	25.9	32.5	20.7	27.4	26.9	25.8	22.3	29.7	29.0	21.9	28.3
	II	24.1	15.3	32.0	29.4	25.2	26.4	25.0	19.8	28.4	27.5	22.5	25.0	18.8	22.8	23.5	22.1	22.3	23.4	23.9	19.6	23.9
	III	19.8	12.9	25.4	24.8	20.0	27.0	21.1	17.9	20.6	25.6	20.4	21.1	16.7	20.6	19.2	20.4	20.2	19.0	20.5	17.3	20.5
December	I	16.9	11.9	19.6	22.4	17.7	25.5	20.8	16.8	18.5	20.3	17.6	16.8	14.4	17.8	15.6	16.5	18.6	18.2	18.0	15.4	18.0
	II	14.4	10.4	13.7	19.7	15.6	15.4	19.3	15.4	16.6	17.9	15.8	14.8	12.7	15.5	13.7	14.2	14.9	21.1	16.0	13.7	15.5
	III	13.4	9.1	11.9	17.8	14.3	13.2	17.1	10.9	15.3	15.5	13.5	11.3	12.0	13.3	12.3	12.4	13.4	19.2	14.7	12.2	13.6
January	I	12.4	9.7	10.7	16.9	12.8	13.5	14.1	11.1	14.0	14.3	12.3	11.1	10.9	11.9	11.3	11.2	12.6	14.9	12.9	11.2	12.5
	II	11.5	12.6	9.9	15.7	12.1	16.3	13.4	10.8	12.9	13.0	11.6	10.4	9.8	11.0	10.4	10.4	10.7	14.1	12.8	10.2	12.0
	III	10.6	14.0	10.1	15.7	11.9	19.3	11.7	10.3	11.9	12.2	10.8	10.2	9.6	10.9	9.7	9.4	10.4	13.6	12.6	9.1	11.7
February	I	10.1	15.4	9.8	15.4	12.0	19.1	9.9	10.2	11.9	12.3	10.2	10.6	9.7	10.3	9.9	9.0	10.2	13.0	11.0	8.6	11.4
	II	10.1	14.0	10.0	16.7	10.5	20.0	9.4	11.0	11.2	12.1	11.0	10.4	10.2	10.4	11.1	9.4	10.6	12.6	10.2	8.4	11.5
	III	10.5	15.6	9.5	20.6	9.9	21.3	8.8	9.7	12.3	12.4	11.5	9.8	10.8	12.6	11.0	14.2	13.1	13.1	11.4	8.9	12.4
March	I	13.2	21.9	9.7	17.6	13.4	21.2	13.9	13.9	14.3	14.3	13.7	10.0	12.3	14.1	16.7	12.8	13.8	14.4	16.9	15.5	14.7
	II	16.5	19.4	12.0	23.2	18.0	19.5	23.0	18.5	20.8	21.7	13.9	15.3	13.2	13.7	15.6	14.0	15.3	19.1	17.6	15.7	17.3
	III	16.5	28.3	15.7	29.0	37.5	20.1	34.1	32.6	21.3	25.5	16.9	17.6	17.7	28.1	18.2	16.6	31.5	25.3	15.2	30.7	23.9
April	I	31.7	27.7	14.5	39.3	33.8	24.6	40.2	24.5	28.2	20.5	21.4	22.5	25.9	19.9	27.1	22.5	41.6	26.6	28.9	33.2	27.7
	II	35.1	32.8	39.3	37.1	54.5	31.0	33.5	34.6	53.2	32.1	34.7	36.9	34.6	41.2	37.5	35.9	31.8	42.4	39.3	44.7	38.1
	III	38.1	39.4	51.8	38.1	44.0	35.5	41.5	48.9	57.7	40.1	46.3	28.2	48.8	32.8	65.4	27.8	44.3	56.9	42.3	47.8	43.8
May	I	45.3	54.5	48.8	58.7	47.9	53.8	69.0	79.7	65.6	55.3	51.6	36.4	46.9	31.1	40.9	45.2	39.9	53.6	37.4	47.4	50.4
	II	53.8	55.1	73.6	60.1	55.0	56.8	53.5	112.6	72.5	71.9	50.0	61.6	46.7	82.2	45.9	54.5	49.1	58.1	34.0	66.1	60.7
	III	52.9	85.4	68.2	59.3	49.9	59.6	74.9	71.7	88.3	77.0	77.1	51.3	51.5	64.0	66.6	93.5	57.4	61.1	130.3	53.9	69.7
Average Annual Flow (Cumecs)		**48.5**	**44.2**	**48.8**	**54.2**	**52.9**	**47.2**	**55.6**	**54.0**	**67.3**	**71.9**	**62.8**	**51.0**	**48.2**	**66.9**	**60.4**	**52.9**	**47.5**	**60.0**	**55.8**	**48.2**	**55**
Annual Yield (Mcum)		**1537**	**1406**	**1545**	**1714**	**1676**	**1495**	**1762**	**1714**	**2132**	**2276**	**1983**	**1617**	**1528**	**2115**	**1913**	**1680**	**1509**	**1913**	**1778**	**1531**	**1741**
Annual Runoff (mm)		**1372**	**1255**	**1380**	**1531**	**1497**	**1335**	**1573**	**1530**	**1903**	**2032**	**1771**	**1443**	**1365**	**1888**	**1708**	**1500**	**1347**	**1708**	**1588**	**1367**	**1555**

Table 3.21: 10-Daily Discharges Estimated at D-7 Dam Site (cumecs)

Year / Month	10-daily	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	Average
June	I	65.1	51.4	58.2	85.1	69.1	54.0	68.9	62.3	87.0	64.0	81.4	93.0	66.5	86.0	58.2	66.0	99.7	55.5	80.9	50.4	70.1
	II	76.1	76.8	86.5	79.4	89.3	62.7	80.2	74.7	159.2	57.0	131.2	77.3	85.7	99.7	92.1	71.8	80.9	87.4	135.2	40.8	87.2
	III	76.8	60.0	80.8	88.0	94.9	101.1	89.1	131.2	152.9	175.5	140.5	95.2	92.9	159.8	127.3	85.5	89.7	93.8	103.2	70.3	105.4
July	I	85.7	91.5	91.3	94.6	116.0	74.2	87.0	92.0	151.9	170.9	168.9	83.1	115.6	211.7	184.2	88.6	93.0	72.6	89.6	112.7	113.8
	II	82.8	82.4	88.6	120.0	104.6	74.1	91.9	64.9	147.9	261.7	153.0	116.4	100.7	208.3	170.6	133.6	96.5	113.4	124.2	79.8	120.8
	III	107.0	97.5	76.9	99.8	84.4	93.8	84.4	117.7	119.7	165.2	115.3	116.4	114.9	118.4	150.6	114.6	99.7	282.8	112.1	121.8	119.7
August	I	99.4	79.6	77.5	71.2	109.8	89.6	173.4	94.7	116.0	122.9	102.5	88.0	77.2	78.0	122.3	130.1	65.4	99.5	92.0	118.0	100.4
	II	126.6	82.0	85.6	89.8	99.8	78.3	122.4	95.8	158.8	159.8	160.5	92.0	158.2	110.4	100.2	155.1	57.3	145.2	121.8	116.8	115.8
	III	92.8	102.9	101.6	81.5	96.1	86.6	107.0	123.6	141.2	129.8	75.6	121.1	105.5	140.9	95.1	126.3	103.5	95.9	164.2	102.9	109.7
September	I	94.9	77.0	83.8	81.1	92.5	69.2	90.0	89.9	98.5	175.6	118.6	87.1	70.8	147.9	88.3	89.9	70.8	158.2	96.0	67.4	97.4
	II	72.5	51.0	86.3	79.0	81.4	74.3	69.0	93.8	88.3	101.1	140.3	81.2	60.6	172.9	53.4	49.1	95.4	80.2	66.1	78.4	83.7
	III	55.3	53.1	82.2	79.0	78.3	51.0	81.4	69.0	103.7	99.1	117.4	62.3	46.3	71.7	76.0	64.8	65.6	56.1	56.5	54.2	71.2
October	I	52.1	39.3	63.2	88.9	62.7	57.9	64.9	64.5	56.7	94.7	57.7	77.4	40.4	76.6	145.0	60.5	45.5	61.7	46.7	67.6	66.2
	II	40.9	27.1	44.1	66.2	49.2	50.2	63.3	38.8	54.1	46.1	40.6	53.7	30.5	43.4	56.3	32.4	35.4	48.6	32.0	34.8	44.4
	III	40.2	23.0	34.9	43.1	37.3	36.5	47.3	31.8	38.1	48.2	29.5	32.6	26.6	39.1	33.1	41.0	26.1	31.0	34.1	25.1	34.9
November	I	30.9	17.7	32.3	33.6	29.2	27.3	27.7	24.5	27.5	33.1	24.1	30.2	19.3	25.5	25.1	24.1	20.8	27.6	27.0	20.4	26.4
	II	22.5	14.3	29.8	27.4	23.5	24.5	23.3	18.4	26.4	25.6	20.9	23.3	17.5	21.2	21.9	20.6	20.8	21.8	22.3	18.2	22.2
	III	18.4	12.1	23.6	23.1	18.6	25.1	19.7	16.7	19.2	23.8	19.0	19.6	15.6	19.2	17.9	19.0	18.9	17.7	19.1	16.1	19.1
December	I	15.8	11.1	18.2	20.9	16.5	23.7	19.4	15.6	17.2	18.9	16.4	15.7	13.4	16.6	14.5	15.3	17.4	17.0	16.8	14.4	16.7
	II	13.4	9.7	12.7	18.3	14.6	14.4	18.0	14.3	15.4	16.6	14.7	13.7	11.9	14.4	12.8	13.2	13.9	19.6	14.9	12.7	14.5
	III	12.4	8.5	11.1	16.6	13.3	12.3	15.9	10.2	14.3	14.5	12.6	10.6	11.2	12.4	11.5	11.5	12.5	17.9	13.7	11.4	12.7
January	I	11.5	9.0	10.0	15.7	12.0	12.6	13.2	10.4	13.0	13.3	11.4	10.3	10.1	11.1	10.6	10.4	11.7	13.8	12.0	10.4	11.6
	II	10.7	11.7	9.2	14.7	11.2	15.2	12.5	10.1	12.0	12.2	10.8	9.7	9.2	10.3	9.7	9.7	10.0	13.2	11.9	9.5	11.2
	III	9.9	13.0	9.4	14.6	11.1	17.9	10.9	9.6	11.1	11.3	10.1	9.5	9.0	10.2	9.0	8.7	9.7	12.6	11.8	8.5	10.9
February	I	9.4	14.3	9.1	14.4	11.1	17.8	9.2	9.5	11.1	11.4	9.5	9.9	9.1	9.6	9.2	8.3	9.5	12.1	10.3	8.0	10.7
	II	9.4	13.0	9.3	15.5	9.8	18.7	8.7	10.3	10.4	11.3	10.2	9.7	9.5	9.7	10.3	8.8	9.9	11.7	9.5	7.9	10.7
	III	9.8	14.6	8.9	19.2	9.2	19.9	8.2	9.1	11.4	11.6	10.7	9.2	10.0	11.7	10.2	13.3	12.2	12.2	10.6	8.3	11.5
March	I	12.3	20.4	9.1	16.4	12.4	19.8	12.9	12.9	13.3	13.3	12.8	9.3	11.4	13.2	15.6	11.9	12.8	13.4	15.7	14.4	13.7
	II	15.4	18.0	11.2	21.6	16.7	18.2	21.4	17.2	19.4	20.2	13.0	14.3	12.3	12.8	14.5	13.1	14.2	17.7	16.4	14.7	16.1
	III	15.4	26.3	14.6	27.0	34.9	18.7	31.8	30.4	19.8	23.8	15.8	16.4	16.5	26.1	17.0	15.5	29.4	23.6	14.1	28.5	22.3
April	I	29.5	25.8	13.5	36.6	31.4	22.9	37.5	22.9	26.3	19.1	20.0	21.0	24.2	18.5	25.2	21.0	38.7	24.8	26.9	30.9	25.8
	II	32.7	30.6	36.6	34.5	50.8	28.9	31.2	32.2	49.6	29.9	32.3	34.3	32.3	38.4	34.9	33.4	29.7	39.5	36.6	41.6	35.5
	III	35.5	36.7	48.2	35.5	41.0	33.0	38.7	45.5	53.7	37.4	43.1	26.2	45.5	30.6	60.9	25.9	41.2	53.0	39.4	44.5	40.8
May	I	42.2	50.7	45.4	54.6	44.6	50.1	64.3	74.2	61.1	51.5	48.1	33.9	43.6	29.0	38.1	42.1	37.2	49.9	34.8	44.1	47.0
	II	50.1	51.3	68.5	56.0	51.2	52.9	49.8	104.9	67.5	67.0	46.6	57.4	43.5	76.5	42.7	50.8	45.7	54.1	31.6	61.5	56.5
	III	49.3	79.5	63.6	55.2	46.5	55.5	69.8	66.8	82.2	71.7	71.8	47.8	47.9	59.6	62.0	87.1	53.5	56.9	121.3	50.2	64.9
Average Annual Flow (Cumecs)		**45.1**	**41.2**	**45.4**	**50.5**	**49.3**	**44.0**	**51.8**	**50.3**	**62.7**	**66.9**	**58.5**	**47.5**	**44.9**	**62.3**	**56.3**	**49.3**	**44.3**	**55.9**	**52.0**	**44.9**	**51.1**
Annual Yield (Mcum)		**1431**	**1309**	**1439**	**1597**	**1561**	**1392**	**1641**	**1596**	**1985**	**2120**	**1847**	**1505**	**1423**	**1970**	**1782**	**1565**	**1405**	**1781**	**1656**	**1426**	**1621**
Annual Runoff (mm)		**1371**	**1254**	**1378**	**1529**	**1495**	**1333**	**1571**	**1529**	**1901**	**2030**	**1769**	**1442**	**1363**	**1887**	**1707**	**1499**	**1346**	**1706**	**1586**	**1366**	**1553**

