INTRODUCTION

Floods and flash floods are the deadliest of natural disasters. Floods bring misery to those who live in the flood prone areas not only cause loss of precious life but also cause a great disruption to daily normal life. Its effects can be reduced by analyzing the prevailing atmospheric conditions on micro scale, future possible variability in it and then possible accurate forecast .The timely dissemination of the flood information to the concerned authorities, media and public contributes a lot in minimizing the losses due to floods. The floods depend upon the current base flow of river sites, intensity and duration of rainfall & topography .These parameters are monitored by weather radars, weather satellites, Hydrometeorological Models, telemetric network & by the network of meteorological observatories and timely reception of hydrological data of different river sites. Significant features of the flood season-2011 was the unprecedented torrential rainfalls of more than 1000 mm over south east Sindh which caused severe urban flooding in the area. Although there was no significant flood in the rivers of Pakistan .However during the flood season the exceptionally heavy rainfall in Sindh province caused urban flooding which could be termed as calamity.

The Flood Forecasting Division Lahore (FFD), since its establishment is serving the nation by issuing flood forecasts during each flood season (15th June, to 15th October). Similarly FFD monitored flood season 2011 carefully through its Hydrometeorological Bulletins, Warnings, and then by keeping informed different Government agencies, press and electronic media, in order to minimize mass destruction.

The compilation of flood report after each flood season is a regular feature observed by FFD Lahore. Flood report for the year 2011 has been prepared under the able guidance and kind instructions of Director General, Meteorological Services and Chief Meteorologist FFD. It contains all the details pertaining to flood forecasting like monsoon lows tracks, rainfall during wet spells, flood peaks, monthly and seasonal Isohyetal maps, normal isopercental maps, flood limits and flood evaluation report .

Chief Meteorologist
Flood Forecasting Division
Lahore

FLOOD FORECASTING DIVISION LHR

HYDROMETEOROLOGICAL REPORT 2011

1. HIGHLIGHTS

- Monsoon remained torrential over southeast Sindh this year and very heavy rain fell over the area. Most parts of the upper catchments of all the major rivers received normal rainfall.
- A total number of five monsoon lows originated form the Bay of Bengal. However, three were able to reach in the vicinity of Pakistan.
- The seasonal precipitation (July 2011 to September 2011) Isopercental pattern is the indicative of significantly above normal rainfall in southeast Sindh and some parts of north Balochistan. Northern parts of the country received near normal rainfall,whereas Western Balochistan remained almost dry during the period.
- Eight rain bearing spells occurred during the monsoon season, 2011.
- The supply of Hydro-Meteorological data from WAPDA Punjab and Sindh Irrigation & Drainage Authorities (PIDA&SIDA) remained satisfactory.
- The concerned federal and provincial authorities along with press and electronic media were also daily informed about the prevailing weather/flood conditions through fax & Internet as well.
- 39 Significant Flood Forecasts /warnings were also issued by FFD during Monsoon season 2011, whenever the weather/flood situation demanded.
- Overall accuracy of forecast issued by FFD during the season 2011 has been calculated as 95.8%.

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2. TRACKS OF LOWS DURING MONSOON SEASON 2011

During the monsoon season 2011 (15th June to 15th October) five monsoon lows emerged from Bay of Bengal, path followed by each low is shown in figure below.

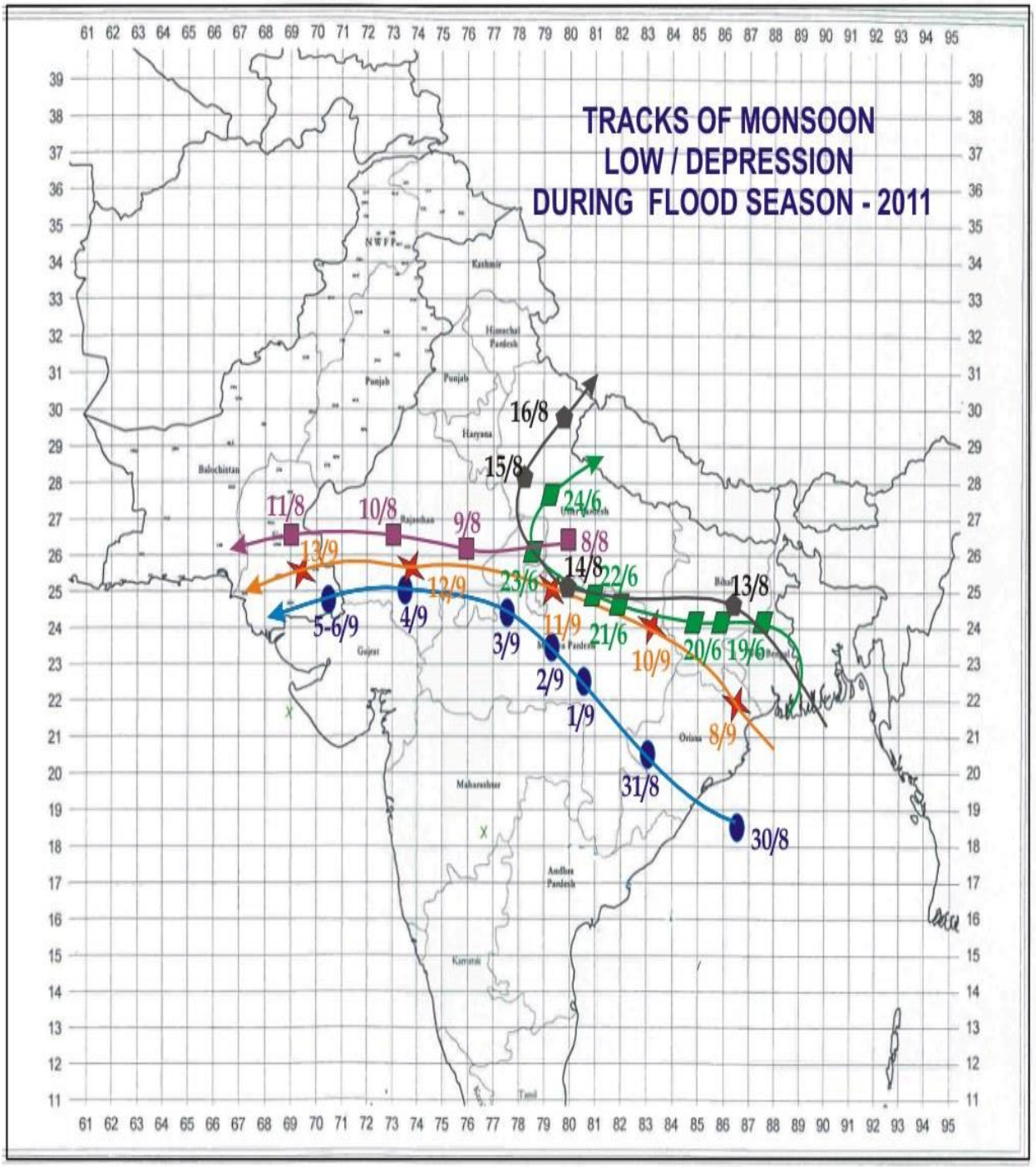

Figure 1:(Tracks of Monsoon Lows / depressions during Flood Season-2011)

3. SIGNIFICANT HYDROMETEOROLOGICAL EVENTS DURING THE MONTH OF JUNE, 2011:

Only one rainfall spell occurred during the period.

3.1 METEOROLOGICAL EVENTS:

During the month of June 2011 only one Monsoon low developed over Bay of Bengal on 15th June 2011 which intensified into a well marked low and further converted into a deep depression on 17th. Initially it took west-northwesterly direction and reached over Madhya Pradesh India on 22nd June 2011.From here it recurved northeast wards and fizzled out over Uttar Pradesh (India) .

The rainfall which occurred over Pakistan during June, 2011 was due to the accentuation of seasonal low over Balochistan, passing of westerly wave in the North of the country and influx of monsoon current from Arabian Sea.

3.1.1 WET SPELL OF JUNE 2011 (FROM 28-06-2011 TO 29-06-2011):

The only wet spell of June 2011 which lasted for two days was mainly caused by the interaction of western disturbance and the moist current from the Arabian Sea. Rainfall distribution during the spell is given below.

