TABLES

CHAPTER 3

INVESTIGATION AND ANALYSIS

Table 3.1.1 (1/3) FINAL RESULT OF CONTROL POINTS (DELI RIVER)

Projection : U.T.M
Zone : 47
Semi-Major Axis : 6378160.00000
Semi-Minor Axis : 6356774.50409
Flattering : 1/298.24700
Scale Factor : 0.99960000
Latitude of Origin : 0°00'00"
Longitude of Origin : 99°00'00"

STATION	X(m)	Y(m)	ELEVATION
DG1	390,553.936	464,660.218	33.097
DG2	390,483.085	464,635.065	34.766
DG3	389,614.073	464,499.064	32.697
DG4	389,522.496	464,488.166	33.387
DG5	387,522.423	463,805.525	42.417
DG6	387,393.315	463,880.823	40.772

Table 3.1.1 (2/3) FINAL RESULT OF CONTROL POINTS (FLOODWAY)

Projection : U.T.M
Zone : 47
Semi-Major Axis : 6378160.00000
Semi-Minor Axis : 6356774.50409
Flattering : 1/298.24700
Scale Factor : 0.99960000
Latitude of Origin : 0°00'00"
Longitude of Origin : 99°00'00"

STATION	X(m)	Y(m)	ELEVATION
FG1	390,361.882	465,527.072	38.386
FG2	390,357.092	465,646.881	40.511
FG3	390,321.531	466,645.229	37.534
FG4	390,318.565	466,807.727	36.692
FG5	390,674.667	468,704.513	
FG6	390,582.720	468,755.082	
FG7	390,323.938	468,140.249	35.107
FG8	390,298.374	468,209.297	35.406

Table 3.1.1 (3/3) FINAL RESULT OF CONTROL POINTS (PERCUT RIVER)

Projection : U.T.M
Zone : 47
Semi-Major Axis : 6378160.00000
Semi-Minor Axis : 6356774.50409
Flattering : 1/298.24700
Scale Factor : 0.99960000
Latitude of Origin : 0°00'00"
Longitude of Origin : 99°00'00"

STATION	X(m)	Y(m)	ELEVATION
PG 1	391,362.694	468,427.982	
PG 2	391,359.363	468,286.369	
PG 3	392,901.047	468,295.385	
PG 4	392,975.097	468,296.469	
PG 5	394,130.141	469,217.177	
PG 6	394,114.872	469,440.349	
PG 7	395,624.443	470,248.993	
PG 8	395,619.267	470,055.288	
PG 9	397,080.044	471,484.065	21.286
PG10	397,047.785	471,179.693	22.007
PG11	400,070.653	471,234.335	
PG12	400,031.144	471,371.002	
PG13	401,964.077	472,262.485	
PG14	402,004.623	472,307.712	11.999
PG15	404,722.099	473,125.599	
PG16	404,864.951	473,135.841	
PG17	406,842.634	474,261.935	
PG18	406,905.214	474,161.766	
PG19	408,570.515	474,590.699	2.024
PG20	408,768.491	474,661.512	
PG21	410,615.481	475,491.761	1.232
PG22	410,646.816	475,572.265	1.277
PG23	411,077.571	476,791.991	
PG24	411,099.395	476,866.756	

Table 3.1.2 ORIENTATION SURVEYING (GPS) ACCURACY CONTROL CHART

Session No	Station	Distance	Closure Tolerance	Closure Ratio
1	1022 DG1 DG2 DG3 DG4	10,003.962m	Δx= - 0.003m Δy= - 0.001m Δz= 0.005m	0.6 PPM
2	1022 DG3 DG4 DG5 DG6	14,344.115m	Δx= 0.008m Δy= - 0.002m Δz= 0.006m	0.7 PPM
3	GPS14 GPS20 1022 DG1 DG3	26,932.797m	Δx= - 0.008m Δy= - 0.013m Δz= - 0.016m	0.8 PPM
4	GPS14 GPS20 FG1 FG2 FG3	23,523.135m	Δx= - 0.015m Δy= - 0.013m Δz= 0.033m	1.6 PPM
5	FG2 FG3 FG4 FG5 FG6	6,312.745m	Δx= 0.002m Δy= 0.001m Δz= 0.005m	0.8 PPM
6	GPS14 GPS20 PG1 PG2 PG3	20,619.506m	Δx= - 0.003m Δy= 0.004m Δz= - 0.017m	0.8 PPM
7	PG3 PG4 PG5 PG6 PG7	6,839.007m	Δx= 0.001m Δy= 0.001m Δz= - 0.005m	0.7 PPM
8	PG7 PG8 PG9 PG10 PG11	10,120.646m	Δx= - 0.003m Δy= - 0.007m Δz= 0.007m	1.0 PPM
9	PG11 PG12 PG13 PG14 PG15	10,176.739m	Δx= 0.002m Δy= - 0.003m Δz= 0.010m	1.0 PPM
10	PG15 PG16 PG17 PG18 PG19	8,374.660m	Δx= - 0.001m Δy= 0.001m Δz= 0.007m	0.8 PPM
11	PG19 PG20 PG21 PG22 PG23	6,951.527m	Δx= - 0.005m Δy= - 0.001m Δz= 0.008m	1.3 PPM
12	PG22 PG23 PG24	1,508.916m	Δx= 0.000m Δy= 0.000m Δz= - 0.001m	0.7 PPM

Table 3.1.3 LEVELING ACCURACY CONTROL CHART

Route	Station	Distance	Closure	Limit	Remarks
1	TTG541~TTG542	3.24km	+ 4 mm	± 72mm	Closed route
2	TTG542~TTG543	3.68km	− 4 mm	± 76mm	〃
3	TBM1~DNO1	4.07km	+10 mm	± 80mm	Double-run
4	DNO19~DNO50	4.38km	− 9 mm	±104mm	〃
5	PH8~PBM1	27.32km	−25 mm	±209mm	Closed route
6	PBM1~PH1	7.05km	−26 mm	±106mm	〃
7	PH1~PP1	3.40km	+18 mm	± 73mm	〃
8	PP1~PH2	4.81km	+17 mm	± 87mm	〃
9	PH2~PBM3	1.99km	− 6 mm	± 56mm	〃
10	PBM3~PH3	1.68km	− 7 mm	± 51mm	〃
11	PP2~PH4	3.32km	− 2 mm	± 72mm	〃
12	PH4~PR1	1.52km	− 3 mm	± 49mm	〃
13	PR1~PH5	3.57km	− 6 mm	± 75mm	〃
14	PH5~PH6	3.47km	+ 1 mm	± 74mm	〃
15	PH6~PH7	3.76km	+ 1 mm	± 77mm	〃
16	PH7~PH8	3.57km	− 9 mm	± 75mm	〃
17	TBM1~PH8	6.47km	+ 9 mm	± 77mm	〃
18	TBM1~PH8(FO)	6.46km	+ 8 mm	± 77mm	〃
19	FH1~FH1	2.06km	− 7 mm	± 57mm	Double-run
20	FH1~FH2	1.24km	− 8 mm	± 44mm	Cloused route
21	FH3~FH4	0.47km	− 5 mm	± 27mm	〃
22	DBM1~DBM1	0.40km	+ 2 mm	± 25mm	Double-run
23	FH6~FH3	1.10km	+ 2 mm	± 41mm	Cloused route
24	FH3~FG3	1.10km	−11 mm	± 41mm	〃
25	PH61~PH3	1.90km	+ 1 mm	± 56mm	〃

Table 3.2.1 DESIGN VALUES OF SOIL

Soil Classification	Features	Cohesion C (kg/cm^2)	Internal Friction ϕ (degree)	Wet Density γ (g/cm^3)
Gravel	High density	0	40	2.0
	Low density	0	35	1.8
Sand Containing Gravel	High density	0	40	2.1
	Low density	0	35	1.9
Sand	High density	0	35	2.0
	Low density	0	30	1.8
Sandy Soil (Silty Sand, Clayey Sand)	High density	less than 0.3	30	1.9
	Low density	0	25	1.7
Clayey Soil (Sandy Clay)	High stiffness	0.5	25	1.8
	Low stiffness	0.3	20	1.7
	Soft	0.15	15	1.6
Silt, Clay	High stiffness	0.5	20	1.7
	Low stiffness	0.3	15	1.6
	Soft	0.15	10	1.4

Source : Japan Highway Public Corporation

Table 3.2.2 (1/2) SOIL TEST RESULTS ON SHEAR STRENGTH INDICES

Soil Classification			Depth (m)	Cohesion C (kg/cm²)	Internal Angle ϕ (degree)	Wet Density γ_w (g/cm³)	SPT N Value
1. Percut River (Bore No. B1 - B15)							
Alluvium	CL1	Silty and sandy clay Low stiffness	0.0 - 12.0	0.05 - 0.1	10° - 15°	1.3 - 1.6	1 - 10
	CL2	Silty and sandy clay Medium stiffness	6.0 - 8.0	0.1 - 0.3	10° - 20°	1.4 - 1.8	8 - 20
	SP1	Fine sand, Low density	2.0 - 5.0	0	20° - 30°	1.7 - 1.8	5 - 15
	CH1	Clay, Low to medium stiffness	0.0 - 7.0	0.1 - 0.3	10° - 20°	1.3 - 1.6	2 - 15
	SM	Silty sand, Medium density	3.0 - 8.0	0	20°	1.7	11 - 15
	OL	Organic clay and silt Low to medium stiffness	10.0 - 18.0	0.15 - 0.4	10° - 20°	1.4 - 1.7	3 - 20
	SC1	Clayey sand, Low density	4.0 - 10.0	0	20° - 30°	1.7	3 - 10
	SP2	Medium size sand Low to medium density	17.0 - 28.0	0	25° - 35°	1.7 - 1.9	8 - 35
Medan Formation (Diluvium)	SC2	Clayey sand, Low to medium density	5.0 - 11.0	0	20° - 30°	1.6 - 1.7	8 - 25
	CL3	Sandy clay, Low stiffness	5.0 - 18.0	0.06 - 0.11	10° - 20°	1.4 - 1.6	3 - 12
	CL4	Silty and Sandy clay, Medium stiffness	2.0 - 5.0	0.3 - 0.5	15° - 20°	1.6 - 1.7	10 - 15
	OH	Organic clay, Medium stiffness	10.0 - 14.0	0.3 - 0.5	15° - 20°	1.6 - 1.7	18 - 25
	SP3	Fine to Medium size sand Low to medium density	16.0 - 25.0	0	25° - 35°	1.8	9 - 25
	SW1	Well graded Fine to medium size sand	12.0 - 16.0	0	30° - 35°	1.8 - 1.9	20 - 35
	SP7	Coarse sand containing gravel	15.0 - 30.0	0	30° - 40°	1.9 - 2.0	20 - 50
2. Percut River (Bore No. B16 - B29)							
Alluvium	SC1	Clayey sand, Low density	0.0 - 2.0	0	20° - 25°	1.7	5 - 6
	CH1	Clay, Low to medium stiffness	2.0 - 7.0	0.3 - 0.4	15° - 20°	1.6 - 1.7	10 - 15
Medan Formation (Diluvium)	SC2	Clayey sand Low to medium density	0.0 - 17.0	0	20° - 30°	1.7 - 1.9	5 - 35
	SC3	Clayey sand, Medium to high density	9.0 - 25.0	0	25° - 30°	1.7 - 1.9	10 - 50
	CH2	Clay, Low stiffness	0.0 - 10.0	0.1 ~ 0.3	10° - 15°	1.3 - 1.6	2 - 10
	CH3	Clay, Low to medium stiffness	12.0 - 15.0	0.15 - 0.5	10° - 20°	1.5 - 1.7	9 - 20
	SP4	Fine to medium size sand Medium to high density	5.0 - 22.0	0	30° - 40°	1.8 - 2.0	20 - 50
	CL4	Sandy clay, Medium stiffness	14.0 - 16.0	0.2 - 0.5	20° - 25°	1.6 - 1.7	20 - 25
	SP5	Medium size to coarse sand Low to medium density	5.0 - 33.0	0	30° - 35°	1.7 - 1.8	12 - 25
	SP6	Medium size to coarse sand High density	27.0 - 30.0	0	40°	1.9 - 2.0	40 - 50
	SP7	Coarse sand containing gravel, Medium to high density	17.0 - 38.0	0	30° - 40°	1.8 - 2.0	20 - 50
	SW2	Fine to medium size sand Well graded, High density	20.0 - 30.0	0	40°	1.9 - 2.0	40 - 50
Toba Tuff	Qtf	Uncemented tuff	22.0 - 28.0	0	40°	1.8 ~ 2.0	20 - 50

Table 3.2.2 (2/2) SOIL TEST RESULTS ON SHEAR STRENGTH INDICES

Soil Classification			Depth (m)	Cohesion C (kg/cm²)	Internal Angle φ (degree)	Wet Density γ_w (g/cm³)	SPT N Value
3. Medan Floodway (Bore No. B29 - B37)							
Medan Formation (Diluvium)	CH2	Clay, Low stiffness	0.0 - 5.0	0.15 - 0.3	10° - 15°	1.4 - 1.6	3 - 10
	CL3	Sandy clay, Low stiffness	0.0 - 7.0	0.15 - 0.3	10° - 15°	1.4 - 1.6	3 - 10
	SC2	Clayey sand, Low to medium density	6.0 - 13.0	0	20° - 25°	1.7 - 1.8	2 - 15
	SC3	Clayey sand, Medium to high density	1.0 - 20.0	0	25° - 30°	1.7 - 1.9	11 - 40
	SP4	Medium size sand Medium to high density	13.0 - 16.0	0	35° - 40°	1.9 - 2.0	30 - 50
	SP5	Medium size to coarse sand Low to medium density	7.0 - 10.0	0	25° - 30°	1.7 - 1.8	5 - 20
	SP6	Medium size to coarse sand Medium to high density	8.0 - 22.0	0	30° - 40°	1.8 - 2.0	15 - 50
	SP7	Coarse sand containing gravel High density	12.0 - 23.0	0	35° - 40°	1.9 - 2.0	35 - 50
	SW1	Fine to medium size sand Well graded, Medium to high density	2.0 - 13.0	0	30° - 40°	1.8 - 2.0	15 - 50
	SW2	Fine to medium size sand Well graded, High Density	20.0 - 25.0	0	35° - 40°	1.9 - 2.0	30 - 50
Toba Tuff	Qtf	Uncemented tuff	13.0 - 25.0	0	30° - 40°	1.8 - 2.0	20 - 50
4. Medan Floodway - Diversion Weir and Deli Weir - (Bore No. B35, B37, B38, B39)							
Medan Formation	CH2	Clay Low stiffness	0.0 - 7.0	0.1 - 0.3	10° - 15°	1.4 - 1.6	3 - 8
	CL4	Silty and sandy clay Medium stiffness	0.0 - 3.0	0.3 - 0.5	15° - 20°	1.6 - 1.7	23 - 24
	SP3	Fine sand, Low to medium density	2.0 - 4.0	0	20° - 30°	1.7 - 1.8	5 - 17
	CH3	Sandy clay Medium Stiffness	4.0 - 7.0	0.2 - 0.4	15° - 20°	1.6 - 1.7	10 - 20
	SP5	Medium size to coarse sand Low to medium density	7.0 - 10.0	0	20° - 30°	1.7 - 1.8	5 - 20
	SP6	Medium size to coarse sand Medium density	10.0 - 12.0	0	30° - 35°	1.8	20 - 25
	SW1	Fine to medium size sand Well graded, Medium to high density	2.0 - 7.0	0	30° - 40°	1.8 - 2.0	20 - 50
Toba Tuff (Diluvium)	Qtf	Uncemented tuff	5.0 - 20.0	0	35° - 40°	1.9 - 2.0	30 - 50
	SP4	Medium size sand, Medium to high density	14.0 - 23.0	0	30° - 40°	1.8 - 2.0	20 - 50
	CH4	Clay Medium to high stiffness	17.0 - 30.0	0.3 - 0.5	15° - 25°	1.6 - 1.8	10 - 40
	CH5	Clay High stiffness	21.0 - 34.0	2.5 - 5.0	0°	1.8	40 - 50
	SP6	Medium size to coarse sand, Medium to high density	32.0 - 35.0	0	35° - 40°	1.8 - 2.0	25 - 50
	SW2	Fine to medium size sand, Well graded, High density	21.0 - 25.0	0	35° - 40°	1.9 - 2.0	30 - 50

Table 3.2.3 FIELD SOIL TEST RESULT ON PERMEABILITY INDEX

Location of Sampling				Soil Classification	Permeability Coefficient	Elevation of Riverbed
Borehole No.		Depth (m)	Elevation (El.m)		K (cm/s)	(El.m)
Bandar Sidoras Weir	B7	7.0 ~ 10.00	0.20 ~ -2.80	Fine sand	1.36×10^{-4}	5.1
Diversion Weir on Floodway	B37	9.0 ~ 11.00	25.79 ~ 23.79	Medium size sand	1.85×10^{-5}	24.3
		15.0 ~ 20.45	19.79 ~ 14.34	Uncemented tuff	1.72×10^{-5}	
Weir on Deli River	B35	7.0 ~ 10.00	24.27 ~ 21.27	Uncemented tuff	1.33×10^{-4}	
		10.0 ~ 13.00	21.27 ~ 18.27	Uncemented tuff	1.09×10^{-4}	
	B38	14.0 ~ 23.00	20.37 ~ 11.37	Uncemented tuff	3.67×10^{-5}	
		25.0 ~ 30.00	9.37 ~ 4.37	Clay	1.33×10^{-7}	
	B39	3.0 ~ 5.00	21.32 ~ 19.32	Fine to medium size sand	1.30×10^{-4}	
		14.0 ~ 17.00	10.32 ~ 7.32	Fine sand containing clay	1.90×10^{-7}	

Table 3.2.4 PERMEABILITY COEFFICIENT OF SOIL

Soil Classification	Permeability Coefficient (cm/sec)	Degree of Permeability
Gravel	more than 0.1	High
Sand	$0.1 \sim 1 \times 10^{-3}$	Medium
Sandy Soil (Silty Sand)	$1 \times 10^{-3} \sim 1 \times 10^{-5}$	Low
Clayey Soil (Sandy Clay)	$1 \times 10^{-5} \sim 1 \times 10^{-7}$	Very low
Clay	less than $\times 10^{-7}$	Impermeable

Source : Design Standard by Japan Road Institute

Table 3.2.5 SOIL TEST RESULT ON CONSOLIDATION INDEX

Location of Sampling			Soil Classification	Compression Index	Consolidation Coefficient	Coefficient of Volume Compressibility
Borehole No.	Depth (m)	Elevation (m)		(Cc)	(10^{-3} cm^2/sec)	m_v (cm^2/kg)
B1	4.0 ~ 4.80	-2.72 ~ -3.52	Sandy clay	0.0907	5.44	0.0756
	8.0 ~ 8.80	-6.72 ~ -7.52	Silty clay	0.0977	5.80	0.0771
	15.0 ~ 15.80	-13.72 ~ -14.52	Clay containing silt	0.0994	5.51	0.0713
B2	10.0 ~ 10.80	-9.30 ~ -10.10	Silty clay	0.0971	5.50	0.0736
	16.0 ~ 16.80	-15.30 ~ -16.10	Silty clay	0.0971	5.51	0.0713
	22.0 ~ 22.80	-21.30 ~ -22.10	Sandy clay	0.1223	5.23	0.0556
B3	8.0 ~ 8.80	-7.23 ~ -8.03	Sandy clay	0.0943	5.65	0.0728
	12.0 ~ 12.80	-11.23 ~ -12.03	Clay containing peat material	0.1359	5.26	0.0641
	15.0 ~ 15.80	-14.23 ~ -15.03	Clay containing peat material	0.1121	5.59	0.0740
B4	11.0 ~ 11.80	-7.20 ~ -8.00	Silty clay	0.0961	5.44	0.0862
	16.0 ~ 16.80	-12.20 ~ -13.00	Fine sand containing clay	0.2700	7.00	0.0385
B6	4.0 ~ 4.80	2.95 ~ 2.15	Sandy clay	0.1554	5.63	0.0557
B10	7.0 ~ 7.80	-0.69 ~ -1.49	Fine sand containing clay	0.1725	6.73	0.0506
B13	6.0 ~ 6.80	2.79 ~ 1.99	Fine sand containing clay	0.1061	5.74	0.0650
	10.0 ~ 10.80	-1.20 ~ -2.00	Organic clay	0.1189	5.66	0.0730
B14	10.0 ~ 10.80	1.94 ~ 1.14	Sandy clay	0.1328	5.77	0.0654
B29	8.0 ~ 8.80	23.25 ~ 22.45	Silty clay	0.0881	5.47	0.0917
	10.0 ~ 10.80	21.25 ~ 20.45	Fine sandy clay	0.097	5.65	0.0679
B35	24.0 ~ 24.80	7.27 ~ 6.47	Clay	0.1287	5.33	0.0640
	26.0 ~ 26.80	5.27 ~ 4.47	Clay	0.1967	5.24	0.0484

Table 3.2.6 EVALUATION OF SUITABILITY FOR DIKE MATERIAL

Borehole No.	Right/Left Bank	Soil Classification	Depth (m)	Properties of Dike Material				Suitability of Dike Material
				Permeability	Compactibility	Resistibility against Seepage	Resistibility against Deformation	
A1	Right	CLc	0.0 - 3.57	Low	Fair	Fair	Poor	Poor
		SM	3.57 - 6.0	Medium	Good	Poor	Poor	Poor
A2	Left	CLs	0.0 - 0.75	Low	Fair	Fair	Fair	Fair
		CLc	0.75 - 6.0	Low	Fair	Fair	Poor	Poor
A3	Left	CLs	0.0 - 3.5	Low	Fair	Fair	Fair	Fair
		SC	3.5 - 6.0	Low	Good	Fair	Fair	Good
A4	Right	CLs	0.0 - 1.75	Low	Fair	Fair	Fair	Fair
		SM	1.75 - 6.0	Medium	Good	Poor	Poor	Poor
A5	Right	CLc	0 - 1.85	Low	Fair	Fair	Poor	Poor
		SC	1.85 - 2.20	Low	Good	Fair	Fair	Good
		CLc	2.20 - 4.25	Low	Fair	Fair	Poor	Poor
		SC	4.25 - 6.0	Low	Good	Fair	Fair	Good
A6	Right	CLs	0.0 - 0.95	Low	Fair	Fair	Fair	Fair
		SW	0.95 - 6.0	High	Good	Poor	Good	Poor
A7	Right	CH	0.0 - 1.18	Low	Poor	Good	Fair	Poor
		SP	1.18 - 1.85	High	Good	Poor	Good	Poor
		CH	1.85 - 6.0	Low	Poor	Good	Fair	Poor
A8	Left	CH	0.0 - 1.35	Low	Poor	Good	Fair	Poor
		SC	1.35 -6.0	Low	Good	Fair	Fair	Good

