CS-87

WATER AVAILABILITY STUDIES - UJH RIVER BASIN

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1991-92

PREFACE

Water availability studies form a basic pre-requisite before any water resources project is undertaken. Assured and dependable supplies during the project life are necessary for any economically viable scheme.

The National Institute of Hydrology established its regional centre at Jammu, in the year 1990 to cater the needs of state Irrigation, Flood Control and Allied Departments in the field of hydrology. The Regional Centre has its jurisdiction in the states of J & K, H.P. and hilly parts of U.P. In the present report an attempt has been made in arriving at dependable yields of river UJH in the Jammu region of J&K state. The report should be useful to the Irrigation and Flood Control Department, Jammu.

The report has been prepared by Sri S.V.N. Rao, Scientist 'C' and Sri M.K.Sharma, S.R.A., W.R.R.C., Jammu.

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ABSTRACT

Water availability studies form the basic pre-requisite before any water resources project is undertaken over a stream. The study enables one in arriving at dependable flows for the proposed project life. However dependable flows computed would depend upon the quality and length of data available for analysis. Normally historical data of 30 - 40 years provide good results.

In the report an attempt has been made to study and assess the water available (yield) in the ujh river basin which feeds the main river Ravi in the state of J & K. The analysis has been separated into two components viz., monsoon and nonmonsoon seasons, however it may be noted that the S.W. monsoon provides a major contribution to the annual rainfall and hence the yield. The study should help in the design of water resources projects proposed to be taken over the stream.

1.0 INTRODUCTION:

The ujh river with its source in Western Himalayas has a basin size of 970 Sq Kms. Being a tributary of river Ravi it begins at the foot hills of Bhaderwah, travels westwards for about 100kms and then joins Ravi at Nainkot in Pakistan. A barrage was constructed in 1985 over Ujh tributary near Kathua to divert the flows into a canal for irrigation under Ravi - Tawi scheme.

The river flows are mostly monsoon based with 70 to 75 % as monsoon contribution, while the remaining are due to the snowmelt from the hills of Bhaderwah. About 20 % of the catchment is mountainous and is snowbound for 4 - 6 months of the year. The flood of sept 1988 had exceeded the design capacity causing extensive damage to the existing barrage. The State Govt therefore desired that a complete study of the hydrology of river Ujh be carried out to tackle such floods and to mitigate their impact through proper planning. A study of Hydrometeorology, water availability and design flood are being undertaken by the National Institute of Hydrology, Regional Centre, Jammu. The present report on Water availability study is second in the series of case studies, the first being a report on hydrometeorology.

Before we plan any project on a river, the first and foremost task is to assess its available water at different times of the year. Water availability is the lifeline of any irrigation or multipurpose scheme. The success of a scheme depends on how accurate has been the estimation of total quantity of water available and its variability. Proper estimation of water availability is therefore essential.

Water availability studies are being carried out by conventional and Systems Engg. approach. In this report conventional method has been adopted using exceedance frequencies of historical flow data. However data gaps, inconsistencies and sample size have been the bottlenecks in the analysis. The report should help for assessing the water potential in the design of water resources projects.

2.0 PROBLEM DEFINITION:

The Ujh tributary of river Ravi experiences floods in the monsoon season and occasionally during the winter rains. The river flows have a snowmelt component from the snow bound hills of Bhaderwah at altitudes ranging above 4000 mts.

The floods of Sept 1988 were unusual and had exceeded the design capacity of the barrage constructed downstream of Panjitirthi on river Ujh thereby causing extensive damage to the downstream areas. The state Govt therefore decided that a complete study of hydrology of river Ujh be carried out to mitigate the impact of floods through proper planning. A study of hydrometeorology followed by water yield studies and design flood estimation have therefore been proposed. In the present report water yield studies have been carried out in arriving at dependable yield for nonmonsoon and monsoon periods for river Ujh.

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 of Punjab. The head waters of Ujh lie in the Kailas parvat lake at an altitude of 4300 mtrs near the Bhaderwah hills of Jammu province . It 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 togather 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 dam site is 990 Sq Kms Planimetered from topo sheet. The catchment is quite hilly and rugged varying in altitude from 510M 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 snowboundfor 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 73.4 degree Fahrenheit can be taken to represent the southern part of the catchment and that of Dalhousie of 60.6 degree Fahrenheit of the eastern portion. The temperature at higher altitudes in the northern part is expected to be low .The climate conditions vary from semi arid to humid from south to

