3.5 Sediment Balance after the Eruption of 1982

The detailed sediment balance at the southeastern slope basin at Mt. Galunggung after the eruption of 1982 in accordance with Table - 3.1, Table - 3.2, Table - 3.4 and Table 3.8 is shown in Table - 3.9. Table - 3.10 shows the summary of sediment balance for each basin.

Table - 3.9 Sediment Balance for Each Basin of Mt. Galunggung

(unit: 1,000 m^3)

River Basin	Ejected Material Volume	Erosion Volume	Unstable Materials			Accumulated Sediment Volume in Sandpocket
			Accumulated Materials	Riverbed Materials	Total	
S. Ciloseh	7,200	7,200	0	548	548	(3,850)
S. Cikunir	40,400	32,830	7,610	1,862	9,472	34,456 (1,740)
South Slope	18,500	0	0	0	0	-
Total	66,140	58,530	7,610	2,410	10,020	34,456 (5,590)

Notes: 1. ( ) shows the overflowing volume from Sinagar
2. "-" means no sandpocket

The sediment balance at the Ciloseh - Cimampang basin, the Cikunir-Cibanjaran basin and on the southern slope is summarized as follows.

(1) Ciloseh - Cimampang Basin

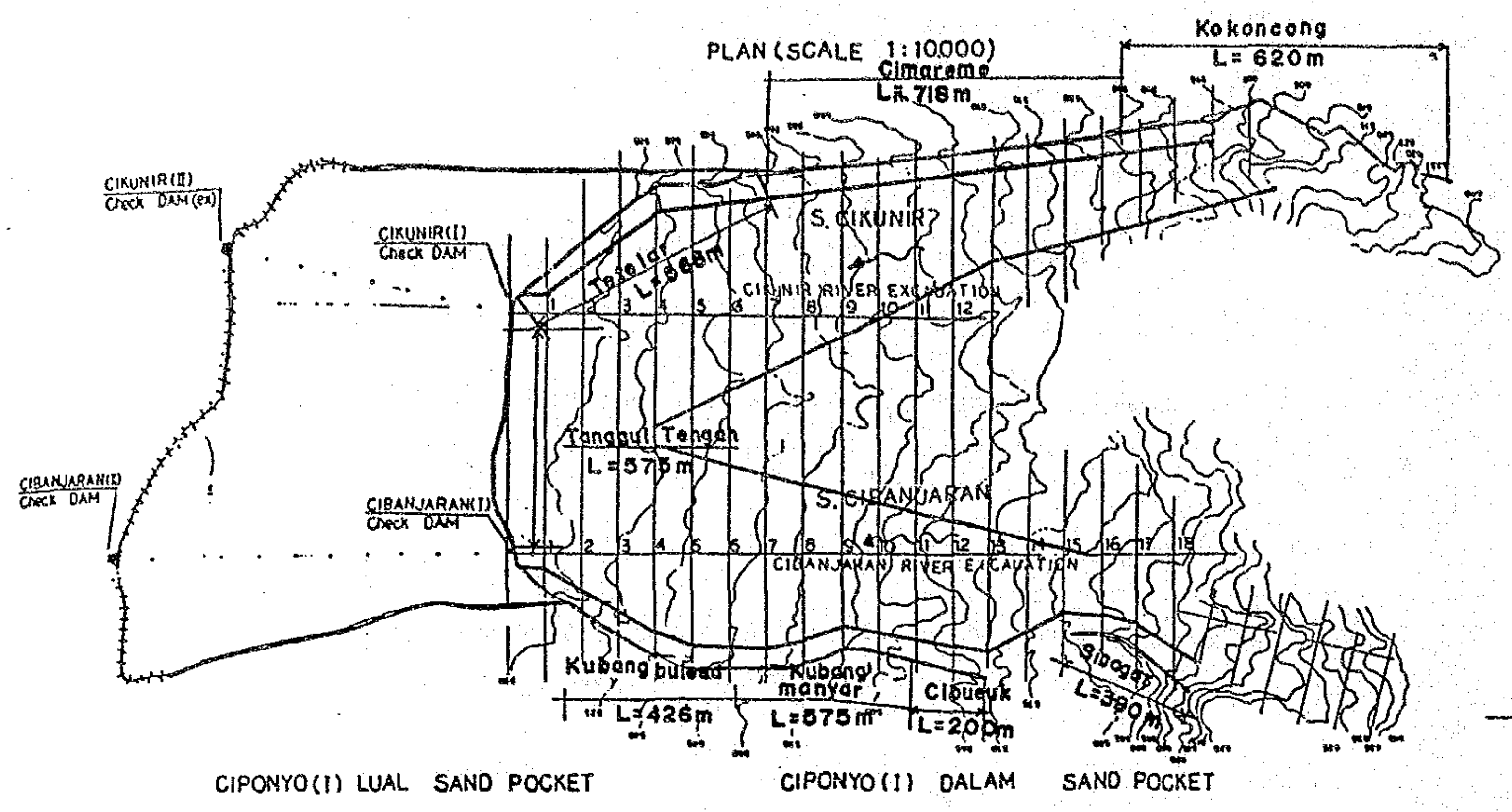
The ejected materials more than 7.2 million m^3 which were accumulated in the basin by the 1982 eruption ran off thoroughly to the lower reaches until August, 1987, and only the unstable materials on the riverbed is observed around the basin. Its volume is 548 thousand m^3.

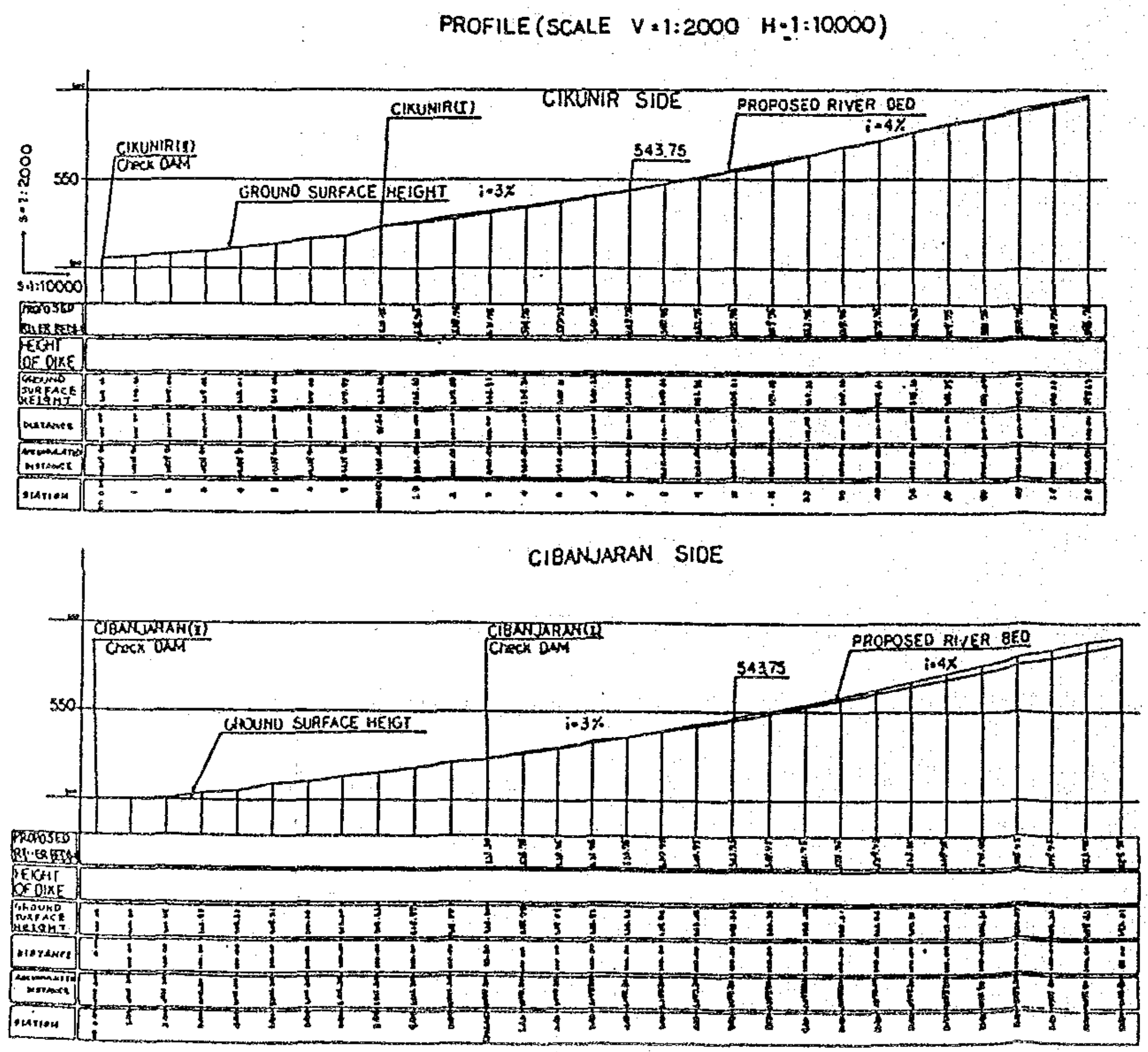
The accumulated sediment of 3.85 million m^3 at Sandpocket Negla and Cimampang is the one which was overflowed from the spot of Sinagar in S. Cibanjaran.

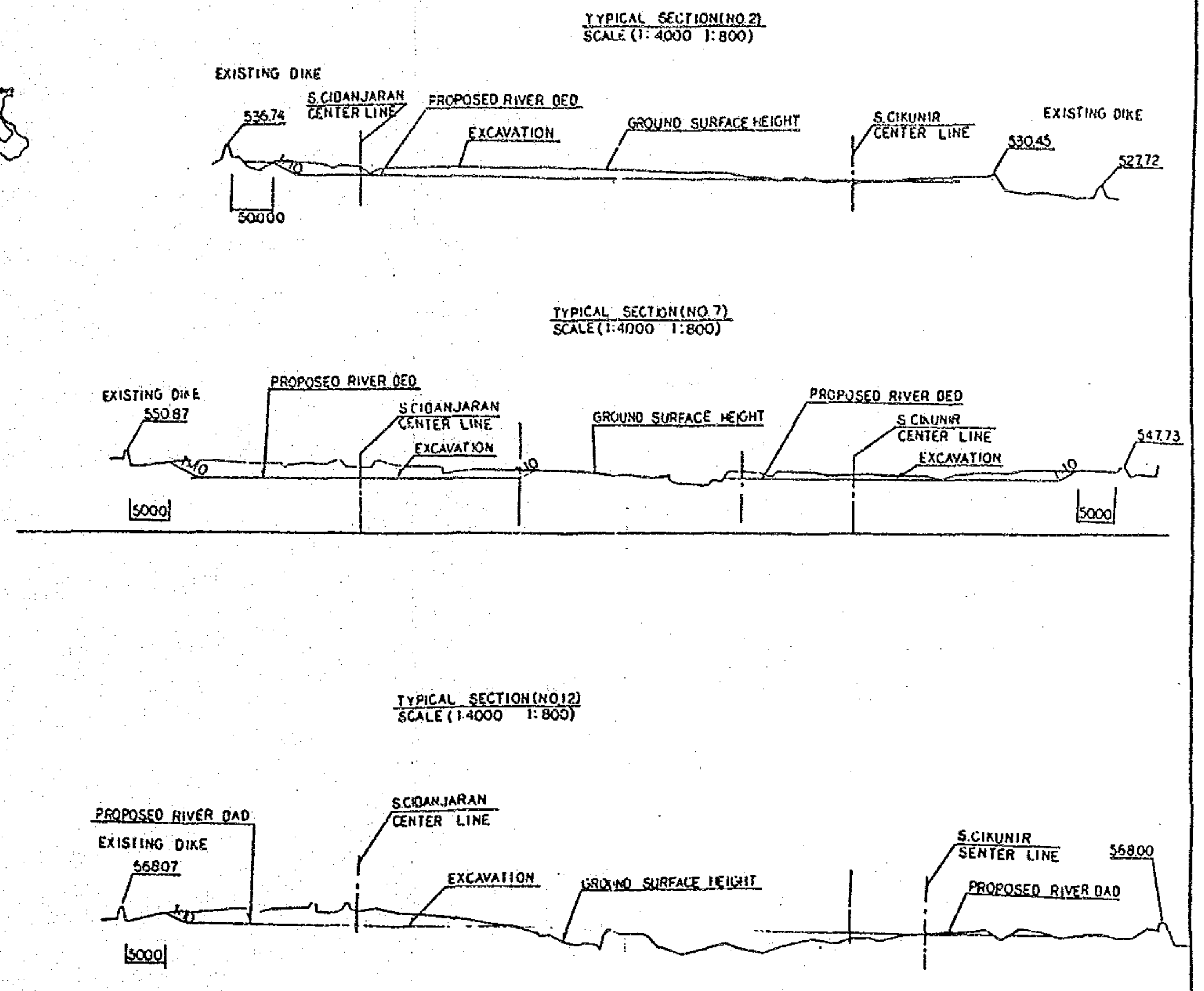
(2) Cikunir - Cibanjaran Basin

As merely the ejected materials volume at the time of August, 1982 reached 40.4 million m^3.

32.8 million m^3 of the ejected materials of this basin already ran off, and it seemed to be the secondary erosion such as bank erosion, and bed erosion that occurred as these ran off. Though 34.46 million m^3 of it was accumulated on the present sandpockets, 1.74 million m^3 overflowed at the spot of Sinagar on S. Cibanjaran and was accumulated around the S. Cimampang basin.







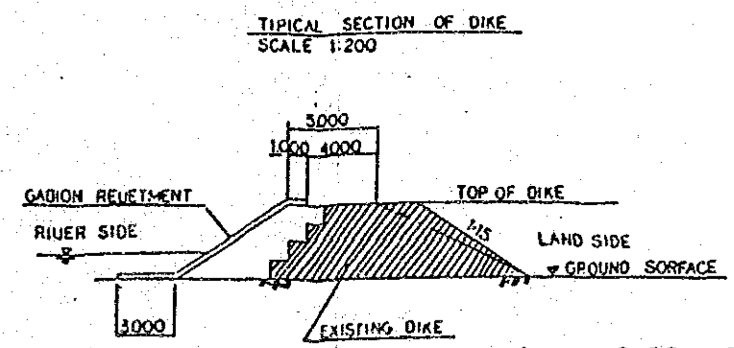


Fig. - 3.12 Alternative I - A (Raising Dike)

The sediment volume accumulated on the S. Cimampang basin which overflowed at the spot of Sinagar is 5.59 million m^3, of which 1.74 million m^3 are from 1982 and 3.85 million m^3 accumulated on the Sandpocket Negla, as well as the Sandpocket Cimampang, afterwards.

The volume of unstable materials is estimated as more than 9.5 million m^3 (ladu deposit; 7.6 million m^3, unstable materials in riverbed: 1.9 million m^3).

(3) South Slope Basin

The ejected materials of 18,500 10^3 m^3 ran off to the lower reaches. There is no unstable materials in the southern slope basin.

3.6 Spare Capacity of Sandpockets in August, 1987

The accumulated sediment volume and the spare capacity of each sandpocket at the time of August, 1987 were estimated from the result of the cross sectional survey of the sandpockets executed by JICA Study Team in August 1987.

3.6.1 Estimation Method of Accumulated Sediment Volume in Sandpocket

Two kinds of topographical maps or cross sections such as, before and after the deposition, is required in order to estimate the sediment volume in the sandpocket. However, there was no map before the deposition in this study.

Accordingly, in this study, the sediment volume at the time of Aug. 1987 was estimated presuming the ground surface (the former ground line) before their construction in consideration of the relation between the ground height of landside and the height of deepest riverbed, the existence of the banking section, the present condition of the ground height of communities in the sandpockets by using cross sectional map surveyed by JICA team in August 1987.

The method estimation by presuming the former ground line and the accumulated area of the sediment were shown in Fig. - 3.8 taking account the existing geographical features, the condition of deposition, etc.

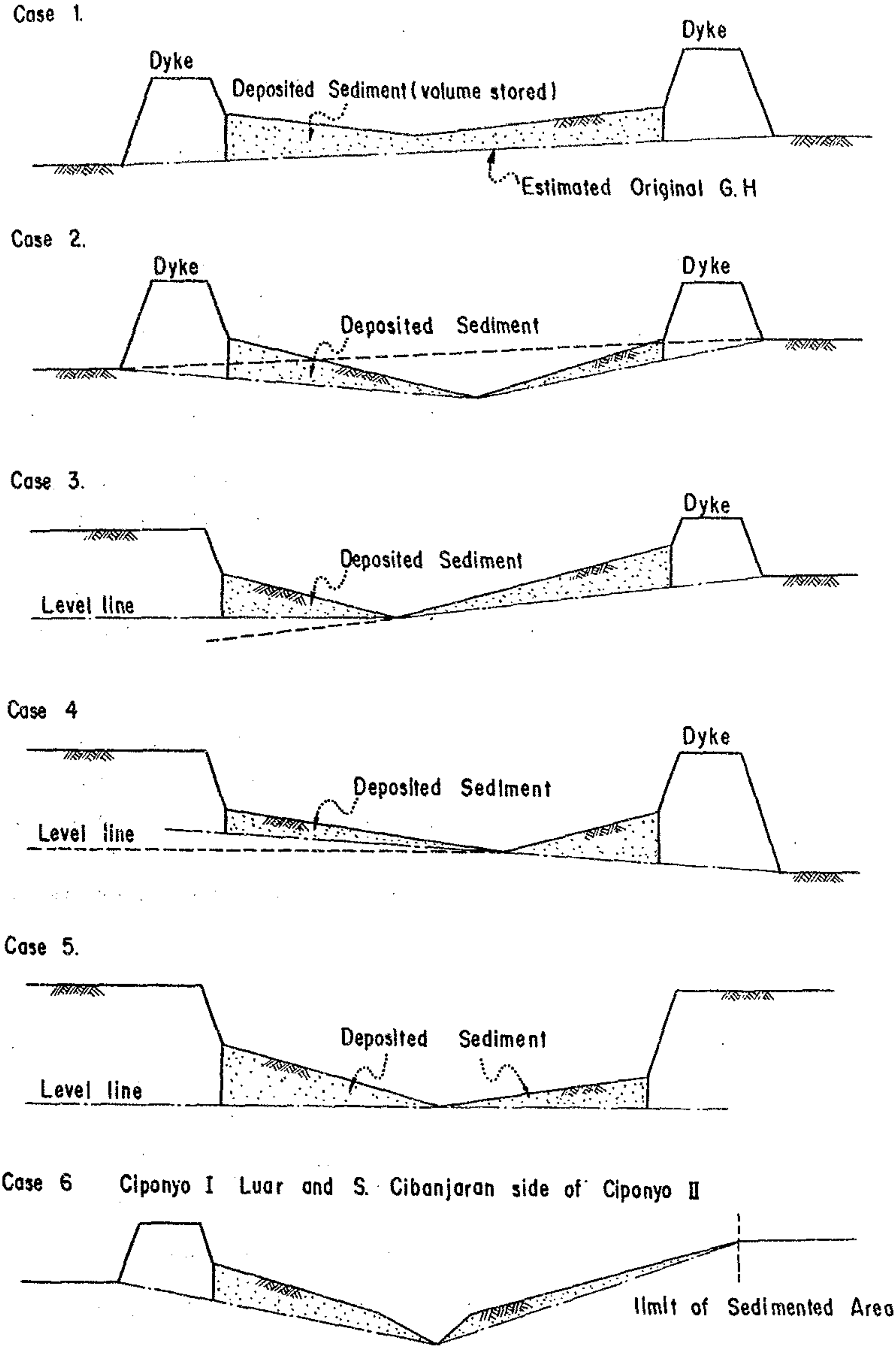


Fig. - 3.8 Estimation Method of Accumulated Sediment Volume

3.6.2 Supposed Allowable Sedimentation Line

The spare capacity of sand pocket is defined as the possible deposited sediment volume under the design sedimentation line. The design sedimentation line is usually established in consideration of the sediment runoff form, the security for the flood discharge.

In this study, establishing the following cases as the supposed allowable sedimentation level, non-deposit area under this level is supposed to be the spare capacity of the sand pockets. (See Fig. - 3.10 shown below.)

The line connecting the line which envelopes the point 1 m lower from the top of bank and the line which starts from the crest of spill way (over flow) of consolidation dam is made "the supposed allowable longitudinal sedimentation line". (refer to Fig. - 3.12 - 3.15 and Table - 3.10)

The line which connects the supposed allowable sedimentation line of both the right bank and the left bank is made "the supposed allowable sedimentation line".

However, the Ciponyo I dalam, while the runoff sediment concentrated on the right area and left area near the bank as well as lower area of sand pocket, the central area of the sand pocket is difficult to be deposited. Therefore, the supposed allowable sedimentation line in the central area of sand pocket Ciponyo I is assumed to run parallel with the former ground line.

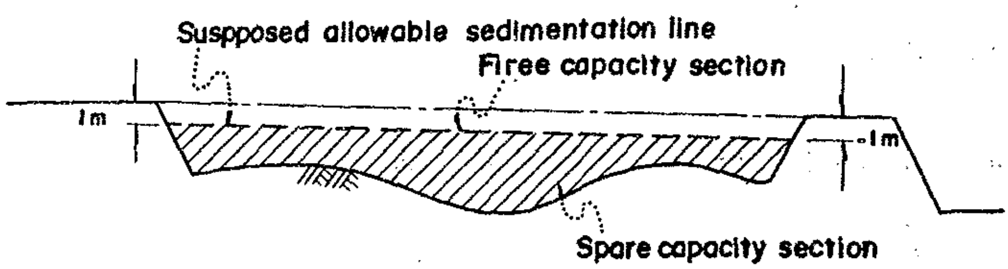


Fig. - 3.9 Supposed Allowable Sedimentation Level

The supposed allowable sediment gradient in the sand pockets is shown in Table - 3.10.

The supposed allowable sediment gradient of sand pocket gradient of sand pockets located in the S. Ciloseh basin is gentle compared with that of sand pocket in the S. Cikunir basin.

The spare capacity is calculated based on the average sectional method adopting cross section.

Besides, when the riverbed is over the supposed allowable sedimentation line, the volume is established as the excess sediment volume.

