TABLES

CHAPTER 2

PRESENT CONDITION OF THE STUDY AREA

Table 2.1.1 DAILY RAINFALL RECORDS AVAILABLE AT ESTATE

No.	Name of Station	Elevation (m.MSL)	Location: Longitude	Location: Latitude	Year of Record: 55	60	65	70	75	80	85	90	95
1.01	Balai Penelitian	32	98° 41'	3° 33'	AAAAA	AAAAA	AAAAA	AAAAA	AAAAA	AAAAA	AAAAA	AAAAA	A
1.06	Glugur	80	98° 33'	3° 31'	AAAAA	AAAAA	AAAAA	AAAAA	AAAAA	BB			
1.09	Klumpang	14	98° 36'	3° 40'	AAAAA	AAAAA	AAAAA	AAAAA	AAAAA	BBAAA	AABBA	BAAAA	
1.16	Sei Semayang	29	98° 34'	3° 35'	AAAAA	AAAAA	AAAAA	AAAAA	BA BA	AABAB	BABAB	AAAAA	
1.19	Seruwai	6	98° 42'	3° 44'	AAAAA	AAAAA	AAAAA	AAAAA	AAAAA	BAAAA	AAAAB	AAAAA	
3.03	Aek Pancur	50	98° 47'	3° 28'	AAAAA	AAAAA	AAAAA	AAAAB	AAAAA	AAAAA	AAAAA	AAAAA	
3.08	Batu Gingging	118	98° 48'	3° 23'	AAA	AAAAA	AAAAB	BBB			BB		
3.32	Silinda	207	98° 48'	3° 14'			A	AAAAA	BBBBA	AAAAA	AAAAA	BAAAA	

Note : A = complete data, B = incomplete data

Table 2.1.2 HOURLY RAINFALL RECORDS AVAILABLE AT PMG

No.	Name of Station	EL (m.MSL)	Location: Longitude	Location: Latitude	Year of Record: 55	60	65	70	75	80	85	90	95
1	Sampali	25	98° 47'	3° 47'					AAA	AAAAA (1977 - 1994)	AAAAA	AAAAA	

Note : A = data available

Table 2.1.3 WATER LEVEL STATIONS IN THE STUDY AREA

No.	Name of Station	River System	Recorded since	Gauge Type
3	Helvetia	Deli	1974	Staff
4	Simeme	- do -	1971	Staff/Automatic
5	Tembung	Percut	1974	Staff/Automatic

Table 2.1.4 DAILY WATER LEVEL AND DISCHARGE RECORDS

No.	Name of Station	River System	Catchment Area (km^2)	Start Year	Data Existence: 55	60	65	70	75	80	85	90	95
3	Helvetia	Deli	341	1974.9				H	HHHHH	QQQQQ	QQQQQ	QQQ	
4	Simeme	Deli	158	1971.7				HQQH	HHHHH	QQQQQ	QQQQQ	QQQQ	
5	Tembung	Percut	171	1974.9				HH	HHHHH	HHHHH	HHHHH	QQQQ	

Note : H = Water Level Data (by Hydrology Section)
Q = Discharge Data (prepared by IHE)

Table 2.1.5 CLIMATOLOGICAL DATA AT SAMPALI STATION (PMG) IN MEDAN

Item	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Average
Monthly Rainfall	mm	78	61	81	121	174	102	145	148	198	271	208	190	1,777
Mean Temperature	°C	25	26	26	27	27	27	26	26	26	26	26	26	26
Mean Max. Temp.	°C	31	32	33	33	33	33	32	32	31	31	31	31	32
Mean Min. Temp.	°C	21	21	21	22	23	22	22	22	22	22	22	22	22
Relative Humidity	%	85	84	84	84	85	84	83	84	86	87	87	86	85
Rainy Days	dys	8	8	8	11	13	9	13	14	18	19	18	15	154
Sunshine Duration	%	49	54	59	57	57	60	59	58	49	45	43	47	53
Wind Velocity	m/s	1.3	0.81	0.85	78	0.73	0.74	0.81	0.76	0.75	0.75	0.75	0.85	1
Pan Evaporation	mm/d	3.8	4.5	4.5	4.7	4.6	4.7	4.5	4.8	4.1	4	3.9	3.4	1,566

Note : Data (by PMG) except evaporation are the average of 1974 - 1984

Evaporation data is expressed on the average of 1980 - 1989

Table 2.1.6 MEAN MONTHLY RAINFALL OF BASIN

(unit : mm/month)

River Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Deli	126	100	125	153	225	170	171	215	274	310	255	213	2,337
Percut	132	114	131	158	234	168	195	211	284	315	252	208	2,402

Note : Average of 1954 - 1994 using several rainfall station

Table 2.1.7 ANNUAL MAXIMUM FLOOD DISCHARGE

Station	Simeme			Helvetia			Tembung		
C.A.	158 km^2			341 km^2			171 km^2		
River	Deli			Deli			Percut		
Year	Date	Water Level (m)	Discharge (m^3/s)	Date	Water Level (m)	Discharge (m^3/s)	Date	Water Level (m)	Discharge (m^3/s)
1980	30 Oct	2.43	160	6 Dec	3.90	158	x	x	x
1981	16 Dec	2.42	158	29 Oct	3.58	136	x	x	x
1982	29 Dec	2.49	168	x	x	x	x	x	x
1983	30 Sep	2.53	174	x	x	x	x	x	x
1984	x	x	x	27 Jul	4.35	199	30 Oct	3.06	83
1985	6 Oct	2.90	235	6 Nov	4.60	224	21 May	3.49	105
1986	6 Dec	3.01	253	3 Feb	4.75	240	7 Dec	4.67	178
1987	16 Sep	2.43	160	x	x	x	10 Dec	4.45	163
1988	19 Sep	2.48	166	x	x	x	1 Apr	2.97	79
1989	24 Sep	2.12	119	24 Nov	4.55	219	19 Dec	4.24	149
1990	26 Nov	2.93	240	x	x	x	26 Nov	4.91	195
1991	11 Oct	2.35	149	13 Oct	2.95	101	26 Mar	3.17	89
1992	23 Dec	2.41	157	2 Oct	3.16	112	23 Dec	4.77	185
1993	1 Jul	1.93	96	18 Sep	2.99	103	5 Nov	3.62	112

Table 2.1.8 FLOW REGIME AT SIMEME (DELI RIVER)

(unit : m^3/s)

Year	Frequency							Average
	Max	25%	50%	80%	95%	99%	Min	
1984	x	x	x	x	x	x	x	x
1985	38.40	10.30	6.71	4.31	3.93	3.51	2.57	8.38
1986	27.20	8.35	4.76	3.65	2.81	2.33	2.23	6.66
1987	30.90	9.26	6.59	4.94	4.06	3.70	3.48	8.53
1988	25.90	9.85	8.08	4.97	5.16	6.13	4.43	9.08
1989	25.10	8.34	5.45	4.53	4.10	4.21	4.25	6.79
1990	34.60	9.55	6.50	4.70	3.60	3.20	2.80	7.58
1991	28.30	9.80	6.30	3.70	3.00	2.72	2.48	7.47
1992	43.20	9.85	7.12	4.74	3.56	2.98	2.94	8.01
1993	20.60	8.54	5.88	4.53	3.76	3.29	3.04	7.06
Average	30.47	9.32	6.38	4.45	3.78	3.56	3.14	7.73
Specific Discharge ($m^3/s\cdot km^2$)	0.193	0.059	0.040	0.028	0.024	0.023	0.020	0.049

Table 2.1.9 FLOW REGIME OBSERVED AT HELVETIA (DELI RIVER)

(unit : m^3/s)

Year	Frequency							Average
	Max	25%	50%	80%	95%	99%	Min	
1984	75.90	22.00	16.40	11.80	10.20	9.60	9.30	18.42
1985	81.50	20.40	13.90	8.85	5.52	4.69	4.58	16.13
1986	74.00	21.00	14.90	9.45	6.60	6.12	6.12	17.23
1987	42.90	17.70	12.10	7.50	8.85	9.90	10.40	14.28
1988	70.90	24.40	17.90	16.00	9.90	9.00	8.40	21.47
1989	85.00	23.80	17.90	12.10	9.90	8.85	8.40	20.84
1990	x	x	x	x	x	x	x	x
1991	54.80	22.00	13.90	9.00	7.35	6.60	5.88	17.28
1992	66.90	20.20	14.00	9.70	7.50	6.60	5.76	16.64
1993	48.00	19.60	13.70	9.60	7.20	5.88	4.69	15.92
Average Q	66.66	21.23	14.97	10.44	8.11	7.47	7.06	17.58
Specific Discharge ($m^3/s\cdot km^2$)	0.195	0.062	0.044	0.031	0.024	0.022	0.021	0.052

Table 2.1.10 FLOW REGIME OBSERVED AT TEMBUNG

(unit : m^3/s)

Year	Frequency							Average
	Max	25%	50%	80%	95%	99%	Min	
1990	79.60	10.10	6.97	4.21	2.68	1.69	1.56	8.47
1991	41.90	11.00	8.28	5.90	3.49	2.80	2.54	9.27
1992	56.40	9.39	7.40	5.72	4.54	3.60	2.01	8.50
1993	42.60	11.90	8.81	6.62	5.18	4.52	3.86	10.16
Average Q	55.13	10.60	7.87	5.61	3.97	3.15	2.49	9.10
Specific Discharge ($m^3/s\cdot km^2$)	0.322	0.062	0.046	0.033	0.023	0.018	0.015	0.053

Table 2.2.1 AREA, CENSUS POPULATION, GROWTH RATE, POPULATION DENSITY, NUMBER OF HOUSEHOLD AND HOUSEHOLD SIZE OF INDONESIA, NORTH SUMATRA, PROVINCE AND THE STUDY AREA

Administration	Area (km²)	Population			Population Density (person/km²)		Number of Households			Average Size of Household (person/household)	
		1980	1990	Annual Growth Rate (%)	1980	1990	1980	1990	Annual Growth Rate (%)	1980	1990
I Indonesia(1000pop)	1,919,317	147,490	179,379	1.98	76	92	30,372	39,772	2.73	4.86	4.51
II North Sumatra Prov.(1000	70,789	8,361	10,256	2.06	117	143	1,548	2,023	2.71	5.40	5.07
III Study Area	905.95	1,618,141	2,128,975	2.78	1,786	2,350	278,135	401,288	3.73	5.82	5.31
(1) Kodya Medan	265.10	1,373,737	1,730,052	2.33	5,182	6,526	232,864	324,084	3.36	5.90	5.34
Kecamatan											
1 Medan Tuntungan	14.90	11,743	48,539	15.25	788	3,258	2,322	10,095	15.83	5.06	4.81
2 Medan Johor	15.00	36,096	71,296	7.04	2,406	4,753	6,216	13,321	7.92	5.81	5.35
3 Medan Amplas	14.74	55,550	86,634	4.54	3,769	5,877	9,539	15,700	5.11	5.82	5.52
4 Medan Denai	7.96	63,736	106,946	5.31	8,007	13,435	11,520	19,194	5.24	5.53	5.57
5 Medan Tembung	6.80	92,115	117,904	2.50	13,546	17,339	16,360	21,918	2.97	5.63	5.38
6 Medan Kota	5.50	95,225	93,043	-0.23	17,314	16,917	15,578	16,977	0.86	6.11	5.48
7 Medan Area	3.80	118,373	116,779	-0.14	31,151	30,731	18,970	21,298	1.16	6.24	5.48
8 Medan Baru	4.94	52,016	49,499	-0.49	10,530	10,020	8,107	9,760	1.87	6.42	5.07
9 Medan Polonia	8.28	42,977	53,605	2.23	5,190	6,474	7,366	10,162	3.27	5.83	5.28
10 Medan Maimun	3.98	46,484	49,148	0.56	11,679	12,349	8,119	9,426	1.50	5.73	5.21
11 Medan Selayang	19.80	31,120	54,801	5.82	1,572	2,768	5,561	10,517	6.58	5.60	5.21
12 Medan Sunggal	15.70	64,620	91,675	3.56	4,116	5,839	11,015	16,953	4.41	5.87	5.41
13 Medan Helvetia	11.60	75,756	110,903	3.88	6,531	9,561	12,600	20,773	5.13	6.01	5.34
14 Medan Petisah	4.50	80,693	79,575	-0.14	17,932	17,683	13,721	15,141	0.99	5.88	5.26
15 Medan Barat	6.60	74,274	87,489	1.65	11,254	13,256	12,082	16,302	3.04	6.15	5.37
16 Medan Timur	7.60	98,797	109,433	1.03	13,000	14,399	16,345	20,993	2.53	6.04	5.21
17 Medan Deli	21.00	72,491	100,109	3.28	3,452	4,767	12,442	18,809	4.22	5.83	5.32
18 Medan Labuhan	46.00	38,815	55,624	3.66	844	1,209	7,018	10,258	3.87	5.53	5.42
19 Medan Belawan	10.00	81,165	83,666	0.30	8,117	8,367	14,120	15,033	0.63	5.75	5.57
20 Medan Perjuangan	4.40	101,561	104,458	0.28	23,082	23,740	16,723	20,097	1.85	6.07	5.20
21 Medan Marelan	32.00	40,130	58,928	3.92	1,254	1,842	7,140	11,357	4.75	5.62	5.19
(2) Kab. Deli Serdang	640.85	244,404	398,923	5.02	381	622	45,271	77,204	5.48	5.40	5.17
Kecamatan											
1 Pancur Batu	122.53	35,957	47,961	2.92	293	391	6,861	9,793	3.62	5.24	4.90
2 Namo Rambe	62.30	12,660	17,444	3.26	203	280	2,573	3,577	3.35	4.92	4.88
3 Patumbak	46.79	21,186	34,522	5.00	453	738	3,901	6,612	5.42	5.43	5.22
4 Deli Tua	9.36	21,325	32,806	4.40	2,278	3,505	4,047	6,499	4.85	5.27	5.05
5 Labuhan Deli	127.23	23,581	36,774	4.54	185	289	4,322	7,198	5.23	5.46	5.11
6 Percut Sei Tuan	190.79	105,894	197,192	6.41	555	1,034	19,092	37,304	6.93	5.55	5.29
7 Pantai Labu	81.85	23,801	32,224	3.08	291	394	4,475	6,221	3.35	5.32	5.18

Source : Sensus Punduduk 1980 dan 1990

Table 2.2.2 GDP OF INDONESIA AND GRDP OF NORTH SUMATRA PROVINCE, KAB. DELI SERDANG AND KODYA. MEDAN, 1987 -1992

(Unit : Rp Billion)

No. Items	1987	1988	1989	1990	1991	1992	Annual Growth Rate (%) 1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	Average
I. At Current Prices												
1 Indonesia	124,817	142,105	167,185	195,597	227,502	260,786	13.9	17.6	17.0	16.3	14.6	15.9
2 North Sumatra Province	6,210	7,671	9,039	10,449	11,806	13,834	23.5	17.8	15.6	13.0	17.2	17.4
3 Kab. Deli Serdang	774	939	1,114	1,341	1,508	1,792	21.3	18.6	20.4	12.5	18.8	18.3
4 Kodya. Medan	1,533	1,836	2,241	2,588	2,944	3,447	19.8	22.1	15.5	13.8	17.1	17.6
II. At 1983 Constant Prices												
1 Indonesia	94,518	99,981	107,437	115,217	123,181	131,102	5.8	7.5	7.2	6.9	6.4	6.8
2 North Sumatra Province	4,309	4,825	5,298	5,743	6,177	6,630	12.0	9.8	8.4	7.6	7.3	9.0
3 Kab. Deli Serdang	542	593	646	726	777	836	9.4	8.9	12.4	7.0	7.6	9.1
4 Kodya. Medan	1,085	1,197	1,356	1,468	1,582	1,737	10.3	13.3	8.3	7.8	9.8	9.9

Source : (1) Statistical Year Book of Indonesia, 1990 and 1993, Biro Pusat Statistik.
(2) North Sumatra in Figures 1993, the Statistical Office of North Sumatra Province and the Provincial Development Planning Board of North Sumatra Province.

Table 2.2.3 GDP PER CAPITA OF INDONESIA AND GRDP OF NORTH SUMATRA PR0VINCE, KAB. DELI SERDANG AND KODYA. MEDAN, 1987 -1992

(Unit : Rp 1000)

No. Items	1987	1988	1989	1990	1991	1992	Annual Growth Rate (%) 1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	Average
I. At Current Prices												
1 Indonesia	720	829	957	1,098	1,254	1,414	15.1	15.4	14.7	14.2	12.8	14.5
2 North Sumatra Province	648	784	905	1,026	1,131	1,283	21.0	15.4	13.4	10.2	13.4	14.7
3 Kab. Deli Serdang	523	624	721	845	927	1,077	19.3	15.5	17.2	9.7	16.2	15.6
4 Kodya. Medan	954	1,117	1,334	1,505	1,662	1,926	17.1	19.4	12.8	10.4	15.9	15.1
II. At 1983 Constant Prices												
1 Indonesia	542	583	615	647	679	711	7.6	5.5	5.2	4.9	4.7	5.6
2 North Sumatra Province	449	493	531	563	594	612	9.8	7.7	6.0	5.5	3.0	6.4
3 Kab. Deli Serdang	367	394	420	457	477	503	7.4	6.6	8.8	4.4	5.5	6.5
4 Kodya. Medan	675	728	807	853	892	971	7.9	10.9	5.7	4.6	8.9	7.6

Source : (1) Statistical Year Book of Indonesia, 1990 and 1993, Biro Pusat Statistik.
(2) North Sumatra in Figures 1993, the Statistical Office of North Sumatra Province and the Provincial Development Planning Board of North Sumatra Province.

Table 2.2.4 HARVESTED AREA, PRODUCTION AND YIELD RATE OF MAJOR FOOD CROPS IN NORTH SUMATRA PROVINCE

Crops	1988	1989	1990	1991	1992	1993	Annual Growth Rate (%)					
							1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	Average
1 Wet land paddy												
Harvest area (ha)	592,775	599,523	618,657	645,898	672,915	680,277	1.14	3.19	4.40	4.18	1.09	2.80
Production (tons)	2,318,139	2,369,841	2,478,460	2,584,678	2,715,280	2,750,463	2.23	4.58	4.29	5.05	1.30	3.49
Yield rate (tons/h	3.91	3.95	4.01	4.00	4.04	4.04	1.08	1.35	-0.11	0.84	0.20	0.67
2 Dry land paddy												
Harvest area (ha)	80,110	79,900	63,141	67,162	79,721	74,292	-0.26	-20.97	6.37	18.70	-6.81	-0.60
Production (tons)	164,799	171,033	139,294	145,715	179,914	167,689	3.78	-18.56	4.61	23.47	-6.79	1.30
Yield rate (tons/h	2.06	2.14	2.21	2.17	2.26	2.26	4.06	3.06	-1.65	4.02	0.02	1.90
3 Wet & Dry paddy												
Harvest area (ha)	672,885	679,423	681,798	713,060	752,636	754,569	0.97	0.35	4.59	5.55	0.26	2.34
Production (tons)	2,482,938	2,540,874	2,617,754	2,730,393	2,895,194	2,918,152	2.33	3.03	4.30	6.04	0.79	3.30
Yield rate (tons/h	3.69	3.74	3.84	3.83	3.85	3.87	1.35	2.67	-0.27	0.46	0.53	0.95
4 Maize												
Harvest area (ha)	82,760	86,818	88,099	93,772	115,974	122,039	4.90	1.48	6.44	23.68	5.23	8.34
Production (tons)	168,277	175,991	187,799	222,162	262,412	271,298	4.58	6.71	18.30	18.12	3.39	10.22
Yield rate (tons/h	2.03	2.03	2.13	2.37	2.26	2.22	-0.30	5.16	11.14	-4.49	-1.75	1.95
5 Cassava												
Harvest area (ha)	26,768	37,879	28,384	27,302	31,073	29,325	41.51	-25.07	-3.81	13.81	-5.63	4.16
Production (tons)	327,662	488,693	365,911	337,656	373,983	350,446	49.15	-25.12	-7.72	10.76	-6.29	4.15
Yield rate (tons/h	12.24	12.90	12.89	12.37	12.04	11.95	5.40	-0.08	-4.06	-2.68	-0.71	-0.43
6 Sweet potatoes												
Harvest area (ha)	16,002	18,611	15,410	15,911	15,239	16,486	16.30	-17.20	3.25	-4.22	8.18	1.26
Production (tons)	155,436	182,942	153,202	132,140	135,096	146,465	17.70	-16.26	-13.75	2.24	8.42	-0.33
Yield rate (tons/h	9.71	9.83	9.94	8.30	8.87	8.88	1.20	1.14	-16.46	6.75	0.21	-1.43
7 Peanuts												
Harvest area (ha)	24,641	26,812	19,907	16,505	19,049	24,607	8.81	-25.75	-17.09	15.41	29.18	2.11
Production (tons)	28,502	31,303	25,646	15,682	18,350	24,801	9.83	-18.07	-38.85	17.01	35.16	1.01
Yield rate (tons/h	1.16	1.17	1.29	0.95	0.96	1.01	0.93	10.35	-26.25	1.39	4.63	-1.79
8 Soybeans												
Harvest area (ha)	29,957	24,213	29,671	37,135	45,644	51,384	-19.17	22.54	25.16	22.91	12.58	12.80
Production (tons)	29,981	24,759	33,360	35,912	44,216	52,786	-17.42	34.74	7.65	23.12	19.38	13.50
Yield rate (tons/h	1.00	1.02	1.12	0.97	0.97	1.03	2.17	9.95	-13.99	0.17	6.05	0.87
9 Green peas												
Harvest area (ha)	8,094	10,547	7,731	7,899	12,559	13,353	30.31	-26.70	2.17	58.99	6.32	14.22
Production (tons)	7,645	9,966	7,579	7,338	11,616	12,363	30.36	-23.95	-3.18	58.30	6.43	13.59
Yield rate (tons/h	0.94	0.94	0.98	0.93	0.92	0.93	0.04	3.75	-5.24	-0.44	0.10	-0.36
10 Upland crops												
Harvest area (ha)	188,222	204,880	189,202	198,524	239,538	257,194	8.85	-7.65	4.93	20.66	7.37	6.83
Production (tons)	717,503	913,654	773,497	750,890	845,673	858,159	27.34	-15.34	-2.92	12.62	1.48	4.63
Yield rate (tons/h	3.81	4.46	4.09	3.78	3.53	3.34	16.98	-8.33	-7.48	-6.66	-5.49	-2.19

Source : (1) Statistical Year Book of Indonesia, 1990 and 1993, Biro Pusat Statistik.
(2) North Sumatra in Figures 1993, the Statistical Office of North Sumatra Province and the Provincial Development Planning Board of North Sumatra Province.

