REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

FINAL REPORT
FOR
THE STUDY
OF
WIDAS FLOOD CONTROL AND DRAINAGE PROJECT
PART-II STUDY

SUPPORTING REPORT

MARCH, 1986

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

JICA FINAL REPORT FOR THE STUDY OF WIDAS FLOOD CONTROL AND DRAINAGE PROJECT PART-II STUDY JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO, JAPAN

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T A B L E O F C O N T E N T S

ANNEX

ANNEX - 1

SOCIO-ECONOMY

ANNEX - 1 SOCIO -ECONOMY

ANNEX-1 shows the supporting tables of Socio - economy in chapter-2 of Main Report

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Table 1.1 LAND USE CATEGORIES BY KECAMATAN : UNIT HA

Kecamatan	Rice-field	Upland field	Home-yard	Forest-ry	Settle-ment	Others	Total
1. Sawahan	1062	902	1058	7916	638	12	11589
2. Ngetos	1315	1275	684	2612	78	20	6021
3. Berbek	2028	344	517	1650	259	30	4830
4. Loceret	2765	966	535	2134	286	182	6869
5. Pace	2834	781	457	167	557	41	4846
6. Prambon	2424	253	843	-	586	9	4116
7. Ngrongot	1939	678	1505	-	1031	146	5299
8. Kertosono	1241	233	691	-	40	54	2260
9. Patianrowo	1805	717	386	-	276	95	3279
10. Baron	2073	458	905	-	82	116	3670
11. Tanjunganom	3926	372	1657	-	1072	57	7084
12. Sukomoro	2666	102	456	-	163	151	3539
13. Nganjuk	1388	52	313	-	396	109	2259
14. Bagor	2405	284	594	1604	184	44	5115
15. Wilangan	1133	76	329	3413	83	30	5064
16. Rejoso	4341	517	1267	9367	415	64	15971
17. Gondang	4328	480	441	2255	326	127	7957
18. Ngluyu	1096	650	196	6649	216	17	8824
19. Lengkong	1605	519	158	5956	317	163	8717
20. Jatikalen	1017	802	367	1744	187	87	4203
Grand-total	43,439	10,462	13,395	45,468	7,190	1,555	121,510

Source : Statistical bureau of Kabupaten Nganjuk

Table 1.2 TOTAL MIGRANT IN KABUPATEN NGANJUK
BY KECAMATAN DURING PELITA III

No.	NAME OF KECAMATAN	TOTAL MIGRANT IN 1979/1980		1980/1981		1981/1982		1982/1983		1983/1984		'79/'80 to '83/'84	
		No. of Household		No. of Household		No. of Household		No. of Household		No. of Household		No. of Household	
1.	Lengkong	-	-	31	131	45	185	32	138	48	215	156	669
2.	Gondang	-	-	13	50	32	130	30	126	79	348	154	654
3.	Rejoso	-	-	39	160	366	1,536	251	1,032	97	412	753	3,160
4.	Ngluyu	-	-	34	135	60	250	20	82	72	288	186	755
5.	Jatikalen	-	-	37	151	83	333	8	34	13	49	141	567
6.	Pace	-	-	13	43	26	78	7	35	32	144	78	300
7.	Ngetos	20	98	37	164	9	37	34	141	3	15	103	455
8.	Sawahan	19	92	60	241	58	210	115	448	33	115	285	1,106
9.	Berbek	-	-	16	65	5	20	29	120	57	241	107	446
10.	Loceret	43	198	12	52	25	114	124	517	25	103	229	984
11.	Sukomoro	-	-	52	233	23	103	50	240	16	68	141	644
12.	Wilangan	36	169	8	37	35	130	103	424	61	260	243	1,020
13.	Nganjuk	-	-	18	73	31	125	17	72	3	13	69	283
14.	Baron	-	-	56	272	181	802	67	330	18	84	322	1,488
15.	Tanjunganom	-	-	30	134	187	755	142	617	73	328	432	1,834
16.	Patianrowo	13	64	13	61	20	87	29	152	49	210	124	574
17.	Kertosono	2	11	91	345	105	461	9	31	3	8	210	856
18.	Ngronggot	-	-	32	135	307	1,356	37	149	19	80	395	1,720
19.	Prambon	-	-	2	12	27	110	9	47	27	129	65	298
20.	Bagor	-	-	13	71	55	227	70	275	27	109	165	682
	TOTAL	133	632	607	2,585	1,680	7,049	1,183	5,010	755	3,219	4,358	18,495

Source : Rencana Pembangunan Lima Tahun ke Empat (1984/1985 to 1988/1989) of Kabupaten Nagnjuk

Table 1.3 DETERMINATION OF URBAN DESAS

Population density (per km^2)	Percentage of households engaged primarily in agriculture	Numbers of " Urban " facilities	Points
Less than 500	More than 95	-	1
500 - 999	91 - 95	0	2
1000 - 1499	86 - 90	1	3
1500 - 1999	76 - 85	2	4
2000 - 2499	66 - 75	3	5
2500 - 2999	56 - 65	4	6
3000 - 3499	46 - 55	5	7
3500 - 3999	36 - 45	6	8
4000 - 4999	26 - 35	7	9
Above 5000	Less than 25	8 or more	10

Source : " Definisi Desa Urban dalam Sensus Penduduk 1980 "
Central burean of statistic , 1979.

Table 1.4 URBAN POPULATION BY KABUPATEN AND KOTAMADYA IN EAST JAVA AND TOTAL URBAN POPULATION IN INDONESIA - 1980 CENSUS

Name of Kabupaten/ Kotamadya/Province (District/Municipality/ Province)	Total Population (Person)	Total Urban Population (Person)	Ratio
Kabupaten:			
Kab. Nganjuk	882,832	87,832	9.94
Pacitan	478,037	14,180	2.96
Ngawi	769,286	20 887	2.71
Trenggalek	564,542	29,318	5.19
Pamekasan	539,055	42,831	7.94
Sampang	604,541	42,839	7.08
Mojokerto	705,596	47,848	6.78
Bondowoso	612,160	49,426	8.07
Magetan	608,820	49,717	8.16
Sumenep	854,925	53,982	6.31
Ponorogo	783,381	55,523	7.08
Madiun	640,561	56,262	8.78
Probolinggo	866,318	59,544	6.87
Tuban	871,898	64,451	7.39
Bangkalan	688,362	69,303	10.06
Blitar	1,037,258	74,245	7.15
Kediri	1,235,265	79,565	6.44
Bojonegoro	999,418	83,542	8.35
Lamongan	1,049,956	90,006	8.57
Lumajang	874,516	98,512	11.26
Situbondo	525,046	100,663	19.17
Gresik	729,039	103,439	14.18
Jombang	941,988	105,796	11.23
Tulungagung	833,232	141,094	16.93
Pasuruan	1,034,967	165,038	15.94
Sidoarjo	854,298	185,354	21.69
Malang	2,045,939	194,069	9.48
Jember	1,881,091	329,031	17.49
Banyuwangi	1,420,837	366,564	25.79
Total Kabupaten in East Java	25,933,164	2,860,861	11.03
Kotamadya :			
Kt.madya Mojokerto	68,849	68,507	99.50
Blitar	78,503	75,509	96.18
Pasuruan	95,864	91,268	95.20
Probolinggo	100,296	98,126	97.83
Madiun	150,562	145,636	96.72
Kediri	221,830	173,433	78.18
Malang	511,780	470,128	91.86
Surabaya	2,027,913	1,737,019	85.65
Total Kotamadya in East Java	3,255,597	2,859,626	87.83
Total East Java	29,188,761	5,720,487	19.59
Total Indonesia	146,934,948	32,845,769	22.35

Table 1.5 POPULATION OF AGE GROUP BY KECAMATAN
in KAB.NGANJUK (CENCUS 1980)

No. Kecamatan	Population Base on Age Group						Total
	0 - 4	5 - 9	10 - 14	15 - 24	25 - 49	50 - Up	
URBAN							
1. Berbek	507	507	521	752	1096	524	3907
2. Loceret	224	240	262	413	561	327	2027
3. Kertosono	2435	2575	2609	4536	5745	3077	20977
4. Patianrowo	333	398	337	431	773	385	2657
5. Baron	462	596	553	941	1223	730	4505
6. Tanjunganom	2198	2281	2221	3702	5246	2722	18370
7. Nganjuk	3652	3962	4242	7744	9354	4962	33916
8. Bagor	147	175	147	323	467	214	1473
Sub Total	9958	10734	10892	18842	24465	12941	87832
Percentage	11	12	12	21	28	15	100
RURAL							
1. Sawahan	3488	4279	3896	5309	9578	4142	30692
2. Ngetos	3446	4103	3407	4715	8959	3702	28332
3. Berbek	5282	5400	5059	6986	12167	6048	40942
4. Loceret	6512	7493	6406	9649	15897	7600	53557
5. Pace	6335	7119	6694	9205	14861	7825	52039
6. Prambon	7251	7971	7792	11369	17256	8500	60139
7. Ngronggot	8234	8986	8185	10751	18112	8468	62736
8. Kertosono	3715	3700	3437	4844	7750	4073	27519
9. Patianrowo	4118	4884	4206	5761	10032	4798	33799
10. Baron	5002	5431	4628	6623	10811	5640	38135
11. Tanjunganom	8990	10043	9220	13603	22029	11164	75049
12. Sukomoro	4236	4810	4161	6071	9481	4514	33273
13. Nganjuk	2912	3102	2950	4160	6661	3404	23189
14. Bagor	5268	6006	5587	8449	13820	7470	46600
15. Wilangan	3181	3520	2991	4087	7546	3033	24358
16. Rejoso	6727	8138	7242	10985	18277	9136	60505
17. Gondang	5594	6014	5178	7821	13367	6711	44685
18. Ngluyu	1606	1778	1557	2505	4587	2215	14248
19. Lengkong	3151	3443	3261	4964	8681	4271	27771
20. Jatikalen	1881	2295	1959	2866	5357	2849	17207
21. Grogol	15130	18038	16664	23736	37197	17440	128214
22. Gemarang	1466	1852	1843	2473	4418	1945	14000
23. Saradan	2074	2378	2187	2905	5076	252	14875
Sub Total	117437	133016	120667	172719	287027	136722	951855
Percentage	12	14	12	18	30	14	100
URBAN and RURAL							
TOTAL	127395	143750	131559	191561	311492	149663	1038208
Percentage	12	14	12	18	30	14	100

Table 1.6 GDP BY INDUSTRIAL ORIGIN AT CURRENT MARKET PRICES

Unit 10^9Rp.

	Sector	1975	1976	1977	1978	1979	1980	1981	1982
1	Agriculture	4003	4812	5906	6706	8996	11290	13643	15668
		(31.7)	(31.1)	(31.0)	(29.5)	(28.1)	(24.8)	(25.3)	(26.3)
1.1	Food Crop	2555	3044	3660	3991	4892	6358	8102	9961
		(20.2)	(19.7)	(19.2)	(17.5)	(15.3)	(14.0)	(15.0)	(16.7)
1.2	Farm Non Food Crop	358	481	762	801	1201	1305	1327	1227
		(2.8)	(3.1)	(4.0)	(3.5)	(3.7)	(2.9)	(2.5)	(2.1)
1.3	Estate	184	213	326	404	590	693	904	1026
		(1.5)	(1.4)	(1.7)	(1.8)	(1.8)	(1.5)	(1.7)	(1.7)
1.4	Husbandry	303	346	305	462	690	991	1258	1418
		(2.4)	(2.2)	(1.6)	(2.0)	(2.2)	(2.2)	(2.3)	(2.4)
1.5	Forestry	413	513	525	653	1048	1142	1140	983
		(3.3)	(3.3)	(2.8)	(2.9)	(3.3)	(2.5)	(2.1)	(1.6)
1.6	Fishery	191	215	328	393	575	803	912	1053
		(1.5)	(1.4)	(1.7)	(1.7)	(1.8)	(1.8)	(1.7)	(1.8)
2	Mining	2485	2930	3600	4358	6980	11673	12971	11708
		(19.7)	(18.9)	(18.9)	(19.2)	(21.8)	(25.7)	(24.0)	(19.6)
3	Industry	1124	1453	1817	2420	3311	5288	5822	7681
		(8.9)	(9.4)	(9.5)	(10.6)	(10.3)	(11.6)	(10.8)	(12.9)
4	Utility	70	98	106	118	149	225	288	380
		(0.6)	(0.6)	(0.6)	(0.5)	(0.5)	(0.5)	(0.5)	(0.6)
5	Construction	590	813	1023	1242	1790	2524	3118	3507
		(4.7)	(5.3)	(5.3)	(5.5)	(5.6)	(5.6)	(5.8)	(5.9)
6	Trade	2104	2552	2959	3450	4725	6391	7966	8865
		(16.6)	(16.5)	(15.5)	(15.2)	(14.8)	(14.1)	(14.7)	(14.9)
7	Transport	521	663	843	1032	1422	1965	2352	2795
		(4.1)	(4.3)	(4.4)	(4.5)	(4.4)	(4.3)	(4.4)	(4.7)
8	Financial	151	207	236	396	655	752	1404	1604
		(1.2)	(1.3)	(1.2)	(1.7)	(2.0)	(1.7)	(2.6)	(2.7)
9	House Rental	258	319	542	671	914	1200	1439	1703
		(2.0)	(2.1)	(2.8)	(2.9)	(2.9)	(2.6)	(2.7)	(2.9)
10	Public Service	864	1074	1394	1685	2200	3142	3905	4429
		(6.8)	(6.9)	(7.3)	(7.4)	(6.9)	(6.9)	(7.2)	(7.4)
11	Private Service	473	547	607	668	835	996	1119	1293
		(3.7)	(3.5)	(3.2)	(2.9)	(2.6)	(2.2)	(2.1)	(2.2)
	GDP	12643	15467	19033	22746	32027	45446	54027	59633
		(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)

Source : Statistik Indonesia 1984

Remarks : Parentheses shows percentage distribution of GDP

Table 1.7 GRDP OF EAST JAVA BY INDUSTRIAL ORIGIN AT CURRENT MARKET PRICES

Unit: 10^6 Rp

	1975	1965	1977	1978	1979	1980	1981	1982
1. AGRICULTURE	756,365	935,194	1,100,715	1,304,191	1,647,932	2,191,376	2,814,322	2,858,167
	(41.8)	(40.4)	(40.4)	(40.7)	(38.4)	(36.8)	(37.5)	(34.0)
1.1 FOOD CROP	575,447	724,006	787,465	935,127	1,293,999	1,718,932	2,224,319	2,177,014
	(31.8)	(31.2)	(28.9)	(29.2)	(30.2)	(28.8)	(29.7)	(25.9)
1.2 SMALL HOLDER ESTATE CROPS	30,022	33,295	47,811	51,118	122,529	172,581	228,137	257,058
	(1.7)	(1.4)	(1.8)	(1.6)	(2.9)	(2.9)	(3.0)	(3.1)
1.3 BIG ESTATE	62,602	84,759	144,480	177,022	53,820	56,271	45,433	47,721
	(3.5)	(3.7)	(5.3)	(5.5)	(1.3)	(0.9)	(0.6)	(0.6)
1.4 HUSBANDRY	67,805	71,828	85,961	102,240	118,042	164,753	221,739	266,812
	(3.7)	(3.1)	(3.2)	(3.2)	(2.8)	(2.8)	(3.0)	(3.2)
1.5 FORESTRY	6,972	6,110	10,621	8,721	13,165	21,415	20,304	21,127
	(0.4)	(0.3)	(0.4)	(0.3)	(0.3)	(0.4)	(0.3)	(0.3)
1.6 FISHER	13,517	15,196	24,375	29,964	46,378	57,423	74,392	88,434
	(0.7)	(0.7)	(0.9)	(0.9)	(1.1)	(1.0)	(1.0)	(1.1)
2. MINING	3,184	3,251	3,390	4,494	11,650	15,677	13,187	17,443
	(0.2)	(0.1)	(0.1)	(0.1)	(0.3)	(0.3)	(0.2)	(0.2)
3. INUDSTRY	301,705	417,528	475,766	589,676	611,836	920,308	1,142,208	1,284,798
	(16.7)	(18.0)	(17.4)	(18.4)	(14.3)	(15.4)	(15.2)	(15.3)
4. UTILITY	8,247	10,507	12,699	15,735	17,929	27,543	37,987	56,265
	(0.5)	(0.5)	(0.5)	(0.5)	(0.4)	(0.5)	(0.5)	(0.7)
5. CONSTRUCTION	8,720	9,838	10,674	11,490	35,688	53,050	63,631	78,771
	(0.5)	(0.4)	(0.4)	(0.4)	(0.8)	(0.9)	(0.8)	(0.9)
6. TRADE	325,256	446,795	527,233	588,079	1,024,202	1,447,445	1,733,448	2,078,196
	(18.0)	(19.3)	(19.3)	(18.3)	(23.9)	(24.3)	(23.1)	(24.7)
7. TRANSPORT	69,639	93,006	129,091	166,019	255,524	358,523	477,293	633,477
	(3.9)	(4.0)	(4.7)	(5.2)	(6.0)	(6.0)	(6.4)	(7.5)
8. FINANCIAL	18,249	28,366	34,863	35,124	56,481	81,739	107,113	141,857
	(1.0)	(1.2)	(1.3)	(1.1)	(1.3)	(1.4)	(1.4)	(1.7)
9. RENTAL HOUSE	110,293	125,870	134,929	136,371	80,026	104,602	132,117	165,028
	(6.1)	(5.4)	(4.9)	(4.3)	(1.9)	(1.8)	(1.8)	(2.0)
10. PUBLIC	186,065	219,570	266,065	304,700	457,688	639,114	821,995	910,095
	(10.3)	(9.5)	(9.8)	(9.5)	(10.7)	(10.7)	(11.0)	(10.8)
11. PRIVATE BUSINESS	20,843	27,732	31,897	51,640	87,376	118,885	153,496	183,926
	(1.2)	(1.2)	(1.2)	(1.6)	(2.0)	(2.0)	(2.0)	(2.2)
GRDP	1,808,566	2,317,657	2,727,321	3,207,520	4,286,334	5,958,263	7,496,797	8,407,993
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)

SOURCE : DALAM ANGKA OF JAWA TIMUR 1980 and 1983

REMARKS : PARENTHESES SHOWS PERCENTAGE DISTRIBUTION OF GRDP BY SECTOR

Table 1.8 GDP BY INDUSTRIAL ORIGIN AT 1975 CONSTANT PRICES

Unit 10^9Rp.

	Sector	1975	1976	1977	1978	1979	1980	1981	1982	Annual Growth Rate (%)
1	Agriculture	4003	4221	4249	4470	4637	4866	5110	5222	3.9
		(31.7)	(31.4)	(29.0)	(28.3)	(27.7)	(26.3)	(25.7)	(25.7)	
1.1	Food Crop	2555	2647	2596	2752	2861	3117	3390	3447	4.4
		(20.2)	(19.7)	(17.7)	(17.4)	(17.1)	(16.9)	(17.1)	(16.9)	
1.2	Farm Non Food Crops	358	370	448	443	460	476	491	524	5.6
		(2.8)	(2.8)	(3.1)	(2.8)	(2.7)	(2.6)	(2.5)	(2.6)	
1.3	Estate	184	188	201	210	231	233	244	285	6.5
		(1.5)	(1.4)	(1.4)	(1.3)	(1.4)	(1.3)	(1.2)	(1.4)	
1.4	Husbandry	303	323	265	277	304	319	330	345	1.9
		(2.4)	(2.4)	(1.8)	(1.8)	(1.8)	(1.7)	(1.7)	(1.7)	
1.5	Forestry	413	466	477	531	506	462	369	294	-
		(3.3)	(3.5)	(3.3)	(3.4)	(3.0)	(2.5)	(1.9)	(1.4)	
1.6	Fishery	191	199	210	220	230	240	256	269	5.0
		(1.5)	(1.5)	(1.4)	(1.4)	(1.4)	(1.3)	(1.3)	(1.3)	
2	Mining	2485	2872	3214	3158	3144	3104	3210	2821	1.8
		(19.7)	(21.4)	(21.9)	(20.0)	(18.8)	(16.8)	(16.2)	(13.7)	
3	Industry	1124	1231	1398	1635	1839	2483	2477	2510	12.2
		(8.9)	(9.2)	(9.5)	(10.4)	(11.0)	(13.4)	(12.5)	(12.3)	
4	Utility	70	78	83	97	118	133	153	180	14.4
		(0.6)	(0.6)	(0.6)	(0.6)	(0.7)	(0.7)	(0.8)	(0.9)	
5	Construction	590	621	747	857	904	1030	1159	1222	10.9
		(4.7)	(4.6)	(5.1)	(5.4)	(5.4)	(5.6)	(5.8)	(6.0)	
6	Trade	2104	2200	2330	2482	2731	3000	3319	3504	7.6
		(16.6)	(16.3)	(15.9)	(15.7)	(16.3)	(16.2)	(16.7)	(17.2)	
7	Transport	521	587	753	882	961	1045	1159	1231	13.1
		(4.1)	(4.4)	(5.1)	(5.6)	(5.7)	(5.7)	(5.8)	(6.0)	
8	Financial	151	174	225	244	267	308	342	382	14.2
		(1.2)	(1.3)	(1.5)	(1.5)	(1.6)	(1.7)	(1.7)	(1.9)	
9	Rental House	258	273	328	377	399	436	467	490	9.6
		(2.0)	(2.0)	(2.2)	(2.4)	(2.4)	(2.4)	(2.4)	(2.4)	
10	Public Service	864	910	1056	1178	1236	1489	1648	1710	10.2
		(6.8)	(6.8)	(7.2)	(7.5)	(7.4)	(8.1)	(8.3)	(8.4)	
11	Private Service	473	484	478	506	519	530	543	555	2.3
		(3.7)	(2.0)	(3.3)	(2.6)	(3.1)	(2.9)	(2.7)	(2.7)	
	GDP	12,643	13,450	14,641	15,796	16,768	18,474	19,863	20,353	7.0
		(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	

Source : Statistik Indonesia 1984

Remarks : Parentheses shows percentage distribution of GDP

Table 1.9 GRDP OF EAST JAVA BY INDUSTRIAL ORIGIN AT 1975 CONSTANT PRICES

Unit 10^6 Rp.

	Sector	1975	1976	1977	1978	1979	1980	1981	1982	Annual Growth Rate (%)
1	Agriculture	756,365	753,357	758,058	778,593	1,022,868	1,100,871	1,124,817	1,062,096	5.0
		(41.8)	(39.7)	(37.5)	(35.9)	(40.2)	(38.3)	(35.3)	(32.7)	
1.1	Food Crop	575,447	581,809	576,629	575,631	839,039	908,925	911,214	822,681	5.2
		(31.8)	(30.7)	(28.6)	(26.5)	(32.9)	(31.7)	(28.6)	(25.3)	
1.2	Small Holder	30,022	27,431	26,465	31,921	71,244	81,621	94,867	112,543	20.8
	Estate Crops	(1.7)	(1.4)	(1.3)	(1.5)	(2.8)	(2.8)	(3.0)	(3.5)	
1.3	Big Estate	62,602	63,895	65,462	73,369	27,194	19,714	18,891	18,540	-16.0
		(3.5)	(3.4)	(3.2)	(3.4)	(1.1)	(0.7)	(0.6)	(0.6)	
1.4	Husbandry	67,805	59,317	64,033	71,716	59,384	63,596	71,182	77,383	1.9
		(3.7)	(3.1)	(3.2)	(3.3)	(2.3)	(2.2)	(2.2)	(2.4)	
1.5	Forestry	6,672	6,657	6,909	6,950	6,549	6,749	6,506	7,007	0.7
		(0.4)	(0.4)	(0.3)	(0.3)	(0.3)	(0.2)	(0.2)	(0.2)	
1.6	Fishery	13,517	14,427	18,561	19,007	19,458	20,266	22,157	23,942	8.5
		(0.7)	(0.8)	(0.9)	(0.9)	(0.8)	(0.7)	(.07)	(0.7)	
2	Mining	3,184	3,015	2,950	3,501	6,774	7,033	6,703	7,939	13.9
		(0.2)	(0.2)	(0.1)	(0.2)	(0.3)	(0.2)	(0.2)	(0.2)	
3	Industry	301,705	330,082	362,654	405,164	318,539	397,039	487,698	500,337	7.5
		(16.7)	(17.4)	(18)	(18.7)	(12.5)	(13.8)	(15.3)	(15.4)	
4	Utility	8,247	8,527	8,987	12,168	15,505	18,301	22,724	27,236	18.6
		(0.5)	(0.4)	(0.4)	(0.6)	(0.6)	(0.6)	(0.7)	(0.8)	
5	Construction	8,918	9,504	9,404	9,767	22,874	27,977	32,799	37,142	22.6
		(0.5)	(0.5)	(0.5)	(0.5)	(0.9)	(1.0)	(1.0)	(1.1)	
6	Trade	325,256	360,004	398,291	421,828	566,407	665,362	765,034	820,408	14.1
		(18)	(19)	(19.7)	(19.4)	(22.2)	(23.2)	(24.0)	(25.3)	
7	Transport	69,639	82,034	99,661	124,170	159,267	169.118	216,338	238,771	19.2
		(3.9)	(4.3)	(4.9)	(5.7)	(6.3)	(5.9)	(6.8)	(0.9)	
8	Financial	18,249	21,289	22,244	25,426	33,796	35,716	39,932	49,854	15.4
		(1.0)	(1.1)	(1.1)	(1.2)	(1.3)	(1.2)	(1.3)	(1.5)	
9	Rental House	110,293	115,860	118,880	121,835	59,995	64,912	70,252	76,039	-5.2
		(6.1)	(6.1)	(5.9)	(5.6)	(2.4)	(2.3)	(2.2)	(2.3	
10	Public Service	186,065	188,569	212,190	228,001	287,240	326,395	356,042	358,616	9.8
		(10.3)	(9.9)	(10.5)	(10.5)	(11.3)	(11.4)	(11.2)	(11.0)	
11	Private Business	20,843	23,052	25,493	39,258	54,308	58,812	63,975	68,002	18.4
		(1.2)	(1.2)	(1.3)	(1.8)	(2.0)	(2.0)	(2.0)	(2.1)	
	GRDP	1,808,566	1,895,824	2,019,173	2,169,711	2,547,573	2,871,536	3,186,314	3,246,440	8.7
		(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	

Source : Dalam Angka of Jawa Timur 1980 and 1983

Remarks : Parentheses shows percentage distribution of GRDP

Table 1.10 PRODUCTION OF FOOD CROPS BY KECAMATAN IN 1983

Unit : ton

	Paddy	Maize	Cassava	Peanut	Soybean	Total
Lengkong	8,796 (83.5)	1,200	454	24	54	10,528(100)
Gondang	21,064 (76.4)	4,487	539	-	1,448	27,538(100)
Rejoso	22,774 (67.5)	2,512	5,224	-	3,233	33,743(100)
Ngluyu	6,146 (74.5)	1,949	131	2	23	8,251(100)
Jatikalen	5,405 (75.7)	953	745	32	1	7,136(100)
Pace	14,510 (42.9)	11,082	6,209	54	1,986	33,841(100)
Ngetos	9,777 (35.5)	4,757	12,594	369	13	27,510(100)
Sawahan	7,535 (36.2)	2,335	10,794	126	-	20,790(100)
Berbek	16,680 (75.5)	1,831	3,228	39	301	22,079(100)
Loceret	19,140 (47.3)	12,548	7,215	503	1,028	40,434(100)
Sukomoro	18,777 (82.5)	2,526	-	11	1,447	22,761(100)
Wilangan	11,154 (77.0)	723	2,150	-	465	14,492(100)
Nganjuk	8,839 (71.1)	1,095	1,525	6	964	12,429(100)
Baron	13,069 (71.5)	2,595	2,028	48	546	18,286(100)
Tanjunganom	42,758 (77.5)	7,140	2,085	41	3,150	55,174(100)
Patianrowo	14,397 (94.0)	572	242	17	94	15,332(100)
Kertosono	8,501 (83.9)	1,098	184	30	320	10,133(100)
Ngronggot	15,339 (70.4)	3,395	1,759	212	1,077	21,782(100)
Prambon	21,565 (89.4)	1,231	66	20	1,236	24,118(100)
Bagor	22,206 (75.6)	828	4,369	-	1,981	29,384(100)
Grogol	11,029 (13.3)	3,389	67,974	159	283	82,834(100)
Gemarang	822 (33.0)	752	894	20	-	2,488(100)
Saradan	1,012 (57.2)	179	237	7	333	1,768(100)

Source : Dalam Angka of Kab. Nganjuk, Kediri and Madiun

Remarks : Parentheses show percentage share of paddy out of total food crop production.

Table 1.11 PRODUCTION OF CROPS PER HOUSEHOLD BY KECAMATAN

Unit : ton/house

Kecamatan	Paddy	Maize	Cassava	Peanut	Soybean
Lengkong	2.27	0.31	0.12	0.01	0.01
Gondang	3.20	0.68	0.08	-	0.22
Rejoso	2.49	0.27	0.57	-	0.35
Ngluyu	2.61	0.83	0.06	-	0.01
Jatikalen	1.99	0.35	0.27	0.01	-
Pace	2.29	1.75	0.98	0.01	0.31
Ngetos	1.94	0.94	2.50	0.07	-
Sawahan	1.22	0.38	1.74	0.02	-
Berbek	3.47	0.38	0.67	0.01	0.06
Loceret	2.78	1.82	1.05	0.07	0.15
Sukomoro	3.75	0.51	-	-	0.29
Wilangan	3.93	0.25	0.76	-	0.16
Nganjuk	3.06	0.38	0.53	-	0.33
Baron	2.64	0.52	0.41	0.01	0.11
Tanjunganom	3.84	0.64	0.19	-	0.28
Patianrowo	3.19	0.13	0.05	-	0.02
Kertosono	3.31	0.43	0.07	0.01	0.12
Ngronggot	2.36	0.52	0.27	0.03	0.17
Prambon	4.47	0.26	0.01	-	0.26
Bagor	3.75	0.14	0.74	-	0.33
Grogol	0.80	0.25	4.96	0.01	0.02

Table 1.12 BASIC INDICATORS RELATED TO FOOD CROPS IN 1983

	Paddy	Maize	Cassava	Peanut	Soybean
Average unit yield of crops in Kab. Nganjuk (ton/ha)	5.61	3.07	9.15	0.95	0.85
Production cost per ha (Rp/ha)	265,390	121,580	64,370	148,120	97,050
Production cost per ton of each crop (Rp/ton)	47,300	39,600	7,040	155,920	114,180
Financial price of each crop per ton (Rp./ton)	144,330	116,410	70,670	444,000	371,200
Net income per ton of each crop (Rp/ ton	97,020	76,800	63,640	288,080	257,020

Source : Annual Report 1983 issued by Agricultural Office
Dalam Angka of Kab. Nganjuk.