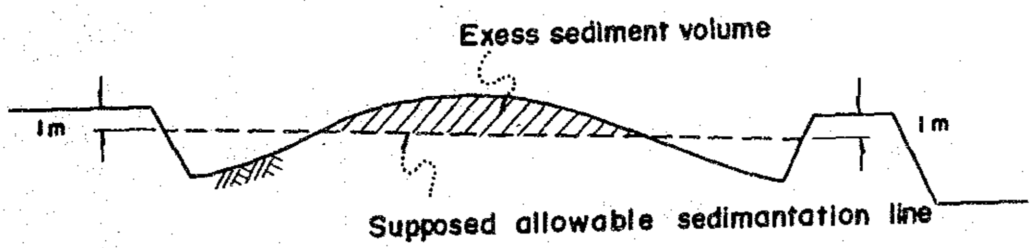


Fig. - 3.10 Supposed Allowable Sedimentation Line Excess Sediemtn Volume

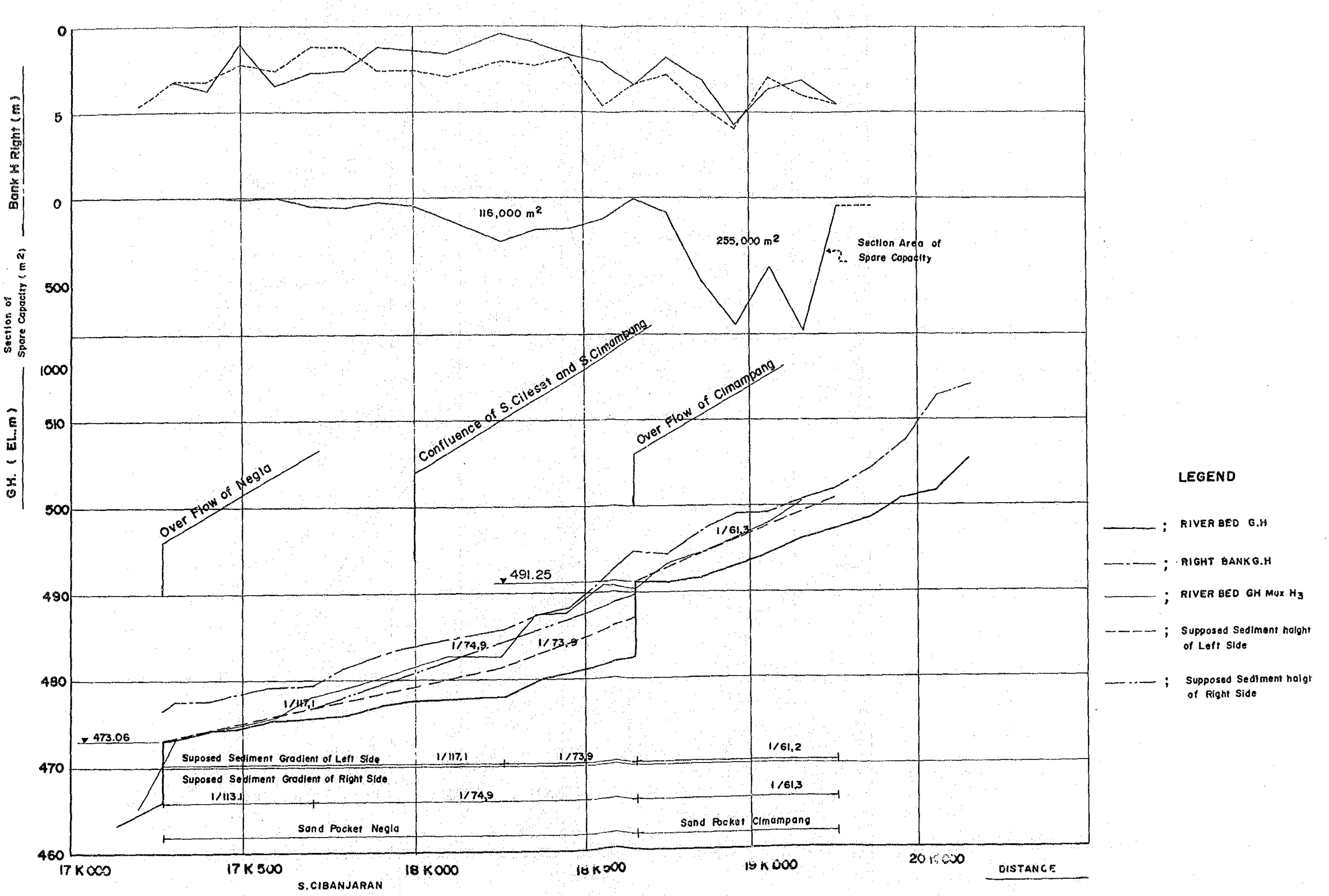


Fig. - 3.11 Longitudinal Section of Sand Pocket Negla and Cimampang (S. Ciloseh and S. Cimampang)

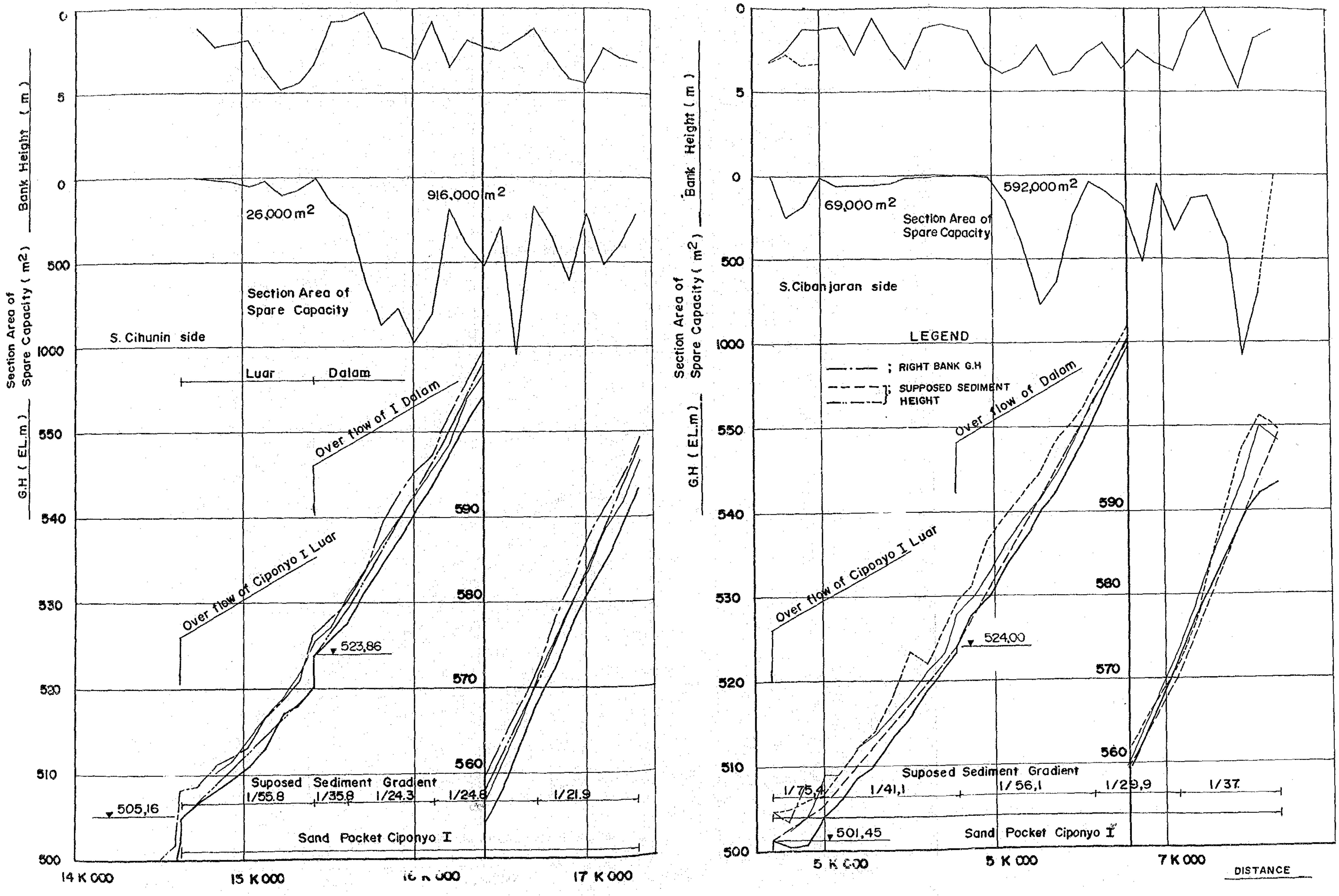


Fig. - 3.12 Longitudinal Section of Sand Pocket Ciponyo I (S. Cikunir and S. Cibanjaran)

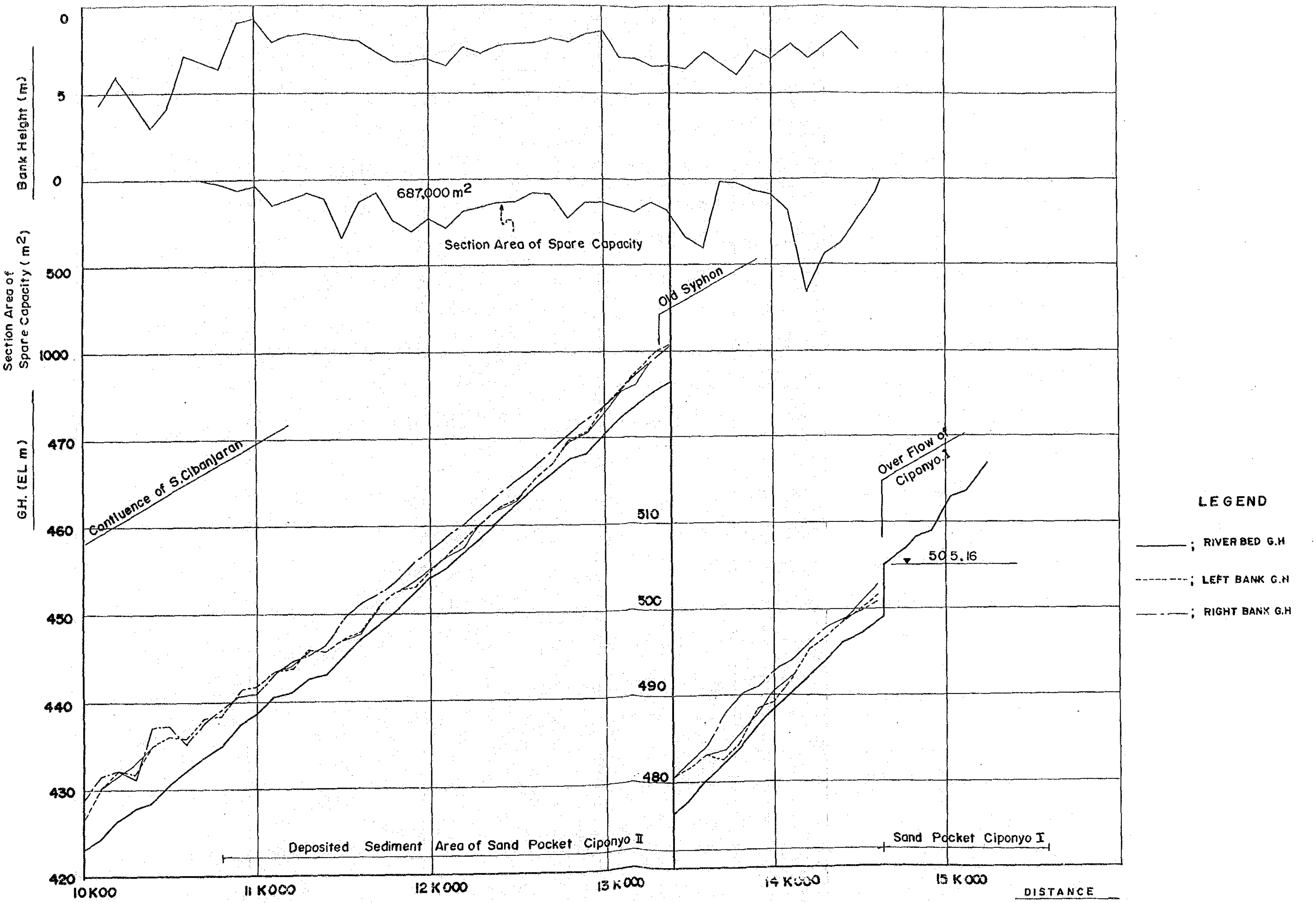


Fig. - 3.13 Longitudinal Section of Sand Pocket Ciponyo II (Ciponyo II)

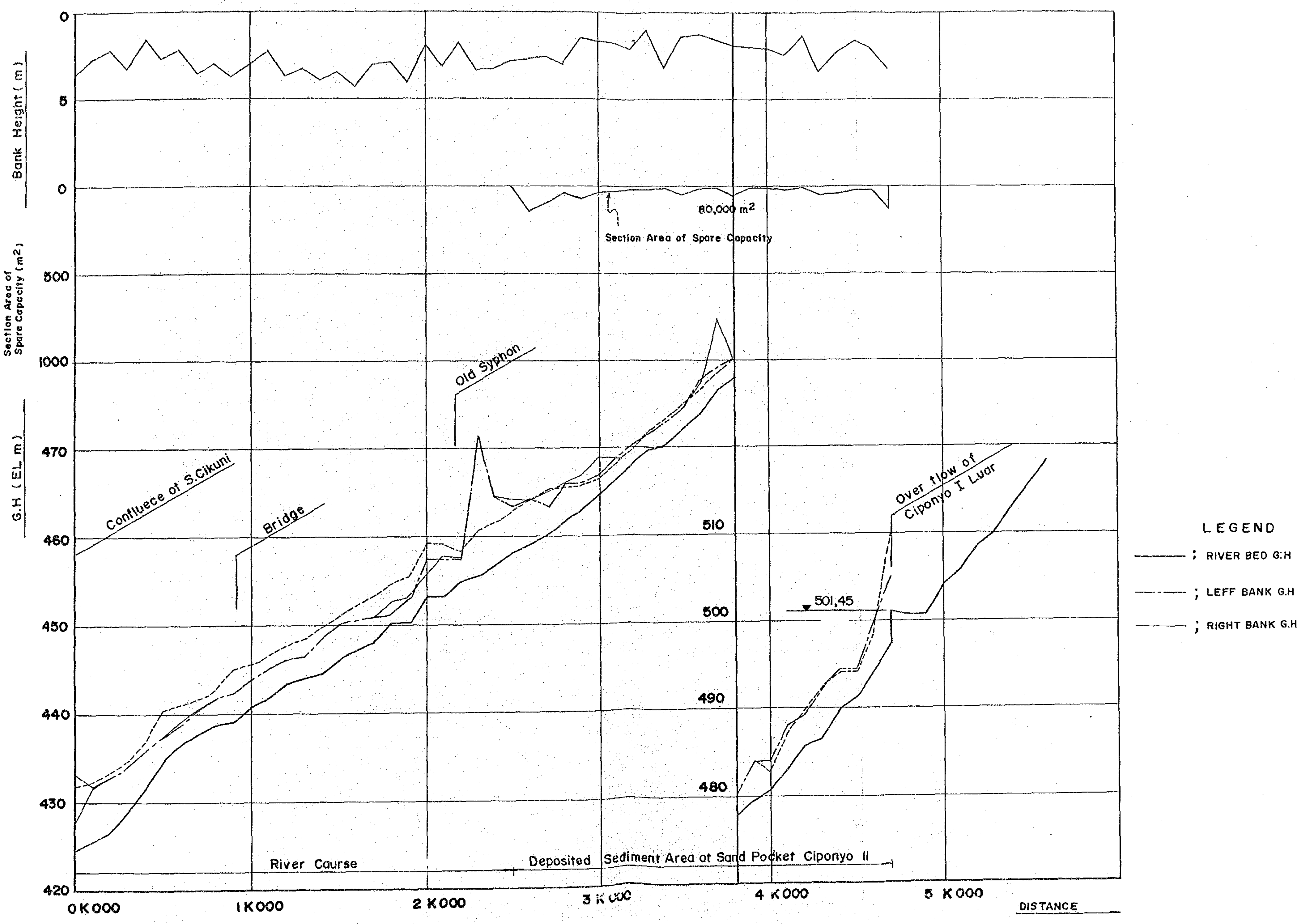


Fig. - 3.14 Longitudinal Section of S. Cibanjaran (Ciponyo II)

Table - 3.11 Supposed Allowable Sediment Gradient in Sandpocket

Name of Sandpocket	Section	Supposed Allowable Sediment Gradient Left Side	Right Side	Actual Riverbed	Remarks
Negla & Cimampang	16k500-17k264	-	-	1/ 84	Downstream
	17k264-17k700	1/117	1/117	1/133	SP Negla
	17k700-18k260	1/117	1/ 75	1/133	
	18k260-18k660	1/117	1/ 75	1/133	
	18k660-18k860	1/ 61	1/ 61	1/571	SP Cimampang
	18k860-19k260	1/ 61	1/ 61	1/ 61	
Ciponyo I (S. Cibanjaran Side	0k600- 2k700	-		1/ 89	SP Ciponyo I
	2k700- 4k000	-		1/ 63	
	4k000- 4k700	-		1/ 45	
	4k700- 5k000	1/ 75		1/122	
	5k000- 5k778	1/ 41		1/ 40	
	5k778- 6k378	1/ 28		1/ 33	SP Ciponyo I Dalam
	6k378- 6k578	1/ 28		1/ 23	
	6k578- 7k078	1/ 28		1/ 23	
	7k078- 7k678	1/ 28		1/ 23	Dalam
Ciponyo I (S. Cikunir Side	10k000-13k600	-		1/ 63	SP Ciponyo II
	13k378-14k400	-		1/ 49	
	14k400-14k630	-		1/ 82	
	14k630-15k030	1/ 56		1/ 72	SP Ciponyo I Luar
	15k030-15k411	1/ 56		1/ 41	
	15k411-15k611	1/ 36		1/ 50	SP Ciponyo I Dalam
	16k611-16k111	1/ 28		1/ 30	
	16k111-16k511	1/ 25		1/ 30	
	16k511-16k711	1/ 25		1/ 23	
	16k711-17k311	1/ 22		1/ 23	

Note) SP: Sandpocket

3.6.3 Spare Capacity of Sandpocket

The calculation of the accumulated sediment volume and the spare capacity, the excess sediment volume of each sandpocket at the time of August, 1987 is shown in Table - 3.12 according to the methods described in section 3.6.1 and 3.6.2. Table - 3.12 also shows the results of the estimate by Mt. Galunggung Project Office based on the topographical survey of July, 1985. (refer to Table - 3.5)

The accumulated area of sediment for the calculation is shown in Fig. - 3.15.

Accumulated Sediment Volume and Spare Capacity of sandpockets are summarized as follows:

a) Accumulated Sediment Volume

The total volume of accumulated sediment volume for 5 sandpockets is 12,400 thousand m^3.
The volume of sandpocket Ciponyo I (5,300 thousand m^3) occupies about 40% of total volume.

b) Spare Capacity of Sandpocket

The total volume of spare capacity is 2,700 thousand m^3.
55% (1,500 thousand m^3) of this volume is accumulated in the Sandpocket Ciponyo I dalam.

Table - 3.12 Accumulated Sediment Volume, Spare Capacity, Excess Sediment Volume

Name of Sandpocket		Accumulated Sediment Volume (10^3 m^3)	Spare Capacity (10^3 m^3)	Excess Sediment Volume (10^3 m^3)
Cimampang		(1,650) 569	(110) 255	22
Negla		(2,100) 1,285	(1,170) 116	449
Sub total		(3,850) 1,854	(1,280) 371	471
Ciponyo I	Dalam	(6,000) 5,326	(700) 1,508	1,079
	Luar	(2,250) 2,500	(250) 94	644
	Total	(8,250) 7,826	(950) 1,602	1,723
Ciponyo II		(3,100) (11,350) 10,509	(1,600) (2,550) 2,369	1,738
T o t a l		(15,200) 12,363	(3,830) 2,749	2,209

( ); Capacity estimated by Mt. Galunggung Project Office at July 1985

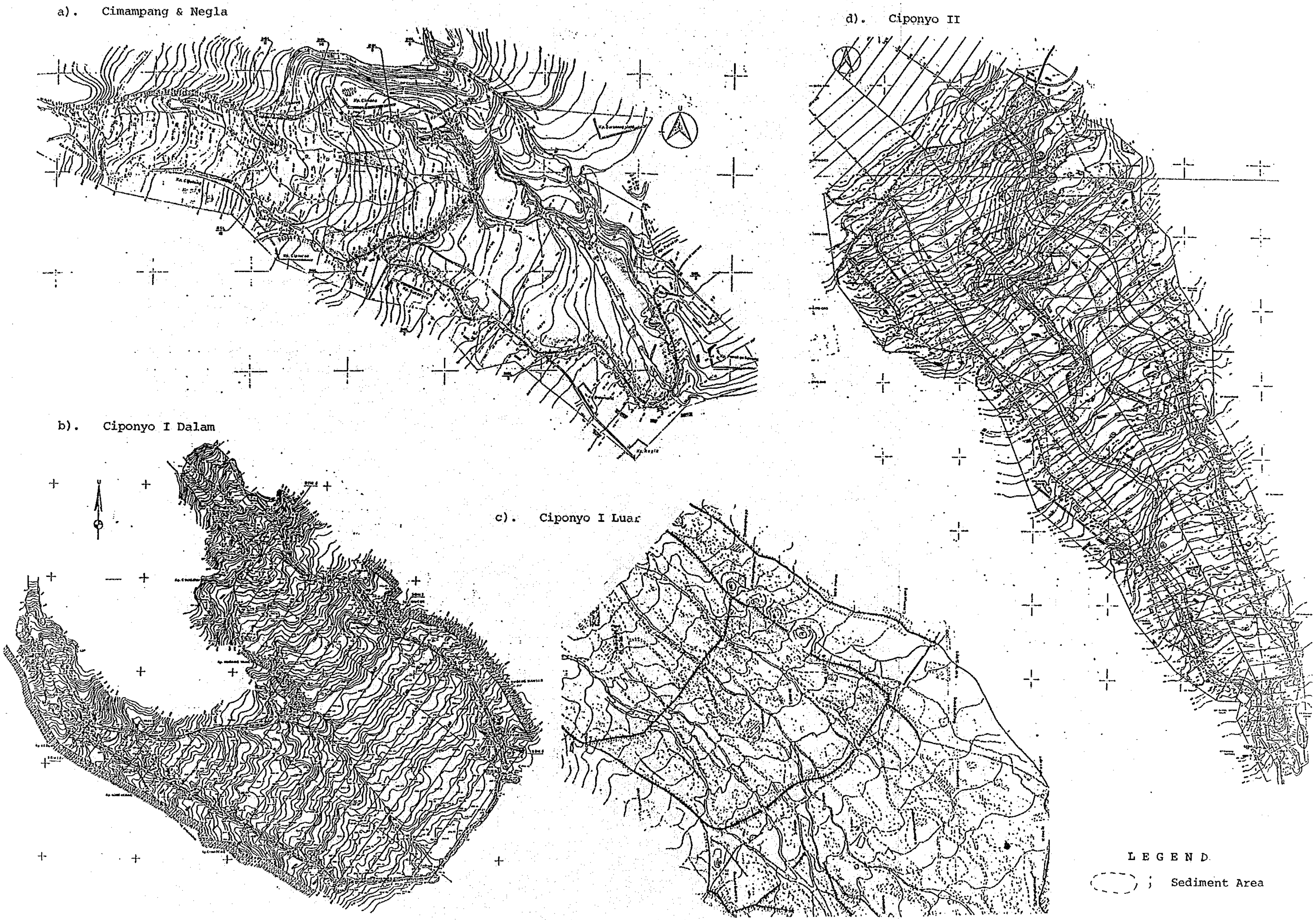


Fig. - 3.15 Sediment of Sand Pocket

4. Hydrology

4.1 General

Hydrological analysis was carried out for the purpose of determining the peak discharge and making a hydrograph with which to calculate sediment run off and determine the hydraulic specifications of disaster prevention facilities. The main work items in this analysis are listed below.