Note CLs: Sandy clay, CLc: Silty clay, CH: Clay, SM: Silty sand, SC: Clayey sand, SW: Well graded sand, SP: Poor graded sand

Table 3.2.7 OPTIMUM MOISTURE CONTENT OF SOIL FOR DIKE MATERIAL

Location of Sampling		Soil Classification	Optimum Moisture Content (%)	Location of Sampling		Soil Classification	Optimum Moisture Content (%)
Borehole No.	Depth (m)			Borehole No.	Depth (m)		
A1	0.00 ~ 1.15	CLc	16.1	A5	0.00 ~ 1.85	CLc	14.3
	1.15 ~ 2.50	CLc	18.4		1.85 ~ 2.20	SC	10.8
	2.50 ~ 3.57	CLc	16.9		2.20 ~ 4.25	CLc	16.6
A2	0.75 ~ 1.35	CLc	16.3	A6	0.95 ~ 2.50	SW	10.7
	1.35~ 2.55	CLc	17.3		2.50 ~ 6.00	SW	10.2
	2.55 ~ 6.00	CLc	18.4				
				A7	1.85 ~ 3.00	CH	15.5
A3	0.00 ~ 1.00	CLs	15.4		3.00 ~ 6.00	CH	15.7
	1.00 ~ 2.25	CLs	15.1				
	2.25 ~ 3.50	CLs	16.5	A8	1.35 ~ 4.00	SC	16.4
					4.00 ~ 6.00	SC	16.9
A4	0.00 ~ 1.75	CLs	14.9				
	1.75 ~ 2.70	SM	11.7				
	2.70 ~ 4.00	SM	11.6				

Note CLs: Sandy clay, CLc: Silty clay, CH: Clay, SM: Silty sand, SC: Clayey sand, SW: Well graded sand

Table 3.3.1 THIESSEN COEFFICIENTS

Period	Rainfall Station	Thiessen Coefficient	
		Deli River (358 km²)	Percut River (186 km²)
1954-1968	No 101	0.39	0.23
	No 106	0.46	0.05
	No 109	0.02	0
	No 119	0.03	0
	No 303	0.03	0.10
	No 308	0.07	0.62
1968-1988	No 101	0.57	0.23
	No 109	0.02	0
	No 116	0.02	0
	No 119	0.03	0
	No 303	0.13	0.22
	No 332	0.23	0.55
1989-1994	No 101	0.57	0.23
	No 109	0.05	0
	No 116	0.02	0
	N0 303	0.13	0.22
	No 332	0.23	0.55

Note : The station No. 119 has been non-operational since 1989

Table 3.3.2 MEAN MONTHLY RAINFALL OF DELI RIVER BASIN

(Unit : mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1954	80	41	34	135	337	249	244	322	121	215	165	274	2,217
1955	255	111	154	246	242	168	141	217	154	325	257	217	2,487
1956	304	141	115	191	211	97	160	197	154	302	385	369	2,626
1957	182	9	189	178	288	314	227	271	405	280	184	189	2,716
1958	108	39	104	106	254	165	96	239	237	361	266	60	2,035
1959	129	40	185	154	192	156	254	296	343	402	336	124	2,611
1960	151	146	93	174	342	113	148	303	221	226	275	189	2,381
1961	145	129	163	209	303	133	320	117	203	393	233	230	2,578
1962	230	106	241	105	118	335	188	300	247	155	156	199	2,380
1963	242	133	38	32	197	219	102	206	308	466	269	216	2,428
1964	67	134	153	145	238	159	210	235	339	341	396	220	2,637
1965	15	137	262	198	207	258	125	290	354	292	314	224	2,676
1966	60	33	149	88	268	276	149	255	445	425	198	192	2,538
1967	133	156	62	143	205	180	168	216	207	345	202	185	2,202
1968	133	24	148	221	260	150	155	290	303	297	128	229	2,338
1969	173	95	62	96	157	253	127	294	227	475	359	204	2,522
1970	182	49	51	155	103	141	169	300	263	374	350	267	2,404
1971	215	196	232	84	363	306	220	328	211	214	180	331	2,880
1972	46	126	79	153	161	207	89	97	375	233	211	192	1,969
1973	124	96	155	119	165	137	123	132	181	357	271	552	2,412
1974	59	293	38	180	282	161	106	174	186	206	300	39	2,024
1975	115	101	87	189	195	105	130	150	284	294	227	383	2,260
1976	75	106	113	95	203	166	281	172	259	204	317	193	2,184
1977	23	141	106	66	75	133	52	348	247	409	293	231	2,124
1978	190	39	88	217	226	110	216	172	245	387	244	192	2,326
1979	114	78	34	269	135	146	238	166	163	346	347	47	2,083
1980	105	146	119	89	242	105	125	334	358	314	249	420	2,606
1981	80	75	61	242	317	69	99	104	267	286	284	152	2,036
1982	14	32	210	222	183	163	211	187	149	322	227	269	2,189
1983	98	57	56	40	242	175	219	153	289	372	176	132	2,009
1984	183	257	165	108	298	104	351	92	135	272	151	161	2,277
1985	107	70	174	267	332	11	153	176	305	319	200	165	2,279
1986	165	141	147	151	212	262	67	50	396	235	211	204	2,241
1987	149	2	215	170	221	184	129	213	338	339	286	181	2,427
1988	124	204	130	70	172	161	338	314	382	207	289	242	2,633
1989	173	33	164	209	203	165	144	298	444	328	216	155	2,532
1990	76	71	53	117	224	103	181	102	422	355	339	171	2,214
1991	35	52	113	104	243	158	126	162	228	288	203	240	1,952
1992	123	72	41	195	248	132	151	166	295	236	172	171	2,002
1993	99	82	154	207	135	139	158	234	305	296	309	208	2,326
1994	69	118	209	148	244	219	105	159	257	211	273	105	2,117
Average	126	100	125	153	225	170	171	215	274	310	255	213	2,337

Table 3.3.3 MEAN MONTHLY RAINFALL OF PERCUT RIVER BASIN

(unit : mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1954	86	122	49	170	316	216	254	321	138	202	168	212	2,254
1955	229	136	124	243	241	165	160	191	158	284	251	177	2,359
1956	283	155	107	227	153	110	199	191	168	364	368	317	2,642
1957	159	23	176	197	285	196	198	186	346	290	166	180	2,402
1958	91	14	40	93	180	155	132	180	201	267	196	47	1,596
1959	70	74	184	105	170	218	349	336	347	323	356	98	2,630
1960	162	112	125	122	312	139	190	168	224	209	225	151	2,139
1961	159	156	193	172	178	137	293	72	280	431	176	161	2,408
1962	176	60	168	125	246	221	157	236	228	161	223	230	2,231
1963	185	200	96	31	162	151	59	106	379	405	344	203	2,321
1964	128	146	197	127	160	156	180	193	368	326	256	179	2,326
1965	17	40	145	109	103	161	83	213	219	259	237	204	1,790
1966	38	61	142	49	154	260	290	228	218	251	102	84	1,877
1967	85	129	116	126	158	217	165	264	225	442	206	111	2,244
1968	135	25	59	198	228	207	240	290	372	252	143	269	2,418
1969	232	110	72	104	239	258	161	363	261	590	384	260	3,034
1970	230	67	59	187	128	152	306	323	247	374	371	296	2,740
1971	274	293	311	122	478	388	240	369	313	199	216	405	3,608
1972	48	116	86	195	185	212	70	133	333	230	200	182	1,990
1973	115	136	219	76	125	177	148	117	165	401	258	455	2,392
1974	73	265	70	160	238	165	163	124	219	150	269	72	1,968
1975	102	105	113	156	258	78	148	134	266	317	249	307	2,233
1976	73	194	154	124	187	145	277	230	303	246	420	256	2,609
1977	30	117	73	95	104	194	68	381	262	355	313	287	2,279
1978	150	70	57	232	358	132	246	170	225	350	245	217	2,452
1979	90	88	48	308	173	192	284	218	198	395	353	63	2,410
1980	157	205	144	93	278	115	176	381	379	386	286	467	3,067
1981	102	152	75	230	397	84	151	111	281	309	275	124	2,291
1982	22	58	198	278	300	145	211	210	186	319	221	209	2,357
1983	97	62	46	46	273	139	249	211	323	454	262	150	2,312
1984	252	267	199	168	383	136	378	152	140	251	152	231	2,709
1985	198	107	162	251	374	15	203	173	374	354	182	194	2,587
1986	227	80	148	149	211	232	62	46	397	270	194	255	2,271
1987	186	2	261	240	263	206	156	183	385	376	292	178	2,728
1988	123	181	158	105	171	191	406	382	429	240	316	215	2,917
1989	178	43	203	249	209	119	192	252	460	348	173	156	2,582
1990	67	71	86	111	253	129	179	77	482	355	311	240	2,361
1991	43	51	153	132	231	170	110	179	244	375	192	274	2,154
1992	166	123	50	245	286	139	165	165	384	223	207	158	2,311
1993	87	124	176	176	193	126	187	195	290	351	327	160	2,392
1994	82	121	215	172	238	156	94	196	248	219	267	76	2,084
Average	132	114	131	158	234	168	195	211	284	315	252	208	2,402

Table 3.3.4 ANNUAL MAXIMUM DAILY RAINFALL

Unit : mm/day)

Year	Date	Deli River	Year	Date	Percut River
1954	12 Dec	57.5	1954	1 Oct	84.3
1955	21 Dec	64.8	1955	1 Apr	58.8
1956	28 Nov	165.6	1956	27 Nov	109.1
1957	7 Sep	92.7	1957	7 Sep	85.6
1958	25 Oct	77.8	1958	1 Nov	68.2
1959	30 Sep	79.6	1959	30 Sep	103.8
1960	9 Dec	77.1	1960	21 Jan	72.6
1961	5 May	85.0	1961	30 Jul	67.0
1962	10 Jun	78.3	1962	19 Nov	55.6
1963	1 Jan	76.8	1963	28 Nov	78.6
1964	30 Apr	69.4	1964	19 Jan	50.2
1965	27 Aug	72.9	1965	11 Nov	31.1
1966	28 Sep	58.6	1966	1 Jul	54.9
1967	16 Dec	46.7	1967	27 Jun	46.5
1968	15 Sep	57.4	1968	30 Nov	50.8
1969	29 Sep	62.8	1969	7 Jan	102.1
1970	30 sep	65.0	1970	5 Nov	61.7
1971	15 Aug	60.6	1971	10 Feb	60.7
1972	14 Sep	55.6	1972	13 Nov	54.4
1973	26 Oct	68.2	1973	4 Mar	59.2
1974	29 Oct	49.6	1974	29 Dec	60.5
1975	27 Dec	62.8	1975	19 Mar	51.2
1976	9 Jan	46.8	1976	8 Nov	83.4
1977	7 Nov	55.1	1977	20 Dec	62.0
1978	3 Dec	76.1	1978	12 Oct	78.4
1979	13 nov	66.4	1979	13 Nov	68.5
1980	6 Dec	78.7	1980	21 Dec	77.8
1981	16 Oct	48.9	1981	16 Nov	53.7
1982	31 Dec	65.3	1982	23 May	69.9
1983	6 Jul	70.1	1983	29 Jul	109.6
1984	21 Oct	57.6	1984	29 Jul	63.9
1985	24 Apr	54.7	1985	30 Sep	114.2
1986	3 Feb	65.4	986	6 Dec	61.4
1987	16 Sep	97.8	1987	15 Sep	90.7
1988	30 Sep	62.0	1988	30 Sep	82.1
1989	13 Sep	69.0	1989	13 Sep	70.2
1990	18 May	67.2	1990	1 May	60.7
1991	20 Oct	58.9	1991	20 Oct	65.1
1992	27 Sep	55.7	1992	27 Sep	83.4
1993	4 Nov	52.7	1993	4 Nov	65.9
1994	12 Nov	48.4	1994	14 Jan	47.4

Table 3.3.5 PROBABLE DAILY RAINFALL BY GUMBEL METHOD

(Unit: mm/day)

Return Period (Year)	Deli River		Percut	
	B-P Study 1954 - 1988	D/D Study 1954-1994	B-P Study 1954-1988	D/D Study 1954-1994
2	66.3	64.8	67.9	67.2
3	76.0	74.0	77.2	76.0
4	82.2	79.8	83.2	81.6
5	86.8	84.1	87.6	85.7
8	96.1	92.9	96.5	94.1
10	100.4	96.9	100.6	98.0
15	108.1	104.1	107.9	104.9
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
60	133.7	128.2	132.4	127.9
80	139.0	133.2	137.5	132.6
100	143.0	137.0	141.4	136.3
150	150.4	143.9	148.4	142.9
200	155.6	148.8	153.4	147.6

Table 3.3.6 PARAMETERS IN STORAGE FUNCTION MODEL

River	Basin or Channel	Area (km^2)	Storage Coefficient						
			K	P	TL (hr)	f	Kr	Pr	TL (hr)
Deli ($158 km^2$)	D1	93	3.5	0.8	2.2	0.3			
	D2	65	3.5	0.8	1.5	0.3			
	D3	44	3.5	0.8	0.4	0.3			
	D4	99	3.5	0.8	2.3	0.3			
	D5	40	3.5	0.8	0.9	0.3			
	D6	17	3.5	0.8	0.1	0.3			
	1						5.7	0.6	0.12
	2						14.1	0.6	0.29
	3						25.3	0.6	0.69
Percut ($186 km^2$)	Pr1	105	3.5	0.8	1.4	0.3			
	Pr2	66	3.5	0.8	0.3	0.3			
	Pr3	15	3.5	0.8	0.1	0.3			
	1						18.9	0.6	0.35
	2						4.7	0.6	0.13

Note : Saturation Rainfall Depth Rsa = 300 mm
Base Flow Qb = 0.035 $m^3/s/km^2$

Table 3.3.7 DESIGN STORM RAINFALL PATTERN

Hour	Ratio	Hourly Rainfall (mm)					
		Deli River			Percut River		
		25-year	40-year	100-year	25-year	40-year	100-year
1	0.02	2.26	2.42	2.74	2.26	2.42	2.72
2	0.03	3.39	3.63	4.11	3.39	3.63	4.08
3	0.03	3.39	3.63	4.11	3.39	3.63	4.08
4	0.03	3.39	3.63	4.11	3.39	3.63	4.08
5	0.10	11.30	12.10	13.70	11.30	12.10	13.60
6	0.47	53.11	56.87	64.39	53.11	56.87	63.92
7	0.13	14.69	15.73	17.81	14.69	15.73	17.68
8	0.05	5.65	6.05	6.85	5.65	6.05	6.80
9	0.04	4.52	4.84	5.48	4.52	4.84	5.44
10	0.04	4.52	4.84	5.48	4.52	4.84	5.44
11	0.03	3.39	3.63	4.11	3.39	3.63	4.08
12	0.03	3.39	3.63	4.11	3.39	3.63	4.08
Total	1.00	113.00	121.00	137.00	113.00	121.00	136.00

Table 3.3.8 PROBABLE FLOOD DISCHARGES IN DELI RIVER

Return Period (Year)	Peak Discharge of Project Flood (m^3/s)						
	P1 341 km^2	P2 301 km^2	P3 202 km^2	P4 158 km^2	P5 93 km^2	p1 40 km^2	p2 99 km^2
2	272	245	156	151	100	50	109
5	369	334	210	203	134	67	143
10	437	397	247	239	157	78	167
20	502	457	281	273	179	89	189
25	523	477	292	284	187	93	196
30	540	492	301	292	192	96	202
40	567	518	315	307	202	100	211
50	589	538	326	318	209	104	219
100	655	600	359	352	232	115	241

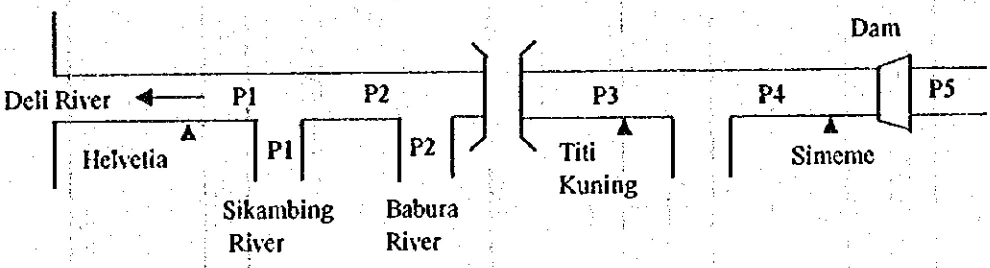


Table 3.3.9 PROBABLE FLOOD DISCHARGES IN PERCUT RIVER

Return Period	Peak Discharge of Project Flood (m^3/s)		
	River Mouth P1 186 km^2	Tembung P2 171km^2	Dam Site P3 105km^2
2 year	138	132	122
5 year	183	181	160
10 year	215	213	184
20 year	249	245	208
25 year	258	253	214
30 year	267	261	220
40 year	282	274	231
50 year	293	285	239
100 year	326	315	262

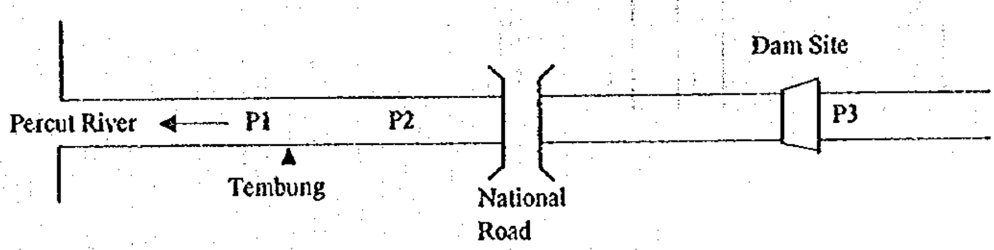


Table 3.3.10 DISCHARGE RATING OF DIVERSION WEIRS

(unit : m^3/s)

Immediate Plan	Water Level (EL.m) at in Retarding Channel							
Water Level (El.m)	24.7	27.0	28.3	32.0	32.55	32.8	33.7	34.2
Outflow	0.0	25.0	50.0	100.0	134.0	155.0	244.0	338.0
to Deli River	0.0	25.0	50.0	100.0	134.0	155.0	200.0	250.0
to Percut River					0.0	5.0	44.0	88.0
Urgent Plan	Water Level (EL.m) at in Retarding Channel							
Water Level (El.m)	24.7	27.0	28.3	32.05	32.3	33.2	34.0	34.6
Outflow	0.0	25.0	50.0	97.0	104.0	199.0	321.0	447.0
to Deli River	0.0	25.0	50.0	97.0	100.0	150.0	200.0	250.0
to Percut River				0.0	4.0	49.0	121.0	197.0

Table 3.1.11 OUTLET CONDITION OF LAUSIMEME DAM

Water Level (El.m)		250.5	251.0	251.5	252.0	252.5
Depth	(m)	0.0	0.5	1.0	1.5	2.0
Outflow	(m^3/s)	0.0	35.0	99.0	181.9	28.0
Storage	(m^3)	0.0	975,000	1,950,000	2,925,000	3,900,000

Note : EL 250.5 = Normal Water Level

Table 3.3.12 FLOOD DISCHARGE WITH FLOODWAY IN IMMEDIATE PLAN

Return Period	Peak Discharge (m³/s)										
	Q1	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q11	Q12	Q13
2 year	100	151	156	151	244	272	5	122	132	134	142
5 year	134	203	210	181	313	348	29	160	181	202	210
10 year	157	239	247	202	359	399	45	184	213	251	255
20 year	179	273	281	220	402	446	61	208	245	300	300
25 year	187	284	292	225	416	462	67	214	253	314	314
30 year	192	292	301	230	427	474	71	220	261	327	327
40 year	202	307	315	238	445	494	77	231	274	348	348
50 year	209	318	326	244	459	509	82	239	285	365	365
100 year	232	352	359	261	502	557	98	262	315	413	414

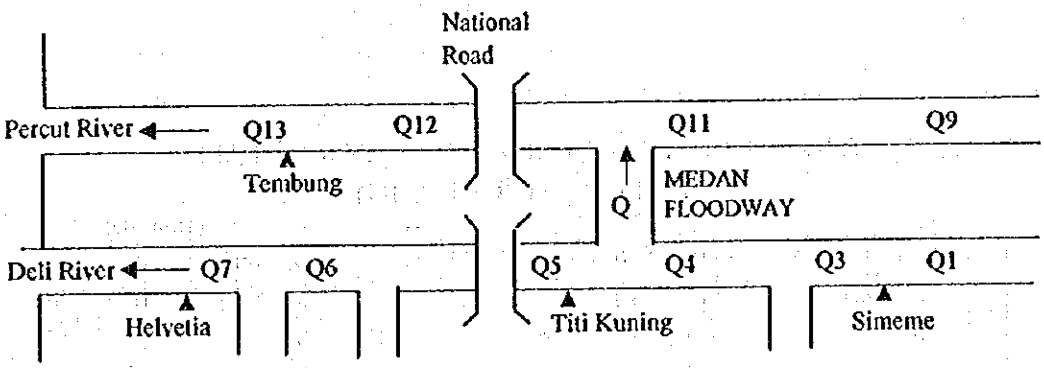


Table 3.3.13 FREQUENCY OF DAILY RAINFALL (DELI RIVER BASIN)

(Unit : Days)

Daily Rainfall (mm)	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0
in 1984	10	9	6	4	2	2	0	0	0
in 1985	16	12	8	6	4	0	0	0	0
in 1986	14	9	6	4	2	2	1	1	0
in 1987	22	15	9	6	4	1	1	1	1
in 1988	19	13	7	4	2	2	2	0	0
in 1989	16	12	7	6	2	1	1	1	0
in 1990	18	11	7	5	2	2	1	1	0
in 1991	11	9	6	3	2	1	0	0	0
in 1992	18	11	6	3	1	1	0	0	0
in 1993	16	11	6	6	3	0	0	0	0
Average (days/year)	16.0	11.2	6.8	4.7	2.4	1.2	0.6	0.4	0.1

Table 3.3.14 FREQUENCY OF DAILY RAINFALL (PERCUT RIVER BASIN)

(Unit : Days)