Table 1.13 REALIZATION OF IRRIGATION PROJECT IN NGANJUK, 1983/1984 and 1984/1985

No.	TYPE OF PROJECT	1983/1984		1984/1985	
		Quantity	Expense (Rp)	Quantity	Expense (Rp)
I.	APBD I AND APBD II PROJECTS				
1.	Dam Repair	1	13,000,000.-	2	29,400,000.-
2.	Water pump rehabilitation	3	6,107,500.-	-	-
3.	Water pump erection	1	8,000,000.-	-	-
4.	The erection of concrete plate as river and retaining wall	-	-	1	17,000,000.-
5.	Strata rehabilitation	-	-	1	2,425,000.-
	TOTAL	5	27,107,500.-	4	48,825,000.-
II.	PROJECT FINANCED BY GRANTS				
1.	Drainpipe erection	608 M	46,709,000.-	757,2 M	76,017,070.-
2.	The perfection of drainage ditch and its supplementary building	-	-	1 unit	19,629,745.-
3.	Sluice Erection	1	12,555,000.-	-	-
	TOTAL	608 M	59,264,000.-	757.2 M	98,646,815.-
		1		1 unit	
III.	PROJECTS CONDUCTED AND FINANCED BY DEPARTEMENT OF PUBLIC WORK, ON NGANJUK AND KEDIRI				
a .	Rehabilitation, Exploitation and maintenance				
1.	Repair of secondary drainage ditch	1700 M	8,479,000.-	-	-
2.	Repair of main drainage ditch	500 M		3000 M	
3.	Dam repair	2		8	
4.	Repair of sectional office	3		-	
5.	Repair of check dam	1		-	
6.	Bridge repair	3	64,426,000.-	-	
7.	Sluice repair	2		-	
8.	Scot Balk repair	2		-	
9.	Embankment repair	1		-	
10.	Transitional building repair	1		-	
11.	Slant repair	-		532.50 M	
12.	Distributor building repair	-		10	

No.	TYPE OF PROJECT	1983 / 1984		1984 / 1985	
		Quantity	Expense (Rp)	Quantity	Expense (Rp)
C.	WARU TURI PROJECT				
1.	Rehabilitation of secondary drainage ditch	7630 M	342,605,000.-	15,593 M	1,063,252,546.-
2.	Rehabilitation of tertiary network	2172 Ha	362,359,000.-	3,915 Ha	720,886,000.-
3.	Rehabilitation of drainage ditchs and its buildings	-	-	6,551 M	442,411,000.-
4.	The erection of new houses for the caretaker	-	-	4	16,540,000.-
	Sub - Total	7630 M 2172 Ha	704,964,000.-	22,144 M 3,915 Ha 4	2,243,089,546.-
D.	EAST JAVA IRRIGATION PROJECT				
1.	Improvement the irrigation network and its building	-	-	745 Ha	869,829,000.-
	Sub - Total	-	-	745 Ha	869,829,000.-
E.	P2AT PROJECT				
1.	Improving Drainage Ditch	2 unit	21,250,000.-	-	-
2.	Pump House Erection	6 unit	39,600,000.-	-	-
3.	Irrigation Network Erection	6 unit	38,400,000.-	6 unit	235,600,000.-
4.	Tracer	-	-	2 unit	29,518,800
5.	Drilling	-	-	2 unit	29,518,800
	Sub - Total	14 unit	99,250,000.-	13 unit	271,086,400.-
	TOTAL OF CENTRAL GOVERNMENT'S PROJECT	14 Unit 20,128 M 13,071 M^2 2,172 Ha 34	1,496,287,400.-	28,669 M 14 unit 4660 Ha 4	3,883,788,946.-
	GRAND TOTAL	55 23,012 M 13,071 M2 2,172 Ha 14 unit	1,655,563,900.-	33 32,958 M 4660 Ha 15 unit	4,157,133,761

No.	TYPE OF PROJECT	1983 / 1984 Quanitity	1983 / 1984 Expense (Rp)	1984 / 1985 Quantity	1984 / 1985 Expense (Rp)
14.	Caretaker's house repair	-	-	1	
15.	Sectional office house repair	-	-	1	
	Sub - Total	2275 M 15	72,905,000.-	3532,5 M	121,265,000.-
b.	Self - managed				
1.	Verdeil Werrk repair	-	-	1	1,150,000.-
2.	Sectional warehouse repair	-	-	1	2,479,000.-
3.	Filling of dry mason as gabion mattress	-	-	1	979,000.-
	Total a + b	2,275 M	72,905,000.-	3532.5 M	125,873,000.-
IV.	PROJECT FINANCED BY CENTRAL GOVERNMENT				
A.	MIDDLE REACH PROJECT				
1.	Wet masonry on Brantas River	930 M	284,622,400.-	485 M	130,802,000.-
2.	Gravelled road for inspection	-	-	1175 M	31,700,000.-
	Sub- Total	930 M	284,622,400.-	1660 M	162,502,000.-
B.	WIDAS PROJECT				
1.	Repair of Widas River Dyke	-	-	250 M	28,011,000.-
2.	Wet Masonry (Main Irrigation Canal)	3738 M	206,969,000.-	3970 M	236,479,000.-
3.	The erection of lining and drop-structure side drain	-	-	645 M	56,792,000.-
4.	Pump erection	-	-	1 unit	16,000,000.-
5.	Inspection road	13071 M^2	60.080.000	-	-
6.	The erection of secondary drainage ditch and supplementary buildings	7830 M 34	140,394,000.-	-	-
	Sub - Total	11,568M, 13,071 M^2 34	407,451,000.-	4865 M 1 unit	337,282,000.-

ANNEX - 2

HYDROLOGY

ANNEX - 2

HYDROLOGY

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LIST OF FIGURES

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2.1 Introduction

Hydrological study is consisted of the following analysis.

- Lowflow analysis at Kedungwarak / Ketandan dam site
- Flood flow analysis under the present river condition and the fall confinement on the entire K. Widas basin.
- Design flood discharge formulation for Kedungwarak and Ketandan dam
- Sediment analysis on the K. Widas

In this ANNEX, detailes of methods/procedures are presented on the above analysis.

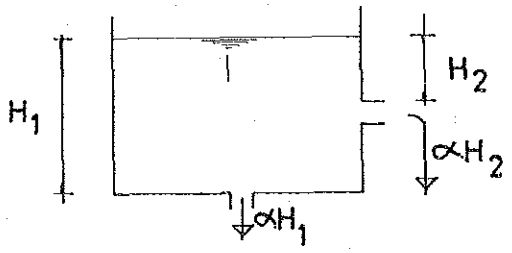
2.2 Low Flow Analysis

Runoff of the Kedungwarak river and the Ketandan river is estimated by Tank Model Method.

2.2.1 Tank Model Method

1. Basic concept of Tank Model

The basic idea of Tank Model is very simple. A tank has two holes, one at the bottom and the other at the side.



When the tank is filled with water, the water will be released from these holes. In the runoff analysis, water released from the side hole corresponds to runoff to a stream and water from the bottom hole goes into the ground water zone.

The depth of water released from a hole is given by the following relation.

$$I = \alpha . H \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where ; I : depth of water released (mm/day)
α : coefficient of hole
H : water depth above the hole (mm)

For the purpose of natural runoff simulation, four tanks combined in series are usually used as shown in Fig. 2.2.1. The top tank corresponds to the surface runoff, the second tank to the sub-surface runoff and the third and fourth to the base flow from the groundwater, respectively.

In the simulation process, daily rainfall depth is put into the top tank and the depth of water released from a hole is calculated by the equation (1). The water from the bottom hole is put into the second tank and the same process is repeated to the fourth tank. The depth of the stream runoff is given as the sum of the water released from the side holes. Loss due to evapotranspiration is expressed by sub - tracting the depth of daily evapotranspiration from the storage of top tank.

2. Soil moisture content

The top tank has a special structure simulating soil moisture content in surface soil layer as shown in Fig. 2.2.1. This structure is effective for the area having distinct wet and dry seasons where surface soils are usually dried up in the dry seasons.

In this model soil moisture structure is divided into two parts, the primary and the secondary soil moisture. This soil moisture zones are set in the bottom of the top tank.

Moisture in these two zones is transferable depending on their relative moisture ration as expressed below.

$$T2 = TC\ (XP/PS - XS/SS) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where ; T2 : Transfer of moisture between primary and secondary layers (plus sign indicates transfer from primary to secondary and minus sign vice versa)
PS : Primary soil moisture capacity
SS : Secondary soil moisture capacity
XP : Primary soil moisture depth
XS : Secondary soil moisture depth
TC : Constant

When primary soil moisture is not saturated and there is free water in lower tanks, water goes up by capillary action so as to fill the primary soil layer with the transfer speed T1 as given below.

$$T1 = TB\ (1 - XP/PS) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where ; T1 : Transfer of capillary action from lower tanks
TB : Constant

3. Zoning

For the purpose of simulating the area distribution of soil moisture content, the drainage area is divided into four sub-areas as shown in Fig. 2.2.1. In the beginning of the dry season the farthest sub-area (S1) from the river is firstly dried up and the dried up area is expanded to S2, S3 and S4 from mountain to the river sides with the dry seasons goes by.

The vertical structure of each zone is assumed to be expressed by the series of four tanks with the same parameters.

Consequently 4 x 4 tanks are required for a river basin to be simulated as shown in Fig. 2.2.1 in which the direction of water released from each hole is illustrated.

2.2.2 Data

Rainfall data summarized on 10-day basis are presented in Table 2.2.1. Intake discharge records of Senggowar area are presented in Table 2.2.2.

2.2.3 Estimated results of runoff

The estimated results of runoff are tabulated in Table 2.2.3 for Kedungwarak river and in Table 2.2.4 for the Ketandan river.

PR#0

TABLE 2.2.1 * ESTIMATED TEN-DAY RAIN * (1/4)

TEMPURAN

Month		1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Jan.	1st	86.00	108.00	69.00	166.00	79.00	90.00	85.00	158.00	134.00	83.00
	2nd	86.00	80.00	79.00	213.00	87.00	17.00	39.00	41.00	103.00	43.00
	3rd	89.00	151.00	79.00	73.00	148.00	60.00	223.00	64.00	75.00	43.00
Feb.	1st	10.00	94.00	138.00	43.00	99.00	117.00	38.00	153.00	63.00	69.00
	2nd	115.00	73.00	13.00	98.00	25.00	28.00	36.00	106.00	111.00	48.00
	3rd	39.00	89.00	285.00	148.00	27.00	84.00	261.00	61.00	33.00	107.00
Mar.	1st	123.00	14.00	54.00	25.00	122.00	107.00	148.00	57.00	73.00	55.00
	2nd	22.00	316.00	74.00	142.00	80.00	134.00	153.00	74.00	71.00	37.00
	3rd	0.00	77.00	144.00	38.00	41.00	6.00	79.00	174.00	41.00	104.00
Apr.	1st	6.00	148.00	320.00	28.00	110.00	21.00	115.00	120.00	54.00	130.00
	2nd	0.00	0.00	69.00	110.00	106.00	16.00	0.00	414.00	96.00	77.00
	3rd	40.00	0.00	179.00	30.00	38.00	42.00	4.00	112.00	48.00	23.00
May	1st	0.00	0.00	117.00	17.00	26.00	18.00	53.00	29.00	29.00	10.00
	2nd	11.00	48.00	48.00	62.00	10.00	18.00	2.00	46.00	66.00	59.00
	3rd	0.00	3.00	3.00	14.00	0.00	63.00	0.00	29.00	25.00	31.00
June	1st	113.00	0.00	0.00	0.00	26.00	61.00	0.00	0.00	45.00	13.00
	2nd	0.00	0.00	0.00	8.00	30.00	9.00	0.00	0.00	0.00	0.00
	3rd	23.00	0.00	0.00	0.00	0.00	51.00	0.00	4.00	0.00	28.00
July	1st	7.00	52.00	52.00	45.00	48.00	0.00	11.00	13.00	7.00	5.00
	2nd	0.00	0.00	0.00	15.00	56.00	38.00	13.00	10.00	0.00	0.00
	3rd	4.00	0.00	0.00	0.00	134.00	17.00	23.00	7.00	0.00	0.00
Aug.	1st	0.00	0.00	0.00	27.00	43.00	0.00	49.00	15.00	0.00	0.00
	2nd	0.00	0.00	0.00	8.00	20.00	15.00	0.00	6.00	0.00	0.00
	3rd	0.00	21.00	0.00	0.00	0.00	33.00	0.00	11.00	0.00	0.00
Sep.	1st	0.00	0.00	0.00	5.00	0.00	9.00	5.00	0.00	4.00	2.00
	2nd	0.00	0.00	0.00	0.00	0.00	4.00	0.00	6.00	0.00	0.00
	3rd	0.00	3.00	0.00	0.00	28.00	0.00	0.00	11.00	0.00	0.00
Oct.	1st	0.00	40.00	0.00	0.00	0.00	0.00	0.00	12.00	0.00	0.00
	2nd	0.00	0.00	0.00	14.00	8.00	35.00	0.00	10.00	0.00	21.00
	3rd	0.00	28.00	0.00	57.00	50.00	0.00	8.00	0.00	0.00	0.00
Nov.	1st	0.00	148.00	4.00	65.00	168.00	53.00	21.00	87.00	0.00	60.00
	2nd	0.00	89.00	64.00	181.00	16.00	0.00	66.00	56.00	8.00	56.00
	3rd	13.00	74.00	39.00	160.00	32.00	37.00	55.00	20.00	39.00	109.00
Dec.	1st	110.00	122.00	87.00	242.00	34.00	86.00	77.00	112.00	100.00	34.00
	2nd	219.00	208.00	46.00	130.00	55.00	131.00	122.00	101.00	145.00	48.00
	3rd	178.00	111.00	228.00	12.00	101.00	68.00	56.00	53.00	29.00	91.00
Totl	1st	1294.00	2097.00	2191.00	2176.00	1847.00	1468.00	1742.00	2172.00	1399.00	1386.00

TABLE 2.2.1 * ESTIMATED TEN-DAY RAIN * (2/4)

TEMPURAN

Month		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Jan.	1st	105.00	74.00	110.00	83.00	72.00	89.00	150.00	69.00	54.00	60.00
	2nd	75.00	208.00	55.00	68.00	3.00	76.00	88.00	41.00	112.00	77.00
	3rd	72.00	130.00	66.00	94.00	122.00	128.00	111.00	47.00	88.00	210.00
Feb.	1st	116.00	41.00	82.00	155.00	138.00	14.00	124.00	224.00	35.00	155.00
	2nd	120.00	98.00	95.00	51.00	130.00	171.00	74.00	69.00	164.00	52.00
	3rd	27.00	63.00	109.00	67.00	48.00	131.00	132.00	59.00	167.00	62.00
Mar.	1st	53.00	179.00	140.00	139.00	56.00	147.00	30.00	138.00	87.00	115.00
	2nd	142.00	3.00	99.00	42.00	94.00	141.00	23.00	57.00	139.00	194.00
	3rd	12.00	47.00	94.00	145.00	34.00	51.00	325.00	270.00	97.00	0.00
Apr.	1st	23.00	34.00	130.00	35.00	94.00	75.00	83.00	183.00	43.00	81.00
	2nd	32.00	152.00	63.00	46.00	0.00	49.00	51.00	76.00	13.00	0.00
	3rd	141.00	162.00	90.00	6.00	0.00	105.00	52.00	57.00	12.00	65.00
May	1st	92.00	6.00	25.00	151.00	1.00	75.00	0.00	130.00	75.00	17.00
	2nd	91.00	0.00	0.00	6.00	6.00	6.00	12.00	52.00	0.00	21.00
	3rd	0.00	0.00	38.00	12.00	17.00	82.00	0.00	110.00	45.00	23.00
June	1st	23.00	42.00	16.00	69.00	0.00	30.00	0.00	37.00	8.00	35.00
	2nd	0.00	35.00	0.00	29.00	42.00	5.00	0.00	68.00	0.00	18.00
	3rd	1.00	7.00	0.00	0.00	30.00	0.00	0.00	101.00	3.00	4.00
July	1st	0.00	0.00	0.00	0.00	0.00	10.00	0.00	11.00	0.00	0.00
	2nd	0.00	2.00	0.00	3.00	0.00	0.00	0.00	105.00	6.00	5.00
	3rd	0.00	0.00	0.00	5.00	0.00	0.00	0.00	63.00	2.00	3.00
Aug.	1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2nd	0.00	5.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
	3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep.	1st	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	13.00
	2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.00
	3rd	0.00	0.00	0.00	16.00	0.00	0.00	4.00	0.00	0.00	0.00
Oct.	1st	0.00	0.00	0.00	114.00	0.00	41.00	0.00	53.00	0.00	0.00
	2nd	0.00	0.00	0.00	129.00	0.00	42.00	0.00	15.00	0.00	32.00
	3rd	0.00	20.00	0.00	1.00	0.00	14.00	0.00	0.00	21.00	35.00
Nov.	1st	64.00	125.00	3.00	125.00	14.00	0.00	0.00	84.00	0.00	0.00
	2nd	97.00	64.00	0.00	30.00	0.00	69.00	2.00	19.00	0.00	50.00
	3rd	16.00	96.00	55.00	37.00	35.00	21.00	35.00	120.00	0.00	39.00
Dec.	1st	59.00	35.00	37.00	5.00	63.00	201.00	240.00	115.00	12.00	8.00
	2nd	38.00	139.00	161.00	0.00	207.00	146.00	20.00	70.00	0.00	60.00
	3rd	34.00	134.00	135.00	185.00	111.00	47.00	202.00	15.00	49.00	113.00
Totl	1st	1433.00	1901.00	1603.00	1854.00	1317.00	1966.00	1758.00	2458.00	1232.00	1573.00

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TABLE 2.2.1 * ESTIMATED TEN-DAY RAIN * (3/4)

TEMPURAN

Month	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Jan. 1st	99.00	85.00	106.00	35.00	124.00	157.00	75.00	246.00	119.00	0.00
2nd	118.00	60.00	54.00	62.00	115.00	5.00	61.00	74.00	107.00	0.00
3rd	49.00	67.00	64.00	94.00	106.00	83.00	75.00	54.00	110.00	0.00
Feb. 1st	63.00	3.00	55.00	80.00	250.00	69.00	306.00	137.00	146.00	0.00
2nd	128.00	48.00	166.00	27.00	30.00	40.00	69.00	137.00	146.00	0.00
3rd	193.00	11.00	91.00	83.00	81.00	65.00	46.00	124.00	94.00	0.00
Mar. 1st	40.00	24.00	53.00	138.00	217.00	129.00	41.00	119.00	56.00	0.00
2nd	43.00	70.00	37.00	60.00	51.00	59.00	84.00	71.00	61.00	0.00
3rd	220.00	83.00	111.00	36.00	55.00	109.00	212.00	95.00	63.00	0.00
Apr. 1st	32.00	0.00	41.00	99.00	66.00	0.00	65.00	55.00	0.00	0.00
2nd	113.00	69.00	89.00	252.00	152.00	74.00	53.00	30.00	189.00	0.00
3rd	35.00	0.00	138.00	0.00	96.00	0.00	24.00	28.00	43.00	0.00
May 1st	98.00	48.00	110.00	6.00	39.00	9.00	4.00	31.00	103.00	0.00
2nd	20.00	0.00	37.00	34.00	18.00	0.00	0.00	74.00	25.00	0.00
3rd	90.00	0.00	92.00	0.00	22.00	0.00	55.00	75.00	87.00	0.00
June 1st	138.00	10.00	7.00	0.00	0.00	0.00	91.00	22.00	111.00	0.00
2nd	0.00	0.00	2.00	0.00	0.00	0.00	3.00	83.00	0.00	0.00
3rd	4.00	0.00	2.00	22.00	0.00	0.00	17.00	91.00	0.00	18.00
July 1st	5.00	0.00	0.00	0.00	0.00	0.00	0.00	135.00	0.00	0.00
2nd	0.00	0.00	42.00	62.00	5.00	0.00	0.00	35.00	0.00	0.00
3rd	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug. 1st	0.00	0.00	4.00	87.00	0.00	0.00	0.00	20.00	0.00	19.00
2nd	0.00	0.00	0.00	4.00	0.00	0.00	0.00	22.00	0.00	0.00
3rd	0.00	0.00	0.00	7.00	0.00	0.00	0.00	7.00	0.00	0.00
Sep. 1st	0.00	0.00	0.00	27.00	14.00	0.00	0.00	10.00	0.00	0.00
2nd	0.00	0.00	27.00	14.00	53.00	0.00	0.00	2.00	0.00	0.00
3rd	0.00	0.00	52.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oct. 1st	19.00	0.00	0.00	32.00	172.00	0.00	0.00	4.00	0.00	0.00
2nd	12.00	0.00	0.00	67.00	14.00	34.00	0.00	0.00	0.00	0.00
3rd	116.00	0.00	7.00	60.00	27.00	105.00	0.00	2.00	82.00	0.00
Nov. 1st	27.00	0.00	63.00	19.00	85.00	73.00	0.00	17.00	23.00	24.00
2nd	145.00	15.00	81.00	101.00	21.00	53.00	0.00	28.00	36.00	31.00
3rd	125.00	92.00	25.00	77.00	22.00	34.00	69.00	9.00	51.00	149.00
Dec. 1st	120.00	128.00	110.00	560.00	135.00	45.00	109.00	58.00	56.00	364.00
2nd	99.00	52.00	123.00	150.00	60.00	88.00	74.00	214.00	106.00	9.00
3rd	0.00	80.00	60.00	41.00	39.00	79.00	120.00	235.00	195.00	140.00
Toti 1st	2151.00	945.00	1849.00	2339.00	2069.00	1310.00	1653.00	2324.00	2009.00	754.00

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TABLE 2.2.1 * ESTIMATED TEN-DAY RAIN * (4/4)

TEMPURAN

Month		1981	1982	1983	mean
Jan.	1st	106.00	154.00	219.00	104.51
	2nd	40.00	39.00	131.00	74.45
	3rd	73.00	74.00	27.00	89.36
Feb.	1st	77.00	235.00	189.00	106.60
	2nd	86.00	67.00	42.00	80.69
	3rd	108.00	31.00	87.00	91.30
Mar.	1st	194.00	172.00	144.00	96.63
	2nd	19.00	149.00	153.00	87.69
	3rd	45.00	26.00	119.00	89.48
Apr.	1st	47.00	16.00	158.00	73.09
	2nd	47.00	20.00	60.00	76.30
	3rd	39.00	143.00	79.00	55.48
May	1st	83.00	10.00	70.00	44.90
	2nd	41.00	0.00	63.00	26.54
	3rd	0.00	0.00	82.00	30.24
June	1st	0.00	0.00	4.00	27.30
	2nd	0.00	0.00	0.00	9.45
	3rd	0.00	0.00	0.00	12.30
July	1st	23.00	0.00	0.00	12.84
	2nd	21.00	5.00	0.00	12.81
	3rd	0.00	0.00	0.00	7.90
Aug.	1st	0.00	0.00	0.00	8.00
	2nd	0.00	0.00	0.00	2.48
	3rd	23.00	0.00	0.00	3.09
Sep.	1st	0.00	0.00	0.00	2.81
	2nd	0.00	0.00	0.00	4.00
	3rd	76.00	0.00	0.00	5.75
Oct.	1st	0.00	0.00	0.00	14.75
	2nd	0.00	0.00	12.00	13.48
	3rd	28.00	0.00	35.00	21.09
Nov.	1st	49.00	4.00	84.00	45.12
	2nd	139.00	22.00	170.00	51.78
	3rd	95.00	0.00	97.00	56.87
Dec.	1st	129.00	122.00	58.00	114.33
	2nd	78.00	114.00	16.00	97.84
	3rd	161.00	177.00	129.00	103.27
Totl	1st	1827.00	1580.00	2228.00	1754.69

Table 2.2.2 INTAKE DISCHARGE RECORDS OF IRRIGATION
UNIT SENGGOWAR EXCEPT NGLUYU AREA UNIT:L/SEC

MONTH		1976	1977	1978	1979	1980	1981	1982	1983	1984	AVERAGE
JAN	1	1103	424	806	551	581	1037	1039	745	377	740
	2	1018	276	684	669	1128	1017	957	502	520	752
	3	807	354	1041	839	1186	907	984	325	1014	829
FEB	1	750	436	1085	653	1290	734	1158	619	843	841
	2	494	464	1326	684	980	762	1224	654	892	831
	3	708	578	1281	714	1149	840	1268	594	917	894
MAR	1	1070	578	943	732	1181	853	804	699	772	848
	2	1137	651	943	732	821	719	811	664	483	773
	3	1071	780	775	665	560	702	763	543	385	694
APR	1	1191	780	345	583	508	651	939	536	128	629
	2	685	694	345	583	539	624	803	722	140	571
	3	534	508	249	557	475	834	670	662	107	511
MAY	1	512	306	265	694	372	811	595	481	249	476
	2	220	268	363	485	293	710	433	479	290	393
	3	167	282	357	339	307	540	261	480	267	333
JUN	1	124	327	363	368	224	330	209	470	193	290
	2	90	318	424	368	104	163	159	300	199	236
	3	72	342	388	221	48	212	74	216	146	191
JUL	1	54	157	375	147	42	292	34	211	120	159
	2	54	90	337	143	30	241	34	194	144	141
	3	48	52	251	105	30	212	34	192	91	113
AUG	1	46	48	374	-	100	112	34	51	111	110
	2	36	42	301	-	42	46	26	32	108	79
	3	36	42	206	-	50	30	18	26	102	64
SEP	1	31	21	244	36	42	15	18	39	161	67
	2	31	13	244	24	29	15	9	36	136	60
	3	31	21	87	24	17	29	0	37	54	33
OCT	1	16	21	106	24	14	47	0	23	45	33
	2	15	17	42	20	11	33	0	34	48	24
	3	40	9	34	21	6	21	0	73	54	29
NOV	1	180	9	34	50	-	36	0	110	39	57
	2	43	9	76	-	-	58	0	124	32	49
	3	140	166	64	119	-	186	0	251	106	129
DEC	1	155	178	219	345	484	265	193	205	220	252
	2	134	199	249	196	718	695	477	133	268	341
	3	224	603	535	473	914	521	449	360	126	467
TOTAL		13067	10063	15761	12164	14275	15300	14477	11822	9887	12980
AVERAGE		363	280	438	380	433	425	402	328	275	369

Table 2.2.3 **********
* ESTIMATED TEN-DAY RUNOFF * (1/4)
****

RUNOFF OF K.MARAK RIVER

Month		1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Jan.	1st	0.44	1.63	0.88	3.36	1.41	1.11	1.63	2.22	1.15	1.77
	2nd	1.41	1.83	0.91	2.72	1.28	0.54	0.56	0.97	1.61	1.26
	3rd	1.09	2.23	1.76	3.13	1.99	0.54	1.98	0.63	1.52	2.39
Feb.	1st	0.61	1.72	1.41	1.10	1.33	0.96	1.97	1.98	0.75	0.69
	2nd	1.05	1.36	1.68	1.13	1.16	0.91	0.72	2.45	1.74	1.04
	3rd	1.08	1.18	3.03	2.80	0.73	1.03	4.14	1.39	1.26	2.15
Mar.	1st	1.80	1.23	4.59	2.33	1.42	1.24	4.46	0.84	1.01	3.35
	2nd	1.01	5.77	1.60	1.85	1.58	2.81	2.77	1.06	1.08	4.15
	3rd	0.54	2.29	2.52	1.68	0.85	0.90	2.68	1.66	0.65	1.32
Apr.	1st	0.36	3.14	6.21	0.73	1.73	0.59	1.67	3.29	1.03	0.98
	2nd	0.23	1.28	3.56	1.51	1.90	0.42	1.40	12.19	1.34	1.19
	3rd	0.24	0.78	3.85	0.78	1.38	0.34	0.76	2.95	0.83	1.58
May	1st	0.20	0.53	2.74	0.55	0.77	0.29	0.62	1.35	0.71	1.50
	2nd	0.17	0.56	1.75	0.73	0.58	0.22	0.50	1.03	0.62	0.56
	3rd	0.15	0.37	1.12	0.50	0.42	0.23	0.33	0.80	0.93	0.40
June	1st	1.49	0.28	0.80	0.35	0.34	0.65	0.27	0.61	0.55	0.29
	2nd	0.40	0.26	0.58	0.27	0.33	0.44	0.25	0.44	0.42	0.28
	3rd	0.20	0.25	0.43	0.24	0.30	0.44	0.23	0.33	0.30	0.42
July	1st	0.14	0.42	0.60	0.34	0.41	0.38	0.22	0.30	0.22	0.80
	2nd	0.11	0.32	0.49	0.27	0.53	0.22	0.20	0.28	0.20	0.33
	3rd	0.10	0.21	0.36	0.21	1.15	0.20	0.19	0.27	0.19	0.23
Aug.	1st	0.09	0.19	0.33	0.19	1.21	0.16	0.35	0.25	0.17	0.20
	2nd	0.07	0.16	0.31	0.18	0.64	0.14	0.26	0.23	0.15	0.18
	3rd	0.06	0.15	0.29	0.16	0.45	0.21	0.15	0.21	0.13	0.16
Sep.	1st	0.04	0.13	0.26	0.14	0.29	0.13	0.12	0.19	0.11	0.14
	2nd	0.03	0.11	0.23	0.12	0.23	0.11	0.11	0.17	0.10	0.12
	3rd	0.03	0.09	0.21	0.10	0.22	0.09	0.09	0.15	0.08	0.10
Oct.	1st	0.03	0.09	0.18	0.09	0.22	0.08	0.07	0.13	0.06	0.08
	2nd	0.02	0.08	0.15	0.07	0.17	0.07	0.06	0.11	0.04	0.06
	3rd	0.02	0.05	0.13	0.07	0.15	0.06	0.04	0.09	0.03	0.04
Nov.	1st	0.02	1.58	0.10	0.30	1.38	0.21	0.03	0.55	0.02	0.03
	2nd	0.02	0.69	0.21	1.65	1.22	0.09	0.19	0.54	0.02	0.03
	3rd	0.02	0.87	0.10	2.58	0.44	0.05	0.09	0.20	0.02	0.60
Dec.	1st	0.71	1.95	0.60	4.70	0.27	0.57	0.31	0.42	0.17	0.77
	2nd	1.80	3.37	0.41	3.94	0.46	0.71	1.18	1.17	1.28	0.78
	3rd	3.47	2.60	2.16	1.05	0.74	0.73	0.55	1.00	0.63	0.20
Totl	1st	0.53	1.10	1.29	1.17	0.82	0.50	0.86	1.18	0.59	0.84

Table 2.2.3 ESTIMATED TEN-DAY RUNOFF (2/4)