(1) Collection and arrangement of hydrological data.
(2) Analysis of rainfall characteristics.
(3) Calculation of probable rainfall.
(4) Runoff analysis.
(5) Making of a design hydrograph.
(6) Calculation of peak discharge by rational formula.

The work flow is shown in Fig. - 4.1.

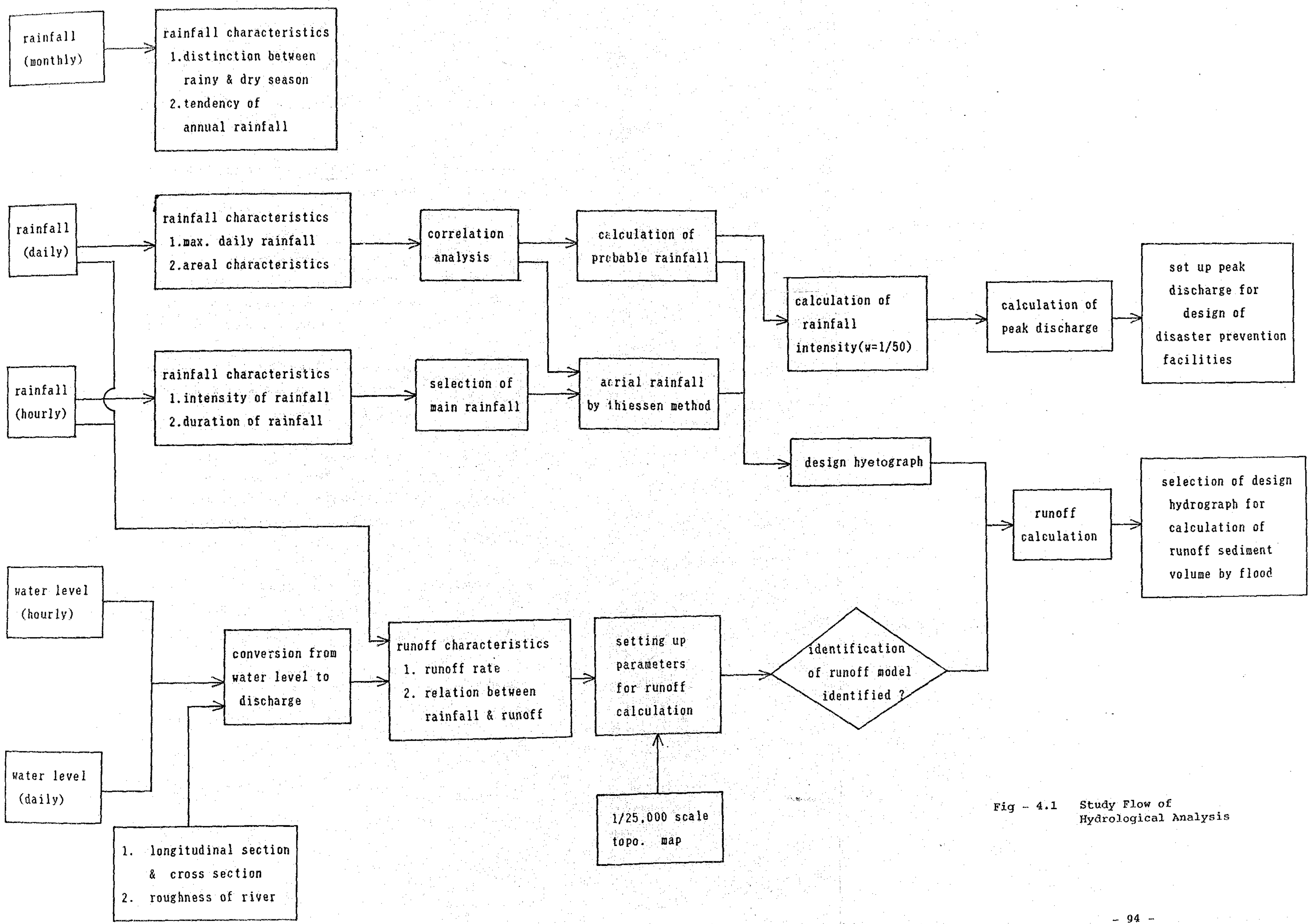


Fig - 4.1 Study Flow of Hydrological Analysis

4.2 Collection and Arrangement of Hydrological Data

The rainfall and water level observation stations in the study area are shown in Table - 4.1 and Fig. - 4.2.

There are nineteen (19) rainfall observation stations. Nine (9) of these use automatic raingauges, three (3) use telemeters and one (1) uses a radar raingauge. The remaining six (6) use conventional raingauges.

The rainfall observation stations are concentrated in the upstream basins of S. Cikunir and S. Ciloseh. There are no stations in the mid and lower and it will be necessary to increase the number of stations if the runoff volume in the entire basin is to be discovered.

The conditions under which rainfall data was arranged are shown in Table - 4.2 and 4.3. Table - 4.2 is a daily rainfall chart, Table - 4.3 is an hourly rainfall chart.

Tasikmalaya and Singaparna are the only observation stations in the basin with daily rainfall data covering a period long enough to calculate the probable rainfall. Both of these stations have data from 1942. Cibasuki, Tanjungsari and Indihiang have data going back to 1978. The other stations were constructed after the opening of the Galunggung Project Office in 1982-83.

There are four (4) observation stations which have accumulated comparatively large amounts of hourly rainfall data:
Cisayong, Tejekelapa, Cigadog and Cisolak.

Table - 4.1 (1) List of Rainfall Observation Stations

NO	STATION	ALTI-TUDE	LONGITUDE (E)	LATITUDE (S)	*) TYPE	OBSERVATION PERIOD	**) BELONGING TO
1	CISAYONG	575	108° 08'32"	07° 15'27"	A & M	OCT. 1982 - UP TO THE PRESENT	M. G. P. O
2	TEJAKELAPA	775	108° 07'19"	07° 13'57"	A & M	OCT. 1983 - UP TO THE PRESENT	M. G. P. O
3	CIGALEUH	675	108° 07'45"	07° 15'02"	A & M	OCT. 1983 - UP TO THE PRESENT	M. G. P. O
4	ANGKREK	510	108° 06'18"	07° 18'16"	A & M	DEC. 1983 - UP TO THE PRESENT	M. G. P. O
5	CIGADOG	580	108° 05'28"	07° 18'12"	A & M	APR. 1984 - UP TO THE PRESENT	M. G. P. O
6	CIBASUKI	480	108° 06'13"	07° 19'21"	M	JAN. 1982 - UP TO THE PRESENT	M. G. P. O
7	CISOLAK	650	108° 02'28"	07° 18'26"	A	JAN. 1983 - UP TO THE PRESENT	M. G. P. O
8	CIKASASAH	490	108° 07'23"	07° 18'10"	M	OCT. 1982 - UP TO THE PRESENT	M. G. P. O
9	CIGANGSA	900	107° 55'52"	07° 18'55"	A & M	JAN. 1985 - UP TO THE PRESENT	M. G. P. O
10	TANJUNGSARI	827	107° 57'55"	07° 20'41"	M	JAN. 1982 - UP TO THE PRESENT	M. G. P. O
11	INDIHIANG	370	108° 11'59"	07° 17'29"	A & M	JAN. 1982 - UP TO THE PRESENT	M. G. P. O
12	PANGAKALAN	660	108° 03'43"	07° 18'06"	A & M	JAN. 1984 - UP TO THE PRESENT	M. G. P. O
13	PASIR MAKANG	750	108° 05'25"	07° 16'22"	Telemeter	NOV. 1982 - UP TO THE PRESENT	M. G. P. O
14	SINAGAR	560	108° 07'06"	07° 16'30"	Telemeter	FEB. 1983 - UP TO THE PRESENT	M. G. P. O
15	CIAKAR	660	108° 10'32"	07° 12'05"	Telemeter	JAN. 1985 - UP TO THE PRESENT	M. G. P. O
16	CINTAWANGA	400	108° 06'30"	07° 21'34"	M	JAN. 1982 - UP TO THE PRESENT	M. G. P. O
17	P.G. GALUNGG.	340	108° 14'24"	07° 18'34"	Rader	JAN. 1983 - OCT. 1985	M. G. P. O
18	TASIKMALAYA	350	108° 14'24"	07° 19'13"	M	JAN. 1942 - DEC. 1985	I. M. G
19	SINGAPARNA	425	108° 06'39"	07° 20'60"	M	JAN. 1942 - DEC. 1983	I. M. G

*) A : Automatic Raingauges, M : Raingauges (Manual Type)

**) M, G, P, O : Mt. Galunggung Project Office

I. M. G : Institute of Meteorology and Geophisics

Table - 4.1 (2) List of Water level Observation Stations

NO	STATION	RIVER	*) TYPE	LONG. (E)	LATI. (S)	OBSERVATION PERIOD	**) BELONGING TO
1	CIGEDE	CILOSEH	S	108° 09'45"	07° 16'29"	Mar. 1984 - Up to the Present	M. G. P. O
2	SUKAMAHI	CILOSEH	S	108° 09'45"	07° 16'29"	Jan. 1986 - Apr. 1986	*
3	S. M. A. II	CILOSEH	S	108° 12'09"	07° 18'10"	Jan. 1985 - Up to the present	*
4	CINEHEL	CILOSEH	S	108° 12'30"	07° 18'21"	Mar. 1984 - Up to the present	*
5	JEMB. CIKUNIR	CIKUNIR	S	108° 09'12"	07° 29'49"	May. 1984 - Up to the present	*
6	JEMB. KP. ASTA	CIKUNIR	S	108° 10'36"	07° 23'24"	Jun. 1984 - Up to the present	*
7	JEMB. CINTARAJA	CIANDA	S	108° 08'08"	07° 20'46"	Apr. 1984 - Feb. 1985	*
8	JEMB. CIPASUNG	CISARNI	S	108° 07'43"	07° 20'46"	Apr. 1984 - Up to the present	*
9	JEMB. CIMERAH	CIMERAH	S	108° 06'13"	07° 21'04"	Apr. 1984 - Up to the present	*
10	JEMB. DANGUR	CIKUNTEN	A	108° 04'54"	07° 21'09"	May 1984 - Up to the present	*
11	JEMB. MANGUNREJA	CIWULAN	S	108° 06'18"	07° 21'49"	May 1984 - Up the present	*
12	SUKARATU	CILOSEH	A				

*) S : Staff Gauge, A : Automatic Water level Recorder

**) M. G. P. O : Mount Galunggung Project Office

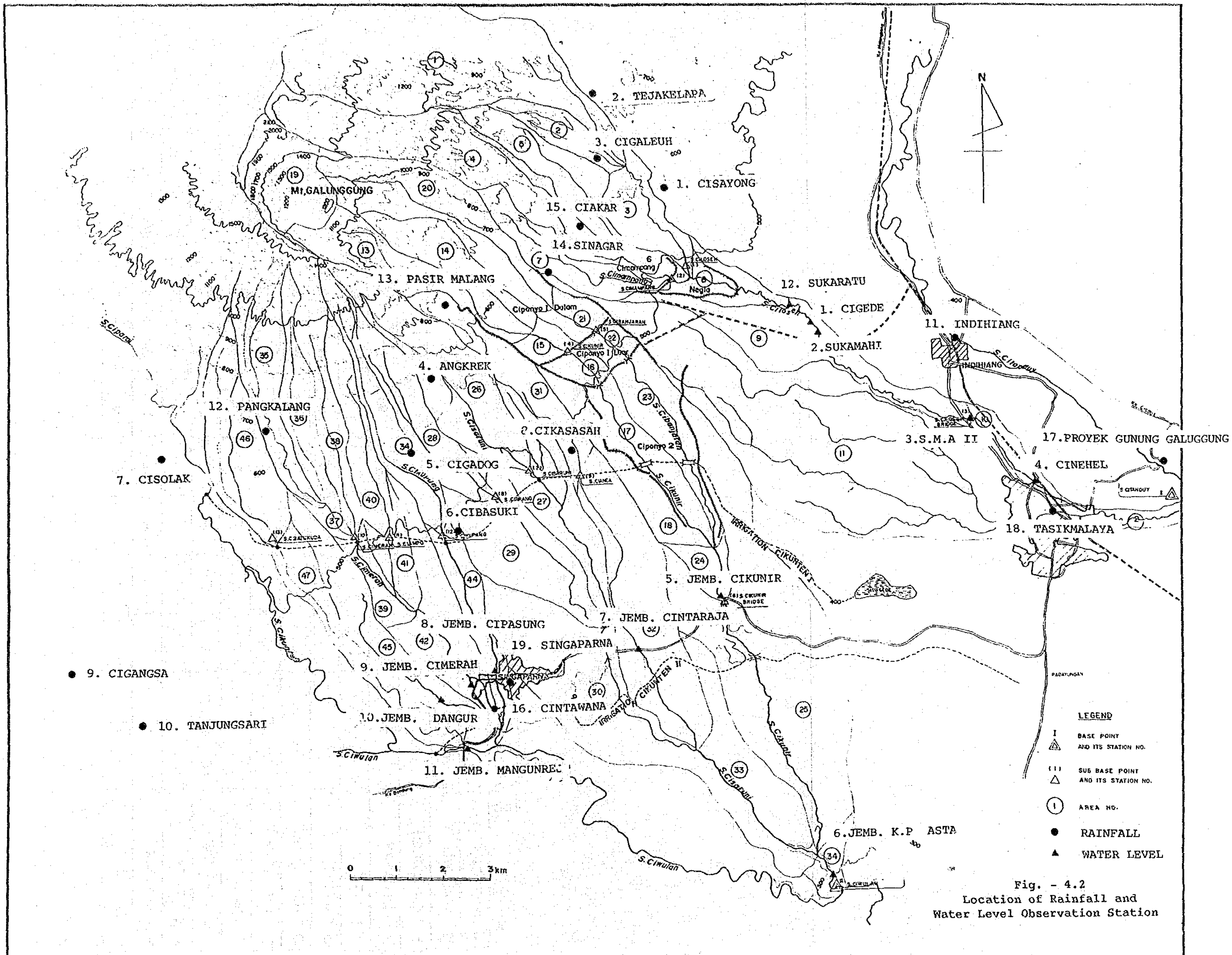


Fig. - 4.2
Location of Rainfall and
Water Level Observation Station

Table - 4.2 Existing Daily Rainfall Data

Stations \ Data / Year	Daily Rainfall										Remarks
	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	
① CISAYONG			○	○	◎	◎	◉	◉	◉	●	
② TEJAKELAPA						●	●	●	●	●	
③ CIGALEUH						●	●	●	●	●	
④ ANGKREK						●	●	●	●	●	
⑤ CIGADOG							●	●	●	●	
⑥ CIBASUKI	○	○	○	○	◉	◉	◉	◉	◉	●	
⑦ CISOLAK						●	●	●	●	●	
⑧ CIKASASAH					●	●	●	●	●	●	
⑨ CIGANGSA								●	●	●	
⑩ TANJUNGSARI	○	○	○	○	◉	○	○	◉	◉	●	
⑪ INDIHIANG	○	○	○	○	◉	◉	◉	◉	◉	●	
⑫ PANGKALAN							●	●	●	●	
⑬ PASIR MALANG					●		●	●	●	●	
⑭ SINAGAR						●	●	●	●	●	
⑮ CIAKAR								●	●	●	
⑯ CINTAWANA					●	●	●	●	●	●	
⑰ P.G. GALUNGG											
⑱ TASIKMAKAYA	○	○	○	○	○	○	○	○			from 1942
⑲ SINGAPARNA	○	○	○	○	○	○	○				from 1942

Note) ● Data from Mt. Galunggung Project Office ◉ Both ● and ○
○ Data from WILAYA PENGAIRAN PRIANGAN

Table - 4.3 (1) Existing Hourly Rainfall Data (1)

Year / Month / Station	1983												1984											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
CISAYONG	○	○	○	○	○	×	×	×	×	×	×	×	×	○	×	×	○	○	○	○	○	○	○	○
TEJAKALAPA	×	×	×	×	×	×	×	×	×	×	×	×	×	×	○	○	×	○	○	○	○	○	○	○
CIGLEUH	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	○	○	○	○	○	○	○
ANGKREK	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	○	○	×	○	○	○	○	○
CISADOG	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	○	○	○	○	○	○	○	○
CISOLAK																		○	○	○	○	○	○	○
CIGANGSA	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	○	○	○	○	×	○	○
INDIHIANG	○	×	×	×	×	×	×	×	×	×	×	×	○	○	○	○	○	○	○	○	○	○	○	×
PANGKALAN	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	○	○	○	○	○	○	○

Table - 4.3 (2) Existing Hourly Rainfall Data (2)

Year / Month / Station	1985												1986											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
CISAYONG	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
TEJAKALAPA	×	×	×	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	×	○	○	○	○
CIGLEUH	○	○	○	○	×	×	○	○	○	○	○	○	○	○	○	○	○	×	×	×	×	×	×	×
ANGKREK	○	○	○	○	○	○	○	×	×	○	○	○	○	○	○	○	○	○	○	○	×	×	×	×
CISADOG	○	○	○	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
CISOLAK	×	×	×	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	×	×	×
CIGANGSA	○	○	○	○	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
INDIHIANG	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
PANGKALAN	○	○	○	○	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×

There are five (5) water level observation stations on S. Ciloseh and two (2) on S. Cikunir. There is one station each on other major rivers.

Of these, the Sukaratu station on S. Ciloseh and the Danger station on S. Cikunir use automatic water level recorders, making it possible to obtain hourly water level records. The other observation stations use staff gauges and make four (4) observations per day.

Water level records date from 1984, providing about 3 years worth. (refer to Table - 4.4). However, the water level has not been converted into discharge and a water level/discharge (H-Q) curve has not been made.

Of the water level records obtained using staff gauges, those from Jemb. Cikunir have been converted into discharge by using an H-Q curve based on the survey results and the results are shown in Fig. - 4.3.

However, as shown in Fig. - 4.3, the discharge is higher for the dry period than for the rainy period, and no discharge peak is found which corresponds to the rainfall peak, it is thought that the data is less than trustworthy.

Table - 4.4 (1)   Existing Water Level Data (1)

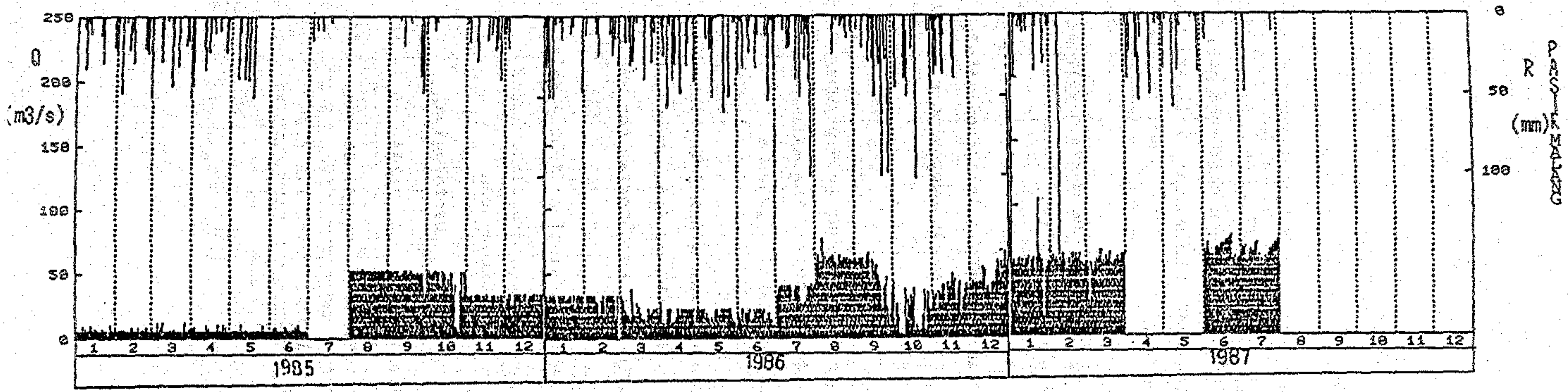
Year / Name of station \ Month	1984												1985											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Cigede	×	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Cinehel	×	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Leuwimida	×	×	×	×	○	○	○	×	×	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Jemb. KP.ASTA	×	×	×	×	×	○	○	○	○	○	○	○	○	○	○	○	○	○	×	○	○	○	○	○
Jemb Cintaraja	×	×	×	○	○	○	○	○	○	○	○	○	○	○	×	×	×	×	×	×	×	×	×	×
Jemb. Cipasung	×	×	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Jemb. Cimerah	×	×	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Jemb. Dangur	×	×	×	×	○	○	○	○	○	○	×	×	○	○	○	○	○	○	○	○	○	○	○	○
Jemb. Manguneja	×	×	×	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

note) ○ : Existing   × : no data

Table - 4.4 (2)   Existing Water Level Data (2)

Year / Name of Station \ Month	1986												1987											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Cigede	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	–						
Cinehel	○	○	○	○	○	○	○	○	○	○	○	○	○	○	–	○	–	–						
Leuwimida	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○						
Jemb. KP.ASTA	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	–	–	–						
Jemb Cintaraja	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–						
Jemb. Cipasung	○	○	○	○	○	○	○	×	○	○	×	○	○	○	○	○	–	–						
Jemb. Cimerah	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○						
Jemb. Dangur	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○						
Jemb. Manguneja	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○						

Rainfall Observation station ; PASIR MALANG and Water. Level Br. Cikunir



Rainfall Obsrevation Station ; CIGADOG and Water Level ; Br. Cikunir

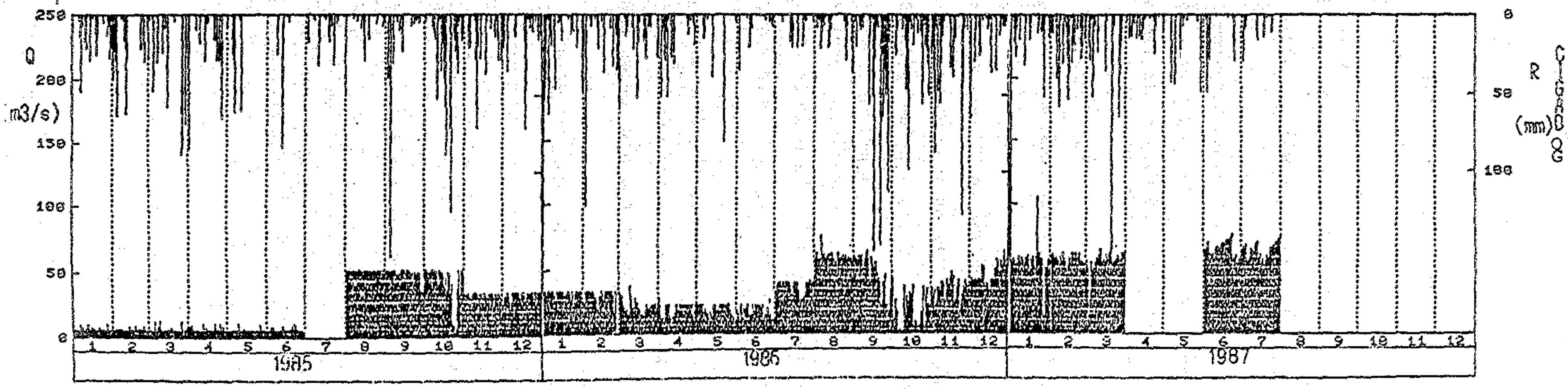


Fig. - 4.3 Comparison of Relationship between Rainfall and Discharge

4.3 Rainfall Characteristics

4.3.1 Depth of Rainfall

(1) Monthly Rainfall and Annual Rainfall

Monthly rainfall and annual rainfall data have been collected over a long period of time at Tasikmalaya and Singaparna. The monthly rainfall data has been arranged by year in Table - 4.5 and 4.6.

