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HYDROMETEOROLOGY OF UJH RIVER SUB BASIN

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(J&K)

PREFACE

A study of Hydrometeorology forms a basic prerequisite before any other study is undertaken by a hydrologist for a water resources project , since it is concerned with proper assessment and management of water resources for its optimum use for irrigation , hydropower and allied purposes.

The National Institute of Hydrology established the Western Himalayan Regional Centre at Jammu in the year 1990, with its jurisdiction of the states of J & K, HP and UP to cater their needs in the area of Hydrology. In the present report some of the hydrometeorological aspects of Ujh river basin in the Jammu region have been presented and discussed. Despite inadequate network of hydrometeorological stations and short length of data available, an attempt has been made to study the hydrometeorology of Ujh basin.

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DIRECTOR

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ABSTRACT

Ujh river is a tributary of Ravi. The Ujh sub basin is a sub Himalayan catchment with a hilly and rugged terrain having altitudes ranging from 510 to 4300 meters. The catchment receives its major contribution from south west monsoon and remaining during winter as a result of western disturbances in the form of snow and rain. Thus it has a unique distribution of precipitation involving orographic influences.

The Ujh river has been experiencing unprecedented floods in the recent times causing widespread damage to life and property in the lower reaches of barrage constructed near Panjitirthi. It was therefore felt a need to study the entire hydrology of Ujh basin.

While the existing network is inadequate an attempt has been made to study the hydrometeorology of Ujh river sub basin using available data. In the report some of the hydrometeorological aspects are presented and discussed.

1.0 INTRODUCTION

Hydrometeorology is of vital importance to a hydrologist as it is concerned with proper assessment and management of water resources for its optimum use for Irrigation, hydropower and allied purposes. As such precipitation being an input to the hydrologic system, any type of input-output analysis requires the interpretation of input data.

Ujh river sub basin of Ravi is about 930 Sq. kms. The source of the river lies in the snow bound hills of the Bhadarwah town at an altitude of 4300 mtrs of Jammu province. Keeping in view of data availability, the present analysis is confined to rainfall data only.

Ujh sub basin mainly comprises of hilly and rugged terrain with altitudes varying from 510 to 4300 mtrs. Orographic influences affect the pattern of rainfall distribution in space & time. The river has been experiencing unusual floods in the recent times thereby causing extensive damage to the lower reaches downstream of the existing barrage. An unusual storm on 25 sept 1988 resulted in a flood that exceeded the design capacity. The HFL stood above the top of spillway gates, endangering the barrage structure. A study of of hydrometeorology followed by water availability and design flood have therefore been proposed.

In the report some of the hydrometeorological aspects have been presented and discussed.

2.0 PROBLEM DEFINITION

The tributary of Ujh with its sources in western Himalayas involves a study of mountain hydrology. The mountainous catchment of Ujh with altitudes ranging from 510 to 4300 mtrs has a typical distribution pattern of rainfall and runoff processes.

For understanding the behaviour of rainfall runoff and other hydrologic processes, a study of climatology, precipitation storms, orographic effect and rainfall distribution in space and time is therefore imperative. However, the study and analysis in this report is confined to rainfall alone , the data for which, could be procured from Irrigation and flood control deptt, Jammu.

3.0 DESCRIPTION OF STUDY AREA

3.1 The Ujh River :

The Ujh river is a tributary of the Ravi, one of the five rivers Punjab. The head waters of Ujh lie in the Kailas parvat lake at an altitude of 4300 mtrs near the Bhadarwah hills of Jammu province. From the source point the river travels for a length of nearly 100 kms before it joins Ravi below Nainkot in west Pakistan. Just upstream of damsite, four streams Bhini, Sutar, Dunarki and Talan together join the Ujh at a place named Panjtirthi. Bhini and Ujh are perennial rivers. The remaining three streams flow only during rainy season.

3.2 The catchment area :

The catchment area of ujh river at damsite is 990 sq. kms planimetered from topo sheet. The catchment is quite hilly and rugged varying in altitude from 510 Mtrs to 4300 Mtrs. A plan of catchment area is shown in Fig No.1. Areas having an altitude of 2000 Mtrs and above which constitute about 20% of the catchment area are generally snowbound for most of the winter.

3.3 Climate :

There are three temperature stations near the catchment viz; Pathankot, Jammu and Dalhousie. The mean annual temperature of Pathankot of 23.0 ^{0} C can be taken to represent the southern part of the catchment and that of Dalhousie of 15.9 ^{o}C of the eastern portion. The temperature at higher altitudes in the northern part is expected to be low. The climatic conditions vary from semi arid to humid from south to northern parts of the catchment.

There are two rainy seasons one from December to March

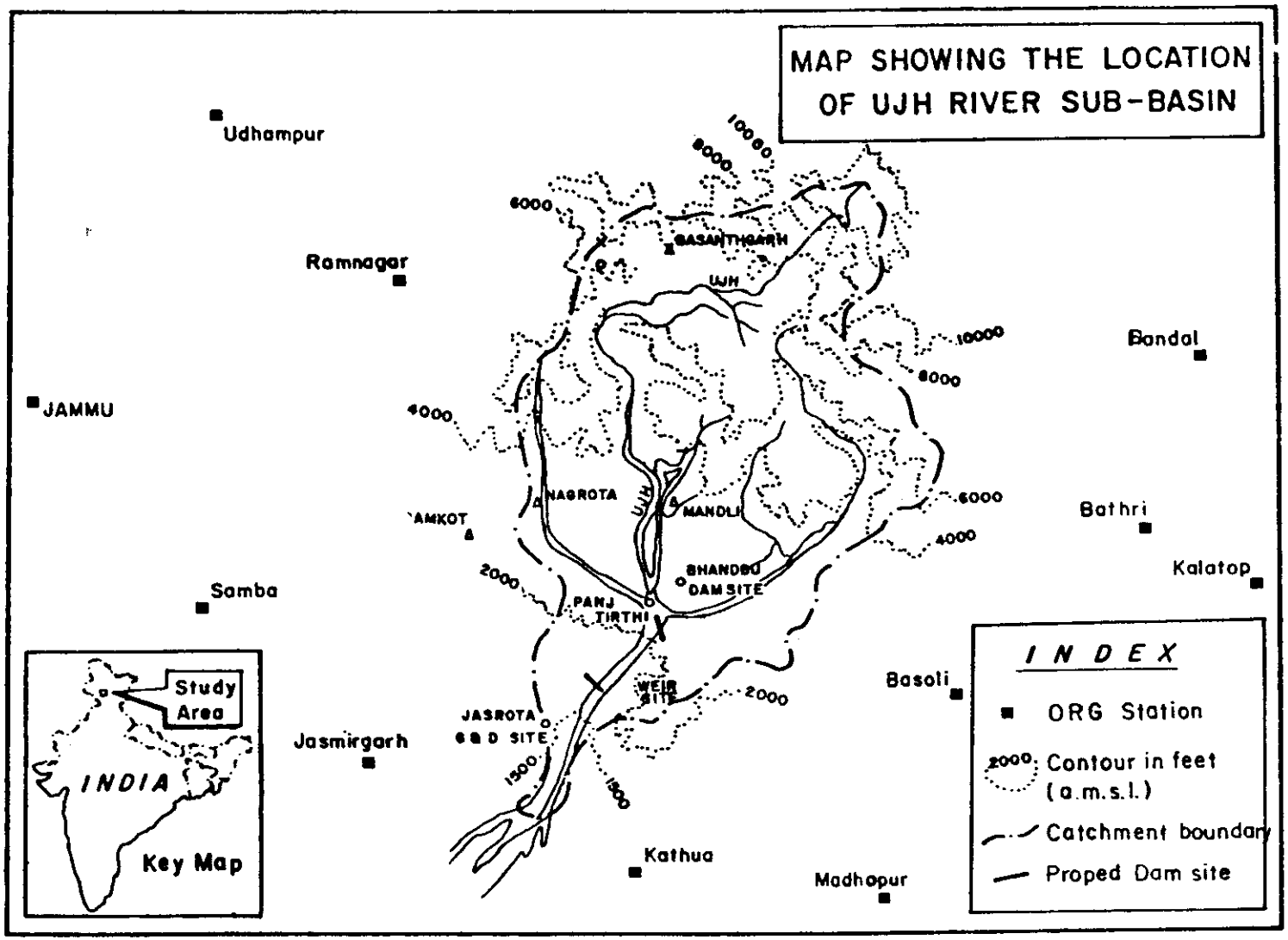

MAP SHOWING THE LOCATION
OF UJH RIVER SUB-BASIN
Udhampur
Ramnagar
JAMMU
Samba
Jasmirgarh
Kathua
Madhopur
Basoli
Bandal
Bathri
Kalatop
BASANTHGARH
UJH
NAGROTA
MANDLI
AMKOT
BHANDOO DAM SITE
PANJ TIRTHI
WEIR SITE
JASROTA G & D SITE
10000
8000
6000
4000
2000
1500
Study Area
INDIA
Key Map
INDEX
ORG Station
Contour in feet (a.m.s.l.)
Catchment boundary
Proped Dam site

Fig.1

associated with the passage of western disturbances and the other mid June to mid September due to south west monsoon currents. The rainfall in October and November is generally small in amount. The cold season precipitation from December to March is chiefly due to western disturbances which advance from Persia and Baluchistan across northern India. These disturbances occasionally give very stormy weather with stormy winds on the higher elevations giving much snow. In April & May thunder storms are occasionally observed giving light to moderate showers of rain. The south west monsoon is a predominant feature in this region. The normal rainfall of some of the stations around Ujh catchment are presented in table 1.