Table 2.2.5 HARVESTED AREA, PRODUCTION AND YIELD RATE OF MAJOR FOOD CROPS IN KAB. DELI SERDANG

Crops	1988	1989	1990	1991	1992	1993	Annual Growth Rate (%)					
							1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	Average
1 Wet land paddy												
Harvest area (ha)	127,323	128,365	131,088	137,777	141,736	146,601	0.82	2.12	5.10	2.87	3.43	2.87
Production (tons)	532,297	537,584	558,981	617,027	610,972	633,993	0.99	3.98	10.38	-0.98	3.77	3.63
Yield rate (tons/h	4.18	4.19	4.26	4.48	4.31	4.32	0.17	1.82	5.03	-3.75	0.32	0.72
2 Dry land paddy												
Harvest area (ha)	5,657	3,798	3,589	3,938	4,489	3,994	-32.86	-5.50	9.72	13.99	-11.03	-5.14
Production (tons)	12,081	8,468	8,243	8,868	10,964	8,821	-29.91	-2.66	7.58	23.64	-19.55	-4.18
Yield rate (tons/h	2.14	2.23	2.30	2.25	2.44	2.21	4.40	3.01	-1.95	8.46	-9.57	0.87
3 Wet & Dry paddy												
Harvest area (ha)	132,980	132,163	134,677	141,715	146,225	150,595	-0.61	1.90	5.23	3.18	2.99	2.54
Production (tons)	544,378	546,052	567,224	625,895	621,936	642,814	0.31	3.88	10.34	-0.63	3.36	3.45
Yield rate (tons/h	4.09	4.13	4.21	4.42	4.25	4.27	0.93	1.94	4.86	-3.70	0.36	0.88
4 Maize												
Harvest area (ha)	8,295	9,382	11,015	14,132	12,874	15,473	13.10	17.41	28.30	-8.90	20.19	14.02
Production (tons)	14,885	16,980	24,286	36,229	31,673	37,492	14.07	43.03	49.18	-12.58	18.37	22.41
Yield rate (tons/h	1.79	1.81	2.20	2.56	2.46	2.42	0.86	21.82	16.27	-4.03	-1.51	6.68
5 Cassava												
Harvest area (ha)	6,606	10,886	7,385	9,184	8,538	9,409	64.79	-32.16	24.36	-7.03	10.20	12.03
Production (tons)	92,951	154,833	105,746	124,980	114,249	122,485	66.57	-31.70	18.19	-8.59	7.21	10.34
Yield rate (tons/h	14.07	14.22	14.32	13.61	13.38	13.02	1.08	0.67	-4.96	-1.67	-2.72	-1.52
6 Sweet potatoes												
Harvest area (ha)	1,351	1,074	1,629	1,938	1,945	2,636	-20.50	51.68	18.97	0.36	35.53	17.21
Production (tons)	14,828	18,737	18,022	17,440	19,534	26,587	26.36	-3.82	-3.23	12.01	36.11	13.49
Yield rate (tons/h	10.98	17.45	11.06	9.00	10.04	10.09	58.95	-36.59	-18.66	11.60	0.43	3.15
7 Peanuts												
Harvest area (ha)	1,330	1,322	1,347	1,417	1,467	3,679	-0.60	1.89	5.20	3.53	150.78	32.16
Production (tons)	2,722	2,701	3,423	2,806	2,679	4,188	-0.77	26.73	-18.03	-4.53	56.33	11.95
Yield rate (tons/h	2.05	2.04	2.54	1.98	1.83	1.14	-0.17	24.38	-22.07	-7.78	-37.66	-8.66
8 Soybeans												
Harvest area (ha)	1,793	2,025	3,257	5,913	10,129	9,980	12.94	60.84	81.55	71.30	-1.47	45.03
Production (tons)	2,167	2,588	4,345	5,920	10,882	10,905	19.43	67.89	36.25	83.82	0.21	41.52
Yield rate (tons/h	1.21	1.28	1.33	1.00	1.07	1.09	5.75	4.38	-24.95	7.31	1.71	-1.16
9 Green peas												
Harvest area (ha)	2,596	2,819	3,199	4,281	6,437	7,606	8.59	13.48	33.82	50.36	18.16	24.88
Production (tons)	2,100	2,318	3,050	4,060	6,147	7,301	10.38	31.58	33.11	51.40	18.77	29.05
Yield rate (tons/h	0.81	0.82	0.95	0.95	0.95	0.96	1.65	15.95	-0.53	0.69	0.52	3.66
10 Upland crops												
Harvest area (ha)	21,971	27,508	27,832	36,865	41,390	48,783	25.20	1.18	32.46	12.27	17.86	17.79
Production (tons)	129,653	198,157	158,872	191,435	185,164	208,958	52.84	-19.83	20.50	-3.28	12.85	12.62
Yield rate (tons/h	5.90	7.20	5.71	5.19	4.47	4.28	22.07	-20.76	-9.03	-13.85	-4.25	-5.16

Source : (1) Statistical Year Book of Indonesia, 1990 and 1993, Biro Pusat Statistik.
(2) North Sumatra in Figures 1993, the Statistical Office of North Sumatra Province and the Provincial Development Planning Board of North Sumatra Province.
(3) Deli Serdang Dalam Angka,1993, Biro Pusat Statistik Kabupaten Deli Serdang

Table 2.2.6 HARVESTED AREA, PRODUCTION AND YIELD RATE OF MAJOR FOOD CROPS IN KODYA. MEDAN

Crops	1988	1989	1990	1991	1992	1993	Annual Growth Rate (%) 1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	Average
1 Wet land paddy												
Harvest area (ha)	5,663	5,996	4,914	5,767	-	5,871	5.88	-18.05	17.36	-	-	1.73
Production (tons)	23,200	23,382	20,890	25,448	24,118	25,626	0.78	-10.66	21.82	-5.23	6.25	2.59
Yield rate (tons/ha	4.10	3.90	4.25	4.41	-	4.36	-4.81	9.01	3.80	-	-	2.67
2 Dry land paddy												
Harvest area (ha)	0	0	0	0	-	0	-	-	-	-	-	-
Production (tons)	0	0	0	0	0	0	-	-	-	-	-	-
Yield rate (tons/ha	0	0	0	0	0	0	-	-	-	-	-	-
3 Wet & Dry paddy												
Harvest area (ha)	5,663	5,996	4,914	5,767	-	5,871	5.88	-18.05	17.36	-	-	1.73
Production (tons)	23,200	23,382	20,890	25,448	24,118	25,626	0.78	-10.66	21.82	-5.23	6.25	2.59
Yield rate (tons/ha	4.10	3.90	4.25	4.41	-	4.36	-4.81	9.01	3.80	-	-	2.67
4 Maize												
Harvest area (ha)	273	311	379	571	-	443	13.92	21.86	50.66	-	-	28.81
Production (tons)	644	458	671	1,013	897	1,075	-28.88	46.51	50.97	-11.45	19.84	15.40
Yield rate (tons/ha	2.36	1.47	1.77	1.77	-	2.43	-37.57	20.22	0.21	-	-	-5.72
5 Cassava												
Harvest area (ha)	499	444	480	465	-	568	-11.02	8.11	-3.13	-	-	-2.01
Production (tons)	6,362	6,078	6,836	6,364	6,238	7,627	-4.46	12.47	-6.90	-1.98	22.27	4.28
Yield rate (tons/ha	12.75	13.69	14.24	13.69	-	13.43	7.37	4.04	-3.90	-	-	2.50
6 Sweet potatoes												
Harvest area (ha)	206	243	259	329	-	330	17.96	6.58	27.03	-	-	17.19
Production (tons)	1,879	2,693	2,532	2,924	3,082	3,320	43.32	-5.98	15.48	5.40	7.72	13.19
Yield rate (tons/ha	9.12	11.08	9.78	8.89	-	10.06	21.50	-11.79	-9.09	-	-	0.21
7 Peanuts												
Harvest area (ha)	175	201	180	282	-	274	14.86	-10.45	56.67	-	-	20.36
Production (tons)	228	282	245	293	316	311	23.68	-13.12	19.59	7.85	-1.58	7.28
Yield rate (tons/ha	1.30	1.40	1.36	1.04	-	1.14	7.69	-2.98	-23.66	-	-	-6.32
8 Soybeans												
Harvest area (ha)	111	125	110	122	-	151	12.61	-12.00	10.91	-	-	3.84
Production (tons)	148	147	133	113	299	161	-0.68	-9.52	-15.04	164.60	-46.15	18.64
Yield rate (tons/ha	1.33	1.18	1.21	0.93	-	1.07	-11.80	2.81	-23.39	-	-	-10.79
9 Green peas												
Harvest area (ha)	167	185	138	167	-	396	10.78	-25.41	21.01	-	-	2.13
Production (tons)	148	159	132	160	317	379	7.43	-16.98	21.21	98.13	19.56	25.87
Yield rate (tons/ha	0.89	0.86	0.96	0.96	-	0.96	-3.02	11.29	0.16	-	-	2.81
10 Upland crops												
Harvest area (ha)	1,431	1,509	1,546	1,936	-	2,162	5.45	2.45	25.23	-	-	11.04
Production (tons)	9,409	9,817	10,549	10,867	11,149	12,873	4.34	7.46	3.01	2.60	15.46	6.57
Yield rate (tons/ha	6.58	6.51	6.82	5.61	-	5.95	-1.06	4.88	-17.74	-	-	-4.64

Source : (1) Statistical Year Book of Indonesia, 1990 and 1993, Biro Pusat Statistik.
(2) North Sumatra in Figures 1993, the Statistical Office of North Sumatra Province and the Provincial Development Planning Board of North Sumatra Province.
(3) Kota Madya Medan Dalam Angka,1993, Biro Pusat Statistik, Kotamadya Medan

Table 2.2.7 PLANTED AREA, PRODUCTION AND YIELD RATE OF MAJOR PLANTS SMALLHOLDER ESTATE IN NORTH SUMATRA PROVINCE

Plants	1988	1989	1990	1991	1992	1993	Annual Growth Rate (%)					
							1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	Average
1 Rubber												
Productive area (ha)	310,293	325,540	328,542	328,955	329,632	331,237	4.91	0.92	0.13	0.21	0.49	1.33
Production (tonnes)	117,261	120,227	170,086	173,016	182,179	169,692	2.53	41.47	1.72	5.30	-6.85	8.83
Yield rate (kg/ha)	378	369	518	526	553	512	-2.27	40.18	1.59	5.08	-7.31	7.45
2 Palm oil												
Productive area (ha)	58,299	66,893	73,498	74,317	76,323	86,535	14.74	9.87	1.11	2.70	13.38	8.36
Production (tonnes)	90,925	74,704	-	162,987	171,080	188,457	-17.84	-	-	4.97	10.16	-0.54
Yield rate (kg/ha)	1,560	1,117	-	2,193	2,242	2,178	-28.40	-	-	2.21	-2.84	-5.81
3 Palm kernel												
Productive area (ha)	58,299	66,893	73,498	74,317	76,323	86,535	14.74	9.87	1.11	2.70	13.38	8.36
Production (tonnes)	12,562	9,960	-	24,821	24,440	26,923	-20.71	-	-	-1.53	10.16	-2.42
Yield rate (kg/ha)	215	149	-	334	320	311	-30.90	-	-	-4.12	-2.84	-7.57
4 Coffee												
Productive area (ha)	63,448	65,628	65,911	65,977	63,998	58,959	3.44	0.43	0.10	-3.00	-7.87	-1.38
Yield rate (tonnes/ha)	28,574	31,409	31,414	31,967	35,784	29,979	9.92	0.02	1.76	11.94	-16.22	1.48
Yield rate (kg/ha)	450	479	477	485	559	508	6.27	-0.41	1.66	15.40	-9.06	2.77
5 Coconut												
Productive area (ha)	140,015	144,927	146,684	146,180	145,514	140,633	3.51	1.21	-0.34	-0.46	-3.35	0.11
Production (tonnes)	89,376	89,472	93,420	96,281	91,577	96,352	0.11	4.41	3.06	-4.89	5.21	1.58
Yield rate (kg/ha)	638	617	637	659	629	685	-3.29	3.16	3.42	-4.45	8.87	1.54
6 Cocoa												
Productive area (ha)	8,645	14,802	15,228	16,980	19,055	19,421	71.22	2.88	11.51	12.22	1.92	19.95
Production (tonnes)	1,608	2,627	3,462	4,447	7,360	8,194	63.37	31.79	28.45	65.50	11.33	40.09
Yield rate (kg/ha)	186	177	227	262	386	422	-4.58	28.10	15.20	47.48	9.23	19.09
7 Tobacco												
Productive area (ha)	439	475	396	376	360	575	8.20	-16.63	-5.05	-4.26	59.72	8.40
Production (tonnes)	179	230	195	187	193	289	28.49	-15.22	-4.10	3.21	49.74	12.42
Yield rate (kg/ha)	408	484	492	497	536	503	18.75	1.70	1.00	7.80	-6.25	4.60
8 Sugar cane												
Productive area (ha)	1,311	1,440	1,511	1,527	1,566	1,133	9.84	4.93	1.06	2.55	-27.65	-1.85
Production (tonnes)	791	812	1,126	1,163	1,547	1,239	2.65	38.67	3.29	33.02	-19.91	11.54
Yield rate (kg/ha)	603	564	745	762	988	1,094	-6.54	32.15	2.20	29.71	10.70	13.64
9 Tea												
Productive area (ha)	300	775	775	775	1,400	1,401	158.33	0.00	0.00	80.65	0.07	47.81
Production (tonnes)	-	-	-	350	575	1,940	-	-	-	64.29	237.39	60.34
Yield rate (kg/ha)	-	-	-	452	411	1,385	-	-	-	-9.06	237.15	45.62

Source : (1) Statistical Year Book of Indonesia, 1990 and 1993, Biro Pusat Statistik.
(2) North Sumatra in Figures 1993, the Statistical Office of North Sumatra Province and the Provincial Development Planning Board of North Sumatra Province.

Table 2.2.8 PLANTED AREA, PRODUCTION AND YIELD RATE OF MAJOR PLANTS OF ESTATE ENTERPRISES (II-IX) IN NORTH SUMATRA PROVINCE

Plants	1988	1989	1990	1991	1992	1993	Annual Growth Rate (%) 1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	Average
1 Rubber												
Productive area (ha)	84,670	84,343	74,994	75,621	72,393	67,362	-0.39	-11.08	0.84	-4.27	-6.95	-4.37
Production (tonnes)	99,975	100,043	85,243	78,686	74,984	74,496	0.07	-14.79	-7.69	-4.70	-0.65	-5.55
Yield rate (kg/ha)	1,181	1,186	1,137	1,041	1,036	1,106	0.46	-4.17	-8.46	-0.46	6.77	-1.17
2 Palm oil												
Productive area (ha)	260,564	288,972	285,702	291,224	301,448	315,108	10.90	-1.13	1.93	3.51	4.53	3.95
Production (tonnes)	853,903	891,476	1,127,737	1,220,043	1,225,783	1,324,962	4.40	26.50	8.19	0.47	8.09	9.53
Yield rate (kg/ha)	3,277	3,085	3,947	4,189	4,066	4,205	-5.86	27.95	6.13	-2.94	3.41	5.74
3 Palm kernel												
Productive area (ha)	260,564	288,972	285,702	291,224	301,448	315,108	10.90	-1.13	1.93	3.51	4.53	3.95
Production (tonnes)	188,538	121,566	246,757	266,458	272,169	291,794	-35.52	102.98	7.98	2.14	7.21	16.96
Yield rate (kg/ha)	724	421	864	915	903	926	-41.86	105.31	5.94	-1.32	2.56	14.12
4 Coffee												
Productive area (ha)	42	42	0	0	0	0	0.00	-	-	-	-	-
Yield rate (tonnes/h	30	30	0	0	0	0	0.00	-	-	-	-	-
Yield rate (kg/ha)	714	714	-	-	-	-	0.00	-	-	-	-	-
5 Cocoa												
Productive area (ha)	10,585	12,715	12,797	15,212	18,099	19,870	20.12	0.64	18.87	18.98	9.79	13.68
Production (tonnes)	11,010	13,129	14,261	13,846	18,942	22,203	19.25	8.62	-2.91	36.80	17.22	15.80
Yield rate (kg/ha)	1,040	1,033	1,114	910	1,047	1,117	-0.73	7.93	-18.32	14.98	6.77	2.12
6 Tobacco												
Productive area (ha)	2,774	2,778	2,793	2,793	2,826	2,685	0.14	0.54	0.00	1.18	-4.99	-0.62
Production (tonnes)	1,364	1,682	1,673	1,849	1,448	1,123	23.31	-0.54	10.52	-21.69	-22.44	-2.17
Yield rate (kg/ha)	492	605	599	662	512	418	23.14	-1.07	10.52	-22.60	-18.37	-1.68
7 Sugar cane												
Productive area (ha)	14,761	13,387	13,203	13,293	13,701	13,698	-9.31	-1.37	0.68	3.07	-0.02	-1.39
Production (tonnes)	83,639	59,318	58,933	80,494	81,639	86,605	-29.08	-0.65	36.59	1.42	6.08	2.87
Yield rate (kg/ha)	5,666	4,431	4,464	6,055	5,959	6,322	-21.80	0.74	35.66	-1.60	6.11	3.82
8 Tea												
Productive area (ha)	8,952	12,030	11,852	11,528	12,305	12,666	34.38	-1.48	-2.73	6.74	2.93	7.97
Production (tonnes)	25,669	26,654	26,269	26,479	26,923	27,165	3.84	-1.44	0.80	1.68	0.90	1.15
Yield rate (kg/ha)	2,867	2,216	2,216	2,297	2,188	2,145	-22.73	0.04	3.63	-4.74	-1.98	-5.16

Source : (1) Statistical Year Book of Indonesia, 1990 and 1993, Biro Pusat Statistik.
(2) North Sumatra in Figures 1993, the Statistical Office of North Sumatra Province and the Provincial Development Planning Board of North Sumatra Province.

Table 2.2.9 PLANTED AREA, PRODUCTION AND YIELD RATE OF MAJOR PLANTS OF SMALLHOLDER ESTATE IN KAB.DELI SERDANG, 1993

Kabupaten/ Kecamatan	Rubber			Palm Oil			Coffee			Coconut			Cocoa			Sugar Cane		
	Productive Area (ha)	Production (tons)	Yield (kg/ha)	Productive Area (ha)	Production (tons)	Yield (kg/ha)	Productive Area (ha)	Production (tons)	Yield (kg/ha)	Productive Area (ha)	Production (tons)	Yield (kg/ha)	Productive Area (Ha)	Production (Tons)	Yield (Kg/Ha	Productive Area (Ha)	Production (Tons)	Yield (Kg/Ha)
Kab. Deli Serdang	22,023	14,271	648	1,041	9,425	9,054	2,044	2,064	1,010	9,901	8,098	818	1,453	893	615	295	316	1,071
Study Area													0	0	-	0	0	-
1 Kec. Pancur Batu	526	368	700	0	0	-	100	660	6,600	63	53	841	0	0	-	0	0	-
2 Kec. Namo Rambe	201	125	622	0	0	-	40	25	625	180	130	722	0	0	-	0	0	-
3 Kec. Patumbak	8	4	500	0	0	-	25	23	920	56	53	946	0	0	-	0	0	-
4 Kec. Deli Tua	0	0	-	0	0	-	0	0	-	116	89	767	0	0	-	0	0	-
5 Kec. Labuhan Deli	0	0	-	0	0	-	0	0	-	548	384	701	0	0	-	0	0	-
6 Kec. Percut Sei Tuan	0	0	-	0	0	-	0	0	-	1,550	1,185	765	0	0	-	0	0	-
7 Kec. Pantai Labu	0	0	-	0	0	-	0	0	-	57	56	982	0	0	-	0	0	-
Total	735	497	676	0	0	-	165	708	4,291	2,570	1,950	759	0	0	-	0	0	-

Source : (1) Statistical Year Book of Indonesia, 1990 and 1993, Biro Pusat Statistik.
(2) North Sumatra in Figures 1993, the Statistical Office of North Sumatra Province and the Provincial Development Planning Board of North Sumatra Province.
(3) Deli Serdang Dalam Angka, 1993, Biro Pusat Statistik, Kab. Deli Serdang

Table 2.2.10 CONSUMER PRCE INDICES AND INFLATION RATE IN MEDAN AND JAKARTA (APRIL 1988 - MARCH 1989 = 100)

Sector	Items	Medan					Jakarta				
		1990	1991	1992	1993	Average Annual Rise Rate (%)	1990	1991	1992	1993	Average Annual Rise Rate (%)
1. General	Price Indices	112.42	120.78	129.62	142.96		112.31	123.79	134.30	148.29	
	Inflation Rate	-	7.44	7.32	10.29	8.35	-	10.22	8.49	10.42	9.71
2. Food	Price Indices	108.09	113.80	121.96	129.43		109.18	118.63	129.45	139.60	
	Inflation Rate	-	5.28	7.17	6.12	6.19	-	8.66	9.12	7.84	8.54
3. Housing	Price Indices	116.78	126.17	134.99	156.85		115.06	127.87	137.65	156.67	
	Inflation Rate	-	8.04	6.99	16.19	10.41	-	11.13	7.65	13.82	10.87
4. Clothing	Price Indices	108.14	116.46	123.97	138.58		113.96	119.98	130.32	147.10	
	Inflation Rate	-	7.47	6.45	11.79	8.57	-	5.28	8.62	12.88	8.93
5. Miscellaneous	Price Indices	117.31	129.10	139.98	153.66		111.90	126.49	137.55	149.03	
	Inflation Rate	-	10.05	8.43	9.77	9.42	-	13.04	8.74	8.35	10.04

Source : Statistical Year Book of Indonesia, 1993, Bior Pusat Statistik

Table 2.2.11 PRODUCER PRICES OF CEREALS, SECONDARY FOOD CROPS AND VEGETABLES IN NORTH SUMATRA PROVINCE

(Unit : Rp / 100 kg)

Agricultural Crops	1990	1991	1992	1993	Annual Rise Rate (%)			
					1990-1991	1991-1992	1992-1993	Average 1990-93
1 Dried Paddy	30,567	35,424	37,597	33,610	15.89	6.13	-10.60	3.81
2 Dried Glutinous Paddy	33,781	33,527	47,572	36,542	-0.75	41.89	-23.19	5.98
3 Yellow Maize	27,186	22,856	34,120	24,823	-15.93	49.28	-27.25	2.04
4 Unbitter Cassava	8,338	9,165	9,227	8,757	9.92	0.68	-5.09	1.83
5 Potatoes	30,583	32,500	24,573	33,621	6.27	-24.39	36.82	6.23
6 Fresh Peanuts	61,875	62,011	64,835	65,835	0.22	4.55	1.54	2.11
7 Soybeans	66,377	84,666	92,723	85,885	27.55	9.52	-7.37	9.90
8 Green Peas	105,335	108,654	120,310	130,113	3.15	10.73	8.15	7.34
9 Cucumber	20,897	22,606	23,028	27,500	8.18	1.87	19.42	9.82
10 Cabbage	19,380	19,005	28,095	15,091	-1.93	47.83	-46.29	-0.13
11 Chili (red)	159,750	149,797	161,660	174,783	-6.23	7.92	8.12	3.27
12 Green Tomatoes	42,404	41,150	60,366	51,515	-2.96	46.70	-14.66	9.69
13 Egg Plant	20,871	31,430	25,221	25,514	50.59	-19.76	1.16	10.67
14 Onion	98,666	81,768	98,012	132,778	-17.13	19.87	35.47	12.74

Source : North Sumatra in Figures 1993, the Statistical Office of North Sumatra Province and the Provincial Development Planning Board of North Sumatra Province.