Daily Rainfall (mm)	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0
in 1984	20	12	8	7	3	3	1	0	0
in 1985	17	11	5	5	4	3	2	2	2
in 1986	15	9	6	4	2	1	1	0	0
in 1987	21	16	12	10	9	8	6	3	2
in 1988	18	9	3	3	1	1	1	1	1
in 1989	13	8	6	3	2	1	1	1	1
in 1990	16	9	4	2	2	1	1	0	0
in 1991	13	6	4	2	2	2	2	1	0
in 1992	19	13	8	6	3	3	3	3	1
in 1993	12	7	5	2	1	1	1	1	0
Average (days/year)	16.4	10	6.1	4.4	2.9	2.4	1.9	1.2	0.7

Table 3.3.15 WATER LEVEL AND SECTION AREA OF DIVERSION POND (AFTER IMPROVEMENT)

Section	Distance (m)	Water Level (cm) - Section Area (m^2)						
		H=25 m	H=27 m	H=29 m	H=31 m	H=33 m	H=34 m	H=35 m
No. 12	0.0	5.3	40.3	75.3	110.3	145.3	162.8	225.3
No. 13-30	72.0	3.7	64.8	206.8	434.0	780.9	962.6	1146.2
No. 13	122.0	0.8	29.5	186.6	484.3	996.9	1286.1	1581.3
No. 14	98.0	0.0	27.6	138.3	356.2	820.0	1065.4	1313.4
No. 15	104.0	0.0	25.5	130.3	342.0	930.9	1242.4	1559.3
No. 16	52.0	0.0	24.5	74.9	153.1	524.8	749.0	982.4
No. 17	48.0	0.0	23.5	72.9	151.0	424.2	612.9	813.5
No. 18	50.0	0.0	21.5	68.6	145.8	263.7	423.3	587.4
No. 19	50.0	0.0	22.3	70.3	146.9	247.0	317.2	411.4
No. 20	54.0	0.0	21.5	66.0	122.6	274.3	372.1	482.8
No. 21	50.0	0.0	20.0	69.9	136.9	347.9	506.3	675.9
No. 22	118.0	0.0	12.8	47.7	96.2	284.6	524.2	783.7
No. 23	94.0	0.0	25.4	70.1	132.1	246.3	355.1	480.2
No. 24	100.0	0.0	9.4	46.3	97.6	182.9	291.6	420.1
No. 25	90.0	0.0	5.4	36.3	81.6	151.8	229.7	348.9
No. 26	98.0	0.0	5.6	39.4	78.3	123.3	160.8	209.5
No. 27	100.0	0.0	9.7	55.3	115.4	184.5	236.3	304.8
No. 28	102.0	0.0	9.9	39.1	89.3	178.4	291.1	416.6
No. 29	106.0	0.0	0.1	28.5	77.8	192.7	335.1	508.7
No. 30	100.0	0.0	1.1	25.7	64.5	165.9	286.5	465.0
No. 31	110.0	0.0	4.1	35.0	77.5	166.2	309.7	480.2
No. 32	98.0	0.0	0.0	27.9	72.1	135.7	234.3	360.4
No. 33	96.0	0.0	0.0	25.5	68.8	138.0	195.6	277.5
No. 34	102.0	0.0	6.4	37.1	76.9	181.4	257.2	335.3
No. 35	92.0	0.1	2.1	26.7	63.4	159.9	301.3	484.9
No. 36	100.0	0.0	0.0	25.1	68.0	139.3	269.0	473.2
No. 37	100.0	0.0	9.5	48.3	96.3	148.9	220.5	358.8
No. 38	100.0	0.0	0.0	19.0	55.8	108.1	180.0	389.2
No. 39	98.0	0.0	0.0	19.7	54.3	121.5	212.3	485.1
No. 40	94.0	0.0	0.0	18.4	98.7	716.2	1087.1	1479.5
No. 41	130.0	0.0	0.0	15.0	196.2	613.7	890.3	1194.6
No. 42	100.0	0.0	0.0	19.2	63.4	277.8	717.1	1200.0
No. 43	100.0	0.0	6.5	29.6	66.0	172.0	555.9	1023.0
No. 44	100.0	0.0	0.0	11.4	47.6	128.0	385.8	765.9
No. 45	100.0	2.5	22.1	60.7	119.4	193.9	277.2	604.8
No. 46	100.0	0.0	0.4	8.3	26.7	133.4	298.8	651.0
No. 47	100.0	42.9	52.7	66.2	81.4	104.5	125.5	249.2
No. 48	100.0	0.0	0.0	0.4	14.3	41.9	60.5	142.8
No. 49	100.0	0.0	0.0	0.0	6.3	22.4	39.6	59.4
No. 50	100.0	0.0	0.0	0.0	2.4	18.7	34.1	52.9
No. 55	500.0	0.0	0.0	0.0	0.0	1.1	9.8	26.5
No. 60	500.0	0.0	0.0	0.0	0.0	0.4	15.0	43.0
No. 63	300.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
Volume (m^3)		5,177	41,430	179,438	432,696	1,027,710	1,592,810	2,346,610

Table 3.3.16 RELATION BETWEEN WATER LEVEL AND VOLUME OF DIVERSION POND (AFTER IMPROVEMENT)

Water level (EL.m)	25.0	27.0	29.0	31.0	33.0	34.0	35.0
Storage Capacity (1000 m^3)	5	41	179	433	1,028	1,593	2,347

Table 3.3.17 SMALLER SCALE FLOOD DISCHARGES AND PONDING (DELI RIVER)

Probability	Daily Rainfall (mm)	Discharge at Diversion Pond Inflow (m^3/s)	Outflow (m^3/s)	Max. Water Level (m)
2 year	65	156	117	32.3
1 year	57	134	96	31.7
2-times / y	52	120	91	31.4
5-times / y	44	98	82	30.6
10-times / y	36	78	68	29.6

Table 3.3.18 SMALLER SCALE FLOOD DISCHARGES (PERCUT RIVER)

Probability	Daily Rainfall (mm)	Discharge at Diversion Pond Inflow (m^3/s)	Outflow (m^3/s)
2 year	67	138	132
1 year	65	134	127
2-times / y	59	120	113
5-times / y	43	82	79
10-times / y	35	64	63

Table 3.3.19 PONDING ANALYSIS OF SMALLER SCALE FLOODS (AFTER IMPROVEMENT)

Time	1-year Flood				2-times/year Flood			
	H (m)	Q (in)	Q (out)	V (m^3)	H (m)	Q (in)	Q (out)	V (m^3)
1.1	25.19	7.14	5.27	8,333	25.19	7.14	5.27	8,330
1.2	25.38	7.39	7.35	11,767	25.37	7.36	7.33	11,737
1.3	25.41	8.10	7.76	12,452	25.41	7.99	7.69	12,335
1.4	25.51	9.52	8.85	14,260	25.50	9.25	8.66	13,947
1.5	25.70	12.05	10.86	17,586	25.66	11.50	10.45	16,901
1.6	26.16	19.24	15.84	25,830	26.06	17.81	14.83	24,160
1.7	27.16	38.97	27.99	51,712	27.06	35.02	26.22	45,375
1.8	28.16	74.75	47.28	120,928	27.91	66.24	42.53	103,901
1.9	29.59	114.16	67.48	254,393	29.28	101.16	63.27	214,781
1.10	30.93	133.53	85.60	424,687	30.40	119.67	78.42	357,223
1.11	31.46	125.60	92.72	570,153	31.15	114.46	88.54	478,134
1.12	31.72	105.59	96.17	646,281	31.35	97.61	91.18	536,376
1.13	31.71	86.36	96.14	645,611	31.32	80.56	90.87	529,396
1.14	31.52	70.75	93.49	587,080	31.13	66.37	88.23	471,493
1.15	31.19	57.97	89.08	490,159	30.62	54.65	81.29	384,181
1.16	30.54	47.31	80.29	374,791	29.86	44.82	71.15	288,839
1.17	29.65	35.57	68.28	261,932	29.14	36.74	61.39	197,101
1.18	28.78	31.62	56.47	163,723	28.17	30.30	47.51	121,762
1.19	27.77	26.26	39.90	94,452	27.49	25.29	34.33	74,492
1.20	27.23	22.15	29.41	56,828	27.10	21.43	27.00	48,178
1.21	26.79	19.01	22.68	37,153	26.61	18.47	20.77	34,002
1.22	26.32	16.59	17.60	28,738	26.28	16.18	17.18	28,050
1.23	26.13	14.71	15.57	25,385	26.10	14.40	15.21	24,786
1.24	25.98	13.24	13.91	22,640	25.95	13.00	13.63	22,179
MAX	31.72	133.53	96.17	646,281	31.35	119.67	91.18	536,376

Time	5-times/year Flood				10-times/year Flood			
	H (m)	Q (in)	Q (out)	V (m^3)	H (m)	Q (in)	Q (out)	V (m^3)
1.1	25.18	7.13	5.27	8,327	25.18	7.12	5.27	8,323
1.2	25.37	7.31	7.30	11,691	25.37	7.26	7.27	11,646
1.3	25.40	7.83	7.58	12,153	25.39	7.67	7.48	11,979
1.4	25.47	8.85	8.37	13,464	25.44	8.47	8.09	13,003
1.5	25.60	10.66	9.81	15,849	25.55	9.87	9.21	14,855
1.6	25.92	15.66	13.30	21,625	25.79	13.67	11.88	19,265
1.7	26.79	29.11	22.77	37,299	26.45	23.71	18.98	31,025
1.8	27.57	53.47	35.94	80,265	27.28	41.81	30.35	60,187
1.9	28.70	81.34	55.43	158,445	28.04	62.95	45.07	113,002
1.10	29.63	97.91	67.97	258,980	28.97	76.93	59.12	177,250
1.11	30.32	96.38	77.35	347,132	29.42	78.08	65.16	232,567
1.12	30.63	84.36	81.54	386,470	29.64	70.47	68.09	260,101
1.13	30.54	70.85	80.27	374,601	29.58	60.53	67.26	252,283
1.14	30.18	59.05	75.35	328,318	29.31	51.25	63.60	217,940
1.15	29.67	49.08	68.51	264,022	28.86	43.13	57.62	169,617
1.16	29.11	40.65	60.91	192,591	28.18	36.16	47.76	122,656
1.17	28.26	33.66	49.27	128,018	27.68	30.31	38.06	87,843
1.18	27.62	28.03	36.95	83,866	27.33	25.56	31.29	63,583
1.19	27.23	23.62	29.52	57,207	27.06	21.78	26.20	45,298
1.20	26.92	20.19	24.11	39,530	26.61	18.81	20.72	33,905
1.21	26.42	17.53	18.64	30,472	26.31	16.48	17.52	28,608
1.22	26.21	15.46	16.41	26,773	26.12	14.66	15.49	25,249
1.23	26.04	13.84	14.58	23,746	25.98	13.22	13.87	22,573
1.24	25.91	12.57	13.15	21,373	25.86	12.07	12.59	20,457
MAX	30.63	97.91	81.54	386,470	29.64	78.08	68.09	260,101

Table 3.3.20 WATER LEVELS IN DELI RIVER UPSTREAM FOR SMALLER FLOODS (AFTER IMPROVEMENT)

Section	Distance (m)	2-year Q (m^3/s)	2-year H (El.m)	1-year Q (m^3/s)	1-year H (El.m)	2-times/y Q (m^3/s)	2-times/y H (El.m)	5-times/y Q (m^3/s)	5-times/y H (El.m)	10-times/y Q (m^3/s)	10-times/y H (El.m)
No. 12	0	156	32.28	134	31.72	120	31.35	98	30.63	78	29.64
No. 13-30	72	156	32.36	134	31.79	120	31.42	98	30.68	78	29.69
No. 13	122	156	32.37	134	31.80	120	31.42	98	30.69	78	29.69
No. 14	98	156	32.37	134	31.80	120	31.42	98	30.69	78	29.70
No. 15	104	156	32.37	134	31.80	120	31.42	98	30.69	78	29.70
No. 16	52	156	32.37	134	31.79	120	31.41	98	30.68	78	29.68
No. 17	48	156	32.37	134	31.79	120	31.42	98	30.68	78	29.69
No. 18	50	156	32.36	134	31.79	120	31.41	98	30.69	78	29.70
No. 19	50	156	32.36	134	31.79	120	31.42	98	30.70	78	29.72
No. 20	54	156	32.37	134	31.80	120	31.42	98	30.69	78	29.72
No. 21	50	156	32.39	134	31.82	120	31.44	98	30.71	78	29.74
No. 22	118	156	32.41	134	31.82	120	31.44	98	30.71	78	29.74
No. 23	94	156	32.43	134	31.88	120	31.49	98	30.77	78	29.82
No. 24	100	156	32.43	134	31.87	120	31.49	98	30.76	78	29.82
No. 25	90	156	32.44	134	31.88	120	31.50	98	30.78	78	29.84
No. 26	98	156	32.46	134	31.91	120	31.53	98	30.83	78	29.93
No. 27	100	156	32.55	134	32.00	120	31.62	98	30.91	78	30.04
No. 28	102	156	32.57	134	32.00	120	31.62	98	30.92	78	30.05
No. 29	106	156	32.63	134	32.05	120	31.66	98	30.95	78	30.11
No. 30	100	156	32.67	134	32.09	120	31.70	98	30.99	78	30.19
No. 31	110	156	32.74	134	32.17	120	31.78	98	31.12	78	30.36
No. 32	98	156	32.77	134	32.20	120	31.82	98	31.16	78	30.41
No. 33	96	156	32.84	134	32.25	120	31.87	98	31.21	78	30.48
No. 34	102	156	32.91	134	32.33	120	31.96	98	31.29	78	30.58
No. 35	92	156	32.94	134	32.38	120	32.01	98	31.32	78	30.60
No. 36	100	156	32.99	134	32.44	120	32.11	98	31.41	78	30.70
No. 37	100	156	33.03	134	32.49	120	32.17	98	31.48	78	30.80
No. 38	100	156	33.02	134	32.47	120	32.14	98	31.45	78	30.77
No. 39	98	156	33.13	134	32.56	120	32.22	98	31.53	78	30.86
No. 40	94	156	33.24	134	32.69	120	32.36	98	31.69	78	31.07
No. 41	130	156	33.24	134	32.69	120	32.36	98	31.71	78	31.17
No. 42	100	156	33.24	134	32.70	120	32.36	98	31.67	78	31.14
No. 43	100	156	33.26	134	32.72	120	32.37	98	31.72	78	31.19
No. 44	100	156	33.31	134	32.78	120	32.40	98	31.72	78	31.20
No. 45	100	156	33.37	134	32.91	120	32.52	98	31.89	78	31.36
No. 46	100	156	33.41	134	32.94	120	32.51	98	31.67	78	31.18
No. 47	100	156	33.44	134	33.03	120	32.64	98	32.28	78	31.77
No. 48	100	156	33.24	134	32.77	120	32.37	98	32.05	78	31.59
No. 49*	100	156	33.93	134	33.69	120	33.53	98	33.27	78	33.01
No. 50	100	156	35.11	134	34.84	120	34.67	98	34.38	78	34.11

Note : Coefficient of Roughness n = 0.035
Mark (*) means supercritical flow

Table 3.3.21 WATER LEVELS IN DELI RIVER UPSTREAM FOR USUAL FLOWS (AFTER IMPROVEMENT)

Section	Distance (m)	25% Q Q (m^3/s)	25% Q H (El.m)	50% Q Q (m^3/s)	50% Q H (El.m)	80% Q Q (m^3/s)	80% Q H (El.m)	Min Q Q (m^3/s)	Min Q H (El.m)	Ave Q Q (m^3/s)	Ave Q H (El.m)
No. 12	0	10.6	26.10	7.3	25.80	5.1	25.60	3.6	25.30	8.8	26.00
No. 13-30	72	10.6	26.12	7.3	25.81	5.1	25.61	3.6	25.32	8.8	26.01
No. 13	122	10.6	26.14	7.3	25.85	5.1	25.65	3.6	25.42	8.8	26.03
No. 14	98	10.6	26.20	7.3	25.92	5.1	25.73	3.6	25.55	8.8	26.09
No. 15	104	10.6	26.27	7.3	26.01	5.1	25.83	3.6	25.66	8.8	26.16
No. 16	52	10.6	26.31	7.3	26.06	5.1	25.87	3.6	25.71	8.8	26.20
No. 17	48	10.6	26.31	7.3	26.11	5.1	25.92	3.6	25.76	8.8	26.24
No. 18	50	10.6	26.39	7.3	26.16	5.1	25.98	3.6	25.81	8.8	26.29
No. 19	50	10.6	26.45	7.3	26.22	5.1	26.05	3.6	25.88	8.8	26.34
No. 20	54	10.6	26.50	7.3	26.27	5.1	26.10	3.6	25.93	8.8	26.39
No. 21	50	10.6	26.54	7.3	26.32	5.1	26.15	3.6	25.99	8.8	26.43
No. 22	118	10.6	26.74	7.3	26.56	5.1	26.42	3.6	26.33	8.8	26.64
No. 23	94	10.6	26.94	7.3	26.77	5.1	26.65	3.6	26.56	8.8	26.85
No. 24	100	10.6	27.03	7.3	26.86	5.1	26.73	3.6	26.63	8.8	26.94
No. 25	90	10.6	27.27	7.3	27.10	5.1	26.97	3.6	26.83	8.8	27.19
No. 26	98	10.6	27.51	7.3	27.35	5.1	27.23	3.6	27.06	8.8	27.42
No. 27	100	10.6	27.59	7.3	27.42	5.1	27.29	3.6	27.13	8.8	27.50
No. 28	102	10.6	27.62	7.3	27.45	5.1	27.30	3.6	27.15	8.8	27.53
No. 29	106	10.6	27.78	7.3	27.61	5.1	27.48	3.6	27.36	8.8	27.69
No. 30	100	10.6	28.05	7.3	27.87	5.1	27.74	3.6	27.65	8.8	27.96
No. 31	110	10.6	28.15	7.3	27.96	5.1	27.80	3.6	27.69	8.8	28.05
No. 32	98	10.6	28.20	7.3	28.01	5.1	27.85	3.6	27.73	8.8	28.10
No. 33	96	10.6	28.31	7.3	28.13	5.1	27.96	3.6	27.83	8.8	28.22
No. 34	102	10.6	28.39	7.3	28.21	5.1	28.05	3.6	27.89	8.8	28.30
No. 35	92	10.6	28.42	7.3	28.23	5.1	28.07	3.6	27.91	8.8	28.32
No. 36	100	10.6	28.48	7.3	28.28	5.1	28.12	3.6	27.95	8.8	28.38
No. 37	100	10.6	28.53	7.3	28.33	5.1	28.16	3.6	27.99	8.8	28.42
No. 38	100	10.6	28.55	7.3	28.35	5.1	28.18	3.6	28.03	8.8	28.44
No. 39	98	10.6	28.64	7.3	28.44	5.1	28.27	3.6	28.12	8.8	28.54
No. 40	94	10.6	28.71	7.3	28.50	5.1	28.32	3.6	28.18	8.8	28.60
No. 41	130	10.6	28.85	7.3	28.64	5.1	28.46	3.6	28.33	8.8	28.74
No. 42	100	10.6	28.98	7.3	28.76	5.1	28.60	3.6	28.47	8.8	28.86
No. 43	100	10.6	29.01	7.3	28.79	5.1	28.62	3.6	28.49	8.8	28.90
No. 44	100	10.6	29.05	7.3	28.83	5.1	28.65	3.6	28.52	8.8	28.93
No. 45	100	10.6	29.15	7.3	28.92	5.1	28.72	3.6	28.57	8.8	29.03
No. 46	100	10.6	29.16	7.3	28.93	5.1	28.74	3.6	28.58	8.8	29.05
No. 47	100	10.6	29.31	7.3	29.04	5.1	28.81	3.6	28.63	8.8	29.18
No. 48*	100	10.6	29.75	7.3	29.56	5.1	29.41	3.6	29.31	8.8	29.65
No. 49	100	10.6	30.84	7.3	30.64	5.1	30.50	3.6	30.39	8.8	30.74
No. 50	100	10.6	31.48	7.3	31.23	5.1	31.06	3.6	30.91	8.8	31.34

Note : Coefficient of Roughness n = 0.035

Mark (*) means supercritical flow

Discharges are converted by catchment area (180 km^2) from flow regime of Simeme (158 km^2)

Table 3.3.22 EXISTING DRAINAGE OUTLET ALONG PERCUT RIVER AND FLOODWAY

	No.	Location	Type	Bottom Width (m)	Top Width (m)	Height (m)	Bottom Elevation (EL.)	Catchment Area (ha.)	Note
Right Bank	SR1	PE. 166 + 80	Trapezoid CC	1.4	1.4	2.5	14.50	37.89	
	SR2	PE. 176 + 85	Trapezoid WC	0.8	1.4	1.9	15.90	50.96	Railway Br.
	SR3	PE. 200 + 10	Trapezoid CC	0.3	0.8	0.7	21.10	0.99	Denai Br.
	SR4	PE. 200 + 25	Circle PC	1.2	0.0	0.0	20.40	11.04	Denai Br.
	SR5	PE. 216 + 0	Trapezoid WC	0.1	0.4	0.4	23.80	0.84	
	SR6	PE. 218 + 30	Trapezoid WC	0.2	0.9	0.8	23.00	10.18	
	SR7	PE. 234 + 20	Trapezoid WC	0.4	0.7	0.6	24.00	15.50	
	SR8	PE. 246 + 30	Rectangle CC	0.8	0.8	0.8	26.60	15.01	Amplas Br.
	SR9	PE. 255 + 20	Rectangle EC	0.5	0.5	0.5	27.50	6.39	
	SR10	PE. 259 + 0	Trapezoid CC	4.0	5.1	3.7	24.30	498.49	
	SR11	PE. 271 + 15	Rectangle EC	0.2	0.2	0.2	28.00	11.85	
	SR12	PE. 272 + 85	Rectangle CC	0.8	0.8	0.5	29.50	14.50	
Left Bank	SL1		***	***	***	***	4.00	17.74	Perkebunan Br.+100m
	SL2	PE. 95 + 0	Rectangle EC	2.0	2.0	2.3	5.50	559.02	
	SL3	PE. 138 + 55	Rectangle EC	1.5	1.5	2.6	11.00	109.23	Payung Br.+110m
	SL4	PE. 155 + 40	Trapezoid EC	1.0	4.0	2.5	12.50	119.25	Under Construction
	SL5	PE. 176 + 55	Trapezoid WC	1.0	0.5	1.0	16.00	54.00	Railway Br.
	SL6	PE. 176 + 85	Trapezoid WC	2.0	3.0	2.0	16.00	62.00	Railway Br.
	SL7	PE. 189 + 40	Rectangle CC	0.5	0.5	0.6	18.00	9.00	
	SL8	PE. 198 + 0	Trapezoid WC	1.0	1.5	1.0	21.00	35.20	
	SL9	PE. 200 + 25	Trapezoid CC	0.3	0.9	2.1	21.00	2.50	Denai Br.
	SL10	PE. 200 + 40	Trapezoid CC	0.5	1.4	2.2	20.50	7.75	Denai Br.
	SL11	PE. 206 + 0	Trapezoid WC	0.6	4.9	1.8	20.30	0.36	Toll-way Br.
	SL12	PE. 206 + 55	Trapezoid WC	0.5	1.0	1.3	23.30	23.00	Toll-way Br.
	SL13	PE. 212 + 0	Rectangle CC	1.0	1.0	1.5	21.00	181.60	JL. Lomo
	SL14	PE. 222 + 0	Box Culvert CC	2.1	2.1	2.4	20.70	345.76	Binjai Br.
	SL15	PE. 222 + 15	Rectangle WC	1.5	1.5	2.0	21.50	32.60	JL. Timur
	SL16	PE. 246 + 35	Trapezoid CC	2.5	3.5	4.5	23.50	108.42	Amplas Br.
	SL17	PE. 250 + 90	Rectangle CC	1.0	1.0	1.0	26.00	14.35	
	SL18	PE. 255 + 15	Rectangle EC	0.2	0.2	0.2	26.50	20.96	Pipe Bridge
	SL19	PE. 258 + 25	Trapezoid WC	0.2	0.7	1.0	27.60	10.17	
	SL20	PE. 259 + 55	Rectangle WC	0.4	0.4	0.4	28.00	3.78	
	SL21	PE. 262 + 0	Trapezoid CC	1.5	1.5	3.0	26.30	55.09	
	SL22	PE. 265 + 0	Rectangle CC	0.6	0.6	1.0	26.80	4.77	
	SL23	PE. 269 + 55	Pipe Culvert PC	1.1	0.0	0.0	30.40	4.09	National Road Br.
	SL24	PE. 269 + 95	Pipe Culvert PC	1.1	0.0	0.0	29.72	9.23	National Road Br.
	SL25	PE. 274 + 60	Rectangle EC	1.0	1.0	1.0	30.00	17.74	
Floodway	SF1	FW. 6 + 50	Rectangle EC	1.0	1.0	1.0	30.00	20.20	
	SF2	FW. 9 + 81	Trapezoide EC	1.5	1.5	1.0	33.00	150.10	
	SF3	FW. 13 + 0	Trapezoide EC	0.5	0.5	0.5	36.50	9.00	
	SF4	FW. 16 + 0	***	***	***	***	35.10	40.50	
	SF5	FW. 25 + 24	Trapezoide EC	5.0	7.0	1.0	32.50	422.11	Butuan River
	SF6	FW. 30 + 0	***	***	***	***	38.00	9.38	
	SF7	FW. 38 + 50	Trapezoide EC	0.5	0.5	0.5	37.50	11.25	

Note : *** is new drainage outlet.