Table 3.22: 10-Daily Discharges at Chapanang Chu Diversion Site (cumecs)

Month (Year)	10-daily	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	Average
June	I	2.5	2.0	2.3	3.3	2.7	2.1	2.7	2.4	3.4	2.5	3.2	3.6	2.6	3.3	2.3	2.6	3.9	2.2	3.1	2.0	2.7
	II	3.0	3.0	3.4	3.1	3.5	2.4	3.1	2.9	6.2	2.2	5.1	3.0	3.3	3.9	3.6	2.8	3.1	3.4	5.3	1.6	3.4
	III	3.0	2.3	3.1	3.4	3.7	3.9	3.5	5.1	5.9	6.8	5.5	3.7	3.6	6.2	5.0	3.3	3.5	3.6	4.0	2.7	4.1
July	I	3.3	3.6	3.6	3.7	4.5	2.9	3.4	3.6	5.9	6.6	6.6	3.2	4.5	8.2	7.2	3.4	3.6	2.8	3.5	4.4	4.4
	II	3.2	3.2	3.4	4.7	4.1	2.9	3.6	2.5	5.7	10.2	5.9	4.5	3.9	8.1	6.6	5.2	3.8	4.4	4.8	3.1	4.7
	III	4.2	3.8	3.0	3.9	3.3	3.6	3.3	4.6	4.7	6.4	4.5	4.5	4.5	4.6	5.9	4.5	3.9	11.0	4.4	4.7	4.7
August	I	3.9	3.1	3.0	2.8	4.3	3.5	6.7	3.7	4.5	4.8	4.0	3.4	3.0	3.0	4.8	5.1	2.5	3.9	3.6	4.6	3.9
	II	4.9	3.2	3.3	3.5	3.9	3.0	4.8	3.7	6.2	6.2	6.2	3.6	6.1	4.3	3.9	6.0	2.2	5.6	4.7	4.5	4.5
	III	3.6	4.0	3.9	3.2	3.7	3.4	4.2	4.8	5.5	5.0	2.9	4.7	4.1	5.5	3.7	4.9	4.0	3.7	6.4	4.0	4.3
September	I	3.7	3.0	3.3	3.2	3.6	2.7	3.5	3.5	3.8	6.8	4.6	3.4	2.8	5.7	3.4	3.5	2.8	6.1	3.7	2.6	3.8
	II	2.8	2.0	3.4	3.1	3.2	2.9	2.7	3.6	3.4	3.9	5.5	3.2	2.4	6.7	2.1	1.9	3.7	3.1	2.6	3.0	3.3
	III	2.1	2.1	3.2	3.1	3.0	2.0	3.2	2.7	4.0	3.9	4.6	2.4	1.8	2.8	3.0	2.5	2.6	2.2	2.2	2.1	2.8
October	I	2.0	1.5	2.5	3.5	2.4	2.2	2.5	2.5	2.2	3.7	2.2	3.0	1.6	3.0	5.6	2.4	1.8	2.4	1.8	2.6	2.6
	II	1.6	1.1	1.7	2.6	1.9	2.0	2.5	1.5	2.1	1.8	1.6	2.1	1.2	1.7	2.2	1.3	1.4	1.9	1.2	1.4	1.7
	III	1.6	0.9	1.4	1.7	1.4	1.4	1.8	1.2	1.5	1.9	1.1	1.3	1.0	1.5	1.3	1.6	1.0	1.2	1.3	1.0	1.4
November	I	1.2	0.7	1.3	1.3	1.1	1.1	1.1	1.0	1.1	1.3	0.9	1.2	0.7	1.0	1.0	0.9	0.8	1.1	1.1	0.8	1.0
	II	0.9	0.6	1.2	1.1	0.9	1.0	0.9	0.7	1.0	1.0	0.8	0.9	0.7	0.8	0.9	0.8	0.8	0.8	0.9	0.7	0.9
	III	0.7	0.5	0.9	0.9	0.7	1.0	0.8	0.6	0.7	0.9	0.7	0.8	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.7
December	I	0.6	0.4	0.7	0.8	0.6	0.9	0.8	0.6	0.7	0.7	0.6	0.6	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.6	0.7
	II	0.5	0.4	0.5	0.7	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.6	0.5	0.5	0.5	0.8	0.6	0.5	0.6
	III	0.5	0.3	0.4	0.6	0.5	0.5	0.6	0.4	0.6	0.6	0.5	0.4	0.4	0.5	0.4	0.4	0.5	0.7	0.5	0.4	0.5
January	I	0.4	0.4	0.4	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.5
	II	0.4	0.5	0.4	0.6	0.4	0.6	0.5	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.4
	III	0.4	0.5	0.4	0.6	0.4	0.7	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.3	0.4	0.5	0.5	0.3	0.4
February	I	0.4	0.6	0.4	0.6	0.4	0.7	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.5	0.4	0.3	0.4
	II	0.4	0.5	0.4	0.6	0.4	0.7	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.5	0.4	0.3	0.4
	III	0.4	0.6	0.3	0.7	0.4	0.8	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.4	0.3	0.4
March	I	0.5	0.8	0.4	0.6	0.5	0.8	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.6	0.5	0.5	0.5	0.6	0.6	0.5
	II	0.6	0.7	0.4	0.8	0.7	0.7	0.8	0.7	0.8	0.8	0.5	0.6	0.5	0.5	0.6	0.5	0.6	0.7	0.6	0.6	0.6
	III	0.6	1.0	0.6	1.1	1.4	0.7	1.2	1.2	0.8	0.9	0.6	0.6	0.6	1.0	0.7	0.6	1.1	0.9	0.5	1.1	0.9
April	I	1.1	1.0	0.5	1.4	1.2	0.9	1.5	0.9	1.0	0.7	0.8	0.8	0.9	0.7	1.0	0.8	1.5	1.0	1.0	1.2	1.0
	II	1.3	1.2	1.4	1.3	2.0	1.1	1.2	1.3	1.9	1.2	1.3	1.3	1.3	1.5	1.4	1.3	1.2	1.5	1.4	1.6	1.4
	III	1.4	1.4	1.9	1.4	1.6	1.3	1.5	1.8	2.1	1.5	1.7	1.0	1.8	1.2	2.4	1.0	1.6	2.1	1.5	1.7	1.6
May	I	1.6	2.0	1.8	2.1	1.7	1.9	2.5	2.9	2.4	2.0	1.9	1.3	1.7	1.1	1.5	1.6	1.4	1.9	1.4	1.7	1.8
	II	1.9	2.0	2.7	2.2	2.0	2.1	1.9	4.1	2.6	2.6	1.8	2.2	1.7	3.0	1.7	2.0	1.8	2.1	1.2	2.4	2.2
	III	1.9	3.1	2.5	2.1	1.8	2.2	2.7	2.6	3.2	2.8	2.8	1.9	1.9	2.3	2.4	3.4	2.1	2.2	4.7	2.0	2.5
Average Annual Flow (Cumecs)		**1.8**	**1.6**	**1.8**	**2.0**	**1.9**	**1.7**	**2.0**	**2.0**	**2.4**	**2.6**	**2.3**	**1.8**	**1.7**	**2.4**	**2.2**	**1.9**	**1.7**	**2.2**	**2.0**	**1.7**	**2.0**
Annual Yield (Mcum)		**55.6**	**50.9**	**55.9**	**62.1**	**60.7**	**54.1**	**63.8**	**62.0**	**77.2**	**82.4**	**71.8**	**58.5**	**55.3**	**76.6**	**69.3**	**60.8**	**54.6**	**69.2**	**64.4**	**55.4**	**63.0**
Annual Runoff (mm)		**1391**	**1272**	**1398**	**1551**	**1517**	**1353**	**1594**	**1551**	**1929**	**2060**	**1795**	**1463**	**1383**	**1914**	**1731**	**1521**	**1365**	**1731**	**1609**	**1386**	**1576**

Table 3.22(a): Combined 10-Daily Discharges at D-7 Plus Chapanang Chu Diversion (cumecs)