Table - 4.7 was rearranged by bringing together the maximum values, minimum values and mean values shown in Table - 4.5 and 4.6.

According to Table - 4.7, the mean annual rainfall is approximately 3,300 mm. The maximum annual rainfall for Tasikmalaya is approximately 4,600 mm (1968) and its minimum is approximately 1,900 mm.

For the hydrological year (from October of one year to September of the following year), the mean is also approximately 3,300 mm, the maximum is approximately 4,800 mm and the minimum is approximately 2,200 mm.

The mean values for monthly rainfall have been graphed in Fig. - 4.4. It is clear from this graph that the trend is for the period between June and September to be the dry season and the other months to comprise the wet season.

Table - 4.5 Mean, Max. Min. of Annual and Hydrological Yearly Rainfall

Item	Tasikmalaya		Singaparna	
	Annual	Hydrological	Annual	Hydrological
Mean	3,294	3,293	3,231	3,163
Max.	4,631	4,804	5,114	4,865
Min.	1,872	2,167	1,670	1,522

Table - 4.6 Monthly Rainfall (1942 - 1986)

(STATION : TASIKMALAYA)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1942	315	503	203	374	326	98	232	87	81	645	375	505	3,744
43	449	303	598	417	281	354	361	226	100	438	508	220	4,255
44	394	461	369	270	206	18	0	2	25				
45	484	283	189	291	138	1	58	42	366	130	582	320	2,844
46													
47													
48													
49													
50			548	205	503		450	73	425	463	234	97	
51	543	253	266	112	246	311	253	155	180	101	107	591	3,118
52	284	337	334	239	205	114	112	231	295	467	792	294	3,704
53	401	272	416	417	358	87	46	12	18	20	317	245	2,609
54	632	471	262	309	217	115	233	263	85	568	611	334	4,100
55	239	137	387	363	153	158	616	242	405	418	308	474	3,900
56													
57	383	183	478	191	112	115	985	143	99	31	326	351	3,397
58			500	233	162	170	334	439	146		290	586	
59	452	407	406	181	472	260	223	3	69	164	168	428	3,233
60	358	647	331	314	441	236	47	46	94	160	443	316	3,493
61	321	229	245	232	329	14	6	1	1	11	233	200	1,872
62													
63	241	299	558	170	22	40	1	0	5	136	216	232	1,920
64	195	178	491	164	273	224	78	118	198	666	171	271	3,027
65	385	127	389	169	258	122	56		3	16	305	563	
66	594	239	441	222	149	37	5	49	154	492	206	390	3,098
67	316	439	134	116	41	2	3	12	16	134	188	661	2,062
68	245	269	463	333	506	544	646	614	201	188	427	194	4,631
69	305	369	330	326	198	199	47	10	39	210	244	424	2,701
70	487	421	580	98	176	416	130	7	80	194	245	334	3,218
71	288	625	416	140	409	231	58	20	332	230	278	372	3,399
72	422	333	305	185	274	4	12	36	2	97	267	613	2,550
73	534	446	347	274	352	126	260	109	459	521	399	411	4,238
74	200	521	200	256	288	50	126	301	350	310	360	431	3,393
75	418	312	312	363	169	34	71	28	385	1,032	234	264	3,622
76	388	345	201	151	39	13	16	32	4	638	506	147	2,480
77													
78	278	281	206	166	358	458	128	239	317	447	374	346	3,568
79	382	518	283	384	703	152	58	168	228	223	379	314	3,792
80	356	227	300	464	180	64	164	242	52	306	440	293	3,088
81	330	350	338	399	374	403	295	86	209	305	387	477	3,953
82	326	209	442	347	53	41	4	0	4	12	105	685	2,228
83	297	453	391	285	485	72	10	0	0	486	348	440	3,267
84	425	857	612	338	170	112	64	200	661	562	187	360	4,548
85	310	432	433	309	309	395	87	110	201	525	241	317	3,669
86													
MEAN	360	364	370	266	269	162	170	121	170	324	328	376	3,294
TOTAL	12,977	12,736	13,704	9,857	9,935	5,840	6,275	4,346	6,289	11,346	11,801	13,550	108,711

Table - 4.7 monthly Rainfall (1942 - 1986)

(STATION : SINGAPARNA)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1942	294	496	291	415	491	263	135	32	169	353	430	333	3752
43	397	399	447	337	322	387	219	300	113	409	585	176	4091
44	336	301	325	264	157	32	0	19	24	212	365	322	2357
45	469	426	148	226	180	0	40	53	277	112	322	446	2754
46			322	367	355	31	18	22	31			469	
47													
48													
49													
50													
51	540	252	188	168	236	293	202	246	253	181	71	601	3231
52	351	166	192	253	99	127	92	287	306	471	116	474	2934
53													
54	417	452	156	418	109	193	303	238	135	281	449	370	3521
55	199	128	562	259	194	201	536	327	249	421	316	418	3810
56	270	226	283	343	337	270	359	266	225	303	311	461	3654
57													
58													
59													
60	318	250	120	265	445	113	76	277	153	201	461	438	3117
61	614	301		442	319	10				99	411	267	
62	465	238	476	582	59	166	539	0	0	541	353	676	4095
63	283	296	412	72	8	90	2	2	3	11	365	378	1922
64	265	100	652	546	173	216	131	290	411	1,039	415	351	4589
65													
66													
67													
68													
69	383	343	410				55	0	93				
70	397		229		176		88	0	122	113	217	355	
71	267	223	435	194	321	262	11	40	192	303	231	296	2825
72	233	200		532	302	0	0	0	0	56	162	343	
73	286	263	455	141	552	291	214	4	521	307	176	621	3836
74	92	414	262	214	248		81	373	248	290		214	
75	483	366	139	331	136	0	27	0	247	581	140	321	2787
76													
77	260	380	646	302	317	359	0	0	0	29	188	292	2772
78	221	240	561	334	451	585	375	460	406	265	631	535	5114
79	494	544	804	543	604	62	36	120	177	225	565	342	4106
80	146	573	440	913	91	40	74	178	3	173	173	171	2975
81	0	0	0	373	243	475	432	75	112	285	323	283	2656
82	289	450	322	225	0	0	0	0	0	43	133	208	1670
83	141	399	131	111	283	43	22	8	0	81	300	218	1737
84	381			664									
85													
86													
MEAN	321	312	350	351	257	173	147	129	160	274	316	374	3,231
TOTAL	9,301	8,431	9,458	9,834	7,208	4,508	4,117	3,617	4,470	7,385	8,209	10,434	74,305

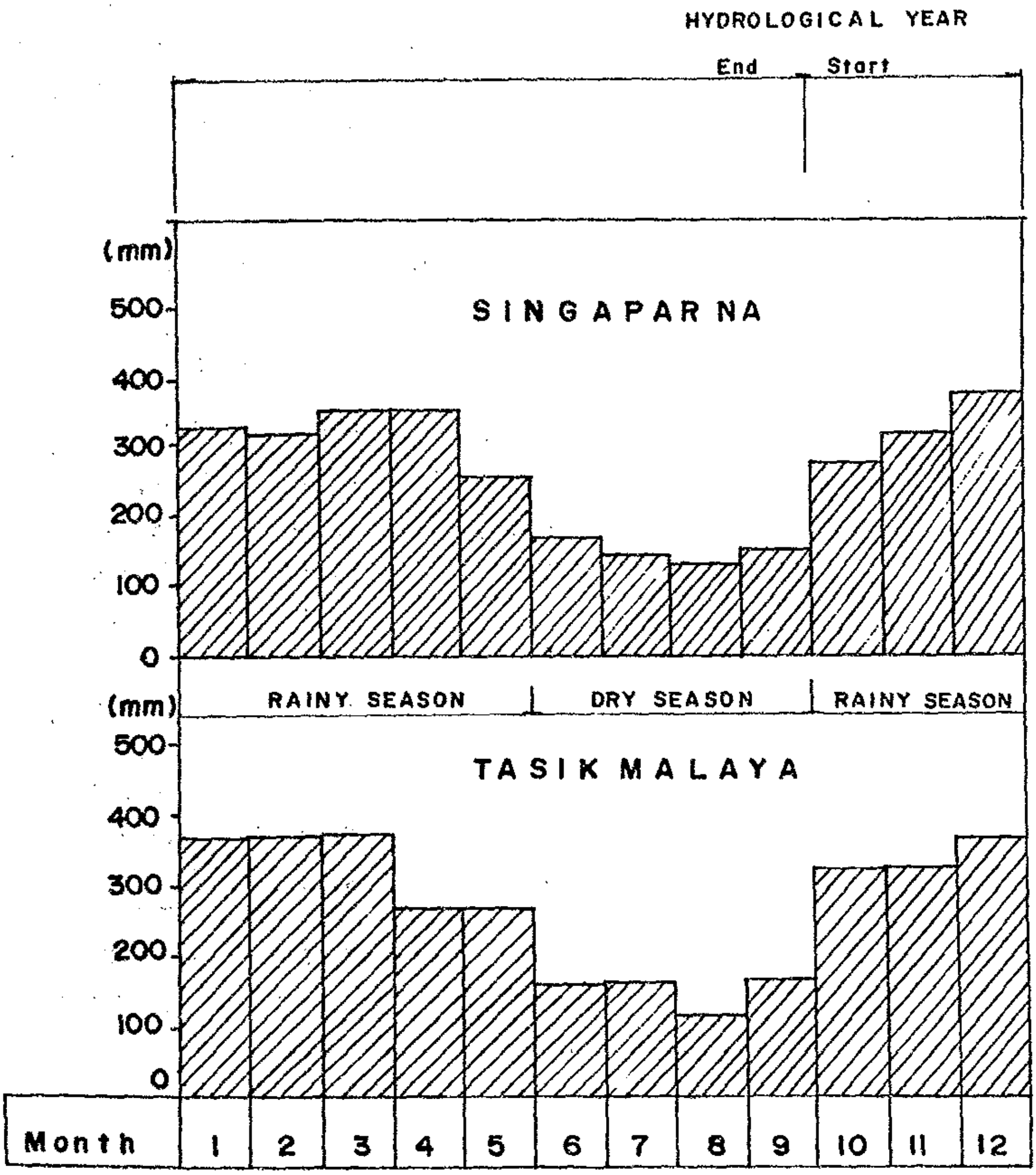


Fig. - 4.4 Mean Monthly Rainfall (1942 - 1984)

The probable rainfall of the annual rainfall for Tasikmalaya and Singaparna has been calculated and the results are shown Table - 4.8.

Looking at Table - 4.8, Tasikmalaya's probable rainfall for a 100 year return period is 5,050 mm. It is 4,840 for a 50 year return period and 4,240 mm for a 10 year return period. Singaparna is 300 mm higher than Tasikmalaya for each period.

Table - 4.8 Probable Annual and Hydrological Yearly Rainfall

Return Period (Year)	Tasikmalaya		Singaparna	
	Annual	Hydrological	Annual	Hydrological
200	5,259	5,741	5,733	5,566
100	5,058	5,413	5,466	5,306
80	4,990	5,306	5,376	5,219
70	4,949	5,242	5,321	5,166
50	4,841	5,078	5,179	5,029
30	4,667	4,826	4,952	4,809
20	4,519	4,620	4,760	4,624
10	4,238	4,252	4,399	4,276
5	3,904	3,851	3,975	3,869
2	3,376	3,205	3,194	3,126
Number of Data	33	28	23	17

Notes: Calculated by Iwai Method.

(2) Daily Rainfall

The maximum daily rainfall values per year for Tasikmalaya and Singaparna are shown in Table - 4.9 and 4.10.

The maximum, minimum and mean values for the maximum daily rainfall per year is rearranged the following table.

Table - 4.9 Mean, Max. Min. of Daily Rainfall

Station / Item	Tasikmalaya	Singaparna
Mean	127 mm	123 mm
Max.	234 (1954.10)	385 (1976)
Min.	68 (1980.11)	51 (1969.9)

( ) : Year, month

According to Table - 4.11 the maximum daily rainfall to have occurred at Tasikmalaya is 234 mm (1954). It is 385 mm at Singaparna (1976).

Table - 4.10 Maximum Daily Rainfall

(Tasikmalaya)

rank by date of occurence		rank by depth of rainfall				
date	rainfall	rank	plotting position thomas	plotting position hazen	date	rainfall
1942. 7	125	1	0.975	0.987	1954. 10	234
1943. 2	106	2	0.950	0.962	1957. 7	214
1944. 5	94	3	0.925	0.936	1979. 11	213
1945. 11	151	4	0.900	0.910	1972. 12	212
1950. 7	164	5	0.875	0.885	1968. 7	193
1951. 1	109	6	0.850	0.859	1958. 8	186
1952. 12	101	7	0.825	0.833	1977. 6	165
1953. -	101	8	0.800	0.808	1984. 10	165
1954. 10	234	9	0.775	0.782	1950. 7	164
1955. 7	90	10	0.750	0.756	1971. 2	164
1957. 7	214	11	0.725	0.731	1945. 11	151
1958. 8	186	12	0.700	0.705	1975. 10	139
1959. 5	84	13	0.675	0.679	1960. 2	138
1960. 2	138	14	0.650	0.654	1978. 6	132
1961. 5	89	15	0.625	0.628	1962. 12	131
1962. 12	131	16	0.600	0.603	1942. 7	125
1963. 3	90	17	0.575	0.577	1983. 5	120
1964. 10	96	18	0.550	0.551	1981. 1	117
1965. 5	97	19	0.525	0.526	1985. 10	112
1966. 1	90	20	0.500	0.500	1973. 1	111
1967. 12	81	21	0.475	0.474	1974. 10	110
1968. 7	193	22	0.450	0.449	1951. 1	109
1969. 3	79	23	0.425	0.423	1943. 2	106
1970. 6	98	24	0.400	0.397	1952. 12	101
1971. 2	164	25	0.375	0.372	1976. 10	101
1972. 12	212	26	0.350	0.346	1953. -	101
1973. 1	111	27	0.325	0.321	1970. 6	98
1974. 10	110	28	0.300	0.295	1965. 5	97
1975. 10	139	29	0.275	0.269	1964. 10	96
1976. 10	101	30	0.250	0.244	1944. 5	94
1977. 6	165	31	0.225	0.218	1982. 12	90
1978. 6	132	32	0.200	0.192	1955. 7	90
1979. 11	213	33	0.175	0.167	1963. 3	90
1980. 11	68	34	0.150	0.141	1966. 1	90
1981. 1	117	35	0.125	0.115	1961. 5	89
1982. 12	90	36	0.100	0.090	1959. 5	84
1983. 5	120	37	0.075	0.064	1967. 12	81
1984. 10	165	38	0.050	0.038	1969. 3	79
1985. 10	112	39	0.025	0.013	1980. 11	68

1) Thomas plot : $1 - \frac{i}{N + 1}$

N = Number of data

i = rank

2) Hazen plot = $1 - \frac{2i - 1}{2N}$

Table - 4.11 Maximum Daily Rainfall

(Singaparna)

Rank by date of occurance		Rank by depth of Rainfall				
Date	Rainfall	Rank	Plotting Position		date	Rainfall
			Thomas	Hazen		
1942. 12	144	1	0.968	0.983	1976. -	385
1943. 11	150	2	0.935	0.950	1983. 5	167
1944. 10	148	3	0.903	0.917	1943. 11	150
1945. 12	83	4	0.871	0.883	1944. 10	148
1946 4	87	5	0.839	0.850	1964. 10	145
1951. 8	105	6	0.806	0.817	1942. 12	144
1952. 12	103	7	0.774	0.783	1979. 11	140
1954. 12	89	8	0.742	0.750	1960. 8	140
1955. 8	120	9	0.710	0.717	1973. 9	138
1956. 12	97	10	0.677	0.683	1981. 10	135
1960. 8	140	11	0.645	0.650	1975. 2	133
1961. 4	73	12	0.613	0.617	1982. 4	125
1962. 11	125	13	0.581	0.583	1962. 11	125
1963. 12	104	14	0.548	0.550	1955. 8	120
1964. 10	145	15	0.516	0.517	1977. 12	119
1969. 9	51	16	0.484	0.483	1974. 10	111
1970. 1	100	17	0.452	0.450	1951. 8	105
1971. 4	86	18	0.419	0.417	1963. 12	104
1972. 4	100	19	0.387	0.383	1952. 12	103
1973. 9	138	20	0.355	0.350	1970. 1	100
1974. 10	111	21	0.323	0.317	1978. 11	100
1975. 2	133	22	0.290	0.283	1972. 4	100
1976. -	385	23	0.258	0.250	1956. 12	97
1977. 12	119	24	0.226	0.217	1954. 12	89
1978. 11	100	25	0.194	0.183	1946. 4	87
1979. 11	140	26	0.161	0.150	1971. 4	86
1980. 4	80	27	0.129	0.117	1945. 12	83
1981. 10	135	28	0.097	0.083	1980. 4	80
1982. 4	125	29	0.065	0.050	1961. 4	73
1983. 5	167	30	0.032	0.017	1969. 9	51

(3) Hourly Rainfall

Table - 4.12 shows hourly rainfall over 50 mm chosen from among the hourly rainfall data. The maximum value of hourly rainfall for this study area is considered to be 90.0 mm (Tejakelapa) and 89.7 mm (Cisayong). The proportion of the total rainfall that the maximum hourly rainfall accounts for is around 0.6. The maximum hourly rainfall accounts for a large proportion of total rainfall.

Table - 4.12 Hourly Rainfall (more than 50 mm of total rainfall)

Station	Date	Total (A)	Max. hourly (B)	(B)/(A)
Teja kelapa	1985 5, 18	81.6	56.4	0.69
	1985 7, 1	159.5	90.0	0.56
	1985 7, 2	67.6	50.9	0.75
	1985 11, 17	127.1	55.3	0.44
	1986 1, 7	112.0	57.7	0.52
	1986 4, 14	91.2	56.2	0.62
		(639)	(366.5)	(0.57)
Cisayong	1983 1, 14	139.8	62.4	0.45
	1983 1, 25	89.0	72.0	0.81
	1983 4, 14	115.5	52.7	0.46
	1983 5, 1	65.3	64.8	0.99
	1986 2, 27	90.4	76.7	0.85
	1986 10, 3	118.9	89.7	0.75
	1986 10, 12	260.0	78.8	0.30
	1986 10, 23	82.7	57.7	0.70
	1986 11, 9	104.6	59.9	0.57
	1986 11, 18	198.1	69.3	0.35
	1986 11, 28	54.1	52.7	0.97
		(1318.4)	736.7	(0.56)
Cisolok	1985 9, 16	66.8	62.5	0.94
	1986 2, 28	74.1	62.3	0.84
		(140.9)	(124.8)	(0.88)
Cigadog	1985 10, 17	96.5	64.9	0.67
	1985 12, 3	80.1	50.5	0.63
	1986 11, 24	117.4	57.3	0.49
		(294.0)	(172.7)	(0.59)
Angkrek	1985 12, 31	72.8	53.7	0.74
	1986 4, 7	105.0	56.4	0.54
	1986 6, 9	94.7	74.3	0.78
		(272.5)	(184.4)	(0.68)

4.3.2 Aerial Distribution

The rainfall at observation stations which recorded more than 30 mm of daily rainfall has been selected out from the daily rainfall data at the main observation stations and correlation analysis has been carried out on it. The results are shown in Table - 4.13.

It is usually considered that the correlation relationship is good when the showing correlation coefficient over r = 0.8.
However, the largest value given at any of the stations was r = 0.7 in this analysis.

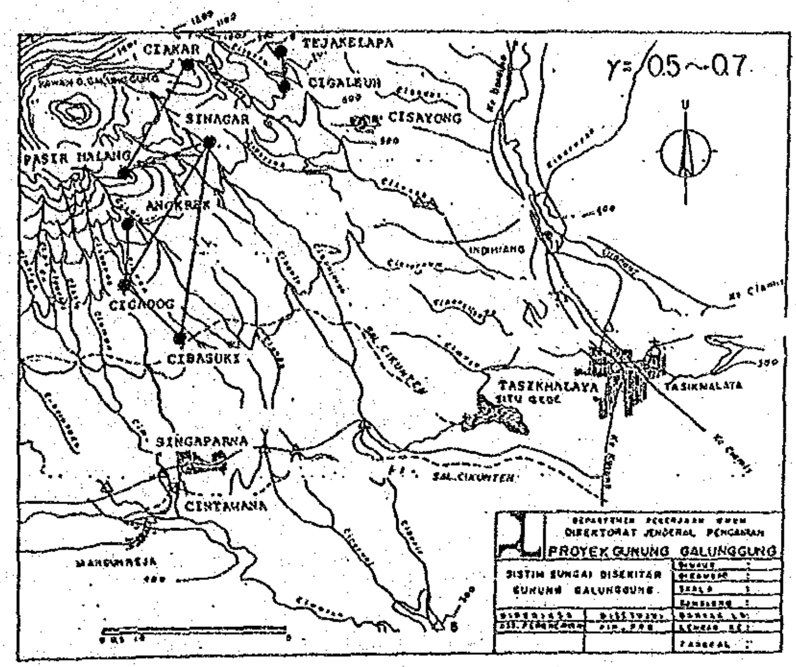
In Fig. - 4.5 the correlation coefficients are shown separated by range. In the range r = 0.5 - 0.7 are neighboring stations: Cigadog/Sinagar, Sinagar/Pasir Malang, Tejakelapa/Cigaleu.