Table 3.3.23 HISTORICAL ANNUAL MAXIMUM SHORT DURATION RAINFALL AT SAMPALI

Year	Duration (Hour)				
	1	2	3	6	12
1977	51.6	51.6	51.6	62.8	112.2
1978	61.8	111.2	118.9	131.2	148.2
1979	54.1	88.4	93.6	101.9	104.0
1980	16.5	28.7	34.8	60.0	83.5
1981	-	-	-	-	-
1982	73.2	88.4	101.6	101.6	101.6
1983	40.7	72.0	94.0	104.4	104.4
1984	90.8	100.6	106.1	109.4	109.4
1985	-	-	-	-	-
1986	61.5	100.5	102.5	102.5	102.5
1987	62.4	67.8	82.3	120.7	134.2
1988	39.4	61.2	65.2	78.1	80.5
1989	52.9	74.3	78.2	79.0	79.0

Table 3.3.24 PROBABLE SHORT DURATION RAINFALL AT SAMPALI

Return Period	r_{day}	Duration (Hour)									
		1		2		3		6		12	
		r_t	r_t/r_{day}	r_t	r_t/r_{day}	r_t	r_t/r_{day}	r_t	r_t/r_{day}	r_t	r_t/r_{day}
(year)	(mm)	(mm/hr)	ratio	(mm/hr)	ratio	(mm/hr)	ratio	(mm/hr)	ratio	(mm/hr)	ratio
2	103.3	52.4	0.507	36.8	0.356	27.0	0.261	15.4	0.149	8.5	0.083
3	115.8	63.0	0.544	43.5	0.375	31.7	0.273	17.5	0.151	9.5	0.082
5	129.6	74.9	0.578	51.0	0.393	36.9	0.284	19.9	0.153	10.6	0.082
8	141.6	85.1	0.601	57.4	0.405	41.3	0.292	21.9	0.155	11.6	0.082
10	147.1	89.8	0.610	60.4	0.410	43.4	0.295	22.8	0.155	12.0	0.082
20	163.8	104.1	0.636	69.4	0.424	49.7	0.303	25.7	0.157	13.3	0.081
Ave.	-	-	0.579	-	0.394	-	0.285	-	0.153	-	0.082

Note : r_{day} = Probable 1-Day Rainfall
r_t = Probable Rainfall Intensity in the Duration (t hour)

Table 3.3.25 ANNUAL MAXIMUM DAILY RAINFALL

Year	Date	Deli River	Year	Date	Percut River
1954	12 Dec	57.5	1954	1 Oct	84.3
1955	21 Dec	64.8	1955	1 Apr	58.8
1956	28 Nov	165.6	1956	27 Nov	109.1
1957	7 Sep	92.7	1957	7 Sep	85.6
1958	25 Oct	77.8	1958	1 Nov	68.2
1959	30 Sep	79.6	1959	30 Sep	103.8
1960	9 Dec	77.1	1960	21 Jan	72.6
1961	5 May	85.0	1961	30 Jul	67.0
1962	10 Jun	78.3	1962	19 Nov	55.6
1963	1 Jan	76.8	1963	28 Nov	78.6
1964	30 Apr	69.4	1964	19 Jan	50.2
1965	27 Aug	72.9	1965	11 Nov	31.1
1966	28 Sep	58.6	1966	1 Jul	54.9
1967	16 Dec	46.7	1967	27 Jun	46.5
1968	15 Sep	57.4	1968	30 Nov	50.8
1969	29 Sep	62.8	1969	7 Jan	102.1
1970	30 sep	65.0	1970	5 Nov	61.7
1971	15 Aug	60.6	1971	10 Feb	60.7
1972	14 Sep	55.6	1972	13 Nov	54.4
1973	26 Oct	68.2	1973	4 Mar	59.2
1974	29 Oct	49.6	1974	29 Dec	60.5
1975	27 Dec	62.8	1975	19 Mar	51.2
1976	9 Jan	46.8	1976	8 Nov	83.4
1977	7 Nov	55.1	1977	20 Dec	62.0
1978	3 Dec	76.1	1978	12 Oct	78.4
1979	13 nov	66.4	1979	13 Nov	68.5
1980	6 Dec	78.7	1980	21 Dec	77.8
1981	16 Oct	48.9	1981	16 Nov	53.7
1982	31 Dec	65.3	1982	23 May	69.9
1983	6 Jul	70.1	1983	29 Jul	109.6
1984	21 Oct	57.6	1984	29 Jul	63.9
1985	24 Apr	54.7	1985	30 Sep	114.2
1986	3 Feb	65.4	986	6 Dec	61.4
1987	16 Sep	97.8	1987	15 Sep	90.7
1988	30 Sep	62.0	1988	30 Sep	82.1
1989	13 Sep	69.0	1989	13 Sep	70.2
1990	18 May	67.2	1990	1 May	60.7
1991	20 Oct	58.9	1991	20 Oct	65.1
1992	27 Sep	55.7	1992	27 Sep	83.4
1993	4 Nov	52.7	1993	4 Nov	65.9
1994	12 Nov	48.4	1994	14 Jan	47.4

Table 3.3.26 PROBABLE DAILY RAINFALL BY GUMBEL METHOD

(Unit : mm/day)

Return Period (Year)	Deli River		Percut River	
	B-P Study 1954 - 1988	D/D Study 1954-1994	B-P Study 1954-1988	D/D Study 1954-1994
2	66.3	64.8	67.9	67.2
3	76.0	74.0	77.2	76.0
4	82.2	79.8	83.2	81.6
5	86.8	84.1	87.6	85.7
8	96.1	92.9	96.5	94.1
10	100.4	96.9	100.6	98.0
15	108.1	104.1	107.9	104.9
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
60	133.7	128.2	132.4	127.9
80	139.0	133.2	137.5	132.6
100	143.0	137.0	141.4	136.3
150	150.4	143.9	148.4	142.9
200	155.6	148.8	153.4	147.6

Table 3.3.27 DISCHARGE AT PROPOSED DRAINAGE OUTLET

Drainage No.	Area A	Condition of Catchment Area: Runoff Coefficient Hilly	Paddy	Fact.	Res.	f	Hydraulic Factor Hilly	Paddy	Fact.	Res.	C	Rainfall Duration T	Return Period	Daily Rainfall R_{oday}	Rate (R_{day}/R_{oday})	Daily Rainfall R_{day}	Rate (Rt/R_{day})	Rainfall Intensity R	Discharge Qout	Specific Discharge q
	(ha.)	0.30	0.70	0.70	0.50	Avg.	290	150	80	100	Avg.	(min)	(Year)	(mm/day)		(mm/day)		(mm/hr.)	(m^3/s)	($m^3/s/km^2$)
SR1	37.89	50	5	0	45	0.41	50	5	0	45	198	54.0	5	115.80	0.939	108.71	0.535	58.12	2.51	6.62
SR2	50.96	70	0	0	30	0.36	70	0	0	30	233	66.2	5	115.80	0.933	108.05	0.501	54.13	2.76	5.41
SR3	0.99	40	0	10	50	0.44	40	0	10	50	174	26.6	2	103.30	0.980	101.21	0.762	77.08	0.09	9.42
SR4	11.04	50	0	0	50	0.40	50	0	0	50	195	44.0	5	115.80	0.958	110.91	0.592	65.68	0.81	7.30
SR5	0.84	30	0	10	60	0.46	30	0	10	60	155	23.5	2	103.30	0.981	101.32	0.810	82.10	0.09	10.49
SR6	10.18	50	0	0	50	0.40	50	0	0	50	195	43.4	5	115.80	0.959	111.03	0.596	66.19	0.75	7.35
SR7	15.50	70	0	10	20	0.38	70	0	10	20	231	53.4	5	115.80	0.953	110.39	0.537	59.31	0.97	6.26
SR8	15.01	30	0	0	70	0.44	30	0	0	70	157	38.4	5	115.80	0.954	110.44	0.634	69.98	1.28	8.55
SR9	6.39	20	0	0	80	0.46	20	0	0	80	138	30.1	2	103.30	0.964	99.61	0.717	71.41	0.58	9.12
SR10	498.49	65	10	5	20	0.40	65	10	5	20	228	91.8	5	115.80	0.869	100.63	0.400	40.25	22.29	4.47
SR11	11.85	20	0	0	80	0.46	20	0	0	80	138	33.2	5	115.80	0.957	110.81	0.682	75.53	1.14	9.65
SR12	14.50	0	0	70	30	0.64	0	0	70	30	86	22.2	5	115.80	0.954	110.49	0.834	92.17	2.38	16.39
SL1	17.74	100	0	0	0	0.30	100	0	0	0	290	68.7	2	103.30	0.951	98.27	0.488	47.97	0.71	4.00
SL2	499.02	85	5	0	10	0.34	85	5	0	10	264	106.9	2	103.30	0.849	87.69	0.360	31.58	14.88	2.98
SL3	109.23	60	30	0	10	0.44	60	30	0	10	229	70.3	2	103.30	0.916	94.62	0.481	45.50	6.07	5.56
SL4	119.25	50	10	20	20	0.46	50	10	20	20	196	62.8	2	103.30	0.914	94.40	0.520	49.05	7.47	6.27
SL5	54.00	0	0	0	100	0.50	0	0	0	100	100	32.8	5	115.80	0.932	107.92	0.686	74.04	5.55	10.28
SL6	62.00	0	0	50	50	0.60	0	0	50	50	90	29.6	5	115.80	0.929	107.58	0.722	77.71	8.03	12.95
SL7	9.00	0	0	50	50	0.60	0	0	50	50	90	21.6	2	103.30	0.960	99.20	0.846	83.89	1.26	13.98
SL8	35.20	0	0	0	100	0.50	0	0	0	100	100	30.6	5	115.80	0.940	108.87	0.710	77.35	3.78	10.74
SL9	2.50	20	0	0	80	0.46	20	0	0	80	138	25.8	2	103.30	0.973	100.53	0.774	77.81	0.25	9.94
SL10	7.75	40	0	0	60	0.42	40	0	0	60	176	38.0	2	103.30	0.962	99.39	0.637	63.33	0.57	7.39
SL11	0.36	0	0	0	100	0.50	0	0	0	100	100	14.5	2	103.30	0.985	101.77	1.033	105.12	0.05	14.60
SL12	23.00	40	0	0	60	0.42	40	0	0	60	176	45.4	5	115.80	0.947	109.70	0.583	63.96	1.72	7.46
SL13	181.60	30	5	5	60	0.46	30	5	5	60	159	57.5	5	115.80	0.902	104.50	0.518	54.14	12.56	6.92
SL14	345.76	25	5	10	60	0.48	25	5	10	60	148	60.0	5	115.80	0.882	102.15	0.507	51.80	23.88	6.91
SL15	32.60	40	0	0	60	0.42	40	0	0	60	176	48.0	5	115.80	0.941	109.02	0.567	61.78	2.35	7.21
SL16	108.42	0	0	10	90	0.52	0	0	10	90	98	35.8	5	115.80	0.916	106.10	0.656	69.64	10.91	10.06
SL17	14.35	70	0	0	30	0.36	70	0	0	30	233	53.9	5	115.80	0.954	110.51	0.535	59.15	0.85	5.91
SL18	20.96	30	0	0	70	0.44	30	0	0	70	157	40.6	5	115.80	0.949	109.87	0.617	67.75	1.74	8.28
SL19	10.17	50	0	0	50	0.40	50	0	0	50	195	43.4	5	115.80	0.959	111.03	0.596	66.19	0.75	7.35
SL20	3.78	50	0	0	50	0.40	50	0	0	50	195	37.0	2	103.30	0.970	100.15	0.646	64.73	0.27	7.19
SL21	55.09	50	0	0	50	0.40	50	0	0	50	195	57.2	5	115.80	0.932	107.87	0.519	56.02	3.43	6.22
SL22	4.77	30	0	0	70	0.44	30	0	0	70	157	31.9	2	103.30	0.967	99.92	0.696	69.53	0.41	8.50
SL23	4.09	0	0	10	90	0.52	0	0	10	90	98	21.0	2	103.30	0.969	100.08	0.858	85.84	0.51	12.40
SL24	9.23	50	0	0	50	0.40	50	0	0	50	195	42.7	2	103.30	0.960	99.17	0.601	59.59	0.61	6.62
SL25	17.74	90	0	0	10	0.32	90	0	0	10	271	64.3	5	115.80	0.951	110.16	0.511	56.32	0.89	5.01
SF1	20.20	100	0	0	0	0.30	100	0	0	0	290	70.2	5	115.80	0.949	109.93	0.481	52.89	0.89	4.41
SF2	150.15	70	0	0	30	0.36	70	0	0	30	233	79.0	5	115.80	0.908	105.11	0.444	46.64	7.00	4.66
SF3	9.00	50	45	0	5	0.49	50	45	0	5	218	43.8	2	103.30	0.960	99.20	0.594	58.89	0.72	8.02
SF4	40.50	80	15	0	5	0.37	80	15	0	5	260	68.6	2	103.30	0.938	96.85	0.489	47.35	1.97	4.87
SF5	422.11	70	0	0	30	0.36	70	0	0	30	233	93.4	5	115.80	0.875	101.34	0.395	40.04	16.90	4.00
SF6	9.38	85	5	5	5	0.35	85	5	5	5	263	55.4	2	103.30	0.960	99.15	0.528	52.34	0.48	5.09
SF7	11.25	0	0	70	30	0.64	0	0	70	30	86	21.3	5	115.80	0.958	110.89	0.852	94.43	1.89	16.79

Table 3.3.28 COMPARISON OF WATER LEVEL AT ESTUARY OF PERCUT RIVER

(1) Existing Alignment

Distance from River Mouth	Discharge = 270 m³/s		Discharge = 330 m³/s	
	Ht = 1.5 m	Ht = 2.0 m	Ht = 1.5 m	Ht = 2.0 m
0.0 km	1.500	2.000	1.500	2.000
1.1 km	1.666	2.055	1.713	2.078
1.6 km	1.932	2.175	2.027	2.236
1.8 km	2.107	2.280	2.234	2.373
2.0 km	2.203	2.347	2.341	2.455
2.2 km	2.284	2.403	2.426	2.520
2.4 km	2.391	2.487	2.542	2.616

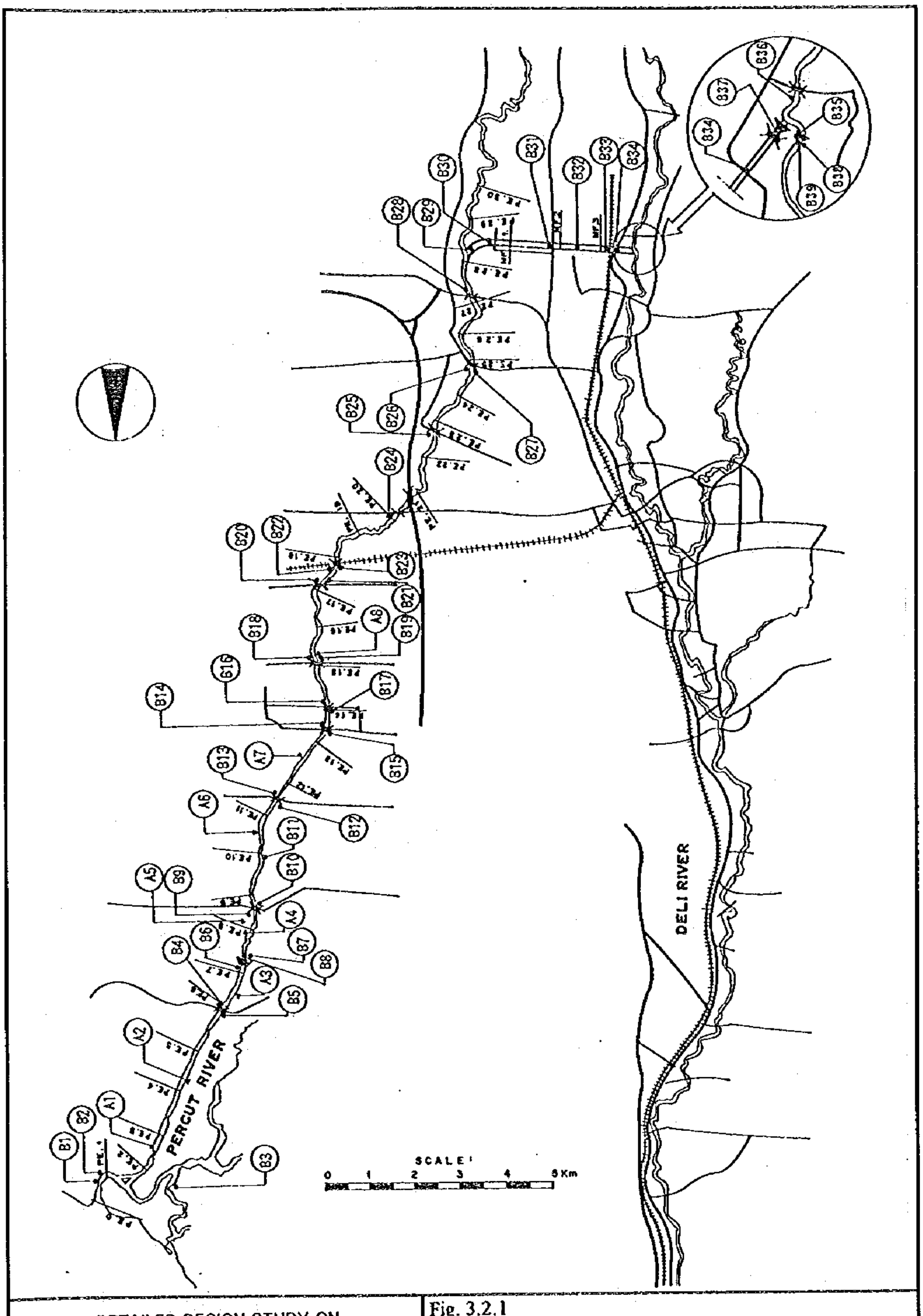
(2) Alignment of B-P Study

Distance from River Mouth	Discharge = 270 m³/s		Discharge = 330 m³/s	
	Ht = 1.5 m	Ht = 2.0 m	Ht = 1.5 m	Ht = 2.0 m
0.0 km	1.500	2.000	1.500	2.000
1.1 km	1.673	2.054	1.723	2.077
1.6 km	1.935	2.175	2.031	2.235
1.8 km	2.109	2.280	2.237	2.373
2.0 km	2.205	2.346	2.343	2.454
2.2 km	2.285	2.403	2.428	2.519
2.4 km	2.392	2.483	2.543	2.615