Month (Year)	10-daily	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	Average
June	I	67.6	53.4	60.5	88.4	71.8	56.1	71.6	64.7	90.3	66.5	84.6	96.6	69.1	89.4	60.5	68.6	103.6	57.6	84.1	52.4	72.9
	II	79.0	79.8	89.9	82.4	92.8	65.1	83.3	77.6	165.4	59.3	136.3	80.3	89.0	103.6	95.6	74.6	84.0	90.8	140.5	42.4	90.6
	III	79.8	62.3	84.0	91.4	98.6	105.1	92.6	136.3	158.8	182.3	146.0	98.9	96.5	166.1	132.3	88.9	93.2	97.5	107.2	73.0	109.5
July	I	89.0	95.1	94.9	98.3	120.5	77.1	90.4	95.5	157.8	177.5	175.5	86.3	120.1	219.9	191.3	92.0	96.6	75.4	93.1	117.0	118.2
	II	86.0	85.6	92.0	124.6	108.7	77.0	95.4	67.5	153.6	271.9	159.0	120.9	104.6	216.4	177.3	138.8	100.2	117.8	129.0	82.9	125.5
	III	111.1	101.3	79.9	103.7	87.7	97.5	87.7	122.2	124.4	171.6	119.8	121.0	119.3	123.0	156.4	119.1	103.5	293.8	116.4	126.6	124.3
August	I	103.2	82.7	80.5	73.9	114.0	93.1	180.1	98.3	120.5	127.7	106.5	91.4	80.2	81.1	127.0	135.2	68.0	103.3	95.6	122.6	104.3
	II	131.5	85.2	89.0	93.3	103.7	81.3	127.2	99.6	165.0	166.0	166.7	95.6	164.3	114.7	104.1	161.1	59.6	150.8	126.5	121.3	120.3
	III	96.4	106.9	105.5	84.7	99.9	89.9	111.1	128.4	146.7	134.8	78.5	125.9	109.6	146.3	98.8	131.2	107.5	99.6	170.6	106.9	114.0
September	I	98.6	80.0	87.1	84.2	96.1	71.9	93.5	93.4	102.3	182.4	123.2	90.4	73.6	153.6	91.7	93.4	73.5	164.4	99.8	70.1	101.2
	II	75.3	53.0	89.7	82.0	84.6	77.2	71.7	97.4	91.7	105.0	145.7	84.3	62.9	179.6	55.5	51.0	99.1	83.3	68.7	81.5	87.0
	III	57.4	55.1	85.4	82.1	81.4	53.0	84.5	71.6	107.8	103.0	122.0	64.7	48.1	74.4	79.0	67.4	68.2	58.2	58.7	56.4	73.9
October	I	54.2	40.9	65.7	92.3	65.1	60.1	67.4	67.0	58.9	98.4	59.9	80.4	41.9	79.6	150.6	62.8	47.2	64.1	48.5	70.2	68.8
	II	42.5	28.1	45.8	68.8	51.1	52.2	65.7	40.3	56.2	47.9	42.1	55.8	31.7	45.0	58.5	33.7	36.8	50.5	33.3	36.1	46.1
	III	41.7	23.9	36.2	44.8	38.7	38.0	49.1	33.1	39.5	50.1	30.7	33.9	27.6	40.6	34.3	42.6	27.1	32.2	35.4	26.1	36.3
November	I	32.2	18.4	33.6	34.9	30.3	28.4	28.7	25.5	28.6	34.4	25.1	31.4	20.0	26.5	26.0	25.0	21.6	28.7	28.1	21.2	27.4
	II	23.3	14.8	31.0	28.5	24.4	25.5	24.2	19.1	27.5	26.6	21.7	24.2	18.2	22.1	22.8	21.4	21.6	22.6	23.1	18.9	23.1
	III	19.2	12.5	24.5	24.0	19.3	26.1	20.4	17.4	19.9	24.8	19.7	20.4	16.2	19.9	18.5	19.7	19.6	18.4	19.8	16.8	19.9
December	I	16.4	11.5	18.9	21.7	17.1	24.7	20.1	16.2	17.9	19.6	17.0	16.3	14.0	17.2	15.1	15.9	18.0	17.7	17.4	14.9	17.4
	II	14.0	10.0	13.2	19.0	15.1	14.9	18.7	14.9	16.0	17.3	15.3	14.3	12.3	15.0	13.3	13.7	14.4	20.4	15.5	13.2	15.0
	III	12.9	8.8	11.5	17.3	13.8	12.8	16.5	10.6	14.8	15.0	13.0	11.0	11.6	12.9	11.9	12.0	12.9	18.5	14.3	11.8	13.2
January	I	12.0	9.4	10.4	16.4	12.4	13.1	13.7	10.8	13.5	13.8	11.9	10.7	10.5	11.5	11.0	10.8	12.2	14.4	12.4	10.8	12.1
	II	11.1	12.2	9.6	15.2	11.7	15.7	13.0	10.4	12.5	12.6	11.2	10.1	9.5	10.7	10.1	10.1	10.3	13.7	12.4	9.8	11.6
	III	10.3	13.5	9.8	15.2	11.5	18.6	11.3	9.9	11.5	11.8	10.4	9.9	9.3	10.6	9.4	9.1	10.1	13.1	12.2	8.8	11.3
February	I	9.8	14.9	9.5	14.9	11.6	18.5	9.6	9.9	11.5	11.9	9.9	10.2	9.4	9.9	9.6	8.7	9.9	12.6	10.7	8.3	11.1
	II	9.8	13.5	9.7	16.1	10.1	19.4	9.1	10.7	10.8	11.7	10.6	10.1	9.9	10.1	10.7	9.1	10.3	12.2	9.8	8.2	11.1
	III	10.2	15.1	9.2	19.9	9.6	20.6	8.5	9.4	11.9	12.0	11.1	9.5	10.4	12.1	10.6	13.8	12.7	12.7	11.0	8.6	12.0
March	I	12.8	21.2	9.4	17.1	12.9	20.5	13.4	13.4	13.8	13.8	13.3	9.7	11.9	13.7	16.2	12.4	13.3	14.0	16.3	15.0	14.2
	II	16.0	18.7	11.6	22.4	17.4	18.9	22.3	17.9	20.1	21.0	13.5	14.8	12.8	13.3	15.1	13.6	14.8	18.4	17.1	15.2	16.7
	III	16.0	27.4	15.2	28.1	36.3	19.4	33.0	31.6	20.6	24.7	16.4	17.0	17.1	27.2	17.6	16.1	30.5	24.5	14.7	29.7	23.1
April	I	30.6	26.8	14.1	38.0	32.7	23.8	38.9	23.7	27.3	19.8	20.7	21.8	25.1	19.2	26.2	21.8	40.2	25.8	28.0	32.1	26.8
	II	33.9	31.8	38.0	35.9	52.8	30.0	32.4	33.4	51.5	31.0	33.6	35.7	33.5	39.9	36.3	34.7	30.8	41.0	38.0	43.2	36.9
	III	36.9	38.1	50.1	36.9	42.6	34.3	40.2	47.3	55.8	38.8	44.8	27.2	47.2	31.8	63.3	26.9	42.8	55.1	40.9	46.2	42.3
May	I	43.8	52.7	47.2	56.8	46.3	52.0	66.8	77.1	63.4	53.5	49.9	35.2	45.3	30.1	39.6	43.8	38.6	51.9	36.1	45.8	48.8
	II	52.0	53.3	71.2	58.1	53.2	54.9	51.7	109.0	70.1	69.6	48.4	59.6	45.2	79.5	44.4	52.7	47.5	56.2	32.9	63.9	58.7
	III	51.2	82.6	66.0	57.3	48.3	57.6	72.5	69.4	85.4	74.5	74.6	49.6	49.8	61.9	64.4	90.5	55.5	59.1	126.1	52.1	67.4
Average Annual Flow (Cumecs)		**46.9**	**42.8**	**47.2**	**52.5**	**51.2**	**45.7**	**53.8**	**52.2**	**65.1**	**69.5**	**60.8**	**49.3**	**46.6**	**64.7**	**58.5**	**51.2**	**46.0**	**58.1**	**54.0**	**46.7**	**53.1**
Annual Yield (Mcum)		**1487**	**1360**	**1495**	**1659**	**1622**	**1446**	**1704**	**1658**	**2062**	**2202**	**1919**	**1564**	**1478**	**2047**	**1851**	**1626**	**1459**	**1852**	**1720**	**1481**	**1684**
Annual Runoff (mm)		**1371**	**1255**	**1379**	**1530**	**1496**	**1334**	**1572**	**1530**	**1902**	**2031**	**1770**	**1443**	**1363**	**1889**	**1707**	**1500**	**1346**	**1708**	**1587**	**1367**	**1554**

Table 4.9 (a): Estimation of Rainfall Excess

1 day PMP	469	mm	
24 hr PMP	469	mm	
say	46.9	Cm	
1St Bell	76%	35.64	cm
2nd Bell	24 %	11.26	cm
2day PMP	258	mm	
48 hr PMP	258	mm	
say	25.8	Cm	
3rd Bell	76%	19.61	cm
4thBell	24 %	6.19	cm

Total area	1044	Sq km
Rainfed area	1029	Sq km
Snow fed area	15	Sq km

Estimation of Rainfall excess (cm)

1 st bell

Time	Percentage of 12 hr Rainfall	Cummulative Rainfall	Incremental Rainfall	Effective Rainfall	Critical	Reverse Critical
0	0	0.00	**0.00**			
1	0.16	5.63	5.63	5.39	1.17	1.17
2	0.30	10.79	5.16	4.92	2.57	1.17
3	0.45	15.95	5.16	4.92	4.92	1.17
4	0.57	20.17	4.22	3.98	5.39	1.64
5	0.64	22.98	2.81	2.57	4.92	2.11
6	0.72	25.80	2.81	2.57	3.98	2.57
7	0.79	28.14	2.35	2.11	2.57	3.98
8	0.84	30.02	1.88	1.64	2.11	4.92
9	0.88	31.42	1.41	1.17	1.64	5.39
10	0.92	32.83	1.41	1.17	1.17	4.92
11	0.96	34.24	1.41	1.17	1.17	2.57
12	1.00	35.64	1.41	1.17	1.17	1.17
			35.64	**32.76**		

2 nd bell

Time	Percentage of 12 hr Rainfall	Cummulative Rainfall	Incremental Rainfall	Effective Rainfall	Critical
0	**0**	0.00	**0.00**		
1	0.16	1.78	1.78	1.54	0.2
2	0.30	3.41	1.63	1.39	0.65
3	0.45	5.04	1.63	1.39	1.39
4	0.57	6.37	1.33	1.09	1.54
5	0.64	7.26	0.89	0.65	1.39
6	0.72	8.15	0.89	0.65	1.09
7	0.79	8.89	0.74	0.50	0.65
8	0.84	9.48	0.59	0.35	0.5
9	0.88	9.92	0.44	0.20	0.35
10	0.92	10.37	0.44	0.20	0.2
11	0.96	10.81	0.44	0.20	0.2
12	1.00	11.26	0.44	0.20	0.2
			11.26	**8.38**	