Table 2.3.1 RIVER IMPROVEMENT WORKS IN THE STUDY AREA BY DPUP

Year	Name of River	Main Works	Quantity	Cost (Rp)	Remarks
1980/1981	Serdang & Padang	Rehabilitation of Works	75 km	7,499,925	Including other 1 river
	Serdang	-ditto-	1,465 m	36,100,000	
1981/1982	Serdang	-ditto-	3,600 m	99,872,000	
	Belawan, Belumai and Belutu	Survey	39 km	4,999,540	Including other 3 rivers
	Serdang	Survey	20 km	4,997,900	Including other 2 rivers
1982/1983	Serdang	Rehabilitation of Dike	6,900 m	260,084,500	
	Batugingging	-ditto-	3,225 m	45,000,000	
1983/1984	Padang	-ditto-	2,315 m	41,300,000	
	Batugingging	Rehabilitation of Dike and construction of groin	904 m	25,700,000	
1987/1988	Padang	-ditto-	1,176 m	49,817,000	
	Belutu	River Widening	3,700 m	89,811,000	
	Deli	Dredging	2,478 m	445,854,000	
1988/1989	Deli	Left dike construction	2,500 m	500,000,000	
	Deli	Right dike construction	920 m	311,612,000	
	Deli	Left dike construction	984 m	440,205,000	
	Deli	Right dike construction	1,810 m	430,194,000	
	Deli	Left dike construction	1,890 m	441,898,000	

Note * : It includes cost for work in other rivers out of the study area

Table 2.3.2 OUTLINE OF THE DPUP FLOOD CONTROL PLAN

No.	Item	Deli R. Downstream	Deli R. Upstream	Babura R.	Percut R.	Serdang R. (Belumai R)
1.	Year of Planning	1985	1988	1988	1988	1983
2.	Location	River mouth to Babura R.	Babura R. to Titi Kuning	Deli R. to Selayang 2	River mouth to Sidorejo	River mouth to National road
3.	Length (km)	28	12	14	20	9(13)**
4.	Return of Period (year)	10	10	10	10	10
5.	Design Discharge (m^3/s)	455 (408)*	267	139	379	630(260)**
6.	Standard Cross Section of Water Channel					
	(1) Cross Section	Double & Single		Single	Double & Single	Double (Single)**
	(2) Width (m)	38 to 63	27 to 36	21 to 33	25 to 57	65(44)**
	(3) Depth (m)	6	4 to 7	4 to 8	6 to 10	1 : 2 (Sandy Soil)
	(4) Slope of Dike	1 : 1.5	1 : 1.5	1 : 1.5	1 : 1 (Protection with concrete block)	
	(5) Crown Width (m)	3	4	4	3	3
	(6) Freeboard (m)	0.6	0.6	0.6	0.6	0.6
7.	Roughness Coefficient	0.03	0.03	0.03	0.03 (low channel) 0.035 (high channel)	0.025
8.	Design Bed slope	1/2830 to 1/890	1/2400 to 1/28(	1/1210 to 1/38(	1/2460 to 1/610	1/1630 to 1/1080
9.	Schedule of Construction	Start in 1989	1995 to 2007	1995 to 2007	1995 to 2007	Not fixed
10.	Finance Source of Construction	OECF and ADB	Foreign loan	Foreign loan	Foreign loan	Foreign loan

Note

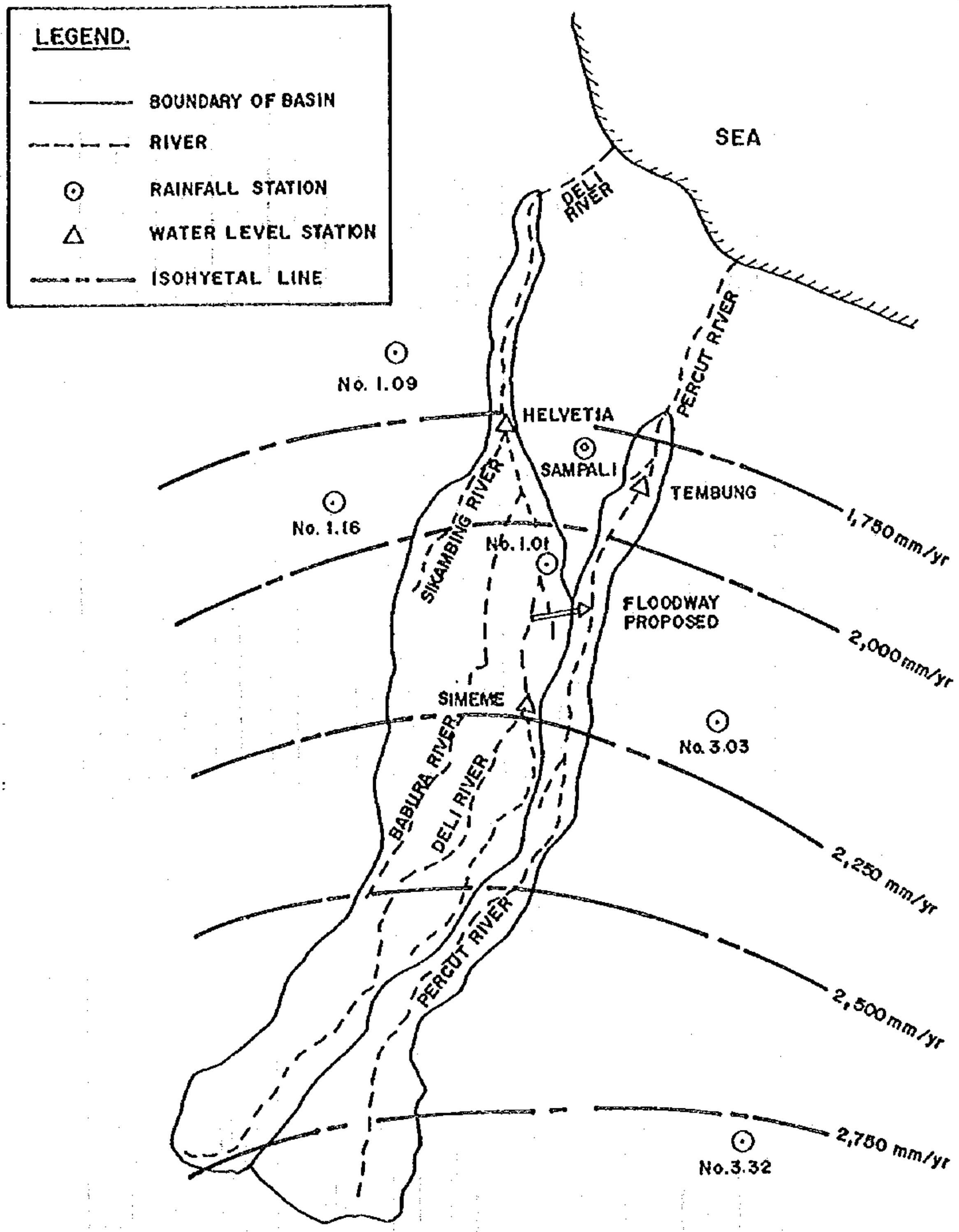
* : The design discharge upstream at the confluence with Sikambing River is 408 m^3/s, which it is 455 m^3/s downstream

** : Figures and terms in parenthes are ones for Belumai River.

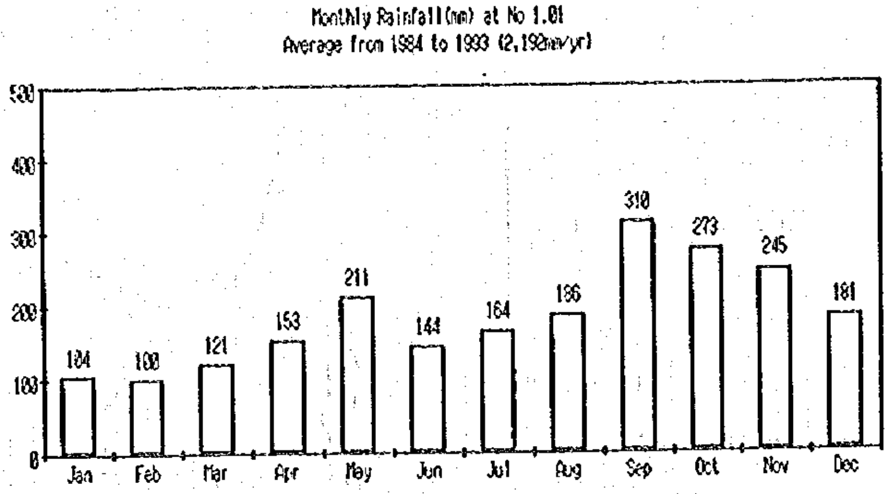
FIGURES

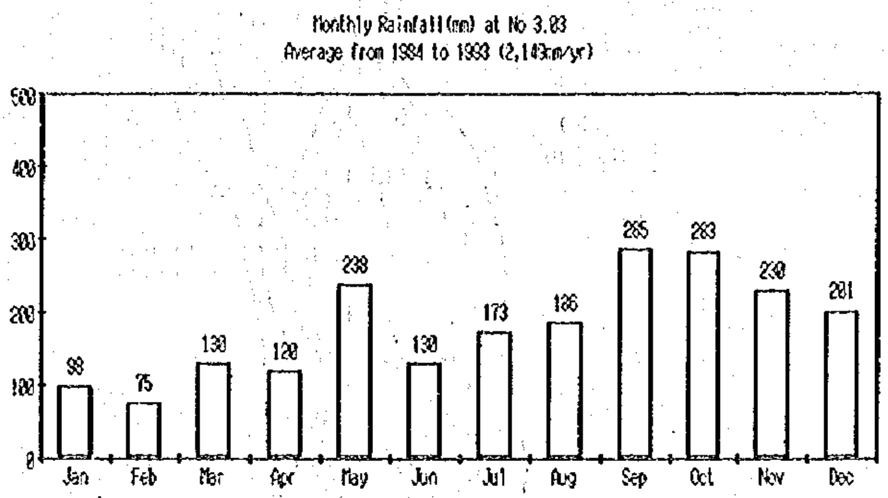
CHAPTER 2

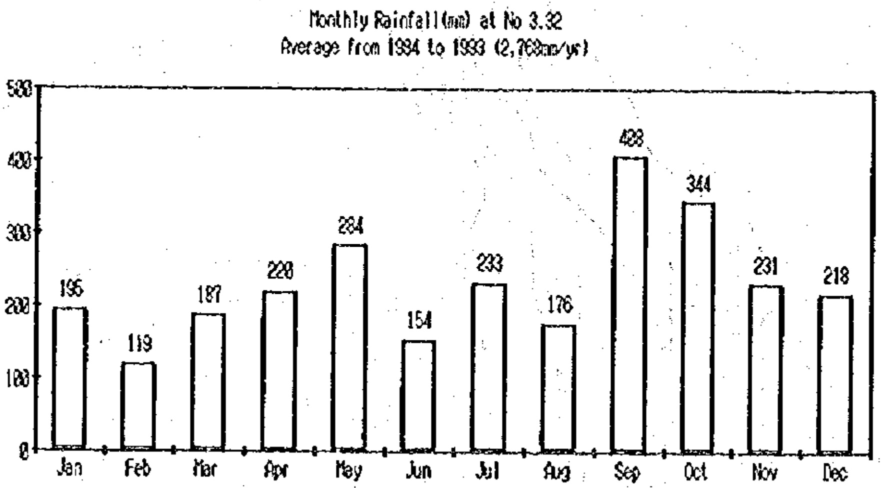
PRESENT CONDITION OF THE STUDY AREA



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.1.1 LOCATION OF RAINFALL AND WATER LEVEL STATIONS
JAPAN INTERNATIONAL COOPERATION AGENCY	



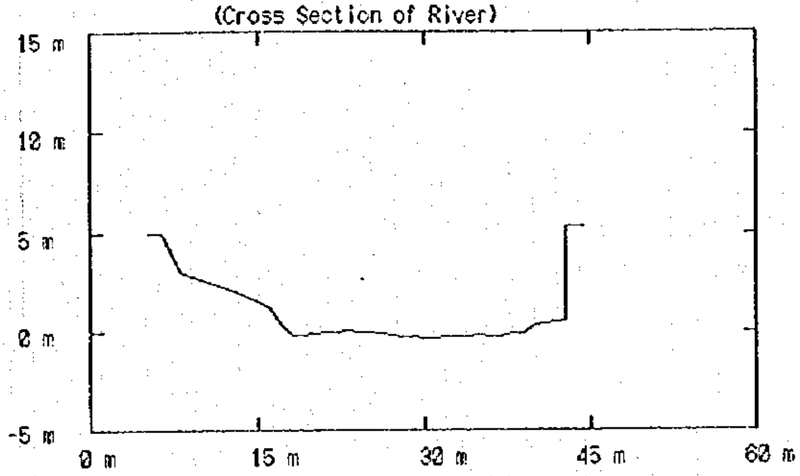




DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.1.2 MONTHLY RAINFALL PATTERNS
JAPAN INTERNATIONAL COOPERATION AGENCY	

Simeme (Deli River) Calculation of Uniform Flow

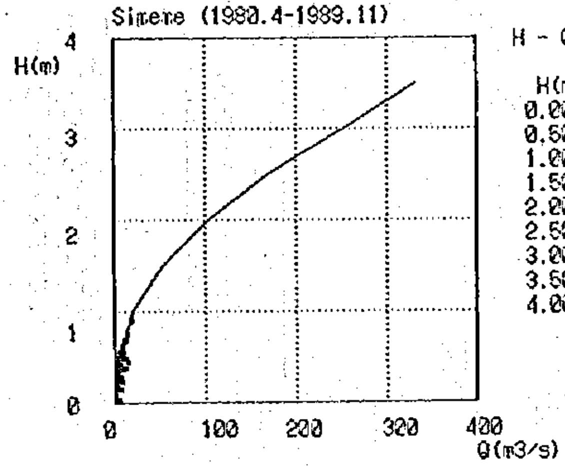
(Cross Section of River)



Simeme (Deli River) Calculation of Uniform Flow

H(m)	A(m2)	P(m)	R(m)	I	n	V(m/s)	Q(m3/s)
3.00	86.90	37.492	2.318	0.00333	0.035	2.889	251.1
3.50	104.34	39.025	2.674	0.00333	0.035	3.178	331.6
4.00	122.02	40.179	3.037	0.00333	0.035	3.459	422.1

Simeme (1980.4-1989.11)



H - Q Rating Curve

H(m)	Q(m3/s)
0.00	1.10
0.50	6.30
1.00	19.70
1.50	54.00
2.00	103.00
2.50	169.00
3.00	251.10
3.50	331.60
4.00	422.10

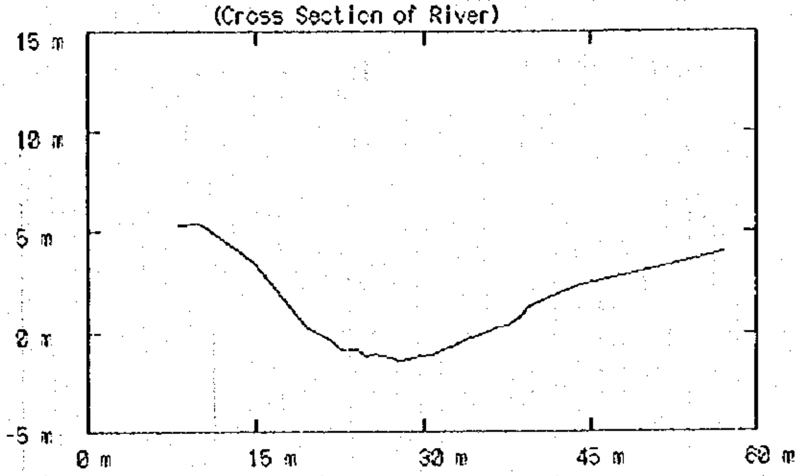
DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.1.3
CROSS SECTION AND RATING CURVE AT SIMEME

Helvetia (Deli River)   Calculation of Uniform Flow

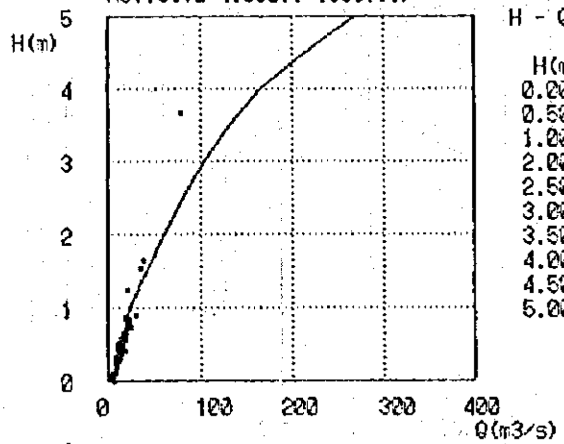
(Cross Section of River)



Helvetia (Deli River)   Calculation of Uniform Flow

H(m)	A(m2)	P(m)	R(m)	I	n	V(m/s)	Q(m3/s)
2.00	53.17	26.418	2.013	0.00063	0.035	1.139	60.5
2.50	66.50	30.059	2.212	0.00063	0.035	1.213	80.6
3.00	81.97	35.044	2.339	0.00063	0.035	1.259	103.2
3.50	99.83	40.029	2.494	0.00063	0.035	1.314	131.1
4.00	120.23	45.481	2.644	0.00063	0.035	1.366	164.2
4.50	142.28	46.839	3.038	0.00063	0.035	1.498	213.2
5.00	164.96	48.198	3.423	0.00063	0.035	1.622	267.6

Helvetia (1980.1-1989.11)



H - Q Rating Curve

H(m)	Q(m3/s)
0.00	6.00
0.50	13.50
1.00	23.00
2.00	60.50
2.50	80.60
3.00	103.20
3.50	131.10
4.00	164.20
4.50	213.20
5.00	267.60

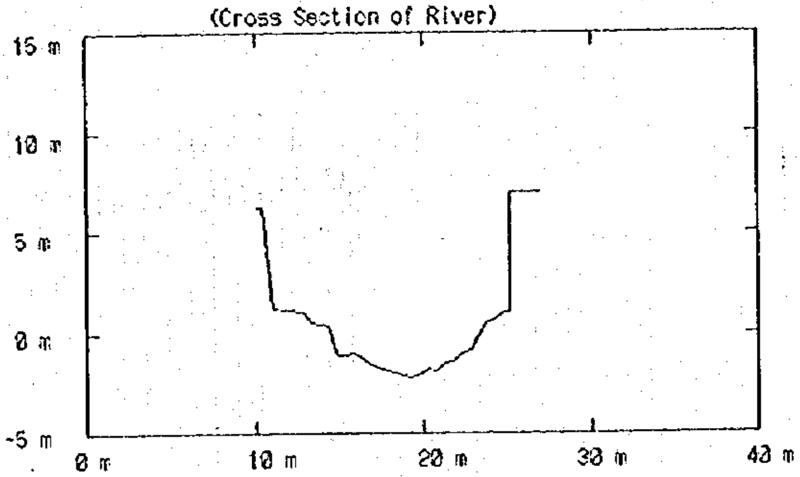
DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.1.4
CROSS SECTION AND RATING CURVE AT HELVETIA

Tembung (Percut River)　　Calculation of Uniform Flow

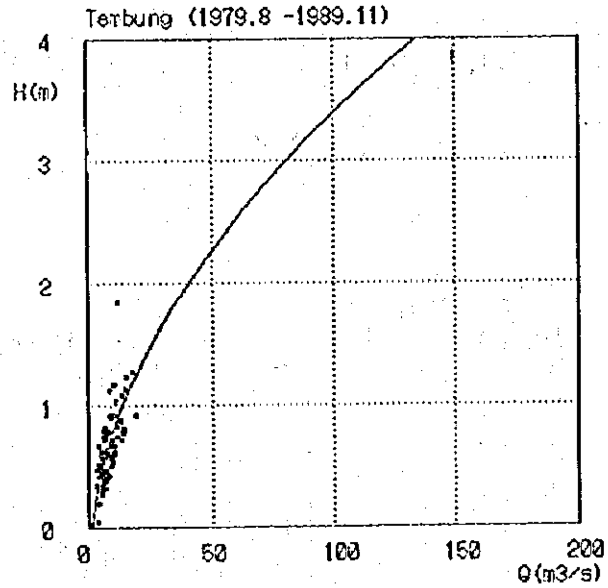
(Cross Section of River)



Tembung (Percut River)　　Calculation of Uniform Flow

H(m)	A(m2)	P(m)	R(m)	I	n	V(m/s)	Q(m3/s)
2.00	37.20	18.576	2.003	0.00100	0.035	1.435	53.4
2.50	44.36	19.579	2.266	0.00100	0.035	1.559	69.1
3.00	51.56	20.583	2.505	0.00100	0.035	1.666	85.9
3.50	58.78	21.587	2.723	0.00100	0.035	1.762	103.6
4.00	66.03	22.590	2.923	0.00100	0.035	1.847	122.0
4.50	73.31	23.594	3.107	0.00100	0.035	1.924	141.1
5.00	80.63	24.597	3.278	0.00100	0.035	1.994	160.7

Tembung (1979.8 -1989.11)