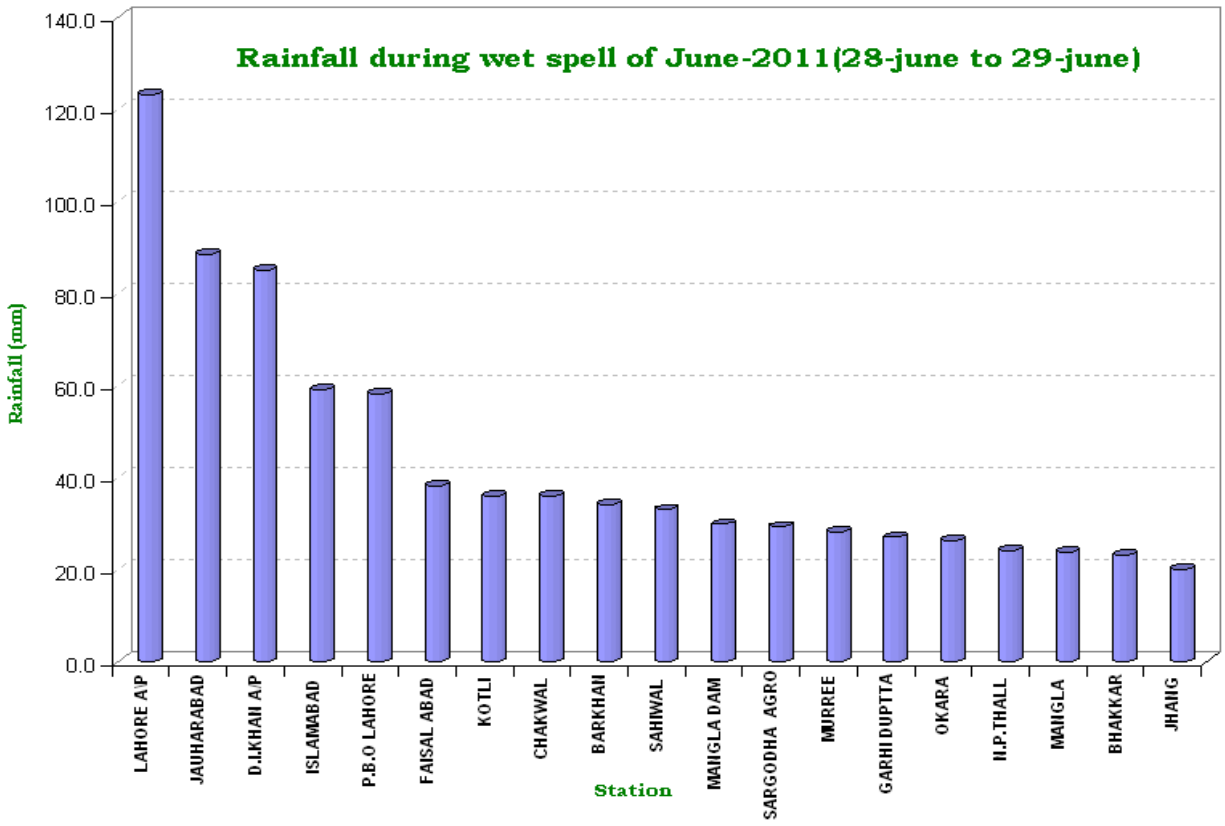

Figure 2:(Wet spell of June-2011(28 June-29 June)

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3.1.2 *RIVERS POSITION DURING JUNE 2011:*

All the rivers, hill torrents and nullahs maintained their normal flows during the period.

4. SIGNIFICANT HYDROMETEOROLOGICAL EVENTS DURING THE MONTH OF JULY 2011:

Two rainfall spells occurred during the month of July-2011.

4.1 *METEOROLOGICAL EVENTS:*

First spell occurred from 7th to 9th July 2011. It was mainly due to a trough of westerly wave passing over the Northern parts of the country and Strong moist current from Bay of Bengal and Arabian Sea which was penetrating in sub mountain areas of Punjab and Kashmir. The second spell of July was observed during 24th to 26th July 2011 was caused due to the interaction of westerly wave passing over the Northern parts of the country and the moist influx from Bay of Bengal as well as Arabian sea. Scattered to widespread rains with moderate falls at isolated places occurred over North Punjab, Khyber Pakhtun Khwa, Kashmir. Rainfall also occurred over Southern Punjab & Northeast Balochistan during this spell.

4.1.1 FIRST WET SPELL (7-07-2011 To-9-07-2011)

First spell of July 2011 which was 2nd of the flood season 2011 lasted for 3 days. It was mainly due to the passage of westerly wave, accentuation of seasonal low and incursion of moist current from Arabian sea & bay of Bengal. The significant rain during the spell is shown below:

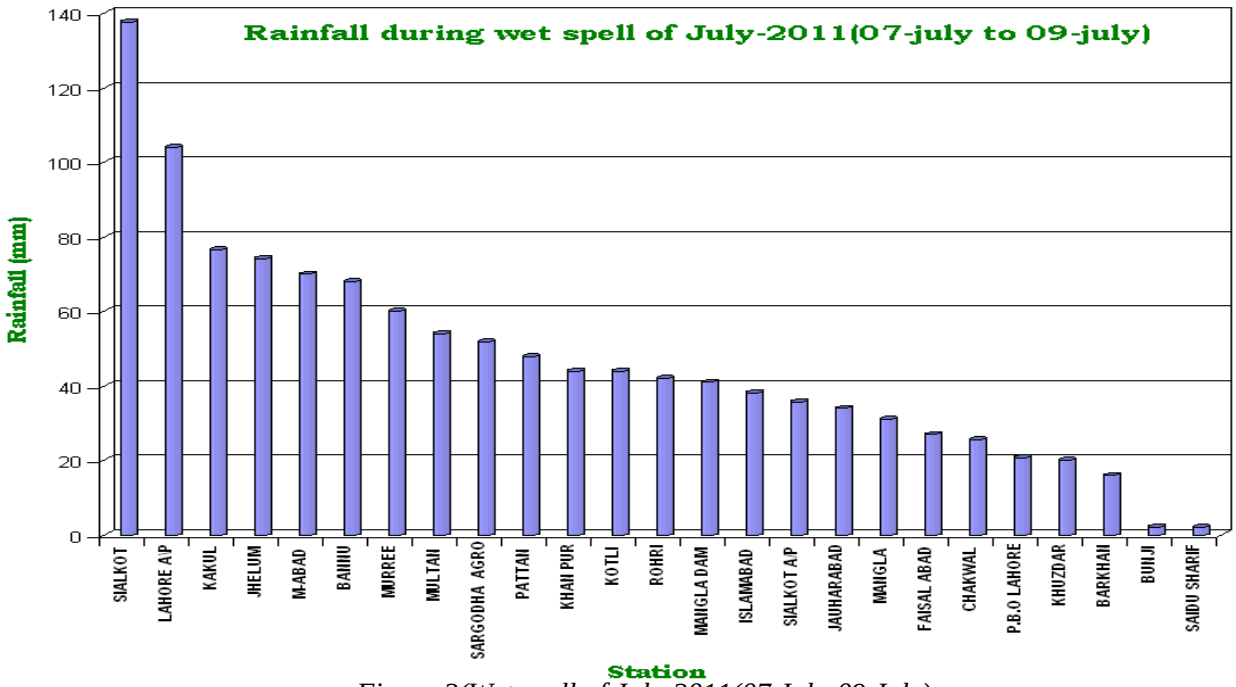

Figure 3(Wet spell of July-2011(07 July-09 July)

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4.1.2 RIVERS POSITION DUE TO THE SPELL

No significant increase in rivers occurred due to the spell.

4.1.3 *SECOND WET SPELL (24-07-2011 TO 26-07-2011)*

This spell lasted for 3 days. The rainfall of moderate intensity was recorded in Khyber Pakhtunkhwa, Punjab and Kashmir as shown below.