4.0 DATA AVAILABILITY

4.1 Rain fall data :

There was no rain gauge station inside the catchment prior to 1956. Fig.1 shows the location of rain gauge stations in and around the catchment. There is no SRRG(self recording rain gauge) in the Ujh sub basin. The data collected by state government includes those of 12 non recording rain gauge stations (ORG) for which data was made available. Daily rainfall data is available from 1956 to 1975 for the 12 ORG stations, of these, two stations Mandli and Kathua have data from 1956 to 1990. Only three stations viz; Mandli, Ujh damsite and Kathua fall within the basin. However the data available has large gaps and inconsistencies.

As already mentioned the number of rain gauge stations in the catchment is not adequate considering the mountainous terrain (as per WMO standards one R.G. station every 150 km) and as such a proper rain & snow gauge network needs to be established.

TABLE - 1

50 YEAR RAINFALL (mm) NORMALS AROUND UJH SUB BASIN

S/N	STATION	LAT N	LONG E	HEIGHT MSL	NO.OF YEAR	MONTH JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	REMARKS
1	JAMMU	32 44'	74 55'	1250	41	64.8	64.8	56.4	32.3	23.1	69.3	327.4	299.5	123.7	15.5	6.6	33.0	1055.8	IMD
2	SAMBA	32 34'	75 07'	1250	50	65.5	52.6	50.5	23.4	23.9	53.1	312.9	338.6	106.2	14.2	6.6	31.5	1079.0	IMD
3	UDHAMPUR	32 55'	75 08'	2535	50	107.9	106.7	90.9	47.7	32.5	90.4	384.8	406.4	149.6	22.1	9.9	50.8	1499.7	IMD
4	RAMNAGAR	32 42'	75 19'	2600	50	113.8	118.1	98.5	57.4	41.7	104.7	442.2	466.9	166.4	23.9	11.9	56.9	1702.4	IMD
5	BADARWAH	32 59'	75 43'	5390	40	159.3	156.0	145.5	94.5	61.5	55.9	128.5	117.6	49.0	36.3	24.1	95.0	1123.2	IMD
6	KATHUA	32 22'	75 32'	1034	50	72.6	62.7	52.0	27.4	17.0	51.0	339.9	352.5	140.7	21.3	5.6	34.3	1177.9	IMD
7	BASHOLI	32 30'	75 49'	1805	50	100.6	94.7	79.5	39.4	23.6	74.4	448.8	480.6	144.8	19.1	8.4	51.8	1565.7	IMD

5.0 PROCESSING & ANALYSIS OF DATA

5.1- Testing and adjusting precipitation data

In order to avoid erroneous conclusions it is important to make proper interpretation of precipitation data which often can not be accepted at face value. Where gaps occur in rain fall data they need to be filled up suitably based on adjacent station data. Some of the methods employed in computing missing rainfall data from adjacent station include.

a) Normal ratio method.

b) Distance power method.

In the present case "Distance power method" is adopted as it is suitable for mountainous catchments.In this method weights are assigned to rainfall stations adjacent to stations where data is missing as inversely proportional to the square of distance separating the two .This method gives reasonable values.

5.2 Data consistency

Non homogeneity occurs when a sudden change overlaps in the hydrologic eco system or in the method of observation on reduction of the basic data and often the response changes suddenly in a hydrologic eco system. Therefore consistency of records need to be checked for known or suspected non homogeneity. Table 2 shows the annual rainfall value along with missing rainfall values duly filled by Distance power method as also the data consistency checked and corrected using the Double mass technique.

5.3 Network requirement

The mean annual rainfall for 15 years (i.e. from 1961 - 75) varies in the range of 145 - 190 cms. For optimum network requirement computations, Bhadarwah, Mandli, Kathua and Jasrota stations mean annual rainfall was examined with Bhadarwah, Jasrota and Kathua just outside the watershed boundary line and Mandli with in the catchment. The coefficient of variation was less than 10 % indicating adequacy of network. However it should be noted that the sample length available was small and as such at least two more R.G. stations need to be added as per WMO norms within the catchment. Also a suitable number of snow gauges need to be installed in the upper reaches of the catchment.

5.4 Monsoon Contribution

The 15 years data analysis of rainfall in and around Ujh basin indicated that a major portion of annual rainfall is contributed by the south west monsoon. The details of 12 station (in & around) mean or Ujh basin during monsoon period (monthly) are shown in table 3.

TABLE - 2

ANNUAL RAINFALL (cm)

S/N	STATION	LAT	LONG	HT.	1961	62	63	64	65	66	67	68	69	70	71	72	73	74	75
1	JAMMU	32 44'	74 55'	1250	162.84	99.45	64.38	107.50	68.47	128.96	131.32	114.86	93.30	122.84	156.92	102.41	148.16	94.40	157.10
2	SAMBA	32 34'	75 07'	1250	194.55	88.32	131.33	110.93	75.39	152.24	180.79	108.73	98.59	126.60	182.70	107.20	158.40	97.50	197.49
3	UDHAMPUR	32 55'	75 08'	2535	212.04	129.09	141.38	142.60	102.81	169.81	151.55	158.88	86.10	95.03	110.33	53.66	188.94	147.26	208.28
4	RAMNAGAR	32 42'	75 19'	2600	230.91	190.47	170.43	209.97	583.97	164.46	177.77	154.78	132.35	119.45	114.75	88.00	62.26	203.90	62.10
5	BADARWAH	32 59'	75 43'	5390	132.92	56.03	172.35	187.92	200.13	163.34	4.35	169.09	133.24	159.22	205.57	93.14	208.31	174.77	233.05
6	KATHUA	32 22'	75 32'	1034	164.32	155.47	127.11	128.11	93.05	136.86	234.40	217.12	147.24	177.35	161.06	96.12	199.55	132.02	206.60
7	BASHOLI	32 30'	75 49'	1805	267.62	135.18	193.11	123.54	87.80	161.54	227.38	181.60	144.16	167.40	205.54	98.56	144.46	149.40	279.43
8	RAMKOTE	32 30'	75 20'	1950	287.62	238.98	167.44	93.14	147.72	214.52	251.13	190.18	143.56	144.34	222.13	97.61	249.52	222.12	242.58
9	BHADDU	32 34'	75 31'	2487	290.80	225.22	281.18	162.54	162.54	132.30	272.46	155.28	130.78	172.21	192.57	69.48	202.27	194.76	210.02
* 10	JASROTA	32 28'	75 25'	1230	164.87	111.59	102.20	148.92	110.86	181.56	273.27	208.60	181.00	178.11	270.23	141.41	163.15	77.10	217.81
11	UJH DAM	32 35'	75 29'	1900	259.24	207.05	202.30	173.00	149.25	182.08	199.25	193.00	152.72	157.76	261.35	124.52	230.58	183.32	235.40
12	MANDLI	32 39'	75 31'	---	262.68	186.12	224.31	127.76	154.98	164.93	221.57	149.29	131.14	178.91	196.02	61.41	209.88	215.27	237.10
	AVERAGE				219.20	151.00	156.60	144.60	161.40	165.20	188.70	166.78	120.00	135.90	189.93	102.80	184.60	157.60	207.20

TABLE - 2 Contd.

ANNUAL RAINFALL (cm)

S/N	STATION	LAT	LONG	HT.	1976	77	78	79	80	81	82	83	84	85	86	87	88	89
1	JAMMU	32 44'	74 55'	1250														
2	SAMBA	32 34'	75 07'	1250														
3	UDHAMPUR	32 55'	75 08'	2535														
4	RAMNAGAR	32 42'	75 19'	2600														
5	BADARWAH	32 59'	75 43'	5390														
6	KATHUA	32 22'	75 32'	1034	186.45	171.98	193.83	60.09	119.68	146.81	128.69	152.38	144.87	157.76	143.13	100.55	227.40	89.26
7	BASHOLI	32 30'	75 49'	1805														
8	RAMKOTE	32 30'	75 20'	1950	239.84	164.18												
9	BHADDU	32 34'	75 31'	2487														
10	JASROTA	32 28'	75 25'	1230														
11	UJH DAM	32 35'	75 29'	1900														
12	MANDLI	32 39'	75 31'	---	67.50	187.76	231.78	43.28	103.34	172.11	181.46	224.00	141.46	113.18	92.90	143.40	281.90	121.20
	AVERAGE				124.20	131.00	202.50	83.60	123.30	120.70	127.00	178.00	118.50	121.00	117.00	107.00	213.00	106.60

NOTE : 1. Values underlined are missing data computed by distance power method.
2. Rainfall data of Ramnagar stn; for 1976 & 77are doubtful.
Rainfall data of Baderwah stn; and Bhaddu stn; for 1967 and 71 are also doubtful.
3. Blanks indicate non availability of data.
4. Height(HT.) is on above MSL.