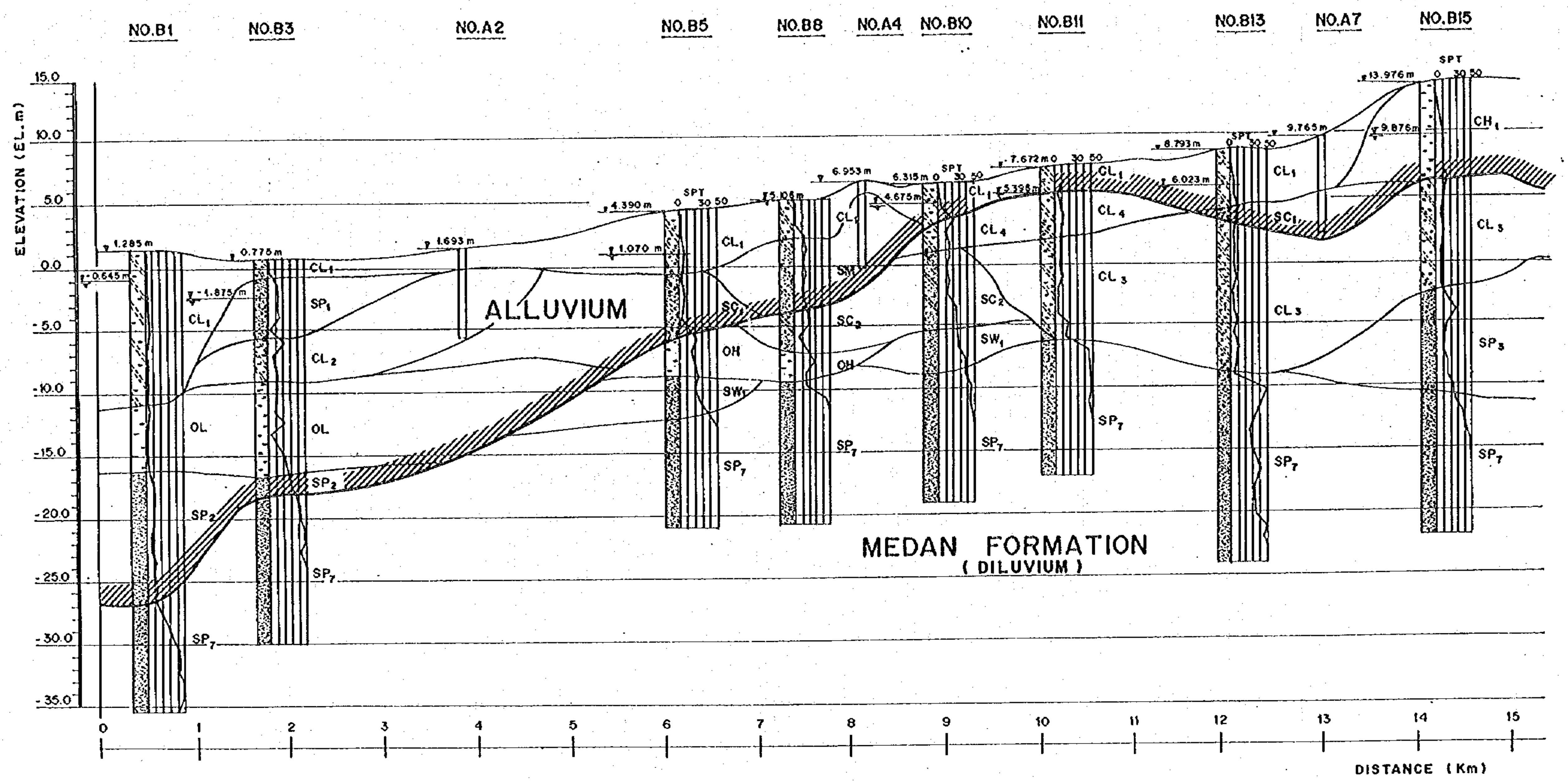
FIGURES

CHAPTER 3

INVESTIGATION AND ANALYSIS



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.2.1 LOCATION OF BOREHOLE
JAPAN INTERNATIONAL COOPERATION AGENCY	



Sand		
Well Graded Sand		
SW_1	:	Diluvial Fine to Medium Size Sand Medium to High Density
Poor Graded Sand		
SP_1	:	Alluvial Fine Sand Low Density
SP_2	:	Alluvial Medium Size Sand Low to Medium Density
SP_3	:	Diluvial Fine to Medium Size Sand Low to Medium Density
SP_7	:	Diluvial Coarse Sand Containing Gravel Medium to High Density

Silty and Clayey Sand		
SM	:	Silty Sand Alluvium Medium Density
SC_1	:	Clayey Sand Alluvium Low Density
SC_2	:	Clayey Sand Diluvium Low to Medium Density

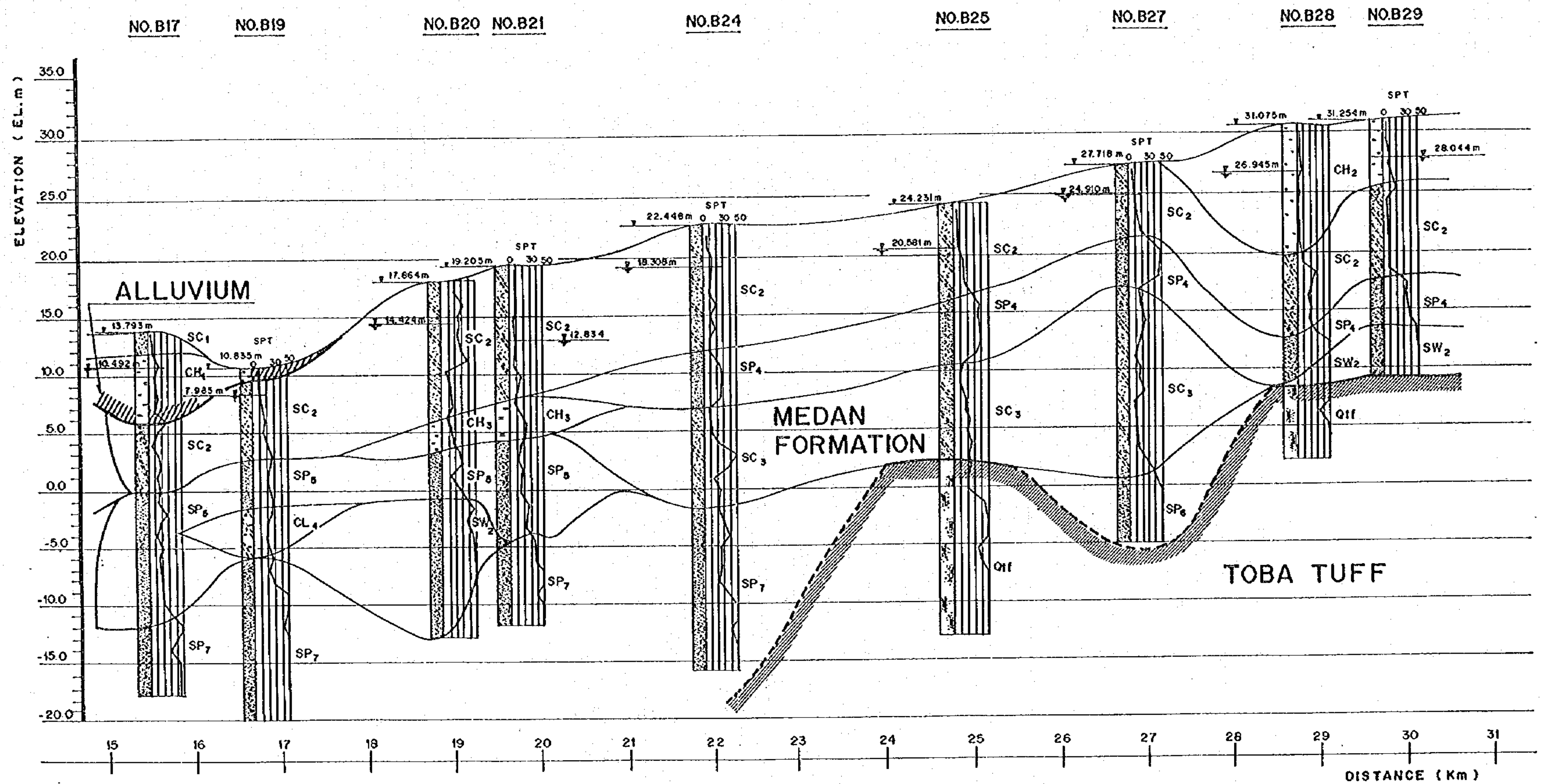
Clay		
CH_1	:	Clay Alluvium Low to Medium Stiffness
OL	:	Organic Clay Alluvium Low to Medium Stiffness
OH	:	Organic Clay Diluvium Medium Stiffness

Silty and Sandy Clay		
CL_1	:	Alluvium Low Stiffness
CL_2	:	Alluvium Medium Stiffness
CL_3	:	Diluvium Low Stiffness
CL_4	:	Diluvium Medium Stiffness

DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.2 (1/4)
GEOLOGICAL PROFILE



Sand

Well Graded Sand

SW_2	:	Diluvial Fine to Medium Size Sand High Density

Poor Graded Sand

SP_4	:	Diluvial Fine to Medium Size Sand Medium to High Density
SP_5	:	Diluvial Medium Size to Coarse Sand Low to Medium Density
SP_6	:	Diluvial Medium Size to Coarse Sand Medium to High Density
SP_7	:	Diluvial Coarse Sand Containing Gravel Medium to High Density

Silty and Clayey Sand

SC_1	:	Clayey Sand Alluvium Low Density
SC_2	:	Clayey Sand Diluvium Low to Medium Density
SC_3	:	Clayey Sand Diluvium Medium to High Density

Clay

CH_1	:	Alluvium Low to Medium Stiffness
CH_2	:	Diluvium Low Stiffness
CH_3	:	Diluvium Low to Medium Stiffness

Silty and Sandy Clay

CL_4	:	Diluvium Medium Stiffness

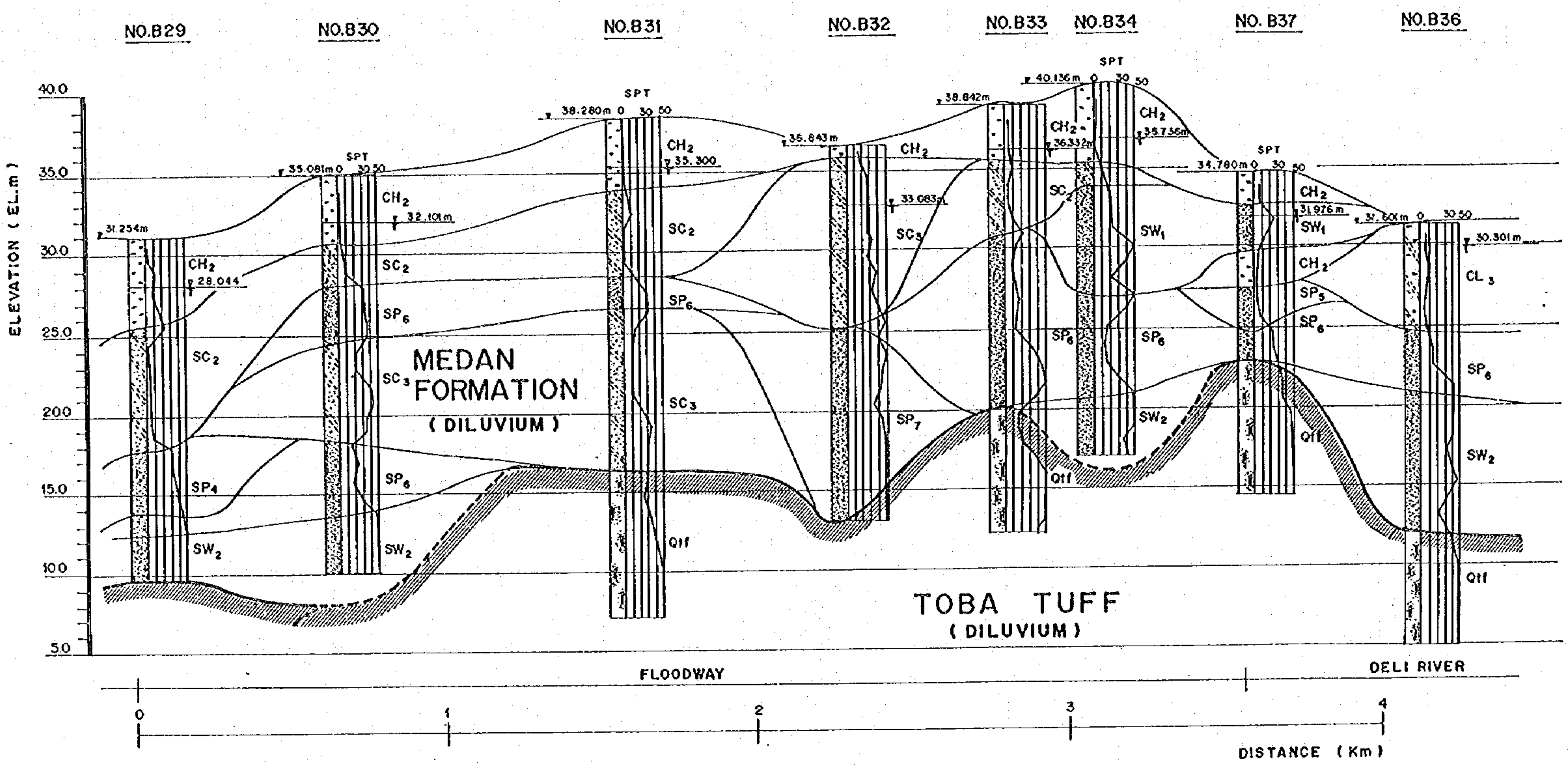
Tuff

Qtf	:	Uncemented Tuff Diluvium Medium to High Stiffness

DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.2 (2/4)
GEOLOGICAL PROFILE



Sand

Well Graded Sand

- SW_1 : Diluvial Fine to Medium Size Sand, Medium to High Density
- SW_2 : Diluvial Fine to Medium Size Sand, High Density

Poor Graded Sand

- SP_4 : Diluvial Fine to Medium Size Sand, Medium to High Density
- SP_5 : Diluvial Medium Size to Coarse Sand, Low to Medium Density
- SP_6 : Diluvial Medium Size to Coarse Sand, Medium to High Density
- SP_7 : Diluvial Coarse Sand Containing Gravel, Medium to High Density

Silty and Clayey Sand

- SC_2 : Clayey Sand, Diluvium, Low to Medium Density
- SC_3 : Clayey Sand, Diluvium, Medium to High Density

Clay

- CH_2 : Diluvium, Low Stiffness

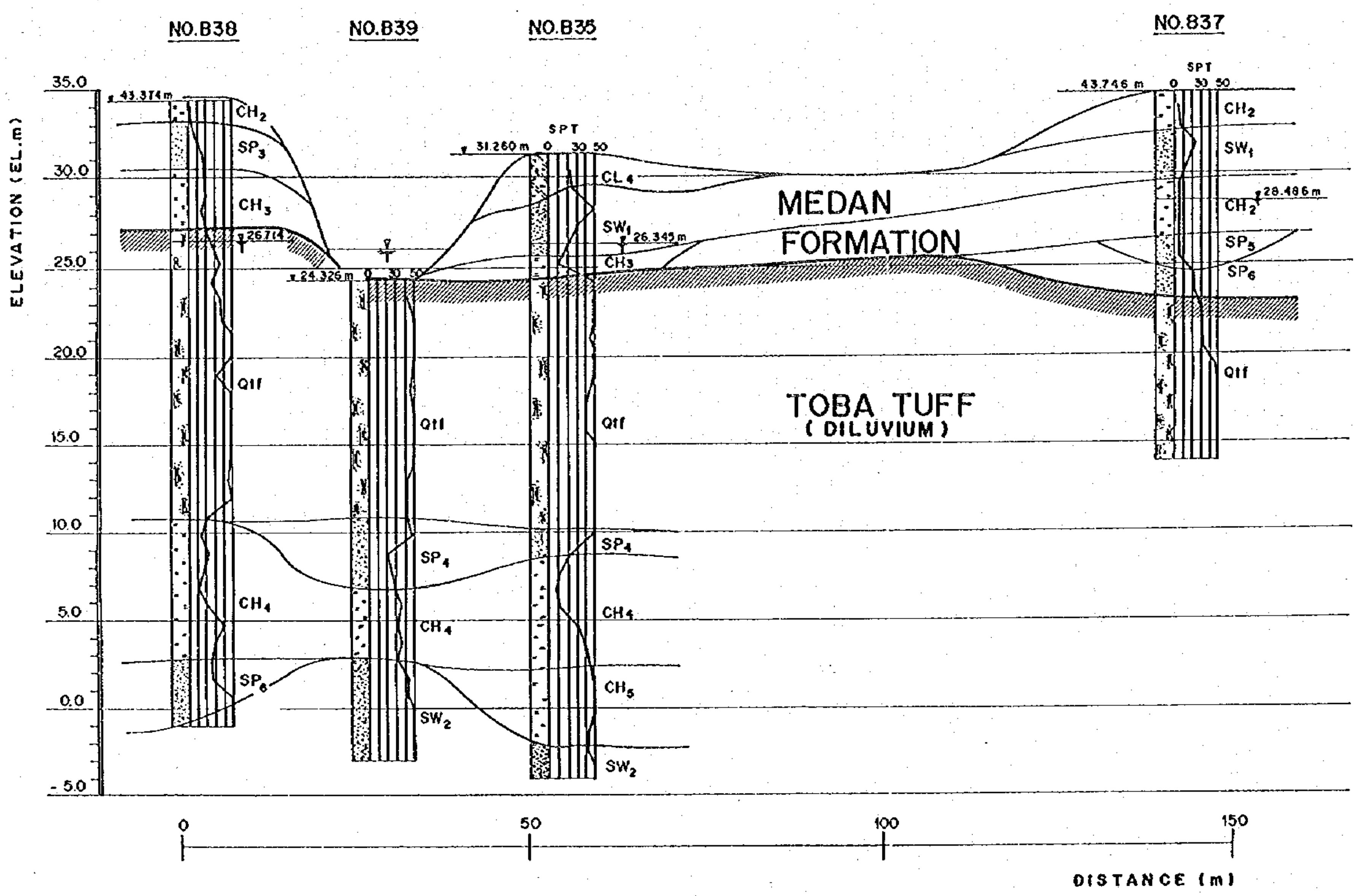
Silty and Sandy Clay

- CL_3 : Diluvium, Low Stiffness

Tuff

- Qtf : Uncemented Tuff, Diluvium, Medium to High Stiffness

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.2.2 (3/4) GEOLOGICAL PROFILE
JAPAN INTERNATIONAL COOPERATION AGENCY	