H - Q Rating Curve

data N= 79

max H= 1.85
max Q= 19.4

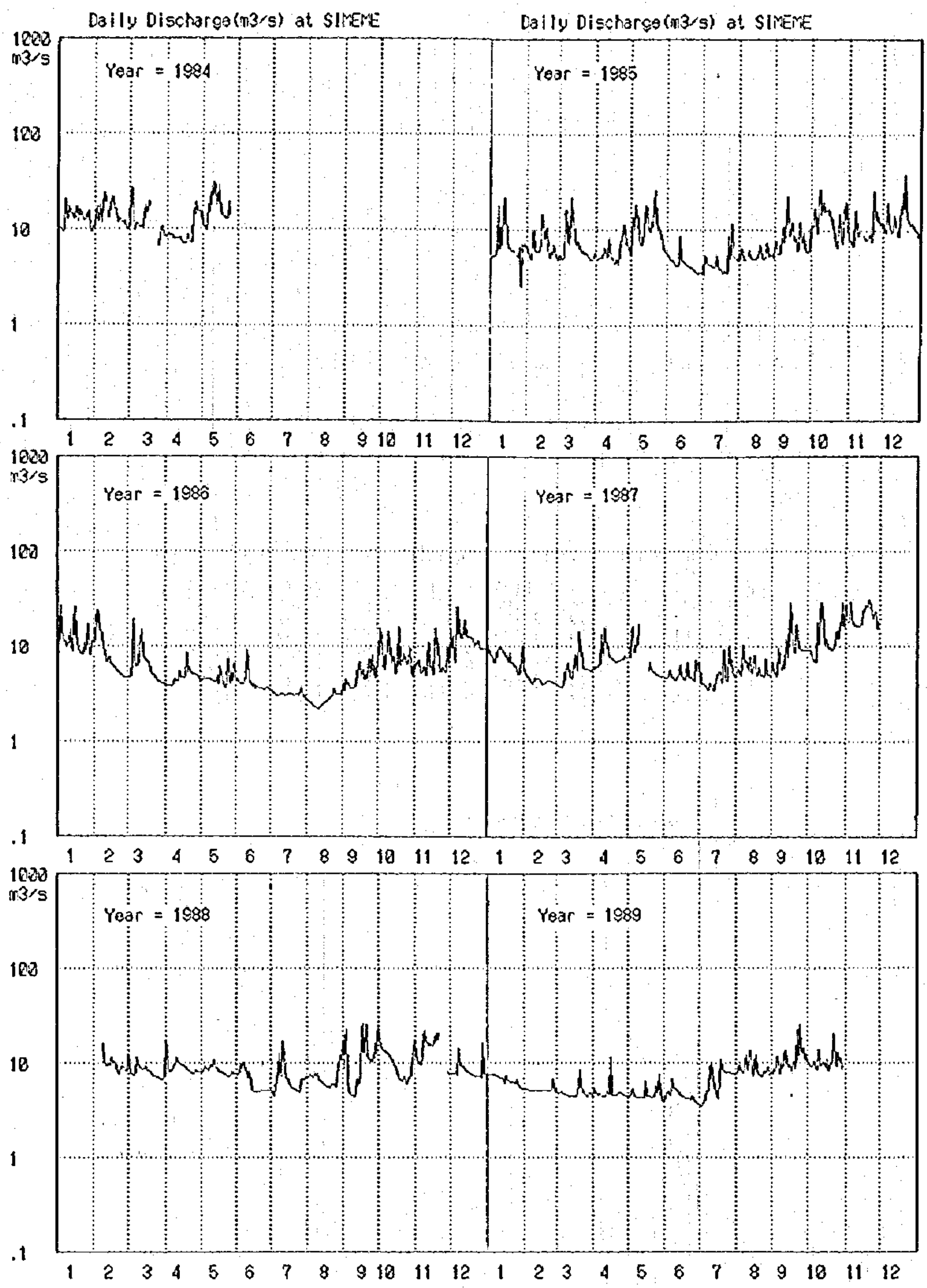
R = 0.673

Q = A (H + B)^2

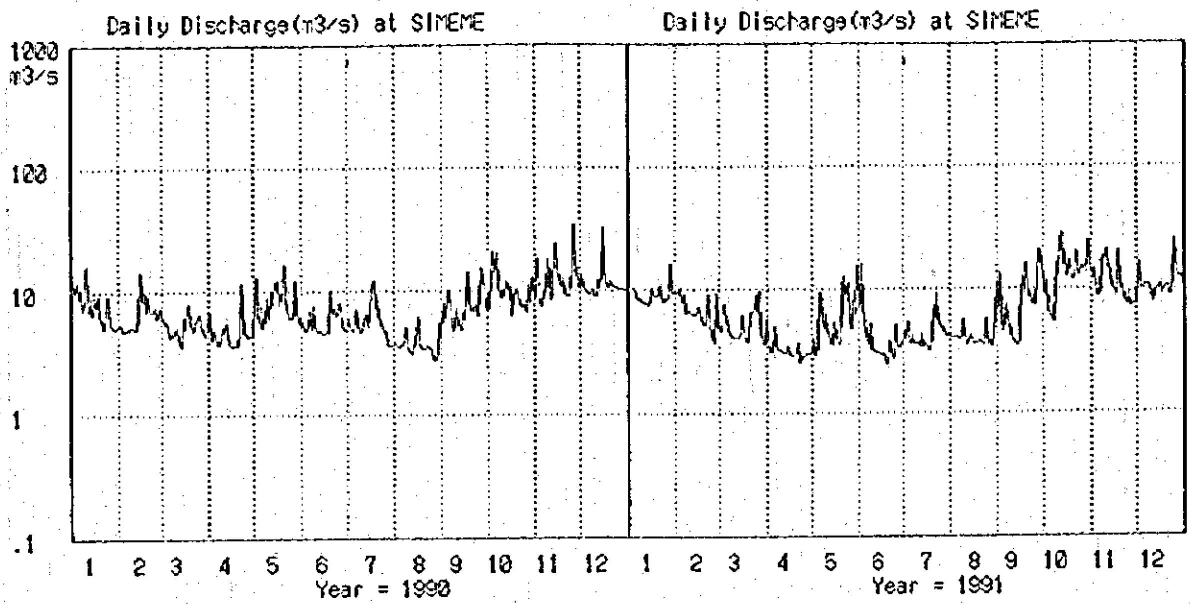
A = 6.87

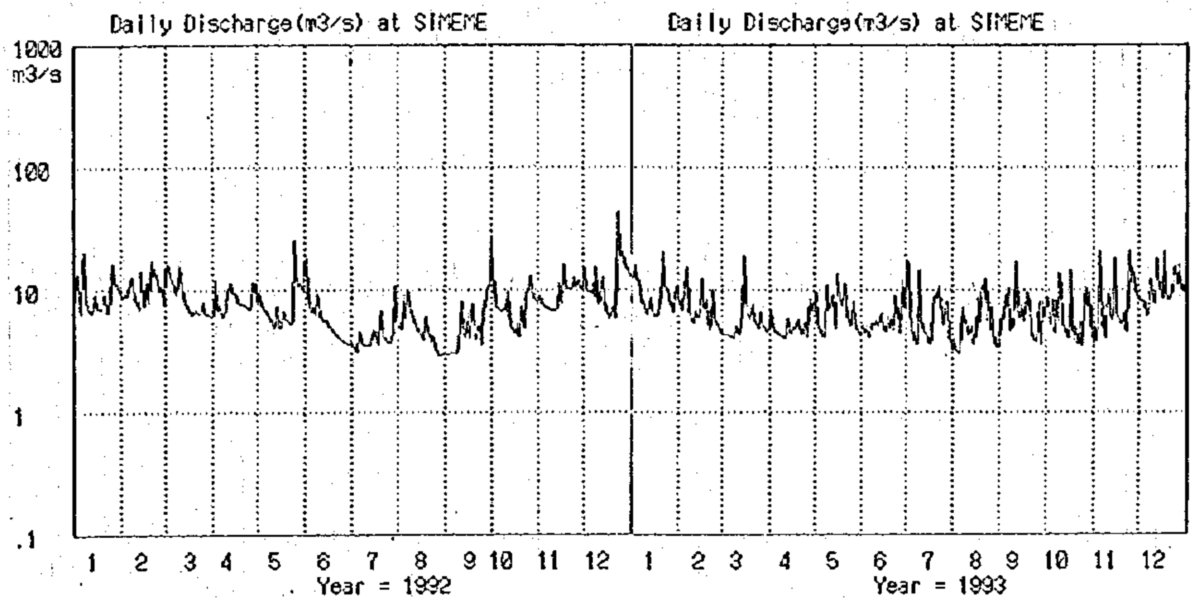
B = 0.422

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.1.5 CROSS SECTION AND RATING CURVE AT TEMBUNG
JAPAN INTERNATIONAL COOPERATION AGENCY	

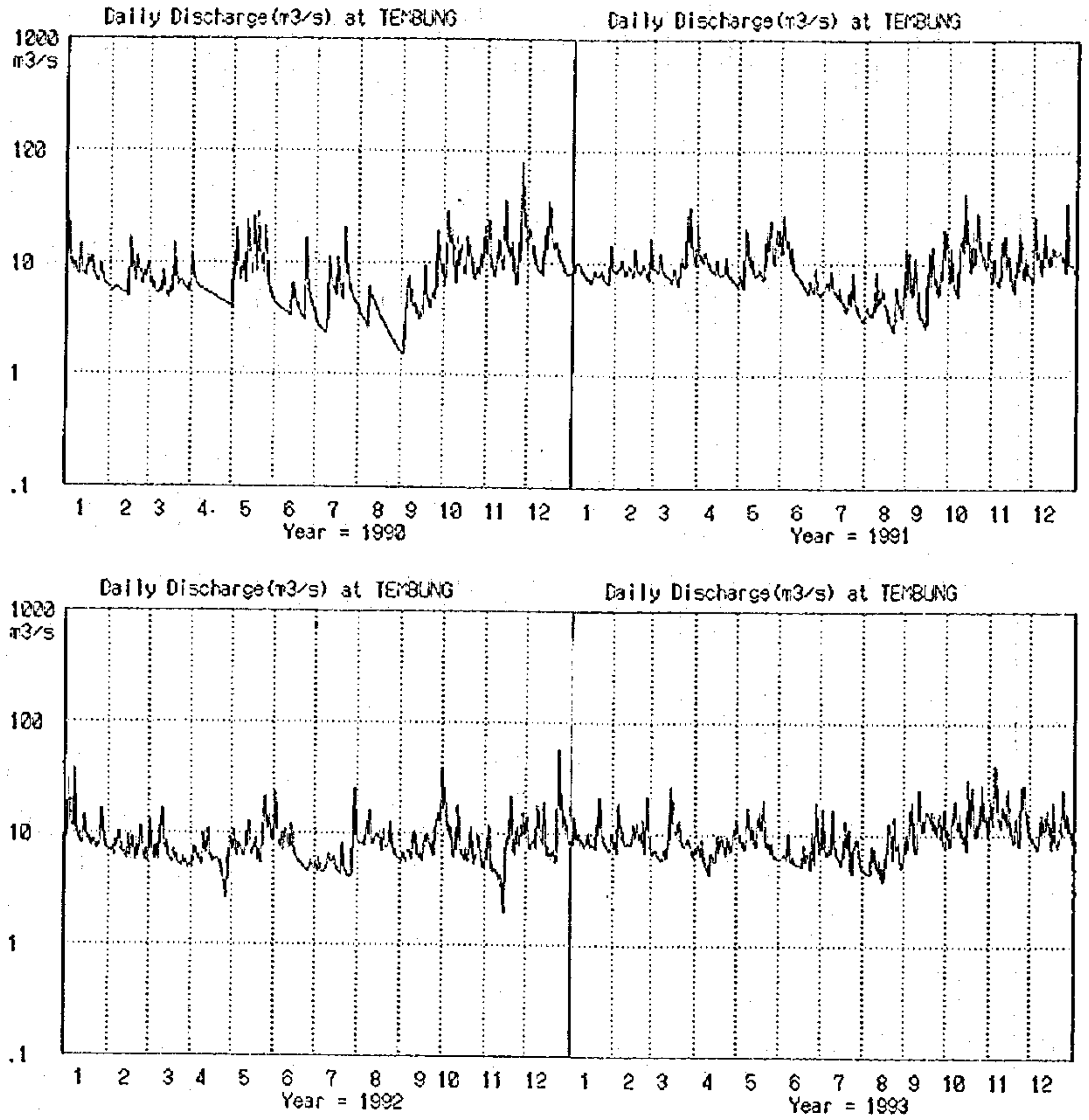


DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.1.6 (1/2) CHART OF DAILY DISCHARGE OBSERVED AT SIMEME
JAPAN INTERNATIONAL COOPERATION AGENCY	

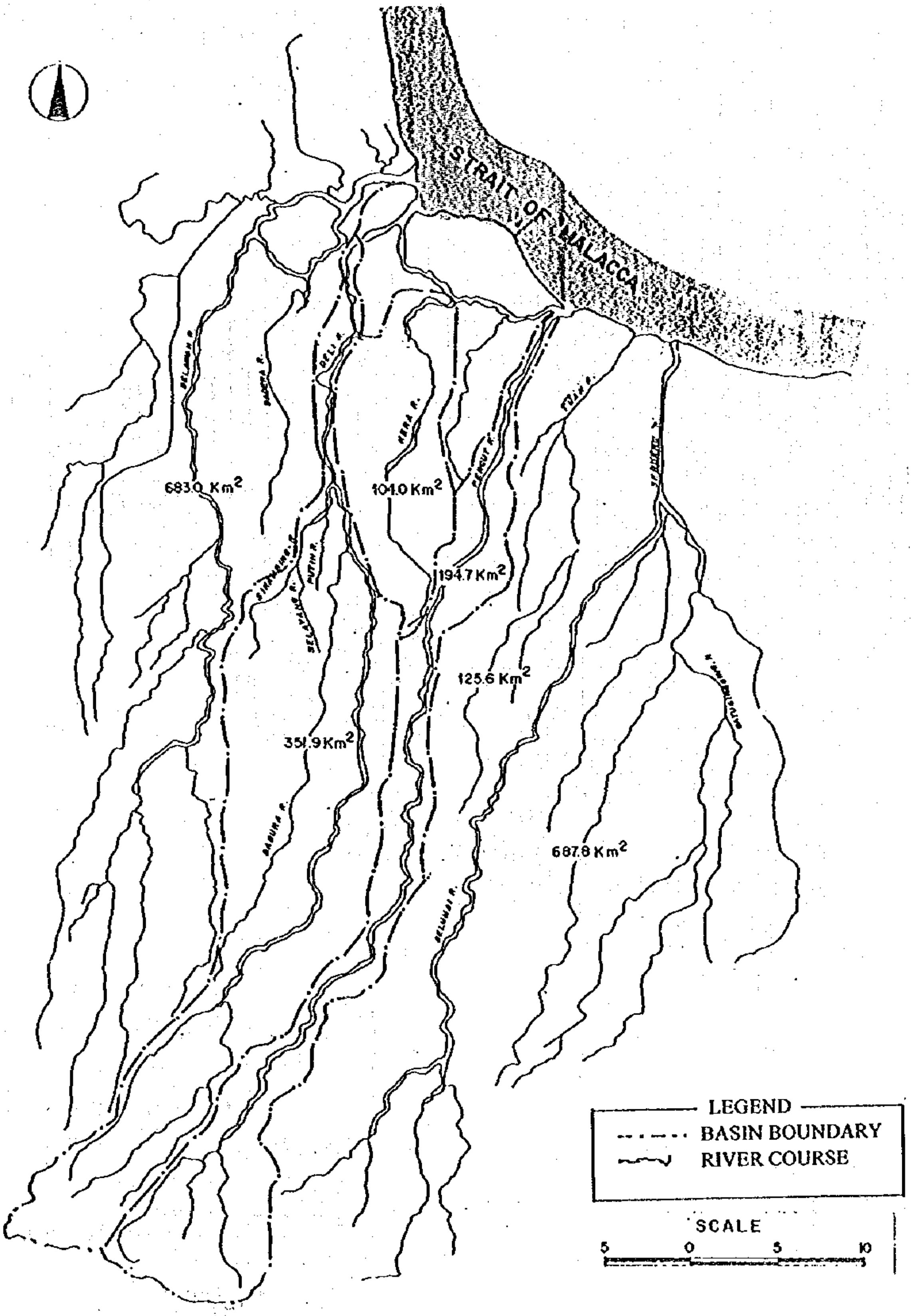




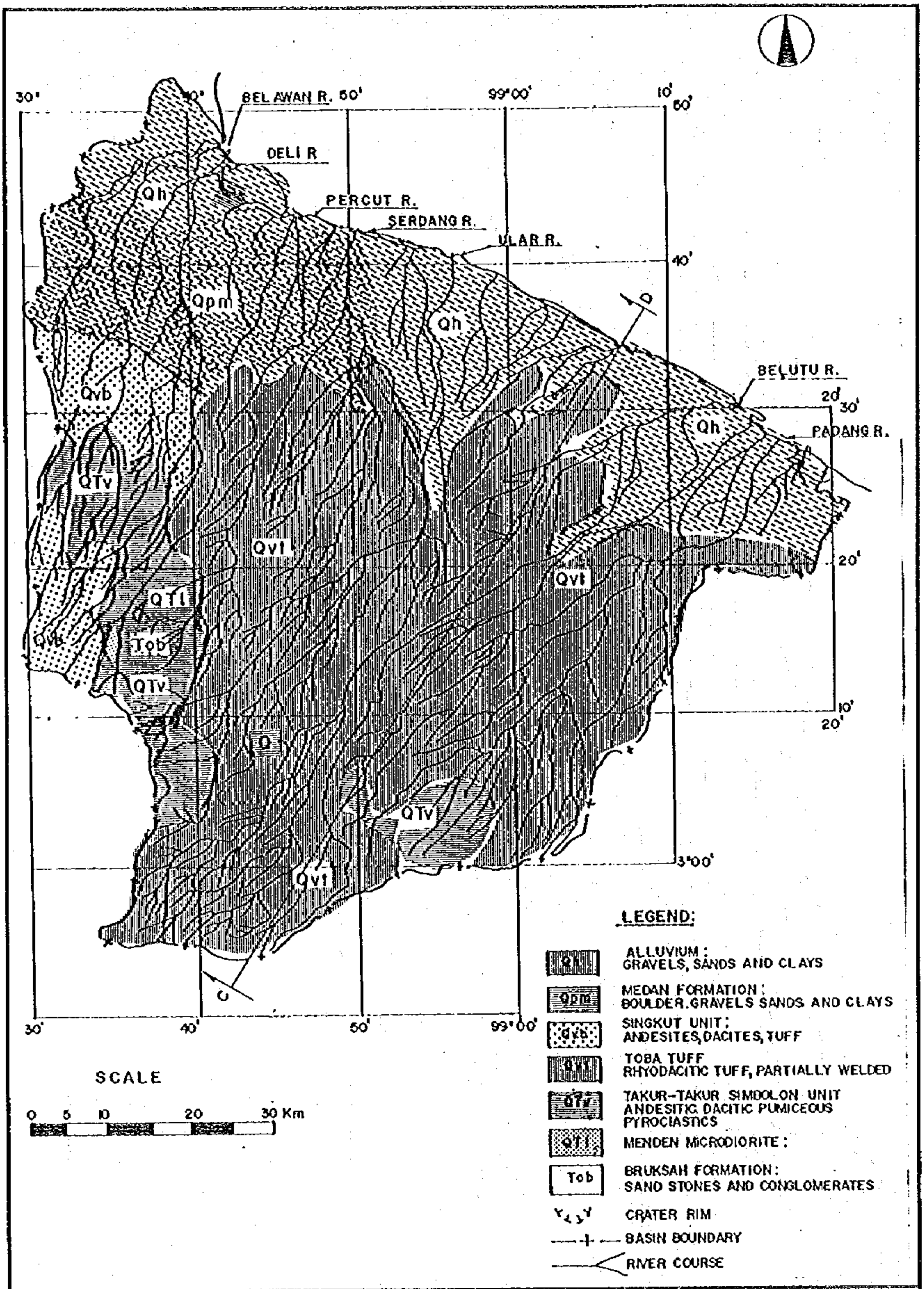
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.1.6 (2/2) CHART OF DAILY DISCHARGE OBSERVED AT SIMEME
JAPAN INTERNATIONAL COOPERATION AGENCY	



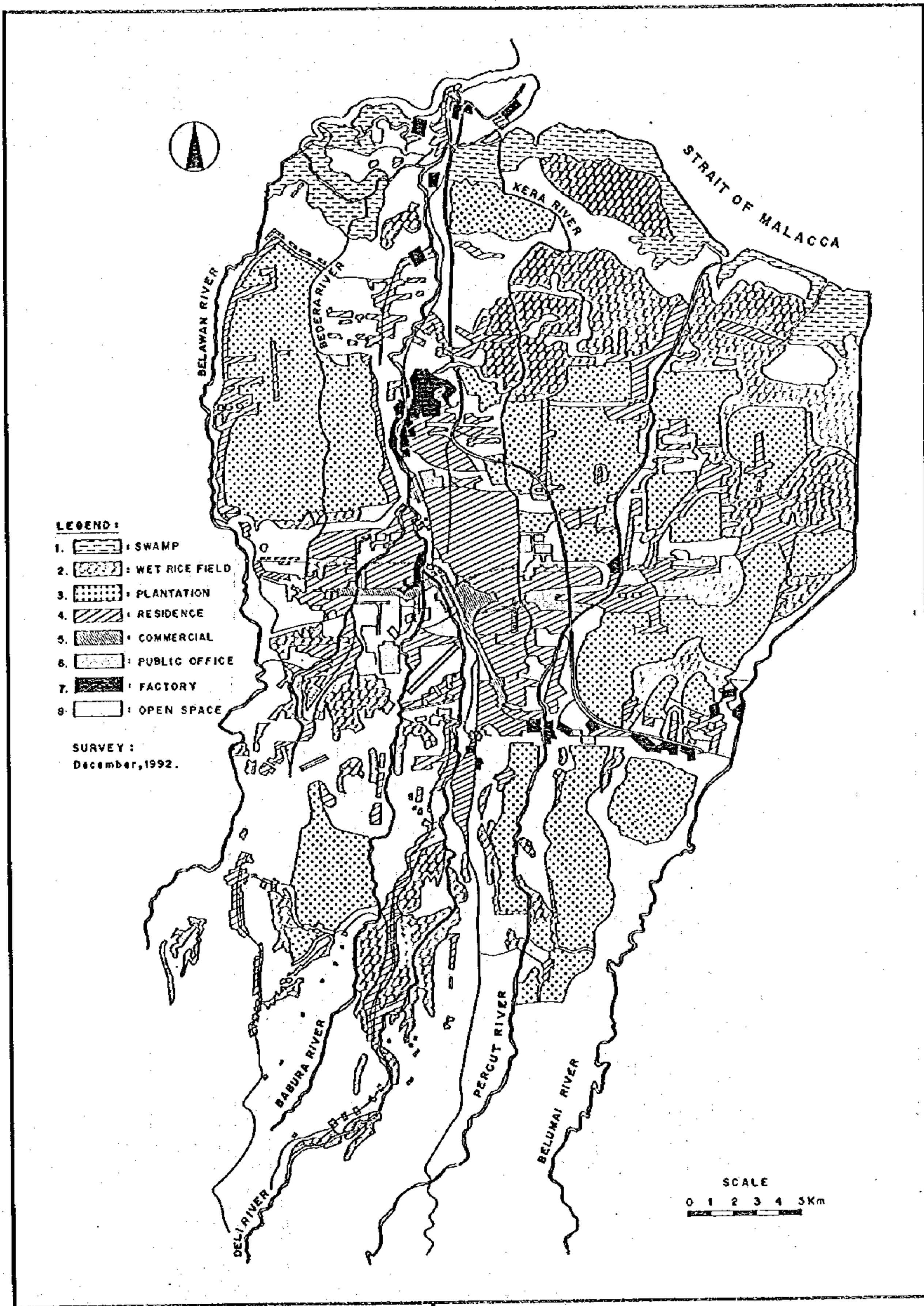
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.1.7 CHART OF DAILY DISCHARGE OBSERVED AT TEMBUNG
JAPAN INTERNATIONAL COOPERATION AGENCY	