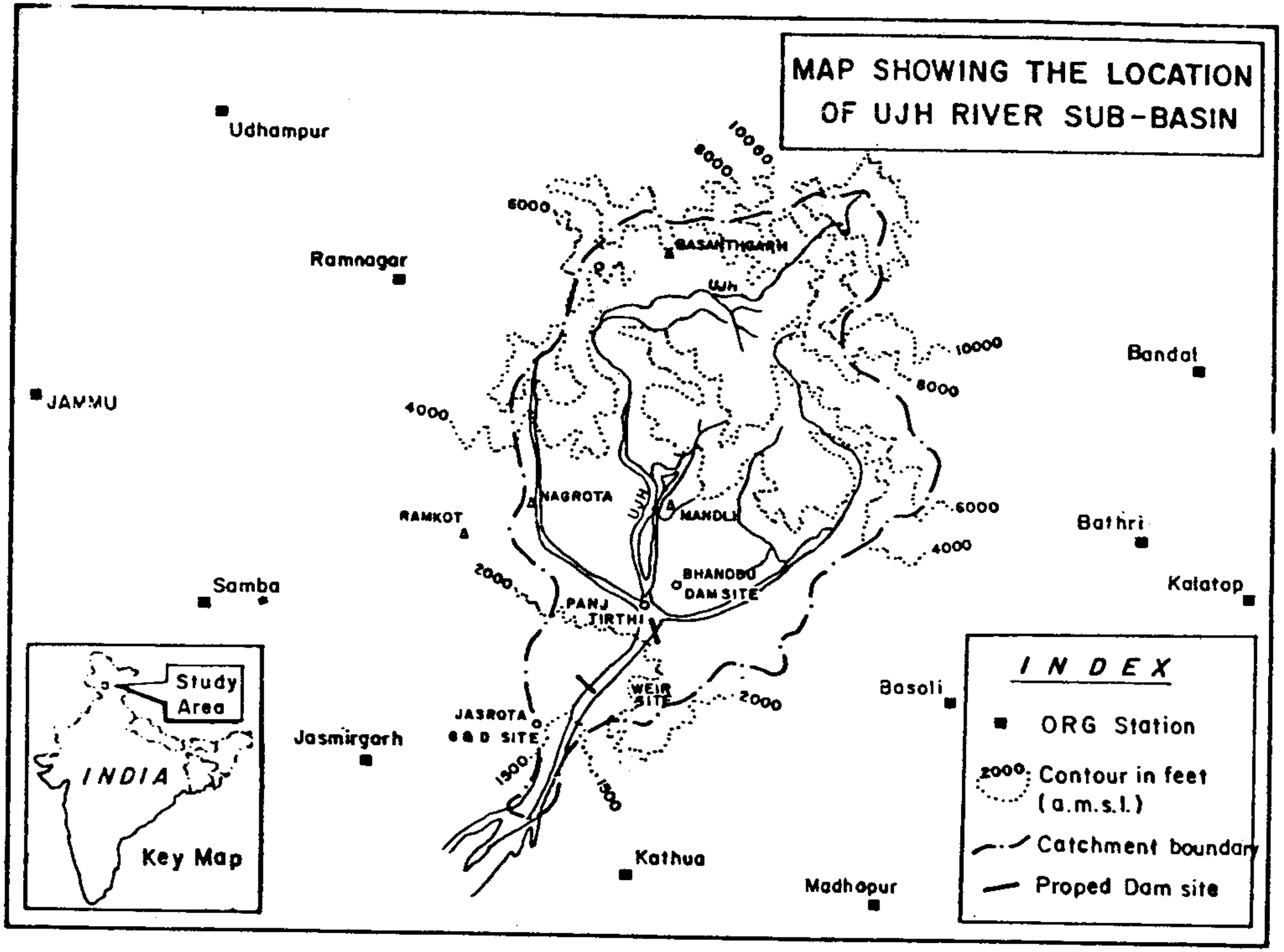

MAP SHOWING THE LOCATION
OF UJH RIVER SUB-BASIN
Udhampur
Ramnagar
JAMMU
Samba
Jasmirgarh
RAMKOT
NAGROTA
BASANTHGARH
UJH
MANDLI
BHANDBU DAM SITE
PANJ TIRTHI
WEIR SITE
JASROTA
G & D SITE
Kathua
Madhopur
Basoli
Bathri
Bandal
Kalatop
10060
8000
6000
4000
2000
1500
10000
Study Area
INDIA
Key Map
INDEX
ORG Station
Contour in feet (a.m.s.l.)
Catchment boundary
Proped Dam site

Fig.1

northern parts of the catchment.

There are two rainy seasons one from December to March associated with the passage of western disturbances and the other mid June to mid September due to south west monsoon currents. The rain fall 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 onthe 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 with 50 yearnormals of annual rainfall being 1400 to 1600 mm around Ujh catchment. The normal rain fall of some of the stations around Ujh catchment are presented in table 1.

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	54.8	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