RUNOFF OF K.MARAK RIVER

Month	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Jan. 1st	0.63	0.34	1.88	1.29	2.02	1.48	1.78	1.85	0.75	0.53
2nd	0.91	1.91	0.92	0.71	0.48	0.93	1.90	0.99	1.12	0.49
3rd	0.65	3.44	0.80	0.96	1.10	1.80	1.27	0.61	0.61	2.83
Feb. 1st	1.98	0.71	1.17	2.49	2.42	0.66	2.72	1.00	0.55	3.86
2nd	1.67	1.64	1.10	1.12	2.17	2.71	1.59	1.79	1.81	2.50
3rd	1.08	1.00	1.67	1.02	1.48	2.45	2.85	1.18	2.66	2.05
Mar. 1st	0.75	1.98	3.22	2.43	1.86	3.74	1.17	2.56	1.91	2.17
2nd	1.97	1.80	1.56	1.13	1.25	2.45	0.76	1.28	1.99	2.96
3rd	0.84	0.76	2.15	2.33	0.90	1.22	4.62	3.20	2.68	1.28
Apr. 1st	0.46	0.52	2.13	0.95	1.32	1.71	3.60	4.40	1.12	1.04
2nd	0.57	1.57	1.66	0.83	0.60	0.90	1.40	2.32	0.81	0.95
3rd	1.68	2.28	2.16	0.56	0.39	1.71	0.89	1.71	0.61	0.76
May 1st	2.25	1.97	1.11	2.19	0.24	1.48	0.69	1.09	0.46	1.08
2nd	1.33	0.68	0.72	0.79	0.18	0.79	0.50	1.05	0.33	1.20
3rd	0.68	0.46	0.54	0.45	0.17	1.01	0.35	1.07	0.26	0.58
June 1st	0.46	0.41	0.73	0.59	0.15	1.29	0.27	1.00	0.24	0.45
2nd	0.32	0.39	0.37	0.46	0.34	0.51	0.25	1.40	0.22	0.34
3rd	0.21	0.27	0.29	0.39	0.19	0.37	0.23	0.81	0.21	0.27
July 1st	0.18	0.21	0.27	0.26	0.18	0.29	0.22	2.00	0.19	0.25
2nd	0.17	0.18	0.25	0.21	0.11	0.26	0.20	1.13	0.17	0.23
3rd	0.15	0.17	0.23	0.20	0.10	0.24	0.18	1.22	0.15	0.21
Aug. 1st	0.13	0.15	0.21	0.18	0.08	0.22	0.16	0.67	0.13	0.19
2nd	0.11	0.13	0.19	0.16	0.07	0.20	0.14	0.51	0.11	0.17
3rd	0.10	0.11	0.17	0.14	0.05	0.18	0.11	0.37	0.09	0.15
Sep. 1st	0.08	0.10	0.14	0.12	0.03	0.16	0.10	0.32	0.07	0.13
2nd	0.06	0.08	0.12	0.10	0.02	0.13	0.08	0.30	0.05	0.11
3rd	0.05	0.06	0.10	0.09	0.01	0.11	0.06	0.28	0.03	0.10
Oct. 1st	0.03	0.05	0.08	0.79	0.01	0.12	0.04	0.26	0.02	0.08
2nd	0.02	0.03	0.06	1.87	0.01	0.12	0.02	0.23	0.01	0.06
3rd	0.02	0.02	0.04	0.46	0.01	0.08	0.01	0.21	0.01	0.05
Nov. 1st	0.08	0.87	0.03	0.56	0.01	0.05	0.01	0.60	0.07	0.04
2nd	0.45	0.82	0.02	0.90	0.01	0.23	0.01	0.66	0.04	0.11
3rd	0.19	1.16	0.23	0.27	0.01	0.10	0.05	0.47	0.06	0.68
Dec. 1st	0.32	0.27	0.05	0.17	0.25	2.39	2.05	1.05	0.12	1.10
2nd	0.17	1.62	2.07	0.09	2.42	3.11	1.01	2.54	0.86	0.64
3rd	0.09	1.43	1.19	1.08	1.66	0.69	3.05	1.36	1.96	3.01
Toti 1st	0.58	0.82	0.82	0.79	0.60	1.00	0.95	1.21	0.62	0.91

PR#0

Table 2.2.3

****
* ESTIMATED TEN-DAY RUNOFF * (3/4)
****

RUNOFF OF K.WARAK RIVER

Month		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Jan.	1st	1.45	0.90	6.61	0.74	2.78	1.34	1.72	2.09	4.19	1.11
	2nd	4.60	1.06	2.72	0.89	1.73	0.92	0.85	1.61	1.29	0.80
	3rd	2.75	2.59	2.51	1.02	0.78	0.64	1.36	2.46	1.48	2.10
Feb.	1st	1.94	1.42	2.08	2.92	1.11	0.46	1.97	0.97	1.34	1.09
	2nd	1.31	0.59	6.22	1.51	1.18	0.38	2.46	2.31	1.50	0.82
	3rd	2.98	0.54	3.74	1.36	0.99	0.40	0.85	2.84	1.87	1.64
Mar.	1st	1.98	0.62	3.09	1.55	3.23	0.99	0.66	1.07	1.00	0.81
	2nd	1.62	2.43	1.59	1.35	3.16	0.96	0.83	1.13	0.85	0.60
	3rd	2.97	2.01	1.40	0.74	3.14	0.74	2.42	1.07	1.07	0.45
Apr.	1st	1.91	0.79	1.20	1.20	1.53	0.82	2.30	0.71	0.51	0.32
	2nd	2.88	0.69	1.23	3.64	3.36	0.54	1.32	0.51	0.62	0.80
	3rd	1.02	0.51	1.51	2.05	3.39	0.41	0.69	0.36	0.96	0.59
May	1st	1.52	1.42	2.32	0.84	2.06	0.28	0.47	0.25	1.13	0.52
	2nd	1.39	1.18	1.58	2.23	1.51	0.21	0.31	0.37	0.69	0.32
	3rd	2.19	0.41	1.77	0.82	1.22	0.19	0.23	0.40	1.01	0.23
June	1st	1.93	0.28	1.00	0.53	0.91	0.17	1.14	1.10	0.80	0.17
	2nd	1.04	0.23	0.74	0.38	0.66	0.16	1.20	0.80	0.58	0.15
	3rd	0.72	0.21	0.55	0.30	0.49	0.14	0.44	0.56	0.36	0.14
July	1st	0.54	0.20	0.42	0.28	0.39	0.12	0.30	1.37	0.25	0.12
	2nd	0.40	0.18	0.38	0.26	0.36	0.10	0.21	0.59	0.20	0.11
	3rd	0.35	0.16	0.35	0.25	0.33	0.09	0.18	0.38	0.19	0.15
Aug.	1st	0.32	0.13	0.33	0.39	0.31	0.07	0.16	0.31	0.17	0.34
	2nd	0.30	0.11	0.31	0.23	0.29	0.05	0.14	0.22	0.15	0.12
	3rd	0.28	0.10	0.28	0.20	0.26	0.04	0.12	0.19	0.13	0.07
Sep.	1st	0.25	0.08	0.26	0.17	0.24	0.02	0.10	0.17	0.11	0.05
	2nd	0.23	0.06	0.31	0.37	0.40	0.01	0.08	0.16	0.09	0.04
	3rd	0.20	0.04	1.49	0.19	0.22	0.01	0.07	0.14	0.08	0.02
Oct.	1st	0.18	0.02	0.51	0.34	0.85	0.01	0.05	0.12	0.06	0.01
	2nd	0.16	0.01	0.28	0.18	0.91	0.01	0.03	0.10	0.04	0.01
	3rd	1.08	0.01	0.38	0.82	0.62	0.01	0.02	0.08	0.02	0.01
Nov.	1st	1.87	0.01	0.56	0.19	1.24	0.42	0.01	0.06	0.01	0.25
	2nd	1.63	0.01	1.63	0.29	0.69	0.06	0.01	0.07	0.01	0.34
	3rd	2.80	0.32	0.99	1.10	0.94	1.12	0.09	0.05	0.09	1.49
Dec.	1st	2.83	1.28	1.26	2.92	3.45	0.62	1.94	0.03	0.51	3.79
	2nd	3.11	1.40	1.50	5.43	2.09	0.54	1.56	0.12	0.49	2.05
	3rd	1.44	1.77	1.14	1.02	1.42	0.85	0.70	3.02	1.39	3.40
Totl	1st	1.50	0.66	1.51	1.07	1.34	0.39	0.75	0.77	0.70	0.70

PR#0

Table 2.2.3

****
* ESTIMATED TEN-DAY RUNOFF *
****

(4/4)

RUNOFF OF K.WARAK RIVER

Month		1981	1982	1983	mean
Jan.	1st	2.67	2.43	2.13	1.77
	2nd	1.49	1.05	2.34	1.36
	3rd	0.91	2.08	1.12	1.61
Feb.	1st	0.79	3.74	2.50	1.59
	2nd	1.00	3.03	1.39	1.67
	3rd	1.08	2.00	1.24	1.74
Mar.	1st	1.10	4.08	1.82	1.98
	2nd	1.52	8.09	2.47	2.04
	3rd	0.83	4.50	0.81	1.73
Apr.	1st	0.66	2.06	1.42	1.59
	2nd	0.41	1.67	1.04	1.68
	3rd	0.64	1.50	0.78	1.23
May	1st	2.13	0.93	1.96	1.14
	2nd	1.14	0.60	0.87	0.81
	3rd	0.57	0.43	0.85	0.64
June	1st	0.40	0.34	0.77	0.63
	2nd	0.27	0.32	0.49	0.46
	3rd	0.23	0.30	0.35	0.34
July	1st	0.33	0.28	0.27	0.39
	2nd	0.30	0.29	0.25	0.29
	3rd	0.20	0.36	0.23	0.28
Aug.	1st	0.17	0.23	0.21	0.25
	2nd	0.15	0.20	0.19	0.20
	3rd	0.13	0.18	0.17	0.17
Sep.	1st	0.11	0.15	0.15	0.14
	2nd	0.09	0.13	0.13	0.14
	3rd	1.15	0.11	0.10	0.18
Oct.	1st	0.59	0.09	0.10	0.16
	2nd	0.11	0.07	0.10	0.16
	3rd	0.05	0.05	0.65	0.16
Nov.	1st	0.23	0.03	0.23	0.35
	2nd	1.29	0.02	0.59	0.44
	3rd	0.64	0.01	1.69	0.59
Dec.	1st	0.36	0.72	0.83	1.17
	2nd	1.54	2.74	0.50	1.60
	3rd	2.20	2.97	0.99	1.54
Totl	1st	0.76	1.33	0.88	0.90

PR#0

Table 2.2.4

****
* ESTIMATED TEN-DAY RUNOFF * (1/4)
****

KETANDAN

Month		1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Jan.	1st	0.21	0.80	0.43	1.65	0.69	0.54	0.80	1.09	0.56	0.87
	2nd	0.69	0.90	0.45	1.34	0.63	0.26	0.27	0.48	0.79	0.62
	3rd	0.54	1.10	0.86	1.54	0.98	0.26	0.97	0.31	0.74	1.17
Feb.	1st	0.30	0.84	0.69	0.54	0.65	0.47	0.97	0.97	0.36	0.34
	2nd	0.51	0.66	0.83	0.56	0.57	0.45	0.35	1.21	0.85	0.51
	3rd	0.53	0.58	1.49	1.38	0.36	0.50	2.04	0.68	0.62	1.06
Mar.	1st	0.88	0.60	2.26	1.15	0.70	0.61	2.19	0.41	0.49	1.64
	2nd	0.50	2.84	0.78	0.91	0.78	1.38	1.36	0.52	0.53	2.04
	3rd	0.26	1.12	1.24	0.82	0.42	0.44	1.32	0.82	0.32	0.65
Apr.	1st	0.17	1.54	3.05	0.36	0.85	0.29	0.82	1.62	0.50	0.48
	2nd	0.11	0.63	1.75	0.74	0.93	0.20	0.69	6.00	0.66	0.58
	3rd	0.11	0.38	1.89	0.38	0.67	0.16	0.37	1.45	0.41	0.77
May	1st	0.10	0.26	1.35	0.27	0.37	0.14	0.30	0.66	0.35	0.73
	2nd	0.08	0.27	0.86	0.36	0.28	0.11	0.24	0.50	0.30	0.27
	3rd	0.07	0.18	0.55	0.25	0.20	0.11	0.16	0.39	0.46	0.20
June	1st	0.73	0.14	0.39	0.17	0.16	0.32	0.13	0.30	0.27	0.14
	2nd	0.19	0.13	0.28	0.13	0.16	0.21	0.12	0.21	0.21	0.14
	3rd	0.10	0.12	0.21	0.12	0.14	0.21	0.11	0.16	0.14	0.21
July	1st	0.07	0.20	0.29	0.16	0.20	0.18	0.10	0.14	0.11	0.39
	2nd	0.05	0.15	0.24	0.13	0.26	0.11	0.10	0.14	0.10	0.16
	3rd	0.05	0.10	0.18	0.10	0.56	0.10	0.09	0.13	0.09	0.11
Aug.	1st	0.04	0.09	0.16	0.09	0.59	0.08	0.17	0.12	0.08	0.10
	2nd	0.03	0.08	0.15	0.09	0.31	0.07	0.13	0.11	0.07	0.09
	3rd	0.02	0.07	0.14	0.08	0.22	0.10	0.07	0.10	0.06	0.08
Sep.	1st	0.02	0.06	0.13	0.07	0.14	0.06	0.06	0.09	0.05	0.07
	2nd	0.01	0.05	0.11	0.06	0.11	0.05	0.05	0.08	0.04	0.06
	3rd	0.01	0.04	0.10	0.05	0.10	0.04	0.04	0.07	0.04	0.05
Oct.	1st	0.01	0.04	0.09	0.04	0.11	0.04	0.03	0.06	0.03	0.04
	2nd	0.01	0.04	0.07	0.03	0.08	0.03	0.02	0.05	0.02	0.03
	3rd	0.01	0.02	0.06	0.03	0.07	0.02	0.02	0.04	0.01	0.02
Nov.	1st	0.01	0.78	0.05	0.15	0.68	0.10	0.01	0.27	0.01	0.01
	2nd	0.01	0.34	0.10	0.81	0.60	0.04	0.09	0.27	0.01	0.01
	3rd	0.01	0.43	0.05	1.27	0.21	0.02	0.04	0.10	0.01	0.29
Dec.	1st	0.34	0.96	0.29	2.31	0.13	0.28	0.15	0.20	0.08	0.37
	2nd	0.88	1.66	0.20	1.93	0.22	0.35	0.58	0.57	0.63	0.38
	3rd	1.71	1.28	1.06	0.51	0.36	0.36	0.27	0.49	0.31	0.09
Totl	1st	0.26	0.54	0.63	0.57	0.40	0.24	0.42	0.58	0.29	0.41

Table 2.2.4 ESTIMATED TEN-DAY RUNOFF (2/4)

KETANDAN

Month	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Jan. 1st	0.31	0.16	0.92	0.63	0.99	0.73	0.87	0.91	0.37	0.26
2nd	0.44	0.94	0.45	0.35	0.23	0.45	0.93	0.48	0.55	0.24
3rd	0.32	1.69	0.39	0.47	0.54	0.88	0.62	0.30	0.30	1.39
Feb. 1st	0.97	0.35	0.57	1.23	1.19	0.32	1.34	0.49	0.27	1.90
2nd	0.82	0.81	0.54	0.55	1.07	1.33	0.78	0.88	0.89	1.23
3rd	0.52	0.49	0.82	0.50	0.73	1.20	1.30	0.58	1.31	1.01
Mar. 1st	0.37	0.97	1.58	1.19	0.52	1.84	0.57	1.26	0.94	1.06
2nd	0.97	0.88	0.76	0.55	0.61	1.20	0.37	0.63	0.98	1.45
3rd	0.41	0.37	1.06	1.14	0.44	0.60	2.27	1.57	1.32	0.63
Apr. 1st	0.23	0.25	1.04	0.47	0.65	0.84	1.77	2.16	0.55	0.51
2nd	0.28	0.77	0.81	0.40	0.29	0.44	0.69	1.14	0.39	0.46
3rd	0.83	1.12	1.06	0.27	0.19	0.84	0.44	0.84	0.30	0.37
May 1st	1.10	0.97	0.54	1.07	0.12	0.72	0.34	0.54	0.22	0.53
2nd	0.65	0.33	0.35	0.38	0.09	0.39	0.24	0.51	0.16	0.59
3rd	0.33	0.22	0.26	0.22	0.08	0.49	0.17	0.52	0.12	0.28
June 1st	0.22	0.20	0.36	0.29	0.07	0.63	0.13	0.49	0.12	0.22
2nd	0.16	0.19	0.18	0.22	0.17	0.25	0.12	0.69	0.11	0.16
3rd	0.10	0.13	0.14	0.19	0.09	0.18	0.11	0.40	0.10	0.13
July 1st	0.09	0.10	0.13	0.13	0.08	0.14	0.10	0.98	0.09	0.12
2nd	0.08	0.09	0.12	0.10	0.05	0.12	0.10	0.55	0.08	0.11
3rd	0.07	0.08	0.11	0.09	0.05	0.11	0.09	0.60	0.07	0.10
Aug. 1st	0.06	0.07	0.10	0.09	0.04	0.11	0.07	0.33	0.06	0.09
2nd	0.05	0.06	0.09	0.08	0.03	0.10	0.06	0.25	0.05	0.08
3rd	0.05	0.05	0.08	0.07	0.02	0.09	0.05	0.18	0.04	0.07
Sep. 1st	0.04	0.05	0.07	0.06	0.01	0.07	0.04	0.16	0.03	0.06
2nd	0.03	0.04	0.06	0.05	0.01	0.06	0.04	0.15	0.02	0.05
3rd	0.02	0.03	0.05	0.04	0.00	0.05	0.03	0.13	0.01	0.05
Oct. 1st	0.01	0.02	0.04	0.39	0.00	0.05	0.02	0.12	0.01	0.04
2nd	0.01	0.01	0.03	0.92	0.00	0.06	0.01	0.11	0.00	0.03
3rd	0.01	0.01	0.02	0.22	0.00	0.04	0.00	0.10	0.00	0.02
Nov. 1st	0.04	0.43	0.01	0.27	0.00	0.02	0.00	0.29	0.03	0.02
2nd	0.22	0.40	0.01	0.44	0.00	0.11	0.00	0.32	0.02	0.05
3rd	0.09	0.57	0.11	0.13	0.00	0.04	0.02	0.23	0.03	0.33
Dec. 1st	0.16	0.13	0.02	0.08	0.12	1.17	1.01	0.51	0.06	0.54
2nd	0.08	0.79	1.02	0.04	1.19	1.53	0.49	1.25	0.42	0.31
3rd	0.04	0.70	0.58	0.53	0.82	0.33	1.50	0.67	0.96	1.48
Totl 1st	0.28	0.40	0.40	0.38	0.29	0.49	0.46	0.59	0.30	0.44

PR#0

Table 2.2.4

****
* ESTIMATED TEN-DAY RUNOFF * (3/4)
****

KETANDAN

Month		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Jan.	1st	0.71	0.44	3.25	0.36	1.37	0.66	0.85	1.02	2.06	0.54
	2nd	2.26	0.52	1.34	0.44	0.85	0.45	0.42	0.79	0.63	0.39
	3rd	1.35	1.27	1.23	0.50	0.38	0.31	0.67	1.21	0.73	1.03
Feb.	1st	0.95	0.70	1.02	1.43	0.54	0.23	0.97	0.47	0.66	0.54
	2nd	0.64	0.29	3.06	0.74	0.58	0.18	1.21	1.14	0.74	0.40
	3rd	1.46	0.26	1.84	0.67	0.49	0.19	0.42	1.40	0.92	0.80
Mar.	1st	0.97	0.30	1.52	0.76	1.58	0.48	0.32	0.52	0.49	0.39
	2nd	0.79	1.19	0.78	0.66	1.55	0.47	0.41	0.55	0.42	0.29
	3rd	1.46	0.99	0.69	0.36	1.54	0.36	1.19	0.52	0.53	0.22
Apr.	1st	0.94	0.39	0.59	0.59	0.75	0.40	1.13	0.35	0.25	0.15
	2nd	1.41	0.34	0.60	1.79	1.65	0.26	0.65	0.25	0.30	0.39
	3rd	0.50	0.25	0.74	1.01	1.66	0.20	0.34	0.17	0.47	0.29
May	1st	0.74	0.70	1.14	0.41	1.01	0.13	0.23	0.12	0.55	0.25
	2nd	0.68	0.58	0.78	1.10	0.74	0.10	0.15	0.18	0.34	0.16
	3rd	1.07	0.20	0.87	0.40	0.60	0.09	0.11	0.20	0.49	0.11
June	1st	0.95	0.14	0.49	0.26	0.44	0.08	0.56	0.54	0.39	0.08
	2nd	0.51	0.11	0.36	0.18	0.32	0.07	0.59	0.39	0.28	0.07
	3rd	0.35	0.10	0.27	0.15	0.24	0.07	0.22	0.27	0.18	0.07
July	1st	0.27	0.09	0.20	0.13	0.19	0.06	0.15	0.67	0.12	0.06
	2nd	0.20	0.08	0.18	0.13	0.17	0.05	0.10	0.29	0.10	0.05
	3rd	0.17	0.07	0.17	0.12	0.16	0.04	0.09	0.18	0.09	0.07
Aug.	1st	0.16	0.06	0.16	0.19	0.15	0.03	0.08	0.15	0.08	0.16
	2nd	0.15	0.05	0.15	0.11	0.14	0.02	0.07	0.11	0.07	0.06
	3rd	0.13	0.04	0.14	0.09	0.13	0.02	0.06	0.09	0.06	0.03
Sep.	1st	0.12	0.04	0.12	0.08	0.11	0.01	0.05	0.08	0.05	0.02
	2nd	0.11	0.03	0.15	0.18	0.20	0.00	0.04	0.07	0.04	0.02
	3rd	0.10	0.02	0.73	0.09	0.10	0.00	0.03	0.06	0.04	0.01
Oct.	1st	0.09	0.01	0.25	0.16	0.41	0.00	0.02	0.06	0.03	0.00
	2nd	0.07	0.00	0.14	0.09	0.45	0.00	0.01	0.05	0.02	0.00
	3rd	0.53	0.00	0.18	0.40	0.30	0.00	0.01	0.04	0.01	0.00
Nov.	1st	0.92	0.00	0.27	0.09	0.61	0.20	0.00	0.03	0.00	0.12
	2nd	0.80	0.00	0.80	0.14	0.34	0.03	0.00	0.03	0.00	0.17
	3rd	1.37	0.15	0.49	0.54	0.46	0.55	0.04	0.02	0.04	0.73
Dec.	1st	1.39	0.63	0.62	1.43	1.70	0.30	0.95	0.01	0.25	1.86
	2nd	1.53	0.69	0.74	2.67	1.03	0.27	0.77	0.05	0.24	1.01
	3rd	0.70	0.87	0.56	0.50	0.69	0.42	0.34	1.48	0.68	1.67
Totl	1st	0.74	0.32	0.74	0.53	0.66	0.19	0.37	0.38	0.34	0.34

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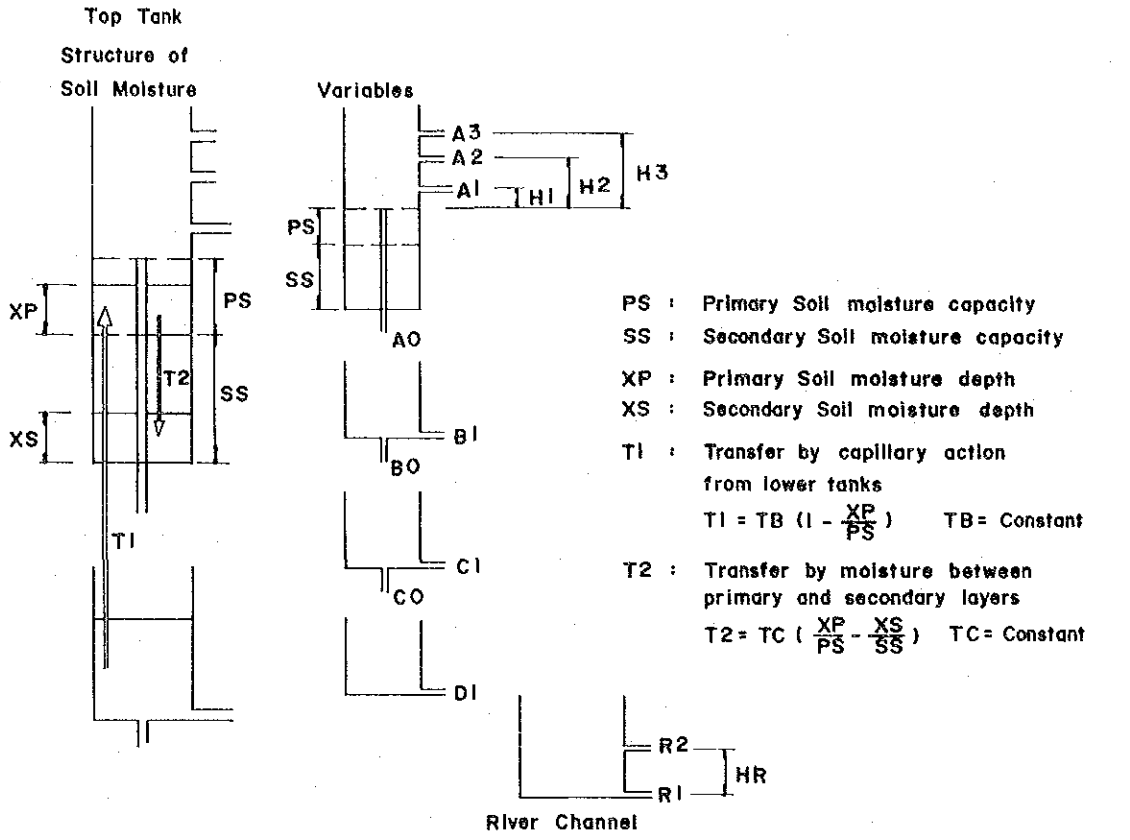
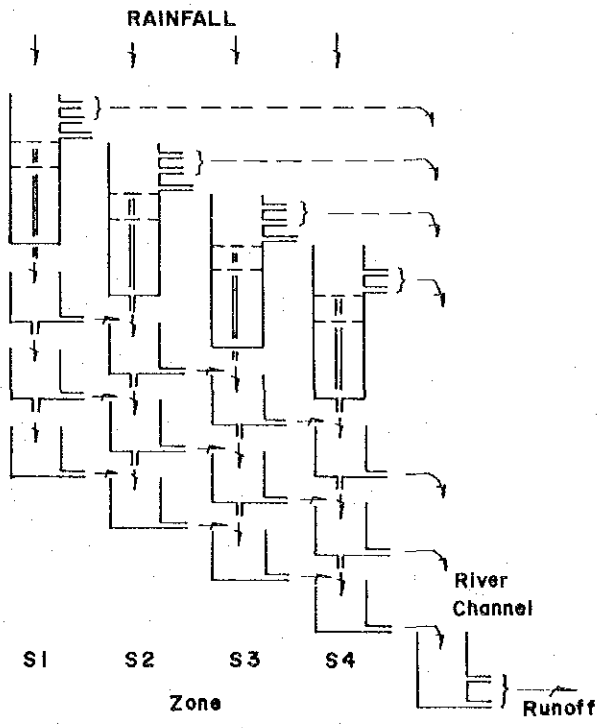
Table 2.2.4 ********** * ESTIMATED TEN-DAY RUNOFF * ********** (4/4)

KETANDAN

Month		1981	1982	1983	mean
Jan.	1st	1.31	1.19	1.05	0.87
	2nd	0.73	0.52	1.15	0.67
	3rd	0.45	1.02	0.55	0.79
Feb.	1st	0.39	1.84	1.23	0.78
	2nd	0.49	1.49	0.68	0.82
	3rd	0.53	0.98	0.61	0.86
Mar.	1st	0.54	2.00	0.89	0.97
	2nd	0.75	3.98	1.21	1.00
	3rd	0.41	2.21	0.40	0.85
Apr.	1st	0.32	1.01	0.70	0.78
	2nd	0.20	0.82	0.51	0.82
	3rd	0.31	0.74	0.38	0.60
May	1st	1.04	0.46	0.96	0.56
	2nd	0.56	0.30	0.43	0.40
	3rd	0.28	0.21	0.41	0.31
June	1st	0.19	0.17	0.38	0.31
	2nd	0.13	0.16	0.24	0.23
	3rd	0.11	0.15	0.17	0.16
July	1st	0.16	0.14	0.13	0.19
	2nd	0.14	0.14	0.12	0.14
	3rd	0.10	0.17	0.11	0.13
Aug.	1st	0.08	0.11	0.10	0.12
	2nd	0.07	0.10	0.09	0.10
	3rd	0.06	0.09	0.08	0.08
Sep.	1st	0.05	0.07	0.07	0.07
	2nd	0.04	0.06	0.06	0.06
	3rd	0.57	0.05	0.05	0.08
Oct.	1st	0.29	0.04	0.04	0.08
	2nd	0.05	0.03	0.05	0.08
	3rd	0.02	0.02	0.32	0.08
Nov.	1st	0.11	0.01	0.11	0.17
	2nd	0.63	0.01	0.29	0.21
	3rd	0.31	0.00	0.83	0.29
Dec.	1st	0.17	0.35	0.41	0.58
	2nd	0.76	1.34	0.24	0.78
	3rd	1.08	1.46	0.48	0.76
Totl	1st	0.37	0.65	0.43	0.44





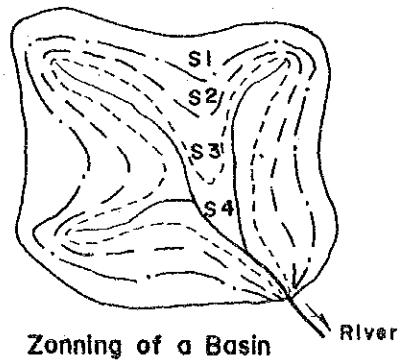


Fig. 2.2.1 STRUCTURE OF TANK MODEL AND TANK ARRANGEMENT IN A BASIN

2.3 Flood Flow Analysis

Flood distribution analysis in the Widas river basin was carried out as a part of the entire Brantas River Basin in the Part I Study. In the Part-II Study for the feasibility study on the Widas flood control and drainage project, the detailed study on flood discharge estimation is performed incorporating the additional hydrological records as much as possible.

The flood analysis consists of the following components :

- modelling of the river basin and channel,
- construction of a river system model in which the river basins and channels are linked,
- rainfall analysis for determining the design rainfall duration, rainfall amount and pattern,
- runoff calculation for the present river condition using the river system constructed and the results of rainfall analysis.