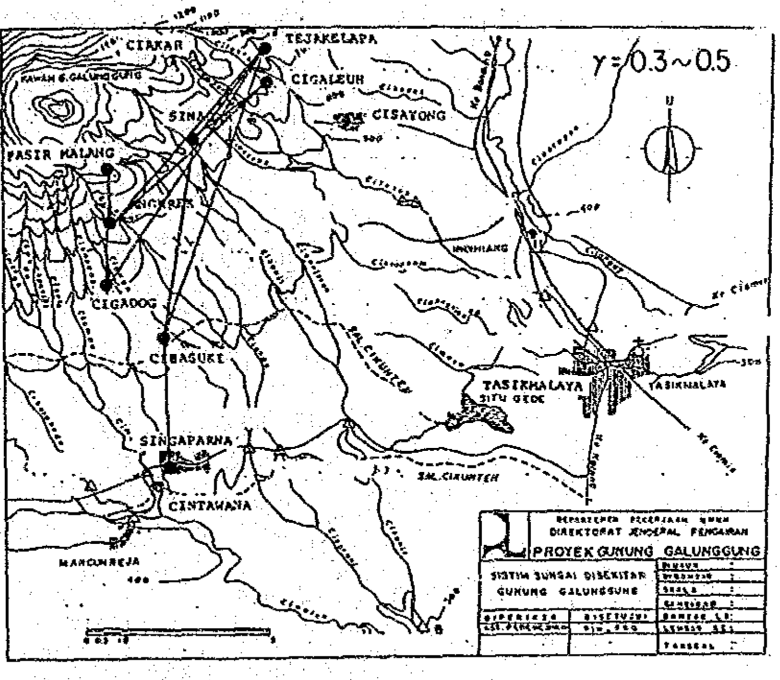
The isohyetal rainfall curve of the major rainfall is shown in Fig. - 4.6. At neighboring observation stations:
Cigadog is 148 mm compared to 31 mm Angrek (Sept. 16 rainfall); Cikasasah is 102 mm compared to 25 m at Cigadog and 58 mm at Cibasuki (Oct. 12 rainfall), showing fairly large differences in rainfall for each area.

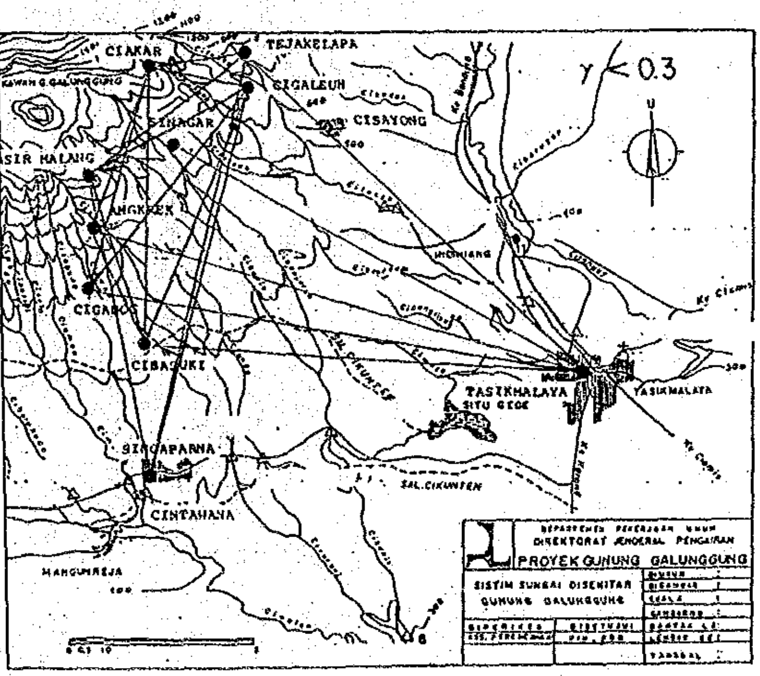
(Y) (X)	(1) SINAGAR	(2) CIGALEUH	(3) TEJAKELAPA	(4) CIAKAR	(5) PASIR MALAN	(6) ANGKREK	(7) CIGADOG	(8) CIBASUKI
1. SINAGAR		a = 0.306 b = 43.612 r = 0.342 (32)	0.354 45.576 0.331 (45)	3.075 77.588 0.651 (11)	0.394 36.291 0.595 (16)		0.654 31.794 0.532 (25)	0.289 48.635 0.307 (34)
2. CIGALEUH	a = 0.383 b = 37.724 r = 0.342 (30)		0.853 19.735 0.657 (82)	0.084 37.468 0.192 (21)	0.190 41.155 0.273 (31)	0.566 30.362 0.423 (41)	0.175 63.233 0.132 (37)	0.247 41.543 0.208 (53)
3. TEJAKELA-PA	0.309 38.607 0.331 (45)	0.506 22.264 0.657 (82)		0.082 37.725 0.278 (32)	0.171 39.739 0.295 (47)	0.388 32.681 0.438 (70)	0.479 37.821 0.444 (49)	0.455 32.563 0.474 (68)
4. CIAKAR	0.138 36.309 0.651 (11)	0.440 33.208 0.192 (21)	0.944 28.944 0.278 (32)		0.319 26.346 0.666 (26)	0.182 47.671 0.158 (37)	0.169 58.232 0.080 (18)	0.779 22.890 0.234 (31)
5. PASIR - MALAN	0.899 5.866 0.575 (16)	0.392 40.506 0.273 (31)	0.509 46.031 0.295 (47)	1.390 6.413 0.666 (26)		0.716 30.088 0.486 (36)	0.583 39.608 0.418 (33)	0.271 47.275 0.241 (53)
6. ANGKREK		0.316 33.665 0.423 (41)	0.496 34.385 0.438 (70)	0.137 38.847 0.158 (37)	0.330 30.810 0.486 (36)		0.612 25.804 0.565 (64)	0.309 42.526 0.278 (76)
7. CIGADOG	0.432 28.237 0.532 (25)	0.100 53.105 0.132 (37)	0.411 39.375 0.444 (49)	0.038 41.710 0.080 (18)	0.299 31.833 0.418 (33)	0.521 28.625 0.565 (64)		0.601 23.237 0.630 (74)
8. CIBASUKI	0.325 37.621 0.307 (34)	0.175 44.043 0.208 (53)	0.475 29.678 0.474 (31)	0.071 41.709 0.234 (53)	0.214 41.373 0.241 (53)	0.250 45.489 0.278 (76)	0.661 25.223 0.630 (74)	

* Y = a . x + b ( ) : the number of data

Table - 4.13 Corelation Anbalysis by Daily Rainfall







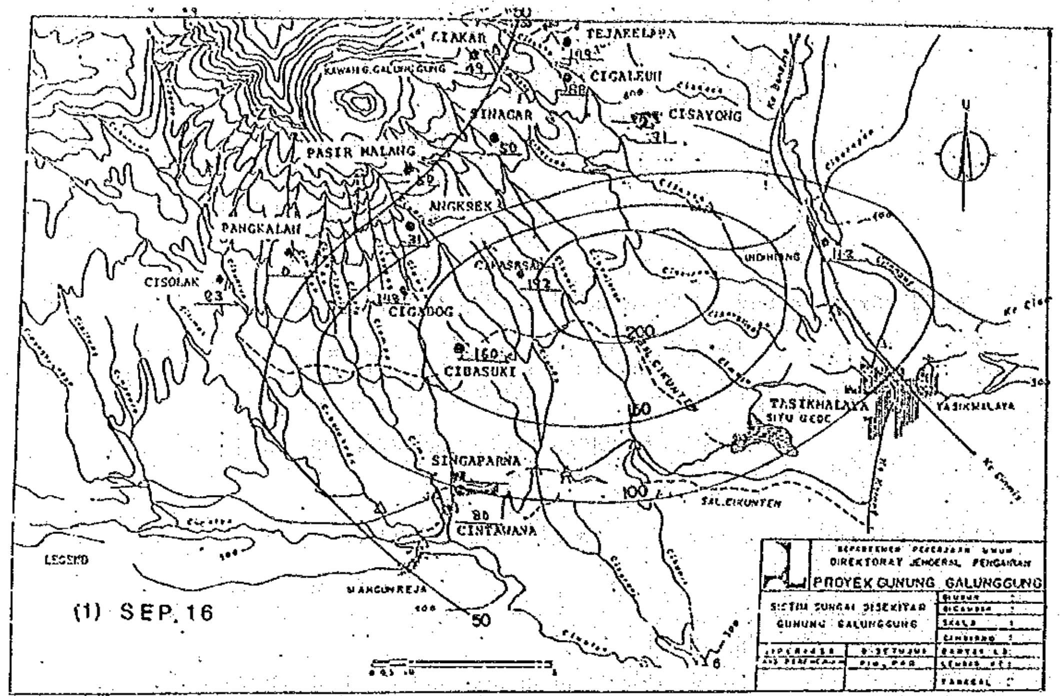
Note)

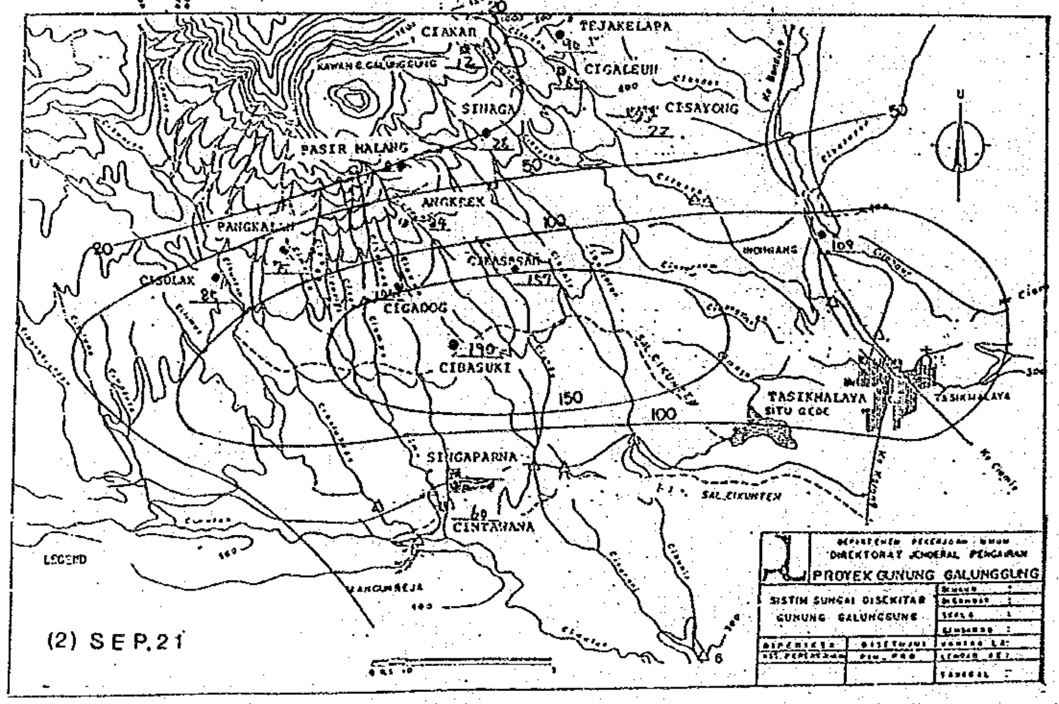
1. both station more than 30mm

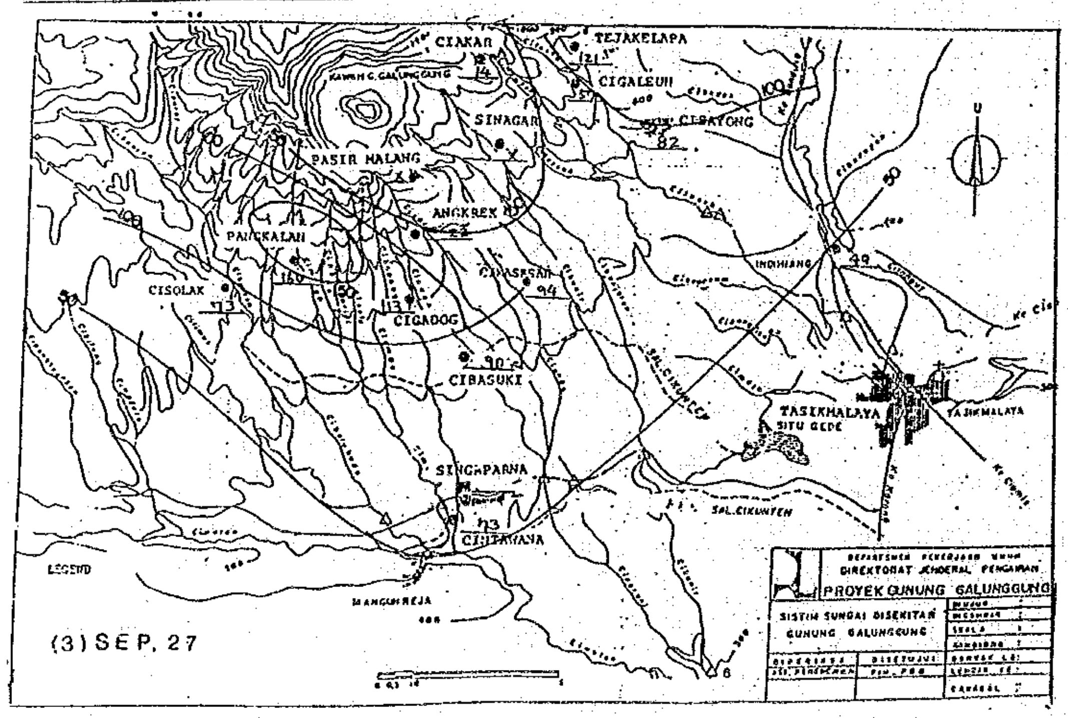
2. No coefficient more than $\gamma = 0.8$

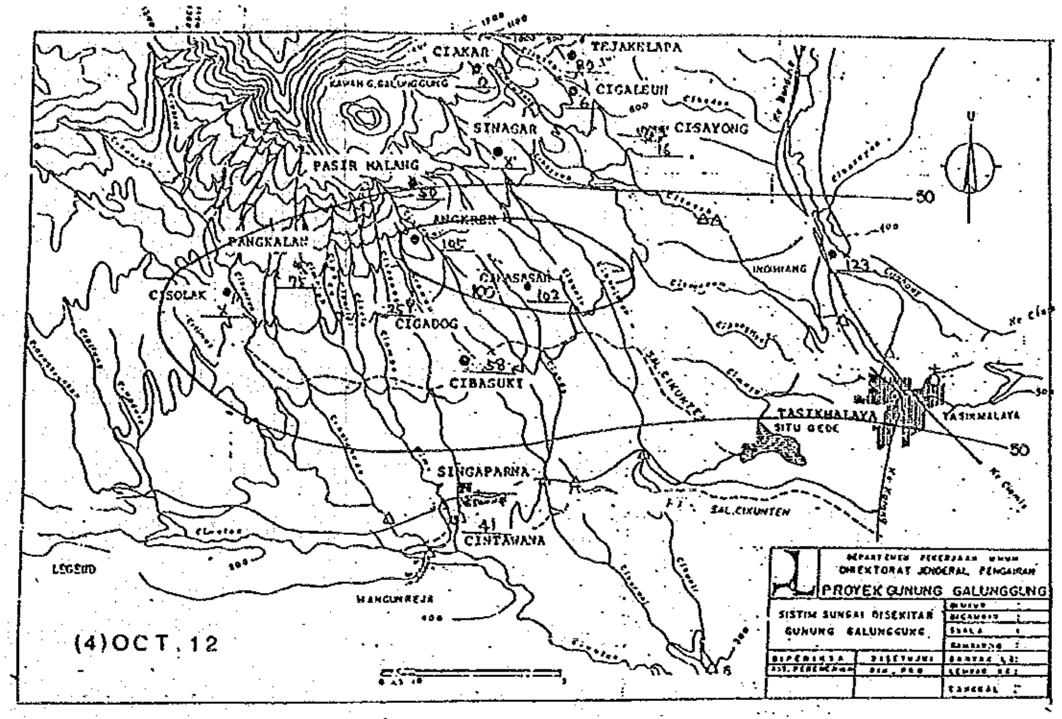
Fig. - 4.5

Correlation Analysis









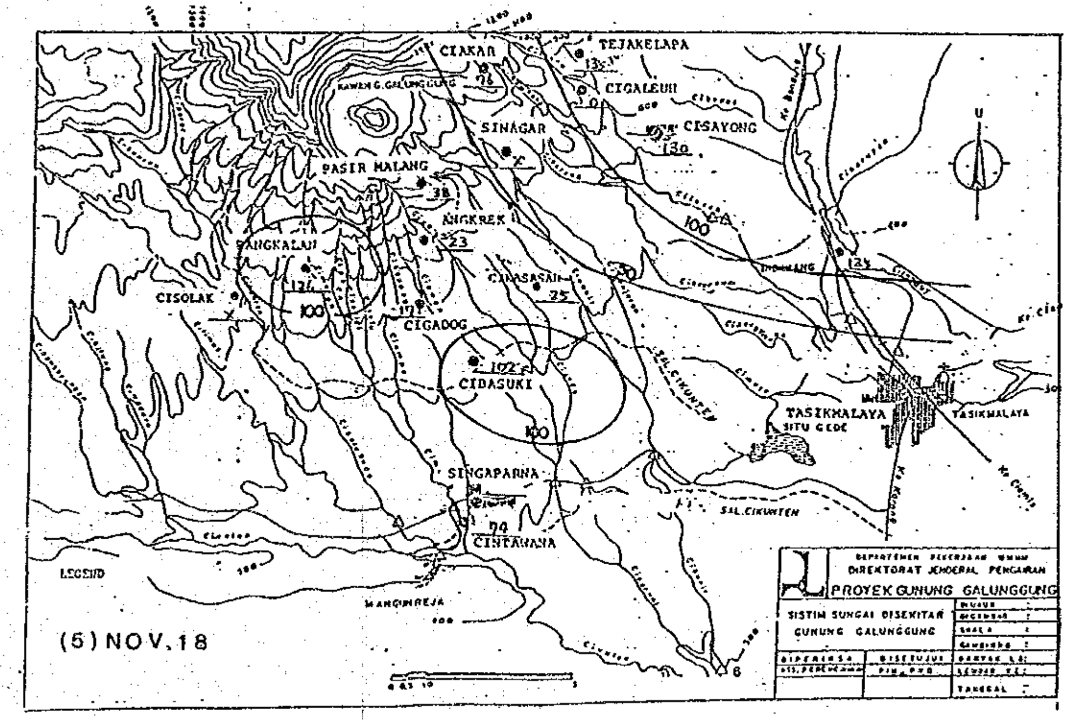


Fig. - 4.6 Isohyetal Map (Daily Rainfall 1968)

4.3.3 Duration of Rainfall

Based on the hourly rainfall data from the main observation stations, the rainfall was divided up into ranges of 3 hours and the frequency distribution characteristics are shown in Table - 4.14 and Fig. - 4.7. The rainfall used for analysis of total rainfall was over 30 mm.

The following tendencies are prevalent in the duration of rainfall at each observation station, according to Fig. - 4.7.

a. The highest frequency for the Tejakelapa, Cisayong, Cisolak and Cigadog observation stations, occurs in the 7 - 9 hour range. Following this are the 4 - 6 hour range and 9 - 12 hour range in that order.

b. The same tendencies are seen for total data of five (5) stations, with 7 - 9, 10 - 12, and 4 - 6 being the most frequent, and then durations under half a day account for most of rainfall.