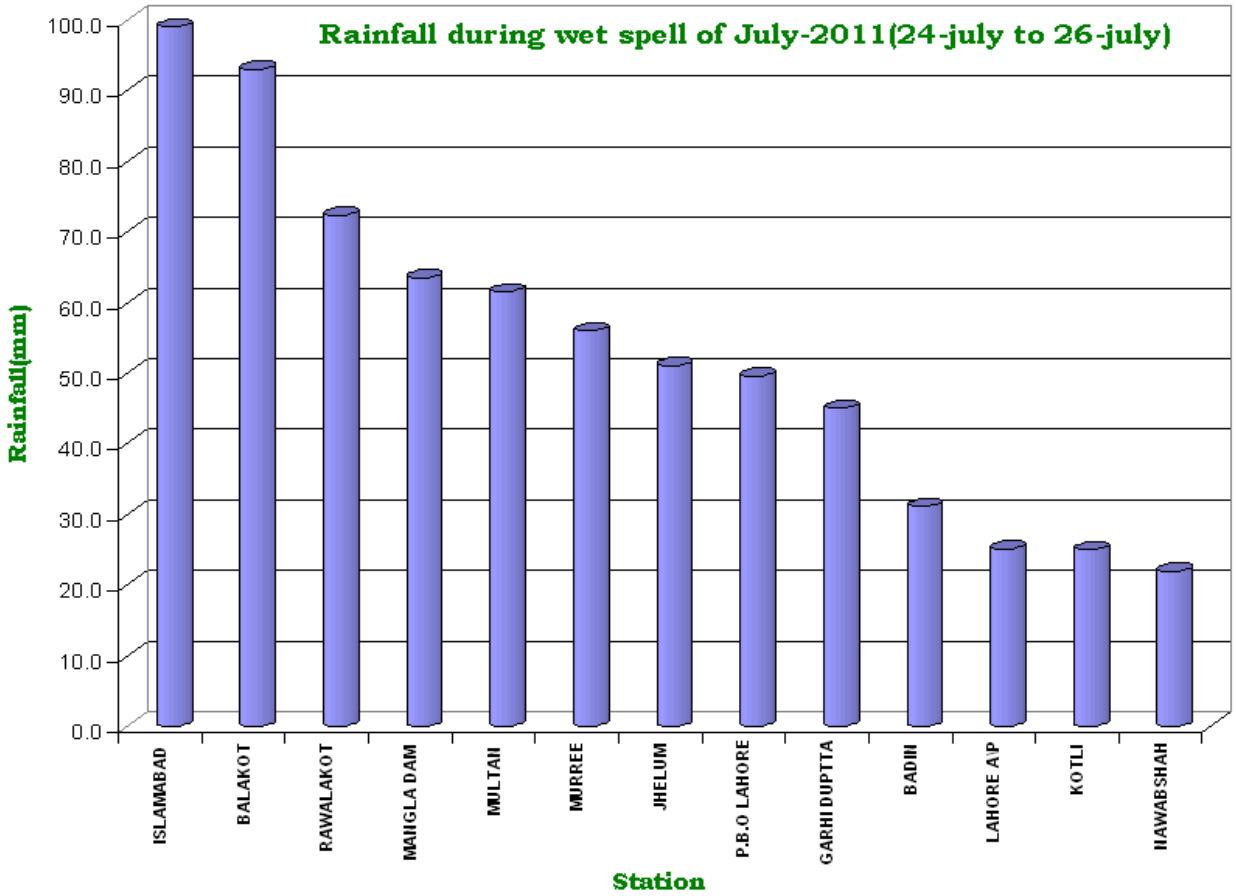

Figure 4(Wet spell of July-2011(24-26 july)

4.1.4 *RIVERS POSITION DUE TO THE 2nd SPELL*

Due to this spell medium flood peak at upstream of River Chenab at Marala was recorded while River Indus at Tarbela and Kalabagh and river Chenab at Khanki attained the low flood peaks.

4.1.5 RAINFALL PATTERN FOR THE MONTH OF JULY 2011

Isohyetal map of July 2011 indicates that the region of maximum rainfall (More than 300 mm) lies around Islamabad. Lesser maximum rainfall (More than 200 mm) regions are Upper Punjab, parts of Kashmir and KPK. The precipitation intensity decreased towards southern parts of the country and little rainfall was observed over Balochistan.

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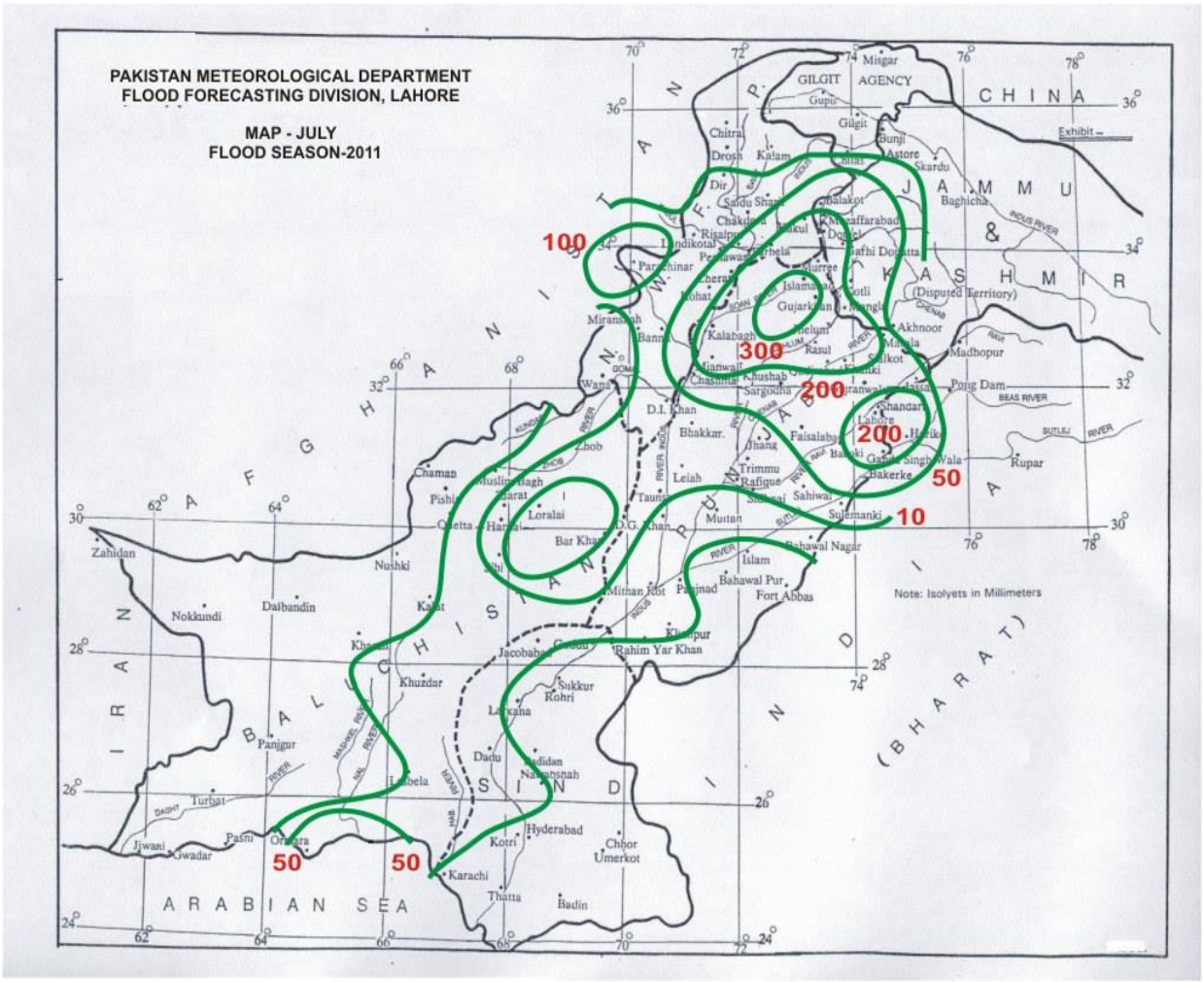

Figure 5:(Isohyetal Map of July 2011)

RIVERS POSITION DURING THE MONTH

Date	Station	UP STREAM (Cusecs)Discharge	Flood level
25-7-11	Marala	152571	Medium
26-7-11	Khanki	118030	Low
27-7-11	Tarbela	268000	Low
27-7-11	Kalabagh	293886	Low

5. SIGNIFICANT HYDROMETEOROLOGICAL EVENTS DURING THE MONTH OF AUGUST 2011:

5.1 METEOROLOGICAL EVENTS:

Three rainfall spells occurred during the month of August. First long spell occurred from 8th to13th August 2011. This spell was caused by the monsoon low which reached over our region after originating in Bay of Bengal interacting with a strong trough of westerly wave moving north of the country .

The monsoon low was developed over north Madhya Pradesh on 8th August. Moving continuously in W-NW direction reached over west Rajasthan and then over Sindh on 11th August, where it became insignificant. Second wet spell was observed from 25th to 26th August which was caused by the passage of westerly wave moving north of the country and moist currents from the Arabian sea. Third spell was due to the well marked low over Gujrat (India) and interaction of westerly wave over northern parts of the country

5.1.1 FIRST WET SPELL (08-08-2011 TO 13-08-2011)

The rainfall during the first spell of August which was 4th of the season occurred during 8th to 13th August 2011 .Very heavy Rainfall was observed in this spell over Sindh province which disrupted the civic life in the province. Completely inundating the major portion of the province bringing the civic life almost to a standstill.