Sand

Well Graded Sand

SW$_1$: Diluvial Fine to Medium Size Sand Medium to High Density

SW$_2$: Diluvial Fine to Medium Size Sand High Density

Poor Graded Sand

SP$_3$: Diluvial Fine to Medium Size Sand Low to Medium Density

SP$_4$: Diluvial Fine to Medium Size Sand Medium to High Density

SP$_5$: Diluvial Medium Size to Coarse Sand Low to Medium Density

SP$_6$: Diluvial Medium Size to Coarse Sand Medium to High Density

Clay

CH$_2$: Diluvium Low Stiffness

CH$_3$: Diluvium Low to Medium Stiffness

CH$_4$: Diluvium Medium to High Stiffness

CH$_5$: Diluvium High Stiffness

Silty and Sandy Clay

CL$_4$: Diluvium Medium Stiffness

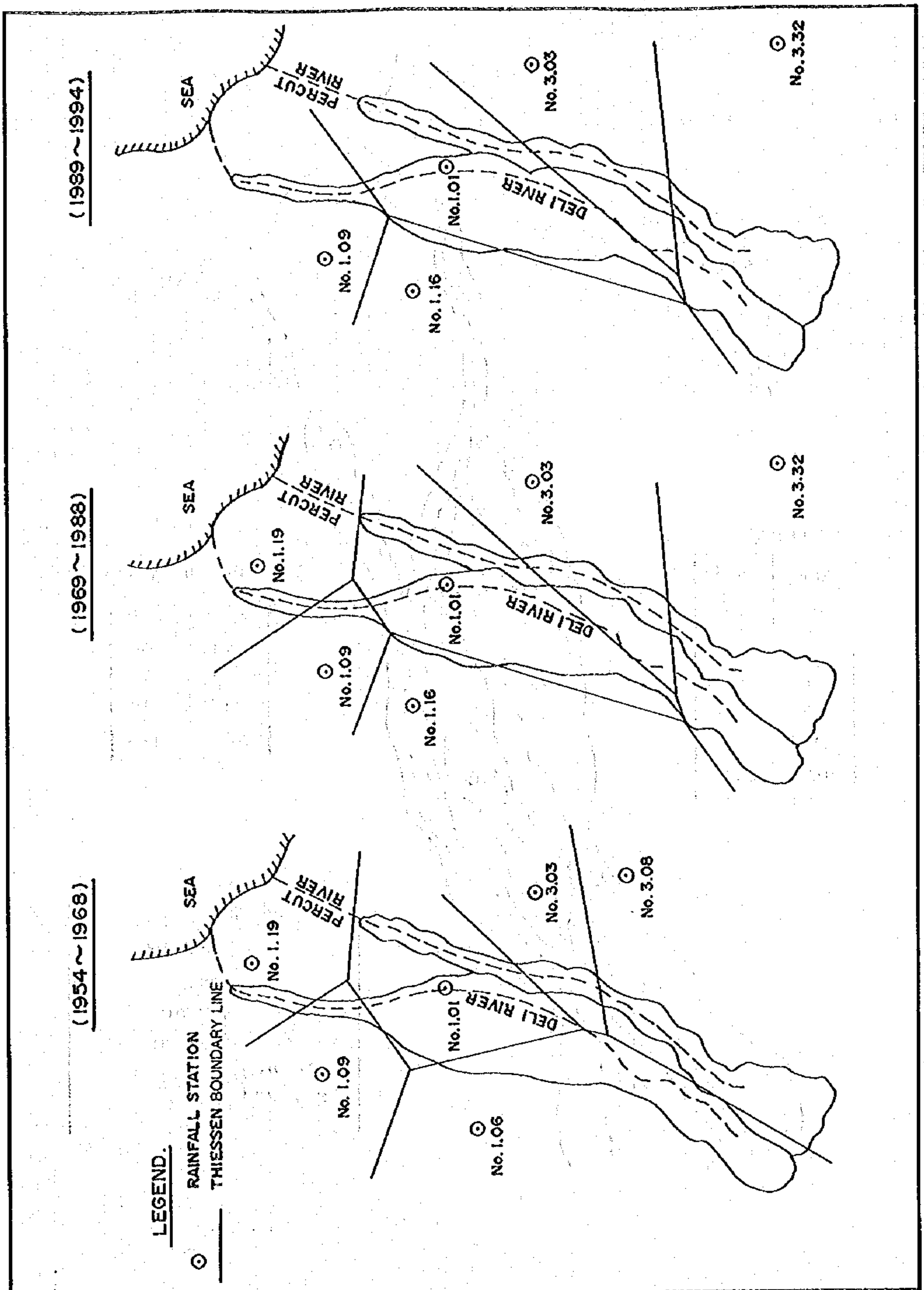
Tuff

Qtf : Uncemented Tuff Diluvium Medium to High Stiffness

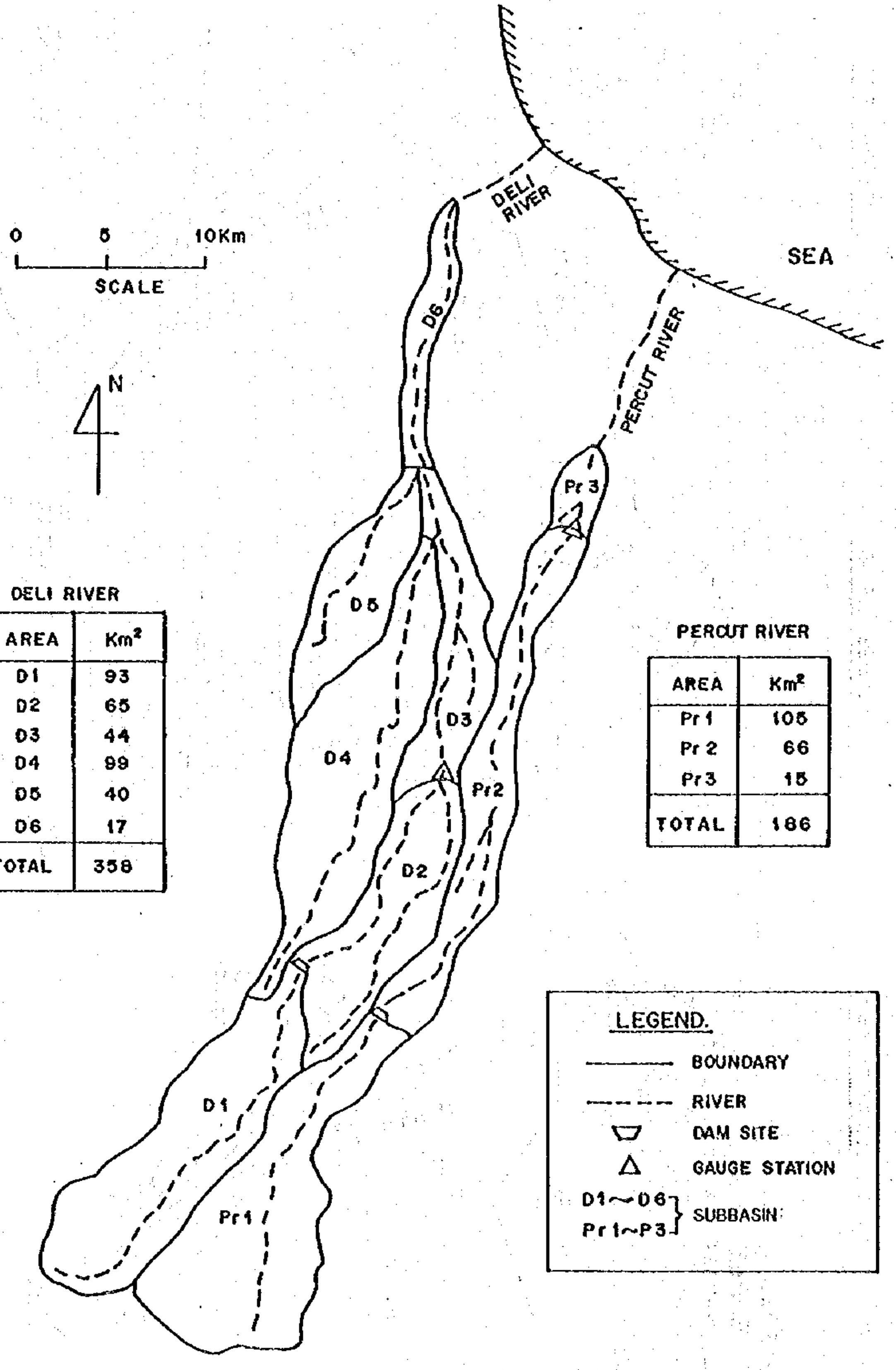
DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.2 (4/4)
GEOLOGICAL PROFILE



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.3.1 THIESSEN POLYGONS FOR BASIN MEAN RAINFALL
JAPAN INTERNATIONAL COOPERATION AGENCY	



DELI RIVER

AREA	Km²
D1	93
D2	65
D3	44
D4	99
D5	40
D6	17
TOTAL	358

PERCUT RIVER

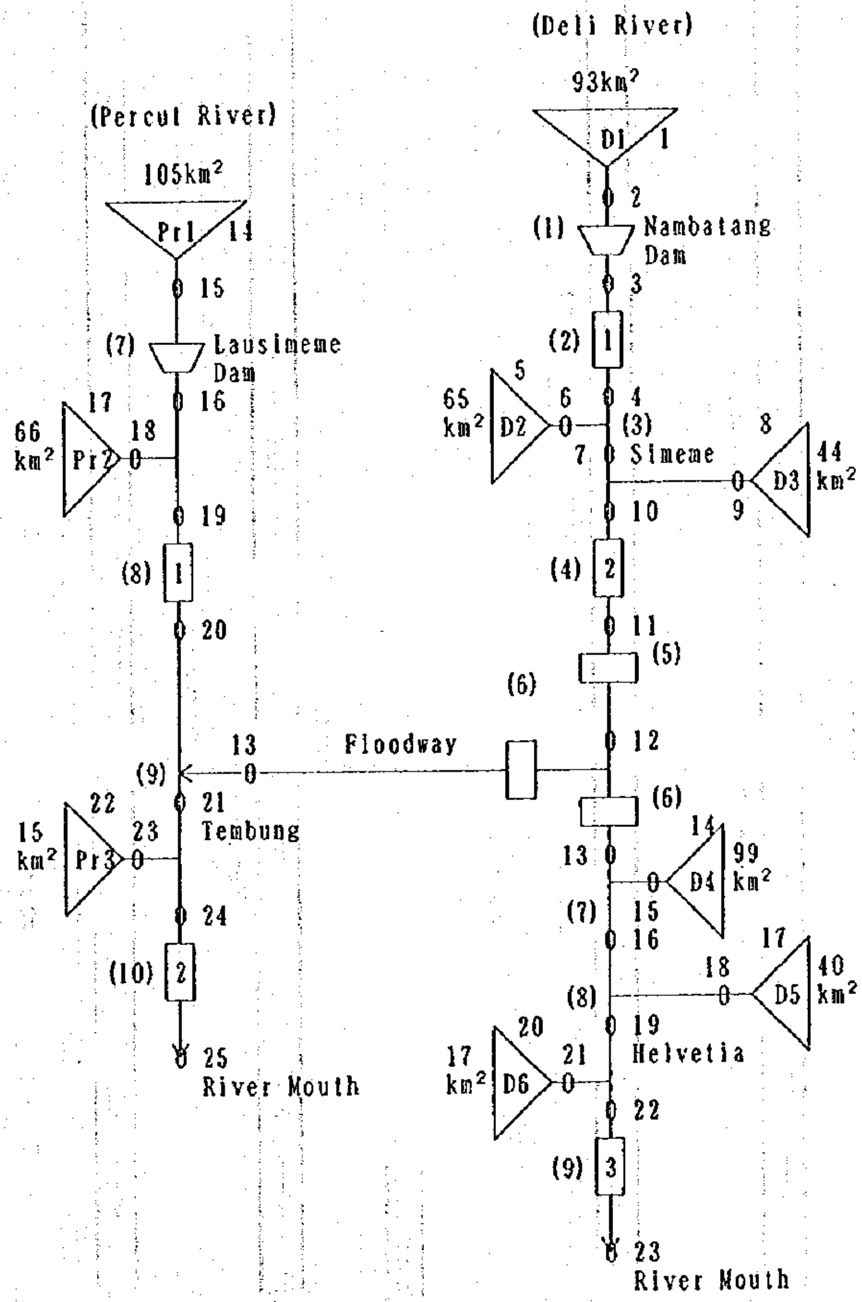
AREA	Km²
Pr 1	105
Pr 2	66
Pr3	15
TOTAL	186

DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

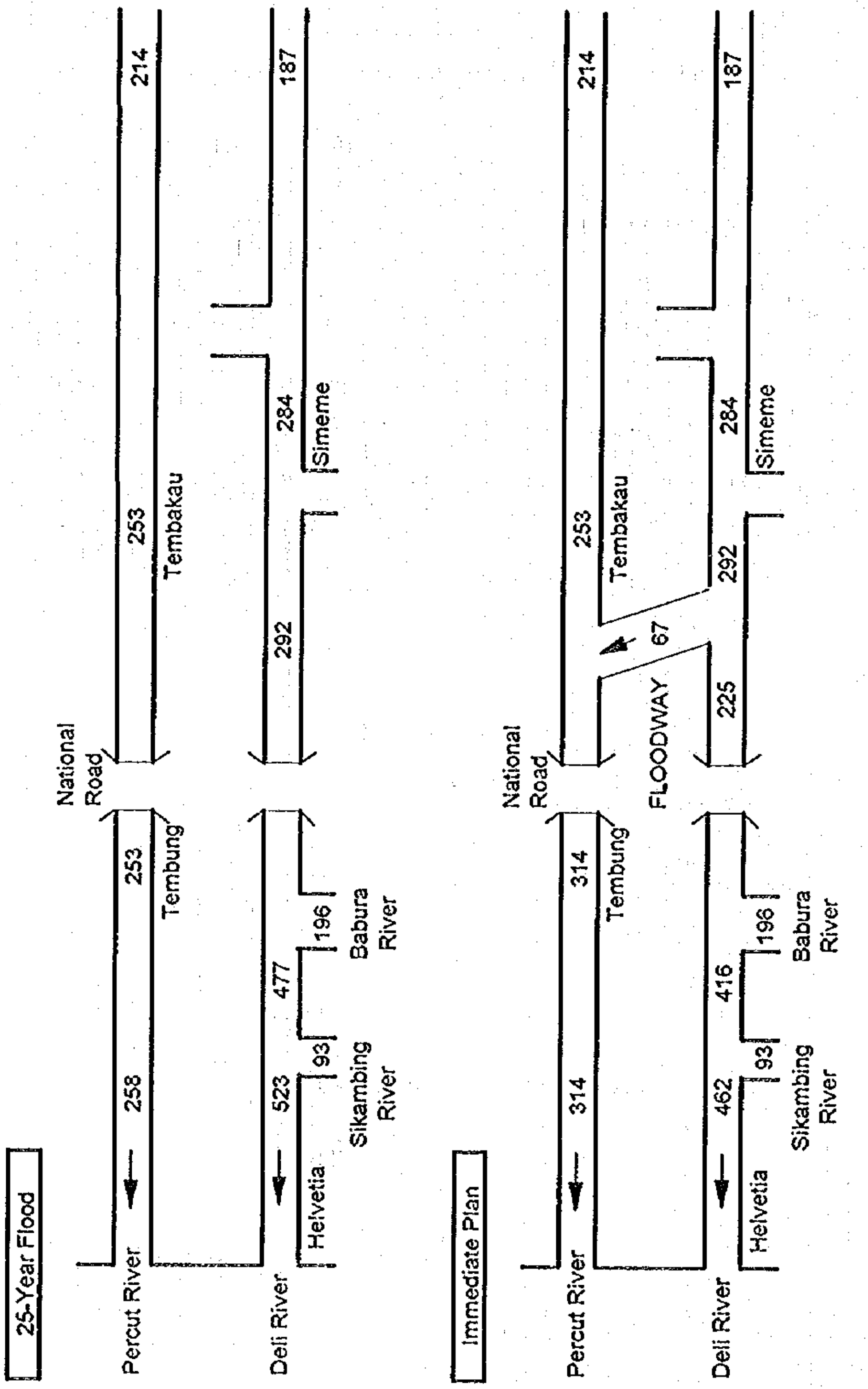
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.3.2
SUBBASIN DIVISION IN STORAGE FUNCTION MODEL

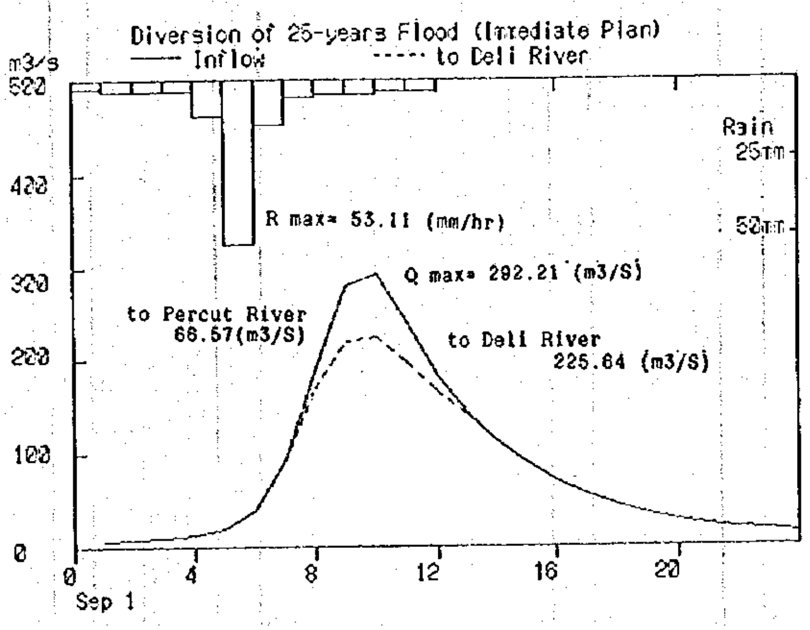
FLOOD RUN-OFF MODEL (DELI AND PERCUT RIVER)



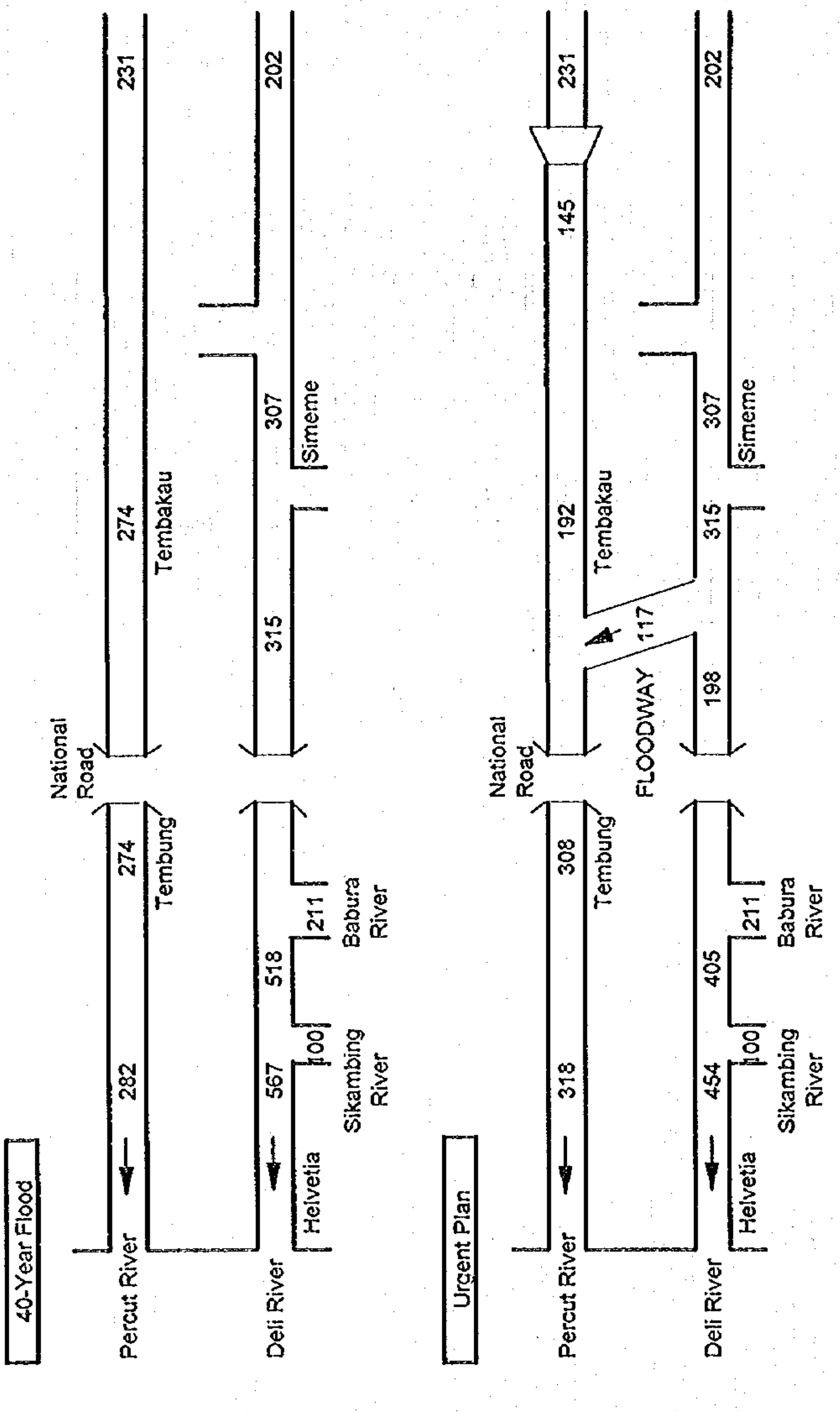
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.3.3 BASIN RUNOFF MODEL
JAPAN INTERNATIONAL COOPERATION AGENCY	



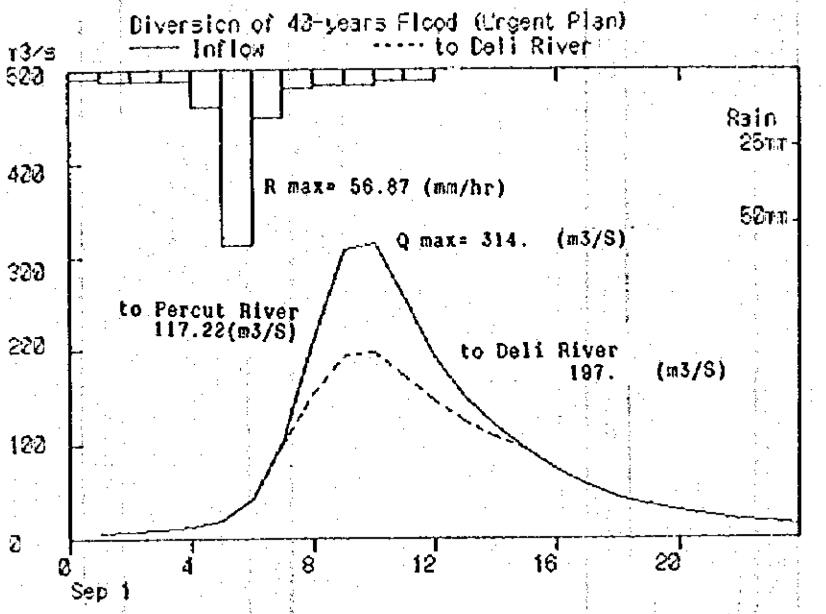
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 3.3.4 PROBABLE FLOOD AND DESIGN DISCHARGE IN IMMEDIATE PLAN

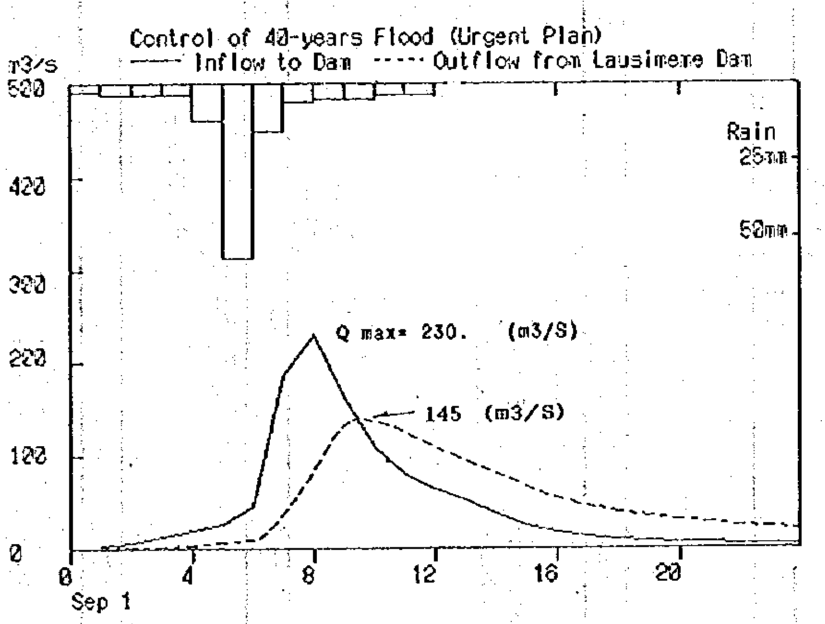


DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.3.5 FLOOD HYDROGRAPHS BY DIVERSION IN IMMEDIATE PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY	

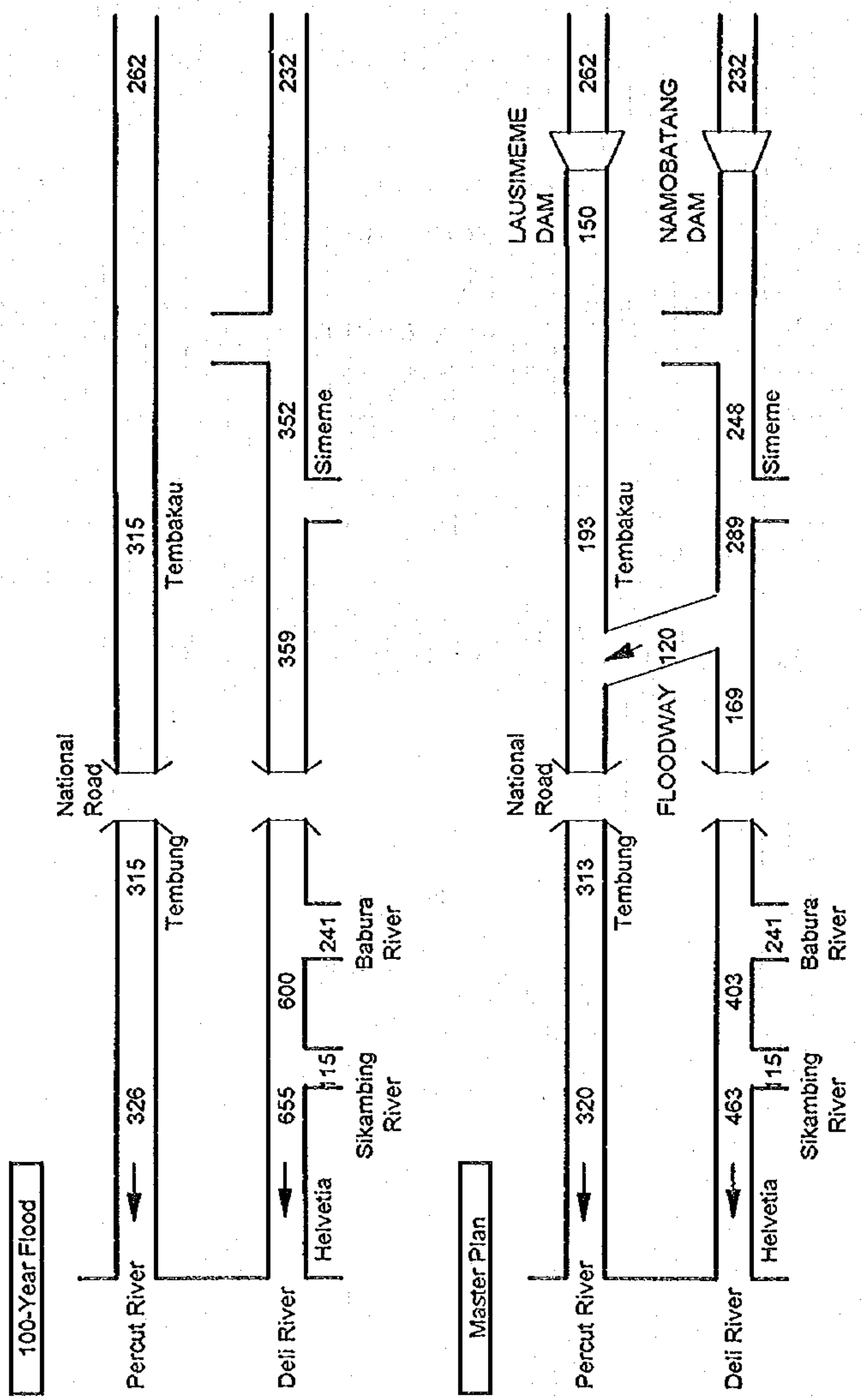


DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.3.6 PROBABLE FLOOD AND DESIGN DISCHARGE IN URGENT PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY	