Table 3
Monsoon Contribution of Annual Rainfall
(12 stations mean)

S.No.	Year	% of Annual Rainfall				
		June	July	Aug	Sept	Seasonal
1	1961	3.7	25.1	29.9	17.2	96
2	1962	3.4	20.3	30.7	21.2	72
3	1963	4.9	21.1	32.3	7.5	66
4	1964	4.1	22.1	25.6	16.6	68
5	1965	2.3	25.8	12.9	12.7	43
6	1966	12.6	23.1	22.1	17.9	75
7	1967	3.2	27.5	26.1	23.7	80
8	1968	58.7	34.8	26.0	3.4	70
9	1969	1.6	22.7	36.1	6.4	67
10	1970	1.2	1.9	34.4	14.4	80
11	1971	14.9	27.4	45.6	2.5	90
12	1972	5.6	28.0	29.2	12.4	75
13	1973	7.7	21.2	40.2	10.6	79
14	1974	3.5	40.4	25.7	3.5	73
15	1975	2.6	34.8	28.7	10.8	72

5.5 Maximum rainfall

Maximum rainfall of one, two and three days durations have been determined for the three rainfall stations viz; Mandli, Ujh damsite and Jasrota which fall within catchment from the historical data. The "Bhaddu" raingauge station which also falls within the catchment is with scant data and hence is not considered for determining maximum rainfall. The maximum one,

two and three days rainfall are shown in table 4-6. The so far recorded highest one, two and three days rainfall within Ujh basin are 215, 425 and 530 mm at Mandli station from 24 to 26 Sept. 88. This storm was unusual and its corresponding flood and caused severe damage as already mentioned in section 1.0.

5.6 Frequency Analysis

The Mandli station lying almost in the centre of catchment whose rainfall distribution should be representative of Ujh watershed in general was subjected to frequency analysis. The annual series was subjected to extreme value frequency analysis (EV-1). The one day rainfall depths for 5, 10, 50, 100 and 1000 years return periods were found to be 166, 197, 266, 295 and 393 mm respectively. The frequency curve shown in Fig.2, should be useful for design purposes.

TABLE -4

MAXIMUM RAINFALL

Station : MANDLI

		JUNE			JULY			AUGUST			SEPTEMBER		
SN.	YEAR	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.
1	1961	28.0 14	-	-	200.0 23	214.0 22,23	239.0 21,22,23	145.0 8	175.0 8,9	225.0 7,8,9	158.0 6	237.0 6,7	262.0 6,7,8
2	1962	30.0 16	52.5 16,17	27.0 15,16,17	65.0 2	87.0 2,3	106.0 2,3,4	168.0 25	247.0 25,26	253.0 25,26,27	110.5 20	220.5 19,20	238.0 19,20,21
3	1963	----------DATA NOT AVAILABLE----------											
4	1964	----------DATA NOT AVAILABLE----------											
5	1965	19.3 29	-	-	175.0 26	226.0 25,26	259.0 24,25,26	86.0 20	94.5 20,21	100.5 20,21,22	18.5 19	-	-
6	1966	12.1 24	97.0 19,20	98.1 19,20,21	72.0 25	104.0 25,26	111.2 20,21,22	120.0 19	141.0 19,20	157.0 18,19,20	90.0 9	175.0 8,9	235.0 8,9,10
7	1967	14.0 29	12.0 15,16	-	95.6 5	160.6 5,6	164.0 5,6,7	80.0 3	125.0 3,4	113.0 3,4,5	71.0 15	123.0 14,15	140.0 14,15,16
8	1968	22.4 10	26.4 10,11	-	125.0 29	249.0 28,29	261.0 27,28,29	49.0 19	57.0 19,20	81.0 19,20,21	60.0 15	-	-
9	1969	27.4 27	-	-	120.0 29	107.0 17,18	123.0 16,17,18	51.0 11	66.0 6,7	78.0 6,7,8	62.0 5	52.0 9,10	-
10	1970	75.0 15	135.0 15,16	-	80.0 1	140.0 1,2	170.0 1,2,3	75.0 3	125.0 3,4	143.0 3,4,5	70.0 4	105.0 4,5	92.0 9,10,11
11	1971	11.7 25	-	-	157.0 24	177.0 23,24	106.5 13,14,15	102.0 6	201.0 5,6	291.0 5,6,7	30.2 2	19.1 8,9	28.5 7,8,9
12	1972	12.5 29	15.9 28,29	26.5 27,28,29	72.0 9	140.2 8,9	71.8 18,19,20	25.0 29	31.0 28,29	40.2 5,6,7	72.4 22	80.7 21,22	91.8 4,5,6
13	1973	13.3 12	24.4 12,13	-	118.0 20	141.3 5,6	224.4 18,19,20	163.0 8	248.0 8,9	319.0 7,8,9	190.0 19	207.0 18,19	213.0 18,19,20
14	1974	50.0 23	-	-	95.0 24	180.0 23,24	255.0 23,24,25	95.0 4	165.0 4,5	215.0 3,4,5	50.0 18	-	-
15	1975	-	-	-	200.0 16	320.0 21,22	370.0 21,22,23	85.0 20	137.0 20,21	157.0 20,21,22	58.0 15	78.0 15,16	83.0 3,4,5

TABLE -4 Contd.

MAXIMUM RAINFALL

Station : MANDLI

		JUNE			JULY			AUGUST			SEPTEMBER		
SN.	YEAR	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.
16	1976	15.0 17	21.0 16,17	23.0 15,16,17	85.0 26	160.0 25,26	165.0 29,30,31	150.0 2	213.0 1,2	222.0 1,2,3	-	-	-
17	1977	170.0 11	180.2 15,16	252.4 15,16,17	-	-	-	60.0 4	95.0 1,2	97.0 1,2,3	50.0 6	73.0 5,6	98.0 4,5,6
18	1978	48.0 30	60.0 29,30	70.0 28,29,30	145.0 3	181.0 14,15	244.0 14,15,16	100.0 9	175.0 9,10	275.0 9,10,11	100.0 15	150.0 14,15	-
19	1979	20.0 27	6.0 12,13	8.0 12,13,14	-	-	-	-	-	-	-	-	-
20	1980	25.0 13	35.0 27,28	-	100.0 14	170.0 14,15	228.0 13,14,15	73.0 2	94.6 2,3	102.6 1,2,3	38.0 10	49.0 10,11	51.0 10,11,12
21	1981	63.0 30	40.0 10,11	-	152.0 14	181.4 13,14	127.0 24,25,26	100.0 13	165.0 12,13	180.0 12,13,14	9.6 30	12.0 17,18	-
22	1982	12.0 15	-	-	55.0 1	65.0 24,25	83.0 24,25,26	75.0 2	105.0 1,2	105.0 9,10,11	24.0 23	-	-
23	1983	23.0 16	48.0 15,16	-	82.0 21	98.0 26,27	113.0 26,27,28	78.0 30	87.0 2,3	127.0 2,3,4	25.0 11	45.0 11,12	60.0 9,10,11
24	1984	24.0 27	45.0 27,28	42.0 16,17,18	62.0 23	86.0 29,30	108.0 28,29,30	85.0 16	95.0 1,2	152.0 19,20,21	32.0 1,2	-	-
25	1985	----------DATA NOT AVAILABLE----------											
26	1986	21.0 24	30.0 26,27	37.0 26,27,28	35.0 19	42.0 19,20	46.0 18,19,20	78.0 4	98.0 4,5	116.0 3,4,5	18.0 29	16.0 26,27	-
27	1987	26.0 10	48.0 9,10	-	30.0 24	58.0 24,25	74.0 24,25	72.0 29	90.0 28,29	96.0 27,28,29	22.0 4	27.0 9,10	30.0 6,7,8
28	1988	27.4 19	18.8 22,23	-	203.0 22	227.0 22,23	242.0 22,23,24	146.0 9	226.0 8,9	252.0 7,8,9	215.0 25	425.0 24,25	530.0 23,24,25
29	1989	20.0 11	19.0 17,18	-	156.0 4	201.0 23,24	221.0 23,24,25	123.0 23	93.0 1,2	35.0 24,25,26	23.0 11	18.0 23,24	-

TABLE - 5

MAXIMUM RAINFALL

Station : JASROTA

		JUNE			JULY			AUGUST			SEPTEMBER		
SN.	YEAR	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.
1	1961	35.6 29	6[illegible].6 29,30	-	106.7 30	137.2 29,30	144.8 29,30,31	86.4 11	106.7 11,[illegible]	175.3 [illegible],12,13	58.4 24	81.3 24,25	86.4 24,25,26
2	1962	17.8 14	17.8 14 [illegible]	20.3 14 15,16	40.6 29	27.9 7,8	35.5 7,8,9	88.9 26	106.7 25,26	111.8 26,27,28	149.9 22	213.4 21,22	221.0 21,22,23
3	1963	58.9 28	69.[illegible] 28,29	-	55.9 30	85.9 30,31	98.6 29,30,31	81.3 11	152.4 11,12	109.3 5,6,7	50.8 3	52.1 3,4	64.8 3,4,5
4	1964	31.0 25	10.[illegible] 14,15	-	37.0 27	72.0 26,27	101.2 26,27,28	127.0 16	133.[illegible] 15,16	-	152.0 1	232.0 1,2	49.6 8,9,10
5	1965	12.0 30	-	-	93.1 31	120.0 23,24	163.0 22,23,24	94.0 22	102.0 21,22	107.8 21,22,23	-	-	-
6	1966	63.5 23	81.0 19,20	92.9 19,20,21	100.0 31	102.0 24,25	127.0 24,25,26	83.0 11	132.0 5,6	154.0 4,5,6	75.0 8	-	-
7	1967	41.3 28	44.[illegible] 28,29	-	133.6 6	161.6 5,6	161.9 4,5,6	135.0 3	140.0 3,4,5	210.0 4,5,6	195.0 12	293.0 12,13	368.0 12,13,14
8	1968	35.0 26	18.0 2,3	18.3 2,3,4	120.0 21	181.0 12,13	185.0 12,13,14	75.0 8	152.0 18,19	202.0 18,19,20	50.0 19	-	-
9	1969 - 1971	----------DATA NOT AVAILABLE----------											
10	1972	27.0 20	-	-	160.0 7	245.0 8,9	256.0 8,9,10	128.0 6	39.0 28,29	-	32.4 14	34.8 14,15	61.6 14,15,16
11	1973	80.0 24	128.0 24,25	184.0 24,25,26	-	-	-	175.0 9	325.0 7,8	375.0 8,9,10	60.0 12	120.0 12,13	150.0 12,13,14
12	1974 - 1990	----------DATA NOT AVAILABLE----------											