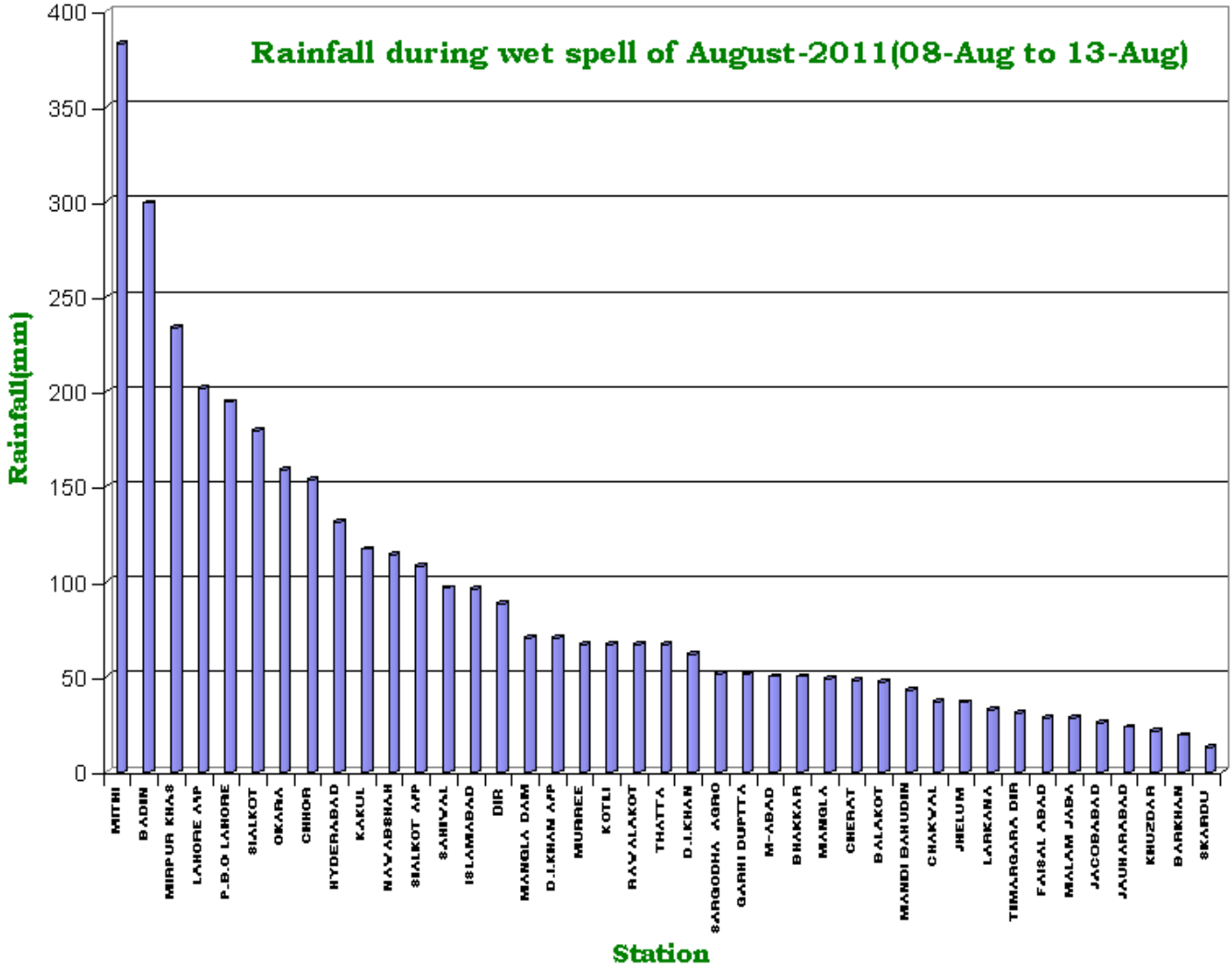

Figure6:(Wet spell of August-2011(08 Aug-13 Aug)

5.1.2 *RIVERS POSITION DURING THE SPELL*

During this spell moderate rains occurred in upper catchments of river Kabul and Chenab which produced Medium flood peak in river Kabul at Nowshera, and low flood wave in river Chenab at Marala ,Khanki & Qadirabad.

5.1.3 *SECOND WET SPELL(25-08-2011 To 26-08-2011)*

This short spell lasted for 2 days from 25th to26th August 2011. It was relatively less active. During this spell moderate rainfall occurred over Rawalakot, Jhelum, Parachinar, and Mandibahauddin as shown in fig below.

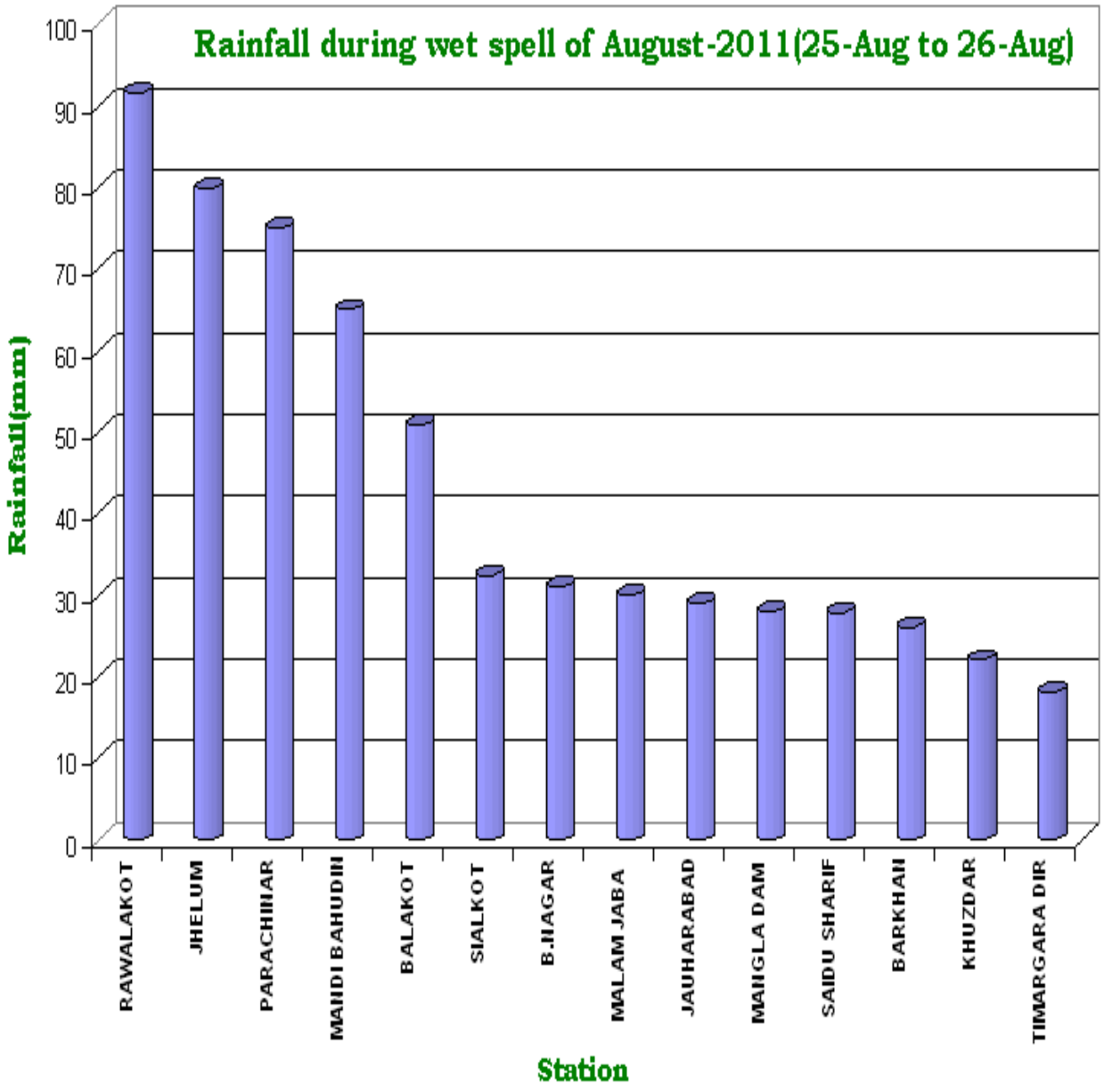

Figure7:(Wet spell of August-2011(25 Aug-26 Aug)

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5.1.4 *RIVERS POSITION DURING THE SPELL*

Due to this spell, No significant flood peak was observed

5.1.5 *THIRD WET SPELL(30-08-2011 To 02-09-2011)*

This spell was due to the well marked low over Gujrat (India) and interaction of westerly wave over northern parts of the country. During this spell heavy to very heavy rainfall was recorded over Sindh and south Punjab as shown in the figure below:

5.1.6 *RIVERS POSITION DURING THE SPELL*

Low flood was observed in river Indus at Chashma during this spell. All the other rivers remained in their normal state. However very heavy rainfall over Sindh caused the urban flooding in the area.