Table - 4.14 Frequency of Rainfall Duration
(Total Rainfall more than 20 mm)

STATION	RERIDO	Rainfall duration (hours)								Remarks
		1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-	(Total)
TEJA KALAPA	1985 May - Dec.	2	13	7	11	6	4	0	1	44
	1986 Jan - Dec.	11	21	27	16	16	8	7	14	120
	Total	13	34	34	27	22	12	7	15	164
CISAYONG	1983 Jan. - May	1	6	14	6	2	0	1	0	30
	1984 Feb.	0	1	6	2	0	0	0	0	9
	1985 May - Dec	3	9	5	7	3	2	0	3	32
	1986 Jan. - Dec.	5	22	24	24	16	6	3	12	112
	Total	9	38	49	39	21	8	4	15	183
ANGKREK	1984 May - Jún.	1	1	0	0	0	0	0	0	2
	1985 May. - Dec.	1	5	5	6	2	1	3	4	27
	1986 Jan. - Aug.	2	10	10	4	1	4	0	11	42
	Total	4	16	15	10	3	5	3	15	71
CISOLOK	1985 May - Dec.	5	11	5	5	6	4	0	0	36
	1986 Jan. - Aug.	4	4	0	0	0	0	0	0	8
	Total	9	15	5	5	6	4	0	0	44
CIGADOG	1984 Apr. - Jun.	2	3	1	1	2	0	1	1	11
	1985 May - Dec.	3	5	13	5	5	1	1	1	34
	1986 Jan. - Dec.	6	13	12	10	4	5	1	4	55
	Total	11	21	26	16	11	6	3	6	100
Grand Toral		46	124	129	97	63	35	17	51	562

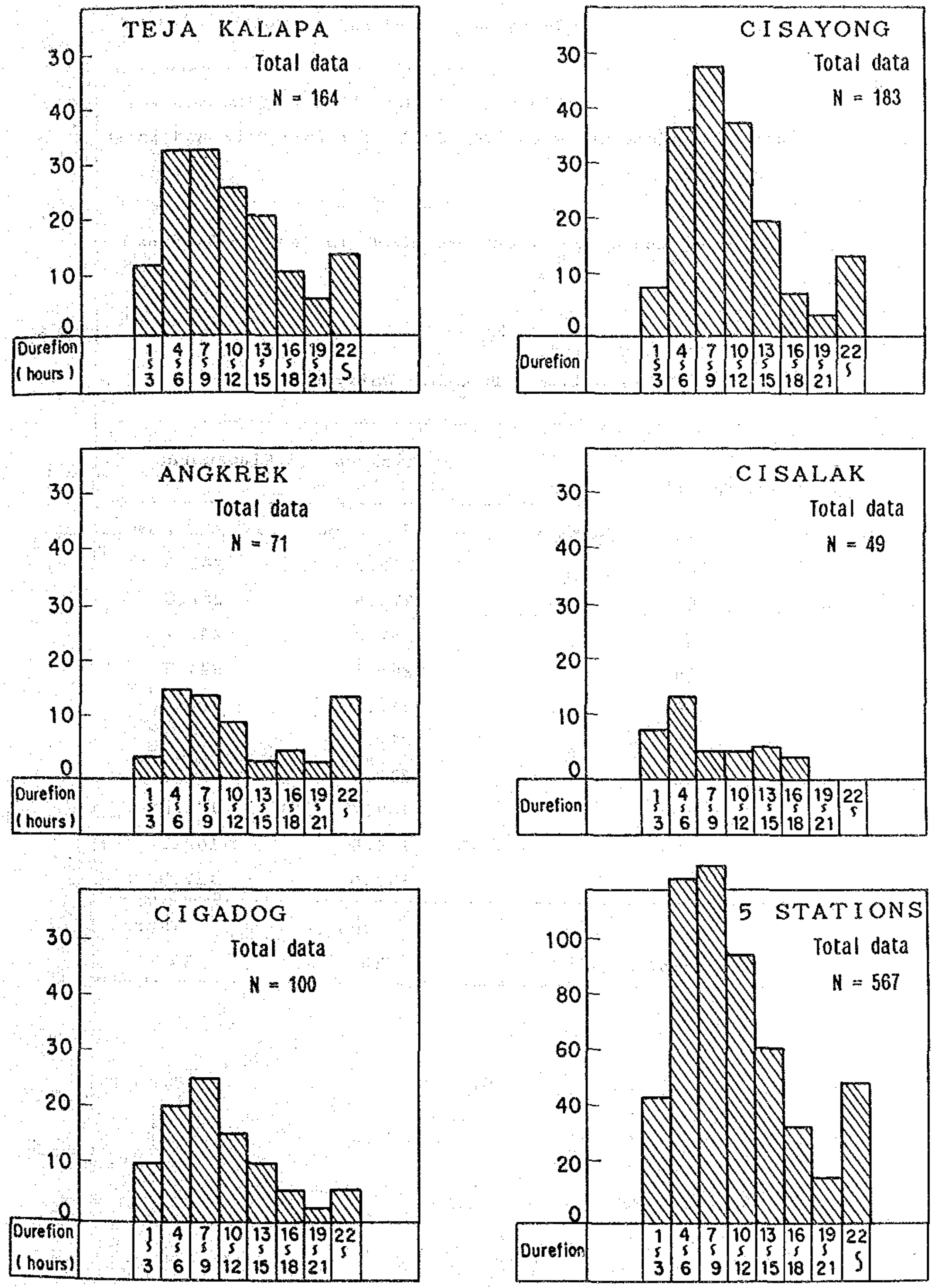


Fig. - 4.7 Frequency distribution of rainfall duration

4.4 Probable Rainfall

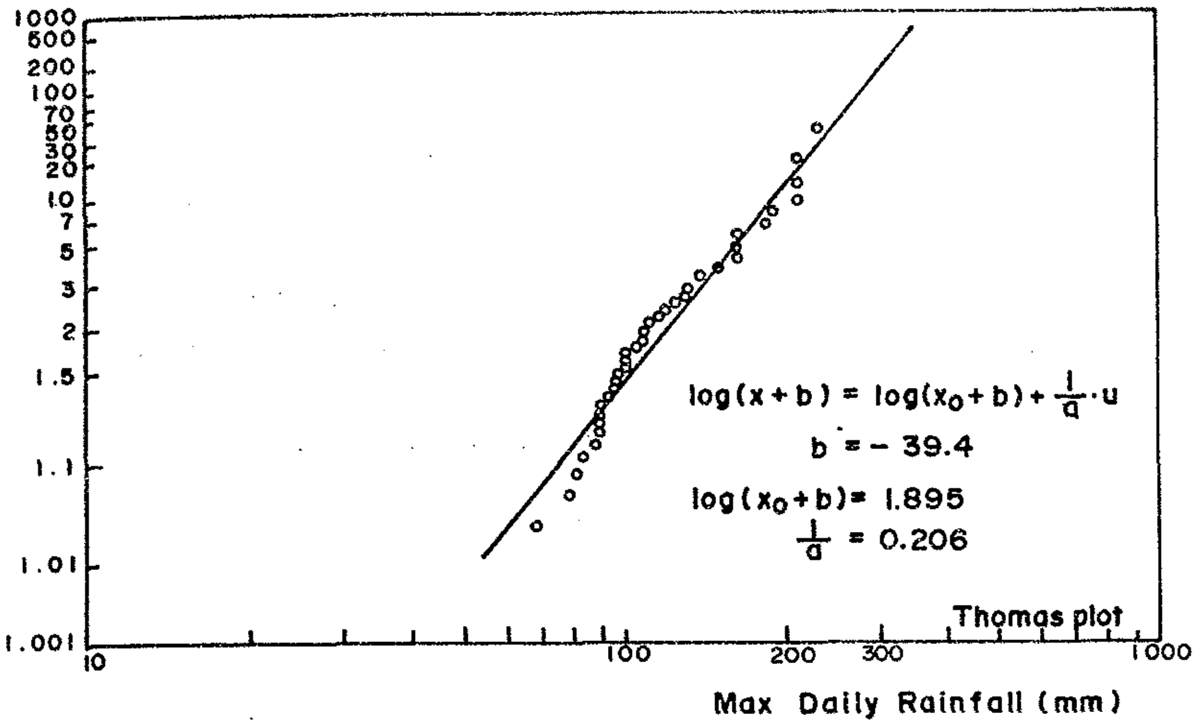
The calculation of probable rainfall by using Iwai Method for Tasikmalaya and Singaparna was made from daily rainfall data and is shown in Tables - 4.9 and 4.10.

The results of the calculations are shown in Table - 4.15 and Fig. - 4.8.

Table - 4.15 Probable Daily Rainfall

Return Period / Station	Tasikmalaya	Singaparna
Years	mm	mm
200	306.2	266.5
100	276.4	252.0
80	267.0	247.2
70	261.5	244.2
50	247.6	236.4
30	227.0	223.8
20	210.9	213.1
10	183.7	192.6
5	156.5	168.1
2	117.9	122.0
	Years	Years
Number of Data	39	30

Tasikumalaya Maximum Daily Rainfall



Singaparna Maximum Daily Rainfall

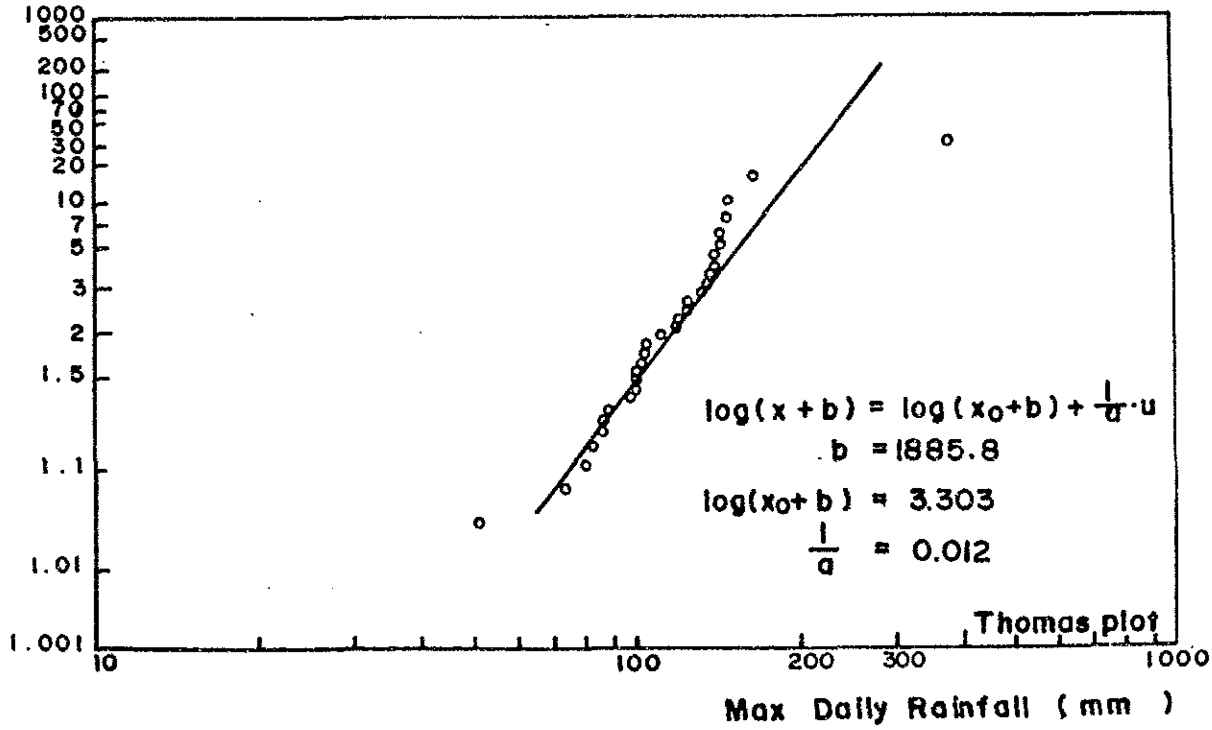


Fig. 4.8 Probable Daily Rainfall

The decision to use Tasikmalaya for representative probable rainfall of the study area was made taking into account the amount of data available and the distribution of plotting position on Fig. - 4.8.

As described above, probable rainfall for the study area is shown in Table - 4.16.

The probable rainfall shown in Table - 4.16 is rounded off up to the unit of 5 mm.

Table - 4.16 Probable Rainfall of Study Area

Return Period	Probable Rainfall
200	310 mm
100	280
50	250
30	230
10	185
5	160
2	120

4.5 Runoff Analysis

4.5.1 Outline

Runoff analysis is basically carried out of identification of the parameters (coefficient analysis) for discharge calculations, and calculation of discharge based on the parameters.

Because the water level observation station (automatic water level recorder) inside the study area is on the Ciloseh River (See Fig. - 4.9), identification (coefficient Analysis) of the parameters will be made using the discharge (conversion of the water level into discharge was made using an H-Q curve made from the cross section and the results of field studies) at this point. The results obtained were then applied to the Cikunir basin.

The method of runoff calculation use the kinematic wave method (equivalent roughness method) in this analysis taking into account the requiring of only a small number of parameters, easiness of handling of parameters for land use change, physical phenomenon of the flow on a slope and channel etc.

4.5.2 Coefficient Analysis

(1) Outline of the Kinematic Wave Method

In the kinematic wave method, the relation between rainfall and runoff is expressed for the slope and the river channels as follows:

Slope flow:

$$h = k\, q^{p} \quad \cdots\cdots (4.1)$$

$$\frac{ah}{at} + \frac{aq}{ax} = re \quad \cdots\cdots (4.2)$$

Channel flow:

$$W = K\, Q^{P} \quad \cdots\cdots (4.3)$$

$$\frac{aw}{at} + \frac{aQ}{ax} = I \quad \cdots\cdots (4.4)$$

Where;

h = Water depth

q = Runoff rate of unit width

re = Effective rainfall intensity

w = Stream cross-sectional area

Q = Flow rate

I = Inflow per unit length from sides to a channel

t = Time

x = Distance

X,p = Coefficients of the flow on a slope

K,p = Coefficients of the channel flow

The phenomenon of runoff is consisted of slope flow and channel flow gathered slope flow and flow from upstream basin.

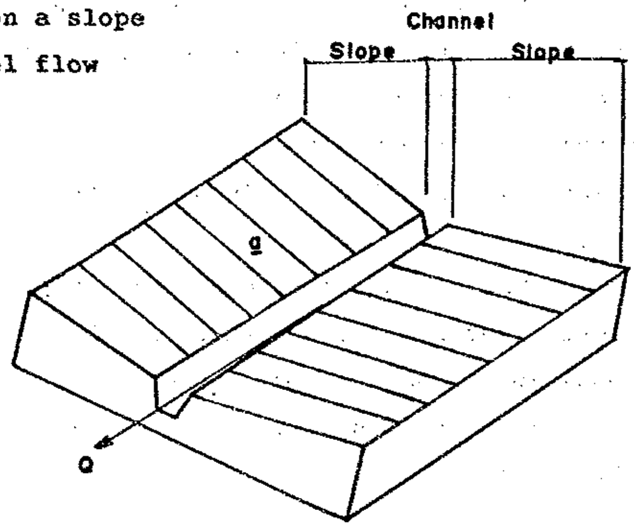


Fig. - 4.9 Schematic Runoff Model

In this model, slope parameters K and P have the following meaning based on the uniform flow formula of Manning type.

$$K = (N/\ \ S\ )^{P},\ P = 3/5 \qquad (4.3)$$

Where;

N = Equivalent roughness coefficient

S = Slope gradient

Channel parameters K and P is also given by the following expression in the Manning formula.

$$Q = A \cdot V = A \cdot R^{2/3} \cdot I^{1/2}/n$$

$$R = K_i \cdot A^{z} \qquad (4.4)$$

$$K = (n/I^{1/2} \cdot K_1^{2/3})^{P},\ P = 3/(3 + 2z) \qquad (4.5)$$

Where;

Q	=	Discharge
A	=	Cross-sectional area (discharge area)
R	=	Hydraulic radius
I	=	Gradient
n	=	Roughness
K_1, z	=	Parameters of channel.

(2) The Runoff Model and the parameter

To make a runoff model for the kinematic wave method, the catchment area was divided as shown in Fig. - 4.10.

When dividing the catchment, the reference point of the disaster prevention plan, the confluence of the rivers and the location of disaster prevention facilities were taken into account.

The number of catchment areas are nine (9) on S. Ciloseh basin (catchment area 33.3 km^2) and thirty-four (34) on S. Cikunir basin (84.42 Km^2). The runoff model by the kinematic wave method is shown in Fig. - 3.11. The parameters of the runoff model for identification are shown in Table - 3.15. The relation cumulative rainfall (Rsa) and cumulative rainfall loss (Rsa - loss) (Cumulative rainfall - cumulative rainfall rainfall loss curve) are shown Table - 2.18 and Fig. - 4.12.

The calculation formula for Table - 4.18 is shown as follows:

$$f = \frac{Q}{Rsa \cdot A}$$

Where;

Rsa	=	Cumulative rainfall
Q	=	Total runoff volume
A	=	Catchment area
f	=	Runoff coefficient
Rsa loss	=	Cumulative rainfall loss.

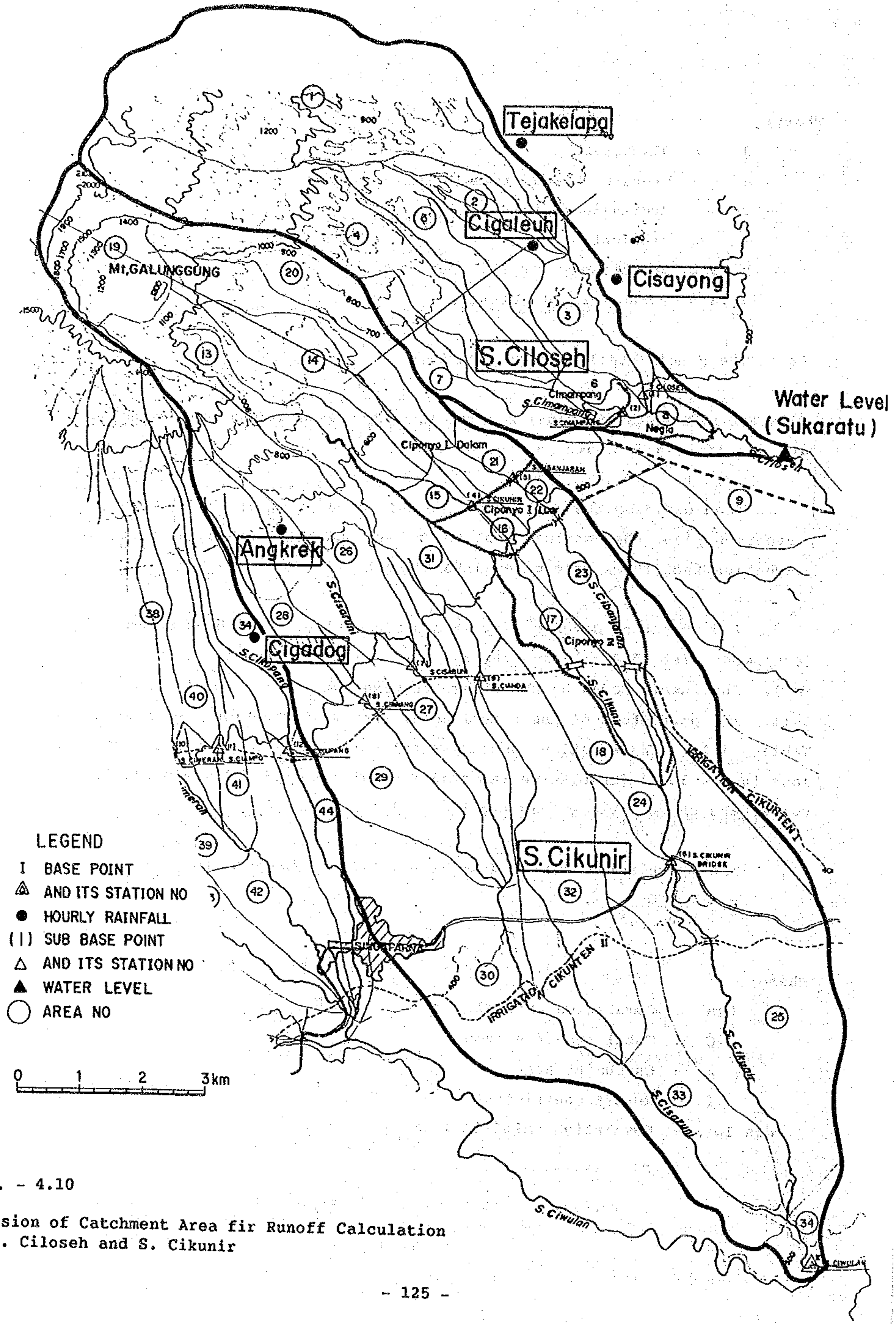


Fig. - 4.10

Division of Catchment Area fir Runoff Calculation in S. Ciloseh and S. Cikunir

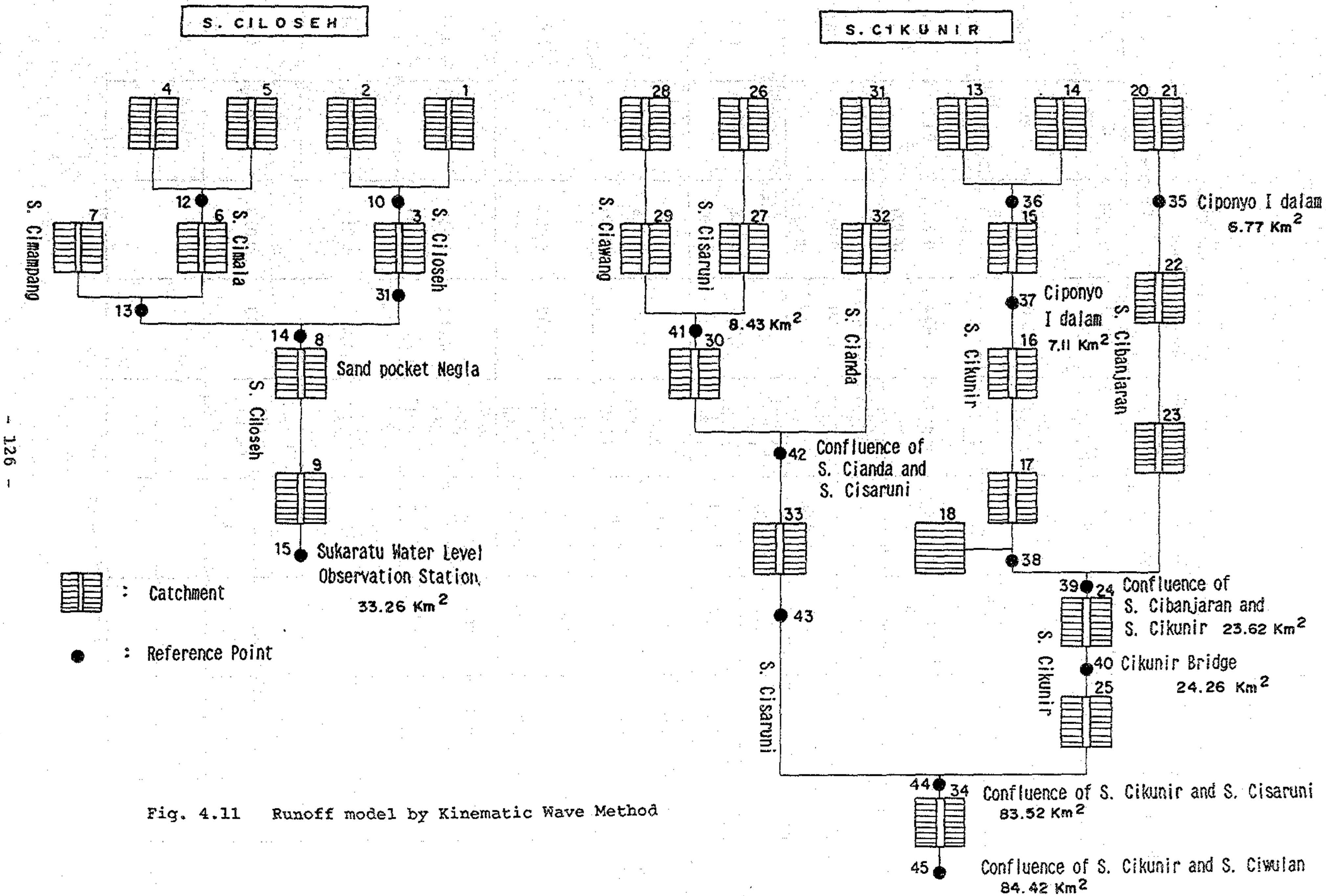


Fig. 4.11 Runoff model by Kinematic Wave Method

Table - 4.17 Parameters of Slope and Channel

Block No.		Area (Km^2)	Slope Length (m)	Slope Gradient s	N=1.5 (N=1.0) K $(N/\sqrt{s})^{0.6}$	Channel Length (m)	Channel Gradient	Channel K	Channel P
1	L	6.97	1,708	0.261	(1.496) 1.908	4,080	0.055 (0.02)	0.60	0.66
	R	5.84	1,431	0.340	(1.382) 1.763				
2	L	0.94	384	0.222	(1.571) 2.003	2,450	0.071 (0.02)	0.60	0.66
	R	0.68	278	0.250	(1.516) 1.933				
3	L	0.69	221	0.041	(2.607) 3.325	3,120	0.048 (0.02)	0.80	0.63
	R	1.81	580	0.058	(2.350) 2.997				
4	L	2.14	495	0.258	(1.501) 1.915	4,320	0.058 (0.02)	1.60	0.59
	R	5.58	1,292	0.338	(1.385) 1.766				
5	L	1.09	310	0.072	(2.202) 2.808	3,520	0.078 (0.02)	0.54	0.73
	R	2.18	619	0.101	(1.989) 2.537				
6	L	0.50	407	0.001	(7.943) 10.131	1,230	0.020	1.12	0.68
	R	0.19	154	0.014	(3.599) 4.590				
7	L	1.25	267	0.041	(2.607) 3.325	4,680	0.053 (0.02)	0.95	0.66
	R	1.63	348	0.038	(2.667) 3.401				
8	L	0.34	276	0.014	(3.599) 4.590	1,230	0.016	0.87	0.64
	R	0.50	407	0.007	(4.431) 5.651				
9	L	0.52	301	0.048	(2.487) 3.171	1,730	0.020	0.46	0.80
	R	0.41	237	0.048	(2.487) 3.171				
Total	L								
	R								