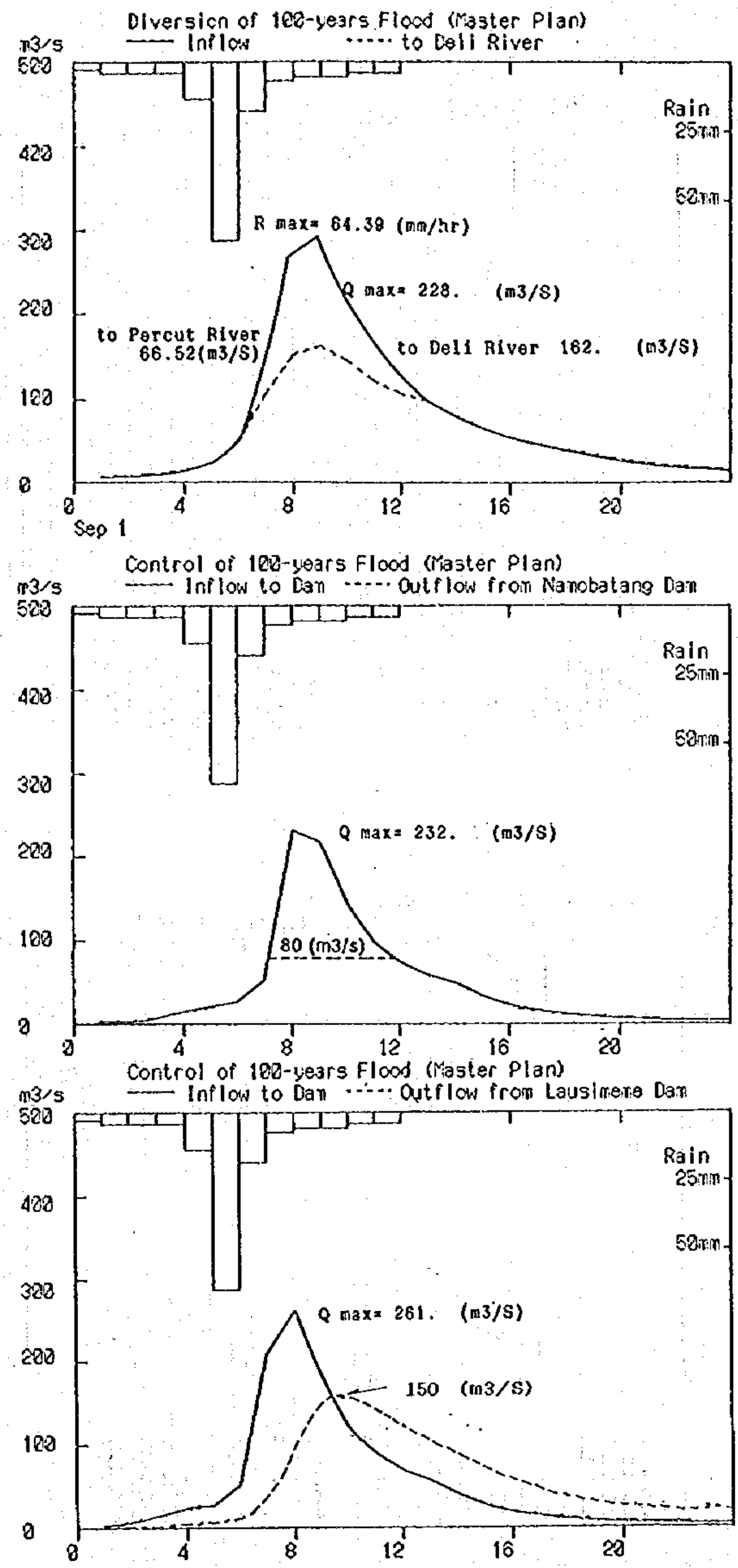
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 3.3.7 FLOOD HYDROGRAPHS BY DIVERSION AND DAM IN URGENT PLAN



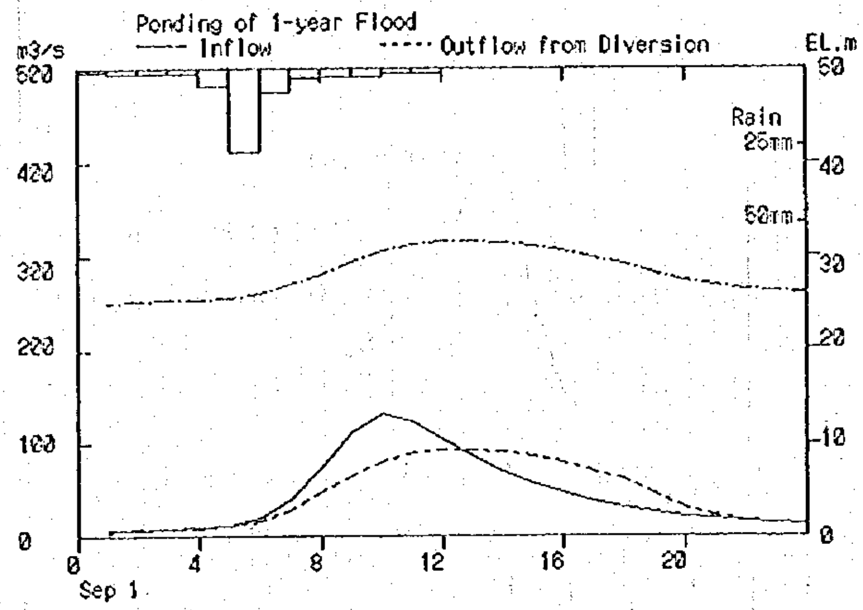
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

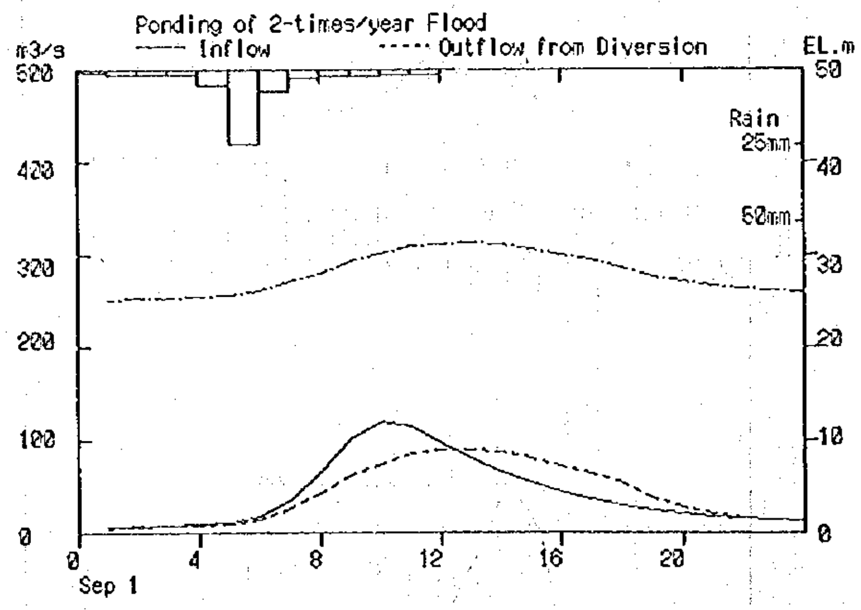
Fig. 3.3.8
PROBABLE FLOOD AND DESIGN DISCHARGE IN MASTER PLAN



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.3.9
JAPAN INTERNATIONAL COOPERATION AGENCY	FLOOD HYDROGRAPHS BY DIVERSION AND DAMS IN MASTER PLAN

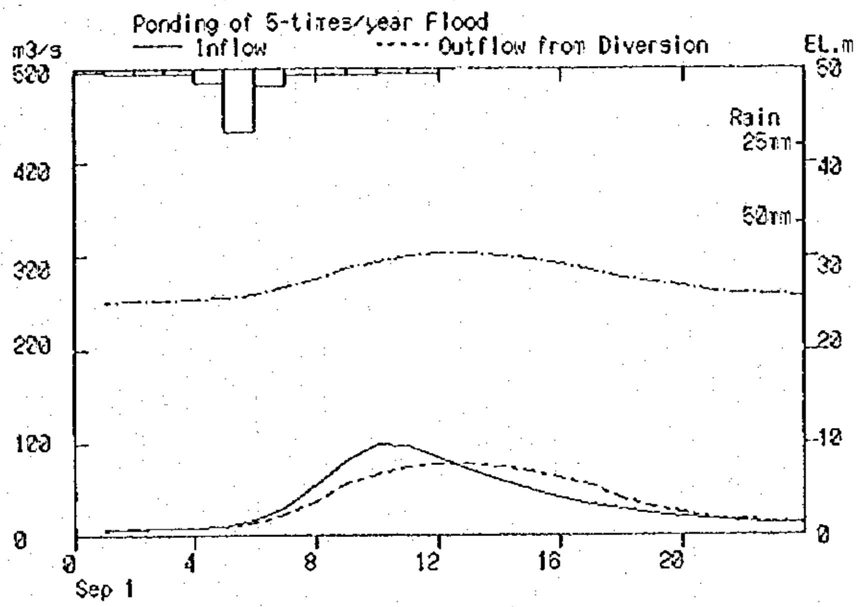


Rainfall	R max= 26.79 (mm/hr)
Inflow	Q max= 133.53 (m3/S)
Outflow from Diversion	Q max= 93.91 (m3/S)
Water Level	H max= 31.55 (EL.m)

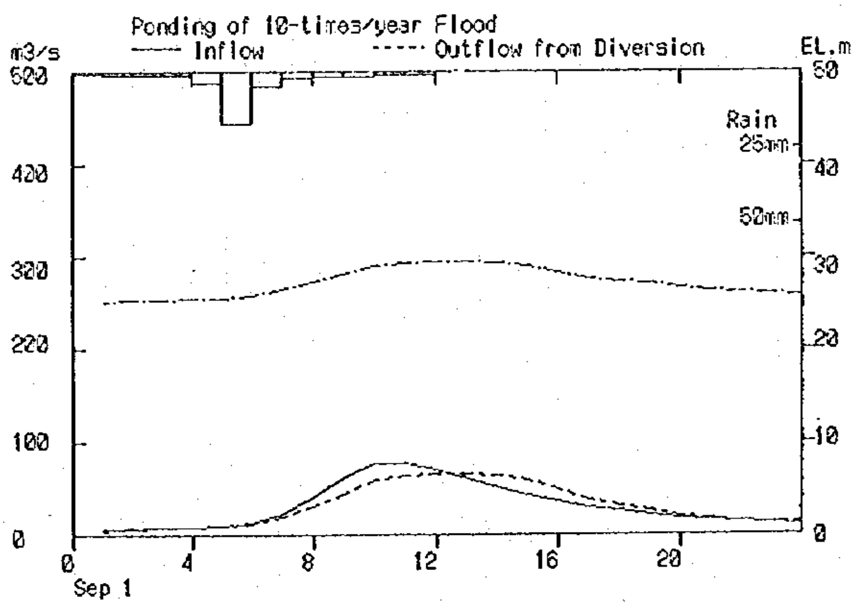


Rainfall	R max= 24.44 (mm/hr)
Inflow	Q max= 119.67 (m3/S)
Outflow from Diversion	Q max= 88.75 (m3/S)
Water Level	H max= 31.17 (EL.m)

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 3.3.10 (1/2) PONDING OF SMALL SCALE FLOODS AT DIVERSION UPSTREAM



Rainfall	R max= 20.68 (mm/hr)
Inflow	Q max= 97.91 (m3/S)
Outflow from Diversion	Q max= 78.05 (m3/S)
Water Level	H max= 30.38 (EL.m)

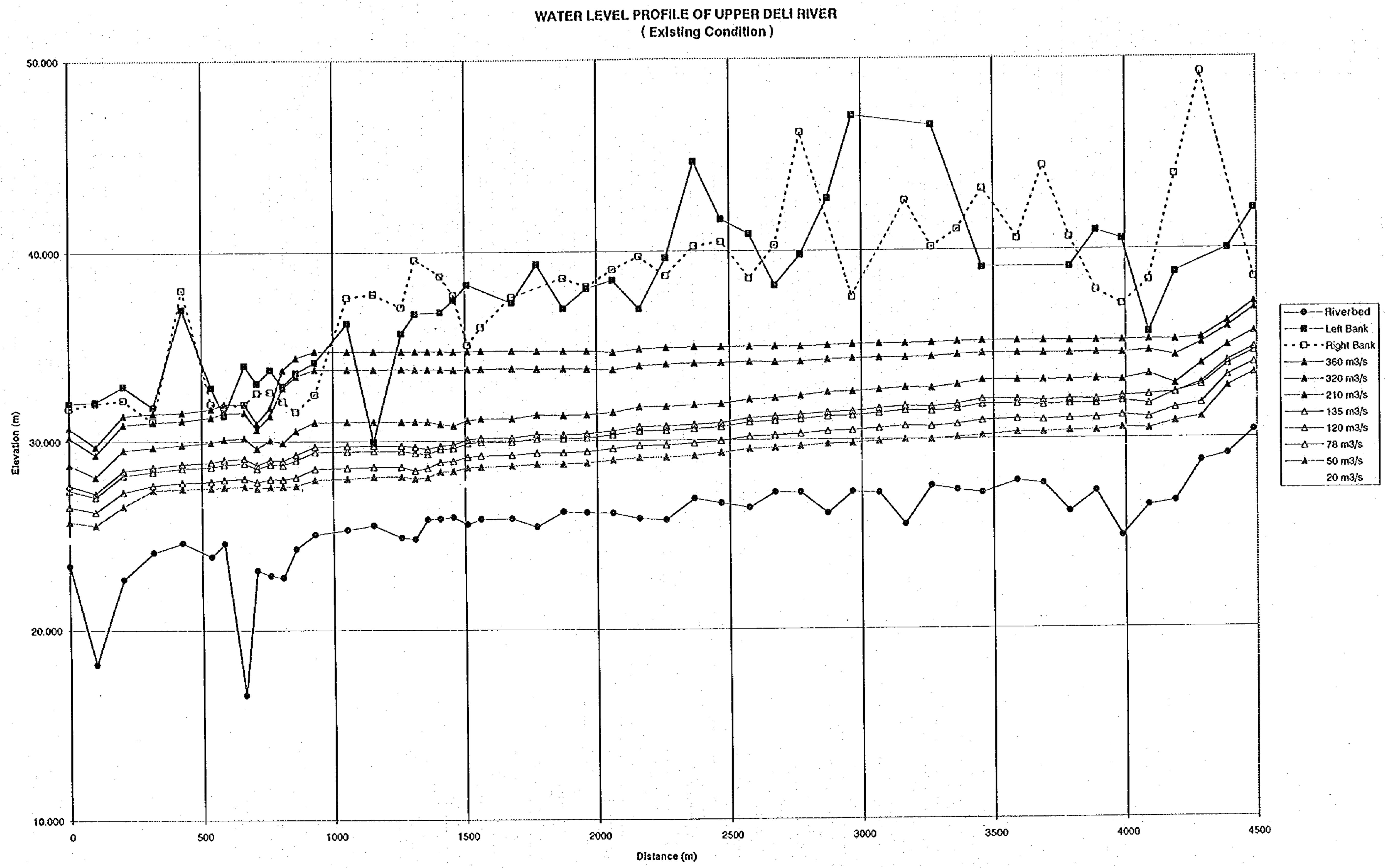


Rainfall	R max= 16.92 (mm/hr)
Inflow	Q max= 78.08 (m3/S)
Outflow from Diversion	Q max= 66.53 (m3/S)
Water Level	H max= 29.52 (EL.m)

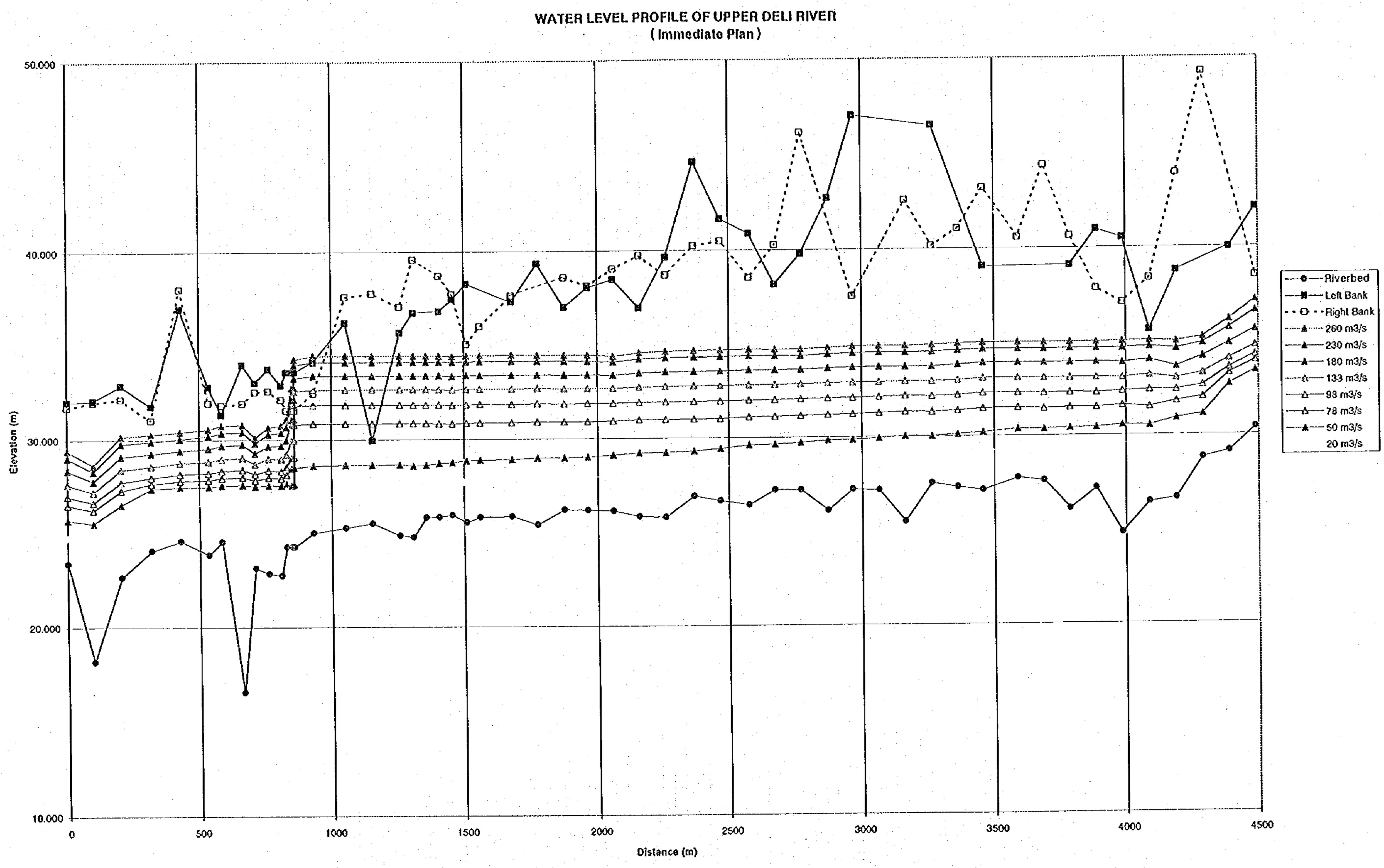
DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