2.3.1 Methods and Procedures

Probable flood discharges are estimated from probable rainfall using the storage function method. The flood analysis is consisted of construction of river system model, rainfall analysis, and flood discharge calculation as mentioned in the previous section.

The general procedurs of the analysis are illustrated in Fig.2.3.1. Table2.3.1 shows the comparison of the procedurs between Part-I and Part-II study.

1. Construction of River System Model

(1) Basin Division / Base Point

The Widas river basin is divided into sub-basins taking into account the base points which are the site for estimating the probable flood discharge. The base points are distributed at the following site.

- Before/after the confluence with the major tributaries
- Proposed/existing dam site
- Proposed/existing flood diversion

(2) Storage Function of River Channel

River channel has a retarding effect for flood discharge according to the river width, channel length, and river bed slope. In this study, it is assumed that the retarding effect is considered for the river channel in the flat plain taking into account the river bed slope.

The effective river width for retarding flood discharge is assumed by using the regime theory as below :

$$B = eQ^{0.5}$$

Where, B : River width (m)

Q : Flood discharge (m^3/sec.)

e : Constant

In the above formula, flood discharge is estimated from the catchment area for the river channel and the relation between the catchment area and specific discharge studied in the Part-I study in case without retarding basin. However, if the diking system exists in the channel, the width of the system is applied.

The storage function of river channel is estimated from the river-cross section, river bed slope, and length in addition to the above river width using the non-uniform or uniform flow calculation method.

The basic formula of storage function is shown below.

$$S = KQ^P$$

Where, S : Storage volume (m^3/sec.)

Q : Flood discharge (m^3/sec.)

K,P : Constant

(3) Dam / Reservoir

If the dam/reservoir has the flood control space, the effect is calculated based on the relation between reservoir water level, storage volume and outflow from the spillway using the following equation.

$$ds/dt = I - O$$

Where, S : Storage volume (m^3)

I : Inflow into reservoir (m^3/sec)

O : Outlow from reservoir (m^3/sec)

(4) Retarding Basin

(a) Natural retarding basin

Natural retarding basin has a retarding effect for flood discharge like a dam/reservoir having a flood control space because of a small discharge capacity of the river channel and a large retarding volume on the flood plain. In this analysis, natural retarding basin is expressed as a model like a dam/reservoir. Retarding volume is estimated based on the topographical map of 1/2,500, and the water level-discharge curve is calculated by means of uniform or non-uniform flow calculation method.

(b) Controlled retarding basin

Controlled retarding basin is designed as a side channel type with overflow weir. Therefore, runoff retarded in the controlled retarding basin is estimated by substracting the control volume assigned from the flood volume from the peak on the estimated flood hydrograph.

(5) Flood Diversion

The flood discharge downstream from the flood diversion is estimated by multiplying the diversion rate to the flood discharge flowing into the flood diversion point. Diversion rate for the existing flood diversion is estimated from the operation record or structural condition.

(6) River System Model

River system models for the present river condition are constructed based on the topographical map of 1/2,500, and 1/50,000.

2. Rainfall Analysis

(1) Design rain storm duration

Design rain storm duration is determined by examination of the rainfall characteristics and pattern in the basin, based on hourly and daily rainfall records.

(2) Hourly rainfall distribution

Based on hourly rainfall recorded at rain storm in the basin, 3 observed rainfall patterns are examined for estimating probable flood discharges. Out of 3 flood discharge, the maximum are adopted as design flood discharge.

Hourly rainfall distribution in sub-basin for the above pattern is estimated by means of Thiessen's method.

(3) Probable rainfall

Probable rainfall is estimated by Gumbel's method using the basin mean annual maximum rainfall at base point. This estimation is made for

the duration from 1-day to design rainfall duration with different return periods.

Basin mean annual maximum rainfall at base point is calculated by means of Thiessen's method.

(4) Probable hourly rainfall pattern

Probable rainfalls are distributed as follows on the basis of the observed rainfall pattern.

(a) Probable 1-day rainfall is distributed to the maximum 1-day rainfall among the observed rainfall.

(b) For probable 2-day rainfall, the difference calculated by sub - structing 1-day rainfall from 2-day rainfall is distributed to the observed according to the observed pattern.

(c) Probable rainfalls from the 3-day to the design duration days are distributed to other days by the same way.

The hourly pattern of the rainfall distributed by the above method is given as below.

$n = Rd/Ro$

$Ri(t) = n \times Rio(t)$

Where,
- Rd : Distributed rainfall amount to a day
- Ro : Observed rainfall amount in a day
- Ri(t) : Hourly rainfall of probable rainfall
- Rio(t) : Hourly rainfall of the observed in a day
- n : Ratio of the observed to the probable rainfall

The above rainfall pattern for design rain storm are modified on the assumption that possible 1-day and 1-hour rainfalls shall be equivalent to or less than the amounts estimated by the following formula.

$$Rp, \text{1-day} = Ri - day \times \exp(-0.2 \times A^{0.2}) / \exp.(-0.1 \times A'^{0.2})$$

Where,
- Rp, 1-day : Possible 1-day rainfall in a sub-basin
- Ri - day : Probable 1-day rainfall at the base point
- A : Catchment area of sub-basin
- A' : Catchment area at the base point

$$Rp.24 \quad (R_{24}/8) \times (8/1)^{2/3}$$

Where,
- Rp.24 : Possible 1-hour rainfall in a sub-basin
- R_{24} : 24 hours rainfall is a sub-basin

The rainfall which exceeds the above possible rainfall is distributed to other basin and/or hour.

3. Base Flow

In the area which has a half-year wet season, the base flow for river channel is high because of daily sequence of rainfall. And if there is a flood control works such as a river dredging and flood diversion, the base flow will change from natural or present condition.

In this study, base flow is estimated by using hourly rainfall in a month corresponding to average of annual maximum rainfall amount in the basin. In this simulation, the rainfall is input to the river system model.

Probable flood discharge is examined under the condition of the simulated maximum base flow.

4. Flood Discharge Calculation

Flood discharge is calculated by the storage function of which basic equation is described as below.

Sub-basin

$$r - q = dSo/dt$$

$$So = K.q^{p}$$

$$q = q_1 (t - T_1)$$

$$Q = 0.2778 (fq + (1-f) q_{sa}) A + Q_B$$

Where, r : Basin average hourly rainfall (mm/hr)

q : Runoff depth from a basin (mm/hr)

Q_1 : Run-off depth from a basin with lag time, T_1 (mm/hr)

q_{sa} : Run-off depth from a basin after saturation rainfall, R_{sa} (mm/hr)

Q : Discharge (m^3/sec.)

f : Run-off coefficient ($r = R_{sa}$ $f = f_1$ $r \quad R_{sa}$ $f = 1.0$)

A : Catchment area (km^2)

Q_B : Base flow (m^3/sec)

K, P : Coefficient

t : Time (hr)

(b) Kuncir flood diversion

Diversion rate for the Kuncir flood diversion/operational condition for present condition, and from the downstream discharge capacity and flood control plan for alternatives.

(c) Reservoir

In the Widas river basin, the Bening dam had constructed in 1982. The Bening dam has a emergency flood control space. However, this volume is operational allowance for the design flood having a rapid rising rimb in hydrograph. From the above consideration, these reservoir give no influence to flood discharge.

2.3.2 Rainfall Analysis

1. Design Rain Storm Duration

Judging from the river length of about 80 km in the Main Widas, the flood discharge flows into the Main Brantas in 10 - 15 hours, assuming that the flood flow velocity is 2 m/sec. However, there exists the retarding basins and the inundation continues for one or two weeks averagely since it rains almost every day with a duration from 8 to 12 hours in a wet season. Therefore, the examination of rainfall duration/ characteristics is needed for determining design rain storm.

Based on the daily rainfall records at ;

- Nganjuk located at the center of the basin,
- Semantok, Ngluyu and Ngrambek located at the northern hills, and
- Sawahan located at Southern mountaneous area.

Daily rainfall amount more than 10 mm occures continuously within 6 duration days as shown in Table 2.3.2.

Consequently, 6 days are adopted as a design rain storm duration.

2. Hourly Rainfall Distribution and Pattern

The following 3 rain storm records are used for comparison of flood discharge by the difference of the rainfall pattern.

- January 23 - 28, 1982
- February 3 - 8, 1982
- January 26 - 31, 1984

The above patterns are selected from the duration, rainfall amount and its distribution in the basin.

Fig. 2.3.2 shows the distribution of 1-day and 6-day rainfall amount and Fig. 2.3.3 shows the hourly rainfall pattern at the confluence with the Main Brantas.

Thiessen polygon and coefficients for calculation of hourly rainfall pattern are shown in Fig. 2.3.4and Table 2.3.3, respectively.

3. Probable Rainfall

There are 37 stations where the daily records are available. Out of these stations, 13 stations illustrated in Fig. 2.3.5 are selected from the location and representative area in addition to the available period of the records.

Thiessen's polygon and coefficients are shown in Fig. 2.3.6 and Table 2.3.4.

Table2.3.5 shows the annual maximum basin mean rainfall with duration from 1-day to 6-day and the frequency curves are described in Fig. 2.3.7.

Probable rainfalls are shown in Table 2.3.6.

4. Probable Rainfall Distribution

Probable rainfall distribution is determined according to the hourly rainfall pattern observed on Jan. and Feb., 1982 and Jan. 1984.

2.3.3 Flood Runoff Coefficient

Relationships between storm rainfall and flood run-off depth at the Karangkates and Selorejo damsites and Ngudikan water level station are as shown on Fig. 2.3.8 based on data at damsites in 1981, 1982 and 1984 and at the water level station in 1976. From this figure, the preliminary run-off coefficient is set at 0.3. The maximum limit of rainfall to saturate the ground surface, depressions, etc. completely is set at 200 mm, taking into account the geological, soil and vegetation conditions in the basin.

2.3.4 Base Flow

Base flow, which is runoff just before the increase in discharge due to flood, is expected to be high in a wet season. And then, the base flow will be varied by construction of floood control facility. Therefore, the base flow for probable flood estimation is simulated by using this rainfall - runoff model and hourly rainfall in a mouth.

Monthly rainfall pattern on Jan. 1983 which are corresponding to the average of annual maximum basin mean monthly rainfall amount in Table 2.3.7 is applied for the simulation. Fig. 2.3.9 shows the basin mean monthly rainfall pattern in the K. Widas basin. In general, it is considered that the base flow is formed by loeg-term runoff. Therefore, the runoff coefficient is estited to be 0.47 according to the runoff record at Ngudikan in Table 2.3.8 water level gauging station which is studied by the Bening dam project.

In this pattern, total amount is 380 mm and 70% of total amount falls in 15 days. Therefore, the base flow at the end of 15th becomes the maximum, 94.0 m^3/sec, on the present river condition as shown in Fig. 2.3.9.

From the above, probable rainfalls are set at 16th to 21st for estimation of probable flood discharge.

Channel Flow

$$S = KQ^P$$

$$\frac{dS}{dt} = I - Q$$

Where,
- S : Channel storage (m^3)
- Q : Outflow from the channel stretch (m^3/sec)
- K, P : Storage functions
- dt : Unit time (sec)
- dS : Incremental channel storage corresponding to dt (m^3)
- I : Inflow to the channel stretch (m^3/sec)

2.3.5 Results of Basic Study

2.3.5.1 River System Model

1. Storage Function Model

According to the flood control plan, the Widas basin is divided into 26 sub-basins as shown in Fig.2.3.5 taking into account the location of base points.

The storage function of sub-basin in Kedung ridge and foot of G. Wilis is determined from the results of Part-I Study and the emperical formula, which is studied on 6 rivers flowing in flat plain in Japan, is applied to sub-basin in the alluvial plain.

The catchment area, river length, coefficients of storage function and lag-time of each sub-basin are summarized in Table 2.3.9.

For 11 channels illustrated in Fig.2.3.10 the coefficients estimated by the uniform and non-uniform flow are listed in Table 2.3.10 In hydraulic calculation, it is assumed that the water level in the Brantas is set to the design high water level of the Brantas Middle Reach River Improvement Project, IInd Stage.

2. River System Model

The river system of the K. Widas under the present condition are shown in Fig. 2.3.10. In the construction of the river system, the following structures and conditions are considered based on the topographic map.

- Retarding basin on K. Widas, K. Kedungsoko, and K. Ulo
- Kuncir flood diversion
- Bening and Kedungwarak dam/reservoir

(a) Retarding basin on K. Widas, K. Kedungsoko and K. Ulo

These retarding basin is still on natural condition. Therefore, the model as same as dam/reservoir is applied for present condition.

Table 2.3.11shows the relation between the water level, retarding volume and outflow discharge of these 3 retarding basin.

2.3.5.2 Probable Flood Discharge

Probable flood discharges at base points under the present river condition are listed in Fig.2.3.11. And then, the flood hydrographs for 25-year probability, which is a design scale of overall flood control scheme are described in Fig. 2.3.12.

Fig.2.3.13 shows the flood peak discharges at the principle site when the probable rainfall occures in the entire K. Widas basin.

Basic high flow discharge on 25-year probability which mean the flood peak discharge in case of full confinement of K. Widas are shown in Fig.2.3.14 and the hydrographs are illustrated in Fig. 2.3.15.

Table 2.3.1 COMPARISON OF THE PROCEDURE IN PART-I AND PART-II STUDY

Item		Part - I	Part - II
River System Model			
(1)	Base Point	(a) After/before the confluence with the main tributaries such as the Kuncir and K. Ulo.	(a) After/before the confluence with tributaries in K. Widas basin.
		(b) Dam/reservoir and flood way.	(b) Dam/reservoir and flood way.
(2)	Basin Division	According to the topographical characteristic and flood control plan.	Same as Part - I
	Nos. of sub-basin	14 Nos.	26 Nos.
	Nos. of river channel	7 Nos.	12 Nos.
(3)	Storage function of sub-basin	Estimated from the runoff records at Lengkong Widas and W.L. stations on the lower reaches in K. Brantas.	In the mountaneous area, the model in Part-I is applied. In the flat plain, the empirical formula is adopted.
	Mountaneous area	14 Nos.	8 Nos.
	Flat plain	-	18 Nos.
(4)	Saturated rainfall/ Preliminary runoff coefficient	Estimated from the runoff/rainfall records at K. Kates dam/Serolejo dam and Ngdikan W.L. Station.	Same as Part - I
	Saturated rainfall	200 mm	
	Preliminary runoff coefficient	0.3	
(5)	Storage function of river channel	Estimated by means of unform/non-uniform flow calculation.	- do -
(6)	Retarding basin		
	Present Condition	River channel model	Dam/reservoir model
	Alternatives	Cut of flood peak discharge according to design capacity	Same as the Part - I.
(7)	Base flow	Estimated from runoff records at Pakel, Kederi and Ploso W.L. Station.	Based on the simulated base flow by using a rainfall pattern observed on Jan. 1983.
Rainfall Analysis			
(8)	Design rain storm duration	3 days are adopted taking into account the scale and length of K. Brantas.	6 days from the rainfall characteristics.
(9)	Rainfall pattern	January 1981 and April 1984.	January and February, 1982 and January 1984.
(10)	Probable rainfall	Based on the rainfall records from 1960 to 1983 at 5 stations in/around the K. Widas basin. Gumbel method is applied for frequency analysis.	Based on the rainfall records from 1950 to 1983 at 13 stations in K. Widas basin. Gumbel method is applied for frequency analysis.
(11)	Probable rainfall pattern	Observed rainfall pattern.	Observed rainfall pattern.

Table 2.3.2 DURATION AND RAINFALL AMOUNT OF RAIN STORMS

	Nganjuk			Sawahan		
	Date	Amount (mm)	Duration (day)	Date	Amount (mm)	Duration (day)
1.	18-22. Feb, 51	139	5	15-20. Dec, 52	242	6
2.	30- 5. Nov, 52	164	6	29- 1. Apr, 55	237	4
3.	7-12. Dec, 54	141	6	11-16. Feb, 58	188	6
4.	12-15. Jan, 57	115	4	5-10. Jan, 59	267	6
5.	10-13. Apr, 58	130	4	31- 2. Feb, 60	226	3
6.	8-14. Feb, 59	305	7	20-23. Jan, 62	296	4
7.	23-24. Mar, 60	137	2	16-19. Jan, 63	184	4
8.	16-20. Feb, 61	194	5	25-28. Apr, 66	249	4
9.	9-12. Feb, 63	122	4	19-24. Jan, 69	280	6
10.	28-31. Jan, 64	150	4	22-24. Mar, 72	209	3
11.	2- 3. Mar, 64	173	2	1- 5. Jan, 74	192	5
12.	11-15. Feb, 66	133	5	29- 2. Apr, 75	243	4
13.	13 . Apr, 67	103	1	3- 7. Jan, 77	227	5
14.	14-15. Feb, 19	137	2	15-16. Feb, 78	227	2
15.	2- 5. Mar, 70	193	4	23-27. Feb, 79	178	5
16.	6- 9. May, 72	198	4	22-27. Jan, 80	182	6
17.	9-13. Dec, 74	222	5	8-12. Mar, 81	161	5
18.	29-31. Dec, 78	292	3	10-13. Jan, 82	230	4
19.	10-15. Apr, 79	259	6	12-15. Mar, 83	321	4
20.	12-16. Apr, 84	166	5	9-12. Jan, 84	141	4

	Date	Amount (mm)	Duration (day)	Station
1.	10-11, Dec, 82	83	2	Semantok
2.	18-19, Dec, 82	95	2	Semantok
3.	25-27, Feb, 83	93	3	Semantok
4.	26-30, Jan, 84	137	5	Semantok
5.	1-4 , Feb, 84	195	4	Semantok
6.	5-7 , Feb, 83	159	3	Ngrambek
7.	11-14, Feb, 83	149	4	Ngrambek
8.	25-27, Feb, 83	124	3	Ngrambek
9.	25-26, Mar, 83	160	2	Ngrambek
10.	11-13, Nov, 83	166	3	Ngrambek
11.	27, Jan, 81	103	1	Ngluju
12.	25-26, Sep, 81	95	2	Ngluju
13.	4-8 , Feb, 82	157	5	Ngluju
14.	3-7 , Mar, 82	170	5	Ngluju
15.	30-4 , Feb, 84	214	6	Ngluju

Table 2.3.3 THIESEN'S COEFFICIENT FOR ESTIMATION OF BASIN MEAN HOURLY RAINFALL

Sub Basin	RAINFALL STATION											
	Sawa-wan	Leng-kong	Kerto-sono	Kali Bening	Bulak mojo	Ngli-man	Seman-tok	Pace	Kali Mati	Ngluyu	Gema-rang	Tunglur
1	0.069	0	0	0.459	0	0.064	0	0	0	0	0.089	0.319
2	0	0	0	0.767	0	0	0	0	0	0	0.052	0.181
3	0	0	0	0.783	0	0	0	0	0	0	0	0.217
4	0	0	0	0.270	0.059	0	0.671	0	0	0	0	0
5	0	0	0	0	0.078	0	0.709	0	0	0.213	0	0
6	0	0	0	0	0	0	0	0	0	1.000	0	0
7	0	0	0	0	0	0	0.652	0	0.087	0.261	0	0
8	0.484	0	0	0	0	0.359	0	0.018	0	0	0	0.139
9	0.121	0	0	0	0	0.268	0	0.611	0	0	0	0
10	0	0	0	0	0	0.156	0	0.638	0.206	0	0	0
11	0	0	0	0	0	0.058	0	0.166	0.776	0	0	0
12	0.294	0	0	0	0	0.631	0	0	0	0	0	0.075
13	0	0	0	0	0.289	0	0	0.714	0	0	0	0
14	0	0	0	0	0.791	0	0	0.024	0.185	0	0	0
15	0	0	0	0	0.345	0	0	0.576	0.082	0	0	0
16	0	0	0	0	0	0	0	0.094	0.906	0	0	0
17	0.106	0	0	0.164	0.102	0.009	0	0.233	0	0	0	0.386
18	0	0	0	0.168	0.832	0	0	0	0	0	0	0
19	0	0	0	0	0.683	0	0.061	0	0.256	0	0	0
20	0	0.009	0	0	0	0	0.696	0	0.184	0.111	0	0
21	0	0.855	0	0	0	0	0.019	0	0.042	0.084	0	0
22	0	0.771	0	0	0	0	0	0	0	0.229	0	0
23	0	0.183	0.276	0	0	0	0	0	0.540	0	0	0
24	0	0	0	0	0.050	0	0	0.700	0	0	0	0.250
25	0	0	0	0	0	0	0	0	1.000	0	0	0
26	0	0	0	0	0	0	0	0	1.000	0	0	0

Table 2.3.4 THIESEN'S COEFFICIENT FOR ESTIMATION OF BASIN MEAN DAILY RAINFALL

	BASE POINT NO.									
Station	1	2	3	4	5	6	7	8	9	10
Ked. Rejo	0.403	0.321	0.146	0.112	0.0	0.0	0.018	0.0	0.0	0.057
Sawahan	0.597	0.273	0.193	0.147	0.0	0.094	0.318	0.618	0.344	0.430
Matokan	0.0	0.352	0.148	0.124	0.0	0.0	0.0	0.0	0.0	0.0
Nganjuk	0.0	0.027	0.064	0.049	0.002	0.089	0.092	0.0	0.318	0.064
Kacangan	0.0	0.0	0.103	0.078	0.131	0.113	0.177	0.051	0.091	0.295
Klodan	0.0	0.0	0.147	0.112	0.389	0.312	0.253	0.325	0.181	0.129
Tretes	0.0	0.027	0.033	0.055	0.0	0.0	0.005	0.0	0.0	0.017
Jati	0.0	0.0	0.090	0.069	0.241	0.192	0.156	0.0	0.051	0.0
Mrican	0.0	0.0	0.077	0.058	0.237	0.160	0.130	0.0	0.0	0.0
Bangle	0.0	0.0	0.0	0.080	0.0	0.0	0.0	0.0	0.0	0.0
Lengkong	0.0	0.0	0.0	0.048	0.0	0.0	0.0	0.0	0.015	0.009
Warujayeng	0.0	0.0	0.0	0.028	0.0	0.040	0.035	0.0	0.0	0.0
Kertosono	0.0	0.0	0.0	0.039	0.0	0.0	0.0	0.0	0.0	0.0
Catchment Area (Km^2)	212	490	1176	1538	392	572	684	79	141	112

Note : Base Point

1 : Ngudikan

2 : K. Widas before the confluence with K. Kedungsoko

3 : K. Widas after the confluence with K. Kedungsoko

4 : K. Widas before the confluence with K. Brantas

5 : K. Kedungsoko before the confluence with K. Kuncir

6 : K. Kedungsoko before the confluence with K. Ulo

7 : K. Kedungsoko before the confluence with K. Widas

8 : Kuncir flood diversion

9 : K. Kuncir before the confluence with K. Kedungsoko

10 : K. Ulo before the confluence with K. Kedungsoko

Table 2.3.5 ANNUAL MAXIMUM BASIN MEAN RAINFALL (1/6)

Unit : mm

NGUDIKAN

YEAR	1-DAY	2-DAY	3-DAY	4-DAY	5-DAY	6-DAY
1950	JUN. 23 72.	FEB. 20 84.	FEB. 20 105.	FEB. 9 146.	FEB. 8 172.	FEB. 8 174.
1951	MAR. 6 93.	MAR. 6 102.	FEB. 18 111.	FEB. 18 135.	FEB. 18 145.	FEB. 18 148.
1952	DEC. 15 66.	DEC. 15 106.	DEC. 15 123.	DEC. 15 161.	DEC. 15 189.	DEC. 15 223.
1953	APR. 21 72.	MAY 4 103.	APR. 21 137.	APR. 21 151.	MAY 1 186.	APR. 30 228.
1954	NOV. 1 63.	NOV. 1 105.	OCT. 31 113.	OCT. 31 119.	DEC. 9 134.	DEC. 9 142.
1955	FEB. 9 88.	FEB. 9 103.	MAR. 30 134.	MAR. 29 173.	MAR. 28 177.	MAR. 27 208.
1956	FEB. 4 56.	JUN. 4 75.	JUN. 4 114.	DEC. 10 117.	JUN. 1 142.	JUN. 1 180.
1957	APR. 29 56.	JAN. 26 76.	JAN. 25 95.	JAN. 24 114.	JAN. 24 129.	JAN. 27 150.
1958	DEC. 31 90.	APR. 11 106.	DEC. 29 142.	FEB. 8 149.	FEB. 7 177.	DEC. 26 210.
1959	DEC. 7 82.	JAN. 6 102.	JAN. 5 135.	FEB. 9 154.	FEB. 8 199.	FEB. 8 212.
1960	JAN. 1 106.	JAN. 1 106.	JAN. 31 137.	JAN. 8 147.	JAN. 7 153.	JAN. 28 163.
1961	APR. 13 59.	FEB. 18 65.	APR. 11 98.	APR. 10 124.	APR. 9 136.	APR. 8 146.
1962	JAN. 23 72.	JAN. 22 140.	JAN. 21 161.	JAN. 20 177.	JAN. 22 212.	JAN. 21 233.
1963	FEB. 3 86.	DEC. 30 95.	FEB. 18 106.	JAN. 13 124.	JAN. 13 144.	JAN. 13 165.
1964	JAN. 12 110.	NOV. 9 132.	NOV. 9 143.	NOV. 8 150.	NOV. 9 158.	NOV. 10 169.
1965	NOV. 29 58.	DEC. 22 66.	DEC. 22 79.	DEC. 22 108.	DEC. 21 120.	DEC. 21 120.
1966	JAN. 29 81.	JAN. 28 129.	JAN. 28 144.	JAN. 28 152.	JAN. 26 165.	JAN. 26 173.
1967	DEC. 2 87.	DEC. 2 104.	DEC. 1 117.	FEB. 23 120.	FEB. 19 140.	FEB. 19 161.
1968	MAR. 26 69.	MAR. 17 114.	MAR. 25 132.	MAR. 29 156.	MAR. 26 206.	MAR. 25 233.
1969	JAN. 12 89.	FEB. 14 129.	FEB. 14 142.	JAN. 20 156.	JAN. 20 188.	JAN. 19 218.
1970	MAY 23 46.	MAR. 6 81.	FEB. 5 108.	MAR. 6 130.	MAR. 6 144.	MAR. 6 150.
1971	FEB. 5 72.	MAR. 16 91.	FEB. 5 104.	FEB. 5 125.	FEB. 5 143.	FEB. 5 158.
1972	FEB. 11 74.	MAR. 22 113.	MAR. 22 145.	MAR. 22 156.	MAR. 22 188.	MAR. 19 213.
1973	MAR. 8 57.	MAR. 8 73.	APR. 25 108.	MAR. 11 127.	MAR. 8 130.	MAR. 8 165.
1974	FEB. 13 63.	DEC. 10 74.	DEC. 9 113.	FEB. 27 124.	FEB. 26 133.	FEB. 27 161.
1975	OCT. 24 72.	APR. 18 91.	MAR. 29 123.	MAR. 29 146.	MAR. 29 162.	MAR. 29 174.
1976	MAR. 9 75.	MAR. 9 122.	MAR. 8 125.	MAR. 8 125.	NOV. 21 133.	JAN. 1 154.
1977	JAN. 4 89.	JAN. 4 138.	JAN. 3 170.	JAN. 3 182.	JAN. 3 194.	FEB. 19 207.
1978	FEB. 15 100.	FEB. 15 140.	FEB. 13 162.	FEB. 13 201.	FEB. 12 211.	FEB. 11 221.
1979	APR. 24 89.	FEB. 24 100.	APR. 13 131.	APR. 24 160.	APR. 12 163.	FEB. 22 171.
1980	JAN. 22 64.	JAN. 21 85.	JAN. 21 96.	JAN. 21 111.	JAN. 21 121.	JAN. 17 158.
1981	DEC. 10 66.	DEC. 9 68.	JAN. 26 78.	JAN. 25 96.	MAR. 2 104.	MAR. 4 114.
1982	DEC. 26 66.	MAR. 12 92.	JAN. 11 130.	JAN. 10 163.	MAR. 9 179.	MAR. 9 193.
1983	MAR. 12 76.	MAR. 14 114.	MAR. 12 147.	MAR. 12 211.	MAR. 11 211.	MAR. 12 259.