Table - 4.18 Runoff Coefficient of Discharge

Flood name	Σ R (mm)	Σ Q (x1000m³)	f*	Σ R1	Remarks
1986. 5.25	31.8	987.5	0.934	2.1	
1986. 6.25	77.6	1,940.8	0.725	19.2	
1986. 9.15	91.6	1,096.9	0.360	58.6	
1986. 9.27	108.4	1,401.8	0.389	66.3	
1986.10.12	144.4	2,318.9	0.483	74.7	
1986.11.10	69.5	486.5	0.210	54.9	
1986.11.18	171.4	1,956.6	0.343	112.6	

*) Calculation point SUKARATU (C.A=33.26 km^3)

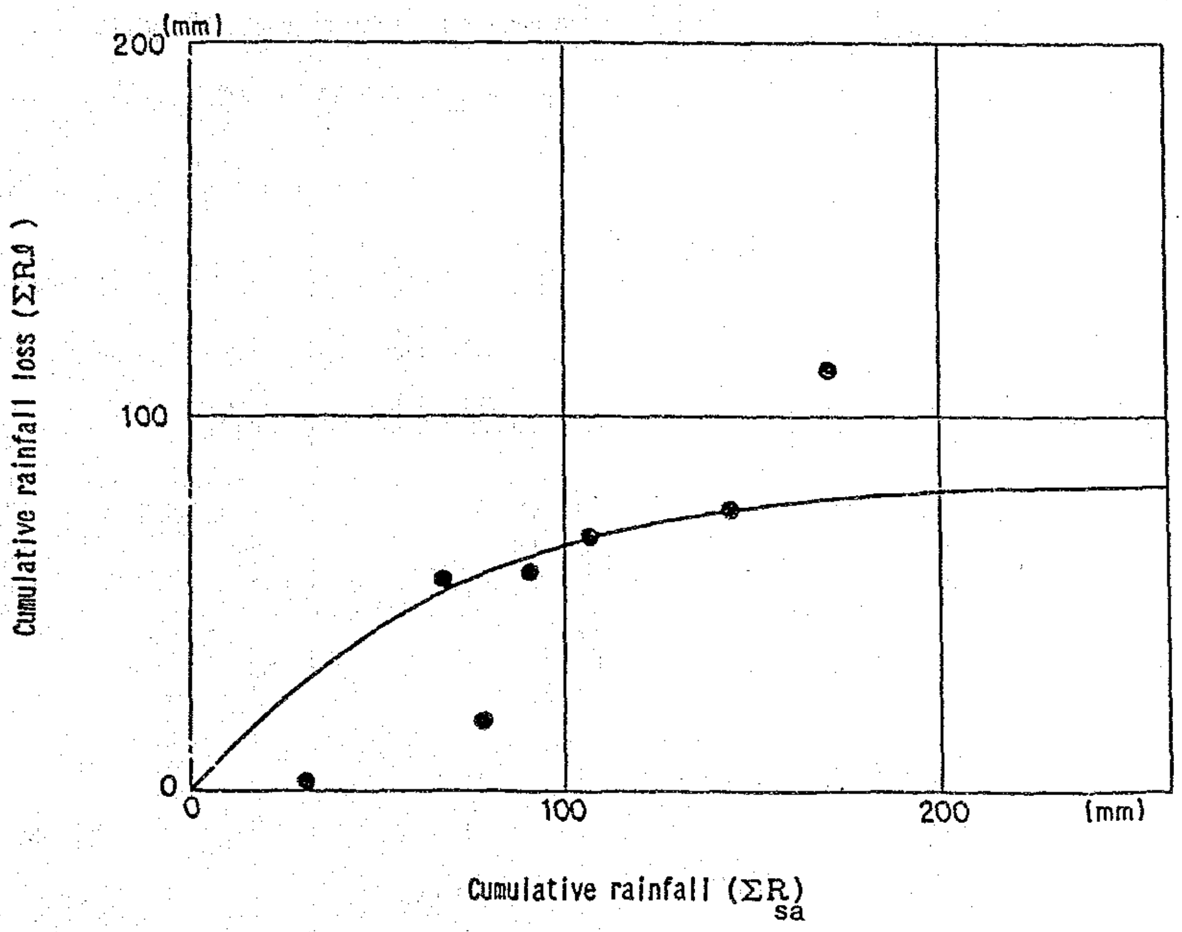


Fig. 4-12 Correlation between Cumulative Rainfall (Rsa) and Cumulative Rainfall Loss (Rsaloss)

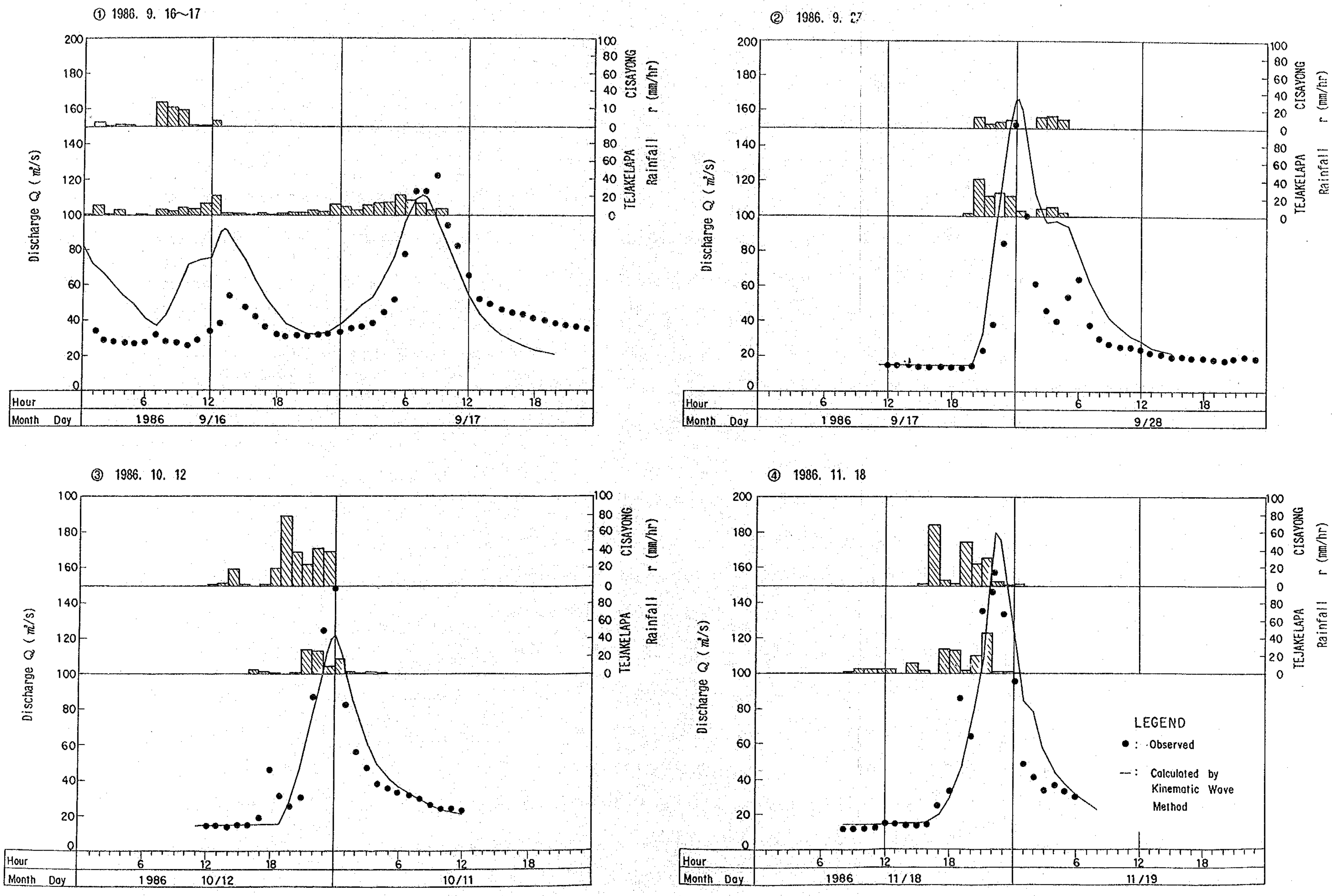


Fig. - 4.13 Comparison of calculated hydrograph and observed hydrograph.

(3) Parameter Analysis

Parameter analysis was mainly performed for cases in which the equivalent roughness and cumulative rainfall-cumulative rainfall loss curve were changed.

The floods for the parameter analysis are listed below.

1) September 15, 1986 Flood
2) September 27, 1986 Flood
3) October 12, 1986 Flood
4) November 18, 1986 Flood

The parameters to be identified finally are equivalent roughness N = 1.5. Cumulative rainfall Rsa = 200 mm and cumulative rainfall loss Rsa loss = 80 mm.

The relationship between observed discharge and calculated discharge is shown in Fig.- 4.13.

4.5.3 Runoff Calculation

Runoff calculation was carried out to make a design hydrograph.

(1) Design Hydrograph

The basic policies to make a design hydrographs are summarized as follows:

a) The scale of plan shall be 1/50 year (50 years).
b) The duration of rainfall shall be decided in one day taking the condition of the number of data into account.
c) Making of design rainfall shall be made by extending the actual hydrograph in units of daily rainfall.
d) The average aerial rainfall shall be calculated by the Thiessen method when there is a difference in the distribution of rainfall by area.

Table - 4.19 is shown a list of extension rates for each rainfall. In Fig. -4.14 is shown a hydrograph of observation stations (Tejakelapa, Cisayong, Cigadog). The Thiessen division is shown in Table - 4.20. A list of kinematic wave method parameters for S. Cikunir basin is shown in Table - 4.21.

Table - 4.19 Extension Rate

Catchment Name	(1) 1986. 9.15 Flood Daily Rain R (mm/day)	k	RR*k (mm/day)	r (mm/hr)	r*k (mm/hr)	(2) 1986. 9.21 Flood Daily Rain R (mm/day)	k	RR*k (mm/day)	r (mm/hr)	r*k (mm/hr)	(3) 1986. 9.27 Flood Daily Rain R (mm/day)	k	RR*k (mm/day)	r (mm/hr)	r*k (mm/hr)
BASIN(13)	129.0	1.938	363.0	20.0	38.8	144.0	1.736	261.0	29.3	50.9	122.0	2.049	250.0	42.2	86.5
BASIN(14)	156.0	1.603	526.0	33.7	54.0	174.0	1.437	255.0	25.3	36.4	145.0	1.724	250.0	41.2	71.0
BASIN(15)	167.0	1.497	404.0	17.1	25.6	121.0	2.066	261.0	23.3	48.1	111.0	2.252	250.0	34.5	77.7
BASIN(16)	102.5	2.439	468.3	15.8	38.5	91.9	2.632	256.0	14.8	39.0	69.1	2.252	250.0	24.4	54.9
BASIN(17)	116.0	2.155	409.0	16.6	35.8	224.0	1.116	250.0	22.3	24.9	109.0	2.294	250.0	33.4	76.6
BASIN(18)	129.0	1.938	363.0	20.0	38.8	237.0	1.055	261.0	30.0	31.6	122.0	2.049	250.0	42.2	86.5
BASIN(20)	135.0	1.852	489.0	21.9	40.6	242.0	1.033	257.0	13.8	14.3	126.0	1.984	250.0	28.8	57.1
BASIN(22)	77.6	1.852	480.0	27.6	51.1	68.8	1.033	71.0	17.5	18.1	71.6	1.984	182.0	15.8	31.3
BASIN(23)	80.3	2.147	438.0	26.9	57.8	76.8	1.033	79.0	17.1	17.7	74.1	1.984	166.0	13.6	27.0
BASIN(24)	129.0	1.938	363.0	20.0	38.8	144.0	1.736	261.0	30.0	52.1	122.0	2.049	250.0	42.2	86.5
BASIN(25)	140.0	1.786	530.0	32.7	58.4	185.0	1.351	326.0	57.0	77.0	131.0	2.049	250.0	35.7	73.1
BASIN(26)	156.0	1.603	711.0	38.5	61.7	109.0	2.294	204.0	30.0	68.8	122.0	2.049	250.0	42.2	86.5
BASIN(27)	156.0	1.603	711.0	38.5	61.7	109.0	2.294	204.0	30.0	68.8	122.0	2.049	250.0	42.2	86.5
BASIN(28)	156.0	1.603	711.0	38.5	61.7	109.0	2.294	204.0	30.0	68.8	122.0	2.049	250.0	42.2	86.5
BASIN(29)	156.0	1.603	711.0	38.5	61.7	109.0	2.294	204.0	30.0	68.8	122.0	2.049	250.0	42.2	86.5
BASIN(30)	156.0	1.603	711.0	38.5	61.7	109.0	2.294	204.0	30.0	68.8	122.0	2.049	250.0	42.2	86.5
BASIN(31)	156.0	1.603	711.0	38.5	61.7	109.0	2.294	204.0	30.0	68.8	122.0	2.049	250.0	42.2	86.5
BASIN(32)	156.0	1.603	711.0	38.5	61.7	109.0	2.294	204.0	30.0	68.8	122.0	2.049	250.0	42.2	86.5
BASIN(33)	156.0	1.603	711.0	38.5	61.7	109.0	2.294	204.0	30.0	68.8	122.0	2.049	250.0	42.2	86.5
BASIN(34)	156.0	1.603	711.0	38.5	61.7	109.0	2.294	204.0	30.0	68.8	122.0	2.049	250.0	42.2	86.5

Catchment Name	(4) 1986. 10.12 Flood Daily Rain R (mm/day)	k	RR*k (mm/day)	r (mm/hr)	r*k (mm/hr)	(5) 1986. 11.18 Flood Daily Rain R (mm/day)	k	RR*k (mm/day)	r (mm/hr)	r*k (mm/hr)
BASIN(13)	23.5	2.646	60.9	12.0	31.8	21.5	1.453	30.5	3.3	4.8
BASIN(14)	94.5	2.646	250.0	25.5	67.5	172.0	1.453	250.0	27.4	39.8
BASIN(15)	76.2	2.646	197.0	17.8	47.1	60.8	1.453	86.4	17.3	25.1
BASIN(16)	146.2	1.710	250.0	41.0	70.1	113.1	2.210	247.2	37.1	82.0
BASIN(17)	84.2	1.710	141.0	20.5	35.1	70.2	2.210	153.0	19.6	43.3
BASIN(18)	23.5	1.710	39.3	12.0	20.5	21.5	2.210	46.9	2.4	5.3
BASIN(20)	98.1	2.548	250.0	20.9	53.3	129.0	1.938	250.0	30.5	59.1
BASIN(22)	260.0	1.000	260.0	78.8	78.8	198.0	1.263	250.0	69.3	87.5
BASIN(23)	254.0	1.000	254.2	76.2	76.2	244.0	1.025	303.9	67.0	68.6
BASIN(24)	23.5	1.710	39.3	12.0	20.5	21.5	2.210	26.7	2.4	5.3
BASIN(25)	126.0	1.984	250.0	28.6	56.7	177.0	1.412	250.0	44.2	62.4
BASIN(26)	23.5	1.710	40.2	12.0	20.5	28.1	2.210	39.8	2.4	5.3
BASIN(27)	23.5	1.710	40.2	12.0	20.5	28.1	2.210	39.8	2.4	5.3
BASIN(28)	23.5	1.710	40.2	12.0	20.5	28.1	2.210	39.8	2.4	5.3
BASIN(29)	23.5	1.710	40.2	12.0	20.5	28.1	2.210	39.8	2.4	5.3
BASIN(30)	23.5	1.710	40.2	12.0	20.5	28.1	2.210	39.8	2.4	5.3
BASIN(31)	23.5	1.710	40.2	12.0	20.5	28.1	2.210	39.8	2.4	5.3
BASIN(32)	23.5	1.710	40.2	12.0	20.5	28.1	2.210	39.8	2.4	5.3
BASIN(33)	23.5	1.710	40.2	12.0	20.5	28.1	2.210	39.8	2.4	5.3
BASIN(34)	23.5	1.710	40.2	12.0	20.5	28.1	2.210	39.8	2.4	5.3

*) Probable Daily Rainfall =250 mm/day (W=1/50)

Table - 4.20 Coefficient of Thiessen

Flood name	Catchment	Rainfall Station name CISAYONG	TEJAKELA.	CIGADOG	Total	Remarks
	BASIN(13)	0.000	0.000	1.000	1.000	
	BASIN(14)	0.056	0.944	0.000	1.000	
	BASIN(15)	0.223	0.000	0.777	1.000	
	BASIN(16)	0.519	0.000	0.481	1.000	
	BASIN(17)	0.257	0.000	0.743	1.000	
	BASIN(18)	0.000	0.000	1.000	1.000	
	BASIN(20)	0.185	0.505	0.310	1.000	
	BASIN(22)	1.000	0.000	0.000	1.000	
	BASIN(23)	0.967	0.033	0.000	1.000	
1986	BASIN(24)	0.000	0.000	1.000	1.000	
	BASIN(25)	0.239	0.761	0.000	1.000	
(1) 9.15	BASIN(26)	0.000	0.000	1.000	1.000	
(2) 9.21	BASIN(27)	0.000	0.000	1.000	1.000	
(3) 9.27	BASIN(28)	0.000	0.000	1.000	1.000	
(4) 10.12	BASIN(29)	0.000	0.000	1.000	1.000	
(5) 11.18	BASIN(30)	0.000	0.000	1.000	1.000	
	BASIN(31)	0.000	0.000	1.000	1.000	
	BASIN(32)	0.000	0.000	1.000	1.000	
	BASIN(33)	0.000	0.000	1.000	1.000	
	BASIN(34)	0.000	0.000	1.000	1.000	

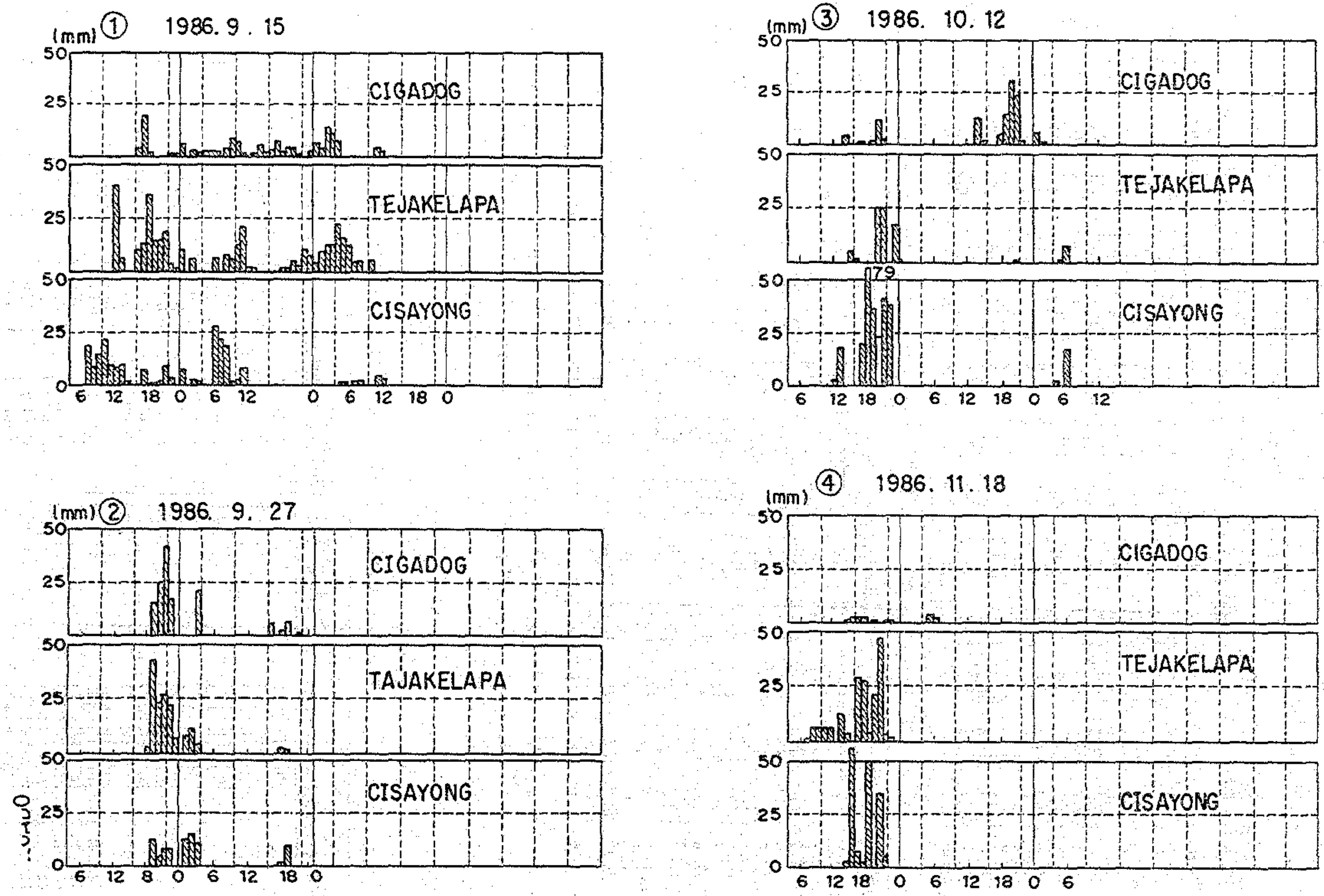


Fig. 4.14 Pattern of Hourly Rainfall for design hydrograph by Kinematic Wave Method

Table - 4.21 (1) Parameters of Slope and Channel

Block No.		Area (Km^2)	Slope		N=1.5 K ($N/\sqrt{s}$)$^{0.6}$	channel (River)			
			Length (m)	Gradient s		Length (m)	Gradient	K	P
⑬	L	1.76	587	0.852	1.338	3,000	0.197 (0.020)	0.670	0.764
	R	2.27	757	0.661	1.444				
⑭	L	1.12	472	0.466	1.604	2,375	0.101 (0.020)	0.880	0.750
	R	1.20	505	0.337	1.768				
⑮	L	0.31	354	0.085	2.674	875	0.034 (0.020)	2.160	0.742
	R	0.45	514	0.058	2.991				
⑯	L	0.32	320	0.031	3.607	1,000	0.020	1.420	0.761
	R	0.47	470	0.021	4.048				
⑰	L	1.49	322	0.062	2.936	4,625	0.016	2.500	0.757
	R	1.00	285	0.105	2.506				
⑱	L	—	—	—	—	4,500	0.043 (0.020)	1.700	0.781
	R	2.57	571	0.035	3.486				
⑳	L	3.05	938	0.800	1.364	3,250	0.185 (0.020)	0.880	0.750
	R	2.71	834	0.660	1.487				
㉑	L	0.60	533	0.038	3.415	1,125	0.036 (0.020)	0.880	0.750
	R	0.41	364	0.055	3.046				
㉒	L	0.46	460	0.022	4.022	1,000	0.020	1.420	0.761
	R	0.39	390	0.051	3.109				
㉓	L	1.11	234	0.449	1.622	4,750	0.016	1.700	0.781
	R	1.93	406	0.135	2.323				

Table - 4.21 (2) Parameters of Slope and Channel

Block No.		Area (Km²)	Slope Length (m)	Slope Gradient s	K	Channel (River) Length (m)	Channel (River) Gradient	Channel (River) K	Channel (River) P
㉔	L	0.33	240	0.042	3.309	1.375	0.015	1.700	0.781
	R	0.71	516	0.019	4.163				
㉕	L	11.45	1,761	0.187	2.108	6.500	0.018	1.700	0.781
	R	4.31	663	0.445	1.626				
㉖	L	4.40	1,303	0.925	1.306	3.375	0.145 (0.020)	1.982	0.614
	R	1.86	551	0.907	1.313				
㉗	L	2.18	513	0.068	2.854	4.250	0.024 (0.020)	1.784	0.613
	R	1.56	367	0.163	2.196				
㉘	L	1.65	367	0.627	1.467	4.500	0.082 (0.020)	1.982	0.614
	R	1.54	342	0.395	1.686				
㉙	L	1.64	410	0.159	2.216	4.000	0.015	1.962	0.610
	R	3.60	900	0.072	2.806				
㉚	L	0.77	1,925	0.065	2.897	4.000	0.018	1.843	0.613
	R	7.32	1,830	0.068	2.853				
㉛	L	2.17	789	0.146	2.273	2.750	0.164 (0.020)	1.982	0.614
	R	0.95	345	0.203	2.058				
㉜	L	5.69	799	0.275	1.878	7.125	0.015	1.962	0.610
	R	2.15	302	0.712	2.370				
㉝	L	3.67	979	0.179	2.138	3.750	0.013	2.006	0.620
	R	1.73	461	0.130	2.351				
㉞	L	0.40	320	0.219	2.012	1.250	0.016	1.906	0.614
	R	0.50	400	0.125	2.380				

(2) Results of Runoff Calculation

The runoff calculation using the kinematic wave method for five (5) flood in the S. Cikunir basin was executed. Peak discharge of main reference point is listed in Table - 4.22.