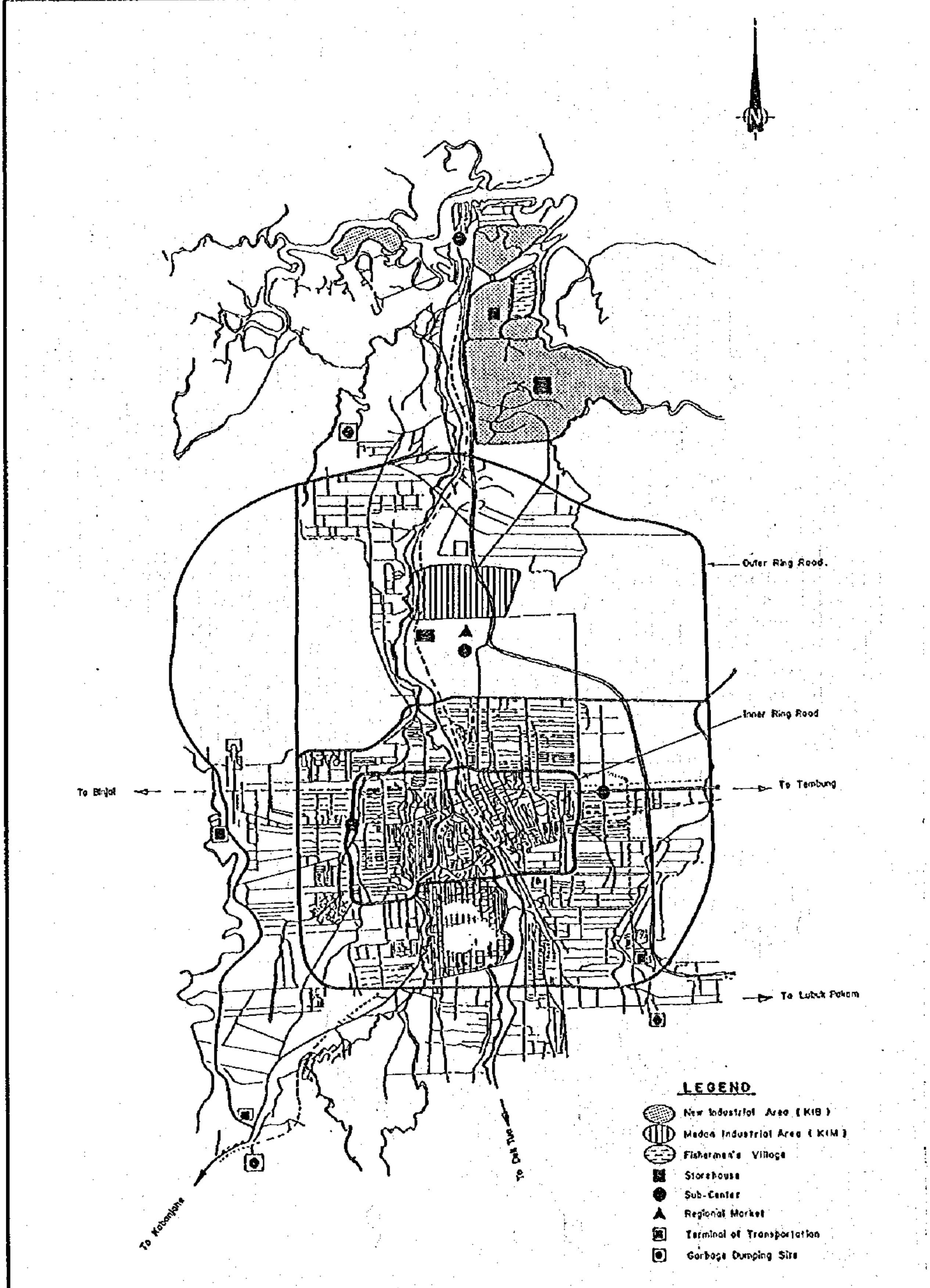
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.1.8 MAJOR RIVER SYSTEM AND CATCHMENT BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	



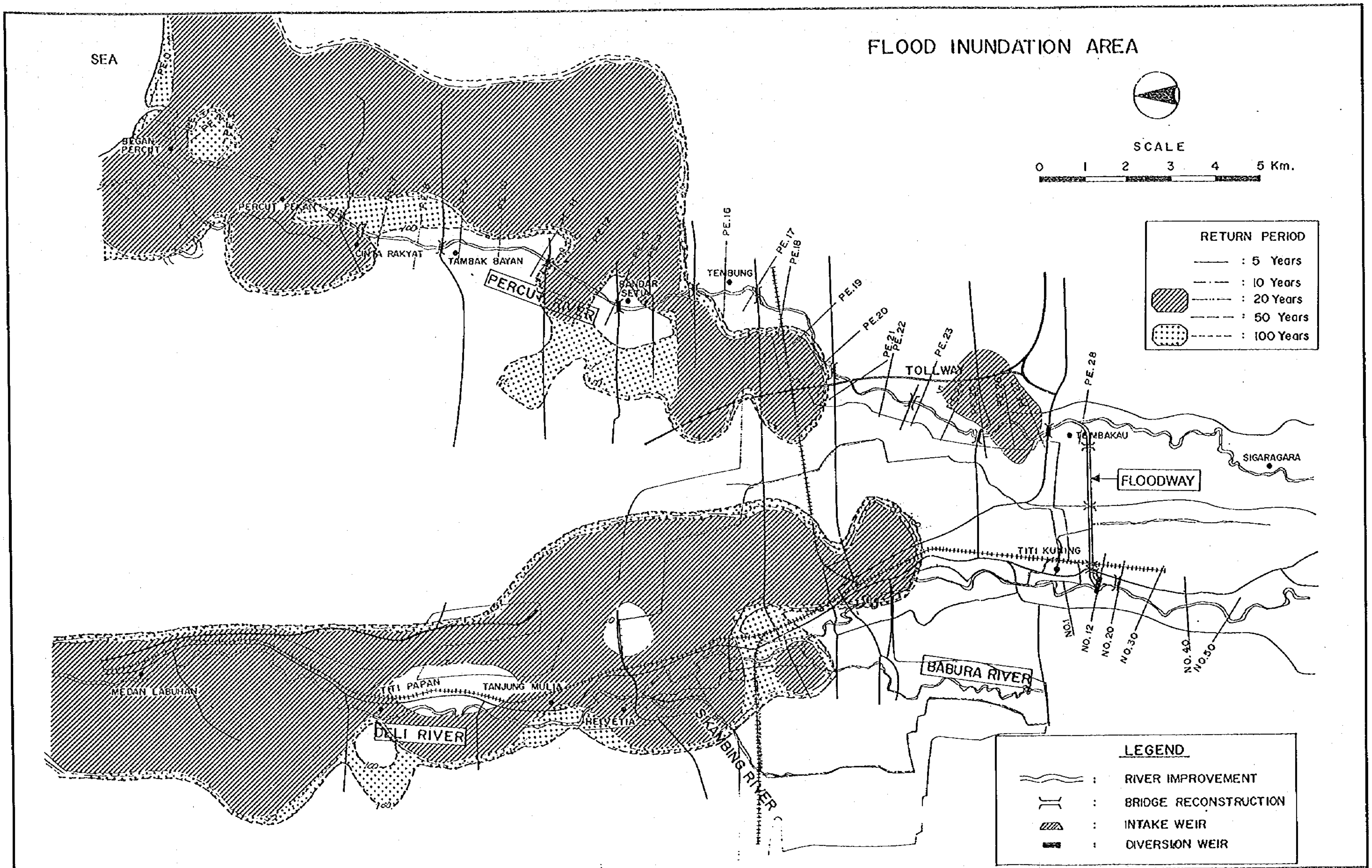
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.1.9 GEOLOGICAL MAP
JAPAN INTERNATIONAL COOPERATION AGENCY	



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.2.1 LAND USE IN DELI-PERCUT RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	



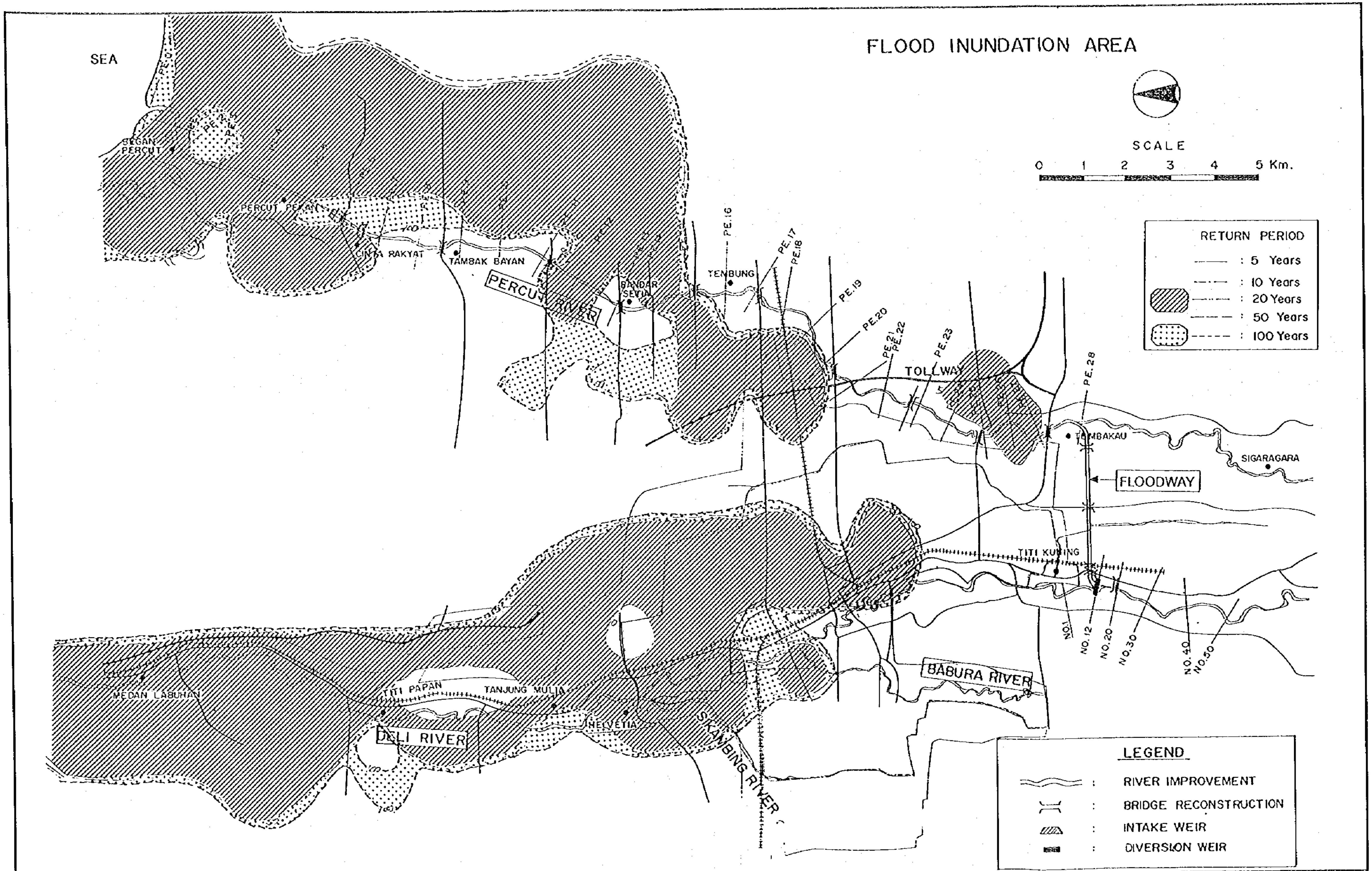
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.2.2 MEDAN CITY URBAN PLANNING
JAPAN INTERNATIONAL COOPERATION AGENCY	



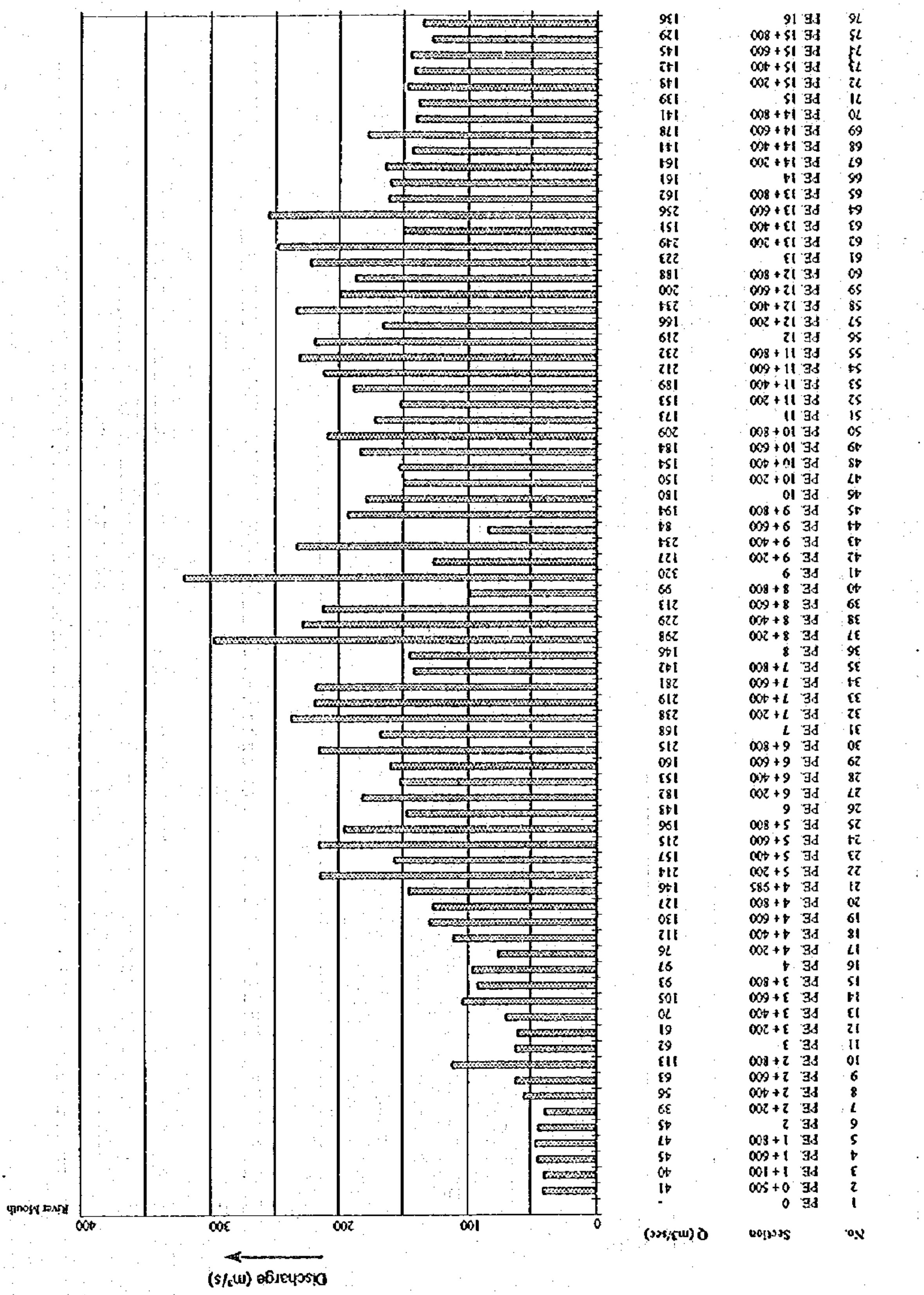
DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.3.1
FLOOD INUNDATION AREA IN DELI-PERCUT RIVER BASIN

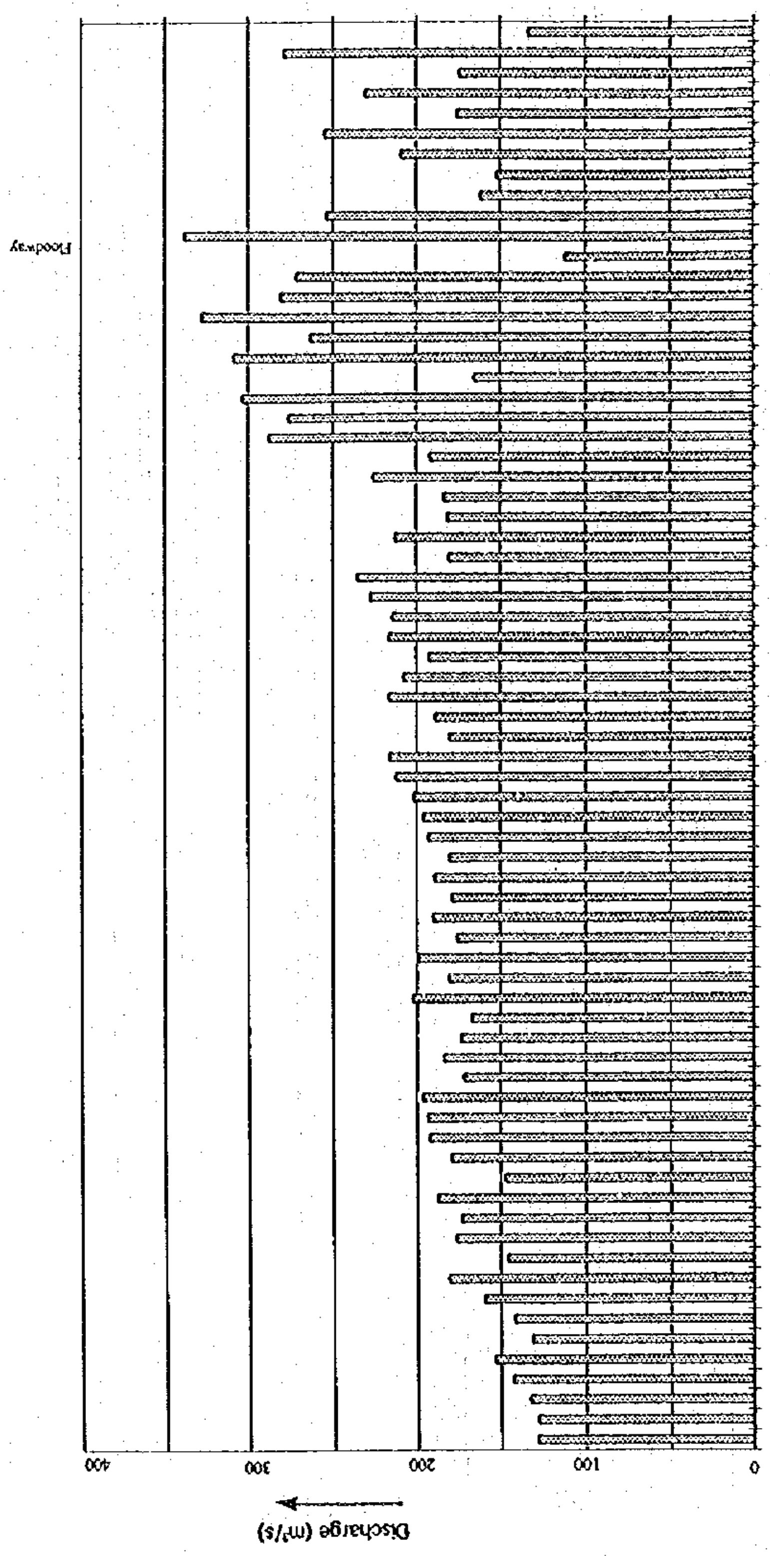


DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.3.1 FLOOD INUNDATION AREA IN DELI-PERCUT RIVER BASIN



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.3.2 (1/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	FLOW CAPACITY OF PERCUT RIVER

No.	Section	Q (m3/sec)
77	PE. 16 + 200	129
78	PE. 16 + 400	129
79	PE. 16 + 600	133
80	PE. 16 + 800	144
81	PE. 17	154
82	PE. 17 + 200	132
83	PE. 17 + 400	143
84	PE. 17 + 600	160
85	PE. 17 + 800	182
86	PE. 18	146
87	PE. 18 + 200	177
88	PE. 18 + 400	174
89	PE. 18 + 600	188
90	PE. 18 + 800	148
91	PE. 19	180
92	PE. 19	193
93	PE. 19 + 200	194
94	PE. 19 + 400	197
95	PE. 19 + 560	172
96	PE. 19 + 800	185
97	PE. 20	174
98	PE. 20 + 160	168
99	PE. 20 + 400	203
100	PE. 20 + 600	181
101	PE. 20 + 800	200
102	PE. 21	176
103	PE. 21 + 150	191
104	PE. 21 + 400	180
105	PE. 21 + 625	190
106	PE. 21 + 800	181
107	PE. 22	193
108	PE. 22 + 200	197
109	PE. 22 + 400	202
110	PE. 22 + 600	213
111	PE. 22 + 800	217
112	PE. 23	181
113	PE. 23 + 200	190
114	PE. 23 + 400	217
115	PE. 23 + 600	208
116	PE. 23 + 800	193
117	PE. 24	217
118	PE. 24 + 200	215
119	PE. 24 + 400	228
120	PE. 24 + 660	236
121	PE. 24 + 800	181
122	PE. 25	213
123	PE. 25 + 210	182
124	PE. 25 + 400	185
125	PE. 25 + 600	226
126	PE. 25 + 830	192
127	PE. 26	288
128	PE. 26 + 200	277
129	PE. 26 + 400	304
130	PE. 26 + 600	166
131	PE. 26 + 800	310
132	PE. 27	264
133	PE. 27 + 200	329
134	PE. 27 + 400	282
135	PE. 27 + 600	272
136	PE. 27 + 800	112
137	PE. 28	339
138	PE. 28 + 200	254
139	PE. 28 + 400	162
140	PE. 28 + 600	152
141	PE. 28 + 800	209
142	PE. 29	255
143	PE. 29 + 200	176
144	PE. 29 + 400	231
145	PE. 29 + 600	175
146	PE. 29 + 800	280
147	PE. 30	134