TABLE -6

MAXIMUM RAINFALL

Station : UJH DAM SITE

		JUNE			JULY			AUGUST			SEPTEMBER		
SN.	YEAR	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.	ONE DAY MAX.	TWO DAY MAX.	THREE DAY MAX.
1	1961	18.3 22	22.4 22,23	-	148.6 23	221.0 23,24	228.0 23,24,25	226.6 9	242.0 9,10	264.7 9,10,11	141.7 4	178.3 7,8	205.5 7,8,9
2	1962	21.8 24	8.5 27,28	-	78.8 24	140.2 24,25	147.9 24,25,26	226.7 27	291.5 27,28	309.9 27,28,29	124.5 21	229.0 21,22	263.6 21,22,23
3	1963	----------DATA NOT AVAILABLE----------											
4	1964	----------DATA NOT AVAILABLE----------											
5	1965	16.4 31	-	-	117.5 22	195.9 22,23	214.7 22,23,24	86.2 22	134.1 21,22	137.1 20,21,22	9 4	-	-
6	1966	100.4 25	126.0 19,20	132.2 27,28,29	199.0 31	128.3 25,26	141.4 24,25,26	88.0 6	118.2 6,7	127.4 6,7,8	33.8 8	34.0 7,8	34.7 6,7,8
7	1967	13.0 16	17.7 16,17	18.2 15,16,17	98.7 6	133.7 5,6	140.7 5,6,7	66.2 12	72.2 12,13	104.4 12,13	60.2 12	70.2 11,12	86.0 12,13,14
8	1968	46.3 11	51.8 10,11	56.4 10,11,12	206.7 20	211.5 20,21	218.7 18,19,20	113.9 19	146.4 18,19	176.1 18,19,20	16.0 19	-	-
9	1969	9.0 16	6.4 27,28	-	103.2 20	116.6 19,20	136.6 18,19,20	234.9 6	263.8 5,6	273.8 4,5,6	35.4 12	41.9 8,9	45.3 7,8,9
10	1970	123.2 15	125.6 14,15	198.4 13,14,15	58.7 31	63.3 30,31	63.7 29,30,31	57.4 14	82.8 13,14	105.6 13,14,15	63.0 4	94.4 2,3	97.9 3,4,5
11	1971	105.8 22	106.8 22,23	112.8 22,23,24	100.6 1	132.6 1,2	208.9 1,2,3	157.5 2	231.5 2,3	233.9 1,2,3	44.5 8	57.5 8,9	-
12	1972	11.8 28	15.0 27,28	26.0 26,27,28	78.9 8	123.1 8,9	124.7 8,9,10	67.0 9	80.6 9,10	89.3 8,9,10	10.6 10	16.2 9,10	26.6 8,9,10
13	1973	48.0 12	70.4 13,14	49.3 24,25,26	67.6 16	124.8 15,16	128.8 26,27,28	160.0 10	209.4 9,10	315.4 8,9,10	82.4 16	102.2 15,16	112.7 15,16,17
14	1974	53.0 25	54.2 24,25	-	179.8 16	253.1 16,17	295.1 15,16,17	158.0 11	185.4 11,12	296.9 11,12,13	10.2 8	8.6 24,25	-
15	1975	32.6 19	48.3 19,20	35.6 28,29,30	171.0 17	144.6 23,24	177.8 22,23,24	194.0 2	313.8 1,2	352.8 1,2,3	98.6 1	99.6 1,2	61.6 15,16,17

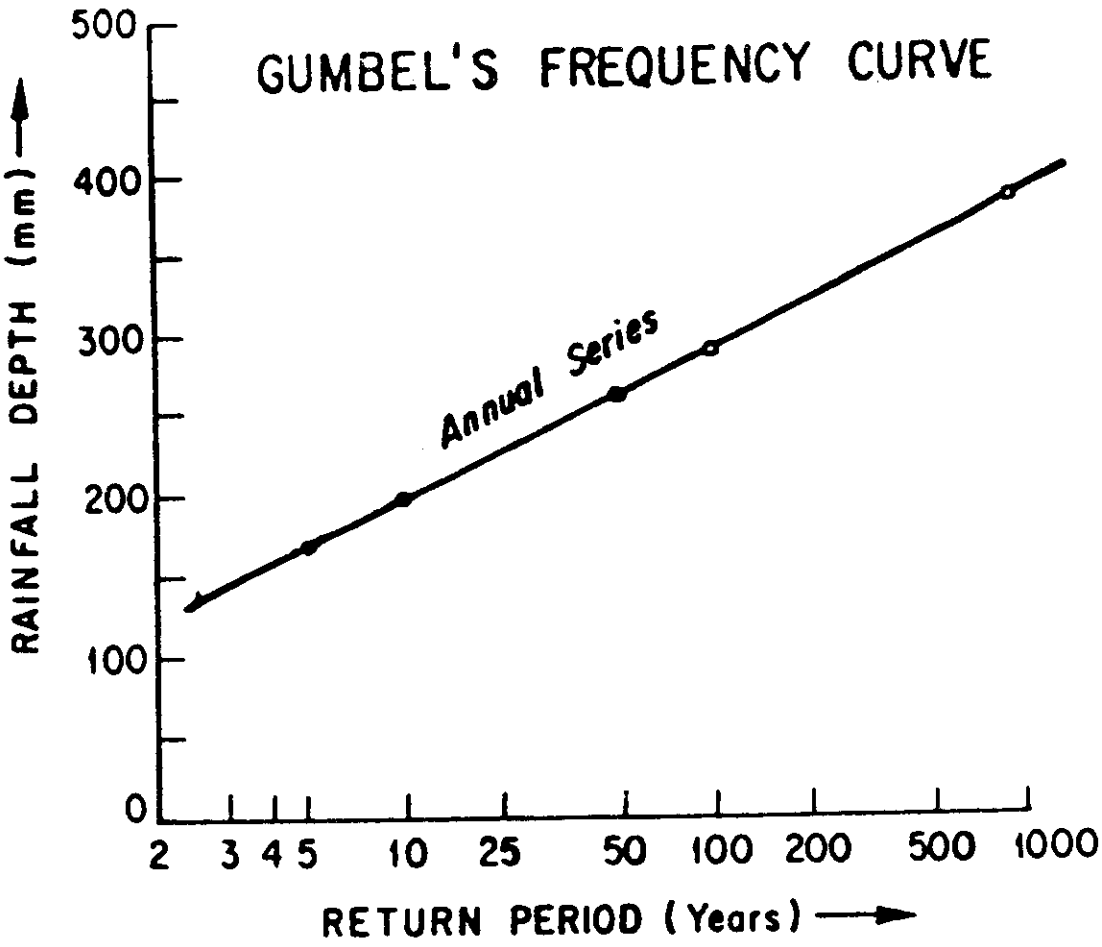

GUMBEL'S FREQUENCY CURVE
RAINFALL DEPTH (mm)
500
400
300
200
100
0
Annual Series
2
3
4
5
10
25
50
100
200
500
1000
RETURN PERIOD (Years)

Fig. 2

5.7 Annual Rainfall pattern and Moving Means

The Mandli raingauge station which lies almost in the centre of catchment is considered to reflect the trend of rainfall pattern of the catchment. Fig.3 shows the yearly distribution of annual rainfall from 1960 to 1989 along with 3 years and 5 years moving means.