3rd bell

Time	Percentage of 12 hr Rainfall	Cummulative Rainfall	Incremental Rainfall	Effective Rainfall	Critical	Reverse Critical
0	0	0.00	**0.00**			
1	0.16	3.10	3.10	2.86	0.53	0.53
2	0.30	5.93	2.84	2.60	1.31	0.53
3	0.45	8.77	2.84	2.60	2.6	0.53
4	0.57	11.09	2.32	2.08	2.86	0.79
5	0.64	12.64	1.55	1.31	2.6	1.05
6	0.72	14.19	1.55	1.31	2.08	1.31
7	0.79	15.48	1.29	1.05	1.31	2.08
8	0.84	16.51	1.03	0.79	1.05	2.60
9	0.88	17.29	0.77	0.53	0.79	2.86
10	0.92	18.06	0.77	0.53	0.53	2.60
11	0.96	18.83	0.77	0.53	0.53	1.31
12	1.00	19.61	0.77	0.53	0.53	0.53
			19.61	**16.73**		

4 th bell

Time	Percentage of 12 hr Rainfall	Cummulative Rainfall	Incremental Rainfall	Effective Rainfall	Critical
0	**0**	0.00	**0.00**		
1	0.16	0.98	0.98	0.74	0.004
2	0.30	1.87	0.90	0.66	0.250
3	0.45	2.77	0.90	0.66	0.660
4	0.57	3.50	0.73	0.49	0.740
5	0.64	3.99	0.49	0.25	0.660
6	0.72	4.48	0.49	0.25	0.490
7	0.79	4.89	0.41	0.17	0.250
8	0.84	5.21	0.33	0.09	0.170
9	0.88	5.46	0.24	0.004	0.090
10	0.92	5.70	0.24	0.004	0.004
11	0.96	5.95	0.24	0.004	0.004
12	1.00	6.19	0.24	0.004	0.004
			6.19	**3.31**	

Table 4.9 (b): Convolution of U.G with Rainfall Excess (Clark's Method)