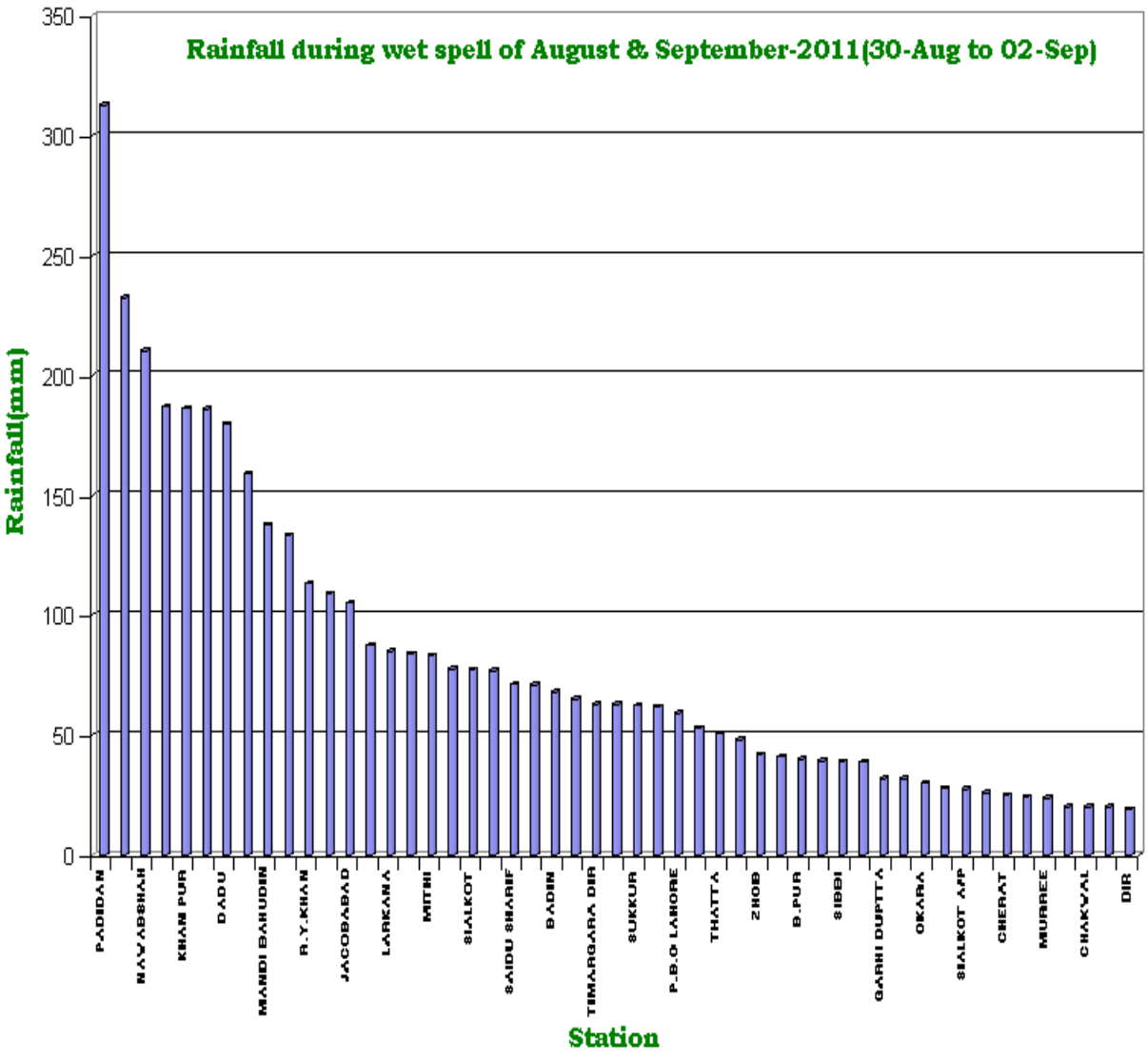

Figure8:(Wet spell of August-2011(30 Aug-02 Sep)

5.1.6 *RAINFALL PATTERN FOR THE MONTH OF AUGUST, 2011*

The monthly isohyetal pattern during the month of August was indicative of quite active monsoon activity over southeastern Sindh. Rainfall maxima exceeding 400 mm in the month of August 2011 was encompassed around Chhor. Rainfall maxima of more than 200mm was also located around Sialkot.

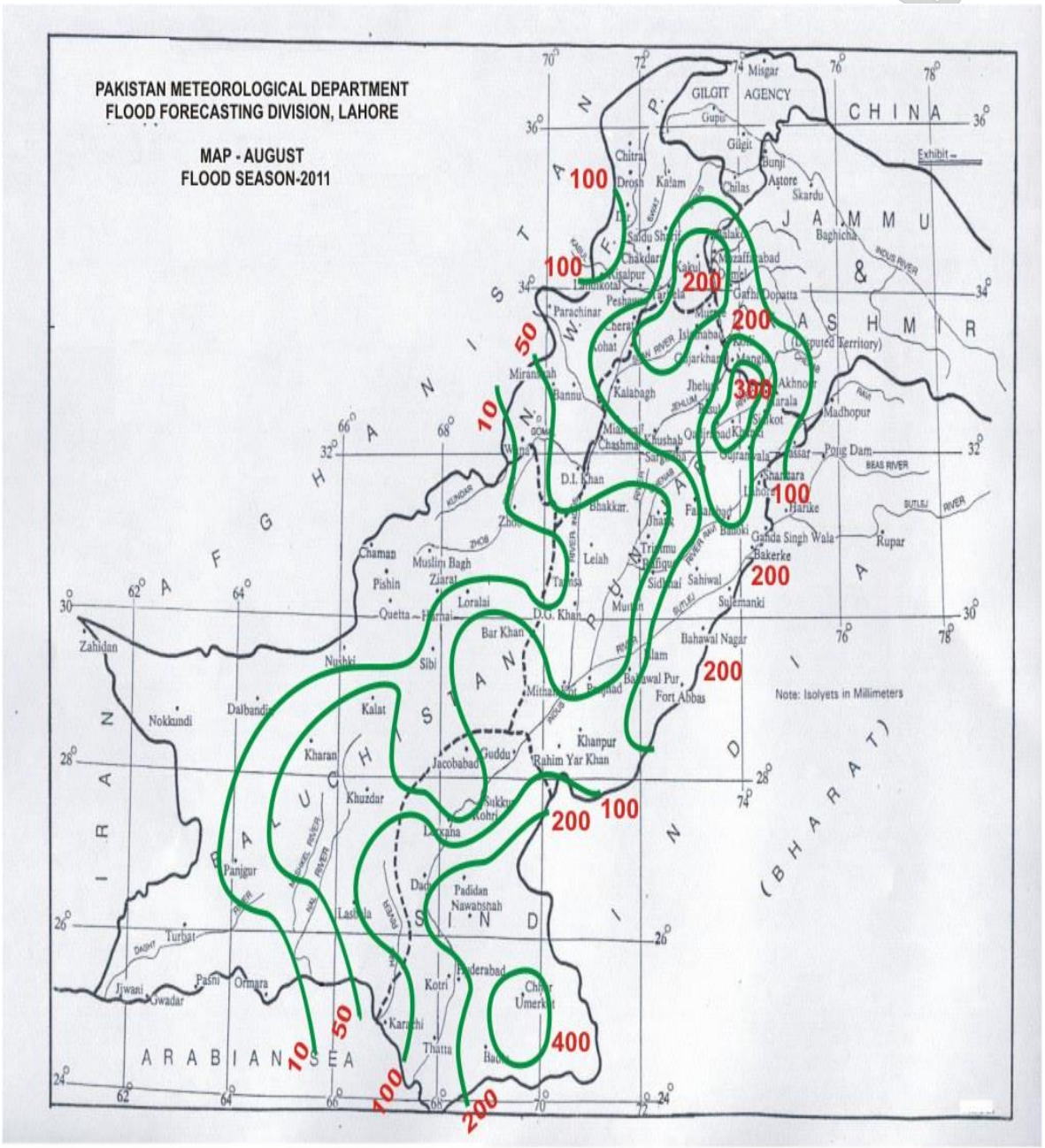

Figure9: (Isohyetal Map of August 2011)

RIVERS POSITION DURING THE MONTH

Date	Station	UP STREAM (Cusecs)	Flood Level
11-8-11	Marala	140307	Low
12-8-11	Nowshera	72000	Low
13-8-11	Khanki	136537	Low
13-8-11	Qadirabad	135295	Low
14-8-11	Balloki	58215	Low
15-8-11	Balloki	72142	Low
23-8-11	Sulemanki	57845	Low
24-8-11	Marala	133064	Low
27-8-11	Sulemanki	75333	Low
28-8-11	Sulemanki	82000	Medium
31-8-11	Chashma	251855	Low

6. SIGNIFICANT HYDROMETEOROLOGICAL EVENTS DURING THE MONTH OF SEPTEMBER 2011:

Two monsoon lows developed during the month of September. The first low originated over the Bay of Bengal at the end of the last month and moving west northwest wards reached Rajasthan India on 6th entered Pakistan on 7th where it dissipated .Second Monsoon low developed over northwest Bay of Bengal on 8th and took the same course , reached in the vicinity of the country on 13th September 2011 but it did not enter Pakistan.Under these meteorological conditions two rainfall spells were observed.

6.1.1 *FIRST WET SPELL (07-09-2011 TO 10-09-2011)*

First rainy spell of September occurred during 7th to 10th September 2011 . During this spell torrential rains of more than 500 mm was recorded over Mithi in southeast Sindh. The southern part of Sindh once again faced a Clamity like situation disrupting the civic life. Moderate rains were also observed over south Punjab and Kashmir.