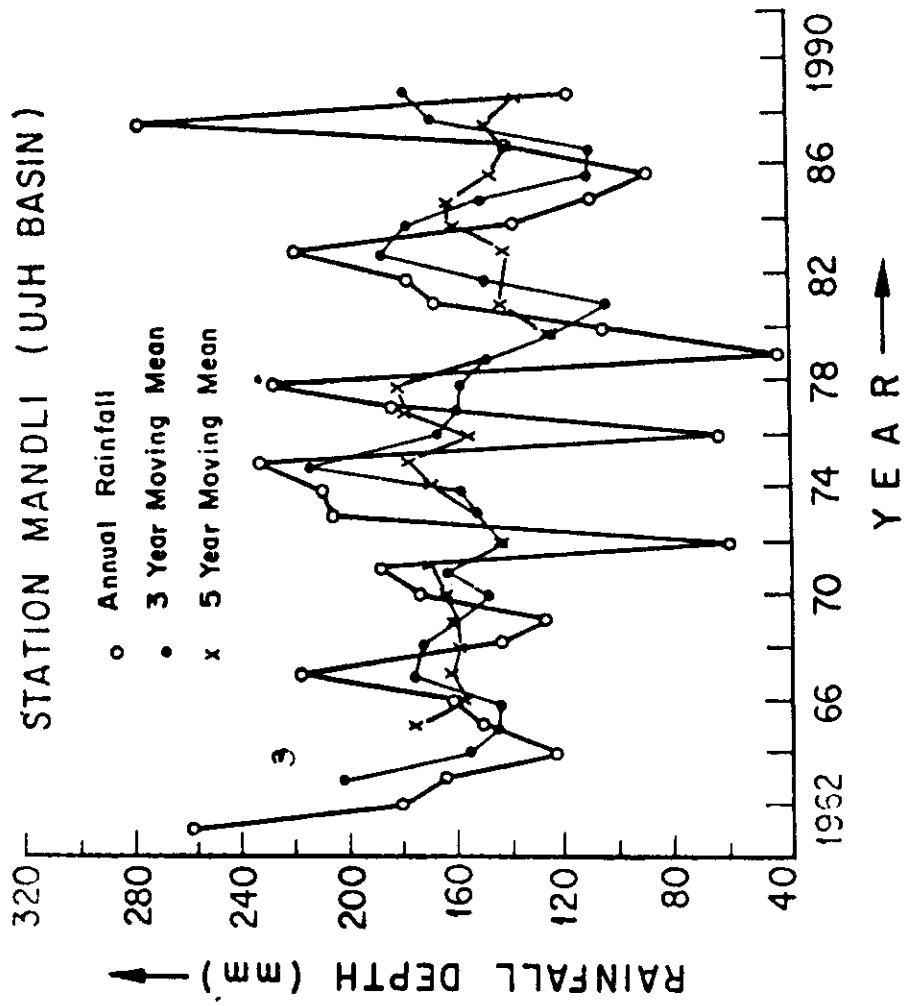

STATION MANDLI (UJH BASIN)
o Annual Rainfall
• 3 Year Moving Mean
x 5 Year Moving Mean
RAINFALL DEPTH (mm)
320
280
240
200
160
120
80
40
1962
66
70
74
78
82
86
1990
YEAR

Fig. 3

6.0 SELECTION OF STORM AND RAIN STORM ANALYSIS

6.1 Selection of storm

In arriving at design storm,a number of rain storms were analysed. For this purpose, the daily rainfall data of various rain gauge stations in and around the basin were scrutinised.Keeping a threshold value of rainfall as 30 mm,all such rain spells during which a number of stations recorded rainfall equal to or above the threshold on one day and above were selected. To select the severest rain storm out of these storms, arithmetic average of the rain storm over the catchment area was computed and two severemost storms were subjected to catchment centered isopercental/ isohyetal analysis. The chronological sequence of important storms and their average depth over the catchment have been computed as shown in table 7.

6.2 Isopercental Computations and DAD Analysis

6.2.1 Methodology

Ujh sub basin being mountainous, the conventional method of isohyetal analysis in arriving at critical depths would give erroneous results. As such isopercental technique (Indian Meteorological deptt,1972) is being adopted to take into account the variation of rainfall with elevation.

The isopercental method essentially requires a base map of either mean annual precipitation of the region or preferably seasonal mean precipitation of the region, for that particular season in which the storm had occurred. There after the ratio of the storm precipitation to the mean annual or seasonal

Table 7

Computed Average depth of rainfall over the basin

Date	Avr depth (mm)
7 Aug 1961	5.97
8 - do -	50.37
9 - do -	88.96
6 Sep 1961	11.90
7 - do -	77.87
8 - do -	47.35
7 Aug 1973	52.71
8 - do -	82.80
9 - do -	132.72
16 Jul 1975	113.16
21 Jul 1975	44.66
22 - do -	57.78
23 - do -	76.87
15 Jun 1977	26.62
16 - do -	11.90
17 - do -	14.44
14 Jul 1980	57.85
15 - do -	118.33
24 Sep 1988	161.28
25 - do -	208.28
26 - do -	197.64
27 - do -	23.61

precipitation is expressed as % and plotted at each station and smooth isolines are drawn. The percental ratios on the lines are then multiplied by the original base map values at a large number of points of intersection by superimposing the isolines to obtain a new set of points. These new points enable one in drawing the final isohyetal map. Thus the storm isohyetal gradients and locations of centres tend to resemble features of the seasonal or

annual isohyetal pattern and get adjusted not only for topographic features but also incorporate the pattern of storm occurrence. While arriving at valid conclusions, same number of stations (and same stations) should be used as far as possible in the analysis.

6.2.2 Analysis

In the present analysis the storm of 7-9 Aug. 1961 and 7-9 Aug. 1973 has been considered for analysis inspite of the fact that the storm of 24-27 Sept.1988 is severemost and unusual. This is due to lack of proper data for most of the stations in and around Ujh sub basin during Sept 88. 12 stations (as shown in Fig.1) data has been used for the analysis.

The isopercental computations were made and subsequently isohyetal maps were obtained for one, two and three days storms (7-9 Aug.1961 & 7-9 Aug.1973). These are shown in Fig.4 through 9. The DAD curve is shown in Fig. 10-11.

Table 8 shows one, two and three days average depths of precipitation from DAD curves. These critical depths should help in the design of projects.

Table 8
Depth Area Duration Values

DURATION	STORM PERIOD	CENTRAL VALUE	AVERAGE DEPTH (MM) OF PRECIPITATION OVER AN AREA (SQ. KM)								
			200	300	400	500	600	700	800	900	930
1 DAY	9 AUG 1961	190	156	135	128	118	110	102	92	88	85
	9 AUG 1973	270	240	232	225	220	215	210	205	200	196
2 DAY	8-9 AUG 1961	210	190	180	175	165	160	155	150	147	145
	8-9 AUG 1973	460	405	395	385	375	365	355	345	337	331
3 DAY	7-9 AUG 1961	260	245	235	226	217	208	200	188	180	177
	7-9 AUG 1973	575	525	497	475	455	437	417	400	380	372

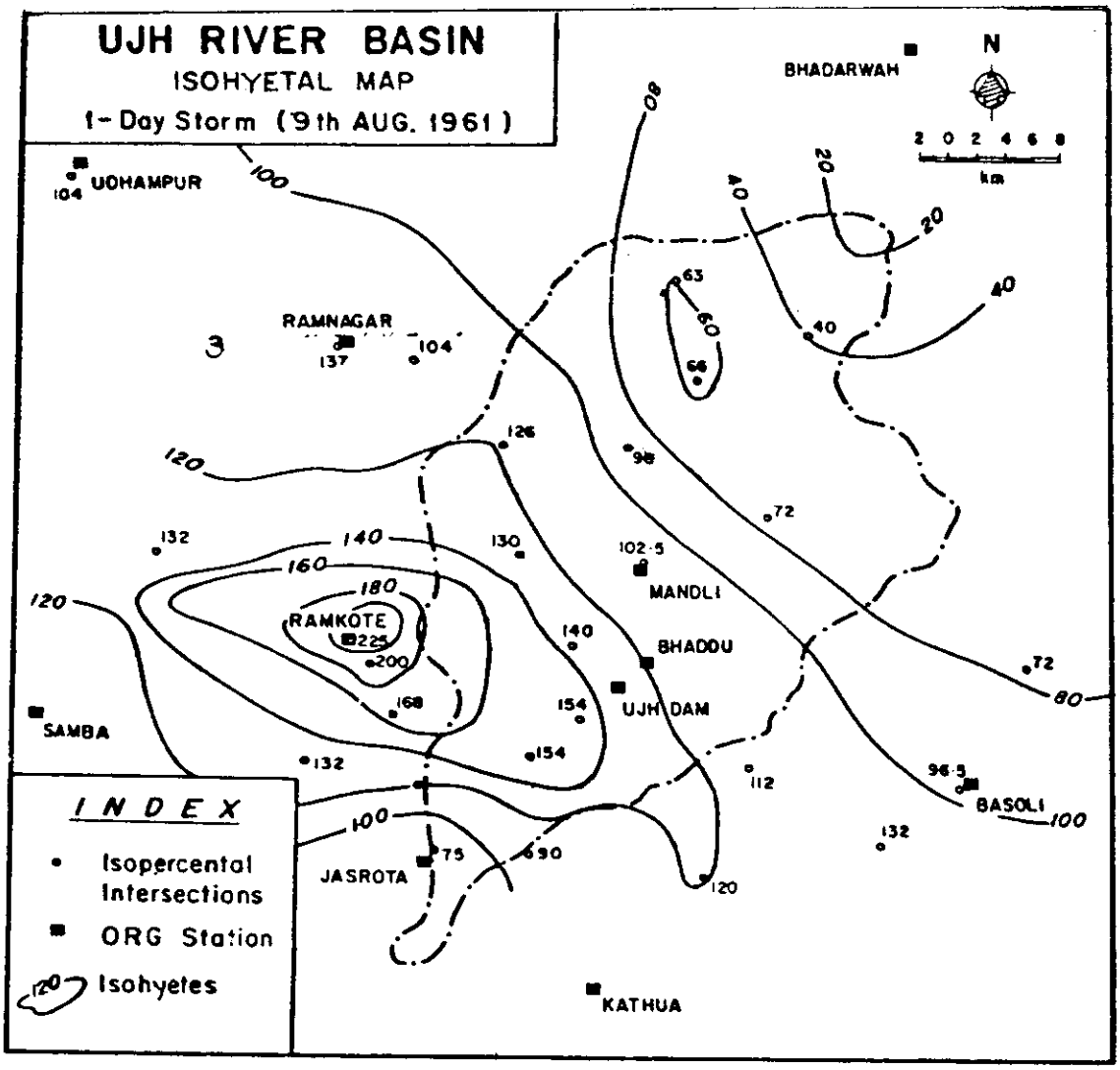

UJH RIVER BASIN
ISOHYETAL MAP
1-Day Storm (9th AUG. 1961)
N
BHADARWAH
UDHAMPUR
RAMNAGAR
RAMKOTE
MANDLI
BHADDU
UJH DAM
SAMBA
JASROTA
BASOLI
KATHUA
INDEX
Isopercental Intersections
ORG Station
Isohyetes