K.WIDAS BEFORE CONFLUENCE WITH K.KEDUNGSOKO

YEAR	1-DAY	2-DAY	3-DAY	4-DAY	5-DAY	6-DAY
1950	JUN. 23 75.	MAR. 30 88.	FEB. 8 94.	FEB. 9 140.	FEB. 8 165.	FEB. 7 170.
1951	FEB. 18 96.	FEB. 18 106.	FEB. 18 122.	FEB. 18 137.	FEB. 18 147.	DEC. 17 151.
1952	DEC. 20 54.	DEC. 19 86.	DEC. 18 113.	DEC. 17 137.	DEC. 16 163.	DEC. 15 203.
1953	APR. 23 85.	FEB. 27 114.	APR. 21 160.	APR. 21 178.	APR. 20 178.	APR. 30 185.
1954	NOV. 1 51.	NOV. 1 79.	DEC. 9 90.	DEC. 9 111.	DEC. 9 135.	DEC. 9 141.
1955	FEB. 9 65.	MAR. 30 93.	MAR. 30 137.	MAR. 29 161.	MAR. 28 166.	MAR. 27 193.
1956	MAR. 8 92.	MAR. 8 131.	MAR. 7 135.	MAR. 8 156.	MAR. 8 197.	MAR. 8 203.
1957	JAN. 22 95.	JAN. 21 121.	JAN. 21 136.	JAN. 21 146.	JAN. 21 161.	JAN. 22 196.
1958	APR. 11 51.	APR. 11 91.	FEB. 7 105.	FEB. 6 119.	MAR. 28 145.	MAR. 27 160.
1959	FEB. 20 60.	JAN. 6 105.	JAN. 5 121.	FEB. 9 151.	FEB. 8 179.	FEB. 8 189.
1960	JAN. 1 66.	JAN. 1 76.	JAN. 1 88.	JAN. 8 100.	MAR. 1 117.	MAR. 1 128.
1961	APR. 11 64.	APR. 10 76.	APR. 11 94.	APR. 10 106.	APR. 9 114.	APR. 8 119.
1962	APR. 30 59.	NOV. 2 95.	NOV. 2 134.	NOV. 2 156.	NOV. 2 176.	NOV. 2 188.
1963	JAN. 3 89.	JAN. 3 102.	JAN. 1 121.	JAN. 1 134.	FEB. 18 138.	FEB. 17 149.
1964	NOV. 10 85.	NOV. 9 113.	NOV. 9 120.	NOV. 8 123.	MAR. 1 130.	MAR. 1 144.
1965	DEC. 17 72.	DEC. 17 84.	DEC. 22 93.	DEC. 14 120.	DEC. 13 154.	DEC. 13 165.
1966	FEB. 15 85.	FEB. 14 142.	FEB. 13 155.	FEB. 12 179.	FEB. 12 184.	FEB. 11 189.
1967	DEC. 2 67.	DEC. 1 84.	DEC. 1 94.	DEC. 1 96.	JAN. 10 114.	JAN. 9 132.
1968	MAR. 5 65.	MAR. 4 98.	DEC. 15 110.	MAR. 4 138.	DEC. 14 156.	MAR. 25 177.
1969	FEB. 14 53.	FEB. 14 90.	JAN. 21 118.	JAN. 21 144.	JAN. 20 162.	JAN. 19 177.
1970	FEB. 6 59.	FEB. 6 105.	FEB. 5 126.	FEB. 4 161.	FEB. 4 177.	FEB. 4 184.
1971	FEB. 5 42.	MAR. 30 58.	NOV. 18 73.	NOV. 17 90.	JAN. 12 99.	NOV. 15 112.
1972	MAY 6 41.	MAY 6 78.	MAY 6 108.	MAY 5 114.	MAY 4 125.	MAY 3 126.
1973	FEB. 12 59.	FEB. 11 102.	FEB. 10 123.	FEB. 11 157.	FEB. 10 177.	FEB. 11 184.
1974	FEB. 27 60.	DEC. 10 101.	DEC. 9 119.	FEB. 27 127.	FEB. 26 137.	FEB. 27 152.
1975	APR. 18 65.	APR. 18 100.	APR. 18 135.	APR. 17 149.	APR. 16 160.	MAR. 5 174.
1976	OCT. 17 43.	NOV. 21 79.	NOV. 21 106.	NOV. 20 130.	NOV. 20 132.	NOV. 20 144.
1977	MAR. 26 76.	JAN. 4 108.	JAN. 3 132.	JAN. 3 137.	JAN. 3 145.	JAN. 3 165.
1978	DEC. 31 83.	DEC. 30 123.	DEC. 29 155.	DEC. 28 172.	DEC. 27 201.	DEC. 26 207.
1979	FEB. 25 56.	APR. 15 83.	FEB. 23 125.	FEB. 22 152.	APR. 12 160.	FEB. 22 163.
1980	JAN. 13 52.	JAN. 21 63.	DEC. 3 77.	DEC. 3 95.	DEC. 2 110.	JAN. 17 131.
1981	DEC. 10 53.	MAY 9 60.	NOV. 22 67.	DEC. 7 74.	JAN. 24 82.	NOV. 22 92.
1982	DEC. 26 71.	MAR. 12 101.	MAR. 12 123.	MAR. 10 146.	MAR. 9 170.	MAR. 9 192.
1983	MAR. 12 58.	FEB. 6 74.	JAN. 31 96.	MAR. 12 136.	MAR. 11 148.	MAR. 12 166.

Note; 1-day to 6-day means rainfall duration.

Table 2.3.5 ANNUAL MAXIMUM BASIN MEAN RAINFALL (2/6)

Unit : mm

K.WIDAS AFTER CONFLUENCE WITH K.KEDUNGSOKO

YEAR	1-DAY	2-DAY	3-DAY	4-DAY	5-DAY	6-DAY
1950	MAR. 24 55.	OCT. 31 68.	FEB. 10 80.	FEB. 9 113.	FEB. 8 132.	FEB. 8 140.
1951	FEB. 18 77.	FEB. 18 89.	FEB. 18 102.	FEB. 18 121.	FEB. 18 127.	FEB. 18 129.
1952	DEC. 15 44.	DEC. 15 81.	DEC. 15 103.	DEC. 15 126.	DEC. 15 151.	DEC. 15 190.
1953	FEB. 28 61.	FEB. 27 91.	APR. 21 104.	APR. 21 130.	APR. 30 145.	APR. 30 175.
1954	DEC. 9 44.	NOV. 1 80.	NOV. 1 90.	DEC. 9 107.	DEC. 9 120.	DEC. 9 132.
1955	FEB. 9 47.	FEB. 9 81.	MAR. 30 112.	MAR. 29 139.	MAR. 28 141.	MAR. 27 162.
1956	DEC. 2 52.	DEC. 2 80.	DEC. 1 94.	MAR. 8 115.	MAR. 8 139.	MAR. 8 145.
1957	JAN. 22 58.	JAN. 22 76.	JAN. 21 92.	JAN. 22 114.	JAN. 22 135.	JAN. 22 169.
1958	APR. 11 70.	APR. 11 109.	APR. 10 118.	APR. 9 123.	MAR. 28 145.	DEC. 26 158.
1959	JAN. 7 58.	JAN. 7 94.	JAN. 6 127.	JAN. 5 148.	FEB. 8 187.	JAN. 5 198.
1960	JAN. 1 73.	JAN. 1 84.	JAN. 1 96.	JAN. 8 108.	MAR. 1 115.	MAR. 1 128.
1961	APR. 13 46.	FEB. 18 67.	FEB. 17 94.	FEB. 16 100.	APR. 9 110.	APR. 8 115.
1962	APR. 30 63.	JAN. 22 92.	JAN. 21 126.	JAN. 20 140.	JAN. 19 168.	JAN. 18 187.
1963	FEB. 3 58.	DEC. 30 70.	JAN. 1 80.	FEB. 18 99.	FEB. 17 114.	FEB. 18 125.
1964	NOV. 10 71.	MAR. 2 98.	MAR. 1 116.	MAR. 2 126.	MAR. 2 151.	MAR. 1 169.
1965	DEC. 17 49.	DEC. 22 70.	DEC. 22 85.	DEC. 22 99.	DEC. 13 106.	DEC. 17 122.
1966	MAR. 14 60.	FEB. 14 91.	FEB. 13 107.	FEB. 12 124.	FEB. 12 138.	FEB. 11 144.
1967	DEC. 2 59.	APR. 1 84.	MAR. 31 93.	MAR. 30 115.	MAR. 29 136.	MAR. 28 144.
1968	MAR. 5 56.	MAR. 4 95.	MAR. 4 113.	MAR. 4 139.	MAR. 4 153.	MAR. 25 176.
1969	MAR. 17 51.	FEB. 14 72.	JAN. 22 80.	JAN. 21 105.	JAN. 20 116.	JAN. 19 127.
1970	FEB. 7 59.	FEB. 6 100.	FEB. 5 128.	FEB. 4 156.	FEB. 4 175.	FEB. 4 181.
1971	FEB. 5 53.	FEB. 4 63.	FEB. 5 84.	FEB. 5 102.	FEB. 5 128.	FEB. 4 138.
1972	MAY 6 40.	MAY 6 73.	MAY 6 99.	DEC. 13 110.	DEC. 13 125.	DEC. 11 134.
1973	MAR. 24 42.	FEB. 11 78.	FEB. 10 100.	FEB. 11 111.	FEB. 10 133.	MAR. 23 139.
1974	FEB. 13 44.	DEC. 10 83.	DEC. 9 97.	DEC. 10 112.	DEC. 9 125.	DEC. 6 142.
1975	OCT. 24 67.	OCT. 23 79.	JAN. 26 96.	JAN. 28 120.	JAN. 28 145.	JAN. 27 154.
1976	NOV. 21 52.	NOV. 21 85.	MAR. 9 103.	MAR. 1 115.	FEB. 28 136.	FEB. 28 148.
1977	MAR. 26 61.	JAN. 4 94.	JAN. 3 107.	JAN. 18 112.	JAN. 18 127.	JAN. 3 135.
1978	DEC. 31 60.	FEB. 15 94.	DEC. 29 114.	DEC. 28 138.	DEC. 27 156.	DEC. 26 163.
1979	FEB. 25 62.	FEB. 24 83.	FEB. 23 111.	FEB. 22 126.	APR. 12 159.	APR. 11 167.
1980	JAN. 17 58.	JAN. 17 74.	JAN. 17 93.	NOV. 26 104.	NOV. 26 122.	JAN. 17 165.
1981	DEC. 10 57.	DEC. 10 63.	JAN. 26 72.	MAR. 9 92.	MAR. 8 100.	DEC. 10 108.
1982	DEC. 26 54.	MAR. 12 75.	MAR. 11 101.	MAR. 10 125.	MAR. 9 154.	MAR. 9 174.
1983	MAY 4 59.	MAR. 11 76.	FEB. 26 115.	MAR. 12 139.	MAR. 11 158.	MAR. 12 184.

CONFLUENCE WITH K.BRANTAS

YEAR	1-DAY	2-DAY	3-DAY	4-DAY	5-DAY	6-DAY
1950	MAR. 24 47.	FEB. 11 64.	FEB. 10 83.	FEB. 9 118.	FEB. 8 136.	FEB. 7 146.
1951	FEB. 18 84.	FEB. 18 95.	FEB. 18 107.	FEB. 18 127.	FEB. 18 131.	DEC. 17 135.
1952	MAR. 1 42.	DEC. 15 71.	DEC. 15 92.	DEC. 15 112.	DEC. 15 134.	DEC. 15 169.
1953	FEB. 28 57.	FEB. 27 97.	FEB. 26 106.	APR. 21 120.	APR. 30 140.	APR. 30 169.
1954	DEC. 9 42.	NOV. 1 74.	DEC. 9 86.	JAN. 4 113.	JAN. 6 119.	DEC. 9 126.
1955	JAN. 16 46.	FEB. 9 77.	MAR. 30 103.	MAR. 29 125.	MAR. 28 128.	MAR. 27 145.
1956	MAR. 8 53.	MAR. 8 80.	DEC. 10 92.	MAR. 8 117.	MAR. 8 139.	MAR. 7 150.
1957	JAN. 22 59.	JAN. 22 77.	JAN. 21 91.	JAN. 22 108.	JAN. 22 127.	JAN. 22 156.
1958	MAR. 15 64.	APR. 11 93.	APR. 10 101.	MAR. 28 113.	MAR. 28 137.	MAR. 27 144.
1959	JAN. 3 52.	FEB. 20 90.	JAN. 6 112.	FEB. 9 141.	FEB. 8 172.	JAN. 3 183.
1960	JAN. 1 71.	JAN. 1 82.	JAN. 1 94.	MAR. 1 105.	MAR. 1 121.	MAR. 1 132.
1961	APR. 11 40.	FEB. 17 65.	FEB. 17 89.	FEB. 16 101.	FEB. 16 105.	FEB. 14 110.
1962	APR. 30 66.	JAN. 21 81.	JAN. 21 112.	JAN. 19 125.	JAN. 19 155.	JAN. 18 174.
1963	FEB. 3 53.	DEC. 30 59.	MAR. 2 74.	FEB. 18 93.	FEB. 17 107.	FEB. 27 116.
1964	NOV. 10 65.	MAR. 2 100.	MAR. 1 116.	MAR. 2 124.	MAR. 2 145.	MAR. 1 161.
1965	DEC. 17 45.	DEC. 22 64.	DEC. 22 80.	DEC. 22 94.	DEC. 13 108.	DEC. 17 118.
1966	FEB. 15 63.	FEB. 14 107.	FEB. 13 123.	FEB. 12 146.	FEB. 12 157.	FEB. 11 164.
1967	DEC. 2 53.	DEC. 1 75.	DEC. 1 83.	MAR. 30 99.	MAR. 29 125.	MAR. 28 145.
1968	MAR. 5 54.	MAR. 4 86.	MAR. 4 102.	MAR. 4 123.	MAR. 4 138.	MAR. 25 167.
1969	MAR. 17 53.	FEB. 14 69.	FEB. 14 75.	JAN. 21 90.	FEB. 14 114.	FEB. 14 123.
1970	FEB. 7 62.	FEB. 6 103.	FEB. 5 132.	FEB. 4 164.	FEB. 4 184.	FEB. 4 192.
1971	FEB. 5 44.	NOV. 19 62.	NOV. 18 81.	NOV. 17 92.	FEB. 5 113.	FEB. 4 121.
1972	MAY 6 38.	MAY 6 70.	MAY 6 91.	DEC. 13 100.	DEC. 13 113.	DEC. 11 122.
1973	MAR. 24 38.	FEB. 11 69.	FEB. 10 87.	FEB. 11 103.	FEB. 10 122.	FEB. 9 127.
1974	DEC. 11 47.	DEC. 10 92.	DEC. 9 103.	DEC. 10 120.	DEC. 9 130.	DEC. 6 140.
1975	OCT. 24 54.	APR. 18 75.	APR. 18 93.	APR. 17 111.	JAN. 28 135.	JAN. 27 143.
1976	MAR. 1 47.	MAR. 9 82.	MAR. 9 99.	MAR. 8 109.	FEB. 28 130.	FEB. 28 141.
1977	MAR. 26 62.	JAN. 4 84.	JAN. 3 94.	MAR. 26 113.	MAR. 26 125.	MAR. 25 137.
1978	DEC. 31 50.	FEB. 15 79.	DEC. 29 107.	DEC. 28 133.	DEC. 27 149.	DEC. 26 156.
1979	FEB. 25 54.	APR. 15 88.	FEB. 23 107.	APR. 13 129.	APR. 12 163.	APR. 11 171.
1980	JAN. 22 47.	DEC. 3 74.	DEC. 3 98.	DEC. 2 112.	DEC. 1 126.	JAN. 17 148.
1981	DEC. 10 58.	DEC. 10 63.	MAR. 9 76.	MAR. 9 93.	MAR. 8 101.	DEC. 10 111.
1982	DEC. 26 62.	DEC. 25 67.	DEC. 24 90.	MAR. 11 112.	MAR. 10 134.	MAR. 9 157.
1983	MAR. 20 52.	FEB. 6 69.	FEB. 26 97.	MAR. 12 117.	MAR. 11 132.	MAR. 12 152.

Note; 1-day to 6-day means rainfall duration.

Table 2.3.5 ANNUAL MAXIMUM BASIN MEAN RAINFALL (3/6)

Unit : mm

K.KEDUNGSOKO BEFORE CONFLUENCE WITH K.KUNCIR

YEAR	1-DAY	2-DAY	3-DAY	4-DAY	5-DAY	6-DAY
1950	NOV. 26 56.	NOV. 26 78.	NOV. 25 86.	NOV. 24 93.	NOV. 23 100.	NOV. 21 113.
1951	JUN. 4 62.	JAN. 5 78.	JAN. 5 105.	JAN. 5 136.	JAN. 5 152.	JAN. 5 159.
1952	FEB. 17 59.	FEB. 17 90.	DEC. 15 110.	DEC. 15 128.	DEC. 15 148.	DEC. 15 171.
1953	APR. 30 60.	APR. 30 101.	APR. 30 107.	APR. 30 125.	APR. 30 145.	APR. 30 158.
1954	DEC. 9 58.	NOV. 1 80.	NOV. 1 95.	DEC. 9 107.	DEC. 9 115.	DEC. 9 128.
1955	FEB. 10 58.	FEB. 9 86.	FEB. 9 95.	MAR. 29 113.	FEB. 9 114.	MAR. 26 136.
1956	JUN. 1 66.	MAY 31 94.	MAY 30 100.	MAY 29 108.	FEB. 4 124.	FEB. 4 143.
1957	MAR. 4 59.	MAR. 4 79.	MAR. 2 113.	MAR. 2 134.	MAR. 2 152.	FEB. 27 169.
1958	APR. 11 90.	APR. 11 143.	APR. 10 148.	APR. 9 155.	APR. 11 161.	APR. 7 182.
1959	JAN. 8 77.	JAN. 7 141.	JAN. 7 180.	JAN. 7 211.	JAN. 6 233.	JAN. 5 257.
1960	APR. 18 82.	APR. 17 101.	APR. 16 118.	APR. 15 122.	FEB. 13 135.	FEB. 12 140.
1961	APR. 1 55.	MAR. 31 72.	JAN. 16 92.	JAN. 17 105.	JAN. 17 107.	JAN. 15 110.
1962	FEB. 21 79.	JAN. 21 99.	JAN. 21 134.	JAN. 20 152.	JAN. 19 180.	JAN. 18 208.
1963	MAR. 17 64.	MAR. 3 87.	MAR. 3 108.	MAR. 15 120.	MAR. 13 135.	MAR. 13 150.
1964	APR. 17 68.	MAR. 2 106.	MAR. 1 117.	MAR. 2 138.	MAR. 2 173.	MAR. 1 184.
1965	FEB. 4 57.	FEB. 4 80.	FEB. 3 100.	FEB. 3 100.	FEB. 3 114.	JAN. 31 117.
1966	MAR. 14 73.	MAR. 14 92.	MAR. 14 110.	DEC. 5 122.	DEC. 5 152.	DEC. 4 156.
1967	FEB. 26 70.	APR. 1 120.	MAR. 31 143.	MAR. 30 186.	MAR. 29 203.	MAR. 29 218.
1968	DEC. 25 51.	MAY 4 88.	MAR. 4 121.	MAR. 4 137.	MAR. 4 162.	MAR. 3 170.
1969	APR. 13 52.	APR. 9 82.	APR. 8 100.	DEC. 15 118.	APR. 9 146.	APR. 8 164.
1970	FEB. 7 68.	FEB. 6 98.	FEB. 5 131.	FEB. 4 159.	FEB. 4 180.	FEB. 4 186.
1971	FEB. 5 65.	MAY 9 87.	FEB. 5 104.	FEB. 5 130.	FEB. 5 172.	FEB. 4 186.
1972	MAR. 26 60.	MAR. 7 75.	MAR. 7 97.	DEC. 14 120.	DEC. 13 141.	JAN. 2 150.
1973	MAY 20 52.	MAR. 24 75.	MAY 18 94.	MAR. 24 100.	MAR. 24 138.	MAR. 24 156.
1974	FEB. 13 59.	DEC. 6 72.	JAN. 11 96.	JAN. 11 113.	JAN. 11 127.	JAN. 11 141.
1975	OCT. 24 88.	OCT. 23 111.	MAR. 29 124.	JAN. 28 157.	JAN. 28 171.	JAN. 27 177.
1976	MAR. 1 67.	FEB. 29 97.	MAR. 1 132.	FEB. 29 161.	FEB. 29 173.	FEB. 28 178.
1977	JAN. 4 53.	JAN. 19 87.	JAN. 18 115.	JAN. 18 129.	JAN. 18 146.	JAN. 17 150.
1978	FEB. 15 58.	FEB. 15 105.	FEB. 15 119.	FEB. 13 135.	FEB. 13 149.	FEB. 12 162.
1979	FEB. 25 69.	FEB. 25 92.	JAN. 10 111.	FEB. 24 119.	APR. 12 147.	JAN. 10 177.
1980	JAN. 17 92.	JAN. 17 124.	JAN. 17 141.	JAN. 17 151.	JAN. 16 152.	JAN. 17 217.
1981	APR. 29 76.	DEC. 10 85.	MAR. 10 105.	MAR. 9 121.	MAR. 8 131.	MAR. 6 146.
1982	JAN. 26 61.	JAN. 26 87.	JAN. 25 112.	JAN. 24 137.	JAN. 23 158.	JAN. 23 165.
1983	MAY 4 63.	FEB. 27 95.	FEB. 26 123.	FEB. 25 136.	FEB. 24 165.	APR. 29 182.

Note; 1-day to 6-day means rainfall duration.

Table 2.3.5 ANNUAL MAXIMUM BASIN MEAN RAINFALL (4/6)

Kedungsoko before confluence with K. Ulo

Unit : mm

YEAR	1-DAY	2-DAY	3-DAY	4-DAY	5-DAY	6-DAY
1950	MAR. 24 54.	OCT. 31 85.	OCT. 30 85.	OCT. 31 104.	OCT. 31 107.	FEB. 8 117.
1951	FEB. 18 59.	JAN. 5 77.	JAN. 5 96.	JAN. 5 125.	JAN. 5 141.	JAN. 5 147.
1952	FEB. 17 52.	DEC. 15 91.	DEC. 15 114.	DEC. 15 132.	DEC. 15 153.	DEC. 15 180.
1953	APR. 30 55.	APR. 30 98.	APR. 29 109.	APR. 30 121.	APR. 30 146.	APR. 30 162.
1954	DEC. 9 54.	NOV. 1 82.	NOV. 1 96.	JAN. 4 103.	APR. 12 114.	APR. 11 126.
1955	FEB. 10 51.	FEB. 9 84.	MAR. 29 98.	MAR. 29 125.	MAR. 28 126.	MAR. 27 139.
1956	JUN. 1 61.	MAY 31 84.	MAY 30 90.	MAY 29 98.	FEB. 4 122.	FEB. 4 142.
1957	MAR. 4 51.	MAR. 4 70.	MAR. 2 98.	MAR. 2 116.	MAR. 2 134.	FEB. 27 158.
1958	APR. 11 87.	APR. 11 131.	APR. 10 140.	APR. 9 147.	APR. 8 153.	APR. 7 175.
1959	JAN. 7 64.	JAN. 7 128.	JAN. 7 161.	JAN. 7 195.	JAN. 6 214.	JAN. 5 239.
1960	APR. 18 77.	APR. 17 95.	APR. 16 110.	APR. 15 113.	FEB. 13 129.	JAN. 8 137.
1961	DEC. 16 49.	MAR. 31 67.	FEB. 17 95.	FEB. 17 100.	DEC. 12 103.	FEB. 16 105.
1962	FEB. 21 77.	JAN. 21 99.	JAN. 21 140.	JAN. 20 157.	JAN. 19 183.	JAN. 18 209.
1963	MAR. 17 64.	MAR. 3 79.	MAR. 3 98.	MAR. 14 113.	MAR. 13 126.	MAR. 13 140.
1964	MAR. 2 66.	MAR. 2 112.	MAR. 1 127.	MAR. 2 142.	MAR. 2 178.	MAR. 1 193.
1965	FEB. 4 50.	FEB. 4 70.	FEB. 3 88.	FEB. 2 91.	FEB. 1 103.	JAN. 31 108.
1966	MAR. 14 74.	MAR. 14 89.	MAR. 14 108.	MAR. 14 115.	DEC. 5 134.	DEC. 4 138.
1967	FEB. 26 58.	APR. 1 114.	MAR. 31 132.	MAR. 30 167.	MAR. 29 186.	MAR. 29 199.
1968	MAY 4 46.	MAY 4 85.	MAR. 4 113.	MAR. 4 132.	MAR. 4 153.	MAR. 25 167.
1969	APR. 13 51.	APR. 9 71.	APR. 8 85.	DEC. 15 106.	APR. 9 135.	APR. 8 150.
1970	FEB. 7 68.	FEB. 6 96.	FEB. 5 129.	FEB. 4 152.	FEB. 4 172.	FEB. 4 177.
1971	FEB. 5 61.	MAY 9 82.	FEB. 5 98.	FEB. 5 122.	FEB. 5 158.	FEB. 4 172.
1972	MAR. 26 52.	MAR. 7 76.	MAR. 7 96.	DEC. 14 117.	DEC. 13 138.	JAN. 2 148.
1973	MAY 20 48.	MAR. 24 71.	MAR. 24 88.	MAR. 24 101.	MAR. 24 134.	MAR. 24 150.
1974	FEB. 13 57.	DEC. 10 69.	JAN. 11 85.	DEC. 10 109.	DEC. 10 121.	DEC. 6 140.
1975	OCT. 24 85.	OCT. 23 105.	MAR. 29 125.	JAN. 28 145.	JAN. 28 161.	JAN. 28 168.
1976	NOV. 21 61.	MAR. 9 96.	MAR. 1 124.	FEB. 29 149.	FEB. 29 162.	FEB. 28 172.
1977	JAN. 4 56.	JAN. 4 81.	JAN. 18 106.	JAN. 18 119.	JAN. 18 136.	JAN. 17 142.
1978	FEB. 15 62.	FEB. 15 113.	FEB. 15 126.	FEB. 13 147.	FEB. 12 160.	FEB. 12 173.
1979	FEB. 25 68.	FEB. 25 87.	APR. 24 107.	FEB. 24 120.	APR. 12 149.	JAN. 10 160.
1980	JAN. 17 82.	JAN. 17 109.	JAN. 17 127.	JAN. 17 135.	DEC. 20 138.	JAN. 17 199.
1981	APR. 29 68.	DEC. 10 76.	MAR. 10 95.	MAR. 9 117.	MAR. 8 126.	MAR. 6 138.
1982	FEB. 24 50.	JAN. 10 80.	JAN. 24 92.	JAN. 10 117.	JAN. 23 131.	MAR. 8 147.
1983	MAY 4 65.	FEB. 27 89.	FEB. 26 121.	FEB. 25 135.	FEB. 24 157.	MAR. 12 175.

Kedungsoko before confluence with K. Widas

YEAR	1-DAY	2-DAY	3-DAY	4-DAY	5-DAY	6-DAY
1950	MAR. 24 58.	OCT. 31 80.	OCT. 30 81.	OCT. 31 102.	FEB. 8 108.	FEB. 8 121.
1951	FEB. 18 63.	FEB. 18 77.	JAN. 5 92.	JAN. 5 117.	JAN. 5 134.	JAN. 5 139.
1952	MAR. 1 49.	DEC. 15 91.	DEC. 15 112.	DEC. 15 132.	DEC. 15 153.	DEC. 15 180.
1953	APR. 30 55.	APR. 30 99.	APR. 29 112.	APR. 30 121.	APR. 30 149.	APR. 30 167.
1954	DEC. 9 52.	NOV. 1 81.	NOV. 1 94.	JAN. 4 104.	JAN. 3 111.	DEC. 9 126.
1955	FEB. 10 45.	FEB. 9 79.	MAR. 29 94.	MAR. 29 122.	MAR. 28 123.	MAR. 27 139.
1956	JUN. 1 59.	MAY 31 80.	DEC. 1 89.	NOV. 30 96.	FEB. 4 120.	FEB. 4 138.
1957	MAR. 4 45.	MAR. 4 62.	MAR. 2 85.	MAR. 2 102.	FEB. 28 125.	JAN. 22 149.
1958	APR. 11 83.	APR. 11 122.	APR. 10 131.	APR. 9 138.	MAR. 28 144.	APR. 7 172.
1959	JAN. 7 62.	JAN. 7 116.	JAN. 7 145.	JAN. 7 180.	JAN. 6 198.	JAN. 5 223.
1960	JAN. 1 77.	APR. 17 90.	APR. 16 102.	JAN. 8 113.	FEB. 13 122.	JAN. 8 139.
1961	APR. 13 57.	FEB. 18 68.	FEB. 17 100.	FEB. 17 104.	FEB. 16 107.	APR. 8 111.
1962	FEB. 21 74.	JAN. 22 99.	JAN. 21 137.	JAN. 20 157.	JAN. 19 181.	JAN. 18 205.
1963	FEB. 3 63.	DEC. 30 75.	MAR. 15 91.	MAR. 14 106.	MAR. 14 119.	MAR. 13 130.
1964	MAR. 2 64.	MAR. 2 107.	MAR. 1 124.	MAR. 2 136.	MAR. 2 170.	MAR. 1 187.
1965	FEB. 4 47.	FEB. 4 66.	FEB. 3 84.	DEC. 22 93.	DEC. 21 101.	DEC. 22 108.
1966	MAR. 14 76.	MAR. 14 90.	MAR. 14 110.	MAR. 14 115.	DEC. 5 144.	DEC. 4 148.
1967	APR. 2 58.	APR. 1 107.	MAR. 31 122.	MAR. 30 153.	MAR. 29 172.	MAR. 29 187.
1968	MAR. 5 49.	MAR. 4 91.	MAR. 4 117.	MAR. 4 139.	MAR. 4 158.	MAR. 25 176.
1969	MAR. 17 50.	APR. 9 65.	APR. 8 78.	DEC. 15 102.	APR. 9 130.	APR. 8 143.
1970	FEB. 7 71.	FEB. 6 98.	FEB. 5 131.	FEB. 4 154.	FEB. 4 171.	FEB. 4 177.
1971	FEB. 5 60.	FEB. 4 73.	FEB. 5 98.	FEB. 5 122.	FEB. 5 155.	FEB. 4 168.
1972	MAR. 26 49.	MAR. 7 77.	DEC. 14 98.	DEC. 14 121.	DEC. 13 143.	DEC. 12 147.
1973	MAR. 24 46.	MAR. 24 76.	MAR. 24 95.	MAR. 24 110.	MAR. 24 142.	MAR. 24 158.
1974	FEB. 13 53.	DEC. 10 70.	DEC. 9 80.	DEC. 10 111.	DEC. 9 121.	DEC. 6 137.
1975	OCT. 24 84.	OCT. 23 102.	MAR. 29 117.	MAR. 29 136.	JAN. 28 151.	JAN. 28 157.
1976	NOV. 21 61.	MAR. 9 93.	MAR. 1 119.	FEB. 29 140.	FEB. 29 153.	FEB. 28 165.
1977	JAN. 4 55.	JAN. 4 82.	JAN. 18 104.	JAN. 18 118.	JAN. 18 134.	JAN. 17 140.
1978	FEB. 15 61.	FEB. 15 112.	FEB. 15 124.	FEB. 13 147.	FEB. 12 163.	FEB. 12 175.
1979	FEB. 25 67.	FEB. 24 85.	APR. 24 108.	APR. 24 122.	APR. 12 155.	APR. 11 166.
1980	JAN. 17 79.	JAN. 17 101.	JAN. 17 118.	JAN. 17 125.	NOV. 26 133.	JAN. 17 189.
1981	APR. 29 65.	DEC. 10 69.	MAR. 10 94.	MAR. 9 115.	MAR. 8 125.	MAR. 6 136.
1982	FEB. 24 49.	JAN. 10 77.	JAN. 10 91.	MAR. 9 119.	MAR. 9 144.	MAR. 8 166.
1983	MAY 4 67.	FEB. 27 91.	FEB. 26 130.	FEB. 25 144.	FEB. 24 168.	MAR. 12 195.

Note; 1-day to 6-day means rainfall duration.