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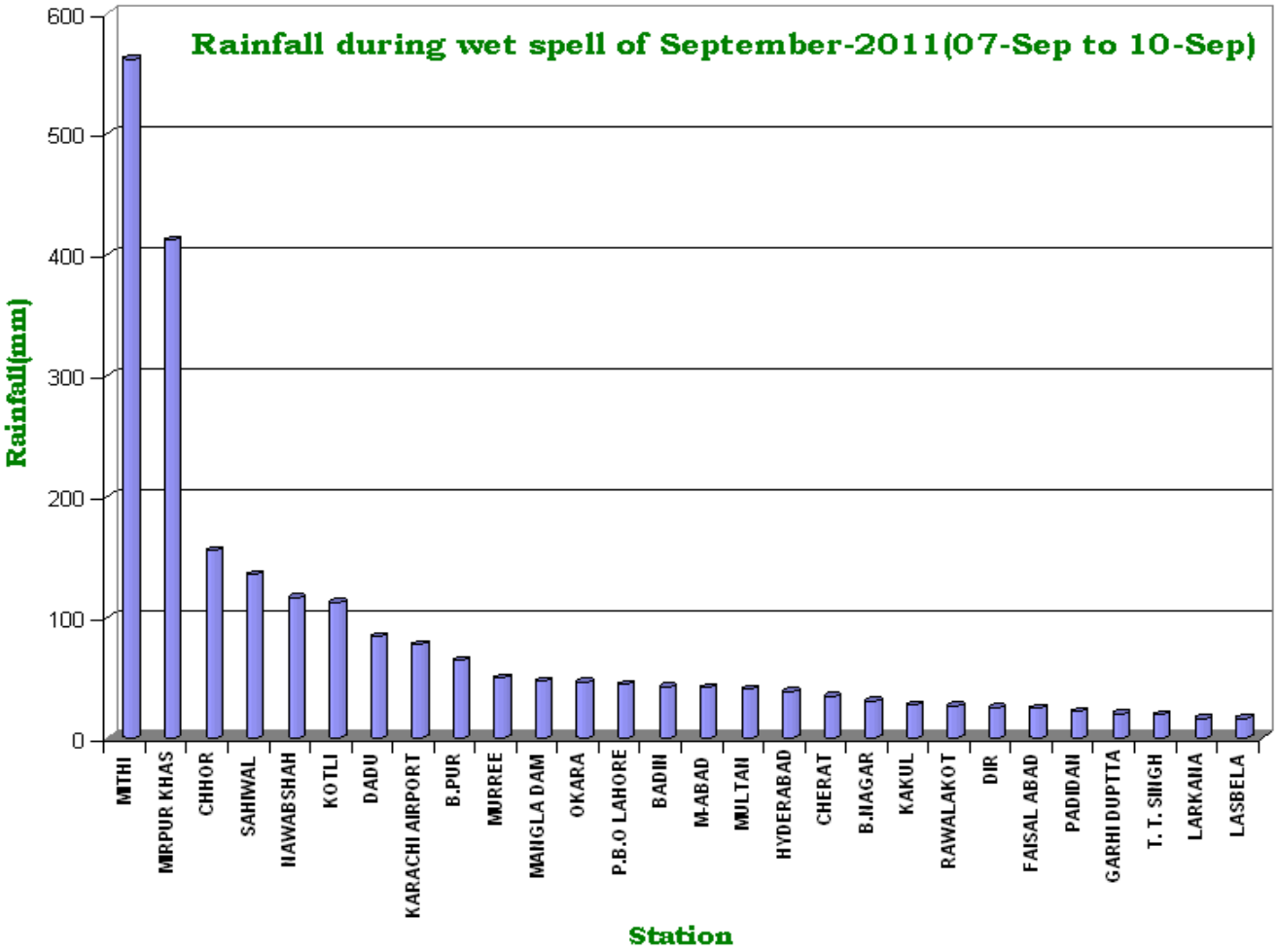

Figure10:Wet spell of September(07 Sep-10 Sep)

6.1.2 ***RIVERS POSITION DURING THE SPELL***

As rainy system affected mainly lower parts of the country therefore no significant change in any river, nullahs and hill torrent was observed.

6.1.3 SECOND WET SPELL (13-09-2011 TO 16-09-2011)

This spell was caused due to the movement of monsoon low from Bay of Bengal and movement of westerly wave from the north of the country. It lasted 4 days. Once again Sindh was at the receiving end from the nature and total rainfall in Sindh exceeded all previous records at some places which created very abnormal situation in the normal pattern of rainfall during the Monsoon period. Upper catchments of river Jhelum also received heavy rainfall at isolated places.

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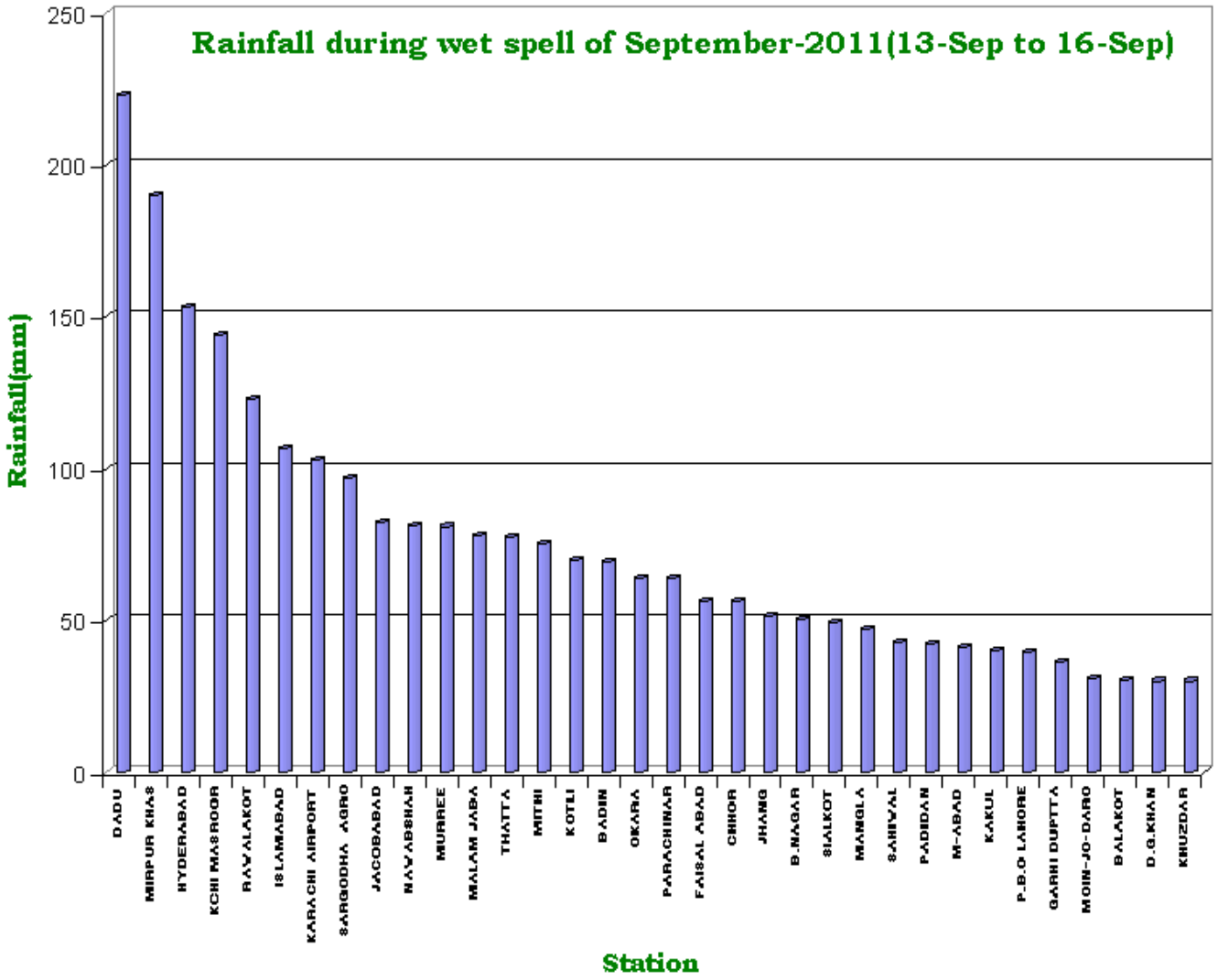

Figure11:Wet spell of September(13 Sep-16 Sep)

6.1.4 *RIVERS POSITION DURING SPELL*

Due to this spell a high flood peak was recorded at Mangla in river Jhelum and medium flood peaks in river Chenab at Marala and Khanki.

6.1.5 *RAINFALL PATTERN FOR THE MONTH OF SEPTEMBER 2011*

A rainfall maxima of more than 300 mm was located around Southeast Sindh over Chhor during the month of September 2011 as shown in figure . A lesser maxima of more than 200 mm was located around Southeastern Punjab over Sahiwal district.