4.0 DATA AVAILABILITY

4.1 Rain fall data :

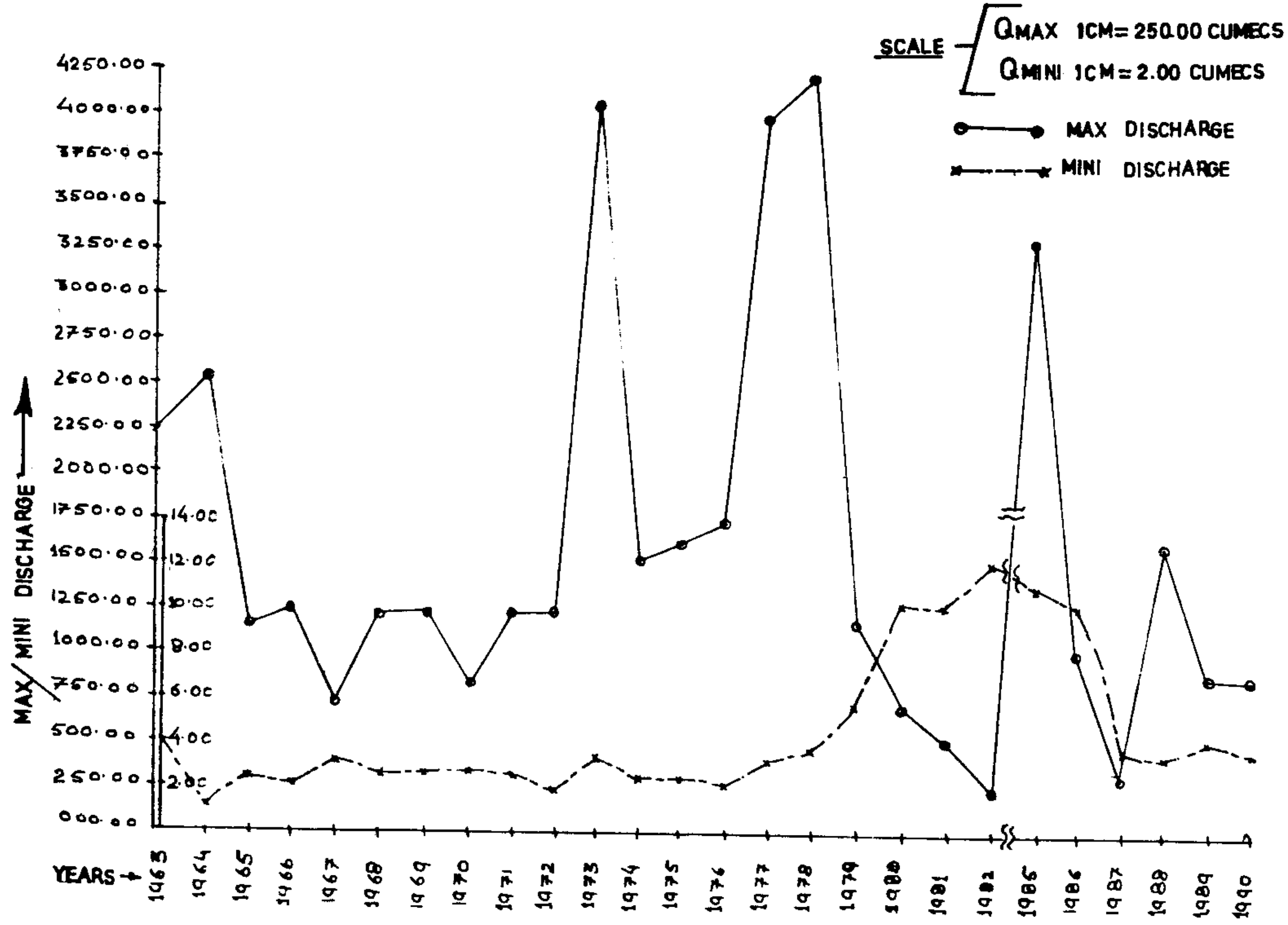
There was no rain gauge station inside the catchment prior to 1956. Fig.1 shows the location of rain gauge stations in and around the catchment.There is also no SRRG(self recording raingauge) in the Ujh sub basin. The data collected by state government includes those of 12 non recording rain gauge stations (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, Bhaderwah and Kathua have data from 1956 to 1990. However the data available has large missing data and inconsistencies.

As already mentioned,the No.of rain gauge station 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.

4.2 Discharge data

The river experiences unusual stage especially during monsoon periods and are generally referred to as flash floods. The maximum and minimum flood peaks for about 20 years is shown in fig 2. Nearly 30 years Guage and Discharge (G & D) data from 1960 to 1990 was made available by the Ravi Tawi project office (J.K.Govt) at Kathua.

ANNUAL MAXIMUM & MINIMUM FLOWS OF RIVER UJH



DATA SOURCES: RAWI TAWI PROJECT AUTHORE TY, KATHUA

FIG-2

5.0 METHODOLOGY FOR WATER AVAILABILITY STUDY

5.1 General

Before we plan any project on a river, the first and foremost task is to assess its available water at different times of the year. The success of a scheme depends on how accurate has been the estimation of total quantity of water available and its variability. Proper estimation of water availablity is therefore very essential.

The objective of water availability studies is to arrive at assured and dependable yields (annual or seasonal) from a river during the project life of a water resources project. The dependable flows computed using exceedance frequency imply a certain degree of risk involved while embarking upon a water resources scheme. The dependable flows computed depend on the sample size. The values adopted by designers should however note that the properties of sample and its size are extended for the project life. For instance the percentage of dependability adopted normally for irrigation, hydropower and water supply (drinking) schemes are 70, 90 and 100 % respectively. This corresponds to 30, 10 and 0 % risk or uncertainty in the predicted flows/ yields. Top priority is given to drinking water since a 100% dependable supply is a must. However, greater the percentage of dependability, lower is yield available from a given stream.

5.1.1 Data Base

For computations of water availability following rainfall and runoff data needs to be collected in the order of preference as given below.

a) Ten daily runoff data i.e the total of the daily runoff in 10 days, at the proposed site for at least 40 to 50 years

OR

b) 1. Ten daily rainfall data for at least 40 years for raingauge stations influencing the catchment of the proposed site

2. Ten daily runoff observations at the proposed site for the last 5 - 10 years.

OR

c) 1. Ten daily rainfall data of the catchment of the proposed site for the last 40 - 50 years.

2. Ten daily runoff observation and concurrent rainfall data at the existing work upstream or downstream of proposed site for the last 5 - 10 years.

OR

d) 1. Ten daily rainfall of the catchment for the last 40 - 50 years for the proposed site.

2. Ten daily runoff observations and concurrent rainfall data at existing works on a nearby river for 5 - 10 years or more provided orographic conditions of the catchment at nearby worksite are similar to that of the proposed site.

It may however be noted that in the event of nonavailability of data in the above-mentioned form, suitable variations may be made judiciously while computing water availablity and also accounted for while interpreting the results.

5.1.2 Water Availability Computation methods

Some of the conventional methods of water availability study are briefly described below.

a) Direct observation method

The method is applied when observed runoff data at the proposed site is available for the last 50 years or so. The annual runoff is computed and arranged in descending order. The synthetic year for a particular dependability is calculated from (N+1) years, where N is the number of years for which runoff data is available. (This method has been adopted for the non monsoon period as dealt in section 6.3).

b) Rainfall - Runoff series method

The method basically consists in extending the runoff data with the help of raifall by means of rainfall runoff relationships developed through their correlation analysis. Depending upon the availability of rainfall runoff data, following three cases arise.