Time	U.G	0.20	0.20	0.20	0.35	0.50	0.65	1.09	1.39	1.54	1.39	0.65	0.20	1.17	1.17	1.17	1.64	2.11	2.57	3.98	4.92	5.39	4.92	2.57	1.17	0.00	0.00	0.00	0.09	0.17	0.25	0.49	0.66	0.74	0.66	0.25	0.00	0.53	0.53	0.53	0.79	1.05	1.31	2.08	2.60	2.86	2.60	1.31	0.53	D.S.R.O	Base Flow	Time (Hrs)	Flood Hydrograph Ordinates (Cumecs)
0	0	0.0																																																0	51	0	51
1	12	2.4	0.0																																															2	51	1	54
2	54	10.7	2.4	0.0																																														13	51	2	65
3	123	24.6	10.7	2.4	0.0																																													38	51	3	89
4	192	38.4	24.6	10.7	4.3	0.0																																												78	51	4	129
5	250	49.9	38.4	24.6	18.7	6.1	0.0																																											138	51	5	189
6	262	52.5	49.9	38.4	43.1	26.8	7.9	0.0																																										219	51	6	270
7	231	46.3	52.5	49.9	67.2	61.6	34.8	13.3	0.0																																									326	51	7	377
8	204	40.8	46.3	52.5	87.4	96.0	80.1	58.4	16.9	0.0																																								478	51	8	530
9	180	36.0	40.8	46.3	91.8	124.8	124.9	134.2	74.5	18.7	0.0																																							692	51	9	744
10	159	31.8	36.0	40.8	81.0	131.2	162.3	209.4	171.2	82.5	16.9	0.0																																						963	51	10	1015
11	140	28.1	31.8	36.0	71.5	115.7	170.5	272.1	267.0	189.7	74.5	7.9	0.0																																					1265	51	11	1316
12	124	24.8	28.1	31.8	63.1	102.1	150.4	285.9	347.1	295.8	171.2	34.8	2.4	0.0																																				1537	51	12	1589
13	109	21.8	24.8	28.1	55.7	90.1	132.7	252.3	364.6	384.5	267.0	80.1	10.7	14.2	0.0																																			1727	51	13	1778
14	96	19.3	21.8	24.8	49.1	79.5	117.1	222.6	321.7	403.9	347.1	124.9	24.6	62.7	14.2	0.0																																		1833	51	14	1885
15	85	17.0	19.3	21.8	43.3	70.2	103.4	196.4	283.9	356.4	364.6	162.3	38.4	144.1	62.7	14.2	0.0																																	1898	51	15	1949
16	75	15.0	17.0	19.3	38.2	61.9	91.2	173.3	250.5	314.5	321.7	170.5	49.9	224.7	144.1	62.7	20.0	0.0																																1975	51	16	2026
17	66	13.2	15.0	17.0	33.7	54.6	80.5	152.9	221.0	277.5	283.9	150.4	52.5	292.1	224.7	144.1	87.9	25.7	0.0																															2127	51	17	2178
18	58	11.7	13.2	15.0	29.8	48.2	71.0	134.9	195.0	244.9	250.5	132.7	46.3	306.9	292.1	224.7	202.0	113.0	31.3	0.0																														2363	51	18	2415
19	52	10.3	11.7	13.2	26.3	42.5	62.7	119.1	172.1	216.1	221.0	117.1	40.8	270.8	306.9	292.1	315.0	259.9	137.7	48.4	0.0																													2684	51	19	2735
20	45	9.1	10.3	11.7	23.2	37.5	55.3	105.1	151.8	190.6	195.0	103.4	36.0	238.9	270.8	306.9	409.5	405.3	316.5	213.2	59.9	0.0																												3150	51	20	3201
21	40	8.0	9.1	10.3	20.4	33.1	48.8	92.7	134.0	168.2	172.1	91.2	31.8	210.8	238.9	270.8	430.2	526.8	493.7	490.2	263.6	65.6	0.0																											3810	51	21	3862
22	35	7.1	8.0	9.1	18.0	29.2	43.0	81.8	118.2	148.4	151.8	80.5	28.1	186.0	210.8	238.9	379.6	553.5	641.7	764.5	605.9	288.7	59.9	0.0																										4653	51	22	4704
23	31	6.3	7.1	8.0	15.9	25.8	38.0	72.2	104.3	131.0	134.0	71.0	24.8	164.2	186.0	210.8	334.9	488.4	674.1	993.7	945.1	663.8	263.6	31.3	0.0																									5594	51	23	5646
24	28	5.5	6.3	7.1	14.0	22.7	33.5	63.7	92.0	115.6	118.2	62.7	21.8	144.8	164.2	186.0	295.5	430.9	594.8	1044.0	1228.4	1035.4	605.9	137.7	14.2	0.0																								6445	51	24	6497
25	24	4.9	5.5	6.3	12.4	20.1	29.6	56.2	81.2	102.0	104.3	55.3	19.3	127.8	144.8	164.2	260.8	380.2	524.9	921.2	1290.5	1345.8	945.1	316.5	62.7	0.1	0.0																							6981	51	25	7033
26	21	4.3	4.9	5.5	10.9	17.7	26.1	49.6	71.7	90.0	92.0	48.8	17.0	112.8	127.8	144.8	230.1	335.5	463.1	812.8	1138.7	1413.8	1228.4	493.7	144.1	0.2	0.1	0.0																						7084	51	26	7136
27	19	3.8	4.3	4.9	9.7	15.6	23.0	43.8	63.2	79.4	81.2	43.0	15.0	99.5	112.8	127.8	203.0	296.0	408.6	717.2	1004.8	1247.5	1290.5	641.7	224.7	0.5	0.2	0.1	0.0																					6762	51	27	6813
28	17	3.3	3.8	4.3	8.5	13.8	20.3	38.6	55.8	70.1	71.7	38.0	13.2	87.8	99.5	112.8	179.1	261.2	360.6	632.8	886.6	1100.8	1138.7	674.1	292.1	0.8	0.5	0.2	1.1	0.0																				6170	51	28	6222
29	15	2.9	3.3	3.8	7.5	12.2	17.9	34.1	49.2	61.8	63.2	33.5	11.7	77.5	87.8	99.5	158.1	230.5	318.2	558.4	782.3	971.3	1004.8	594.8	306.9	1.1	0.8	0.5	4.8	2.1	0.0																			5501	51	29	5552
30	13	2.6	2.9	3.3	6.6	10.7	15.8	30.1	43.4	54.5	55.8	29.6	10.3	68.4	77.5	87.8	139.5	203.4	280.7	492.7	690.3	857.0	886.6	524.9	270.8	1.2	1.1	0.8	11.1	9.1	3.0	0.0																		4672	51	30	4923
31	11	2.3	2.6	2.9	5.9	9.5	14.0	26.5	38.3	48.1	49.2	26.1	9.1	60.3	68.4	77.5	123.1	179.5	247.7	434.8	609.1	756.2	782.3	463.1	238.9	1.0	1.2	1.1	17.3	20.9	13.4	6.0	0.0																	4336	51	31	4388
32	10	2.0	2.3	2.6	5.2	8.4	12.3	23.4	33.8	42.5	43.4	23.0	8.0	53.2	60.3	68.4	108.6	158.3	218.6	383.6	537.4	667.3	690.3	408.6	210.8	0.9	1.0	1.2	22.5	32.7	30.8	26.2	8.0	0.0																3896	51	32	3947
33	9	1.8	2.0	2.3	4.6	7.4	10.9	20.6	29.8	37.5	38.3	20.3	7.1	47.0	53.2	60.3	95.8	139.7	192.9	338.5	474.2	588.8	609.1	360.6	186.0	0.8	0.9	1.0	23.6	42.4	48.0	60.3	35.4	9.0	0.0															3550	51	33	3602
34	8	1.6	1.8	2.0	4.0	6.5	9.6	18.2	26.3	33.1	33.8	17.9	6.3	41.4	47.0	53.2	84.6	123.3	170.2	298.7	418.4	519.5	537.4	318.2	164.2	0.7	0.8	0.9	20.8	44.6	62.4	94.1	81.3	39.6	8.0	0.0														3290	51	34	3342
35	7	1.4	1.6	1.8	3.5	5.7	8.5	16.1	23.2	29.2	29.8	15.8	5.5	36.6	41.4	47.0	74.6	108.8	150.2	263.5	369.2	458.4	474.2	280.7	144.8	0.6	0.7	0.8	18.4	39.3	65.6	122.3	126.8	91.1	35.4	3.0	0.0													3096	51	35	3147
36	6	1.2	1.4	1.6	3.1	5.1	7.5	14.2	20.5	25.7	26.3	14.0	4.9	32.3	36.6	41.4	65.8	96.0	132.5	232.5	325.8	404.5	418.4	247.7	127.8	0.5	0.6	0.7	16.2	34.7	57.9	128.5	164.8	142.1	81.3	13.4	0.1	0.0												2928	51	36	2979
37	5	1.1	1.2	1.4	2.8	4.5	6.6	12.5	18.1	22.7	23.2	12.3	4.3	28.5	32.3	36.6	58.1	84.7	116.9	205.2	287.5	356.9	369.2	218.6	112.8	0.5	0.5	0.6	14.3	30.6	51.1	113.4	173.1	184.8	126.8	30.8	0.2	6.4	0.0											2751	51	37	2802
38	5	1.0	1.1	1.2	2.4	3.9	5.8	11.0	16.0	20.0	20.5	10.9	3.8	25.1	28.5	32.3	51.3	74.7	103.2	181.1	253.7	314.9	325.8	192.9	99.5	0.4	0.5	0.5	12.6	27.0	45.1	100.1	152.8	194.1	164.8	48.0	0.5	28.4	6.4	0.0										2562	51	38	2613
39	4	0.8	1.0	1.1	2.1	3.5	5.1	9.7	14.1	17.7	18.1	9.6	3.3	22.2	25.1	28.5	45.2	65.9	91.0	159.8	223.8	277.9	287.5	170.2	87.8	0.4	0.4	0.5	11.1	23.9	39.8	88.3	134.8	171.3	173.1	62.4	0.8	65.3	28.4	6.4	0.0									2378	51	39	2429
40	4	0.7	0.8	1.0	1.9	3.1	4.5	8.6	12.4	15.6	16.0	8.5	2.9	19.6	22.2	25.1	39.9	58.2	80.3	141.0	197.5	245.2	253.7	150.2	77.5	0.3	0.4	0.4	9.8	21.0	35.1	77.9	118.9	151.1	152.8	65.6	1.1	101.8	65.3	28.4	9.6	0.0								2226	51	40	2277
41	3	0.7	0.7	0.8	1.7	2.7	4.0	7.6	11.0	13.8	14.1	7.5	2.6	17.3	19.6	22.2	35.2	51.3	70.9	124.4	174.3	216.4	223.8	132.5	68.4	0.3	0.3	0.4	8.7	18.6	30.9	68.7	104.9	133.3	134.8	57.9	1.2	132.3	101.8	65.3	42.3	12.8	0.0							2138	51	41	2189
42	3	0.6	0.7	0.7	1.5	2.4	3.5	6.7	9.7	12.1	12.4	6.6	2.3	15.2	17.3	19.6	31.1	45.3	62.5	109.8	153.8	190.9	197.5	116.9	60.3	0.3	0.3	0.3	7.7	16.4	27.3	60.7	92.6	117.7	118.9	51.1	1.0	139.0	132.3	101.8	97.3	56.2	15.9	0.0						2116	51	42	2168
43	3	0.5	0.6	0.7	1.3	2.1	3.1	5.9	8.5	10.7	11.0	5.8	2.0	13.4	15.2	17.3	27.4	40.0	55.2	96.8	135.7	168.4	174.3	103.2	53.2	0.2	0.3	0.3	6.8	14.5	24.1	53.5	81.7	103.8	104.9	45.1	0.9	122.7	139.0	132.3	151.8	129.3	70.2	25.3	0.0					2159	51	43	2210
44	2	0.5	0.5	0.6	1.1	1.9	2.7	5.2	7.5	9.5	9.7	5.1	1.8	11.9	13.4	15.2	24.2	35.3	48.7	85.5	119.7	148.6	153.8	91.0	47.0	0.2	0.2	0.3	6.0	12.8	21.3	47.2	72.1	91.6	92.6	39.8	0.8	108.2	122.7	139.0	197.2	201.7	161.3	111.4	31.6	0.0				2298	51	44	2350
45	2	0.4	0.5	0.5	1.0	1.6	2.4	4.6	6.6	8.3	8.5	4.5	1.6	10.5	11.9	13.4	21.3	31.1	43.0	75.4	105.6	131.2	135.7	80.3	41.4	0.2	0.2	0.2	5.3	11.3	18.8	41.7	63.6	80.8	81.7	35.1	0.7	95.5	108.2	122.7	207.2	262.2	251.6	256.2	139.3	34.8	0.0			2559	51	45	2610
46	2	0.4	0.4	0.5	0.9	1.4	2.1	4.1	5.9	7.4	7.5	4.0	1.4	9.2	10.5	11.9	18.8	27.5	37.9	66.5	93.2	115.7	119.7	70.9	36.6	0.2	0.2	0.2	4.6	9.9	16.6	36.8	56.1	71.3	72.1	30.9	0.6	84.3	95.5	108.2	182.8	275.4	327.1	399.5	320.2	153.2	31.6	0.0		2932	51	46	2983
47	2	0.3	0.4	0.4	0.8	1.3	1.9	3.6	5.2	6.5	6.6	3.5	1.2	8.1	9.2	10.5	16.6	24.2	33.4	58.7	82.2	102.1	105.6	62.5	32.3	0.1	0.2	0.2	4.1	8.8	14.6	32.4	49.5	62.9	63.6	27.3	0.5	74.4	84.3	95.5	161.3	243.0	343.6	519.3	499.4	352.2	139.3	15.9	0.0	3370	51	47	3421
48	1	0.3	0.3	0.4	0.7	1.1	1.7	3.2	4.6	5.7	5.9	3.1	1.1	7.2	8.1	9.2	14.7	21.4	29.5	51.8	72.6	90.1	93.2	55.2	28.5	0.1	0.1	0.2	3.6	7.7	12.9	28.6	43.7	55.5	56.1	24.1	0.5	65.6	74.4	84.3	142.4	214.4	303.2	545.6	649.2	549.4	320.2	70.2	6.4	3768	51	48	3819
			0.3	0.3	0.6	1.0	1.5	2.8	4.0	5.1	5.2	2.7	1.0	6.3	7.2	8.1	12.9	18.9	26.0	45.7	64.0	79.5	82.2	48.7	25.1	0.1	0.1	0.1	3.2	6.8	11.4	25.3	38.6	49.0	49.5	21.3	0.4	57.9	65.6	74.4	125.6	189.2	267.5	481.4	682.0	714.1	499.4	161.3	28.4	4002	51	49	4053
				0.3	0.5	0.9	1.3	2.5	3.6	4.5	4.6	2.4	0.8	5.6	6.3	7.2	11.4	16.6	23.0	40.3	56.5	70.2	72.6	43.0	22.2	0.1	0.1	0.1	2.8	6.0	10.0	22.3	34.0	43.2	43.7	18.8	0.4	51.1	57.9	65.6	110.8	167.0	236.1	424.8	601.8	750.2	649.2	251.6	65.3	4009	51	50	4060
					0.5	0.8	1.1	2.2	3.1	3.9	4.0	2.1	0.7	4.9	5.6	6.3	10.1	14.7	20.3	35.6	49.9	61.9	64.0	37.9	19.6	0.1	0.1	0.1	2.5	5.3	8.9	19.7	30.0	38.2	38.6	16.6	0.3	45.1	51.1	57.9	97.8	147.3	208.3	374.8	531.0	661.9	682.0	327.1	101.8	3796	51	51	3847
						0.7	1.0	1.9	2.8	3.5	3.6	1.9	0.7	4.4	4.9	5.6	8.9	13.0	17.9	31.4	44.0	54.6	56.5	33.4	17.3	0.1	0.1	0.1	2.2	4.7	7.8	17.4	26.5	33.7	34.0	14.6	0.3	39.8	45.1	51.1	86.3	130.0	183.8	330.7	468.5	584.1	601.8	343.6	132.3	3446	51	52	3498
							0.9	1.7	2.4	3.1	3.1	1.7	0.6	3.8	4.4	4.9	7.8	11.4	15.8	27.7	38.8	48.2	49.9	29.5	15.2	0.1	0.1	0.1	1.9	4.1	6.9	15.3	23.4	29.7	30.0	12.9	0.3	35.1	39.8	45.1	76.1	114.7	162.2	291.8	413.4	515.4	531.0	303.2	139.0	3063	51	53	3114
								1.5	2.2	2.7	2.8	1.5	0.5	3.4	3.8	4.4	6.9	10.1	13.9	24.4	34.3	42.5	44.0	26.0	13.4	0.1	0.1	0.1	1.7	3.6	6.1	13.5	20.6	26.2	26.5	11.4	0.2	31.0	35.1	39.8	67.2	101.2	143.1	257.5	364.8	454.8	468.5	267.5	122.7	2701	51	54	2753
									1.9	2.4	2.4	1.3	0.5	3.0	3.4	3.8	6.1	8.9	12.3	21.6	30.2	37.5	38.8	23.0	11.9	0.1	0.1	0.1	1.5	3.2	5.4	11.9	18.2	23.1	23.4	10.0	0.2	27.3	31.0	35.1	59.3	89.3	126.3	227.2	321.9	401.3	413.4	236.1	108.2	2382	51	55	2434
										2.1	2.2	1.1	0.4	2.6	3.0	3.4	5.4	7.9	10.8	19.0	26.7	33.1	34.3	20.3	10.5	0.0	0.1	0.1	1.3	2.8	4.7	10.5	16.1	20.4	20.6	8.9	0.2	24.1	27.3	31.0	52.3	78.8	111.4	200.5	284.0	354.1	364.8	208.3	95.5	2100	51	56	2152
											1.9	1.0	0.4	2.3	2.6	3.0	4.8	6.9	9.6	16.8	23.5	29.2	30.2	17.9	9.2	0.0	0.0	0.1	1.2	2.5	4.2	9.3	14.2	18.0	18.2	7.8	0.2	21.3	24.1	27.3	46.2	69.5	98.3	176.9	250.6	312.4	321.9	183.8	84.3	1852	51	57	1903
												0.9	0.3	2.1	2.3	2.6	4.2	6.1	8.4	14.8	20.8	25.8	26.7	15.8	8.1	0.0	0.0	0.0	1.0	2.2	3.7	8.2	12.5	15.9	16.1	6.9	0.1	18.8	21.3	24.1	40.7	61.3	86.7	156.1	221.1	275.7	284.0	162.2	74.4	1632	51	58	1684
													0.3	1.8	2.1	2.3	3.7	5.4	7.5	13.1	18.3	22.7	23.5	13.9	7.2	0.0	0.0	0.0	0.9	2.0	3.3	7.2	11.0	14.0	14.2	6.1	0.1	16.6	18.8	21.3	35.9	54.1	76.5	137.7	195.1	243.2	250.6	143.1	65.6	1439	51	59	1491
														1.6	1.8	2.1	3.3	4.8	6.6	11.5	16.2	20.1	20.8	12.3	6.3	0.0	0.0	0.0	0.8	1.7	2.9	6.4	9.7	12.4	12.5	5.4	0.1	14.6	16.6	18.8	31.7	47.8	67.5	121.5	172.2	214.6	221.1	126.3	57.9	1270	51	60	1321
															1.6	1.8	2.9	4.2	5.8	10.2	14.3	17.7	18.3	10.8	5.6	0.0	0.0	0.0	0.7	1.5	2.5	5.6	8.6	10.9	11.0	4.7	0.1	12.9	14.6	16.6	28.0	42.1	59.6	107.2	151.9	189.4	195.1	111.4	51.1	1119	51	61	1170
																1.6	2.5	3.7	5.1	9.0	12.6	15.6	16.2	9.6	4.9	0.0	0.0	0.0	0.6	1.3	2.2	5.0	7.6	9.6	9.7	4.2	0.1	11.4	12.9	14.6	24.7	37.2	52.6	94.6	134.0	167.1	172.2	98.3	45.1	986	51	62	1037
																	2.2	3.3	4.5	7.9	11.1	13.8	14.3	8.4	4.4	0.0	0.0	0.0	0.6	1.2	2.0	4.4	6.7	8.5	8.6	3.7	0.1	10.0	11.4	12.9	21.8	32.8	46.4	83.5	118.3	147.4	151.9	86.7	39.8	869	51	63	920
																		2.9	4.0	7.0	9.8	12.2	12.6	7.5	3.8	0.0	0.0	0.0	0.5	1.0	1.7	3.9	5.9	7.5	7.6	3.3	0.1	8.9	10.0	11.4	19.2	29.0	40.9	73.7	104.4	130.1	134.0	76.5	35.1	764	51	64	816
																			3.5	6.2	8.6	10.7	11.1	6.6	3.4	0.0	0.0	0.0	0.4	0.9	1.5	3.4	5.2	6.6	6.7	2.9	0.1	7.8	8.9	10.0	17.0	25.5	36.1	65.0	92.1	114.8	118.3	67.5	31.0	672	51	65	723
																				5.4	7.6	9.5	9.8	5.8	3.0	0.0	0.0	0.0	0.4	0.8	1.4	3.0	4.6	5.8	5.9	2.5	0.1	6.9	7.8	8.9	15.0	22.5	31.9	57.4	81.3	101.3	104.4	59.6	27.3	590	51	66	641
																					6.7	8.4	8.6	5.1	2.6	0.0	0.0	0.0	0.3	0.7	1.2	2.7	4.1	5.2	5.2	2.2	0.0	6.1	6.9	7.8	13.2	19.9	28.1	50.6	71.7	89.4	92.1	52.6	24.1	516	51	67	567
																						7.4	7.6	4.5	2.3	0.0	0.0	0.0	0.3	0.6	1.1	2.3	3.6	4.5	4.6	2.0	0.0	5.4	6.1	6.9	11.7	17.6	24.8	44.7	63.3	78.9	81.3	46.4	21.3	449	51	68	500
																							6.7	4.0	2.1	0.0	0.0	0.0	0.3	0.6	0.9	2.1	3.2	4.0	4.1	1.7	0.0	4.7	5.4	6.1	10.3	15.5	21.9	39.4	55.8	69.6	71.7	40.9	18.8	390	51	69	441
																								3.5	1.8	0.0	0.0	0.0	0.2	0.5	0.8	1.8	2.8	3.5	3.6	1.5	0.0	4.2	4.7	5.4	9.1	13.7	19.3	34.8	49.3	61.4	63.3	36.1	16.6	338	51	70	389
																									1.6	0.0	0.0	0.0	0.2	0.4	0.7	1.6	2.5	3.1	3.2	1.4	0.0	3.7	4.2	4.7	8.0	12.1	17.0	30.7	43.5	54.2	55.8	31.9	14.6	295	51	71	347
																										0.0	0.0	0.0	0.2	0.4	0.6	1.4	2.2	2.8	2.8	1.2	0.0	3.3	3.7	4.2	7.1	10.6	15.0	27.1	38.3	47.8	49.3	28.1	12.9	259	51	72	310
																											0.0	0.0	0.2	0.3	0.6	1.3	1.9	2.4	2.5	1.1	0.0	2.9	3.3	3.7	6.2	9.4	13.3	23.9	33.8	42.2	43.5	24.8	11.4	228	51	73	280
																												0.0	0.1	0.3	0.5	1.1	1.7	2.1	2.2	0.9	0.0	2.5	2.9	3.3	5.5	8.3	11.7	21.1	29.9	37.2	38.3	21.9	10.0	202	51	74	253
																													0.1	0.3	0.4	1.0	1.5	1.9	1.9	0.8	0.0	2.2	2.5	2.9	4.9	7.3	10.3	18.6	26.3	32.8	33.8	19.3	8.9	178	51	75	229
																														0.2	0.4	0.9	1.3	1.7	1.7	0.7	0.0	2.0	2.2	2.5	4.3	6.4	9.1	16.4	23.2	29.0	29.9	17.0	7.8	157	51	76	208
																															0.3	0.8	1.2	1.5	1.5	0.6	0.0	1.7	2.0	2.2	3.8	5.7	8.0	14.5	20.5	25.6	26.3	15.0	6.9	138	51	77	190
																																0.7	1.0	1.3	1.3	0.6	0.0	1.5	1.7	2.0	3.3	5.0	7.1	12.8	18.1	22.6	23.2	13.3	6.1	122	51	78	173
																																	0.9	1.1	1.2	0.5	0.0	1.4	1.5	1.7	2.9	4.4	6.3	11.3	16.0	19.9	20.5	11.7	5.4	107	51	79	158
																																		1.0	1.0	0.4	0.0	1.2	1.4	1.5	2.6	3.9	5.5	9.9	14.1	17.6	18.1	10.3	4.7	93	51	80	145
																																			0.9	0.4	0.0	1.1	1.2	1.4	2.3	3.4	4.9	8.8	12.4	15.5	16.0	9.1	4.2	82	51	81	133
																																				0.3	0.0	0.9	1.1	1.2	2.0	3.0	4.3	7.7	11.0	13.7	14.1	8.0	3.7	71	51	82	123
																																					0.0	0.8	0.9	1.1	1.8	2.7	3.8	6.8	9.7	12.1	12.4	7.1	3.3	62	51	83	114
																																						0.7	0.8	0.9	1.6	2.4	3.4	6.0	8.5	10.6	11.0	6.3	2.9	55	51	84	107
																																							0.7	0.8	1.4	2.1	3.0	5.3	7.5	9.4	9.7	5.5	2.5	48	51	85	99
																																								0.7	1.2	1.8	2.6	4.7	6.7	8.3	8.5	4.9	2.2	42	51	86	93
																																									1.1	1.6	2.3	4.1	5.9	7.3	7.5	4.3	2.0	36	51	87	88
																																										1.4	2.0	3.7	5.2	6.5	6.7	3.8	1.7	31	51	88	82
																																											1.8	3.2	4.6	5.7	5.9	3.4	1.5	26	51	89	77
																																												2.8	4.0	5.0	5.2	3.0	1.4	21	51	90	73
																																													3.6	4.4	4.6	2.6	1.2	16	51	91	68
																																														3.9	4.0	2.3	1.1	11	51	92	63
																																															3.6	2.0	0.9	7	51	93	58
																																																1.8	0.8	3	51	94	54
																																																	0.7	1	51	95	52
																																																			Max	=	7136