Table 2.3.5 ANNUAL MAXIMUM BASIN MEAN RAINFALL (5/6)

Unit : mm

KUNCIR FLOOD DIVERSION

YEAR	1-DAY	2-DAY	3-DAY	4-DAY	5-DAY	6-DAY
1950	MAR. 24 64.	OCT. 31 77.	FEB. 10 83.	MAR. 21 136.	MAR. 20 145.	MAR. 21 151.
1951	MAR. 6 77.	JAN. 5 87.	DEC. 2 104.	JAN. 5 122.	JAN. 5 153.	MAR. 1 161.
1952	DEC. 15 86.	DEC. 15 141.	DEC. 15 171.	DEC. 15 199.	DEC. 15 223.	DEC. 15 254.
1953	MAY 1 76.	APR. 30 126.	APR. 29 147.	APR. 28 148.	APR. 30 196.	APR. 30 225.
1954	NOV. 2 77.	NOV. 1 142.	NOV. 1 151.	OCT. 31 158.	NOV. 1 168.	OCT. 31 175.
1955	FEB. 9 80.	FEB. 9 129.	MAR. 30 172.	MAR. 29 215.	MAR. 29 215.	MAR. 27 231.
1956	JUN. 1 89.	JUN. 1 110.	FEB. 2 115.	JUN. 1 145.	JUN. 1 192.	JUN. 1 225.
1957	MAR. 4 66.	JAN. 25 93.	MAR. 2 126.	MAR. 2 150.	MAR. 2 179.	MAR. 2 197.
1958	DEC. 31 117.	APR. 11 129.	DEC. 29 201.	DEC. 28 205.	DEC. 27 223.	DEC. 26 257.
1959	FEB. 12 108.	JAN. 7 164.	JAN. 7 199.	JAN. 7 248.	FEB. 8 277.	JAN. 5 306.
1960	JAN. 1 123.	JAN. 1 128.	JAN. 31 159.	JAN. 31 198.	JAN. 30 210.	JAN. 30 221.
1961	APR. 13 67.	MAR. 31 91.	FEB. 17 103.	APR. 10 122.	APR. 9 137.	APR. 8 148.
1962	JAN. 22 110.	JAN. 22 209.	JAN. 21 252.	JAN. 20 274.	JAN. 19 296.	JAN. 21 334.
1963	FEB. 3 107.	DEC. 30 112.	JAN. 16 134.	JAN. 13 157.	JAN. 13 186.	JAN. 13 227.
1964	APR. 17 127.	NOV. 10 135.	MAR. 1 151.	FEB. 29 159.	MAR. 1 204.	MAR. 1 228.
1965	NOV. 29 54.	DEC. 22 75.	DEC. 22 96.	DEC. 22 127.	DEC. 21 146.	DEC. 21 146.
1966	MAR. 16 86.	JAN. 28 109.	MAR. 14 131.	APR. 25 156.	APR. 25 164.	MAR. 11 171.
1967	APR. 2 74.	APR. 1 142.	MAR. 31 155.	FEB. 23 196.	MAR. 29 206.	FEB. 21 214.
1968	MAR. 10 71.	MAY 4 104.	APR. 1 133.	MAR. 24 156.	MAR. 26 193.	MAR. 25 231.
1969	JAN. 12 90.	FEB. 14 117.	FEB. 14 129.	APR. 6 137.	APR. 5 160.	JAN. 19 177.
1970	MAR. 7 66.	MAR. 6 99.	MAR. 6 124.	MAR. 6 144.	MAR. 6 157.	MAR. 3 168.
1971	FEB. 5 103.	FEB. 4 120.	FEB. 5 143.	FEB. 5 176.	FEB. 5 203.	FEB. 5 226.
1972	FEB. 11 90.	MAR. 22 110.	MAR. 22 138.	MAR. 6 166.	MAR. 22 187.	MAR. 19 208.
1973	MAR. 8 65.	DEC. 1 94.	MAR. 12 131.	MAR. 11 165.	MAR. 8 183.	MAR. 8 215.
1974	FEB. 13 107.	FEB. 13 112.	FEB. 13 140.	FEB. 13 164.	FEB. 13 183.	FEB. 13 193.
1975	OCT. 24 101.	OCT. 23 118.	MAR. 29 178.	MAR. 29 211.	MAR. 29 225.	MAR. 29 229.
1976	MAR. 9 96.	MAR. 9 140.	MAR. 8 146.	MAR. 7 154.	MAR. 6 159.	MAR. 5 179.
1977	FEB. 21 94.	JAN. 4 147.	JAN. 4 160.	FEB. 21 191.	FEB. 20 224.	FEB. 19 249.
1978	FEB. 15 146.	FEB. 15 205.	FEB. 15 222.	FEB. 13 277.	FEB. 13 294.	FEB. 11 305.
1979	APR. 24 117.	APR. 24 122.	APR. 24 175.	APR. 24 205.	APR. 24 206.	APR. 24 206.
1980	JAN. 17 101.	JAN. 17 125.	JAN. 17 139.	JAN. 17 145.	JAN. 22 162.	JAN. 17 243.
1981	FEB. 18 83.	DEC. 4 86.	MAR. 2 108.	MAR. 9 141.	MAR. 8 159.	MAR. 8 159.
1982	JAN. 11 81.	JAN. 10 138.	JAN. 10 148.	JAN. 10 194.	JAN. 10 200.	JAN. 10 231.
1983	MAR. 12 95.	MAR. 14 132.	MAR. 12 184.	MAR. 12 246.	MAR. 11 260.	MAR. 12 301.

K. Kuncir before the confluence with K. Kedungsoko

YEAR	1-DAY	2-DAY	3-DAY	4-DAY	5-DAY	6-DAY
1950	NOV. 1 72.	OCT. 31 118.	FEB. 10 120.	OCT. 31 142.	FEB. 8 168.	FEB. 8 178.
1951	FEB. 18 69.	FEB. 18 83.	FEB. 18 97.	FEB. 18 122.	FEB. 18 124.	JAN. 20 137.
1952	FEB. 2 60.	DEC. 15 105.	DEC. 15 130.	DEC. 15 153.	DEC. 15 175.	DEC. 15 213.
1953	FEB. 28 54.	APR. 30 92.	APR. 29 132.	APR. 29 134.	APR. 29 152.	APR. 29 192.
1954	JAN. 7 56.	NOV. 1 97.	NOV. 1 107.	JAN. 4 116.	JAN. 3 125.	MAR. 13 140.
1955	FEB. 9 49.	FEB. 9 87.	MAR. 30 119.	MAR. 29 157.	MAR. 28 158.	MAR. 27 169.
1956	JUN. 1 58.	DEC. 2 81.	DEC. 10 97.	JUN. 1 102.	FEB. 4 131.	JUN. 1 149.
1957	JUL. 22 55.	JUL. 21 64.	JAN. 25 90.	JAN. 24 107.	JAN. 25 135.	JAN. 22 156.
1958	APR. 11 87.	APR. 11 115.	DEC. 29 136.	DEC. 28 138.	DEC. 27 150.	DEC. 26 188.
1959	JAN. 7 72.	FEB. 11 131.	FEB. 10 158.	FEB. 9 186.	FEB. 8 252.	FEB. 8 261.
1960	JAN. 1 97.	JAN. 1 104.	JAN. 1 114.	JAN. 8 126.	JAN. 7 133.	JAN. 8 146.
1961	APR. 13 63.	FEB. 17 90.	FEB. 17 127.	FEB. 17 133.	FEB. 16 137.	FEB. 16 141.
1962	FEB. 21 74.	JAN. 22 129.	JAN. 21 170.	JAN. 20 185.	JAN. 19 209.	JAN. 18 236.
1963	FEB. 3 72.	MAR. 17 81.	MAR. 15 90.	MAR. 14 110.	MAR. 14 121.	JAN. 13 139.
1964	NOV. 10 83.	MAR. 2 123.	MAR. 1 152.	FEB. 29 158.	MAR. 2 188.	MAR. 1 216.
1965	DEC. 22 40.	DEC. 22 68.	DEC. 22 79.	DEC. 22 99.	DEC. 21 110.	DEC. 22 121.
1966	MAR. 14 66.	JAN. 28 76.	MAR. 14 97.	MAR. 13 107.	MAR. 12 120.	MAR. 11 131.
1967	APR. 2 76.	APR. 1 117.	MAR. 31 124.	MAR. 30 147.	MAR. 29 170.	MAR. 28 187.
1968	MAR. 18 61.	MAR. 17 95.	MAR. 25 120.	MAR. 25 135.	MAR. 26 167.	MAR. 25 197.
1969	MAR. 17 63.	FEB. 14 114.	FEB. 14 120.	FEB. 14 136.	FEB. 14 160.	FEB. 14 170.
1970	FEB. 7 60.	FEB. 6 83.	FEB. 5 113.	FEB. 5 131.	FEB. 4 145.	MAR. 3 164.
1971	FEB. 5 62.	FEB. 14 81.	FEB. 5 97.	FEB. 5 120.	FEB. 5 142.	FEB. 5 155.
1972	FEB. 11 52.	MAY 7 87.	MAY 6 131.	MAY 6 143.	DEC. 13 148.	DEC. 12 151.
1973	APR. 27 50.	FEB. 11 72.	FEB. 10 100.	MAR. 8 112.	MAR. 24 134.	MAR. 23 155.
1974	FEB. 13 62.	DEC. 10 72.	DEC. 9 97.	DEC. 10 121.	DEC. 9 147.	DEC. 9 154.
1975	OCT. 24 83.	OCT. 23 95.	MAR. 29 134.	MAR. 29 156.	MAR. 29 165.	MAR. 29 171.
1976	MAR. 9 60.	MAR. 9 103.	MAR. 9 121.	MAR. 1 129.	MAR. 1 141.	FEB. 27 163.
1977	JAN. 4 73.	JAN. 4 109.	JAN. 3 122.	JAN. 3 129.	DEC. 21 147.	DEC. 21 154.
1978	FEB. 15 84.	FEB. 15 147.	FEB. 15 157.	FEB. 13 191.	FEB. 12 204.	FEB. 11 216.
1979	APR. 24 75.	FEB. 24 101.	APR. 24 127.	APR. 24 146.	APR. 12 157.	APR. 10 182.
1980	JAN. 17 66.	NOV. 26 88.	NOV. 25 115.	NOV. 26 140.	NOV. 25 168.	NOV. 25 181.
1981	DEC. 10 56.	JAN. 27 72.	JAN. 26 92.	MAR. 9 112.	MAR. 8 124.	MAR. 8 124.
1982	DEC. 26 68.	JAN. 10 93.	DEC. 24 111.	JAN. 10 136.	MAR. 9 154.	MAR. 8 175.
1983	MAY 4 73.	DEC. 25 85.	FEB. 26 128.	MAR. 12 163.	MAR. 12 179.	MAR. 12 220.

Note; 1-day to 6-day means rainfall duration.

Table 2.3.5 ANNUAL MAXIMUM BASIN MEAN RAINFALL (6/6)

Unit : mm

K. Ulo before the confluence with K. Kedungsoko

YEAR	1-DAY	2-DAY	3-DAY	4-DAY	5-DAY	6-DAY
1950	MAR. 24 70.	MAR. 24 72.	MAR. 24 84.	MAR. 21 116.	FEB. 8 126.	FEB. 7 136.
1951	MAR. 6 72.	MAR. 5 79.	FEB. 18 95.	FEB. 18 119.	JAN. 5 122.	MAR. 1 129.
1952	DEC. 15 67.	DEC. 15 109.	DEC. 15 132.	DEC. 15 158.	DEC. 15 180.	DEC. 15 211.
1953	MAY 1 60.	APR. 30 113.	APR. 29 133.	APR. 29 137.	APR. 30 177.	APR. 30 204.
1954	JAN. 17 61.	NOV. 1 103.	NOV. 1 112.	OCT. 31 119.	NOV. 1 124.	JAN. 17 133.
1955	FEB. 9 56.	FEB. 9 87.	MAR. 30 120.	MAR. 29 151.	MAR. 28 152.	MAR. 27 176.
1956	DEC. 2 65.	DEC. 2 89.	DEC. 10 101.	JUN. 1 116.	JUN. 1 146.	JUN. 1 172.
1957	JUL. 22 53.	JAN. 26 72.	JAN. 25 102.	JAN. 24 124.	JAN. 23 140.	JAN. 22 165.
1958	DEC. 31 88.	APR. 11 101.	DEC. 29 146.	DEC. 28 149.	DEC. 27 163.	DEC. 26 202.
1959	FEB. 12 75.	FEB. 11 118.	FEB. 10 146.	JAN. 7 168.	FEB. 8 218.	FEB. 8 225.
1960	JAN. 1 106.	JAN. 1 112.	JAN. 31 124.	JAN. 8 141.	JAN. 31 148.	JAN. 8 161.
1961	APR. 13 85.	APR. 12 85.	FEB. 17 113.	APR. 10 133.	APR. 9 147.	APR. 8 155.
1962	FEB. 17 81.	JAN. 22 144.	JAN. 21 175.	JAN. 20 203.	JAN. 19 223.	JAN. 18 240.
1963	FEB. 3 83.	FEB. 3 86.	FEB. 18 104.	FEB. 17 124.	FEB. 17 137.	JAN. 13 152.
1964	NOV. 10 92.	NOV. 10 111.	MAR. 1 127.	FEB. 29 133.	MAR. 1 161.	MAR. 1 186.
1965	DEC. 22 55.	DEC. 22 83.	DEC. 22 95.	DEC. 22 126.	DEC. 21 137.	DEC. 22 144.
1966	DEC. 6 87.	DEC. 5 101.	MAR. 14 121.	MAR. 13 127.	MAR. 12 141.	MAR. 11 151.
1967	APR. 2 64.	APR. 1 104.	APR. 1 119.	FEB. 23 144.	MAR. 29 148.	MAR. 29 163.
1968	MAR. 26 67.	MAR. 4 111.	MAR. 4 131.	MAR. 4 160.	MAR. 26 182.	MAR. 25 221.
1969	JAN. 12 68.	FEB. 14 106.	FEB. 14 114.	FEB. 14 136.	FEB. 14 158.	FEB. 14 170.
1970	FEB. 7 63.	FEB. 6 91.	FEB. 5 130.	FEB. 5 148.	FEB. 4 165.	FEB. 4 170.
1971	FEB. 5 74.	MAR. 16 86.	FEB. 5 116.	FEB. 5 143.	FEB. 5 167.	FEB. 5 181.
1972	FEB. 11 62.	MAR. 7 92.	DEC. 14 117.	DEC. 13 148.	DEC. 13 173.	DEC. 11 178.
1973	MAR. 24 53.	MAR. 24 92.	MAR. 24 120.	MAR. 23 145.	MAR. 24 167.	MAR. 23 192.
1974	FEB. 13 65.	FEB. 13 68.	DEC. 9 89.	FEB. 13 103.	DEC. 9 125.	FEB. 23 138.
1975	OCT. 24 88.	OCT. 23 101.	MAR. 29 120.	MAR. 29 143.	MAR. 29 153.	MAR. 29 159.
1976	MAR. 9 71.	JAN. 5 104.	MAR. 8 120.	MAR. 8 123.	NOV. 21 133.	JAN. 1 181.
1977	MAR. 26 66.	JAN. 4 111.	JAN. 3 122.	JAN. 3 131.	FEB. 20 150.	FEB. 19 171.
1978	FEB. 15 90.	FEB. 15 145.	FEB. 15 158.	FEB. 13 201.	FEB. 12 219.	FEB. 12 232.
1979	APR. 13 81.	APR. 12 109.	APR. 24 137.	APR. 24 164.	APR. 12 184.	APR. 11 196.
1980	JAN. 17 78.	NOV. 26 90.	JAN. 17 104.	NOV. 26 131.	NOV. 26 147.	JAN. 17 184.
1981	FEB. 18 65.	JAN. 27 70.	MAR. 10 95.	MAR. 9 122.	MAR. 8 136.	MAR. 8 137.
1982	MAR. 9 61.	JAN. 10 96.	MAR. 9 129.	MAR. 9 174.	MAR. 9 209.	MAR. 8 227.
1983	MAR. 12 86.	MAR. 12 111.	MAR. 12 154.	MAR. 12 215.	MAR. 12 241.	MAR. 12 288.

Note; 1-day to 6-day means rainfall duration.

Table 2.3.6 PROBABLE BASIN MEAN RAINFALL AT BASE POINTS (1/3)

Unit : mm

Return Period	Rainfall Duration 1 - day	2 - day	3 - day	4 - day	5 - day	6 - day
(1) Ngudikan						
1.05	54	71	88	113	121	133
2	73	97	120	140	158	176
5	87	118	142	165	185	209
10	98	133	157	183	206	234
25	111	151	176	205	231	263
50	120	265	190	221	249	284
100	129	178	204	237	267	306
(2) K. Widas before the confluence with K. Kedungsoko						
1.05	46	69	84	100	113	125
2	64	91	111	131	146	159
5	78	110	133	155	172	186
10	89	123	149	173	192	707
25	102	140	168	194	215	231
50	111	152	182	210	232	249
100	120	163	196	225	249	266
(3) K. Widas after the confluence with K. Kedungsoko						
1.05	44	67	87	98	110	121
2	55	80	99	117	134	148
5	63	91	112	131	153	170
10	70	99	122	142	166	186
25	77	108	133	155	183	206
50	83	115	142	164	195	220
100	88	122	151	174	207	234
(4) Confluence with K. Brantas						
1.05	38	59	75	92	104	113
2	51	75	92	109	126	139
5	60	86	104	124	143	159
10	67	95	113	135	156	173
25	75	105	124	148	171	190
50	81	113	132	157	183	203
100	87	120	140	167	194	216

Table 2.3.6 PROBABLE BASIN MEAN RAINFALL AT BASE POINTS (3/3)

Unit : mm

Return Period	Rainfall Duration 1 - day	2 - day	3 - day	4 - day	5 - day	6 - day
(8) Kuncir Flood Diversion						
1.05	62.5	83	100	121	142	154
2	88	118	143	170	190	210
5	108	146	177	209	228	255
10	122	168	202	238	257	238
25	140	193	232	272	290	327
50	153	211	254	297	315	356
100	166	230	276	322	340	385
(9) K. Kuncir before the confluence with K. Kedungsoko						
1.05	50	69	90	104	115	127
2	64	93	115	133	149	166
5	76	111	135	154	177	197
10	84	125	150	171	197	221
25	94	142	168	190	221	248
50	101	154	181	205	239	268
100	109	166	194	219	256	288
(10) K. Ulo before the confluence with K. Kedungsoko						
1.05	54	73	93	109	121	193
2	70	96	118	140	157	175
5	82	113	137	164	186	208
10	91	125	151	182	208	234
25	102	140	168	203	233	263
50	110	151	180	219	252	285
100	118	162	192	235	270	307

Table 2.3.6 PROBABLE BASIN MEAN RAINFALL AT BASE POINTS (2/3)

Unit : mm

Return Period	Rainfall Duration 1 - day	2 - day	3 - day	4 - day	5 - day	6 - day
(5) K. Kedungsoko before the confluence with K. Kuncir						
1.05	50	71	88	100	115	123
2	64	91	111	128	146	160
5	74	108	130	151	172	189
10	82	120	143	169	191	211
25	91	135	159	189	213	237
50	98	146	171	204	230	256
100	105	156	183	219	247	275
(6) K. Kedungsoko before the confluence with K. Ulo						
1.05	46	67	83	96	110	121
2	60	87	106	123	140	154
5	70	103	124	144	163	181
10	78	114	137	159	181	202
25	87	128	153	178	201	225
50	94	138	165	191	216	243
100	100	149	176	205	231	261
(7) K. Kedungsoko before the confluence with K. Widas						
1.05	46	67	83	97	110	122
2	59	84	103	121	138	154
5	69	99	120	140	160	179
10	77	110	133	154	176	198
25	86	123	148	170	195	220
50	93	132	159	182	210	236
100	100	142	170	195	224	253

Table 2.3.7 ANNUAL MAXIMUM BASIN MEAN MONTHLY RAINFALL IN K. WIDAS BASIN

YEAR	MONTH	RAINFALL (mm)	YEAR	MONTH	RAINFALL (mm)
1950	FEB	365	1970	FEB	372
1951	DEC	382	1971	FEB	363
1952	MAR	404	1972	DEC	320
1953	APR	363	1973	FEB	359
1954	JAN	423	1974	DEC	342
1955	MAR	394	1975	MAR	391
1956	DEC	343	1976	MAR	366
1957	MAR	436	1977	MAR	359
1958	MAR	409	1978	DEC	377
1959	FEB	530	1979	JAN	367
1960	JAN	357	1980	DEC	349
1961	FEB	240	1981	JAN	306
1962	JAN	421	1982	MAR	401
1963	MAR	416	1983	MAR	493
1964	MAR	413	MEAN		379
1965	DEC	302			
1966	MAR	351			
1967	JAN	356			
1968	MAR	514			
1969	MAR	286			

Table 2.3.8 BASIN MEAN RAINFALL AND RUNOFF AT NGUDIKAN

Month	Hydrological Year							
	60/61	61/62	62/63	64/65	65/66	72/73	73/74	74/75
Nov.	2.7	0.6	4.3	5.4	0.8	1.2	2.5	5.2
Dec.	5.5	3.7	11.6	8.7	6.7	6.7	10.0	6.2
Jan.	5.2	11.6	14.3	11.5	9.2	13.3	12.9	13.3
Feb.	5.9	9.2	12.8	13.4	16.4	15.3	14.7	9.9
Mar.	6.1	8.6	22.9	14.0	14.3	22.0	18.4	11.4
Apr.	4.7	8.6	10.9	7.5	8.0	11.0	12.5	11.5
May	2.6	3.3	1.3	2.9	3.7	13.7	4.9	7.8
Jun.	0.8	1.1	1.0	0.4	1.7	1.4	0.9	1.0
Jul.	0.6	0.7	0.8	0.3	0.3	1.5	0.7	0.7
Aug.	0.5	0.6	0.6	0.2	0.2	1.3	0.7	0.6
Sep.	0.5	0.9	0.5	0.2	0.2	0.6	0.6	1.0
Oct.	0.4	0.4	0.4	0.2	0.5	0.4	4.7	6.2
Mean	2.9	4.1	6.7	5.3	5.1	7.3	6.6	6.2
Runoff Volume (10^6 m^3)	92.8	127.8	211.0	167.8	160.8	229.1	208.7	194.0
Rainfall Volume (10^6 m^3)	261.0	307.8	364.4	290.9	337.1	376.3	425.9	584.1
Runoff Coefficient	0.36	0.42	0.58	0.58	0.48	0.61	0.49	0.33

Average runoff coefficient 0.47

Source: Feasibility Report on the Widas Irrigation Project

Table 2.3.9 STORAGE FUNCTION OF SUB-BASIN

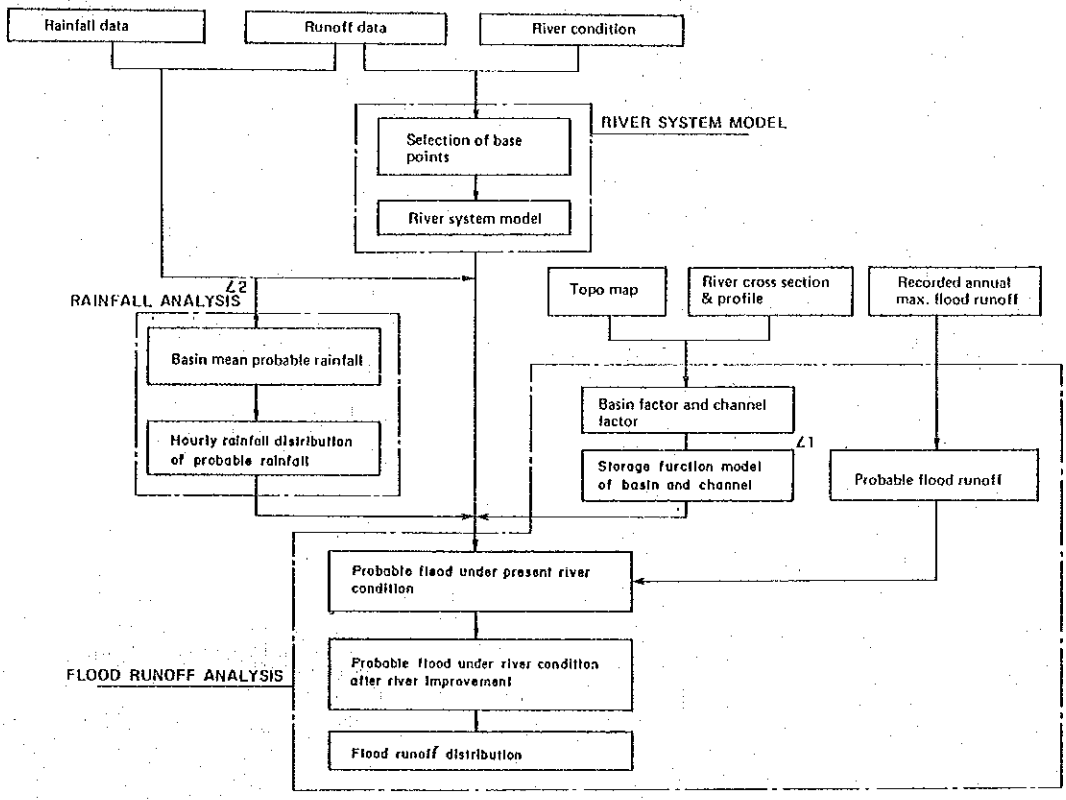
No.	Catchment Area (km^2)	River Length (km)	Coefficient K	P	T
1.	122	30.0	20	1/3	1
2.	90	8.0	20	1/3	0
3.	21	7.5	20	1/3	0
4.	118	22.0	25	1/3	0
5.	72	15.0	25	1/3	0
6.	32	4.0	30	1/3	0
7.	35	13.5	35	1/3	0
8.	28	10.0	20	1/3	0
9.	118	23.0	20	1/3	1
10.	155	23.0	20	1/3	1
11.	91	30.0	30	1/3	1
12.	79	23.0	20	1/3	1
13.	17	7.0	35	1/3	0
14.	13	10.5	11.4	1.0	0
15.	37	7.0	11.4	1.0	0
16.	34	8.5	11.4	1.0	0
17.	63	16.0	25	1/3	0
18.	6	5.0	11.4	1.0	0
19.	18	11.5	11.4	1.0	0
20.	54	16.0	35	1/3	0
21.	38	10.0	35	1/3	0
22.	73	23.0	35	1/3	1
23.	191	30.0	11.4	1.0	1
24.	22	7.0	25	1/3	0
25.	5	1.5	11.4	1.0	0
26.	6	3.5	11.4	1.0	0

Table 2.3.10 STORAGE FUNCTION OF RIVER CHANNEL

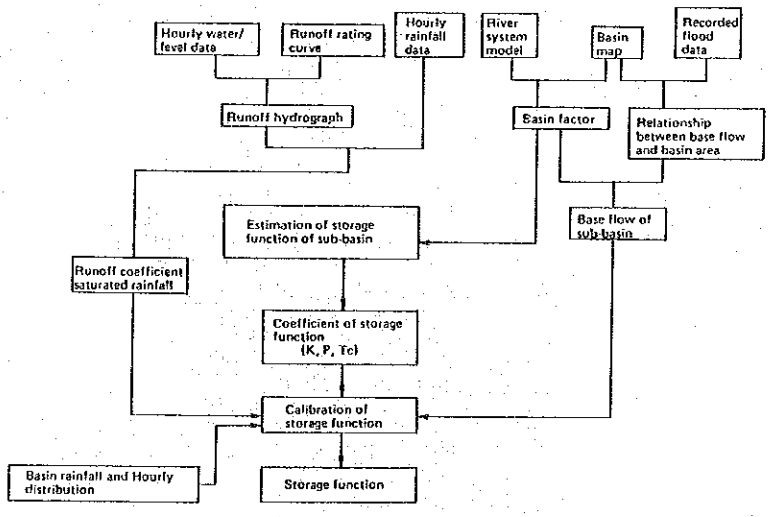
River Channel /1	River Length (km)	Storage Function K	Storage Function P	Lag - Time (hour)
A	12.7	-	- /2	
B	8.3	10.55	0.643 Q 240	1
		0.04	1.646 Q 240	
C	5.3	6.32	0.657	1
		0.19	1.376	
D	7.0	4.71	0.737 Q 202	1
		0.24	1.302 Q 202	
E	3.8	4.14	0.652 Q 260	0
		0.95	0.917 Q 260	
F	8.1	4.66	0.761 Q 400	1
		1.94	0.907 Q 400	
G	2.8	1.50	0.747 Q 360	0
		0.42	0.962 Q 360	
H	3.0	-	-	-
I	15.0	7.79	0.782 Q 30.8	1
		2.48	1.116 Q 30.8	
J	5.0	-	-	-
K	10.0	14.50	0.513 Q 10	1
		8.43	0.748 Q 10	

Table 2.3.11 RELATION BETWEEN WATER LEVEL, STORAGE VOLUME, AND OUTFLOW IN THE RETARDING BASIN

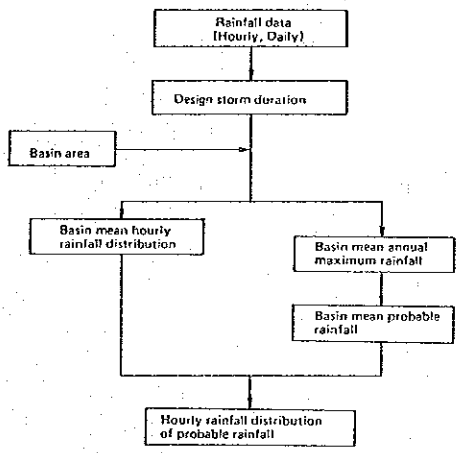
	Water Level (EL.m)	Storage Volume ($\times 10^6$ m^3)	Outflow (m^3/sec)
(1)	Widas Retarding Basin		
	37.6	4.0	0.0
	38.0	7.8	132
	38.5	13.7	230
(2)	Ulo Retarding Basin		
	43.5	0.0	53.0
	44.0	2.0	68.0
	44.5	4.8	81.0
	45.0	7.8	96.0
(3)	Kedungsoko Retarding Basin		
	43.6	0.0	48.0
	44.0	1.4	60.9
	44.5	4.8	74.1
	45.0	9.3	92.0
	45.5	16.4	110.0