Case I: Long term precipitation record along with a stream flow data for a few years is available. (This method has been adopted for monsoon period, refer section 6.2).

CaseII: Long term precipitation record is available at the site along with a few years of stream flow data at a neighbouring site. (This method is not often used)

CaseIII: Sufficient precipitation and streamflow data exist (This is similar to case I with the only difference that the runoff data may be verified through rainfall runoff relationship)

There are other methods such as water balance method, Langbein's Log-deviation method, Strange's tables etc. Of late Systems approach is also being adopted to compute water availability of a given catchment.

5.2 Methodology adopted

The conventional method of assessing water availability of a given catchment discussed in the previous section are detailed below .

1) Processing and adjusting primary data (rainfall) for consistency . In case of missing data suitable methods may be adopted by filling appropriate values. Double mass technique may be used for making data consistent.
2) Mean areal rainfall computation over the catchment (depth in mm) - Rainfall series.
3) Conversion of stream runoff (discharge in cubic metres per sec) into depth (mm) - Runoff series.
4) Modelling of rainfall and runoff using regression
5) Extension of runoff series in case longterm runoff series is not available using regression equations.
6) Computation of dependable flows using exceedance frequencies
7) Plotting the flow duration curve.

6.0 APPLICATION

6.1 General:

The methodology discussed in the previous section has been applied to monsoon and nonmonsoon periods of the water year. The monsoon period being from june to october and nonmonsoon from november to may of a water year. However since flow data is available for most of the period (i.e 26 years) the regression model has been applied to few years only for extension of runoff series. It may be noted that the yield accounted during monsoon and nonmonsoon periods have a certain amount of snowmelt component.

6.2 Monsoon Season (June - Oct)

6.2.1 Processing Of Rainfall Data :

The annual rainfall of various stations is shown in table 2. Table 3 indicates that a major portion of annual rainfall is contributed by the south west monsoon. Further due to lack of proper data as already discussed in section 4.1, the water availability study for the basin was carried out using data of 3 stations i.e Bhaderwah, Mandli and Kathua only on monthly basis using 29 years data (1961 - 89). The consistency of data for the three stations was tested using double mass technique. The data for Mandli and Kathua were found to be reliable while the data of Bhaderwah was found to be inconsistent and was corrected.

6.2 Computation of Mean Areal Rainfall:

In view of the hilly terrain the catchment was divided into 3 parts along contour lines separating primarily on the basis of elevation and weights were assigned to the corresponding R.G

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 09'	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	5330	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	155.60	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	125[illegible]														
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'	2497														
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.[illegible]	131.00	202.50	63.60	123.33	126.71	[illegible]7.00	175.00	118.50	121.00	117.00	107.00	213.00	106.67

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

		% of Annual Rainfall				
S.No	Year	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

stations (Bhaderwah, Mandli and Kathua) proportional to the area separated. The time series of rainfall and runoff (monthly) is shown in table 4.

6.2.1 Rainfall Runoff Relationship:

Since runoff data is not available for some of years for which rainfall data is available, a relation between the two is essential to extend the runoff series. Following steps have been adopted:

1) Plotting the rainfall runoff ordinates to ascertain the nature of relationship.

2) A linear regression relationship between rainfall and runoff was developed. In view of low correlations and a scattered plot, a nonlinear regression equation of the 2nd & 3rd degree have been attempted. The regression output is presented in table 5.

3) Since the results of step 2 have been unsatisfactory, a plot on log log paper was attempted to fit an equation of the type $Y = a X^b$. This was also not satisfactory.

4) Finally a Linear Multiple regression model has been tried to obtain more realistic results. The regression equation fitted for this purpose is given by:

$$Y_i = aX_i + bX_{i-1} + c$$

Where, Y_i = Runoff (mm) during i th month

X_i = Rainfall during i th month

a, b & c constants

The regression model was run on a microcomputer the results of which are indicated in table 6. The results

TABLE 4

TIME SERIES OF RAINFALL AND RUNOFF (MM) OF UJH BASIN

(MONSOON SEASON)