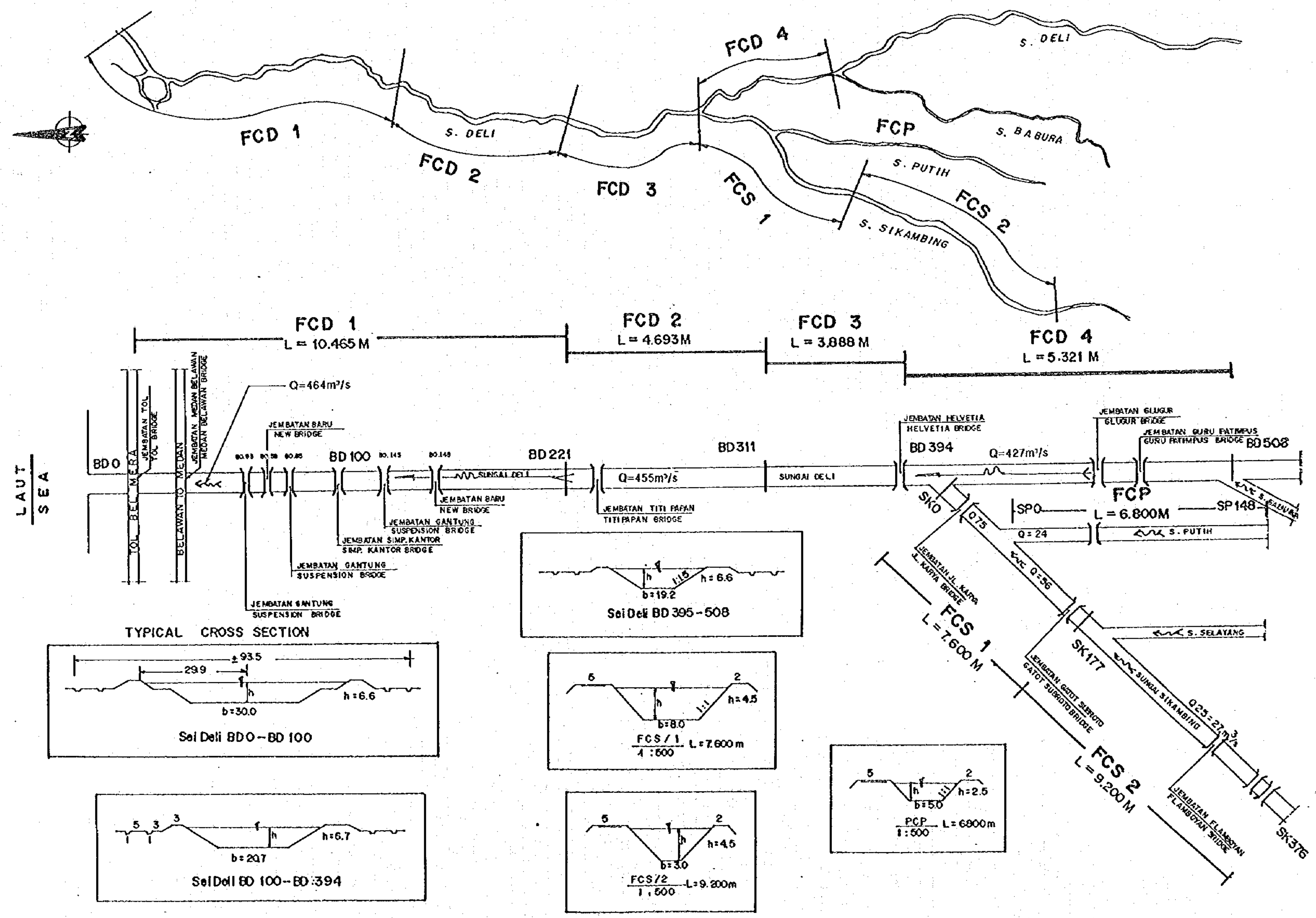


DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

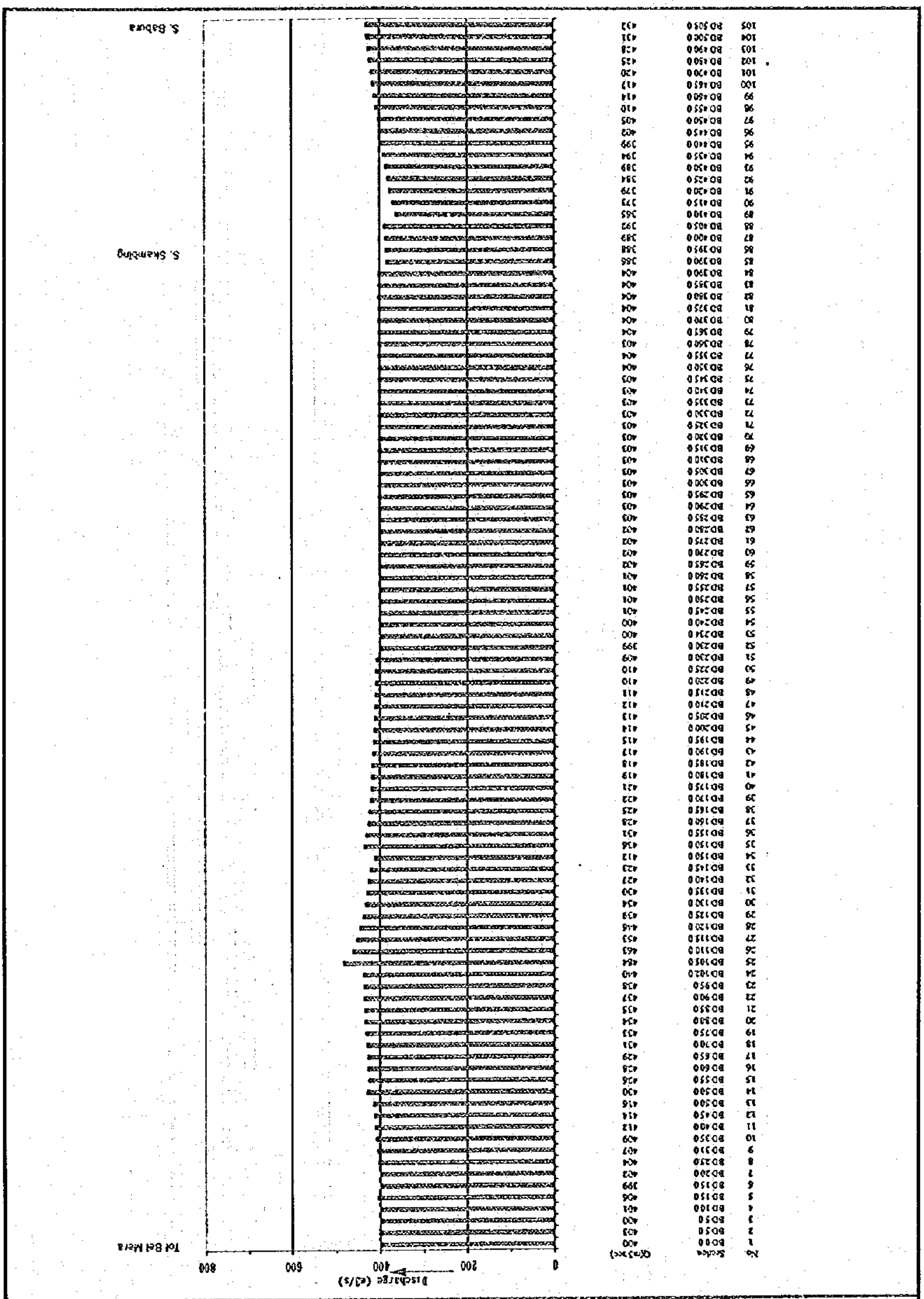
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.3.2 (2/2)

FLOW CAPACITY OF PERCUT RIVER



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.3.3
JAPAN INTERNATIONAL COOPERATION AGENCY	DELI RIVER IMPROVEMENT PROJECT BY BUDP II

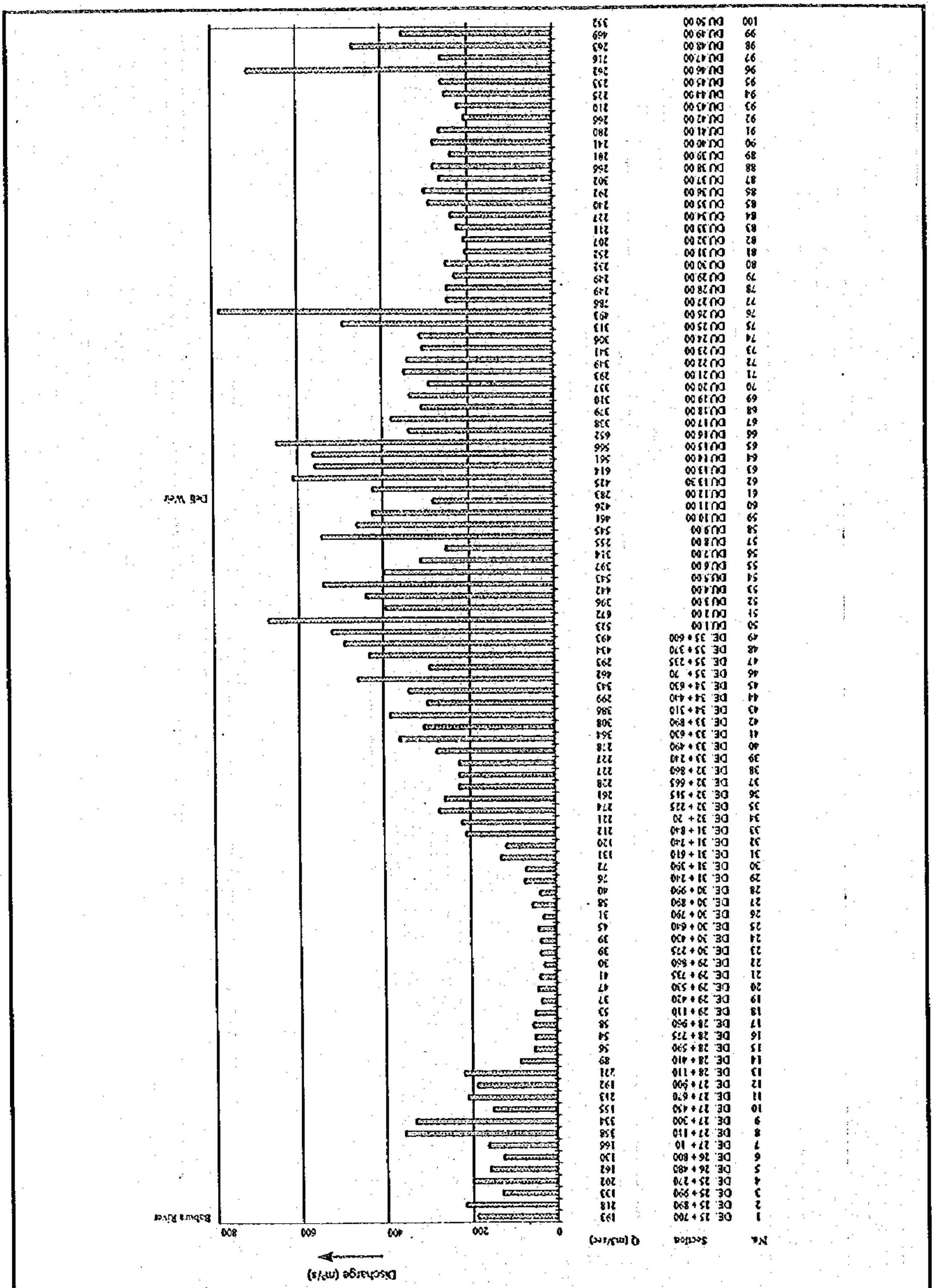


DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

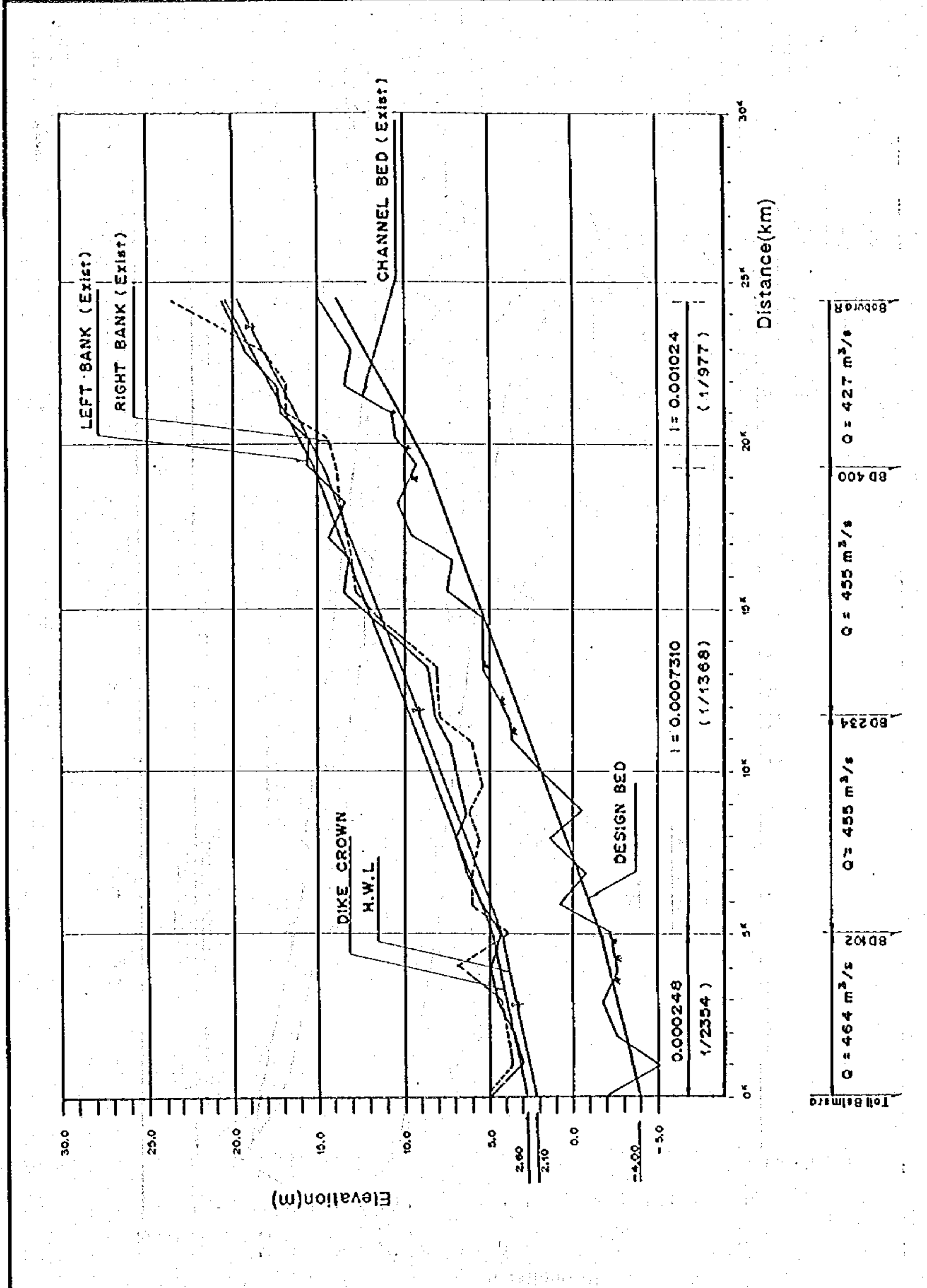
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.3.4

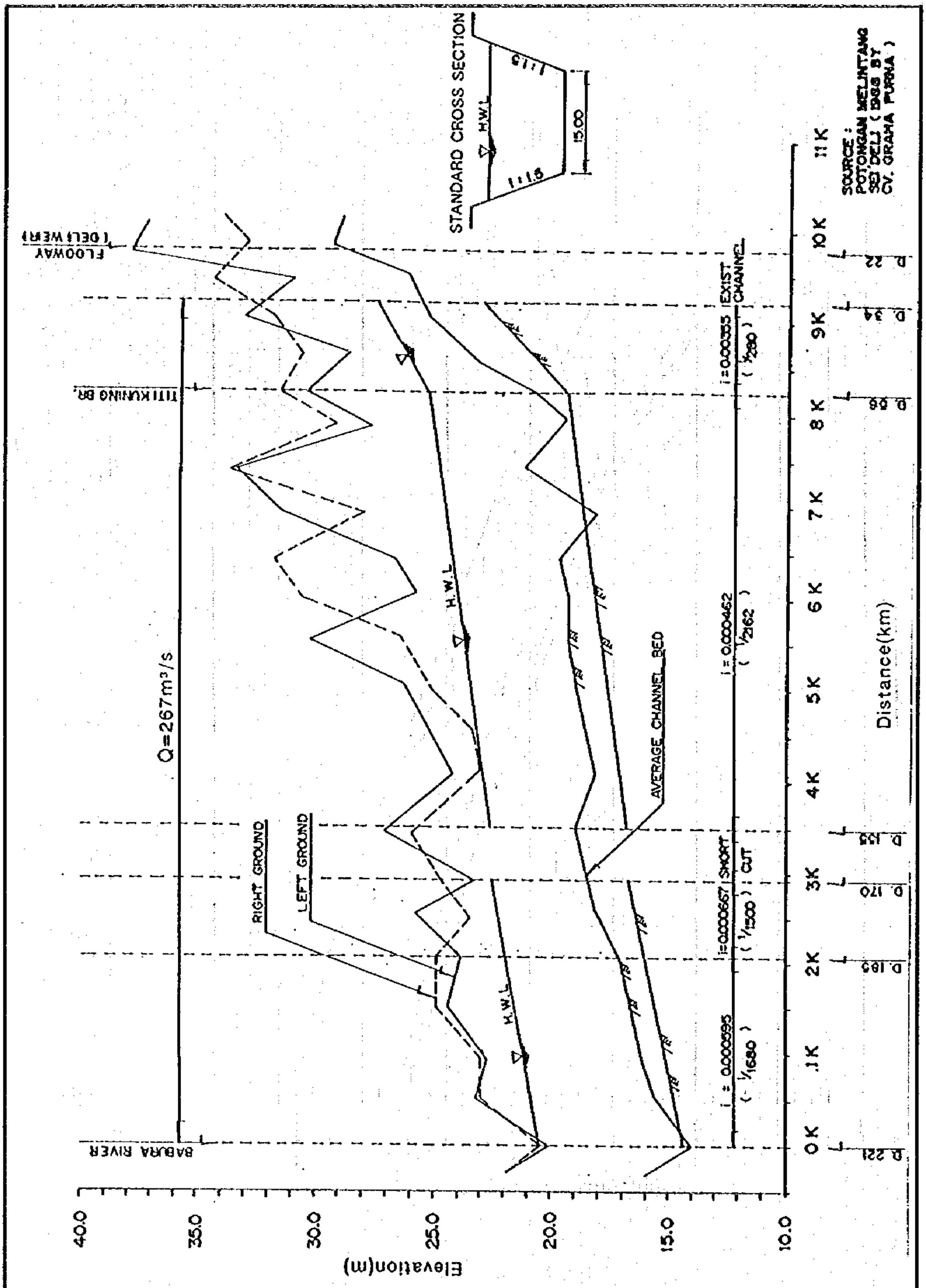
FLOW CAPACITY OF DELI RIVER
(LOWER STRETCH)



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.3.5
JAPAN INTERNATIONAL COOPERATION AGENCY	FLOW CAPACITY OF DELI RIVER (UPPER STRETCH)



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 2.3.6
JAPAN INTERNATIONAL COOPERATION AGENCY	LONGITUDINAL PROFILB OF DELI RIVER UNDER MUDP II



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.3.7 LONGITUDINAL PROFILE OF UPPER DELI RIVER BY 1988 STUDY

CHAPTER 3

INVESTIGATION AND ANALYSIS

CHAPTER 3. INVESTIGATION AND ANALYSIS

3.1 Topographic and River Survey

The area and scope of survey works are as described below.

(1) Topographic Survey

Ground surveys were carried out for 28 km along Percut River and 3.9 km along the route of Medan Floodway. Work sites, volume, mapping scale, etc., are as mentioned below.

(a) Percut River

Since the river channel is relatively narrow (20 to 30 m in width), the mapping scale was 1/1,000, as shown below.

Site	Volume	Map		Remarks
		No. of Sheets	Scale	
River Channel	4.5 km^2	approx. 30	1/1,000	Sheet Size: A0
Structure Site	0.1 km^2	approx. 14	1/200	Sheet Size: A0

(b) Medan Floodway

The river channel of about 2.5 km upstream from the floodway is considered as a retarding channel; therefore, the area was surveyed as an extension of the floodway. Details are as given below.

Site	Volume	Map		Remarks
		No. of Sheets	Scale	
River Channel	0.50 km^2	4	1/1,000	Sheet Size: A0
Structure Site	0.05 km^2	9	1/200	Sheet Size: A0
Floodway	1.25 km^2	6	1/1,000	Sheet Size: A0

(2) River Survey for Longitudinal Profile and Cross Section

Longitudinal profiles and cross-sections were taken along both the Percut River and the Medan Floodway. Details are as given below.

(a) Percut River

Work Item	Volume	Map		Remarks
		No. of Sheets	Scale	
Longitudinal Profile	28 km	approx. 20	H=1/2,000 V=1/200	Sheet Size: A1
Cross Section Survey	approx. 300 sections	approx. 150	H=1/200 V=1/200	Sheet Size: A1

(b) Medan Floodway

Work Item	Volume	Map		Remarks
		No. of Sheets	Scale	
Longitudinal Profile	3.9 km	approx. 3	H=1/2,000 V=1/200	Sheet Size: A1
Cross Section Survey	approx. 50 sections	approx. 25	H=1/200 V=1/200	Sheet Size: A1

(c) Retarding Channel along Deli River

Work Item	Volume	Map		Remarks
		No. of Sheets	Scale	
Longitudinal Profile	2.5 km	approx. 2	H=1/2,000 V=1/200	Sheet Size: A1
Cross Section Survey	approx. 20 sections	approx. 10	H=1/200 V=1/200	Sheet Size: A1

3.1.1 Topographic Survey

<u>Control Point Survey</u>

The control point survey by Global Positioning System (GPS) was executed to determine the X and Y coordinates of the 40 new control points used for the topographic survey and river cross sectioning, as enumerated in Table 3.1.1. Details of the survey are as described below.