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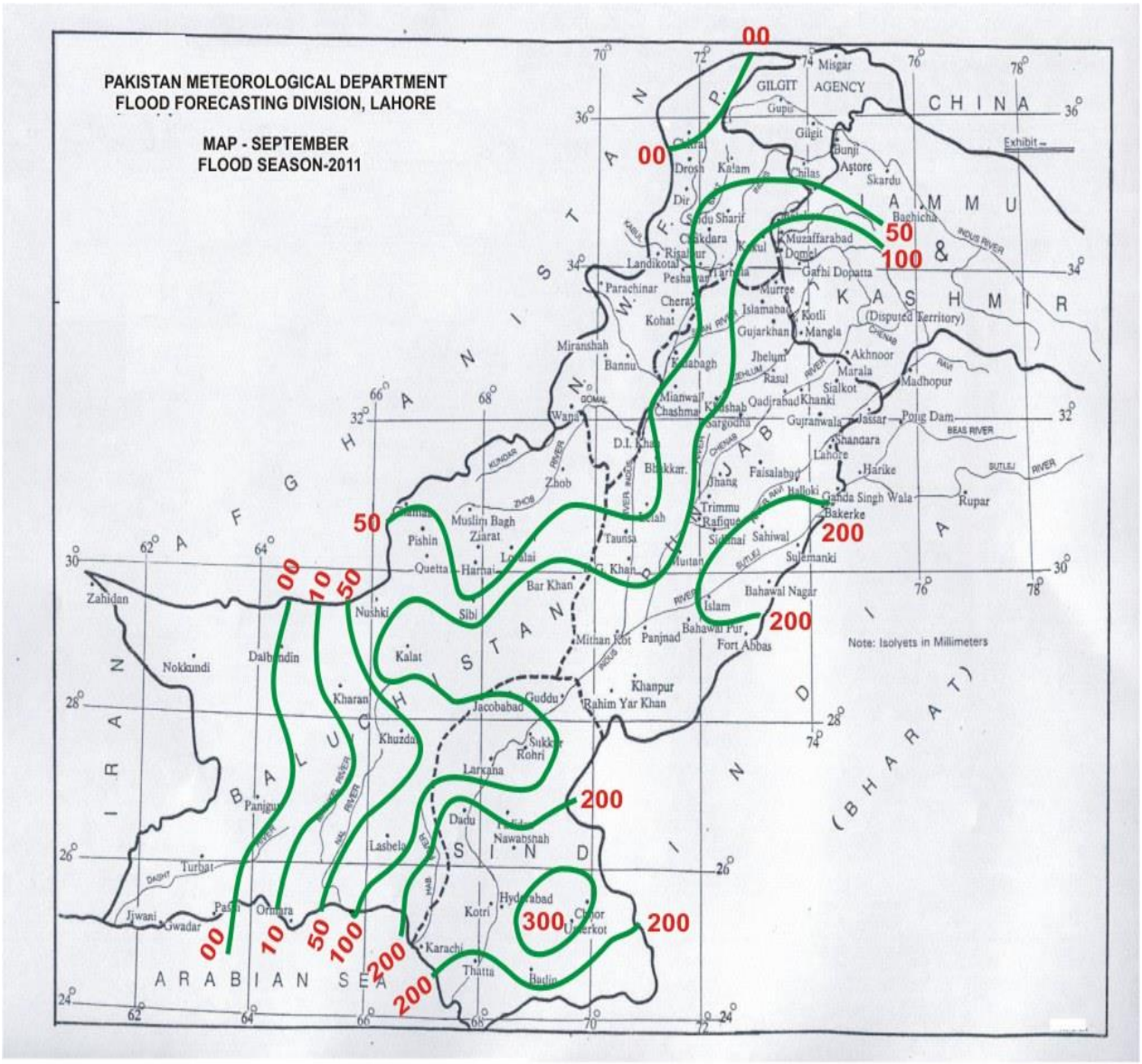

Figure12: Isohyetal Map of September 2011

RIVERS POSITION DURING THE MONTH

Date	Station	UP STREAM (Cusecs)	Flood Level
16-9-11	Mangla	155000	High
16-9-11	Rasul	105814	Low
16-9-11	Marala	169055	Medium
16-9-11	Khanki	171383	Medium
17-9-11	Qadirabad	171004	Medium
17-9-11	Kalabagh	257171	Low
24-9-11	Punjnad	151264	Low

7. SEASONAL RAINFALL PATTERN JULY TO SEPTEMBER (2011)

Seasonal rainfall pattern during the season is shown in figure below.

Regions of maximum precipitation (more than 1000 mm) are located over Chhor in southeast Sindh.The season has been very very active over Sindh and adjoining Balochistan where the monsoon rains are not expected upto this extent.The reason being that the monsoon lows traveled straight towards Sindh in the absence of any strong westerly waves which could pull the lows in the northerly direction.

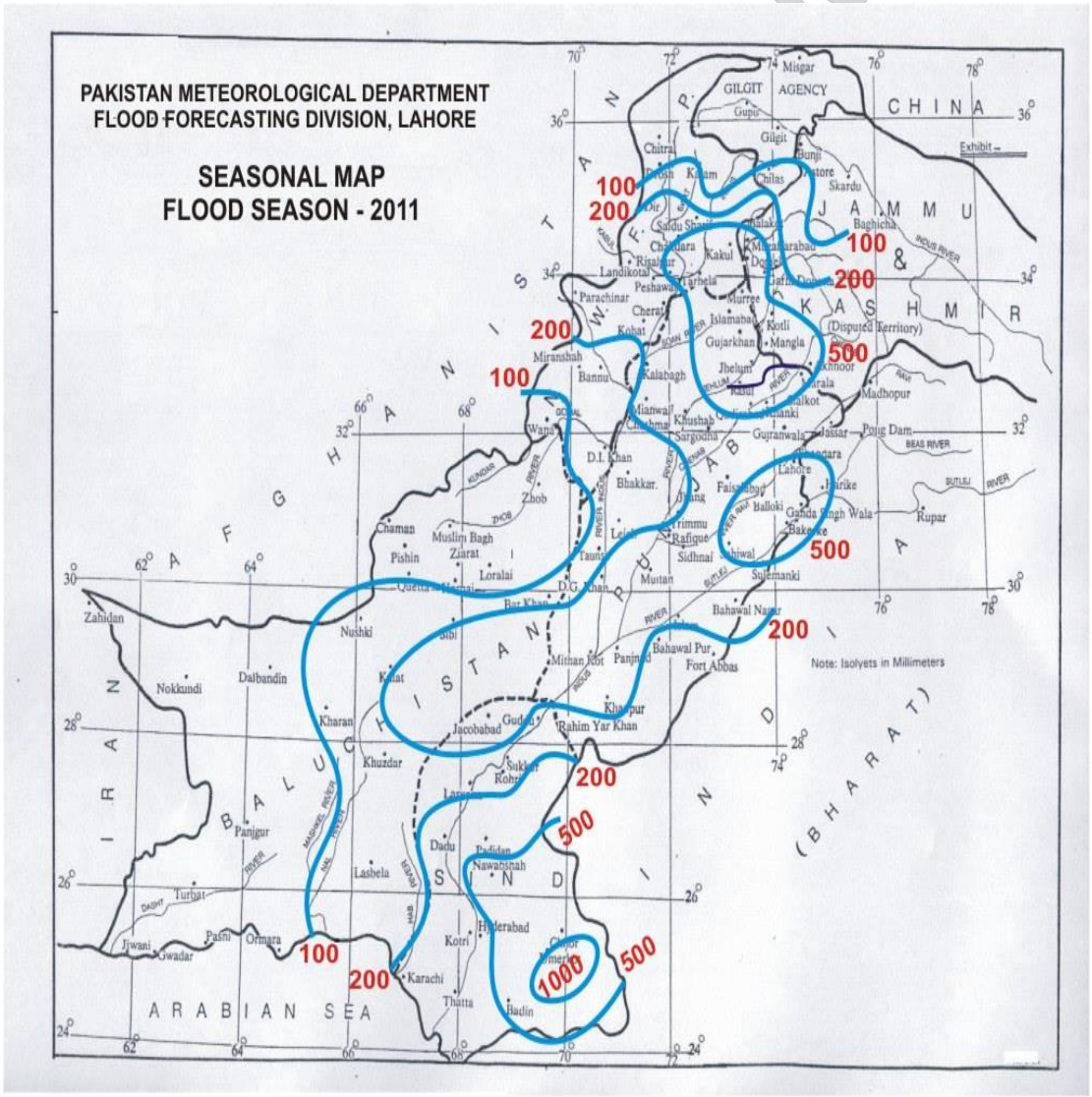

Figure12: Seasonal Isohyetal Map (July – September) 2011

Two lesser maxima of more than 500 mm rainfall was observed one over northeast Punjab and second over north Punjab and adjoining Kashmir .