S.NO.	WATER	JUN.		JUL.		AUG.		SEP.		OCT.		TOTAL	
	YEAR	R/F	R/O	R/F	R/O	R/F	R/O	R/F	R/O	R/F	R/O	R/F	R/O
1	61-62	27.6	36.0*	480.5	324.5*	585.0	462.4*	350.4	187.2*	6.8	25.0*	1450.4	1035.2
2	62-63	61.9	42.3*	227.9	233.1*	434.2	415.0*	318.3	175.5*	1.2	19.4*	1043.7	885.5
3	63-64	75.0	44.0*	357.6	350.0	424.7	413.4	74.3	187.8	0.0	17.4	920.5	1024.0
4	64-65	83.5	37.5	212.9	493.6	298.9	745.6	198.2	101.8	0.0	16.6	784.7	1395.3
5	65-66	13.0	47.6	532.8	391.4	173.4	212.5	37.4	39.2	0.7	16.4	757.7	707.2
6	66-67	203.2	38.3	258.6	139.0	343.3	259.4	348.5	182.9	6.5	29.8	1160.3	649.6
7	67-68	25.9	21.8	360.7	199.1	512.7	393.7	241.8	270.7	3.1	27.1	1144.4	912.5
8	68-69	59.9	44.3	437.5	561.9	208.0	252.5	8.0	32.9	33.5	60.8	746.2	952.7
9	69-70	22.1	40.9	325.3	167.4	307.0	333.4	164.3	58.0	23.9	18.4	842.8	618.2
10	70-71	220.0	134.4	252.9	133.1	447.6	351.3	228.4	158.4	12.8	41.0	1161.8	818.4
11	71-72	62.5	114.0	554.7	235.9	710.4	509.0	60.2	50.8	11.0	25.8	1399.0	935.7
12	72-73	31.6	17.3	288.7	74.9	125.7	183.9	85.1	72.0	27.2	20.9	558:5	369.2
13	73-74	44.8	42.5	448.6	349.0	679.7	871.9	308.8	79.1	8.9	25.2	1491.0	1367.9
14	74-75	60.7	25.3	571.8	324.8	542.9	243.0	40.3	31.3	2.5	30.5	1218.4	655.1
15	75-76	82.5	43.5*	768.3	541.5	520.6	339.3*	192.3	112.0*	2.9	18.4*	1566.8	1054.8
16	76-77	45.4	54.8	507.1	326.0*	214.4	282.6	27.4	103.5	17.3	28.4	811.8	795.4
17	77-78	672.5	93.5	90.3	1359.1	286.2	187.4	201.7	82.2	65.7	23.9	1316.6	1746.2
18	78-79	113.8	159.8	656.1	88.9	577.4	171.7	147.3	102.3	2.1	42.2	1496.9	565.1
19	79-80			-------- RAINFALL DATA NOT AVAILABLE --------									
20	80-81	142.9	59.1	464.9	183.3	194.8	111.9	45.2	44.5	14.2	25.4*	862.2	424.4
21	81-82	119.8	156.1	516.5	268.7	289.6	79.4	28.0	36.0*	6.9	69.7	961.0	610.1
22	82-83	38.4	55.4	229.2	101.6	342.5	152.3	37.1	63.5	29.5	38.7	676.9	411.6
23	83-84	85.8	49.5*	262.0	234.6*	379.6	365.2*	126.1	83.0*	66.3	72.9*	920.0	805.3
24	84-85	91.0	44.1*	277.4	237.5*	475.1	432.8*	73.1	55.0*	0.3	13.7*	917.1	783.2
25	85-86	15.6	46.9	504.6	901.6	268.1	241.2	145.6	98.7	70.3	111.6	1004.3	1400.1
26	86-87	65.3	67.2	190.3	372.5	258.9	290.5	37.7	51.6	36.5	43.4	588.8	825.3
27	87-88	78.3	55.7	124.4	88.5	215.4	50.3	83.8	108.0	91.7	117.6	593.8	420.2
28	88-89	59.9	11.4	956.7	472.2	360.6	199.5	625.9	342.9	4.9	18.7	2008.2	1044.8
29	89-90	60.7	26.0	376.5	208.7	244.6	90.7	64.9	18.6	19.6	5.2	756.5	359.4

Note: * indicate values computed using linear multiple regression

Table No 5.
REGRESSION OUTPUT

S.No	MONTH	LINEAR REGRESSION $Y = c + aX$ corrl. Coefficeint	Inter cept	X Co-efficient	NONLINEAR REGRESSION $Y = c + aX + bX^2$ R Squared	Inter cept	X - Co-efficients	NONLINEAR REGRESSION $Y = c + aX + bX^2 + dX^3$ R Squared	Inter cept	X - Co-efficients
1	June	0.6	35.95	0.11	0.34	36.82	0.07, 0.0008	0.49	-15.01	3.17, -0.04
2	July	0.45	144.96	0.35	0.12	275.0	-0.42, 0.001	0.72	6278.4	-51.5, 0.13, -0.0001
3	Aug	0.51	87.00	0.63	0.33	243.13	0.06, 0.0006	0.42	-522.2	7.51, -0.01, -0.00001
4	Sept	0.85	22.66	0.49	0.55	8.35	0.83, -0.001	0.57	39.9	-0.33, 0.006, -0.00001
5	Oct	0.76	15.12	0.86	0.30	25.28	-0.41, 0.029	0..85	15.38	5.21, -0.46, 0.01

Note: X = Rainfall Y = Runoff

TABLE NO 6.
MULTIPLE LINEAR REGRESSION OUTPUT

S.No	MONTH	Correl. Coefficent	Inter cept(c)	Co - efficients a	b	Remarks
1.	June	0.613	32.28	0.12	0.05	
2.	July	0.48	186.06	0.31	-0.38	$Y_i = c + aX_i + bX_{i-1}$
3.	Aug	0.58	148.64	0.75	-0.26	Y = Runoff
4.	Sept	0.85	28.20	0.49	-0.02	X = Rainfall i = Current month
5.	Oct	0.77	12.00	0.88	0.02	i-1 = Previous Month.

have been found to be reasonably ok.

6.3 Non Monsoon Season (Nov - May)

To account for low flows during nonmonsoon period, the yield has been separately computed. The winter rainfall and snowmelt constitute the inputs for the flows in Ujh during nonmonsoon periods. The winter rainfall as is evident from table 3 is about 20 - 25 % of the annual rainfall. During winter the precipitation in the upper reaches of the Ujh catchment is mostly in the form of snow. This is evident from percentage of snow out of the total precipitation recorded at Bhaderwah as indicated in table 7. The yields have been computed based on actual flows and missing flow data have been averaged. This is because the correlations of rainfall and runoff during nonmonsoon periods may not be meaningful as the winter rainfall cannot be consistent with flows which are mostly due to snowmelt.

6.4 Dependable Flows:

The yield for monsoon and nonmonsoon seasons for river ujh are arranged in descending order and exceedance frequencies using weibulls method calculated. The details of computations are shown in table 6 & 7.