Table 4.11 (a): Estimation of Rainfall Excess

1 day PMP	469 mm		
24 hr PMP	469 mm		
say	46.9 Cm		
1St Bell	76%	35.64 cm	
2nd Bell	24 %	11.26 cm	
2day PMP	258 mm		
48 hr PMP	258 mm		
say	25.8 Cm		
3rd Bell	76%	19.61 cm	
4thBell	24 %	6.19 cm	

Total area	1044 Sq km
Rainfed area	1029 Sq km
Snow fed area	15 Sq km

Estimation of Rainfall excess (cm)

1 st bell

Time	Percentage of 12 hr Rainfall	Cummulative Rainfall	Incremental Rainfall	Effective Rainfall	Critical	Reverse Critical
0	0	0.00	**0.00**			
1	0.16	5.63	5.63	5.39	1.17	1.17
2	0.30	10.79	5.16	4.92	2.57	1.17
3	0.45	15.95	5.16	4.92	4.92	1.17
4	0.57	20.17	4.22	3.98	5.39	1.64
5	0.64	22.98	2.81	2.57	4.92	2.11
6	0.72	25.80	2.81	2.57	3.98	2.57
7	0.79	28.14	2.35	2.11	2.57	3.98
8	0.84	30.02	1.88	1.64	2.11	4.92
9	0.88	31.42	1.41	1.17	1.64	5.39
10	0.92	32.83	1.41	1.17	1.17	4.92
11	0.96	34.24	1.41	1.17	1.17	2.57
12	1.00	35.64	1.41	1.17	1.17	1.17
			35.64	**32.76**		

2 nd bell

Time	Percentage of 12 hr Rainfall	Cummulative Rainfall	Incremental Rainfall	Effective Rainfall	Critical
0	**0**	0.00	**0.00**		
1	0.16	1.78	1.78	1.54	0.2
2	0.30	3.41	1.63	1.39	0.65
3	0.45	5.04	1.63	1.39	1.39
4	0.57	6.37	1.33	1.09	1.54
5	0.64	7.26	0.89	0.65	1.39
6	0.72	8.15	0.89	0.65	1.09
7	0.79	8.89	0.74	0.50	0.65
8	0.84	9.48	0.59	0.35	0.5
9	0.88	9.92	0.44	0.20	0.35
10	0.92	10.37	0.44	0.20	0.2
11	0.96	10.81	0.44	0.20	0.2
12	1.00	11.26	0.44	0.20	0.2
			11.26	**8.38**	

3rd bell

Time	Percentage of 12 hr Rainfall	Cummulative Rainfall	Incremental Rainfall	Effective Rainfall	Critical	Reverse Critical
0	0	0.00	**0.00**			
1	0.16	3.10	3.10	2.86	0.53	0.53
2	0.30	5.93	2.84	2.60	1.31	0.53
3	0.45	8.77	2.84	2.60	2.6	0.53
4	0.57	11.09	2.32	2.08	2.86	0.79
5	0.64	12.64	1.55	1.31	2.6	1.05
6	0.72	14.19	1.55	1.31	2.08	1.31
7	0.79	15.48	1.29	1.05	1.31	2.08
8	0.84	16.51	1.03	0.79	1.05	2.60
9	0.88	17.29	0.77	0.53	0.79	2.86
10	0.92	18.06	0.77	0.53	0.53	2.60
11	0.96	18.83	0.77	0.53	0.53	1.31
12	1.00	19.61	0.77	0.53	0.53	0.53
			19.61	**16.73**		