(1) Datum Coordinates

Two existing GPS stations having the Indonesian Datum, which were established by the JICA Study Team for the B-P Study in 1990, namely GPS14 and GPS20, were chosen by the Survey Team and applied as the *X* and *Y* geographic datum coordinates for this survey.

(2) GPS Observation

At least five satellites were simultaneously observed for one hour for all the control points. In general, the baseline lengths were planned between two to five kilometers.

(3) Post-Processing

The post-processing was done using GPS survey software to obtain the best independent baseline solutions for all the GPS sessions. With the existing two stations (GPS14, GPS20) fixed as the planimetric control on the modified Bessel ellipsoid and the same stations serving as the height control for mean sea level, the whole GPS network was constrained and adjusted by the GPS survey software.

(4) Accuracy of GPS Survey

Accuracy of trigonometric closures for coordinates and height were checked between the control points to be less than 10PPM (1/100,000). The accuracy chart is presented in Table 3.1.2

Leveling

The leveling (minor order) was executed to obtain the heights of control points necessary for the topographic survey, the cross section survey and the longitudinal profile survey. Leveling routes were formed by closed loops and double runs, and temporary bench marks were established at every 2 km interval on the leveling routes. Temporary bench mark was also established at every bridge along the Percut River. The leveling work is described below.

(1) Datum Height

Government bench marks obtained from the Mean Sea Level of Indonesia as established by the Bakosurtanal were applied for the leveling.

(2) Checking of Government Bench Marks

Before starting the leveling work, the heights of three government bench marks, TTG541, TTG542 and TTG543, were confirmed, and the JICA Study Team has decided that the heights were accurate enough for the topographic survey, cross section survey and longitudinal profile survey.

Leveling Loops	Distance	Misclosure
TTG541 to TTG542	5 km	4 mm
TTG542 to TTG543	5 km	4 mm

(3) Accuracy of Leveling

The actual accuracy of the respective leveling routes are as presented in Table 3.1.3. As seen from this table, any misclosure of leveling does not exceed $40\text{mm}\sqrt{S}$ between bench marks and/or control points (where, S is a single distance in kilometer between bench marks).

3.1.2 River Survey

The river survey consisted of the installation of kilometer posts, river longitudinal profile survey, river cross section survey and auxiliary survey, as mentioned below.

(1) Installation of Kilometer Post

Prior to starting the river longitudinal profile survey, kilometer posts made of wooden pegs were installed on the right and left banks of the cross section lines of Deli River and Percut River. When the location of a kilometer post fell very close to a bridge, irrigation intake or water pipe, the post location was moved to the center line. The position of a kilometer post was decided by traverse method in the field.

(2) River Longitudinal Profile Survey

River longitudinal profile survey (the profile survey) by direct leveling was executed to obtain the height of kilometer posts for the river cross section survey and to prepare longitudinal profile sections. Leveling routes were formed by closed loops and double-runs. The total distance of the leveling which covered the Upper Deli River, Percut River and Medan Floodway was approximately 35 km.

The datum height was applied for the longitudinal profile survey as well as the river cross section survey and auxiliary leveling. The heights of TTG bench marks were given into the kilometer posts by direct leveling.

All heights of the kilometer posts resulting from the profile survey, the deepest height of river from the river cross section survey, names of bridges and others were edited by the Auto-Cad system. Longitudinal profile sections at a horizontal scale of 1 : 10,000 and vertical scale of 1 : 100 were prepared on the draft plotting paper sheets using the longitudinal profile data.

(4) River Cross Section Survey

Heights and distances of slope changing points, roads, channels, etc., along the cross section lines were measured by using a total-station, levels and EDM. Water levels and depths of rivers were measured using a survey rod, and the distances of these measured points from kilometer posts and the distances between banks were measured simultaneously. The bridges, irrigation intakes and water pipes of the Upper Deli River, Percut River and Medan Floodway were also measured. The total number of cross sections was 418.

(5) Accuracy

(a) Checking of Kilometer Posts

The check results of differences in height closures between the kilometer posts did not exceed $40\text{mm}\sqrt{S}$ (S: length of single run in kilometer).

(b) Checking of River Cross Sections

At the same kilometer posts checked above, river cross section lines were measured. The check results of height of these cross section line points did not exceed ±50mm and distance errors between the cross section line points were less than 1/300.

3.2 Geological and Soil Mechanics Investigation

Prior to the commencement of design work of the structures, geological and soil mechanics investigations were conducted to obtain the following information:

(1) Geological structure, physical characteristics of soil and ground water level along Percut River and Medan Floodway;

(2) Bearing capacity of the foundation of proposed structures;

(3) Consolidation settlement of soft soil in the downstream of Percut River; and

(4) Permeability of foundation soil under the proposed weirs on Percut River, Deli River and Medan Floodway.

3.2.1 Boring and Tests

Investigation Site

Main structures which required technical analyses on the stability of slope, foundation and substructures are the following:

(1) Dike and excavated channel for river improvement and floodway construction;

(2) Reconstruction and new construction of 14 road bridges, two (2) railway bridges and three (3) pedestrian bridges on Percut River, Medan Floodway and Deli River;

(3) One (1) intake weir, one (1) floodgate and three (3) sluices on Percut River; and

(4) One (1) weir on Deli River and one (1) diversion weir on Medan Floodway.

Boring was conducted at or near both abutments for bridges on the Percut and Deli rivers, except for some locations where house and drainage culverts are situated. For the diversion weir in Deli River and the existing intake weir in Percut River, boring was carried out at three (3) sites: both sides of bank and center of river channel. For the bridge and weir on the proposed floodway, and the sluice and floodgate along Percut River, one (1) site was selected at each location. The total number of boreholes was 39 and the total boring depth was 1,096 m.

Hand-augured boring was also executed for the investigation of dike material in the middle and lower streams of Percut River. The total number of boreholes was 8 and the total boring depth was 48 m. The boring sites are shown in Fig. 3.2.1.

Test Items and Volume

The following soil tests were carried out in the field and in the laboratory in accordance with the American Society for Testing and Materials (ASTM) standards:

(1) Standard Penetration Test

Standard Penetration Test (SPT) was carried out in sections of boreholes, to obtain a continuous record of mechanical strength of soils, uncemented deposits or weathered rock. The tests were performed at every 1 m deep until the foundation rock or hard soil layer with sufficient thickness was encountered. The tests were generally terminated when the N-value was more than 40 to 50 blows per 30 cm with thickness of 5 m or more.

(2) Physical Property Test

Physical property tests such as density, specific gravity, moisture content, grading, liquid limit and plastic limit tests were carried out to classify the soils in detail and to evaluate the specific gravity, wet density, natural void ratio, saturation degree, natural water content, sieve analysis, Atterberg limit, etc.

(3) Mechanical Property Test

Shear strength tests such as uniaxial test or unconfined compression test, triaxial test and direct shearing test were carried out to evaluate the stability of slope, foundation and substructure. Triaxial test instead of uniaxial test was executed to find the cohesion and internal friction angle of soil by using undisturbed sample due to the low plasticity of soil. In case these tests were not applicable for lower or none plasticity, direct shearing test was carried out with disturbed sample to evaluate the internal friction of sandy or silty soil.

Consolidation test with undisturbed sample was carried out to evaluate some property indices on the consolidation settlement caused by additional loading from the proposed dike or structures into a soft clay or silty soil stratum. Permeability test was also carried out in the field to evaluate the permeability coefficient for the analysis of seepage problem of foundation of the proposed weirs crossing the river channel.

Physical property test and compaction test for dike material were practiced to estimate the suitability, moisture-density relationships and optimum moisture water contents of selected soil samples by using hand-augured drilling.

The following table gives the soil investigation items and work volumes. The recovered soil samples were placed in core boxes for reconfirmation of soil conditions in the detailed design.

Items of Work	Borehole No.	Quantity
(1) Mounted Power Boring	B1-B39	1,096 m
(2) Hand -Augured Boring	A1-A8	48 m
(3) Standard Penetration Test	B1-B39	1,096 times
(4) Physical Property Test		
(a) Density	B1-B39, A1-A8	148 samples
(b) Specific Gravity	B1-B39, A1-A8	148 samples
(c) Moisture Content	B1-B39, A1-A8	148 samples
(d) Grading	B1-B39, A1-A8	148 samples
(e) Liquid Limit	B1-B39, A1-A8	148 samples
(f) Plastic limit	B1-B39, A1-A8	148 samples
(5) Mechanical Property Test		
(a) Uniaxial Test, Triaxial Test or Direct Shearing Test	B1-B39	91 samples
(b) Consolidation	B1-B4, B6, B10, B13, B14, B29, B35	20 samples
(c) Permeability Test	B7, B35, B37, B38, B39	9 samples
(d) Compaction Test for Dike Material	A1-A8	21 samples

Geological conditions and soil classifications such as color, density, stiffness, plasticity, gradation, etc., were firstly investigated by sample boring, standard penetration test, physical property test and mechanical property test. The water level in the borehole was also measured. Secondly, some important soil property indices in the design such as cohesion, internal friction angle, wet density, permeability coefficient, consolidation coefficient, etc., were estimated in the tests aforementioned. Soil test for dike material was further carried out.

3.2.2 Geological Condition and Soil Properties

Geological Condition and Soil Classification

Fig. 3.2.2 shows the geological stratification profile along the Percut River and Medan Floodway including the two diversion weirs. A low-lying area facing the Strait of Malacca in the northern part of the Study Area consists of Holocene alluvium sediments such as loose sands and soft clays which were deposited on the Medan Formation. The diluvial plateau named Medan Formation which consists of sands and clays spreads in the central part of the Study Area.

The proposed floodway is situated to pass through the Medan Formation. The Medan Formation which was formed in the middle to upper Pleistocene is deposited on the Toba Tuff. Unlike alluvium, the Medan Formation has been comparatively consolidated or compacted. Toba Tuff which was formed in the middle Pleistocene and diluvial stratum appears in the southern part of the Study Area. It is grayish white in color, consisting of medium to coarse pumice, quartz and biotitic.

(1) Percut River

In the low-lying deltaic area from the estuary to 17 km upstream of Percut River, the alluvium stratum mainly consists of silty and sandy clay with low bearing capacity

(N-value is mostly less than 10) and fine to medium size sand with low to medium density (N-value is from 5 to 35). The depth of the alluvial stratum is 25 m near the river mouth and gradually becomes shallower toward upstream.

The diluvial Medan Formation under the alluvial deposits in the downstream consists of comparatively consolidated clay (N-value is around 5 to 25), fine to medium size sand (N-value is 10 to 40) and coarse sand (N-value is more than 20). The dense coarse sand stratum with high bearing capacity (N-value is more than 40 or 50) appears at 15 m to 30 m deep.

Medan Formation spreads from 17 km to 29 km upstream. The upmost layer (around 10 m in depth) consists of clayey sand with low to medium density (N-value is from 5 to 30) along the midstream, and soft clay (N-value is 2 to 10) along the upstream. Below these layers a fine to medium coarse sand layer (N-value is from 15 to 40) and consolidated clayey sand layer (N-value is 10 to 50) are found. The lower layer of Medan Formation consists of dense sand with high bearing capacity (N-value is more than 20). The more dense sand of Medan Formation and Toba Tuff with N-value of more than 40 appears at 15 m to 25 m deep.

(2) Medan Floodway

The plateau along the floodway comprises Medan Formation on Toba Tuff. The thickness of Medan Formation is 15 to 20 m. The top layer consists of soft clay (N-value is 3 to 10) with 1 to 5 m thick in the east side. Clayey sand stratum appears under this layer and its density varies widely according to depth and location. In the middle of the clayey sand stratum, medium size sand appears in the east side. Near Deli River or Deli Tua, well-graded sand layer (N-value varies from 10 to 50) exists under the top, soft clayey sand. The lower stratum of Medan Formation consists of comparatively dense sand (N-value is more than 15).

The Toba Tuff secures the high bearing capacity (N-value is mostly more than 30) excluding the top weathered layer. The adequate soil stratum (N-value is more than 40 to 50) to support the foundation of bridge appears from 20 to 30 m deep.

(3) Diversion Weir and Deli Weir

The results of boring, B37, at the diversion weir on Medan Floodway show that the upper soil condition of Medan Formation consists of soft clay and loose sand with low bearing capacity (N-value is from 5 to 20) and its depth is around 10 m from ground level. In the lower stratum of Medan Formation, fine sand (N-value is from 20 to 50) exists on the Toba Tuff. The stiff and uncemented Toba Tuff (N-value is more than 30) appears at 12 m deep. The depth of Toba Tuff was confirmed to be until 10 m.

Borehole Nos. B35, B38 and B39 present the soil condition at the weir on Deli River. The right side bank of river consists of sandy clay, well-graded sand and soft clay (N-value is from 10 to 50). The left bank consists of soft clay, fine sand and medium stiffness clay (N-value is from 3 to 20). The uncemented tuff in Toba Tuff has a high bearing capacity (N-value is mostly more than 40) with a depth of 15 m, excluding a thin weathered upper layer. Deeper stratum in the Toba Tuff contains some layers composed of fine sand and clay (N-value varies from 10 to 50).

Major Soil Property Indices

(1) Shear Strength and Wet Unit Weight

Shear strength of soil such as cohesion and internal friction angle and wet density were tested at the laboratory for two or three soil samples of each boring (B1 to B39). The soil test results were checked and modified because of the difficulty of undisturbed soil tests due to the standard value of soil property index presented in Table 3.3.1. Furthermore, the test results of internal friction angle (ϕ) on sandy soil were confirmed and revised by the following formula:

$$\phi = 15 + (15 \times N)^{0.5} \qquad \text{(N: result of SPT)}$$

The modified soil indices for each classified soil are given in Table 3.2.2. The following table shows the relation between cohesion, internal friction angle, and N-value for the sandy soil and the clayey soil.

Soil Classification	N-value	Cohesion (kg/cm^2)	Internal Friction Angle	Wet Density (g/cm^3)
Clayey Soil				
- Low Stiffness	1 - 10	0.05 - 0.3	10 - 15	1.3 - 1.6
- Medium Stiffness	10 - 25	0.3 - 0.5	15 - 25	1.6 - 1.8
Sandy Soil				
- Low Density	3 - 15	0	20 - 30	1.7 - 1.8
- Medium Density	15 - 30	0	30 - 35	1.8 - 1.9
- High Density	30 - 50	0	35 - 40	1.9 - 2.0

(2) Permeability Index

Permeability coefficient of sandy soil was estimated at the three (3) proposed weirs, Bandar Sidoras Weir and two (2) diversion weirs, as shown in Table 3.2.3. Upper soil stratum below the riverbed at Bandar Sidoras Weir (Borehole B6, B7 and B8) is composed of sandy clay (around 3 m thick) and silty sand (around 10 m deep).

Permeability coefficient is estimated at 1.36×10^{-4} cm/s for the silty sand on which field test was carried out. This coefficient is also applicable for the sandy clay.

Soil stratum below the riverbed consists of uncemented tuff of around 15 m thick at the Deli River Weir and more than 10 m thick at the Floodway Weir. Permeability tests in the field have shown the permeability coefficient for tuff to be 1.09 to 1.30×10^{-4} cm/s at the Floodway Weir and 1.72×10^{-4} cm/s at the Deli River Weir. These permeability coefficients were adopted for the structural design. However, the permeability coefficient of 1.0×10^{-3} cm/s for the upper weathered tuff and loose silty sand below the riverbed is proposed in accordance with Table 3.2.4.

(3) Consolidation Settlement Index

The consolidation test was mainly carried out for the estimation of settlement of high embankment (more than 2 m) which is designed for the stretch from the estuary to 15 km upstream of Percut River. The compression index of clayey soil varies between 0.09 and 0.17, and the consolidation coefficient varies between 5.5 and 5.8×10^{-3} cm^2/s for the stretch. These values of indices are very common as clay. The thickness of clay varies between 5 and 20 m. The details of consolidation indices are shown in Table 3.2.5.

(4) Physical Property and Compaction Tests for Dike Material

Dike materials will be taken from borrow areas on the left and right banks or the high water channel in the vicinity of dike from the economic viewpoint. Totally, eight (8) investigation sites (Borehole A1 to A8) were selected in the downstream of Percut River, as shown in Fig. 3.3.1. The suitability of soil for dike material was evaluated by the soil physical properties such as permeability, compatibility and resistibility, as shown in Table 3.2.6.

Topsoil stratum in the downstream (Borehole A1 to A6) mainly consists of sandy and silty clay 1 to 6 m deep. The sandy clay is adequate for dike material considering the low permeability, fair compactibility, fair resistivity against seepage and fair resistivity against deformation. However, the silty clay is not an adequate material in view of the poor resistivity against deformation. It is necessary for the silty clay to be mixed with sand or clayey sand. The design mix ratio of silty clay and sand or clayey sand should be determined by laboratory test before construction. Clayey sand layer in the depth of more than 3.5 m at Borehole A3 and A5 spreads under the sandy and silty clay. Though the clayey sand is the most suitable dike material as indicated in Table 3.2.6, it will be very costly to excavate it.

The upper layer of about 1 m deep below the ground surface at Borehole A7 and A8, which consists of clay soil, is not suitable for embankment due to the difficulty in compaction. However, this clay soil becomes applicable when mixed with sand which is found in the depth of more than 1 m at Borehole A6 and A7. The design mix ratio of clay and sand should be determined by laboratory test before diking. The optimum moisture content for the dike material is given in Table 3.2.7 from the results of the compaction test.

3.3 Hydrological Analysis

3.3.1 Data Collection and Compilation

In the B-P Study, probable daily rainfalls were estimated using rainfall data of 35 years from 1954 to 1988. In this D/D Study, probable daily rainfalls are updated by adding data of six years from 1989 to 1994.

Mean Daily Rainfall of Basin

Thiessen polygons were formulated for calculation of mean basin rainfall of the Deli and Percut river basins, as shown in Fig. 3.3.1. Accordingly, Thiessen coefficients were estimated, as presented in Table 3.3.1. Thiessen polygon with the same six (6) rainfall stations as the B-P Study was made to compute basin rainfalls for the additional six (6) years. However, daily rainfall data at only five stations were used, except Station No. 1.19 under RISPA, because Station No. 1.19 had missing records for the said period. The mean monthly basin rainfalls were calculated for 41 years, as presented in Tables 3.3.2 and 3.3.3.

Probable Daily Rainfall

Annual maximum daily rainfalls were extracted from the annual tables of daily rainfall data, as presented in Table 3.3.4. Probable daily rainfalls were estimated using the Gumbel Method, as in Table 3.3.5. The estimated probable rainfalls are slightly smaller than those of the B-P Study, because small and medium rainfalls were experienced in the last six years.

Return Period (Year)	Deli River		Percut River	
	B-P Study (1954-88)	D/D Study (1954-94)	B-P Study (1954-88)	D/D Study (1954-94)
2	66.3	64.8	67.9	67.2
5	86.8	84.1	87.6	85.7
10	100.4	96.9	100.6	98.0
20	113.5	109.2	113.1	109.7
25	117.6	113.1	117.0	113.4
30	121.0	116.3	120.3	116.4
40	126.3	121.2	125.3	121.2
50	130.4	125.1	129.2	124.9
100	143.0	137.0	141.4	136.3

3.3.2 Probable Flood Discharge

Flood Runoff Model

The Storage Function Model calibrated in the B-P Study was employed for the flood runoff analysis, and the models of Deli and Percut river basins were integrated by adding the diversion system of Medan Floodway. The sub-basin division for the flood runoff model is as shown in Fig. 3.3.2, the composition of flood runoff model is shown in Fig. 3.3.3, and the parameters in the storage function model are as tabulated in Table 3.3.6.

The design storm rainfall pattern adopted is the same as that in the B-P Study. The design storm rainfall of each return period enlarged using probable daily rainfall is given in Table 3.3.7.

Probable Flood Discharge

Inputting the design storms into the flood runoff model mentioned above, probable flood discharges were calculated, as shown below and in Tables 3.3.8 and 3.3.9.

Return Period (Year)	Deli River		Percut River
	Helvetia ($341 km^2$)	Titi Kuning ($202 km^2$)	Tembung ($171 km^2$)
2	272	156	132
5	369	210	181
10	437	247	213
20	502	281	245
25	523	292	253
30	540	301	261
40	567	315	274
50	589	326	285
100	655	359	315

Design Discharge

In the Immediate Plan with the design scale of a 25-year return period, the diversion work from Deli River to Percut River was put in practice. In the Urgent Plan with the project scale of a 40-year return period, some modification on the diversion weir and flood regulation (non-gated overflow type) by Lausimeme Dam located in the upstream of Percut River was carried out. Furthermore, in the Master Plan with the scale of a 100-year return period, flood control operation by Namobatang Dam (gated operation) which is located in the upstream of Deli River was added.

The rating curves of the diversion weir are tabulated in Table 3.3.10, and the hydraulic condition of the outlet of Lausimeme Dam are presented in Table 3.3.11. The hydrographs of probable flood discharge and design flood discharge distribution for the Immediate, Urgent and Master plans are illustrated in Fig. 3.3.4 to 3.3.9.

Plan	Design Flood Discharge (m^3/sec)				
	Return Period / River		Diversion	After Diversion	River Mouth
Immediate Plan	25-year	Deli River	300	230	470
		Percut River	70	320	
Urgent Plan*	40-year	Deli River	320	200	460
		Percut River	120	320	
Master Plan**	100-year	Deli River	300	170	460
		Percut River	120	320	

(Note) * With Lausimeme Dam in Percut River.
** With Lausimeme Dam in Percut River and Namobatang Dam in Deli River.

Medium Scale Floods and Exceeding Floods

The diversion discharge to Percut River with a 25-year return period in the Immediate Plan is 67 m^3/s, and the diversion discharges when medium and small scale floods or exceeding floods occur on condition that the diversion weir is designed for the Immediate Plan were analyzed, as shown in Table 3.3.12.

Return Period	2-yr	5-yr	10-yr	20-yr	30-yr	50-yr	100-yr
Diversion Discharge to Percut River (m^3/sec)	5	29	45	61	71	82	98

Ponding Analysis for Smaller Scale Floods

There is no ponding in the upstream channel of the diversion (retarding channel) at normal time, but ponding takes place in flood time when inflow exceeds the flow capacity of the orifice of the Deli River Weir. To estimate water levels for the utilization plan of higher channel bed in the retarding channel, ponding analyses for smaller scale floods of less than 2-year return period were carried out.

Probable daily rainfalls and their runoff discharges of less than 2-year return period were calculated from the frequency analysis. The exceeding frequency of daily rainfall in the latest ten years are given in Tables 3.3.13 and 3.3.14. The runoff discharge for rainfall was computed by the Storage Function Method with the same parameters as those used in the B-P Study. Probable daily rainfall for smaller scale floods in the Deli river basin are as presented in the following table.