The flow duration curve is shown in figs 3 & 4.

Table 7
PERCENTAGE OF SNOW RECORDED OF BHADERWAH STN

S.No	YEAR	DEC	JAN	FEB	MAR
1.	1967	79.4	100.0	18.6	36.3
2.	68	82.5	100.0	36.7	0.0
3.	69	0.0	91.0	15.9	0.0
4.	70	0.0	47.4	100.0	0.0
5.	71	0.0	88.4	90.4	100.0
6.	72	47.7	89.4	91.2	38.3
7.	73	80.5	49.1	68.7	10.8
8.	74	96.3	100.0	63.9	0.0
9.	75	0.0	93.4	76.3	48.9
10.	76	0.0	56.9	57.5	0.0
11.	77	21.0	96.2	0.0	0.0
12.	78	0.0	2.2	38.3	44.5
13	79	0.0	81.8	80.9	0.0
14	80	69.0	64.4	87.8	0.0
15	81	0.0	85.5	56.9	31.8
16	82	0.0	96.6	50.5	77.6
17	83	0.0	0.0	79.3	3.5
18	84	88.2	36.1	70.4	0.0
19	85	0.0	68.2	0.0	0.0
20	86	85.7	25.3	30.6	0.0
21	87	0.0	80.4	69.5	0.0
22	88	74.3	74.8	0.0	31.2

Data Source: CWC report Vol II 1991.

TABLE - 8

DEPENDABLE YIELD COMPUTATIONS FOR MONSOON SEASON

S NO	WATER YEAR	YIELD (x10^7) in cubic meter						Q in descending order	% OF DEP.
		JUN	JUL	AUG	SEP	OCT	TOTAL		
1	1961-62	3.5	31.5	44.9	18.2	2.4	100.5	169.6	3.2
2	1962-63	4.1	22.7	40.3	17.1	1.9	86.0	136.0	6.4
3	1963-64	4.3	34.0	41.3	18.2	1.7	99.5	135.5	9.6
4	1964-65	3.7	48.0	72.4	9.9	1.6	135.5	132.9	12.9
5	1965-66	4.6	38.0	20.6	3.8	1.6	68.7	102.5	16.1
6	1966-67	3.7	13.5	25.2	17.8	2.9	63.1	101.5	19.3
7	1967-68	2.1	19.3	38.2	26.3	2.6	88.6	100.5	22.5
8	1968-69	4.3	54.6	24.5	3.2	5.9	92.5	99.5	25.8
9	1969-70	4.0	16.3	32.4	5.6	1.8	60.1	92.5	29.0
10	1970-71	13.1	12.9	34.1	15.4	4.0	79.5	90.4	32.2
11	1971-72	11.1	22.9	49.0	4.9	2.5	90.4	88.6	35.4
12	1972-73	1.7	7.3	21.2	7.0	2.0	39.2	86.0	38.7
13	1973-74	4.1	33.9	84.7	7.7	2.5	132.9	80.2	41.9
14	1974-75	2.5	31.6	23.6	3.0	3.0	63.6	79.5	45.1
15	1975-76	4.2	52.6	33.0	10.9	1.8	102.5	78.2	48.3
16	1976-77	5.3	31.7	27.5	10.1	2.8	77.3	77.3	51.6
17	1977-78	9.1	132.0	18.2	8.0	2.3	169.6	76.1	54.8
18	1978-79	15.5	8.6	16.7	9.9	4.1	54.9	68.7	58.0
19	1979-80	5.8	15.6	27.2	6.7	11.4	66.7	66.7	61.2
20	1980-81	5.8	17.8	10.9	4.3	2.5	41.2	63.6	64.5
21	1981-82	15.2	26.1	7.7	3.5	6.8	59.3	53.1	67.7
22	1982-83	5.4	9.9	14.8	6.2	3.6	39.9	60.1	70.9
23	1983-84	4.8	22.8	35.5	8.1	7.1	78.2	59.3	74.1
24	1984-85	4.3	23.1	42.0	5.3	1.3	76.1	54.9	77.4
25	1985-86	4.6	87.6	23.4	9.6	10.8	136.0	41.2	80.6
26	1986-87	6.5	36.2	28.2	5.0	4.2	80.2	40.8	83.8
27	1987-88	5.4	8.6	4.9	10.5	11.4	40.8	39.9	87.1
28	1988-89	1.1	45.9	19.4	33.3	1.8	101.5	39.2	90.3
29	1989-90	2.5	20.3	8.8	1.8	1.5	34.9	34.9	93.5
30	1990-91	2.0	5.5	7.4	7.9	3.5	26.3	26.3	96.7

TABLE 9
DEPENDABLE YEILDS COMPUTATION FOR NON-MONSOON PERIODS (NOV.-MAY)

WATER YEAR	YEILD $(x\ 10^{7}\ M^{3})$	Q DESCEN-NDING ORDER	RANK (M)	% DEPEN-DABILITY
61-62		70.5	1	3.4
62-63	35.1	55.2	2	6.9
63-64	35.0	53.7	3	10.3
64-65	41.0	51.5	4	13.7
65-66	20.5	50.8	5	17.2
66-67	22.2	50.8	6	20.6
67-68	55.2	48.8	7	24.1
68-69	26.3	45.4	8	27.5
69-70	18.9	45.2	9	31.0
70-71	21.4	41.0	10	34.4
71-72	21.5	35.5	11	37.9
72-73	35.5	35.1	12	41.3
73-74	12.8	35.0	13	44.8
74-75	50.8	34.0	14	48.2
75-76	45.4	32.6	15	51.7
76-77	31.2	31.2	16	55.1
77-78	32.6	29.4	17	58.6
78-79	48.8	27.5	18	62.0
79-80	29.4	26.3	19	65.5
80-81	50.8	25.0	20	68.9
81-82	53.7	23.8	21	72.4
82-83	70.5	22.2	22	75.8
83-84	34.0	21.5	23	79.3
84-85	27.5	21.4	24	82.7
85-86	51.5	20.5	25	86.2
86-87	45.2	18.9	26	89.6
87-88	25.0	18.1	27	93.1
88-89	18.1	12.8	28	96.5