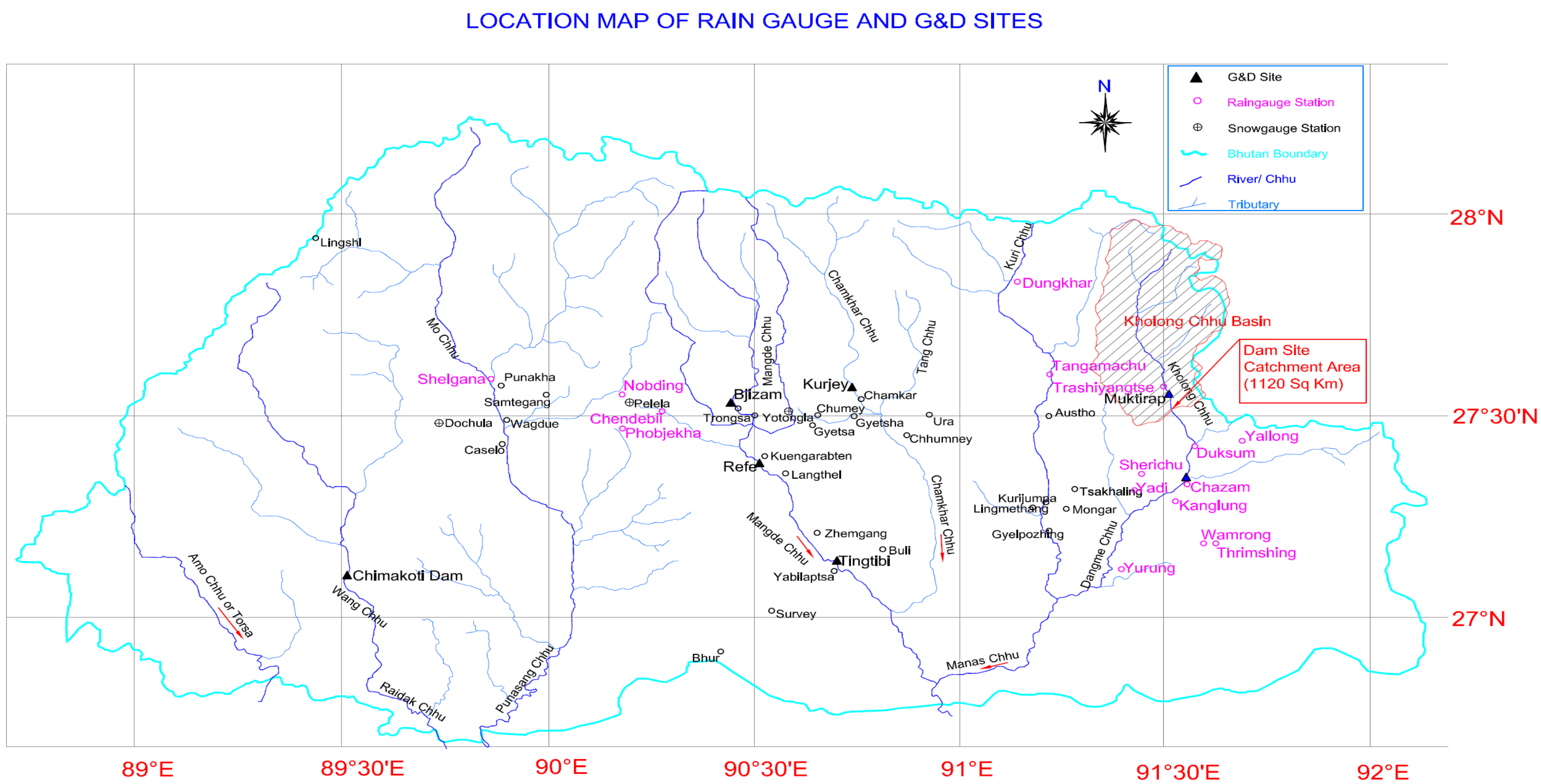
4 th bell

Time	Percentage of 12 hr Rainfall	Cummulative Rainfall	Incremental Rainfall	Effective Rainfall	Critical
0	**0**	0.00	**0.00**		
1	0.16	0.98	0.98	0.74	0.00
2	0.30	1.87	0.90	0.66	0.25
3	0.45	2.77	0.90	0.66	0.66
4	0.57	3.50	0.73	0.49	0.74
5	0.64	3.99	0.49	0.25	0.66
6	0.72	4.48	0.49	0.25	0.49
7	0.79	4.89	0.41	0.17	0.25
8	0.84	5.21	0.33	0.09	0.17
9	0.88	5.46	0.24	0.004	0.09
10	0.92	5.70	0.24	0.004	0.00
11	0.96	5.95	0.24	0.004	0.00
12	1.00	6.19	0.24	0.004	0.00
			6.19	**3.31**	

Table 4.11 (b): Convolution of U.G with Rainfall Excess (Dimensionless U.G)