Return Period	2-year	1-year	2-times/y	5-times/y	10-times/y
Rainfall (mm/day)	65	57	52	44	36
Runoff Discharge (m^3/s)	156	134	120	98	78
Max. Water Level (El. m)	32.28	31.72	31.35	30.63	29.64

The storage capacity of the retarding channel at each water level was calculated using cross sections by the channel survey, as shown in Tables 3.3.15 and 3.3.16. The results of ponding analysis by natural flood control method are as shown in Tables 3.3.17 and 3.3.18 and in Fig. 3.3.10. Maximum water levels of ponding are also presented in Table 3.3.19.

The water levels in the Retarding Channel were also estimated by Non-uniform Flow Calculation, while the starting water level at the Deli River Weir are as given in Table 3.3.20. The water levels of channel for flow regimes in normal time are given in Table 3.3.21 for reference.

Backwater Effect of Diversion Weir

In the upper stretch of the proposed Deli River Weir the water level of the channel becomes higher than that under the existing condition, because of the backwater effect of the proposed weirs. According to the non-uniform calculation, backwater will affect about 3.5 km upstream of the proposed Deli River Weir site, but the effect is very small.

Calculation results are shown in Fig. 3.3.11 to 3.3.13. Based on these calculation results, the flood inundation area after completion of Deli River Weir was estimated, as shown in Fig. 3.3.14.

3.3.3 Drainage Discharge

Existing Condition of Drainage Outlet

Many closed and open drainage channels discharge storm runoff and domestic wastewater into Percut River. Further, some tributaries and drainage channels will be cut by the proposed Floodway. Based on the field survey and hydrographic study with a 1/5,000 topo-map, the existing drainage areas and networks were identified, as shown in Fig. 3.3.15. There are 44 drainage areas in total; 12 drainage channels are found to the right side of Percut River and 25 channels are to the left side; and 7 channels shall bring the storm runoff to the Floodway.

Some channels are lined with concrete, but most of them are mere earth channels with a rectangular or trapezoidal cross section, as presented in Table 3.3.22. On the other hand, the capacity of the existing drainage outlets is mostly inadequate and the structures themselves have deteriorated requiring further improvement or reconstruction.

Therefore, in the course of project construction, all existing drainage channels shall be improved or reconstructed, particularly, their outlet structures. For the drainage channel itself, the improvement works are expected under the MMUDP (MUDP III).

Design Discharge

(1) Design Scale for Drainage Improvement

Based on the Flood Control Manual, the guideline for the design scale is as shown below. The design scale of drainage improvement in terms of return period is a 5-year return period for the urban area and a 2-year for the rural area.

Conveyance System	Project Type **	Return Period (yr) *	
		Initial Phase	Final Phase
Primary Drainage System (CA>500 ha)	Rural	2	5
	Urban P<500,000	5	10
	Urban 500,000<P<2,000,000	5	15
	Urban 2,000,000<P	10	25
Secondary Drainage System (CA<500 ha)	Rural	1	2
	Urban P<500,000	2	5
	Urban 500,000<P<2,000,000	2	5
	Urban 2,000,000<P	5	10
Tertiary Drainage System (CA<10 ha)	Rural and Urban	1	2

(*Note*) * Higher design flood standard shall be applied if economic analysis indicates desirability, or if flooding is a significant risk to human life.
** P = Total Urban Population

(2) Estimation of Short Duration Rainfall

The storm rainfall of short duration was estimated from the data of Sampali Rainfall Station where the hourly rainfall has been recorded only in the Percut river basin. Frequency analyses were made for the short duration rainfall at Sampali Station based on the observation from 1977 to 1989 as shown in Table 3.3.23, and its annual maximum rainfalls of 1, 2, 3 and 6-hour are given in Table 3.3.24. Annual maximum daily rainfalls of the Deli and Percut river basins, as well as their probable daily rainfalls which were estimated using the Gumbel Method, are as shown in Tables 3.3.25 and 3.3.26, respectively. The rainfall intensity of any short duration were further derived by applying Sherman's type rainfall intensity curve, namely:

$$r_t = \alpha \cdot t^{-n}$$

where,

r_t : Rainfall intensity in a duration of t-hour (mm/hour)

t : Duration (hour)

α : Parameter (= 52.4)

n : Parameter

Since the concentration time of storm rainfall in the subject drainage areas could be estimated at 2 hours at the longest, the parameter n was estimated to be 0.510 for the rainfall duration of less than 2 hours.

(4) Estimation of Area Rainfall Intensity

In consideration of the area distribution of storm rainfall that is usually localized within a small area, the design storm rainfall intensity for calculation of storm runoff in each drainage area was modified in accordance with the drainage area.

The relation between point rainfall and area rainfall was derived from Horton's Equation, as below:

$$P/P_o = EXP \cdot [0.1 \cdot (0.6 \cdot A)^{0.31}]$$

where,

P_o : Point rainfall intensity (mm/hr)

P : Area rainfall intensity (mm/hr)

A : Drainage area (km^2)

(5) Runoff Analysis

The Rational Formula was used to simply calculate discharge from rainfall:

$$Q = (f \cdot R \cdot A)/3.6$$

where,

Q : Peak discharge (m^3/s)

f : Run-off coefficient (non-dimensional)

R : Average rainfall intensity in concentration time (mm/hr)

A : Catchment area (km^2)

Flood concentration time for the drainage area was evaluated using the following Kadoya's formula:

$$T = C \cdot (f \cdot r_t)^{-0.35} \cdot A^{0.22}$$

where,

T : Flood concentration time (min.)

r_t : Average rainfall intensity in concentration time (mm/hr)

A : Catchment area (km^2)

f : Runoff coefficient

C : Hydraulic factor for land use

Runoff coefficient and hydraulic factor for land use are as follows:

Land Use	Runoff Coefficient	Hydraulic Factor
Residential Area	0.5	120
Factory / Commercial Area	0.7	90
Hilly / Bush / Plantation	0.3	290
Paddy Field	0.7	90

Based on the foregoing conditions, the peak discharges of drainage areas were estimated, ranging from 0.1 m^3/s to 23.9 m^3/s, as presented in Table 3.3.27.

3.3.4 Estuary of Percut River

Tide Level

The observation of actual tide was made for one month from the middle of June 1995 to the middle of July 1995, and the elevation of Mean High Water Spring was correspondingly estimated to be 1.30 m, based on the following considerations:

(1) According to the published Tide Table of 1995, the difference between Mean High Water Spring and Mean Low Water Spring is 2.12 m. Therefore, the Mean High Water Spring is estimated to be 1.06 m above the Mean Sea Level.

(2) According to the actual tide observation, the elevation of Mean Sea Level is at 0.20 m corresponding to the datum of the National Bench Mark. Therefore, the elevation of Mean High Water Spring is obtained at 1.26 m corresponding to the datum of the National Bench Mark.

Alignment in the Estuary

The existing channel alignment at the estuary of Percut River shows a complicated topography, because a vast low bushland is located in the center of the river mouth. To determine the alignment and stretch for dike construction at the estuary, a comparative study was made between the proposed alignment in the B-P Study and the existing channel alignment.

The results are as summarized in Table 3.3.28. According to the results, there is no critical difference of water level between the proposed alignment in the B-P Study and the existing channel alignment. Therefore, the alignment for this basic design is principally to follow the proposed alignment in the B-P Study until P1K+100, and the existing fishpond will be protected by the earth dike.

Stability of the River Mouth

The river mouth of Percut River is mainly utilized for the navigation of fishing boats and as fishpond area. Based on the existing condition as observed by the bathymetric survey and bed material sampling (refer to Fig. 3.3.16), there are some problems for the navigation of fishing boats at low tide. The typical size of fishing boats is 4 to 5 m long, 1.5 m wide and 0.8 m in draft. Due to the accumulation of sediment at the river mouth, fishing travel is limited to only once a day.

On the other hand, the topography around the river mouth is formed by river discharge and sediment, wave, tide, and current, as graphically presented in Fig. 3.3.17. There is a sand spit at both sides of the river mouth and the top of the spit is gradually moving towards the south and developing towards offshore at a few meters every year. A seabed soil survey was conducted at several locations for 2.0 km offshore from the coastal line and it was found that the spit around the river mouth is formed by the deposition of river materials and that river materials are transported to the offshore area near the river mouth at 1.7 m below MSL. In order to examine the influence of the Project, the changes of the river mouth was analyzed to examine the possibility of closure of the river mouth.

(1) Wave Prediction

Wave conditions are simulated by wind data furnished by the Polonia International Airport. The period of the data is 10 years from 1986 to 1995.

The dominant wind direction is NE-E during dry seasons (April to September) and NE-W in rainy seasons (October to March). The strongest wind moves SE with a velocity of 17.5 m/s.

The effective wind direction affecting wave action at the Percut river mouth is from N-E. The average daily maximum wind was applied for the calculation, and the fetch distance measured as the maximum length from Peninsular Malaysia to the Percut river mouth was 220 km.

To apply the Sverdrup-Munk-Bretschneider method (SMB Method) for wave prediction, two kinds of wind wave can be linked: one is from the correlation between fetch distance and wind speed, and the other from the correlation between fetch time and wind speed. The SMB method recommends choosing a small wave as the design wave.

(2) Conditions of Calculation

The calculation of significant wave height ($H_{1/3}$) and wave period ($T_{1/3}$) was based on the following conditions:

Wind Speed (U)	5.0 m/s
Fetch Distance (F)	220 km
Fetch Time (assumed)	3.0 hrs
Seabed Slope	1/600
MHWL	2.52 m
MLWL	0.40 m
MSL	1.26 m

(3) Results

The significant wave was calculated as follows:

$$H_{1/3} = 0.3\ m \text{ and } T_{1/3} = 2.1\ sec$$

Waves break at the water depth of 0.6 m. Wave with the height of more than 0.3 m is broken before coming to the seashore with depth of 0.6 m. The depth around 0.6 m in the Percut river mouth is the same as the location of the sand spit area and this is the zone for river discharge facing the coastal current.

This zone moves further offshore at low tide and inshore at high tide. Sediment carried by river discharge is deposited in this zone, and this contributes to the development of the spit. The top elevation of the spit does not exceed the design high water level, but remains constant in the existing condition.

Furthermore, based on the results of the bathymetric and seabed soil surveys, seabed sediment has changed at around minus 2.0 m in depth. The seabed profile also varied around the same depth. This means that a longshore current exists and the dominant direction is from NW to SE.

Therefore, it is projected that the river width at the Percut river mouth will not change from the existing condition. Since the proposed dredging works is limited to the inside of the estuary, the flow discharge decreases at the river mouth.

Should the spit grow, however, sedimentation will increase at flood time by the additional discharge from the floodway. On the other hand, the additional discharge will provide more energy to flush out the sediment to the offshore where sediment is easily flushed out by the alongshore currents. Thus, the deposition rate of sediment around the river mouth will not increase after the river improvement works.

3.4 Hydraulic Model Test

3.4.1 Model Construction and Calibration

Model Construction

The model test was conducted by the Research Institute for Water Resources Development (RIWRD), Ministry of Public Works, in Bandung. The scale of model was set at 1/40, taking the capacity of basic facilities and available space in the compound into consideration. The actual dimensions of the model construction are as follows (refer to Fig. 3.4.1).

Deli River (Upstream of Weir)	400 m
Deli River (Downstream of Weir)	200 m
Floodway (Downstream of Weir)	200 m

River channel and floodway were formed with a fixed bed, made of rough plaster (refer to Fig. 3.4.2). The model of diversion weirs were constructed based on the basic design with the following principal features (refer to Figs. 3.4.3 and 3.4.4):

(1) Diversion Weir of Floodway

Type of Weir	Fixed overflow crest
Crest Elevation	EL 32.50 m and 32.00 m
Crest Length	25.0 m
Crest Height	6.0 m
Type of Stilling Basin	Long-apron with baffle blocks
Elevation of Basin	EL 26.50 m
Length of Basin	20.00 m
Height of Baffle Blocks	1.5 m

(2) Diversion Weir of Deli River

Type of Weir	Fixed overflow crest
Crest Elevation	EL 31.10 m and 31.50 m
Crest Length	17.50 m
Crest Height	6.40 m
Type of Stilling Basin	Long-apron with baffle blocks
Elevation of Basin	EL 24.20 m
Length of Basin	20.00 m
Height of Baffle Blocks	1.60 m
Dimension of Orifice	2 m high and 3 m wide

Model Calibration

Prior to the execution of model test, not only the geometric similitude but also the dynamic similitude between the model and the actual condition were examined. Since the subject model test was conducted with a geometric similitude scale of 1 : 40, the similitude ratio of the main hydraulic parameters were as follows:

Parameter	Dimension	Similitude Ratio
Depth/Length	L	$1/40 = 2.500 \times 10^{-2}$
Time	T	$(1/40)^{1/2} = 1.581 \times 10^{-1}$
Velocity	$L \times T^{-1}$	$(1/40)^{1/2} = 1.581 \times 10^{-1}$
Discharge	$L^3 \times T^{-1}$	$(1/40)^{5/2} = 9.882 \times 10^{-5}$
Manning's Roughness	$L^{1/6}$	$(1/40)^{1/6} = 5.408 \times 10^{-1}$

Calibration of the model channel was carried out for the following discharges and Manning's Coefficient of Roughness:

Channel	Discharge (m^3/s)	Coefficient of Roughness	
		Existing	Designed
Deli River	320, 150, 70	0.035	0.033
Floodway	120, 70, 30	-	0.030

Hydraulic Calculation

(1) Uniform Flow Calculation

In designing the river channel in the upper reaches with a single-trapezoid cross section, the design high water levels are set based on the water level profile derived from the uniform flow calculation by Manning's Formula.

(2) Non-Uniform Flow Calculation

For the river channels whose water level is influenced by the downstream water level, non-uniform flow method is employed to compute the water surface profile.

(3) Flow Over/Below Weir

Hydraulic designs for both diversion weirs are made by using the trapezoid-shaped weir.

(a) Flow Over Trapezoid Shaped Weir

The discharge for flow over the trapezoid-shaped weir is derived by Honma's Formula.

(b) Flow of Orifice

The orifice formula is used to calculate the discharge flowing through the orifice of the weir.

(4) Conditions of Calculation

(a) Manning's Coefficient of Roughness

Manning's coefficient of roughness used for both uniform and non-uniform flow calculations are as follows:

Low Water Channel (excavated)	0.033
Low Water Channel (existing)	0.035
Floodway Channel (with revetment)	0.030
Floodplain (existing)	0.040

(b) Design Water Level of River Mouth

The design water level at the river mouth of Percut River was decided in consideration of the tidal effect. The mean sea level was estimated at EL ±0.00 m on the National Bench Mark in accordance with the tide observation conducted by the Study Team in July 1995. In addition, the tide table in 1995 was used to estimate the average amplitude of monthly biggest tide in a year. As the result of adding the average amplitude to the mean sea level, the tide level of EL ±1.26 m was obtained. This tide level is equivalent to the mean high water spring. For the non-uniform flow calculation in the event of flooding, the water level is EL ±1.30 m, rounded from EL 1.26 m.

3.4.2 Model Test

Objective

Basically, the objectives of the hydraulic model test were to confirm the design diversion discharge from Deli River to Medan Floodway and to investigate the proper measures to attain a smooth diversion, as follows:

(1) To secure the successful diversion of the Immediate Plan

To attain the successful diversion of the design discharge of the Immediate Plan, the basic dimensions of the diversion weir were examined and clarified by the model test.

(2) To secure the successful diversion of the Urgent Plan

Considering the realization of Urgent Plan in the near future, the successful diversion of the design discharge of the Urgent Plan were also examined and clarified by the model test.

(3) To examine the diversion condition for smaller/larger scale floods

With regard to the optimum scale of diversion weir set for the Immediate Plan and the Urgent Plan, the diversion discharge and hydraulic characteristics at around the diversion point were examined for both smaller and larger scales of flood, and proper countermeasures were recommended when needed.

Through the model test for the above three items, further considerations and investigations as needed were made to clarify details of alignment, revetment and others, as well as the appurtenant structures of the diversion weir for both Deli River and Medan Floodway, to carry out the detailed design work.

Test on Discharge Diversion

The test results for the Immediate Plan are as summarized below. (For details, refer to "Final Report for Hydraulic Model Test of Medan Flood Control Project, December 1995" prepared by RIWRD.)

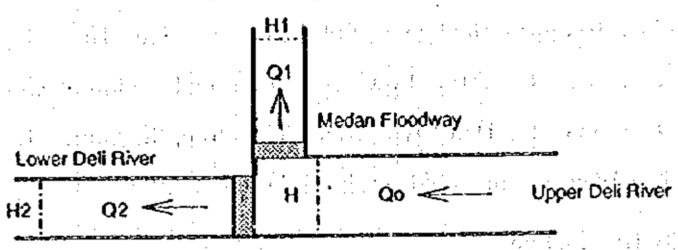
(1) Diversion Discharge

The elevation of the weir crest was confirmed at EL 32.55 m for the Floodway Weir and EL 31.10 m for the Deli River Weir in the Immediate Plan, and EL 32.00 m for the Floodway Weir and EL 31.50 m for Deli River Weir in the Urgent Plan. The other dimensions of the weir were the same as those of the Basic Design.

With the above dimensions of the weir, the inflow discharges from the upstream of Deli River were diverted as follows:

Case	Inflow Q_0	Diversion Q_1	Q_2	H
Immediate Plan				
(a) Big Flood (1/100)	360	99	261	34.32
(b) Design Flood (1/25)	300	70	230	33.98
(c) Small Flood (1/5)	210	30	181	33.44
Urgent Plan				
(a) Bigger Flood (1/100)	360	143	217	34.18
(b) Design Flood (1/25)	320	120	200	33.91
(c) Smaller Flood (1/5)	210	57	153	33.32

(Note) Q_0 : Discharge from the upstream of Deli River (m^3/s)
Q_1 : Diversion discharge to Floodway (m^3/s)
Q_2 : Discharge to the downstream of Deli River (m^3/s)
H : Water level at the section 5 m upstream of weir (m)



Discharge rating curves of the Floodway Weir and the Deli River Weir are, from the test results, shown in Fig. 3.4.5 and Fig. 3.4.6, respectively. The basic design of weirs have been confirmed to attain successful diversion of the design discharge, although a slight change of weir crest elevation was made.

(2) Flow Condition

(a) Water Level

Water levels measured in down and upstream sections of the Deli River Weir for the discharge of Big Flood (360 m^3/s), Design Flood (300 m^3/s for Immediate Plan and 320 m^3/s for Urgent Plan) and Small Flood (210 m^3/s) are as shown in Fig. 3.4.7.

(b) Flow Pattern

Flow patterns (horizontal flow direction) were observed to be almost the same for either the Immediate Plan or the Urgent Plan and for various inflow discharges. Main flow stream line was formed along the center of the retarding channel. Reverse flow (dead water zone) was observed in most part of the left bank side in the retarding channel and in front of the approach alignment (right bank) of the Floodway Weir. (refer to Fig. 3.4.8)

The dead water zones tended to become bigger in the retarding channel and smaller in front of the approach alignment (right bank) of the Floodway Weir as the inflow discharge was increased.

As for the flow pattern (stream line) at/around the weirs, according to the visual observation, the separation of stream line was observed at the approach sections to the Deli River Weir (at right bank). Thus, some modification of the approach alignment was required. No separation of stream line of the flow to Floodway Weir was observed.

The overflow of the diversion discharge to the Floodway Weir was smoothly attained by the approach alignment of the basic design. However, an unfavorable flow pattern with separation flow occurred around the approach alignment of the original design of the Deli River Weir. Therefore, the approach alignment of the Deli River Weir was modified, as shown in Fig. 3.4.9. .

(c) Velocity Distribution

Velocity distribution was measured at the upstream side of the diversion weirs (three cross sections at No. 12+22, No. 13 and No. 14) to grasp the inflow condition to the diversion weirs. Results show that the inflow velocity to the weir is about 0.65 m^3/s to 0.75 m^3/s at Deli River Weir, and about 0.2 m^3/s to 0.4 m^3/s at the Floodway Weir (refer to Fig. 3.4.10) for both the Immediate and Urgent plans.

The apron length of the Deli River Weir was expanded from 20 m (basic design) to 30 m, providing an end-sill at the lowest end of the apron and two circular buffle piers at just downstream of the weir. As for the apron of the Floodway Weir, no modification from the basic design was required.

Test on Floating Logs

(1) Condition of Floating Logs at Weir Sites

Based on the site reconnaissance and interview survey in the upstream reach from Titi Kuning of Deli River, the identified conditions of floating log at the weir sites are as follows:

(a) The upstream mountain area of Deli River is legally delineated as "Protective Forest" by the Government of Indonesia, and logging activities are neither allowed nor found at present.

(b) In the middle reach from Titi Kuning to Namorambe, the topography along the river shows a cultivated hilly land, and farm lands such as paddy fields, plantations and orchards are well developed.

(c) Only small-sized trees such as banana, papaya, coconuts, cacao, coffee, etc., which are produced in the midstream hilly land area, are observed in the river flow of Deli River.

(2) Test on Floating Logs

The test on floating logs was conducted by limiting the size of logs which may clog the orifice of Deli River Weir to 4 m in the prototype. Three cases of flow discharges were selected; 80 m^3/s, 40 m^3/s and 20 m^3/s. The number of floating logs in the retarding channel were assumed at 100, 200 and 300.

In order to investigate the capture ratio of floating logs, a slit structure was placed in front of the orifice. Intervals of the slit were 1.0, 2.0 and 3.0 m with a height of 4 m.

Test results are summarized as follows:

(a) In the slit intervals of 1.0 m and 2.0 m, the capture ratio (the ratio of number of logs captured at the slit to the total number of logs flowing down) shows more than 80%, for both of the 80 m^3/s and 40 m^3/s discharges.

(b) When the slit interval was 3.0 m, the capture ratio shows less than 80% for both of the 80 m^3/s and 40 m^3/s discharges.

(c) The above tendency was the same for the smaller discharge of 20 m^3/s (open flow condition in the orifice).

(d) When the discharge overflows the weir, all logs flow out to the downstream of the weir.

Therefore, the orifice may be clogged in case many of the floating logs with a size of 4 m or longer flow to the weir with small floods of 20 m^3/s to 80 m^3/s. However, it may be rare that floating logs of more than 100 flow into the retarding channel on a small flood time. Further, many floating logs should totally overflow the weir as the flood discharge becomes big enough for overflow. Therefore, no countermeasure for floating logs is required since the floating logs may not give adverse effect of flood flow over the diversion weirs.