FLOW DURATION CURVE
[NON MONSOON PERIOD NOV-MAY]

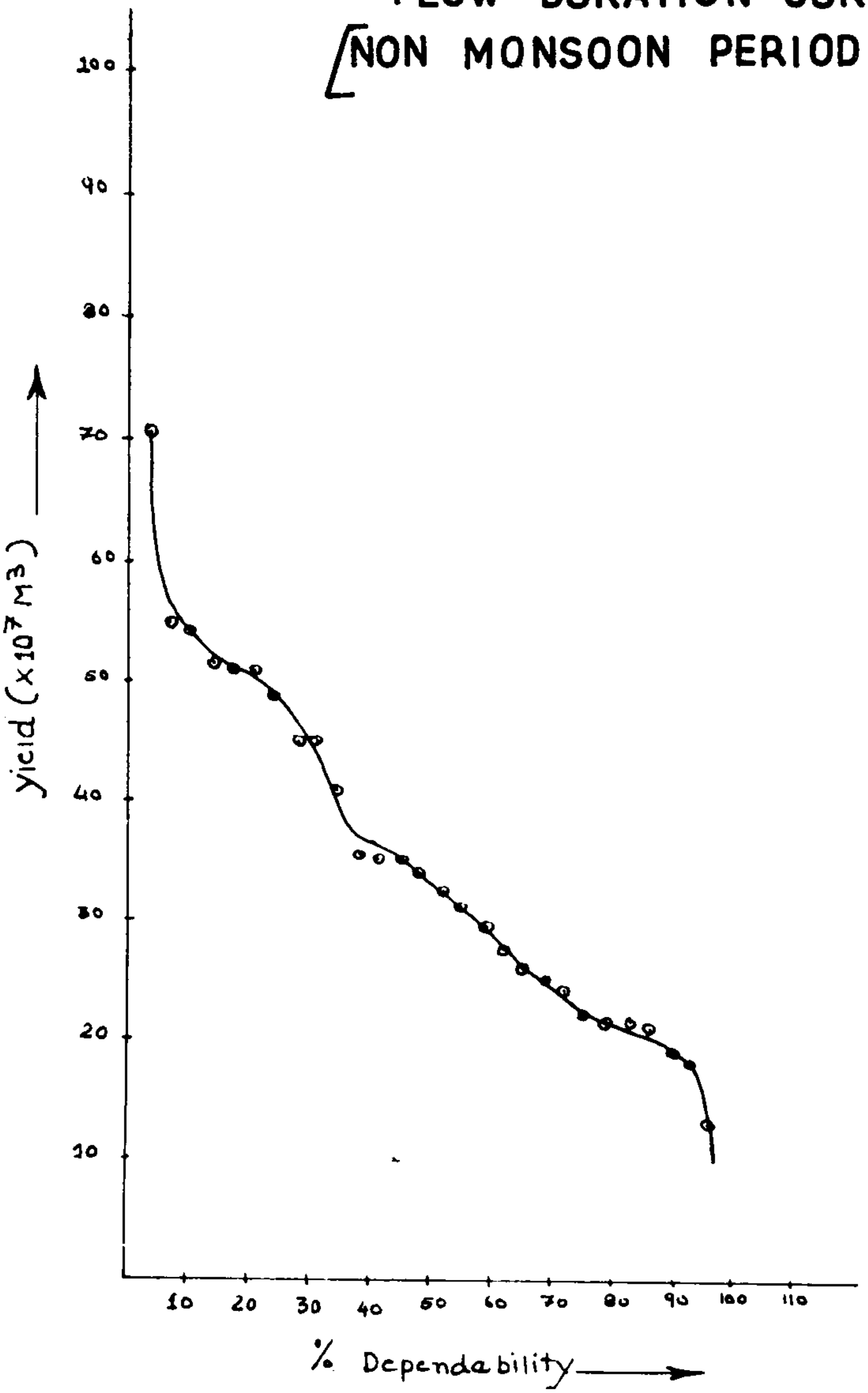


FIG-3

FLOW DURATION CURVE
[MONSOON PERIOD OF JUNE - OCT]