GENERAL FLOW CHART OF FLOOD ANALYSIS



∠1. STORAGE FUNCTION MODEL OF BASIN AND CHANNEL



∠2. RAINFALL ANALYSIS

Fig.2.3.1 GENERAL PROCEDURE

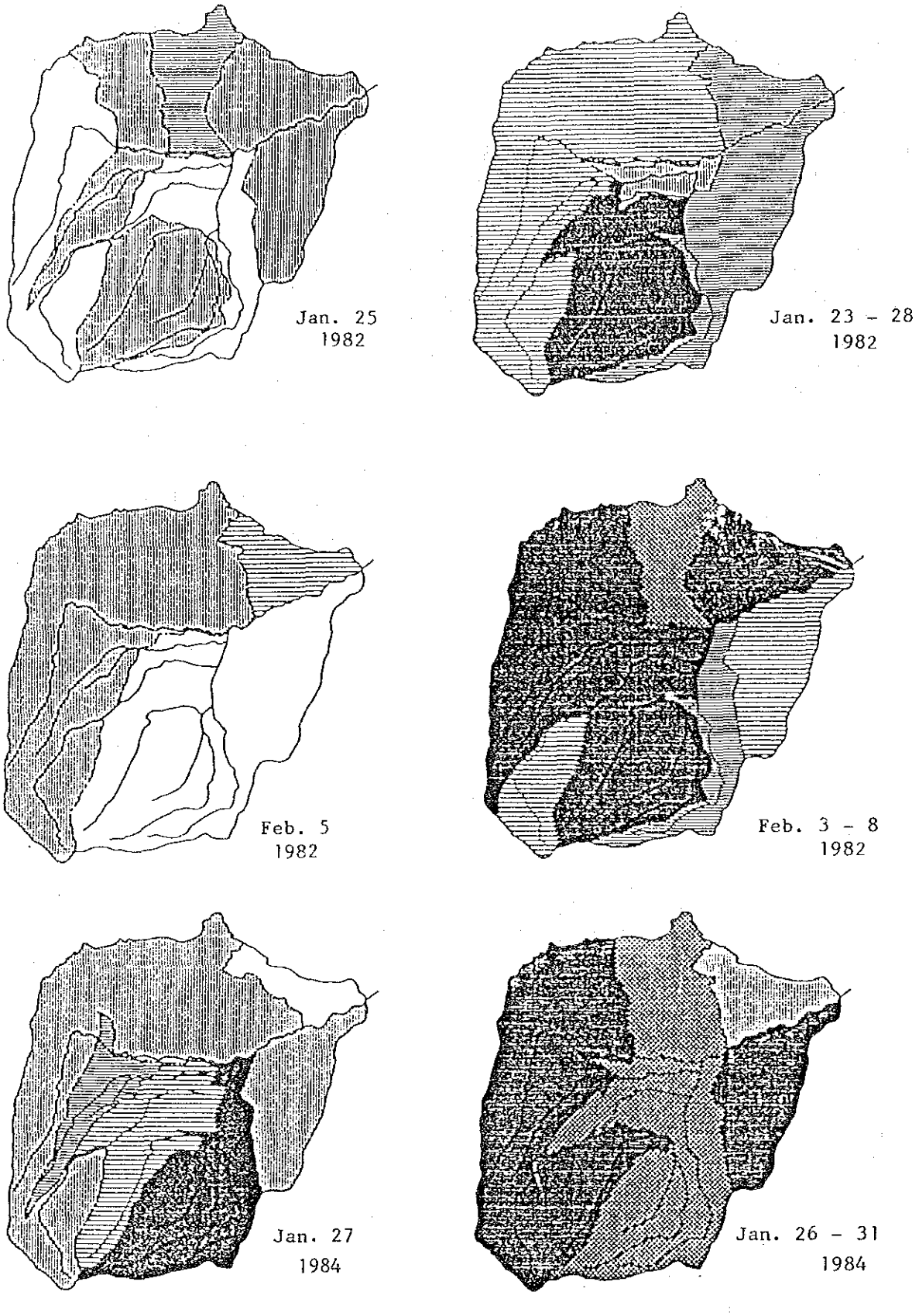


Fig. 2.3.2 1 - DAY / 6 - DAY RAINFALL AMOUNT ON JAN / FEB. 1982, AND JAN. 1984

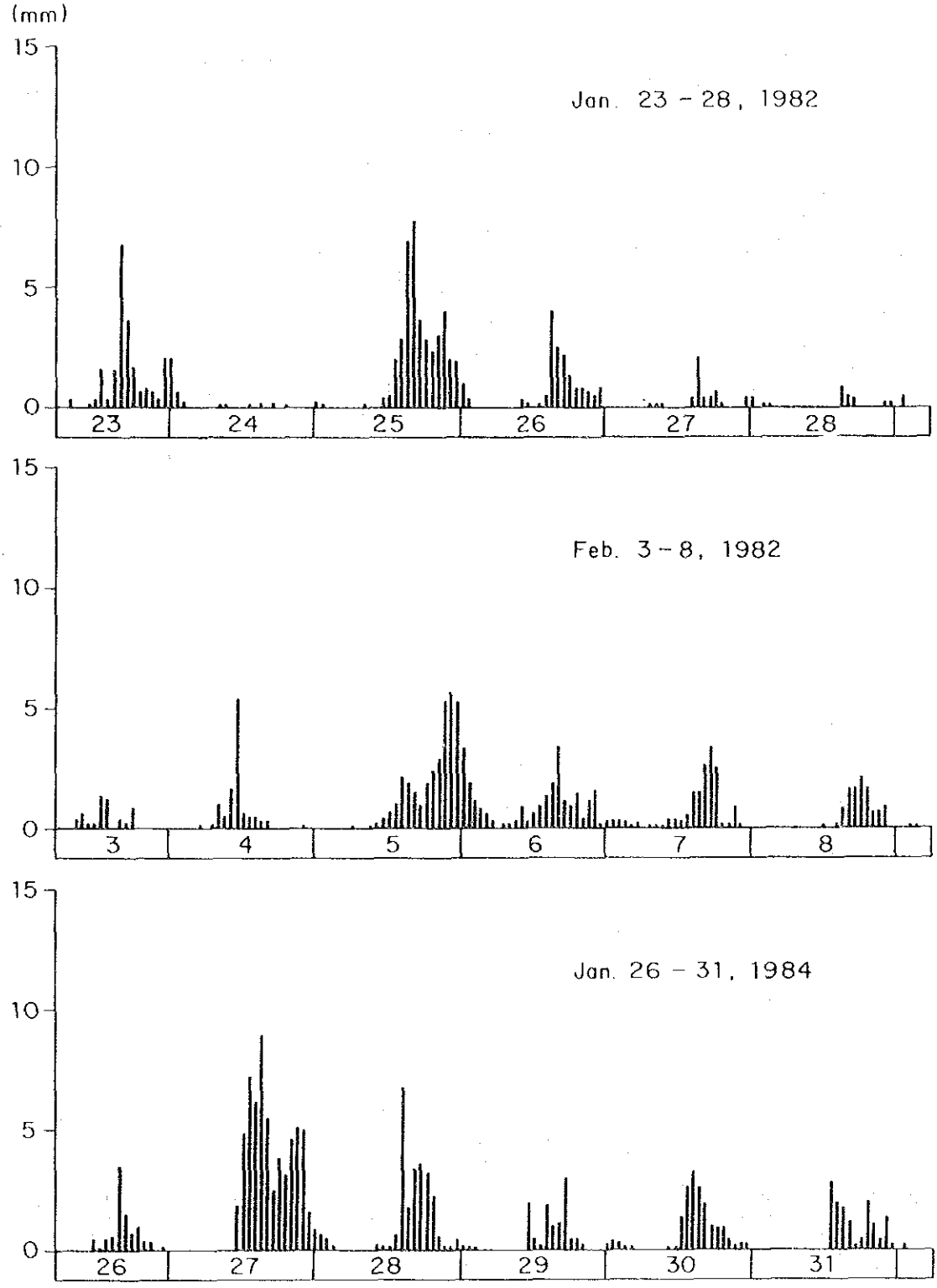


Fig.2.3.3 BASIN MEAN HOURLY RAINFALL DISTRIBUTION IN ENTIRE WIDAS RIVER BASIN

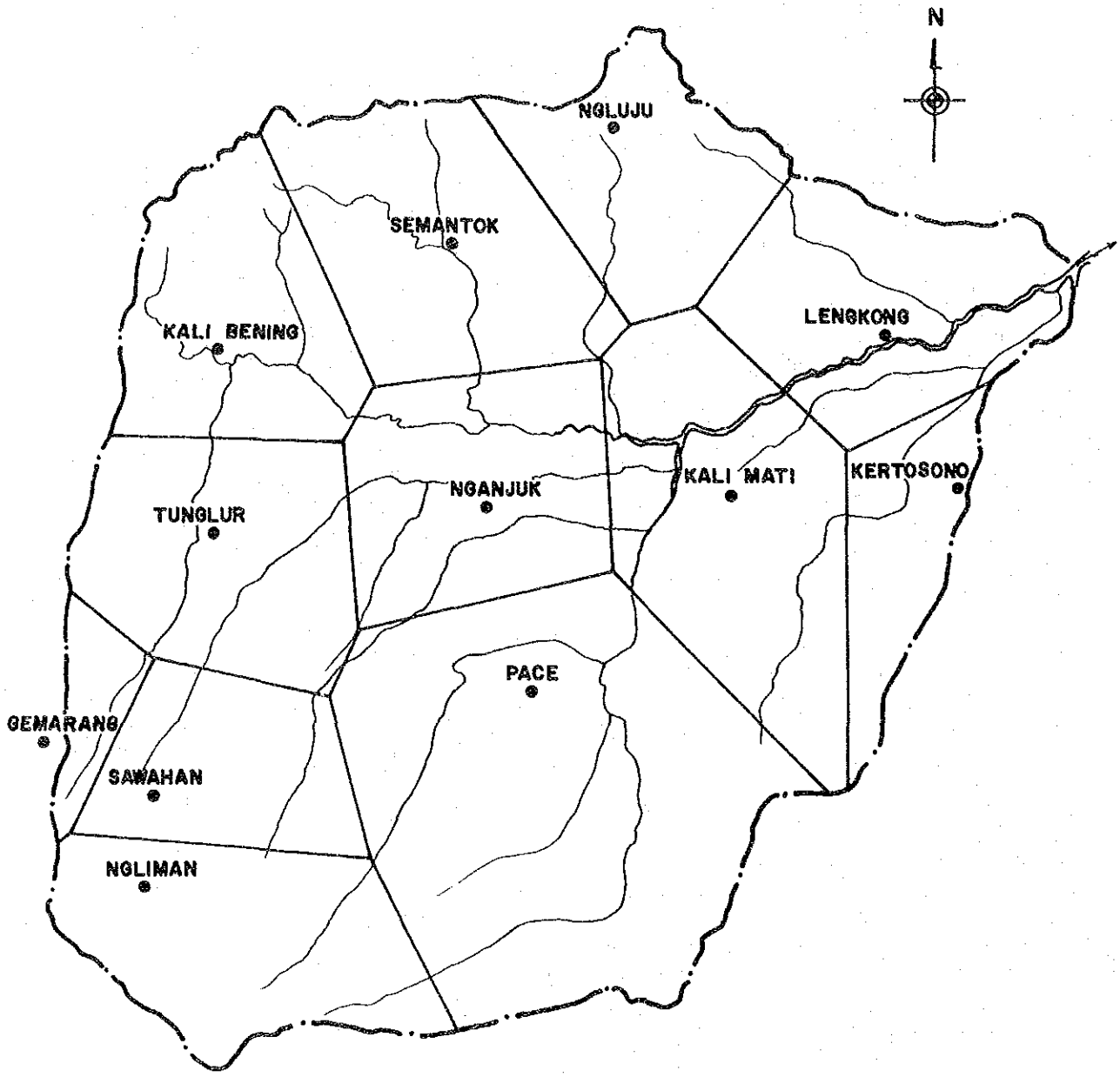


Fig. 2.3.4 THIESEN POLYGON FOR ESTIMATION OF BASIN MEAN HOURLY RAINFALL

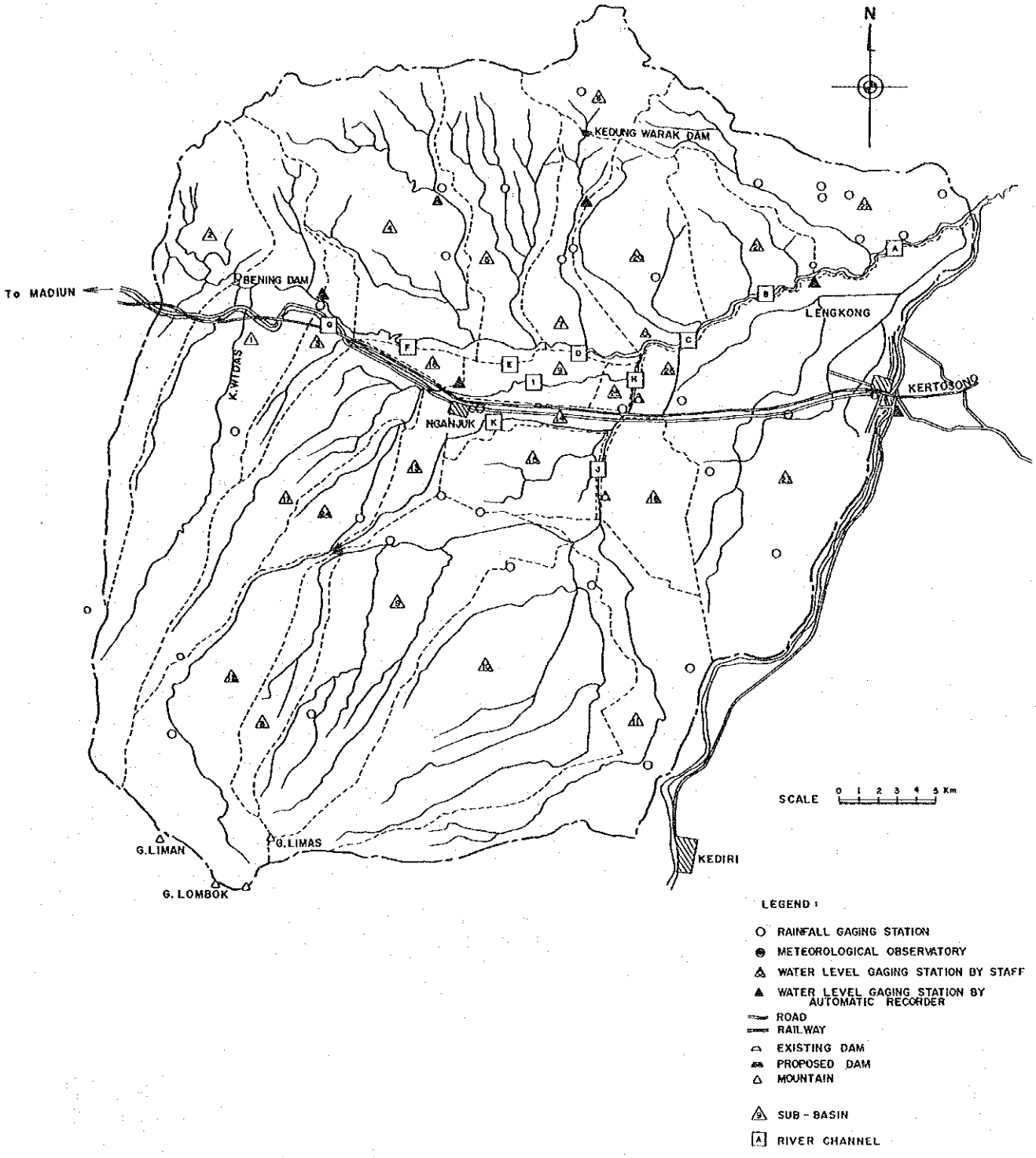


Fig. 2.3.5 SUB-BASIN AND RIVER CHANNEL

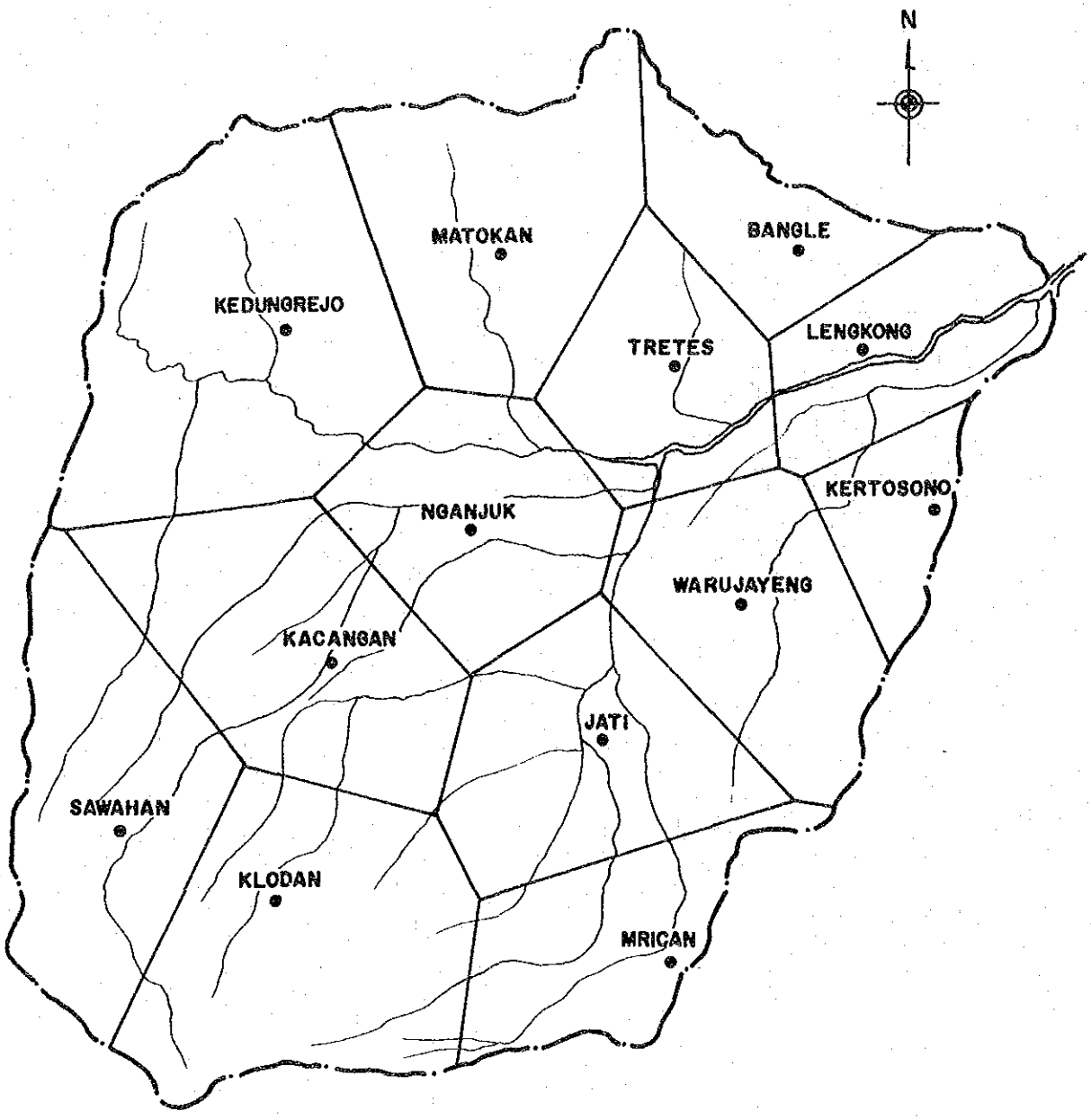
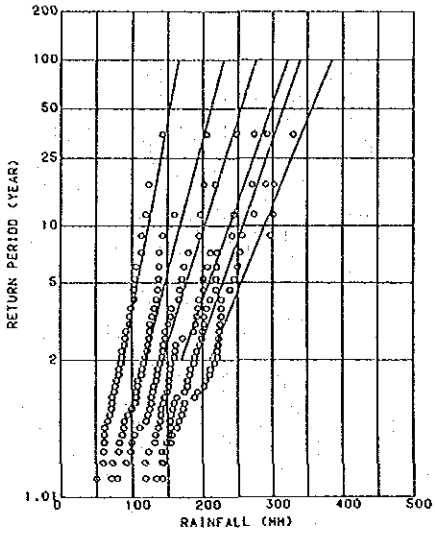
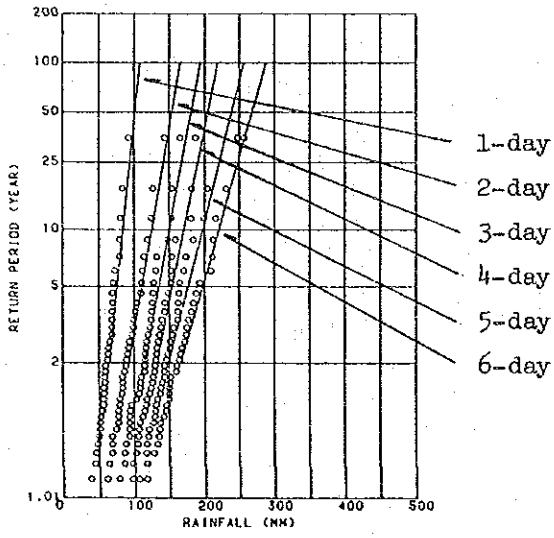


Fig. 2.3.6 THIESEN POLIGON FOR ESTIMATION OF BASIN MEAN DAILY RAINFALL

Kuncir Flood Diversion



K. Kuncir before the confluence with K. Kedungsoko



K. Ulo before the confluence with K. Kodungsoko

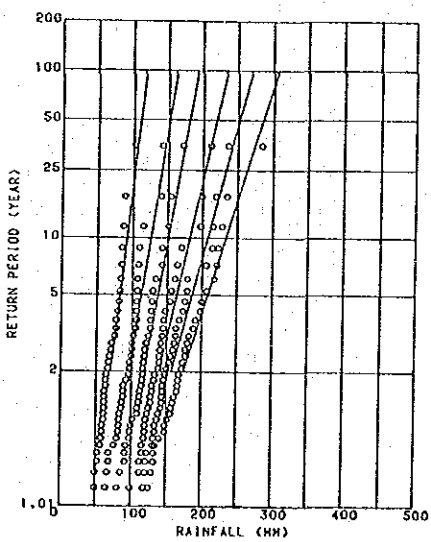
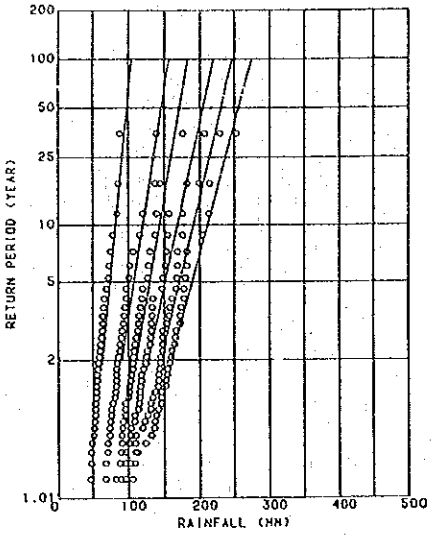
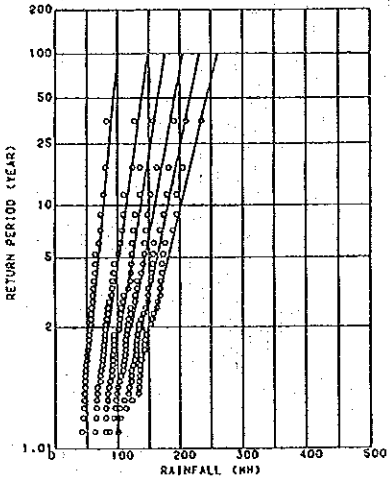


Fig. 2.3.7 FREQUENCY CURVE OF ANNUAL MAXIMUM BASIN MEAN RAINFALL (1/3)

K. Kedungsoko before the confluence with K. Kuncir



Kedungsoko before the confluence with K. Ulo



K. Kedungsoko before the confluence with K. Widas

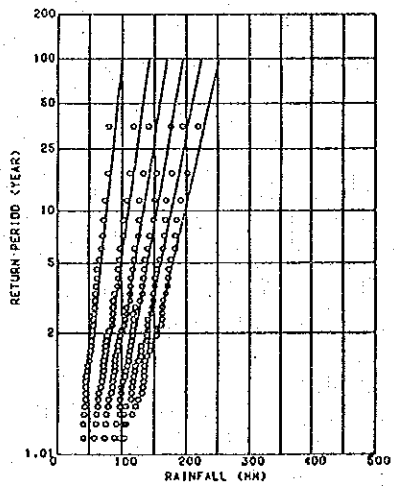
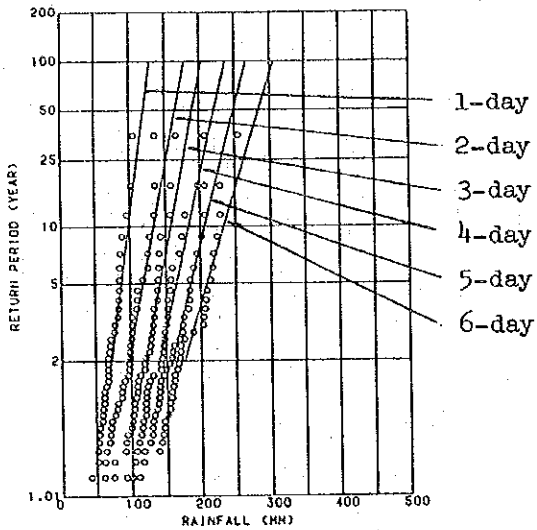
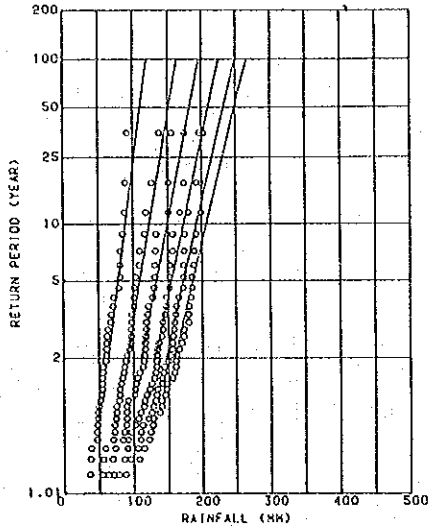


Fig. 2.3.7 FREQUENCY CURVE OF ANNUAL MAXIMUM BASIN MEAN RAINFALL (2/3)

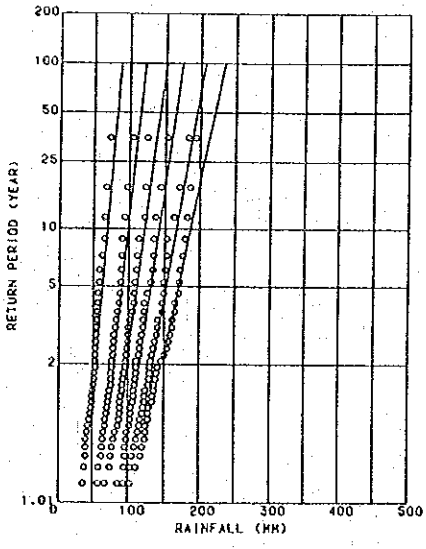
Ngudikan



K. Widas before the confluence with K. Kedungsoko



K. Widas after the confluence with K. Kedungsoko



Confluence with K. Brantas

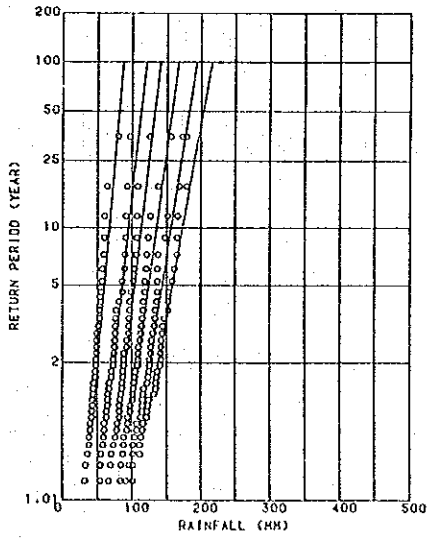


Fig. 2.3.7 FREQUENCY CURVE OF ANNUAL MAXIMUM BASIN MEAN RAINFALL (3/3)