Fig.4

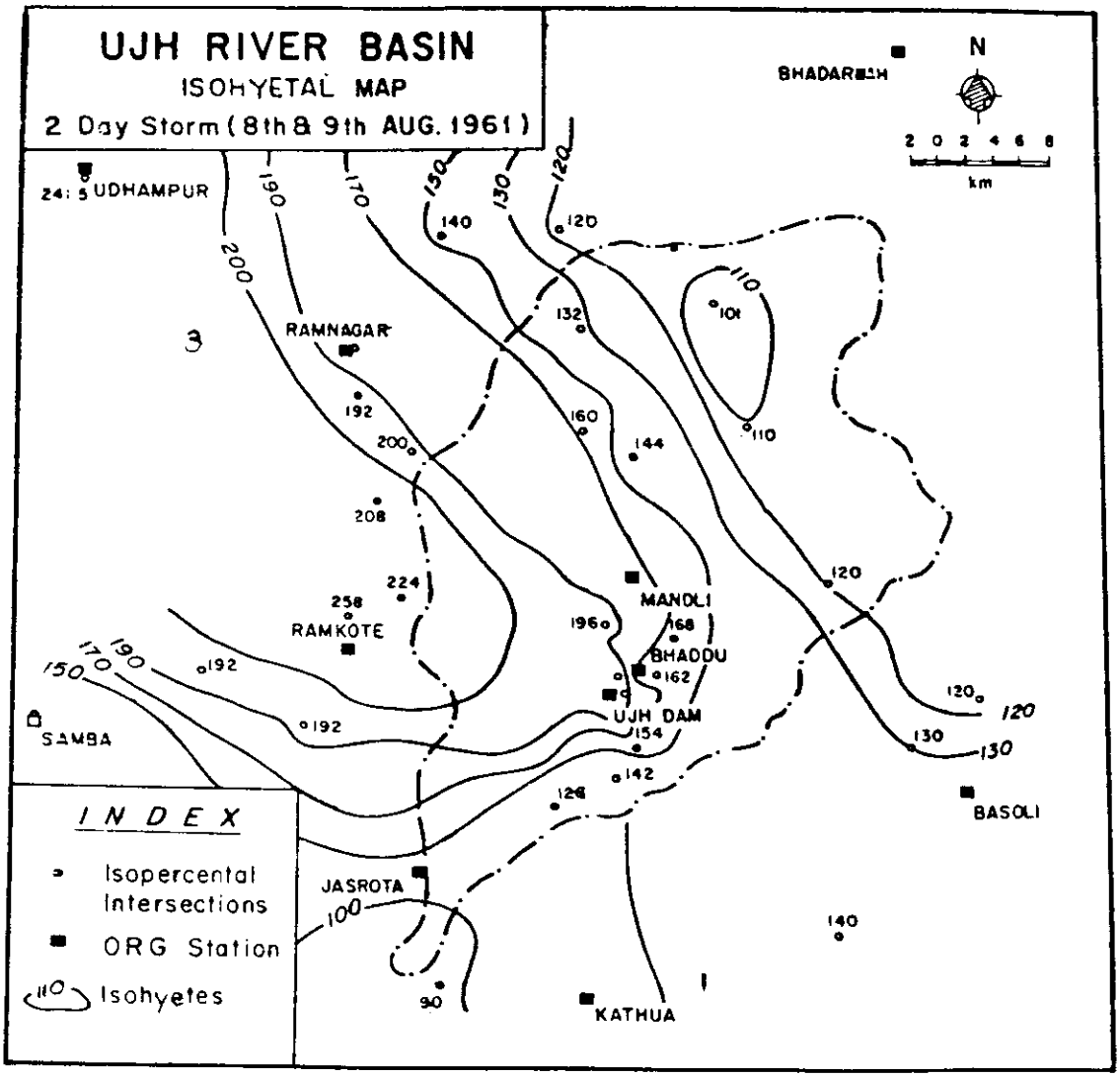

UJH RIVER BASIN
ISOHYETAL MAP
2 Day Storm (8th & 9th AUG. 1961)
N
2 0 2 4 6 8
km
BHADARSH
UDHAMPUR
RAMNAGAR
RAMKOTE
MANDLI
BHADDU
UJH DAM
SAMBA
JASROTA
KATHUA
BASOLI
INDEX
Isopercental Intersections
ORG Station
Isohyetes

Fig.5

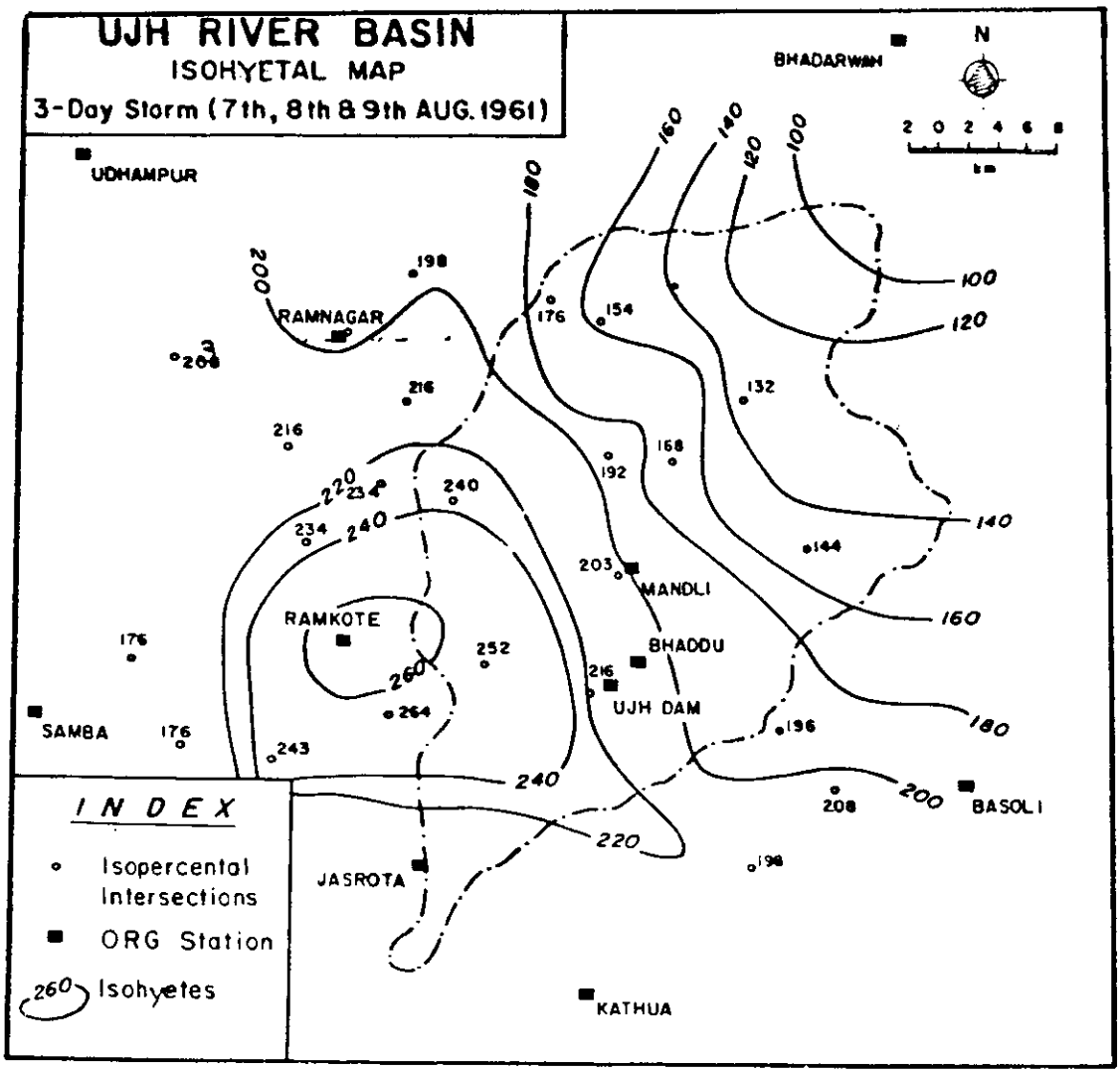
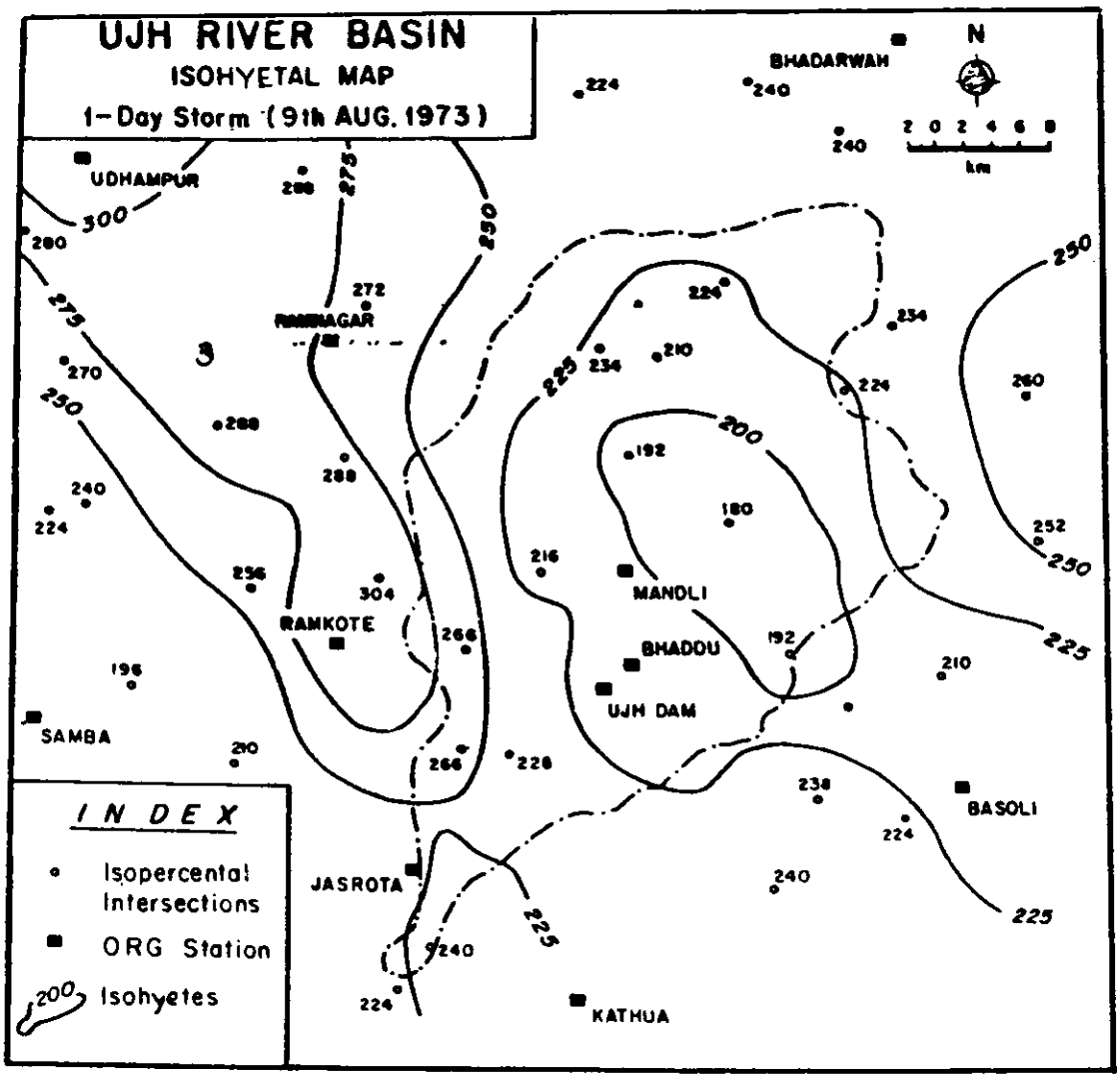