8. SEASONAL ISOPERCENTAL MAP OF PRECIPITATION FROM JULY-2011 TO SEPTEMBER-2011

The seasonal precipitation isopercental map indicates that a major portion of the country received above normal rainfall. Southeast Sindh received 500% above normal which resulted into local urban flooding in area. Some parts of northeast Balochistan also received more than 500% rain. Catchments of all the major rivers remained almost in normal rainfall conditions. Western Balochistan remained almost dry during the monsoon season 2011.

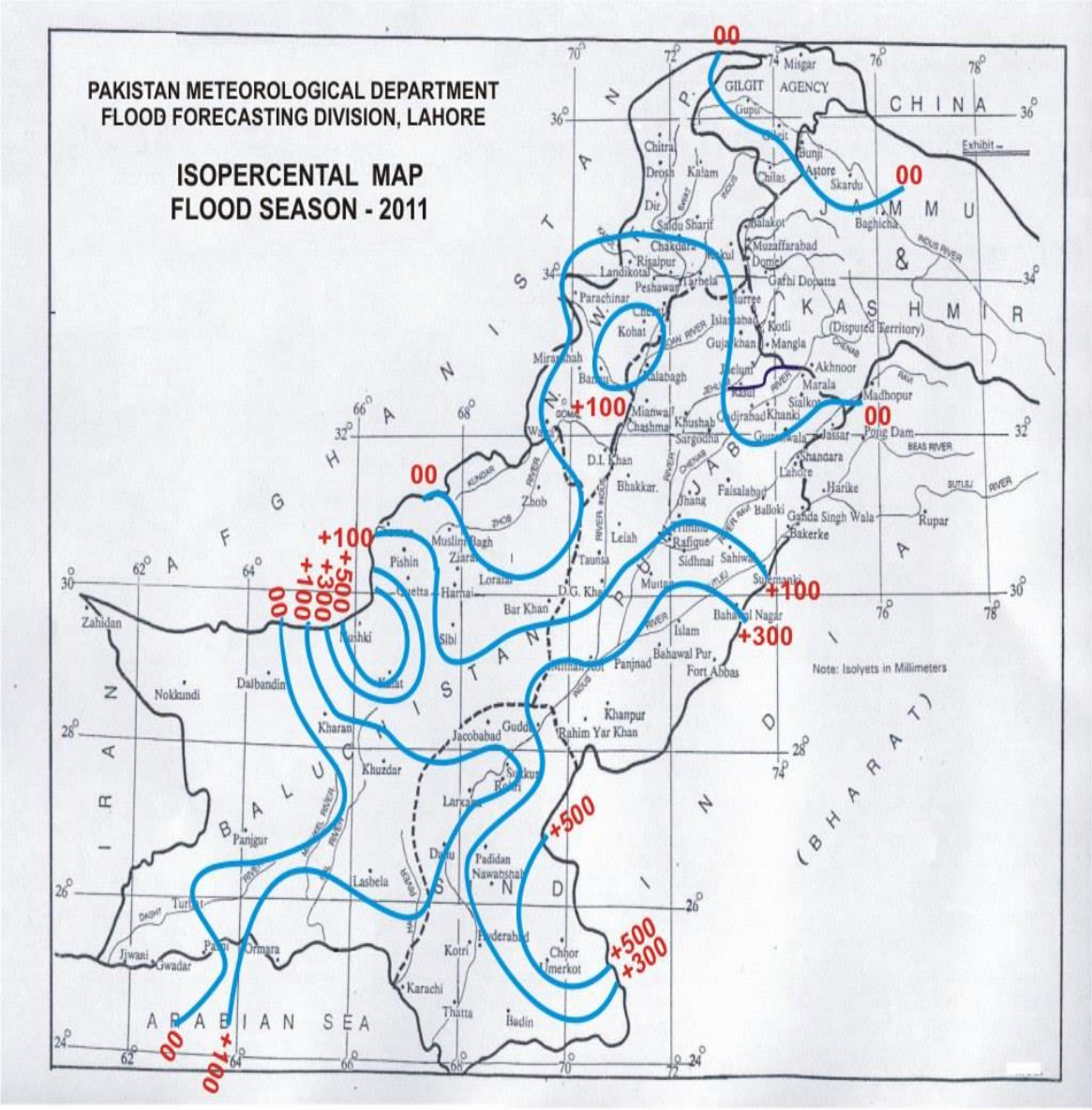

Figure13: Seasonal Isopercental Map (July – September) 2011

9. FLOOD FORECAST EVALUATION REPORT:

The Flood Forecast evaluation report for 2011 for each category of flood is given below.

FLOOD SEASON-2011
Comparison of Forecast & Observed Discharge (Cusecs)

Date	Station	Forecast(Thousands of Cusecs)	Actual (Cusecs)	Per. Accuracy (%)
25-7-11	Marala	80-160	152571	100
26-7-11	Khanki	100-150	118030	100
27-7-11	Tarbela	250-270	268000	100
11-8-11	Marala	100-180	140307	100
12-8-11	Nowshera	40-60	72000	83
13-8-11	Khanki	100-140	136537	100
13-8-11	Qadirabad	70-110	135295	78
14-8-11	Balloki	50-60	58215	100
15-8-11	Balloki	60-80	72142	100
23-8-11	Sulemanki	55-70	57845	100
24-8-11	Marala	100-190	133064	100
27-8-11	Sulemanki	69-75	75333	100
28-8-11	Sulemanki	70-75	82000	91
31-8-11	Chashma	220-240	251855	95
31-8-11	Taunsa	220-255	249177	100
16-9-11	Mangla	250 F 100	155000	100
16-9-11	Rasool	40 R 120	105814	100
16-9-11	Khanki	40-130	171383	76
16-9-11	Marala	100 R 180	169055	100
17-9-11	Qadirabad	145R170F120	171004	99
17-9-11	Kalabagh	240-280	257171	100
24-9-11	Punjnad	120-130	151264	86

R: Rising
F: falling

The overall accuracy of the forecast issued by FFD Lahore during the flood season 2011 has been calculated which shows a good 95.82% against all odds.

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FLOOD LIMITS (IN LACS OF CUSECS):

RIVER	SITE	DESIGN CAPACITY	LOW	MED	HIGH	VERY HIGH	EXCEPTIONALLY HIGH
KABUL	NOWSHERA	-	0.45	0.47	1.0	2.0	4.0
	WARSAK	15.0	0.30	0.45	1.0	2.0	4.0
INDUS	TARBELA	15.0	2.5	3.75	5.0	6.5	8.0
	ATTOCK	-	2.5	3.75	5.0	6.5	8.0
	KALABAGH	9.5	2.5	3.75	5.0	6.5	8.0
	CHASHMA	9.5	2.5	3.75	5.0	6.5	8.0
	TAUNSA	10.0	2.5	3.75	5.0	6.5	8.0
	GUDDU	12.0	2.0	3.5	5.0	7.0	9.0
	SUKKUR	9.0	2.0	3.5	5.0	7.0	9.0
	KOTRI	8.5	2.0	3.0	4.5	6.5	8.0
JHELUM	KOHALA	-	1.0	1.5	2.0	3.0	4.0
	MANGLA	10.6	0.75	1.1	1.5	2.25	3.0
	RASUL	8.5	0.75	1.1	1.5	2.25	3.0
CHENAB	MARALA	11.0	1.0	1.5	2.0	4.0	6.0
	KHANKI	8.0	1.0	1.5	2.0	4.0	6.0
	QADIRABAD	8.07	1.0	1.5	2.0	4.0	6.0
	TRIMMU	6.45	1.5	2.0	3.0	4.5	6.0
	PANJNAD	7.0	1.5	2.0	3.0	4.5	6.0
RAVI	JASSAR	2.75	0.5	0.75	1.0	1.5	2.0
	RAVI SYPHON	4.5	0.4	0.65	0.9	1.35	1.8
	SHAHDARA	2.5	0.4	0.65	0.9	1.35	1.8
	BALLOKI	2.25	0.4	0.65	0.9	1.35	1.8
	SIDHNAI	1.5	0.3	0.46	0.6	0.9	1.3
SUTLEJ	SULEMANKI	3.25	0.5	0.8	1.2	1.75	2.25
	ISLAM	3.0	0.5	0.8	1.2	1.75	2.25

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Classification of Cyclonic Disturbances for Pakistan

Type of Disturbance	Pressure (hpa)	Corresponding Wind Speed	Effects during Landfall
Depression	≤996	22-27 Knots	Gusty winds and damages detaching fruit from the trees.
Deep Depression	986-995	28-33 Knots	Negligible damages to houses, trees, some crops and caravan.
Cyclonic Storm	971-985	34-47 Knots	Minor house damage, significant damage to signboards, trees and small crafts.
Severe Cyclonic Storm	956-970	48-63 Knots	Some roof and structural damage, destruction of some caravans and power failure
Very Severe Cyclonic Storm	930-955	64-119 Knots	Significant structural damage, caravans blown away & dangerous air born debris.
Exceptionally sever Cyclonic Storm	≤929	120 Knots or more	Widespread destructions, uprooting trees.

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