Time	U.G	0.20	0.20	0.20	0.35	0.50	0.65	1.09	1.39	1.54	1.39	0.65	0.20	1.17	1.17	1.17	1.64	2.11	2.57	3.98	4.92	5.39	4.92	2.57	1.17	0.00	0.00	0.00	0.09	0.17	0.25	0.49	0.66	0.74	0.66	0.25	0.00	0.53	0.53	0.53	0.79	1.05	1.31	2.08	2.60	2.86	2.60	1.31	0.53	D.S.R.O	Base Flow	Time (Hrs)	Flood Hydrograph Ordinates (Cumecs)
0	0	0.0																																																0	51	0	51
1	41	8.2	0.0																																															8	51	1	60
2	137	27.4	8.2	0.0																																														36	51	2	87
3	255	51.0	27.4	8.2	0.0																																													87	51	3	138
4	338	67.6	51.0	27.4	14.4	0.0																																												160	51	4	212
5	362	72.4	67.6	51.0	48.0	20.5	0.0																																											259	51	5	311
6	312	62.4	72.4	67.6	89.3	68.5	26.7	0.0																																										387	51	6	438
7	255	51.0	62.4	72.4	118.3	127.5	89.1	44.7	0.0																																									565	51	7	617
8	208	41.6	51.0	62.4	126.7	169.0	165.8	149.3	57.0	0.0																																								823	51	8	874
9	168	33.6	41.6	51.0	109.2	181.0	219.7	278.0	190.4	63.1	0.0																																							1168	51	9	1219
10	138	27.6	33.6	41.6	89.3	156.0	235.3	368.4	354.5	211.0	57.0	0.0																																						1574	51	10	1626
11	113	22.6	27.6	33.6	72.8	127.5	202.8	394.6	469.8	392.7	190.4	26.7	0.0																																					1961	51	11	2013
12	93	18.6	22.6	27.6	58.8	104.0	165.8	340.1	503.2	520.5	354.5	89.1	8.2	0.0																																				2213	51	12	2264
13	77	15.4	18.6	22.6	48.3	84.0	135.2	278.0	433.7	557.5	469.8	165.8	27.4	48.0	0.0																																			2304	51	13	2356
14	63	12.6	15.4	18.6	39.6	69.0	109.2	226.7	354.5	480.5	503.2	219.7	51.0	160.3	48.0	0.0																																		2308	51	14	2360
15	52	10.4	12.6	15.4	32.6	56.5	89.7	183.1	289.1	392.7	433.7	235.3	67.6	298.4	160.3	48.0	0.0																																	2325	51	15	2377
16	44	8.8	10.4	12.6	27.0	46.5	73.5	150.4	233.5	320.3	354.5	202.8	72.4	395.5	298.4	160.3	67.2	0.0																																2434	51	16	2485
17	37	7.4	8.8	10.4	22.1	38.5	60.5	123.2	191.8	258.7	289.1	165.8	62.4	423.5	395.5	298.4	224.7	86.5	0.0																															2667	51	17	2719
18	30	6.0	7.4	8.8	18.2	31.5	50.1	101.4	157.1	212.5	233.5	135.2	51.0	365.0	423.5	395.5	418.2	289.1	105.4	0.0																														3009	51	18	3061
19	24	4.8	6.0	7.4	15.4	26.0	41.0	83.9	129.3	174.0	191.8	109.2	41.6	298.4	365.0	423.5	554.3	538.1	352.1	163.2	0.0																													3525	51	19	3576
20	19	3.8	4.8	6.0	13.0	22.0	33.8	68.7	107.0	143.2	157.1	89.7	33.6	243.4	298.4	365.0	593.7	713.2	655.4	545.3	201.7	0.0																												4299	51	20	4350
21	16	3.2	3.8	4.8	10.5	18.5	28.6	56.7	87.6	118.6	129.3	73.5	27.6	196.6	243.4	298.4	511.7	763.8	868.7	1014.9	674.0	221.0	0.0																											5355	51	21	5406
22	14	2.8	3.2	3.8	8.4	15.0	24.1	48.0	72.3	97.0	107.0	60.5	22.6	161.5	196.6	243.4	418.2	658.3	930.3	1345.2	1254.6	738.4	201.7	0.0																										6613	51	22	6664
23	12	2.4	2.8	3.2	6.7	12.0	19.5	40.3	61.2	80.1	87.6	50.1	18.6	132.2	161.5	196.6	341.1	538.1	801.8	1440.8	1663.0	1374.5	674.0	105.4	0.0																									7813	51	23	7865
24	11	2.2	2.4	2.8	5.6	9.5	15.6	32.7	51.4	67.8	72.3	41.0	15.4	108.8	132.2	161.5	275.5	438.9	655.4	1241.8	1781.0	1821.8	1254.6	352.1	48.0	0.0																								8590	51	24	8642
25	9	1.8	2.2	2.4	4.9	8.0	12.4	26.2	41.7	57.0	61.2	33.8	12.6	90.1	108.8	132.2	226.3	354.5	534.6	1014.9	1535.0	1951.2	1663.0	655.4	160.3	0.2	0.0																							8690	51	25	8742
26	8	1.6	1.8	2.2	4.2	7.0	10.4	20.7	33.4	46.2	51.4	28.6	10.4	73.7	90.1	108.8	185.3	291.2	431.8	827.8	1254.6	1681.7	1781.0	868.7	298.4	0.6	0.2	0.0																						8112	51	26	8163
27	7	1.4	1.6	1.8	3.9	6.0	9.1	17.4	26.4	37.0	41.7	24.1	8.8	60.8	73.7	90.1	152.5	238.4	354.7	668.6	1023.4	1374.5	1535.0	930.3	395.5	1.1	0.6	0.2	0.0																					7079	51	27	7130
28	6	1.2	1.4	1.6	3.2	5.5	7.8	15.3	22.2	29.3	33.4	19.5	7.4	51.5	60.8	73.7	126.3	196.2	290.4	549.2	826.6	1121.1	1254.6	801.8	423.5	1.5	1.1	0.6	3.7	0.0																				5930	51	28	5982
29	4	0.8	1.2	1.4	2.8	4.5	7.2	13.1	19.5	24.6	26.4	15.6	6.0	43.3	51.5	60.8	103.3	162.5	239.0	449.7	679.0	905.5	1023.4	655.4	365.0	1.6	1.5	1.1	12.3	7.0	0.0																			4885	51	29	4936
30	2	0.4	0.8	1.2	2.5	4.0	5.9	12.0	16.7	21.6	22.2	12.4	4.8	35.1	43.3	51.5	85.3	132.9	197.9	370.1	556.0	743.8	826.6	534.6	298.4	1.4	1.6	1.5	23.0	23.3	10.3	0.0																		4041	51	30	4092
31	0	0.0	0.4	0.8	2.1	3.5	5.2	9.8	15.3	18.5	19.5	10.4	3.8	28.1	35.1	43.3	72.2	109.7	161.9	306.5	457.6	609.1	679.0	431.8	243.4	1.1	1.4	1.6	30.4	43.4	34.3	20.1	0.0																	3399	51	31	3450
32			0.0	0.4	1.4	3.0	4.6	8.7	12.5	16.9	16.7	9.1	3.2	22.2	28.1	35.1	60.7	92.8	133.6	250.7	378.8	501.3	556.0	354.7	196.6	0.9	1.1	1.4	32.6	57.5	63.8	67.1	27.1	0.0																2939	51	32	2990
33				0.0	0.7	2.0	3.9	7.6	11.1	13.9	15.3	7.8	2.8	18.7	22.2	28.1	49.2	78.1	113.1	207.0	310.0	415.0	457.6	290.4	161.5	0.7	0.9	1.1	28.1	61.5	84.5	125.0	90.4	30.3	0.0															2638	51	33	2690
34					0.0	1.0	2.6	6.5	9.7	12.3	12.5	7.2	2.4	16.4	18.7	22.2	39.4	63.3	95.1	175.1	255.8	339.6	378.8	239.0	132.2	0.6	0.7	0.9	23.0	53.0	90.5	165.6	168.3	101.4	27.1	0.0														2461	51	34	2512
35						0.0	1.3	4.4	8.3	10.8	11.1	5.9	2.2	14.0	16.4	18.7	31.2	50.6	77.1	147.3	216.5	280.3	310.0	197.9	108.8	0.5	0.6	0.7	18.7	43.4	78.0	177.4	223.1	188.7	90.4	10.3	0.0													2344	51	35	2396
36							0.0	2.2	5.6	9.2	9.7	5.2	1.8	12.9	14.0	16.4	26.2	40.1	61.7	119.4	182.0	237.2	255.8	161.9	90.1	0.4	0.5	0.6	15.1	35.4	63.8	152.9	238.9	250.1	168.3	34.3	0.2	0.0												2212	51	36	2263
37								0.0	2.8	6.2	8.3	4.6	1.6	10.5	12.9	14.0	23.0	33.8	48.8	95.5	147.6	199.4	216.5	133.6	73.7	0.3	0.4	0.5	12.4	28.6	52.0	125.0	205.9	267.9	223.1	63.8	0.6	21.7	0.0											2035	51	37	2086
38									0.0	3.1	5.6	3.9	1.4	9.4	10.5	12.9	19.7	29.5	41.1	75.6	118.1	161.7	182.0	113.1	60.8	0.3	0.3	0.4	10.2	23.5	42.0	101.9	168.3	230.9	238.9	84.5	1.1	72.6	21.7	0.0										1845	51	38	1896
39										0.0	2.8	2.6	1.2	8.2	9.4	10.5	18.0	25.3	36.0	63.7	93.5	129.4	147.6	95.1	51.5	0.2	0.3	0.3	8.4	19.2	34.5	82.3	137.3	188.7	205.9	90.5	1.5	135.2	72.6	21.7	0.0									1693	51	39	1745
40											0.0	1.3	0.8	7.0	8.2	9.4	14.8	23.2	30.8	55.7	78.7	102.4	118.1	77.1	43.3	0.2	0.2	0.3	6.9	15.8	28.3	67.6	110.9	153.9	168.3	78.0	1.6	179.1	135.2	72.6	32.4	0.0								1622	51	40	1674
41												0.0	0.4	4.7	7.0	8.2	13.1	19.0	28.3	47.8	68.9	86.2	93.5	61.7	35.1	0.2	0.2	0.2	5.7	13.1	23.3	55.4	91.1	124.3	137.3	63.8	1.4	191.9	179.1	135.2	108.2	43.1	0.0							1647	51	41	1698
42													0.0	2.3	4.7	7.0	11.5	16.9	23.1	43.8	59.0	75.5	78.7	48.8	28.1	0.1	0.2	0.2	4.7	10.7	19.3	45.6	74.6	102.1	110.9	52.0	1.1	165.4	191.9	179.1	201.5	143.9	53.7	0.0						1756	51	42	1808
43														0.0	2.3	4.7	9.8	14.8	20.6	35.8	54.1	64.7	68.9	41.1	22.2	0.1	0.1	0.2	4.0	8.8	15.8	37.7	61.4	83.6	91.1	42.0	0.9	135.2	165.4	191.9	267.0	267.8	179.5	85.3	0.0					1977	51	43	2028
44															0.0	2.3	6.6	12.7	18.0	31.8	44.3	59.3	59.0	36.0	18.7	0.1	0.1	0.1	3.3	7.5	13.0	30.9	50.8	68.8	74.6	34.5	0.7	110.2	135.2	165.4	286.0	354.9	334.1	285.0	106.6	0.0				2350	51	44	2402
45																0.0	3.3	8.4	15.4	27.9	39.4	48.5	54.1	30.8	16.4	0.1	0.1	0.1	2.7	6.3	11.0	25.5	41.6	57.0	61.4	28.3	0.6	89.0	110.2	135.2	246.5	380.1	442.8	530.4	356.2	117.3	0.0			2886	51	45	2938
46																	0.0	4.2	10.3	23.9	34.4	43.1	44.3	28.3	14.0	0.1	0.1	0.1	2.2	5.1	9.3	21.6	34.3	46.6	50.8	23.3	0.5	73.1	89.0	110.2	201.5	327.6	474.2	703.0	663.0	391.8	106.6	0.0		3536	51	46	3588
47																		0.0	5.1	15.9	29.5	37.7	39.4	23.1	12.9	0.1	0.1	0.1	1.7	4.1	7.5	18.1	29.0	38.5	41.6	19.3	0.4	59.9	73.1	89.0	164.3	267.8	408.7	753.0	878.8	729.3	356.2	53.7	0.0	4158	51	47	4209
48																			0.0	8.0	19.7	32.3	34.4	20.6	10.5	0.0	0.1	0.1	1.4	3.2	6.0	14.7	24.4	32.6	34.3	15.8	0.3	49.3	59.9	73.1	132.7	218.4	334.1	649.0	941.2	966.7	663.0	179.5	21.7	4547	51	48	4598
49																				0.0	9.8	21.6	29.5	18.0	9.4	0.0	0.0	0.1	1.3	2.7	4.8	11.8	19.8	27.4	29.0	13.0	0.3	40.8	49.3	59.9	109.0	176.4	272.5	530.4	811.2	1035.3	878.8	334.1	72.6	4569	51	49	4620
50																					0.0	10.8	19.7	15.4	8.2	0.0	0.0	0.0	1.1	2.4	4.0	9.3	15.8	22.2	24.4	11.0	0.2	33.4	40.8	49.3	89.3	144.9	220.1	432.6	663.0	892.3	941.2	442.8	135.2	4229	51	50	4281
51																						0.0	9.8	10.3	7.0	0.0	0.0	0.0	1.0	2.0	3.5	7.8	12.5	17.8	19.8	9.3	0.2	27.6	33.4	40.8	73.5	118.7	180.8	349.4	540.8	729.3	811.2	474.2	179.1	3660	51	51	3711
52																							0.0	5.1	4.7	0.0	0.0	0.0	0.8	1.9	3.0	6.9	10.6	14.1	15.8	7.5	0.2	23.3	27.6	33.4	60.8	97.7	148.0	287.0	436.8	594.9	663.0	408.7	191.9	3044	51	52	3095
53																								0.0	2.3	0.0	0.0	0.0	0.7	1.5	2.8	5.9	9.2	11.8	12.5	6.0	0.1	19.6	23.3	27.6	49.8	80.9	121.8	235.0	358.8	480.5	540.8	334.1	165.4	2491	51	53	2542
54																									0.0	0.0	0.0	0.0	0.6	1.4	2.3	5.4	7.9	10.4	10.6	4.8	0.1	15.9	19.6	23.3	41.1	66.2	100.9	193.4	293.8	394.7	436.8	272.5	135.2	2037	51	54	2088
55																										0.0	0.0	0.0	0.5	1.2	2.0	4.4	7.3	8.9	9.2	4.0	0.1	12.7	15.9	19.6	34.8	54.6	82.5	160.2	241.8	323.2	358.8	220.1	110.2	1672	51	55	1723
56																											0.0	0.0	0.4	1.0	1.8	3.9	5.9	8.1	7.9	3.5	0.1	10.1	12.7	15.9	29.2	46.2	68.1	131.0	200.2	266.0	293.8	180.8	89.0	1376	51	56	1427
57																												0.0	0.2	0.7	1.5	3.4	5.3	6.7	7.3	3.0	0.1	8.5	10.1	12.7	23.7	38.9	57.6	108.2	163.8	220.2	241.8	148.0	73.1	1135	51	57	1186
58																													0.0	0.3	1.0	2.9	4.6	5.9	5.9	2.8	0.1	7.4	8.5	10.1	19.0	31.5	48.5	91.5	135.2	180.2	200.2	121.8	59.9	937	51	58	989
59																														0.0	0.5	2.0	4.0	5.2	5.3	2.3	0.0	6.4	7.4	8.5	15.0	25.2	39.3	77.0	114.4	148.7	163.8	100.9	49.3	775	51	59	826
60																															0.0	1.0	2.6	4.4	4.6	2.0	0.0	5.8	6.4	7.4	12.6	20.0	31.4	62.4	96.2	125.8	135.2	82.5	40.8	641	51	60	693
61																																0.0	1.3	3.0	4.0	1.8	0.0	4.8	5.8	6.4	11.1	16.8	24.9	49.9	78.0	105.8	114.4	68.1	33.4	529	51	61	581
62																																	0.0	1.5	2.6	1.5	0.0	4.2	4.8	5.8	9.5	14.7	21.0	39.5	62.4	85.8	96.2	57.6	27.6	435	51	62	486
63																																		0.0	1.3	1.0	0.0	3.7	4.2	4.8	8.7	12.6	18.3	33.3	49.4	68.6	78.0	48.5	23.3	356	51	63	407
64																																			0.0	0.5	0.0	3.2	3.7	4.2	7.1	11.6	15.7	29.1	41.6	54.3	62.4	39.3	19.6	292	51	64	344
65																																				0.0	0.0	2.1	3.2	3.7	6.3	9.5	14.4	25.0	36.4	45.8	49.4	31.4	15.9	243	51	65	295
66																																					0.0	1.1	2.1	3.2	5.5	8.4	11.8	22.9	31.2	40.0	41.6	24.9	12.7	205	51	66	257
67																																						0.0	1.1	2.1	4.7	7.4	10.5	18.7	28.6	34.3	36.4	21.0	10.1	175	51	67	226
68																																							0.0	1.1	3.2	6.3	9.2	16.6	23.4	31.5	31.2	18.3	8.5	149	51	68	201
69																																								0.0	1.6	4.2	7.9	14.6	20.8	25.7	28.6	15.7	7.4	126	51	69	178
70																																									0.0	2.1	5.2	12.5	18.2	22.9	23.4	14.4	6.4	105	51	70	157
71																																										0.0	2.6	8.3	15.6	20.0	20.8	11.8	5.8	85	51	71	136
72																																											0.0	4.2	10.4	17.2	18.2	10.5	4.8	65	51	72	117
73																																												0.0	5.2	11.4	15.6	9.2	4.2	46	51	73	97
74																																													0.0	5.7	10.4	7.9	3.7	28	51	74	79
75																																														0.0	5.2	5.2	3.2	14	51	75	65
76																																															0.0	2.6	2.1	5	51	76	56
77																																																0.0	1.1	1	51	77	53
78																																																	0.0	0	51	78	51
																																																			Max	=	8742

Figure 3.1: Map Showing the Gauge - Discharge and Raingauge sites



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