UJH RIVER BASIN
ISOHYETAL MAP
3-Day Storm (7th, 8th & 9th AUG. 1961)
N
BHADARWAH
UDHAMPUR
RAMNAGAR
RAMKOTE
MANDLI
BHADDU
UJH DAM
SAMBA
JASROTA
KATHUA
BASOLI
INDEX
Isopercental Intersections
ORG Station
Isohyetes

Fig. 6


UJH RIVER BASIN
ISOHYETAL MAP
1-Day Storm (9th AUG. 1973)
N
BHADARWAH
UDHAMPUR
RAMNAGAR
RAMKOTE
MANDLI
BHADOU
UJH DAM
SAMBA
JASROTA
KATHUA
BASOLI
INDEX
Isopercental Intersections
ORG Station
Isohyetes
km

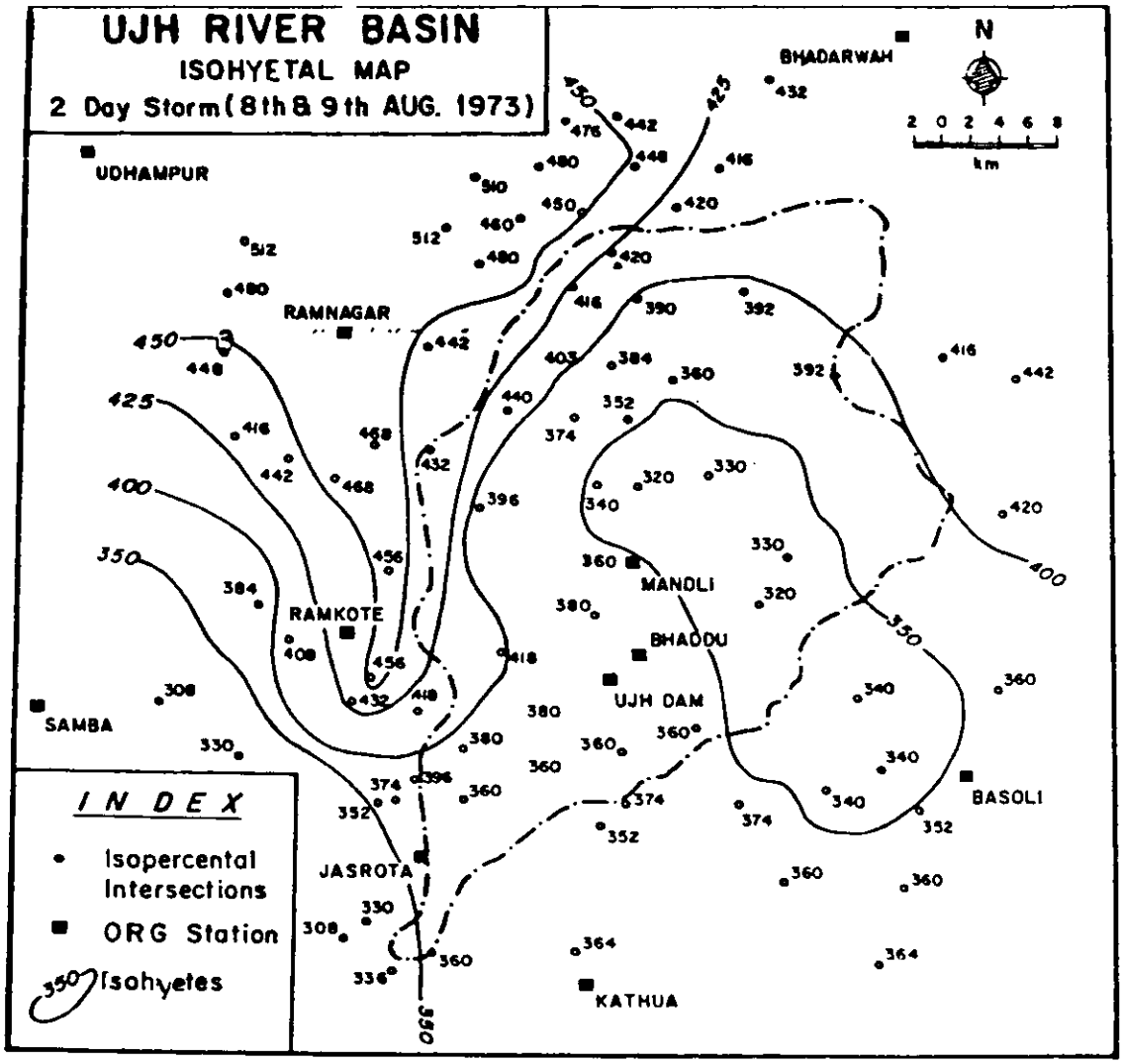

UJH RIVER BASIN
ISOHYETAL MAP
2 Day Storm (8th & 9th AUG. 1973)
N
2 0 2 4 6 8
km
BHADARWAH
UDHAMPUR
RAMNAGAR
RAMKOTE
MANDLI
BHADDU
UJH DAM
SAMBA
JASROTA
BASOLI
KATHUA
INDEX
Isopercental Intersections
ORG Station
Isohyetes