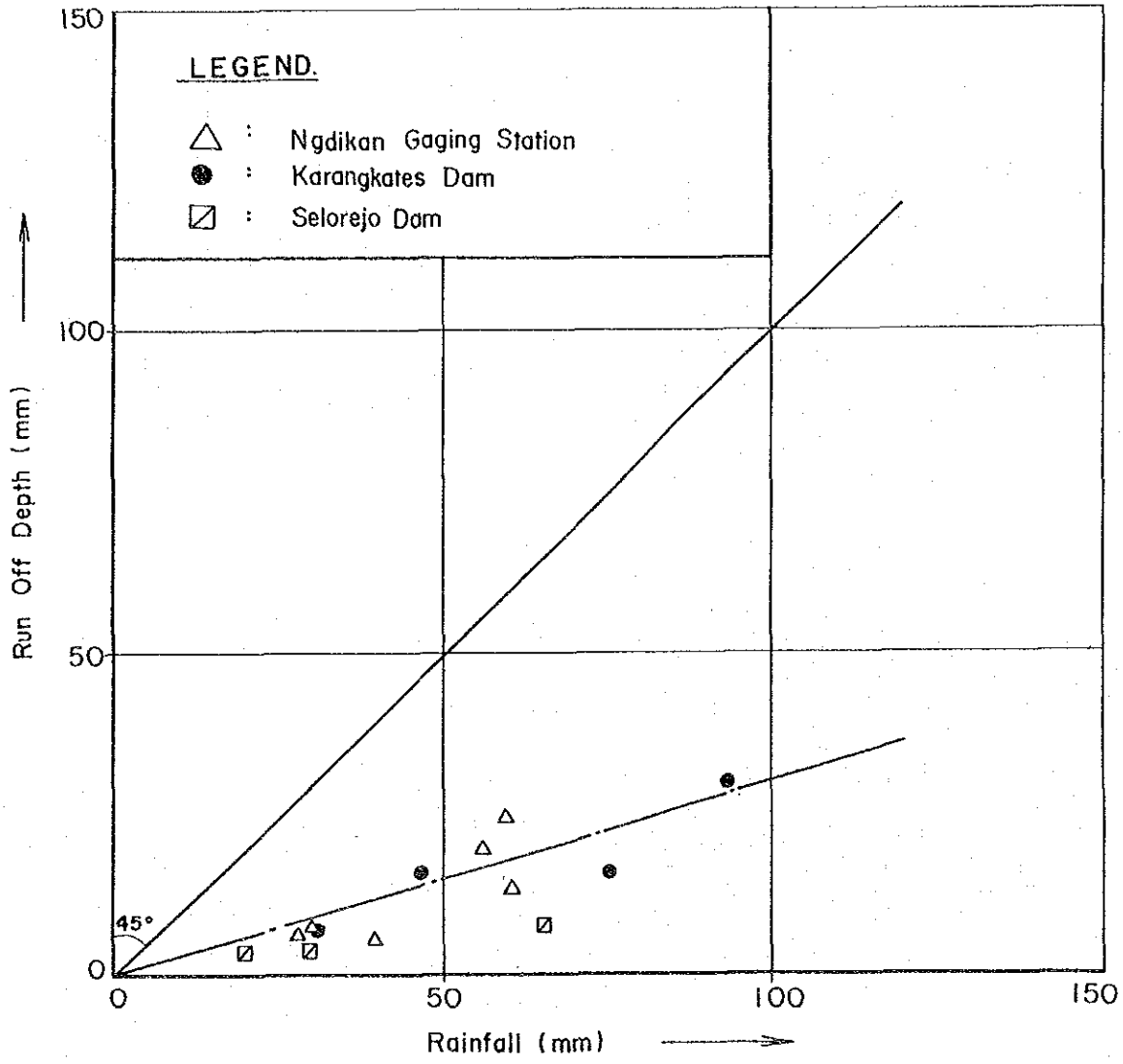


Fig. 2.3.8 RELATION BETWEEN RUN-OFF DEPTH AND RAINFALL AMOUNT DURING FLOOD

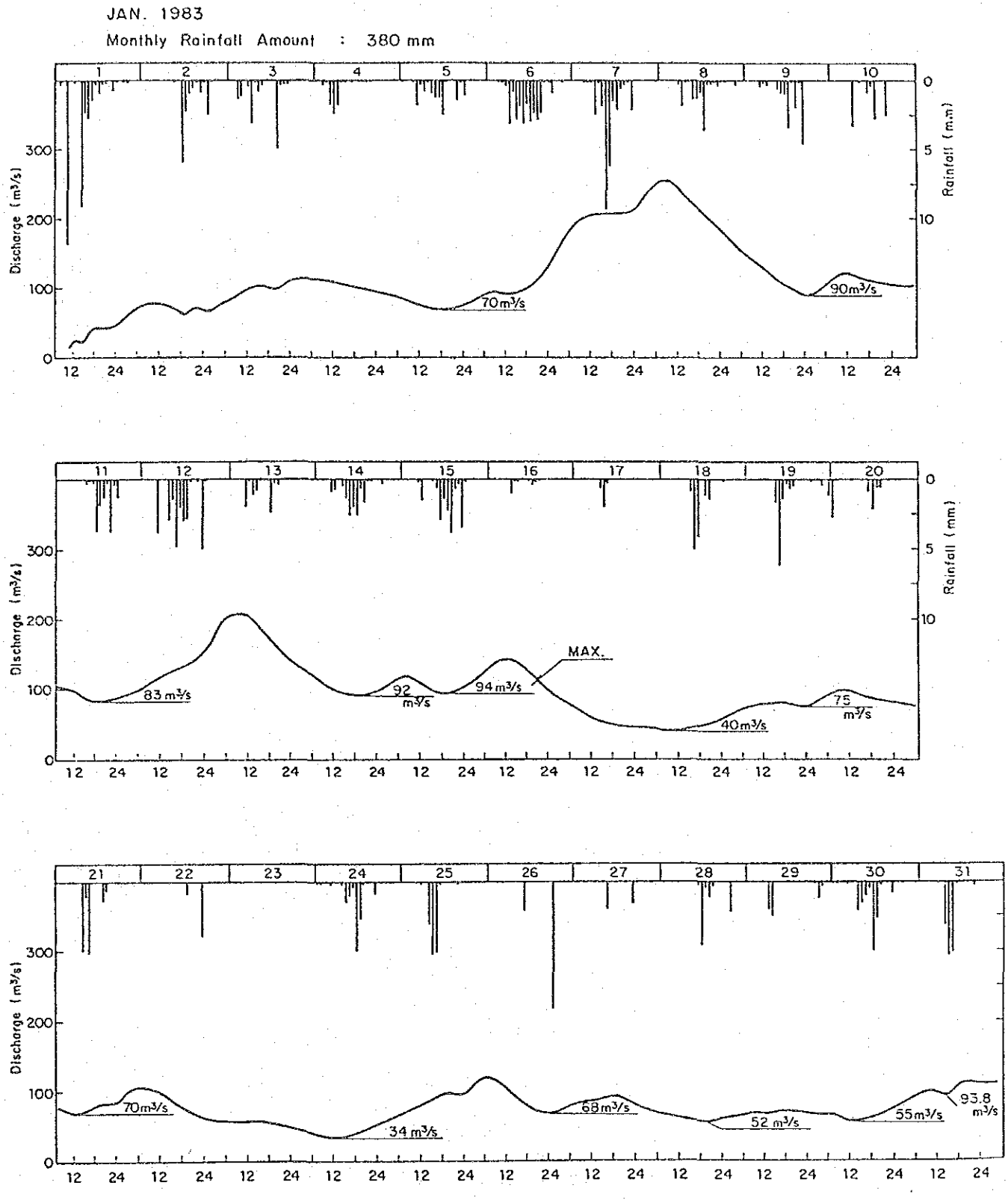


Fig. 2.3.9 BASIN MEAN MONTHLY RAINFALL PATTERN AND BASE FLOW

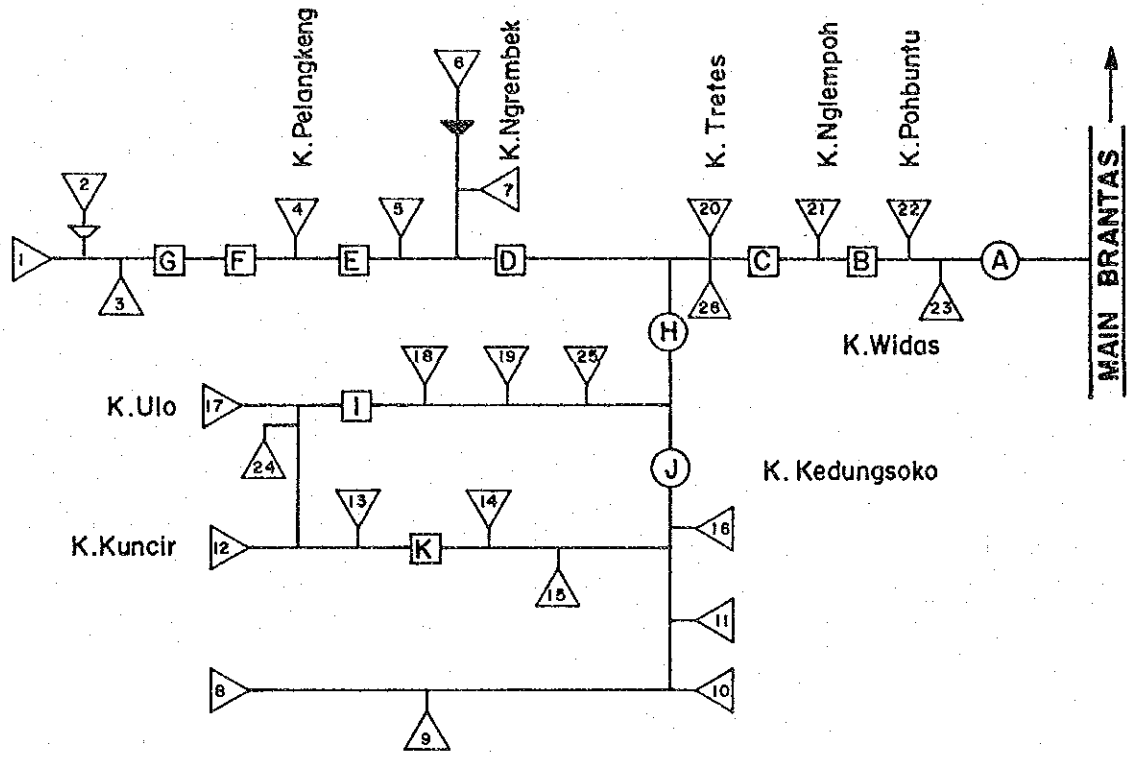
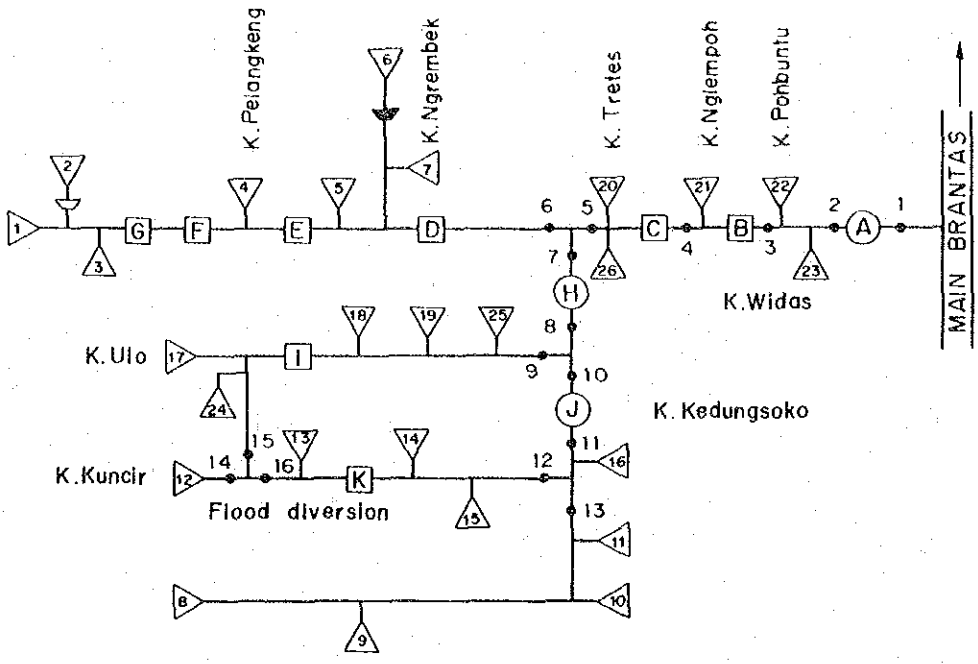


Fig. 2.3.10 RIVER SYSTEM MODEL OF K.WIDAS UNDER PRESENT RIVER CONDITION



(Unit : m^3/sec)

POINT NO.	RETURN PERIOD (YEAR)						
	1.05	2	5	10	25	50	100
1	139	187	213	236	257	273	289
A Δ.1	5.1	6.8	8.4	10.3	11.9	13.0	15.2
2	238	319	374	411	456	492	530
3	196	263	295	321	355	379	404
4	214	268	308	338	377	405	432
5	219	274	317	352	387	420	448
6	220	292	367	425	487	533	581
7	59	75	84	89	98	104	112
H Δ.1	3.0	3.8	5.3	6.6	8.6	10.2	12.0
8	108	138	157	174	195	224	264
9	67	87	110	128	165	223	290
10	57	74	80	84	87	92	109
J Δ.1	3.5	4.6	6.0	7.0	9.4	10.2	11.0
11	219	285	354	402	458	508	557
12	30	39	53	67	85	97	104
13	218	279	346	400	461	510	557
14	78	110	140	162	188	211	236
15	55	77	98	113	132	148	165
16	23	33	42	49	56	63	71

Δ.1 Retarded volume ($10^6 m^3$) in retarding basin

Fig. 2.3.11 PROBABLE FLOOD PEAK DISCHARGES AT BASE POINTS UNDER PRESENT CONDITION

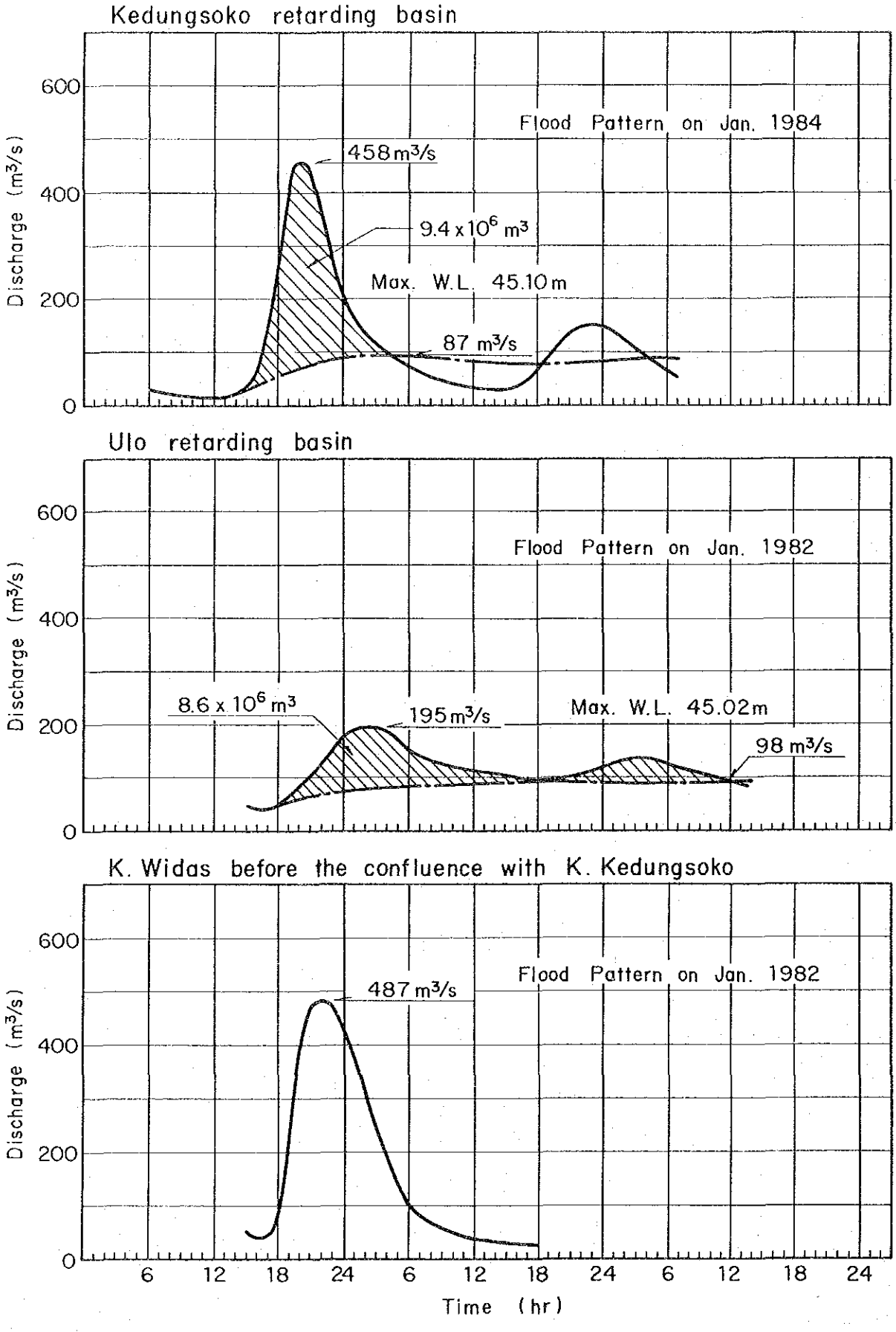


Fig. 2.3.12 FLOOD HYDROGRAPHS ON THE PRESENT CONDITION (1/2)

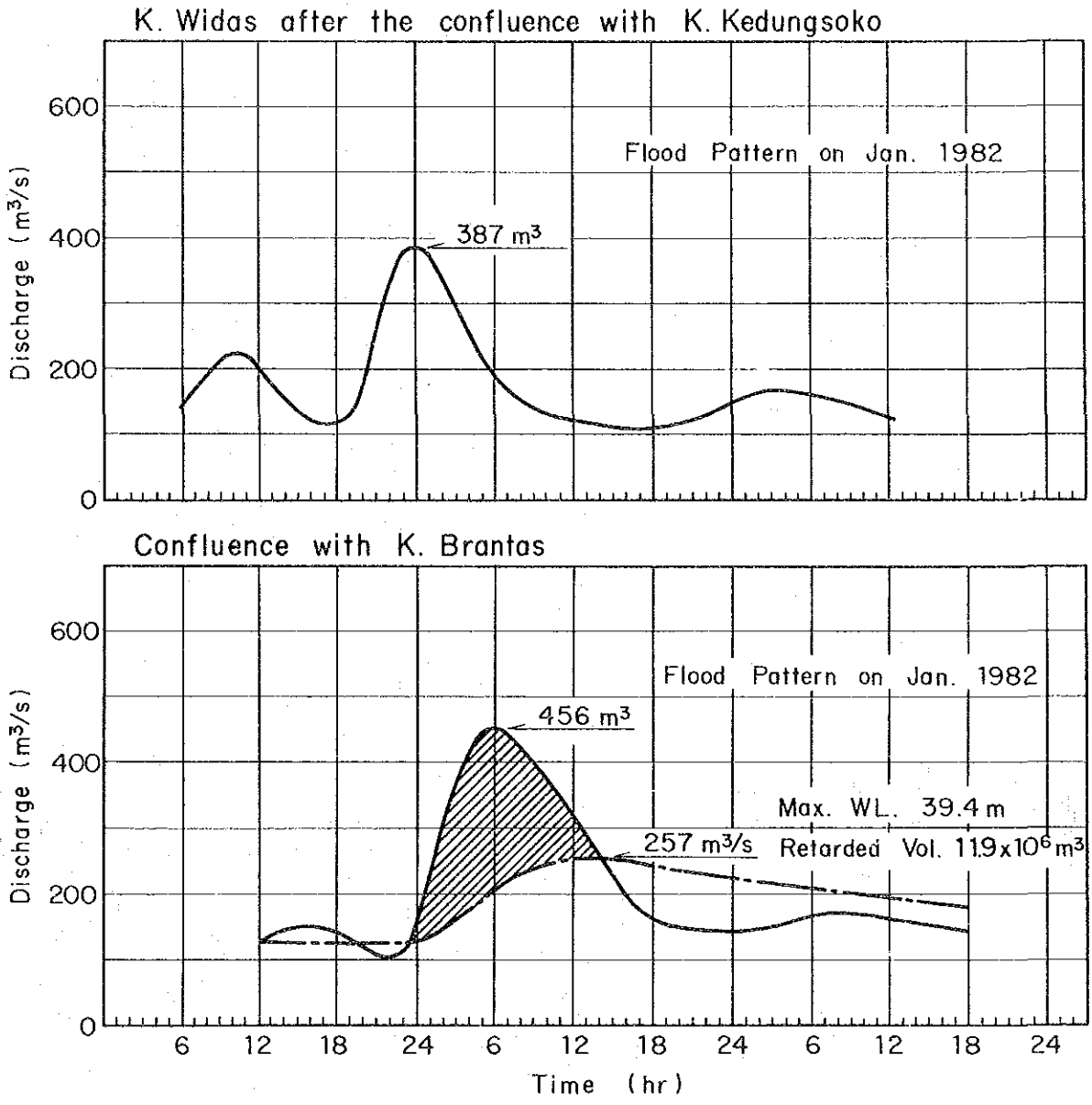
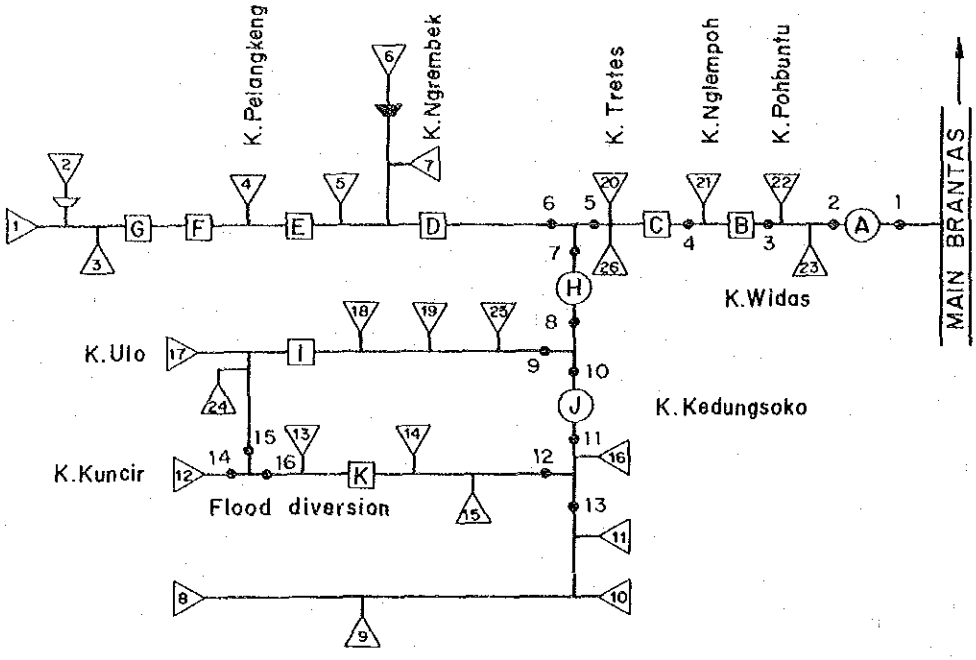


Fig. 2.3.12 FLOOD HYDROGRAPHS ON THE PRESENT CONDITION (2/2)



(Unit : m^3/sec)

POINT NO.	RETURN PERIOD (YEAR)						
	1.05	2	5	10	25	50	100
1	139	187	213	236	257	273	289
A ∠1	5.1	6.8	8.4	10.3	11.9	13.0	15.2
2	238	319	374	411	456	492	530
3	180	240	275	300	332	364	382
4	179	238	288	313	352	397	411
5	179	238	292	319	357	407	416
6	137	183	232	268	303	341	363
7	53	71	75	77	80	83	86
H ∠1	2.2	3.0	4.0	4.4	5.0	5.5	6.0
8	92	122	138	152	168	180	193
9	41	55	69	80	93	103	112
10	53	70	76	80	84	87	89
J ∠1	3.0	4.0	5.1	6.0	6.8	7.2	9.1
11	190	253	313	360	412	452	493
12	19	25	31	35	41	46	51
13	179	238	296	341	391	429	468
14	21	28	37	44	52	59	65
15	15	20	26	31	16	41	45
16	6	8	11	13	36	18	20

∠1 Retarded volume ($10^6 m^3$) in retarding basin

Fig.2.3.13 FLOOD PEAK DISCHARGES UNDER PRESENT RIVER CONDITION DUE TO PROBABLE RAINFALL IN ENTIRE K.WIDAS BASIN

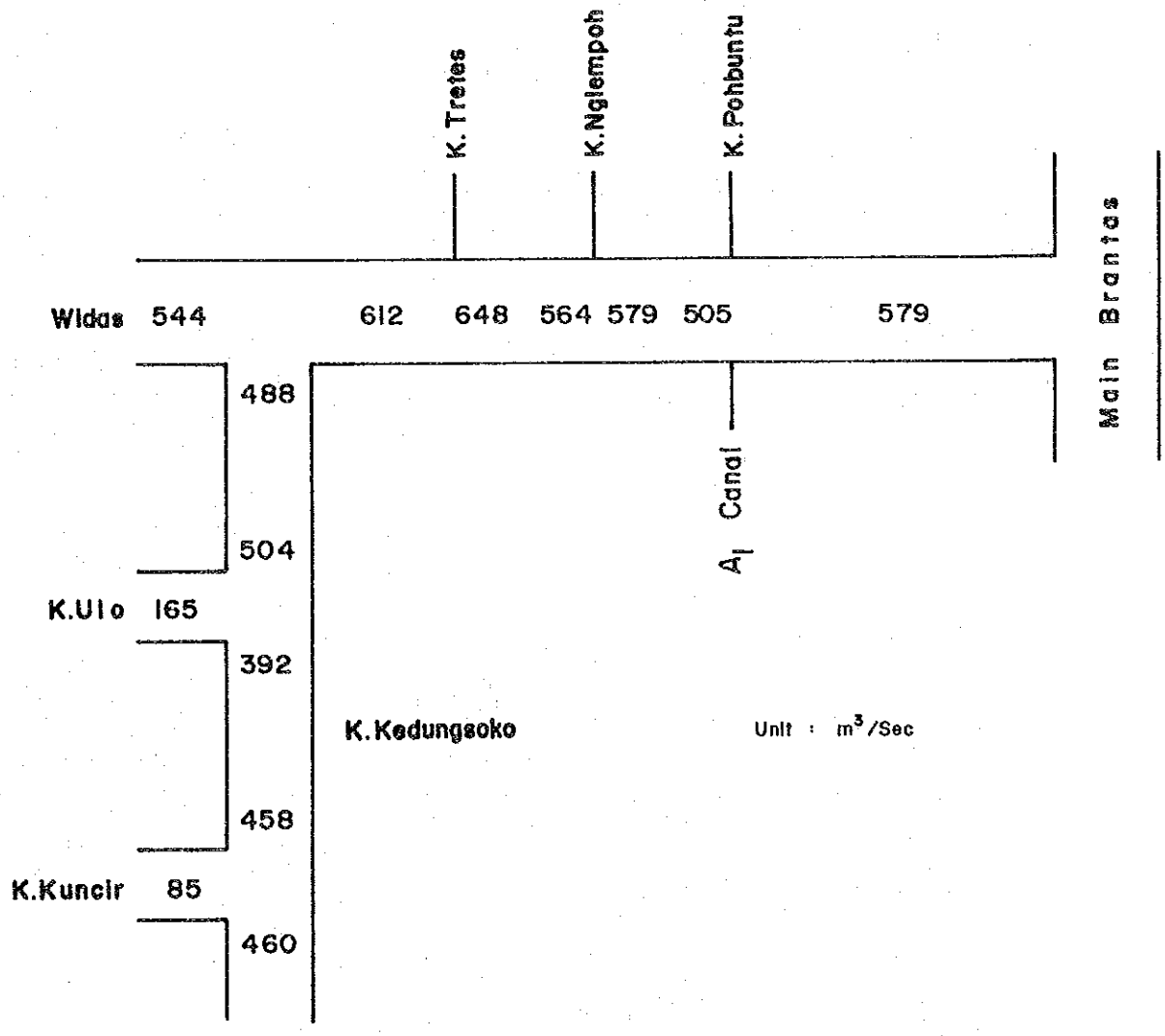


Fig. 2.3.14 **25-YEAR BASIC HIGH FLOW DISCHARGES**

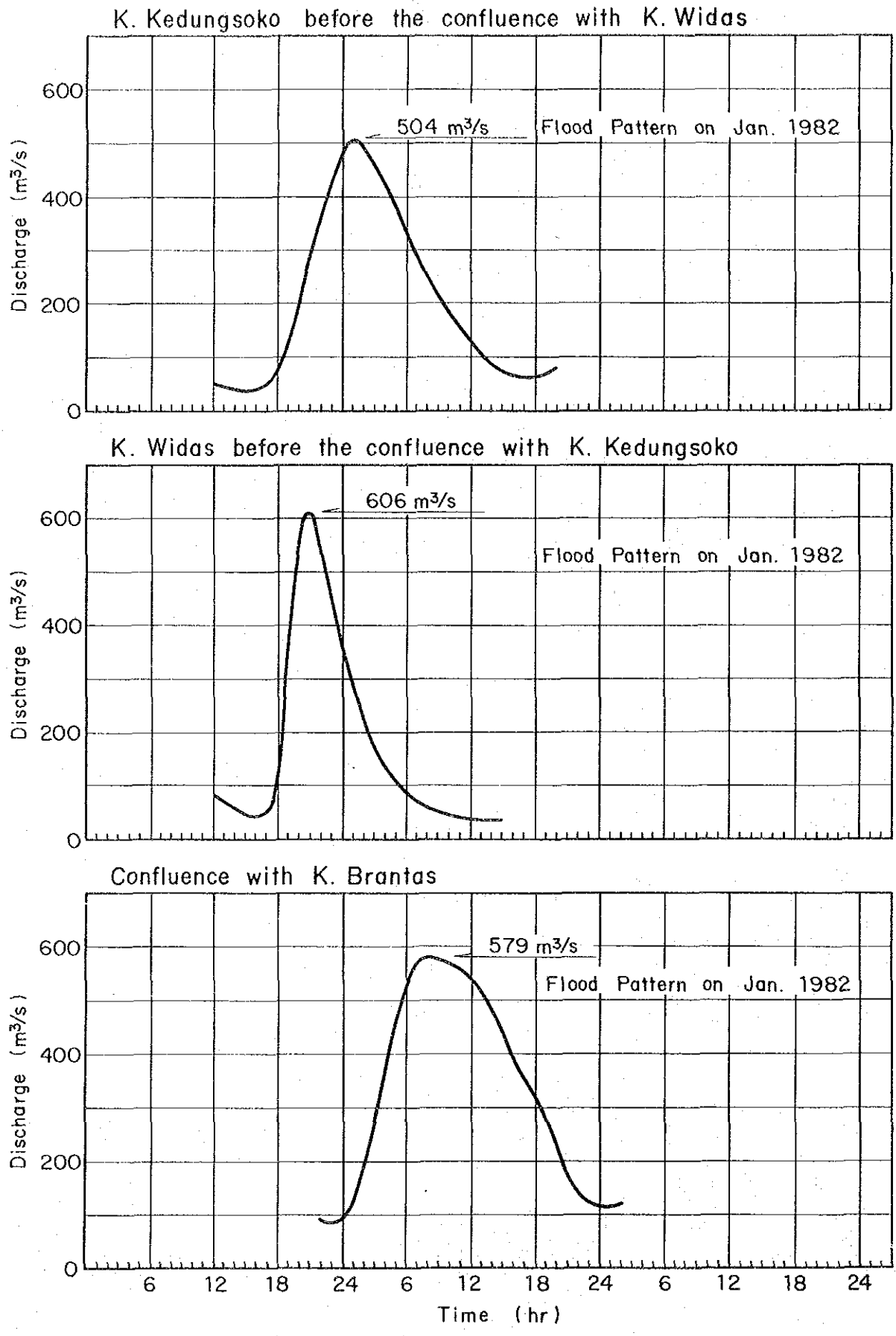


Fig. 2.3.15 FLOOD HYDROGRAPHS OF BASIC HIGH FLOW DISCHARGES

2.4 UNIT HYDROGRAPH METHOD OF FLOOD ANALYSIS AT DAM SITES

The method of unit hydropgraph analysis by using dimensionless hydrograph is as follows ; (refer to Fig. 2.4.1 and 2.4.2).

2.4.1 Assumption

Storm duration and distribution over a watershed affect the shape of the resulting unit-graphs. Direct averaging of unit-graphs of different storm durations gives erroneous results. However, such unit-graphs can be averaged by covering the unit graphs to dimensionless form. .

2.4.2 Hydrograph Analysis

Given : Recorded hydrograph at given point on a stream.

Required: Factors for deriving unit-graph to be applied at point of derivation, at another point on stream if of comparable run-off characteristics, or to comparable ungaged watershed.

Procedure :

(a) Plot recorded hydrograph on cartesian coordinate paper and on semilog paper,

(b) Estimate base flow by trial and error. Subtract base flow from recorded hydrograph and plot net hydrograph. If the base flow has been estimated correctly, the descending limb of hydrograph will be a straight line (exponential recession),

(c) Compute volume of net hydrograph as follows :
   (1) Add average hourly discharge to a point such as y on the exponential recession.
   (2) Total volume is sum of volume to y plus volume after y.

(d) Compute time of occurrence of one-half volume of hydrograph. The time to center of volume T_{cd}, equals time from beginning of rain of net hydrograph to time one-half volume has passed measuring point.

(e) Compute dimensionless graph as follows and plot on semilog paper,
   (i) Abscissa -- hours from beginning of excess rain expresses as present of T_{cv}.
   (ii) Ordinate -- discharge in m^3/sec of (at respective abscissa) multiplied by T_{cv}, all divided by net hydrograph volume expressed as m^3/sec.
   Days $(\frac{\text{hours}}{24})$