Table - 4.22 Peak Discharge in Return Period 50 Years

Ref. Point Area (km^3) / Rainfall	Ciponyo I dalam (Cibanjaran) $6.77\ km^2$	Ciponyo I dalam (Cikunir) $7.11\ km^2$	Cikunir Bridge $24.26\ km^2$	S. Cikunir S. Ciwulan $84.42\ km^2$
(1) Sept. 16, 86	41 (4)	46 (4)	112 (5)	462 (4)
(1) Sept. 21, 86	32 (5)	70 (2)	186 (3)	750 (2)
(1) Sept. 27, 86	79 (2)	122 (1)	321 (1)	1,112 (1)
(1) Oct. 12, 86	82 (1)	65 (3)	216 (2)	510 (3)
(1) Nov. 18, 86	70 (3)	39 (5)	160 (4)	343 (5)

Note) ( ): Rank of Peak discharge.

According to Table - 4.22, the maximum values of peak discharge for each base point are: Ciponyo I (Cibanjaran), 80 m^3/s; Cikunir Bridge, 320 m^3/s, S. Ciwulan confluence, 1,110 m^3/s.

The reason the peak discharge differs for each flood is that the hourly rainfall was different after extension.

4.6 Design Hydrograph

The peak discharge at the S. Ciwulan confluence and the Cikunir Bridge have been listed in order to Table - 4.23 based on the runoff calculation results in 4.5.3.

Table - 4.23 Rank of Peak Discharge

(1) Confluence of S. Ciwulan

Bank	Peak Discharge (m^3/s)	Flood
1	1,112	Sept. 27, 1986
2	750	Sept. 21, 1986
3	510	Oct. 12, 1986
4	462	Sept. 16, 1986
5	343	Nov. 18, 1986

(2) Cikunir Bridge

Bank	Peak Discharge (m^3/s)	Flood
1	321	Sept. 27, 1986
2	216	Oct. 12, 1986
3	186	Sept. 21, 1986
4	160	Nov. 18, 1986
5	112	Sept. 16, 1986

According to Table - 4.23 the September 27 flood gave the highest values for either point.

The values of peak discharge and the volume of the runoff hydrograph must be taken into account by design hydrographs. However, for purposes of this study, it has been decided to selects the highest peak discharge value and adopt the September 27 flood as the design hydrograph.

The hydrographs of the main reference points of the design hydrograph are shown in Fig. - 4.15.

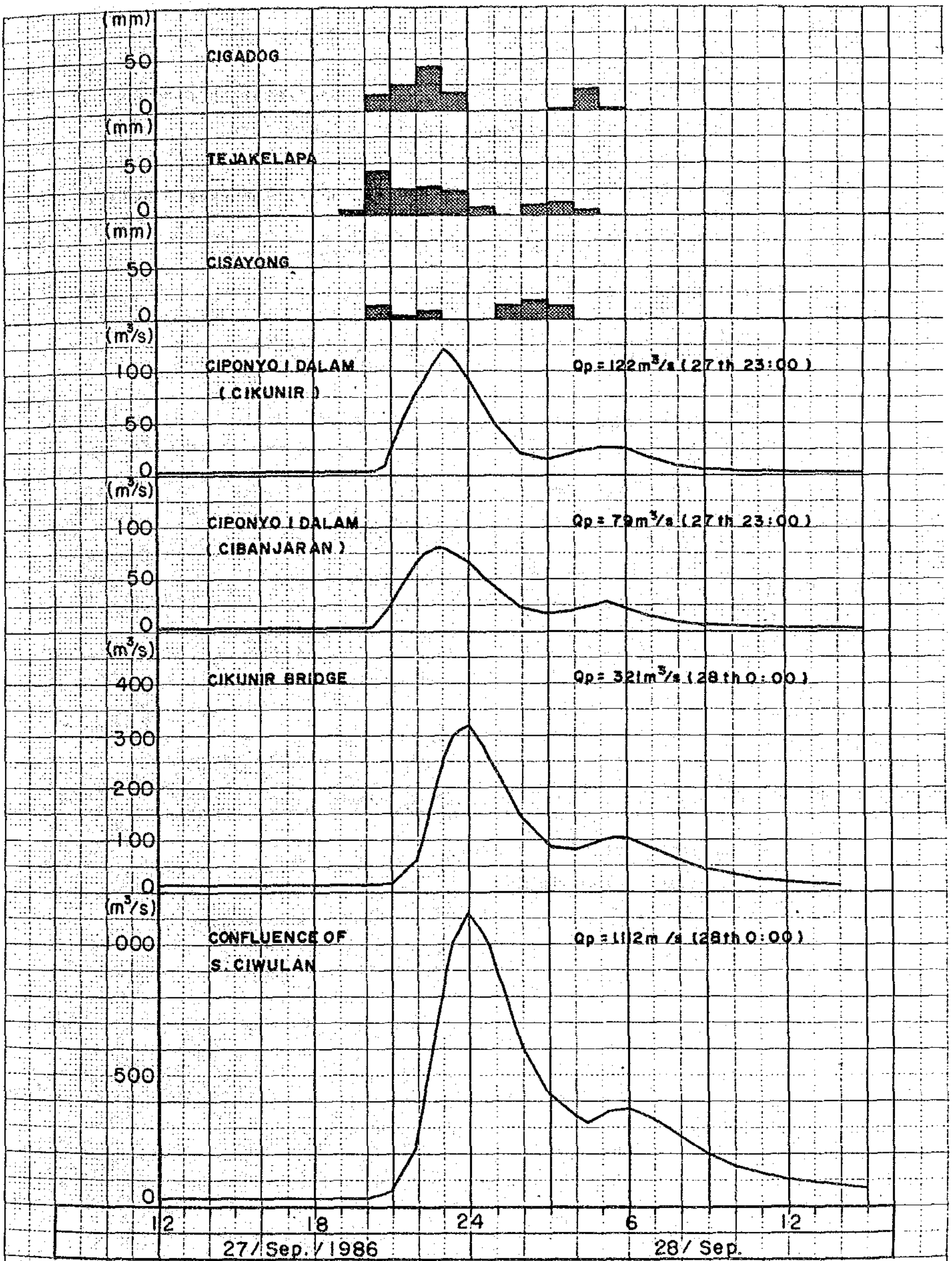


Fig. 4.15 Design Hydrograph

4.7 Calculation of Peak Discharge

The calculation of the peak discharge for each return period was executed and results are shown in Table - 4.24 to Table 4.26.

The method for calculation of rainfall intensity and peak discharge are as follows;

(1) Rainfall Intensity

$$r = \frac{R_{24}}{24} \left(\frac{24}{T} \right)^{2/3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.7)$$

Where;

r = Rainfall intensity (mm/hr)

R_{24} = Daily rainfall (mm)

R = Concentration time (hr)
(by Kraven method)

(2) Discharge

$$Q = 1/3.6 \,.\, f \,.\, r \,.\, A \quad \ldots\ldots\ldots\ldots\ldots\ldots (4.8)$$

Where;

Q = Discharge (m^3/sec)

f = Run-off coefficient (f = 0.7)

r = Rainfall intensity (mm/hr)

A = Catchment area (Km^2).

Table - 4.24 (1) Probable Flood Discharge (S. Ciloseh)

River Name	Site Name No	Site Name Name	Catchment Area** A (Km2)	River Length L (Km)	Velocity of Flood V (Km/hr)	Time of Flood Concentration T (hr)	Probable Rainfall Intensity r (mm/hr) 1/100 280 mm	1/50 250 mm	1/25 220 mm	Probable Flood Discharge*** Q (m³/s) 1/100	1/50	1/25
S. Cisoleh	1.	Check Dam CLS - 3	12.66	9.20	12.6	0.7	123.3	110.1	96.8	304	271	238
	2.	C with Tributary	12.81 (14.43)	9.38	12.6	0.7	123.3	110.1	96.8	307 (346)	274 (309)	241 (272)
	3.	Check Dam CLS - 2	14.65	10.10	12.6	0.8	112.8	100.7	88.5	(346	(309)	(272)
	4.	Check Dam CIS - 1	14.83	10.60	12.6	0.8	112.8	100.7	88.5	(346)	(309)	(272)
	5.	C with S. Cimampang	16.93 (31.49)	12.60	12.6	1.0	97.2	86.8	76.3	(346) (595)	(309) (531)	(272) (467)
	6.	Negla Overflow	32.33	13.83	12.6	1.1	91.2	81.4	71.6	(595)	(531)	(467)
	7.	C with Tributary	(36.81)	17.27.	12.6	1.4	77.6	69.3	61.0	(595)	(531)	(467)
	8.	Ciloseh Bridge	38.16	21.25	12.6	1.7	68.2	60.9	53.5	(595)	(531)	(467)
	9.	C with S. Cimulu	39.14 (62.17)	24.44	12.6	1.9	63.3	56.5	49.7	(595) (765)	(531) (683)	(467) (601)
	10.	C.with S. Citanduy	63.64	29.00	12.6	2.3	55.8	49.7	43.8	(765)	(683)	(601)
S. Cimala	1.	C with S. Cimampang	3.27	5.08	12.6	0.4	170.0 179.0	152.7 159.9	136.7 140.5	109 114	98 102	87 89
S. Cimampang	1.	Check Dam CMP - 2	6.25	7.20	12.6	0.6	136.6	122.0	107.2	166	148	130
	2.	Check Dam CMP - 1	7.05	8.00	12.6	0.6	136.6	122.0	107.2	187	167	147
	3.	C with S. Cimala	7.72 (10.99)	9.63	12.6	0.8	112.8	100.7	88.5	187 (241)	167 (215)	147 (189)
	4.	C with S. Cipeureu	11.68 (14.56)	10.96	12.6	0.9	104.2	93.1	81.8	241 (295)	215 (264)	189 (232)
S. Cipeureu	1.	C with S. Cimampang	2.88	5.48	12.6	0.4	179.0	159.9	140.5	100	90	79
S. Cimulu	1.	C with S. Cimampang	23.03	14.19	12.6	1.1	91.2	81.4	71.4	408	365	321

* C : Confluence with another river

** ( ) : Catchment Area at the down stream of confluence

*** Q = 0.2778frA

Q : peak discharge of Flood (m3/s)

f : run off coefficient = 0.7

r : rainfall inrensity (mm/hr)

A : catchment area (Km2)

Table - 4.24 (2)   Probable Flood Discharge (S. Cikunir)

River Name	No.	Site Name	Catchment Area A (Km2)	River Length L (Km)	Velocity of Flood V (Km/hr)	Time of Flood Concentration T (hr)	Probable Rainfall Intensity r (mm/hr) 1/100 280mm	1/50 250mm	1/25 220mm	Probable Flood Discharge Q (m3/s) 1/100	1/50	1/25
S. Cikunir	1.	Check Dam CKN - 5	2.75	4.35	12.6	0.4	179.0	159.9	140.5	96	86	75
	2.	Check Dam CKN - 4	3.00	4.70	12.6	0.4	179.0	159.9	140.5	104	93	82
	3.	Check Dam CKN - 3	3.20	5.15	12.6	0.4	179.0	159.9	140.5	111	100	87
	4.	C with S. Cibukur	4.03 (6.35)	6.79	12.6	0.5	154.3	137.8	121.1	121 (191)	108 (170)	95 (150)
	5.	Ciponyo I D. Overflow	7.11	7.68	12.6	0.6	136.6	122.0	107.2	189	169	148
	6.	Ciponyo I L. Overflow	7.90	8.69	12.6	0.7	123.3	110.1	96.8	189	169	149
	7.	Consolidation Dam CKN-2	9.10	10.38	12.6	0.8	112.8	100.7	88.5	200	178	157
	8.	Consolidation Dam CKN-1	10.03	11.96	12.6	0.9	104.2	93.1	81.8	203	185	160
	9.	C with S. Cibanjaran	12.96 (23.62)	11.88	12.6	0.9	104.2	93.1	81.8	262 (479)	235 (428)	206 (376)
	10.	Cikunir Bridge	24.66	14.42	12.6	1.1	91.2	81.4	71.6	479	428	376
	11.	C with S. Cisaruni	40.42 (83.52)	20.95	12.6	1.7	68.1	60.8	53.5	535 (1,105)	478 (987)	420 (869)
	12.	C with S. Ciwulan	84.42	22.32	12.6	1.8	65.6	58.6	51.5	1,105	987	869
S. Cibanjaran	1.	Crater	3.59		-	0.5	146.3	131.5	117.7	103	92	83
	2.	Check Dam CBJ - 5	4.21	4.20	12.6	0.4	179.0	159.9	140.5	147	131	115
	3.	Check Dam CBJ - 4	4.41	4.70	12.6	0.4	179.0	159.9	140.5	153	137	120
	4.	Consolidation Dam CBJ-3	4.71	5.35	12.6	0.4	179.0	159.9	140.5	164	146	129
	5.	Ciponyo I	5.76	6.21	12.6	0.5	154.3	137.8	121.1	173	154	136
	6.	Ciponyo I D. Overflow	6.77	7.28	12.6	0.6	136.6	122.0	107.2	180	161	141
	7.	Ciponyo I L. Overflow	7.62	8.27	12.6	0.7	123.3	110.1	96.8	183	163	143
	8.	Consolidation Dam CBJ-2	9.39	10.10	12.6	0.8	112.8	100.7	88.5	206	184	162
	9.	Cross point of Cikunten I	10.06	11.10	12.6	0.9	104.2	95.1	81.8	206	184	162
	10.	Consolidation Dam CBJ-1	10.25	11.80	12.6	0.9	104.2	95.1	81.8	208	190	176
	11.	C with S. Cikunir	10.46	13.09	12.6	0.9	97.2	86.8	76.3	208	190	176
S. Cibukur	1.	C with S. Cikunir	2.32	4.95	12.6	0.4	179.0	159.9	140.5	81	72	63
S. Cisaruni	1.	Check Dam CSR - 5	1.16	2.92	12.6	0.4	179.0	159.5	140.5	40	36	32
	2.	Consolidation CSR - 4	1.70	3.32	12.6	0.4	179.0	159.5	140.5	59	53	46
	3.	Consolidation CSR - 3	2.22	3.72	12.6	0.4	179.0	159.5	140.5	77	69	61
	4.	Consolidation CSR - 2	2.35	4.22	12.6	0.4	179.0	159.5	140.5	82	73	64
	5.	Consolidation CSR - 1	2.47	4.72	12.6	0.4	179.0	159.5	140.5	86	77	67
	6.	Cross pint of Cikunten I	6.26	6.82	12.6	0.5	154.3	137.8	121.1	188	168	147
	7.	C with S. Ciawang	10.00 (18.43)	11.07	12.6	0.9	104.2	93.1	81.8	203 (373)	(334)	(242)
	8.	C with S. Cianda	26.52 (37.70)	15.21	12.6	1.2	85.9	76.7	67.5	443 (630)	396 (562)	348 (495)
	9.	C with S. Cikunir	43.10	18.96	12.6	1.5	74.1	66.1	58.2	621	554	488
S. Ciawang	1.	Cross point of Cikunten I	3.19	5.51	12.6	0.4	179.0	159.9	140.5	111	99	87
	2.	C with S. Cisaruni	8.43	9.68	12.6	0.6	112.8	100.7	88.5	185	165.1	145
S. Cianda	1.	Consolidation Dam (2) (Existing Dam)	2.60	4.95	12.6	0.4	179.0	159.9	140.5	91	81	71
	2.	Cross point of Cikunten I	3.12	5.95	12.6	0.5	154.3	137.8	121.1	94	84	73
	3.	C with S. Cisaruni	11.18	13.00	12.6	1.0	97.2	86.8	76.3	211	189	166

Table - 4.24 (3) Probable Flood Discharge (S. Cimerah and S. Cibatukuda)

River Name	No	Site Name	Catchment Area A (Km2)	River Length L (Km)	Velocity of Flood V (Km/hr)	Time of Flood Concentration T (hr)	Probable Rainfall Intensity r (mm/hr) 1/100 280mm	1/50 250mm	1/25 220mm	Probable Flood Discharge Q (m3/s) 1/100	1/50	1/25
S. Cimerah	1.	Check Dam CMR - 5	1.30	3.19	12.6	0.4	179.0	159.9	140.5	45	40	36
	2.	Check Dam (1)	3.40	5.51	12.6	0.4	179.0	159.9	140.5	112	100	88
	3.	Check Dam CMR - 3 (Existing Dam)	3.78	5.11	12.6	0.4	179.0	159.9	140.5	132	118	103
	4.	Check Dam CMR - 2	3.97	6.08	12.6	0.5	154.3	137.8	121.1	132	118	103
	5.	Check Dam CMR - 1	4.24	7.40	12.6	0.6	136.6	122.0	107.2	132	118	103
	6.	C with S. Cipada	4.71 (7.20)	8.48	12.6	0.7	123.3	110.1	96.8	132 (173)	118 (154)	103 (136)
	7.	Cross point of Cikunten I	7.74 (10.95)	9.49	12.6	0.8	112.8	100.7	88.5	170 (240)	152 (214)	133 (188)
	8.	C with S. Ciampo	12.14 (16.09)	11.86	12.6	0.9	104.2	93.1	81.8	246 (326)	220 (291)	193 (256)
	9.	C with S. Ciwulan	20.16 (29.83)	16.23	12.6	1.3	81.5	72.8	64.0	320 (473)	285 (422)	251 (371)
S. Cipada	1.	Consolidation Dam (1)	2.30	4.90	12.6	0.4	179.0	159.9	140.5	80	72	63
	2.	Consolidation Dam (2)	2.54	5.25	12.6	0.4	179.0	159.9	140.5	88	79	69
	3.	C with S. Cimerah	2.49	5.48	12.6	0.4	179.0	159.9	140.5	87	77	68
S. Cipada	1.	Check Dam CPD - 2	0.72	2.68	12.6	0.4	179.0	159.9	140.5	25	22	20
	2.	Check Dam CPD - 1	0.99	3.38	12.6	0.4	179.0	159.9	140.5	34	31	24
	3.	Consolidation Dam (3)	2.80	5.50	12.6	0.4	179.0	159.9	140.5	97	87	77
	4.	C with S. Cimerah	3.21	6.59	12.6	0.5	154.3	137.8	121.1	96	86	76
S. Cisala	1.	Check Dam CSL - 6	0.60	1.99	12.6	0.4	179.0	159.9	140.5	21	19	16
	2.	Check Dam CSL - 5	1.24	2.59	12.6	0.4	179.0	159.9	140.5	43	39	34
	3.	Check Dam CSL - 4	1.67	3.19	12.6	0.4	179.0	159.9	140.5	58	52	46
	4.	Check Dam CSL - 3	1.84	3.59	2.6	0.4	179.0	159.9	40.5	64	57	50
	5.	Check Dam CSL - 2	2.10	4.19	12.6	0.4	179.0	159.9	140.5	73	65	57
	6.	Check Dam CSL - 1	2.37	4.59	12.6	0.4	179.0	159.9	140.5	82	74	65
	7.	C with S. Cimerah	3.21	6.59	12.6	0.5	154.3	134.8	121.1	112	100	88
S. Ciampo	1.	Cross point of Cikunten I	2.64	4.89	12.6	0.4	199.0	159.9	140.5	92	82	72
	2.	C with S. Cimerah	3.95	6.69	12.6	0.5	154.3	134.8	121.1	119	106	93
S. Cikupang	1.	Check Dam CKP - 3	1.16	3.13	12.6	0.4	179.0	159.9	140.5	40	36	32
	2.	Check Dam CKP - 2	1.50	3.73	12.6	0.4	179.0	159.9	140.5	52	47	41
	3.	Check Dam CKP - 1	1.83	4.73	12.6	0.4	179.0	159.9	140.5	64	57	50
	4.	Cross point of Cikunten I	3.40	6.93	12.6	0.6	136.6	122.0	107.2	90	81	71
	5.	C with S. Cimerah	5.71	11.56	12.6	0.9	104.2	93.1	81.8	116	103	91
S. Cibatukuda	1.	Cross point of Cikunten I	4.77	5.76	12.6	0.5	154.3	137.8	121.1	143	128	112
	2.	C with S. Cimerah	8.17	12.77	12.6	1.0	97.2	86.8	76.3	154	138	121