Fig 8

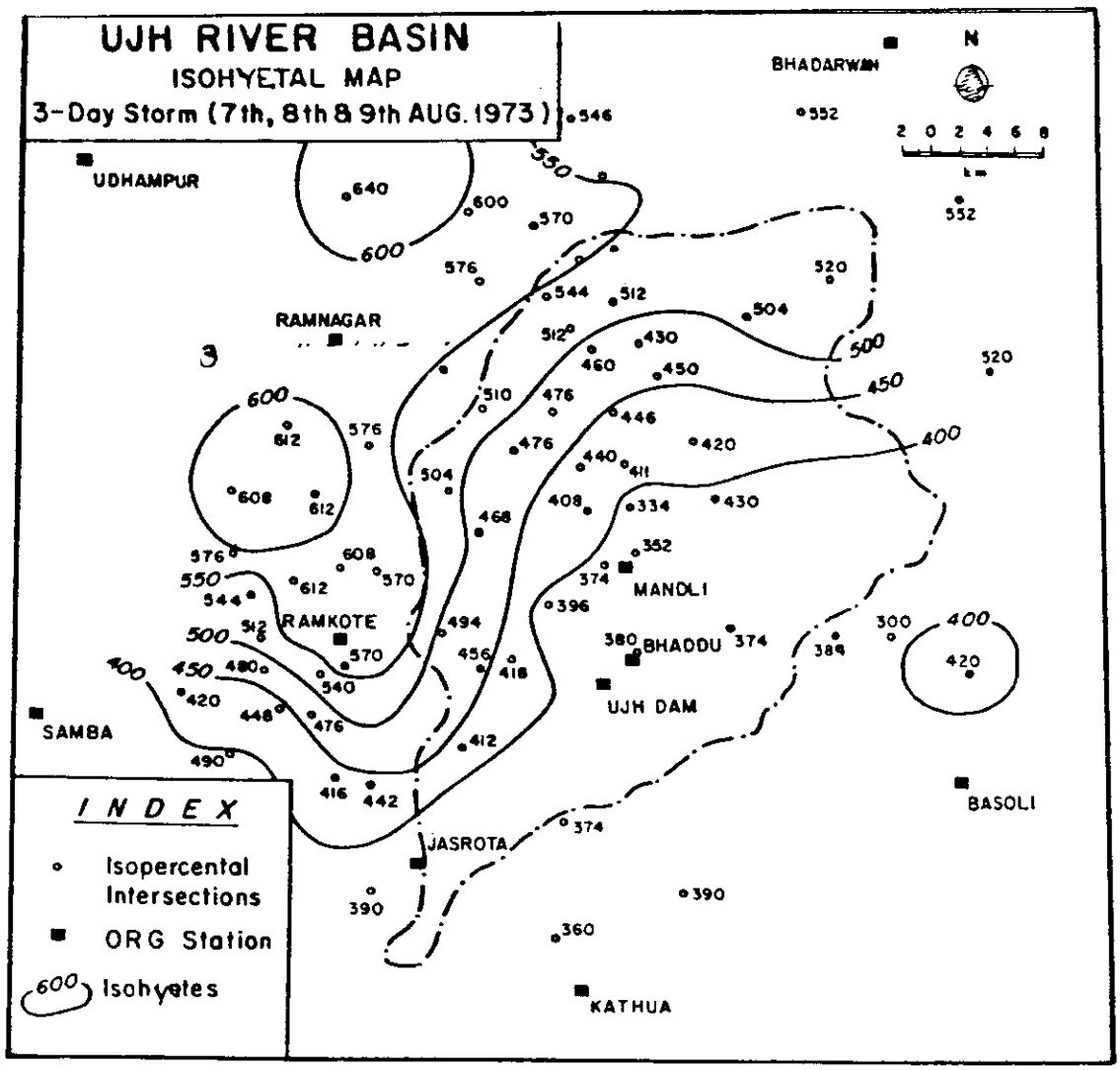

UJH RIVER BASIN
ISOHYETAL MAP
3-Day Storm (7th, 8th & 9th AUG. 1973)
N
2 0 2 4 6 8
km
BHADARWAH
UDHAMPUR
RAMNAGAR
RAMKOTE
MANDLI
BHADDU
UJH DAM
SAMBA
JASROTA
BASOLI
KATHUA
INDEX
Isopercental Intersections
ORG Station
Isohyetes

Fig. 9

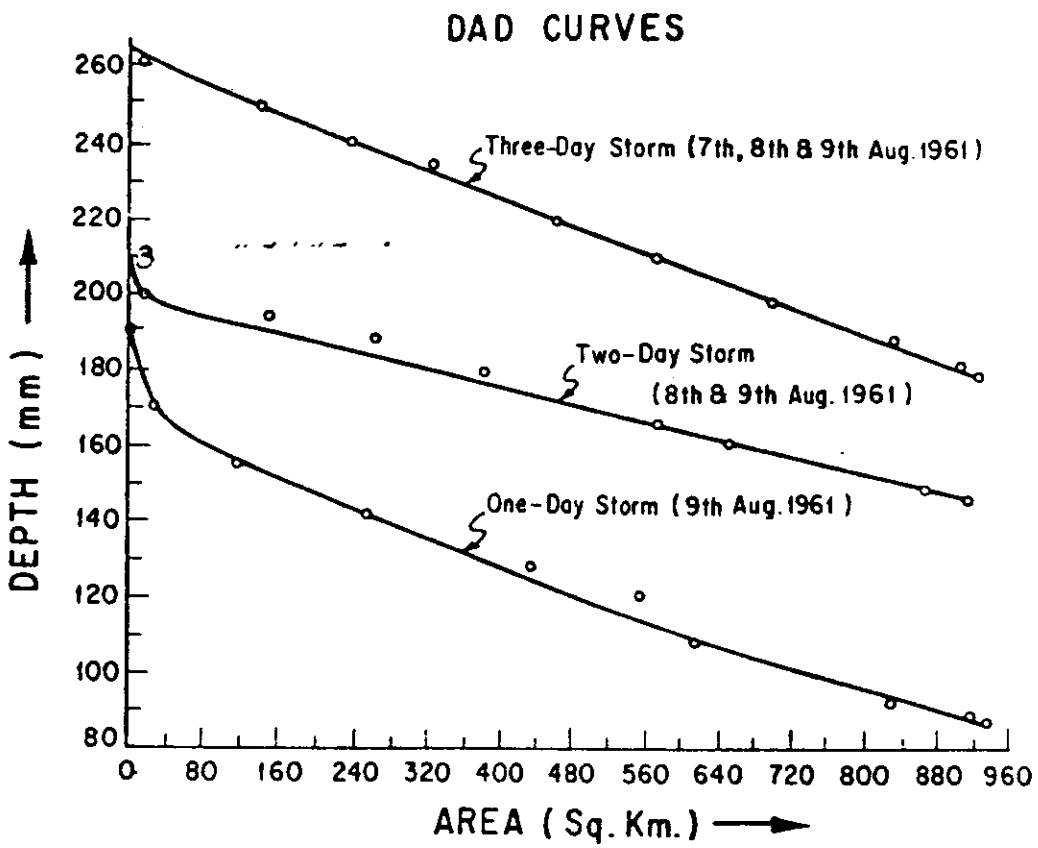

DAD CURVES
DEPTH (mm)
260
240
220
200
180
160
140
120
100
80
Three-Day Storm (7th, 8th & 9th Aug. 1961)
Two-Day Storm
(8th & 9th Aug. 1961)
One-Day Storm (9th Aug. 1961)
0
80
160
240
320
400
480
560
640
720
800
880
960
AREA (Sq. Km.)

Fig.10

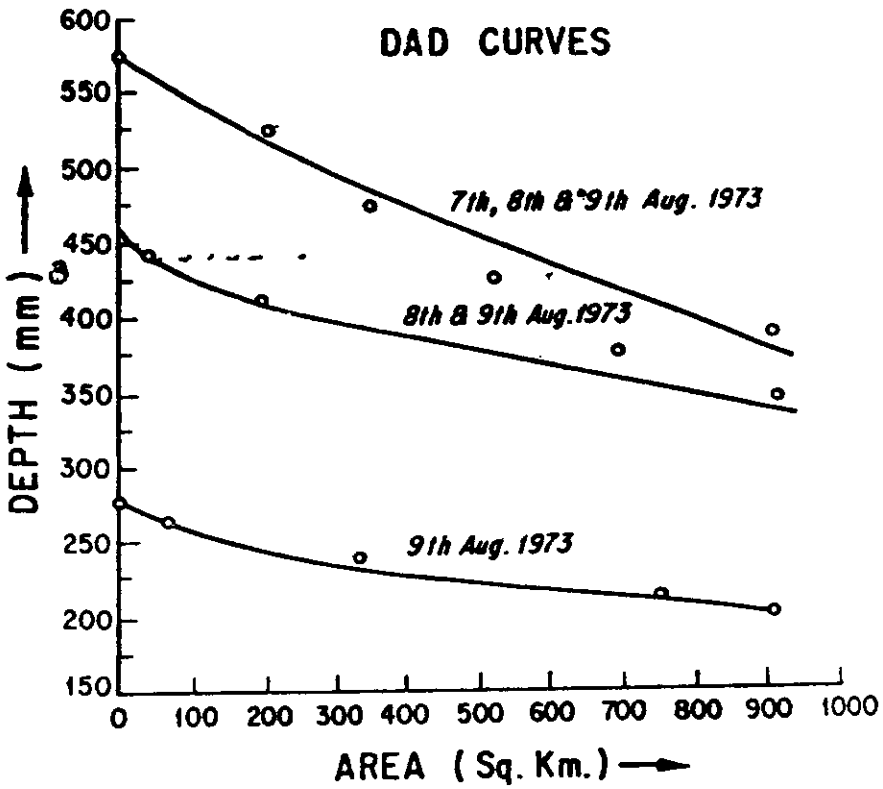

DAD CURVES
600
550
500
450
400
350
300
250
200
150
DEPTH (mm)
7th, 8th & 9th Aug. 1973
8th & 9th Aug. 1973
9th Aug. 1973
0
100
200
300
400
500
600
700
800
900
1000
AREA (Sq. Km.)

Fig.11

7.0 CONCLUSIONS

The following conclusions may be drawn from the study made on various hydrometeorological aspects.

1. The present analysis of rainfall data gives an overall picture of rainfall pattern and its distribution over the catchment from the limited data that is available.

2. The net work of hydrometeorological stations needs to be improved on WMO norms. Also there is an urgent need to establish reliable data collection network systems in Ujh catchment.

3. Of the nearly 30 years of data available only 15 years data is continuous while the rest has large gaps which can not be filled in for any hydrometeorological analysis as indicated in table 2.

4. The computed average annual rainfall ranges from 140-180 cm. This trend is also reflected in annual series and moving means plotted in Fig 2.

5. The frequency analysis for various return periods provide the depths of maximum likely storms in the basin.

6. There is further scope for studies to be carried out such as design storm estimation by storm maximisation technique, water availability studies and rainfall runoff modelling in order to have a better understanding of the hydrology of Ujh catchment.

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