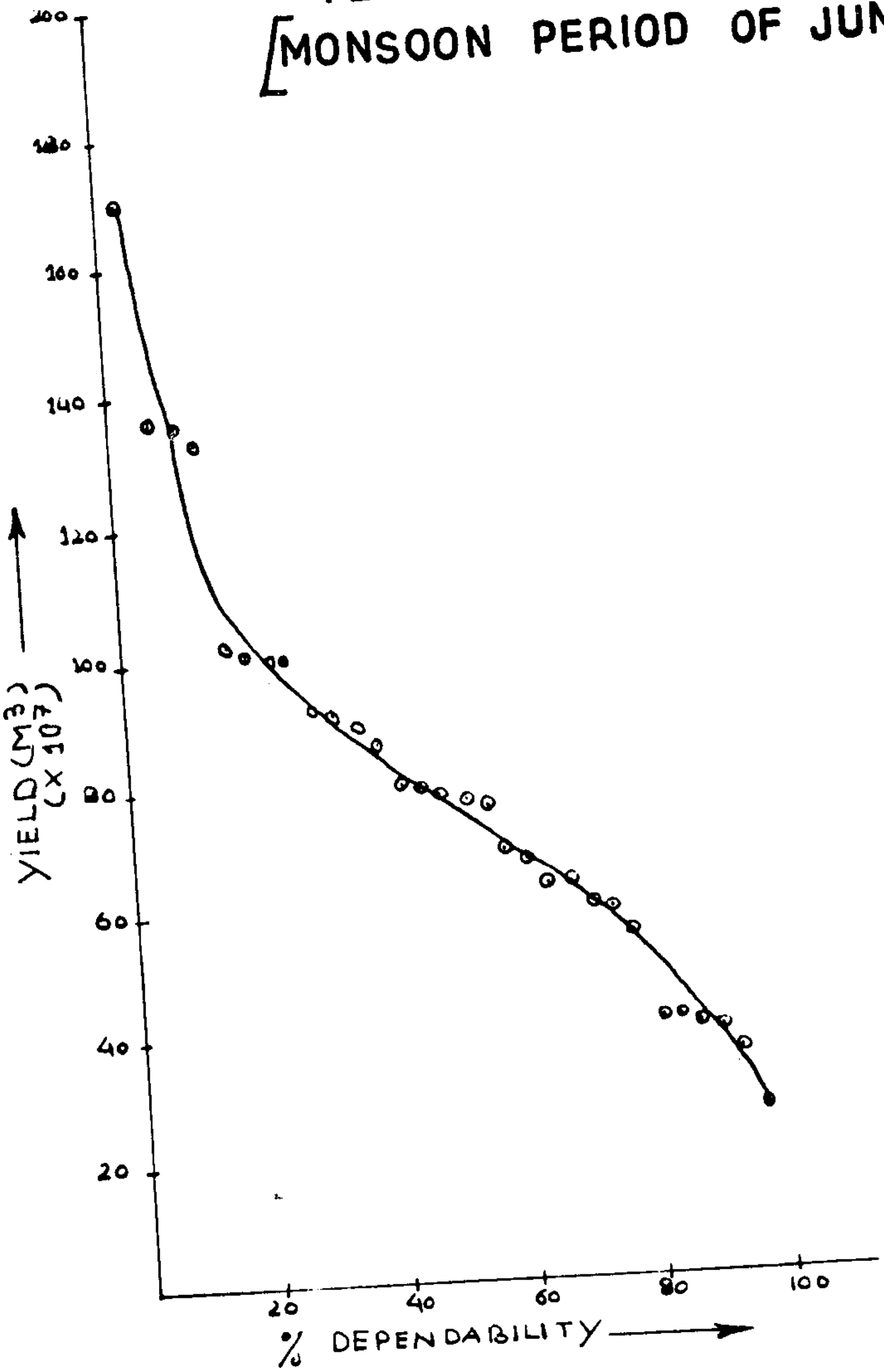


FIG - 4

7.0 RESULTS AND DISCUSSIONS

The results obtained after analysis provide a basic insight into the hydrology of river Ujh. The results may be summarised as under:

1) While 12 rain gauge stations fall in and around Ujh basin, the mean areal depths of rainfall have been computed taking only 3 stations viz., Bhaderwah, Mandli and Kathua. This is due to lack of data for most of the stations beyond 1978 as is evident from table 2. The rainfall and runoff series are indicated in table 4.

2) The results of linear multiple regression have been used to extend the rainfall runoff series as indicated in table 4.

3) Multiple linear regression and polynomial regression as already discussed in section 6.1.3 provides reasonable results though not satisfactory. The results are shown in table 5 & 6.

4) The dependable yield for various exceedance frequencies is indicated in table 8. & 9. for monsoon and nonmonsoon periods.

5) Following dependable yields may be adopted for design purposes.

% OF DEPENDABILITY	YIELD (X 10^7 M^3)	
	MONSOON	NONMONSOON
50	76	33
60	68	29
75	56	22
90	39	19
95	30	15

8.0 CONCLUSIONS

Following conclusions may be drawn from the results obtained.

1) The data length, reliability and network are not adequate for a comprehensive analysis. Hence efforts should be made by concerned state agencies for the improvement in network and for development and maintenance of reliable data systems.
2) The dependable yields computed from given data should help the design engineers while proposing suitable water resources projects on river Ujh.
3) The computed yields include snowmelt component. However the proportion of snowmelt contribution is not known.
4) The rainfall runoff relationship could not be established satisfactorily by regression models. One of the reasons could be that snowmelt component has not been accounted. A significant amount of snowmelt feeds the river during spring and summer seasons and continues even during monsoon. The low correlations between rainfall and runoff could be due to this.
5) A study of snow hydrology of Ujh river basin in the upper reaches would be of great help in understanding the runoff process in the catchment.

REFERENCES

1. Multiple linear regression., NIH report.,DP 6., UM 3.
2. Rao S.V.N. 'Hydrometeorology of Ujh river basin - A Case Study' NIH report (Unpublished).
3. Mutreja K N 'Applied Hydrolgoy' pp894 - 899. Tata Mc Graw Hill publishers. N.Delhi.

ACKNOWLEDGMENT

I would like to acknowledge with thanks Sri K S Ramashastri Sc F and Co-ordinator for his guidance and critical examination of this report. I am thankful to sri B C Patwary, Sc E & Head for his valuable suggestions in the preparation of this report.

I am also thankful to the Ex. Engineer, Ravi Tawi Project, Kathua for providing data related to Ujh river basin.

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