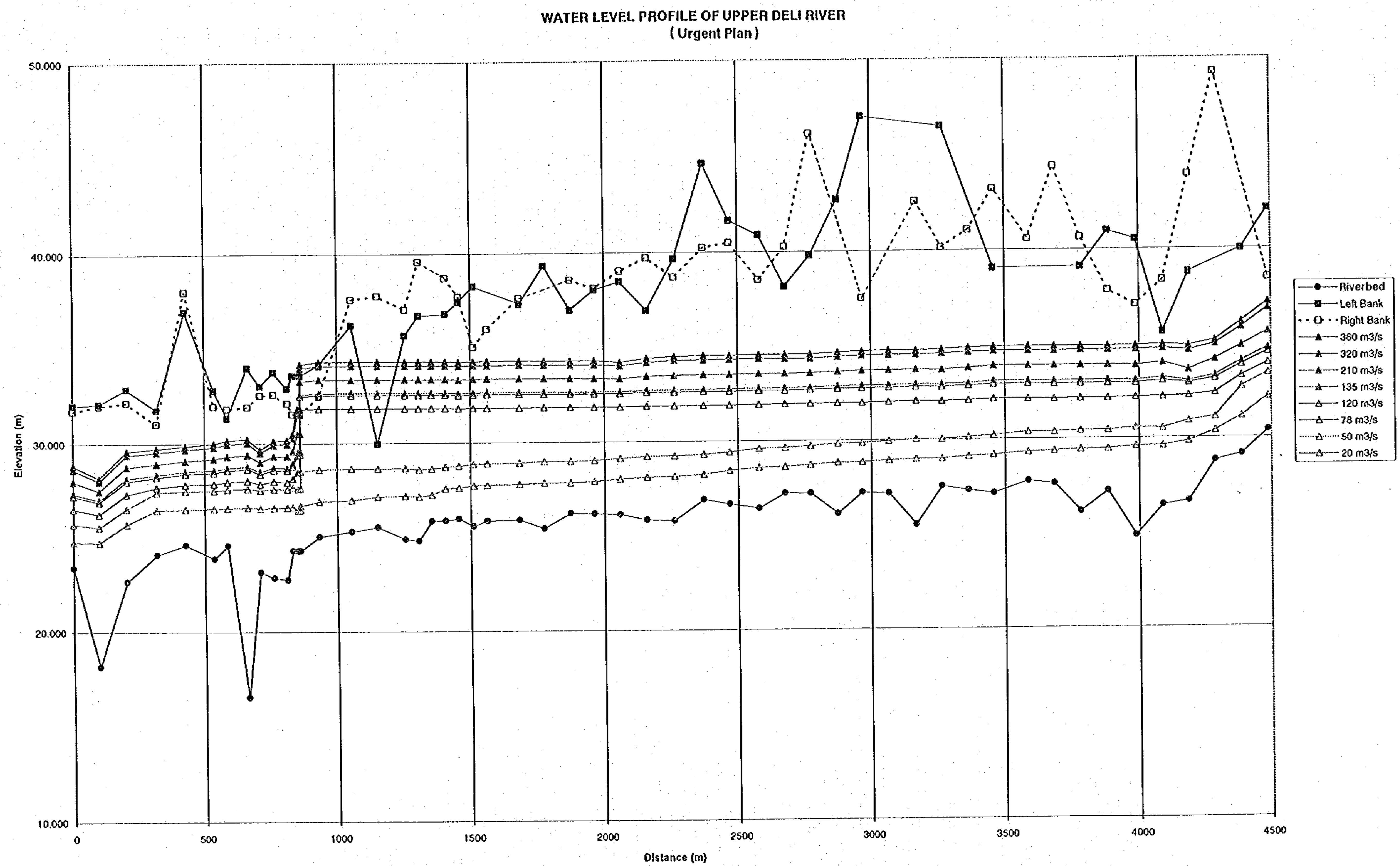
Fig. 3.3.10 (2/2)
PONDING OF SMALL SCALE FLOODS AT DIVERSION UPSTREAM



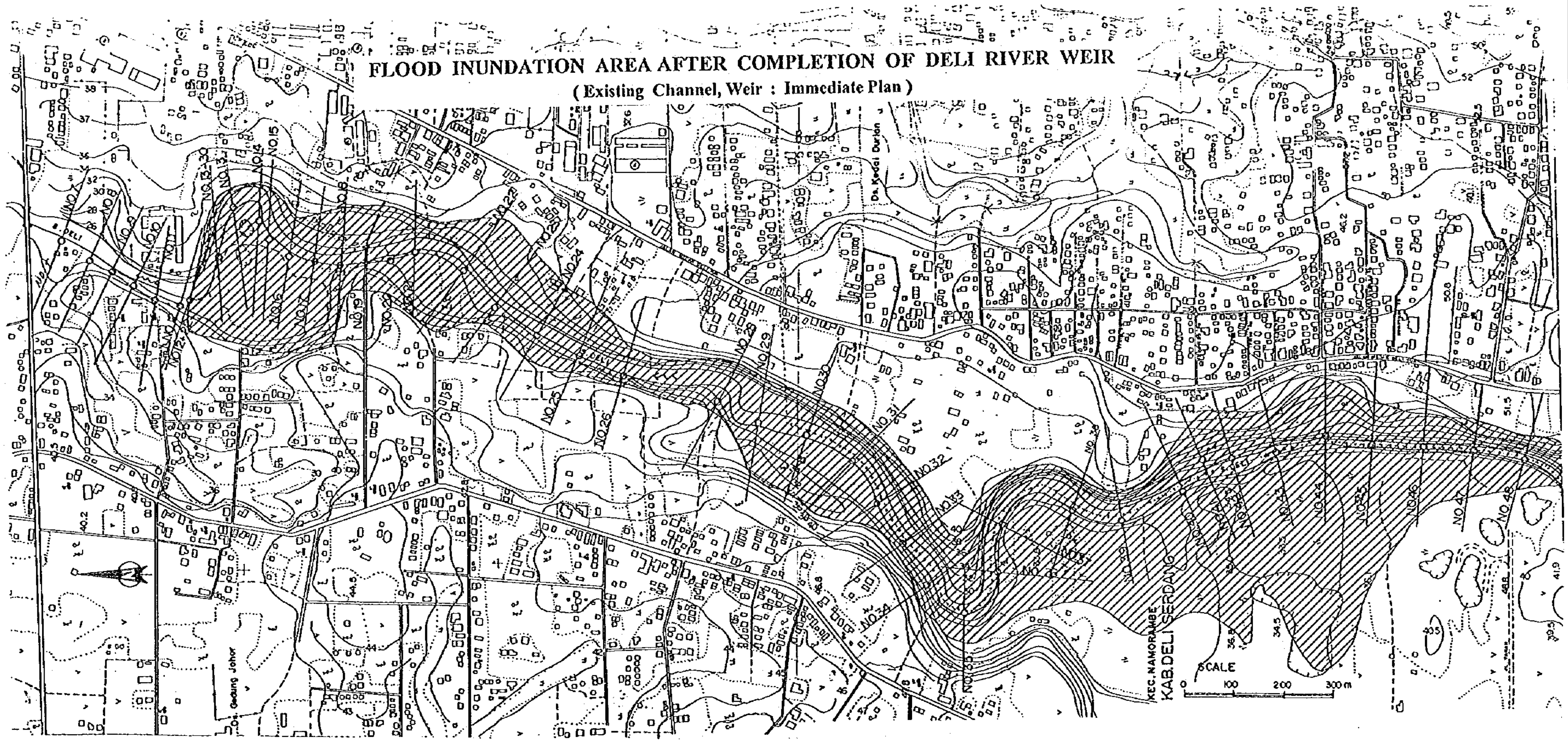
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.3.11 WATER LEVEL PROFILE IN RETARDING CHANNEL OF DELI RIVER WITHOUT WEIR
JAPAN INTERNATIONAL COOPERATION AGENCY	



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.3.12 WATER LEVEL PROFILE IN RETARDING CHANNEL OF DELI RIVER WITH WEIR OF IMMEDIATE PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY	



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.3.13 WATER LEVEL PROFILE OF RETARDING CHANNEL OF DELI RIVER WITH WEIR OF URGENT PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY	



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.3.14 INUNDATION AREA AFTER CONSTRUCTION OF DIVERSION WORKS
JAPAN INTERNATIONAL COOPERATION AGENCY	

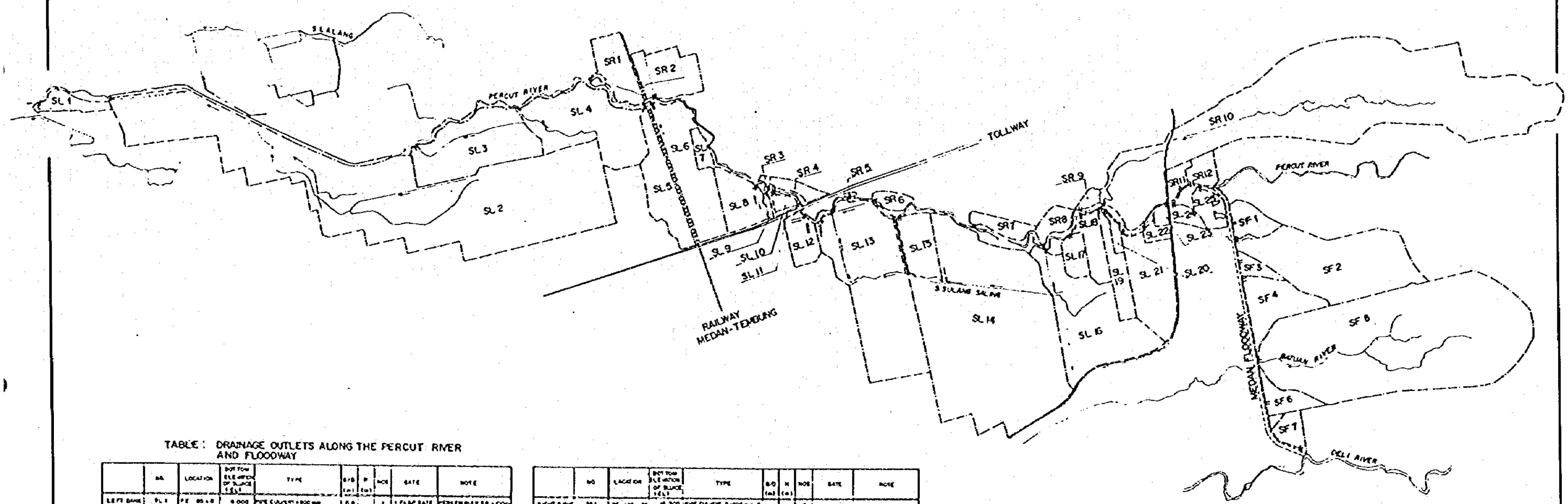


TABLE : DRAINAGE OUTLETS ALONG THE PERCUT RIVER AND FLOODWAY

	NO.	LOCATION	BOTTOM ELEVATION OF SLUICE (EL)	TYPE	B/D (m)	H (m)	NOS	GATE	NOTE
LEFT BANK	SL 1	PE 85+0	6.000	PIPE CULVERT ϕ800 mm	0.8		1	1 FLAP GATE	[illegible]
	SL 2	PE 96+95	9.800	BOX CULVERT 2.0×1.5×1	2.0	1.5	2	2 SLICE GATES	
	SL 3	PE 136+55	11.000	BOX CULVERT 1.5×1.5×1	1.5	1.5	1	1 SLICE GATE	[illegible] BRIDGE
	SL 4	PE 150+90	12.800	BOX CULVERT 2.0×1.5×1	2.0	1.5	1	1 SLICE GATE	UNDER CONSTRUCTION
	SL 5	PE 176+90	15.000	BOX CULVERT 1.5×1.5×1	1.5	1.5	1		[illegible] BR
	SL 6	PE 176+80	16.000	BOX CULVERT 2.0×1.5×1	2.0	1.5	1		RAILWAY BR
	SL 7	PE 189+40	18.000	PIPE CULVERT ϕ800 mm			1		
	SL 8	PE 196+30	20.300	PIPE CULVERT ϕ1000 mm×2			2		
	SL 9	PE 210+25	20.300	PIPE CULVERT ϕ800 mm	0.8		1		DENAI BR
	SL 10	PE 200+40	20.300	PIPE CULVERT ϕ800 mm	0.8		1		DENAI BR
	SL 11	PE 206+0	20.300	PIPE CULVERT ϕ800 mm	0.8		1		TOLL-WAY BR
	SL 12	PE 206+50	20.700	OPEN DITCH [illegible]	1.0	1.0	1		TOLL-WAY BR
	SL 13	PE 212+0	20.800	BOX CULVERT 1.5×1.5×2	1.5	1.5	2		JL. [illegible]
	SL 14	PE 227+0	20.700	BOX CULVERT 2.1×2.1×2	2.1	2.1	2		[illegible]
	SL 15	PE 233+15	21.500	PIPE CULVERT ϕ1000 mm			1		JL. [illegible]
	SL 16	PE 246+40	23.300	BOX CULVERT 2.0×2.0×1	2.0	2.0	1		AMPLAS BR
	SL 17	PE 250+90	24.000	PIPE CULVERT ϕ800 mm	0.8		1		
	SL 18	PE 254+15	25.500	PIPE CULVERT ϕ800 mm			2		PIPE BRIDGE
	SL 19	PE 256+25	27.600	PIPE CULVERT ϕ800 mm	0.8		1		
	SL 20	PE [illegible]	26.000	PIPE CULVERT ϕ600 mm	0.6		1		
	SL 21	PE [illegible]	26.300	PIPE CULVERT ϕ1000 mm×2			2		
	SL 22	PE [illegible]	26.600	PIPE CULVERT ϕ800 mm	0.8		1		
	SL 23	PE [illegible]	26.500	OPEN DITCH ϕ600 mm	0.6	1.0	1		NATIONAL ROAD BR
	SL 24	PE [illegible]	[illegible]	OPEN DITCH ϕ600 mm	0.6	1.0	1		NATIONAL ROAD BR
	SL 25	PE [illegible]	[illegible]	PIPE CULVERT ϕ800 mm			1		
RIGHT BANK	SR 1	PE 166+80	15.500	PIPE CULVERT ϕ800 mm×2			2		
	SR 2	PE 176+00	15.900	PIPE CULVERT ϕ1000 mm×2			2		RAILWAY BR
	SR 3	PE 200+10	21.000	OPEN DITCH ϕ800 mm	0.8	1.0	1		DENAI BR
	SR 4	PE 200+25	20.400	PIPE CULVERT ϕ1000 mm			1		DENAI BR
	SR 5	PE [illegible]	22.300	OPEN DITCH ϕ600 mm	0.6	1.0	1		
	SR 6	PE [illegible]	23.000	PIPE CULVERT ϕ800 mm			1		
	SR 7	PE 234+20	24.000	PIPE CULVERT ϕ800 mm			1		
	SR 8	PE 246+30	25.300	PIPE CULVERT ϕ600 mm			1		AMPLAS BR
	SR 9	PE 255+20	27.300	PIPE CULVERT ϕ800 mm			1		
	SR 10	PE 238+0	[illegible]	BOX CULVERT 2.0×2.0×2	2.0	2.0	2		RIVER
	SR 11	PE 271+40	28.000	PIPE CULVERT ϕ800 mm	0.8		1		
	SR 12	PE 279+45	28.300	PIPE CULVERT ϕ1000 mm			1		
FLOODWAY	SF 1	FW 6+30	[illegible]	PIPE CULVERT ϕ1000 mm	1.0		1		
	SF 2	FW [illegible]	30.370	BOX CULVERT 2.0×2.0×1	2.0	2.0	1		
	SF 3	FW 10+0	[illegible]	PIPE CULVERT ϕ1000 mm	1.0		1		
	SF 4	FW 15+0	[illegible]	PIPE CULVERT ϕ1000 mm	1.0		1		
	SF 5	FW [illegible]	[illegible]	BOX CULVERT 2.0×2.0×2	2.0		2		BATUAN RIVER
	SF 6	FW 33+0	[illegible]	PIPE CULVERT ϕ1000 mm	1.0		1		
	SF 7	FW [illegible]	32.800	PIPE CULVERT ϕ1000 mm	1.0		1		

0 0.5 1.0 1.5 2.0 2.5 3.0 Km
SCALE 1 : 25000

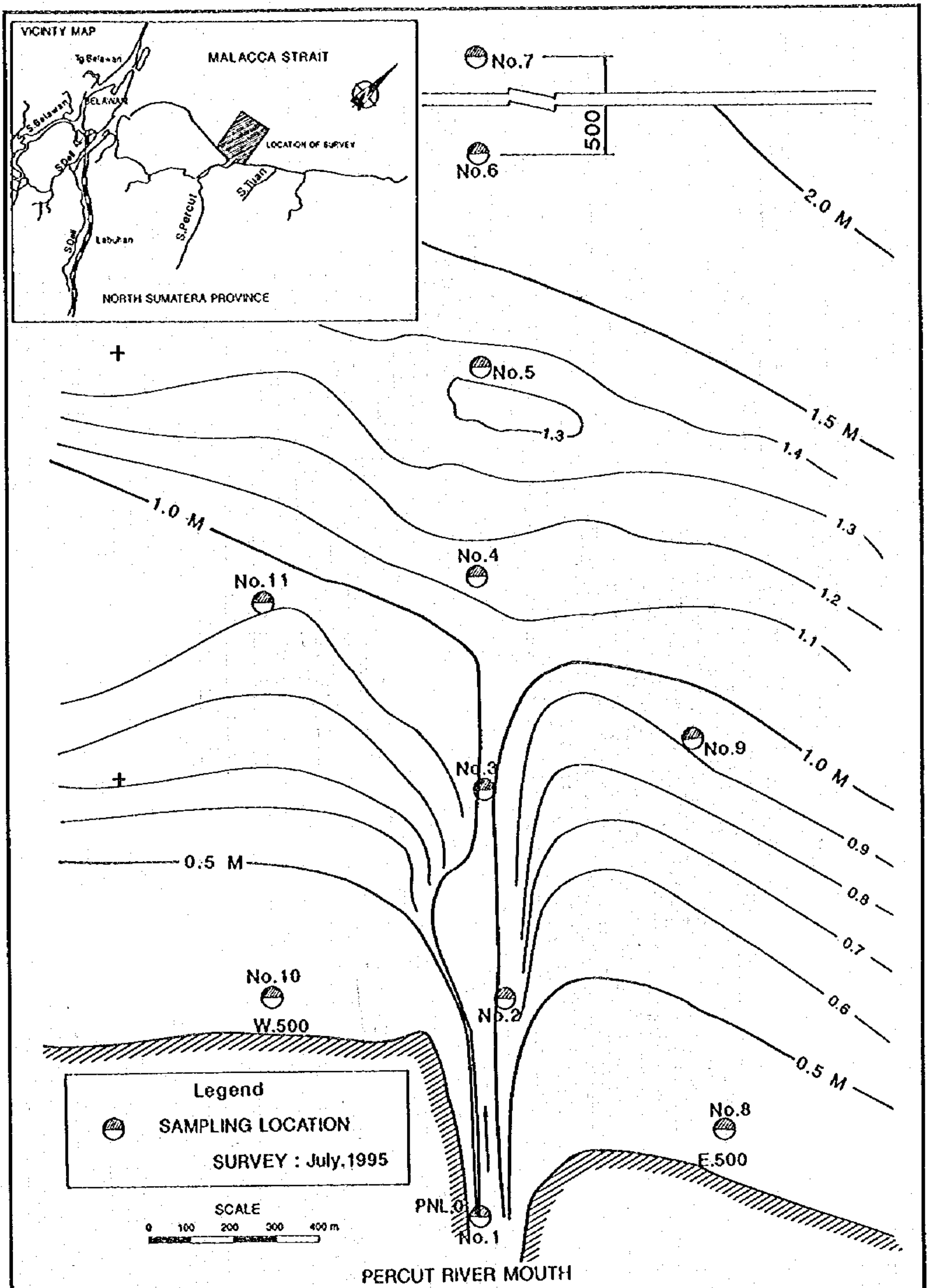
LEGEND

- BOUNDARY OF DRAINAGE AREA
- ROAD
- RAILWAY
- DRAINAGE CHANNEL
- RIVER

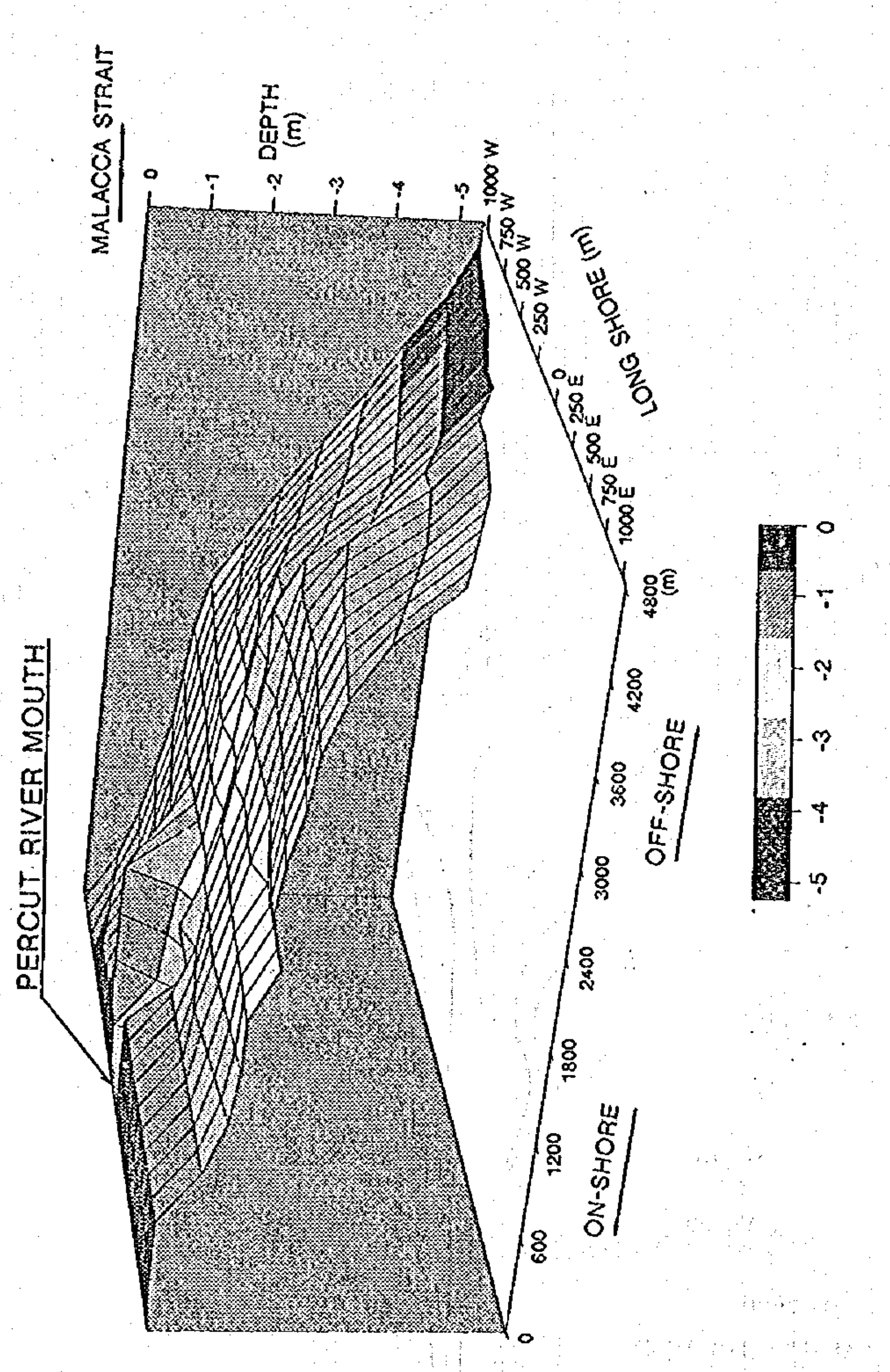
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

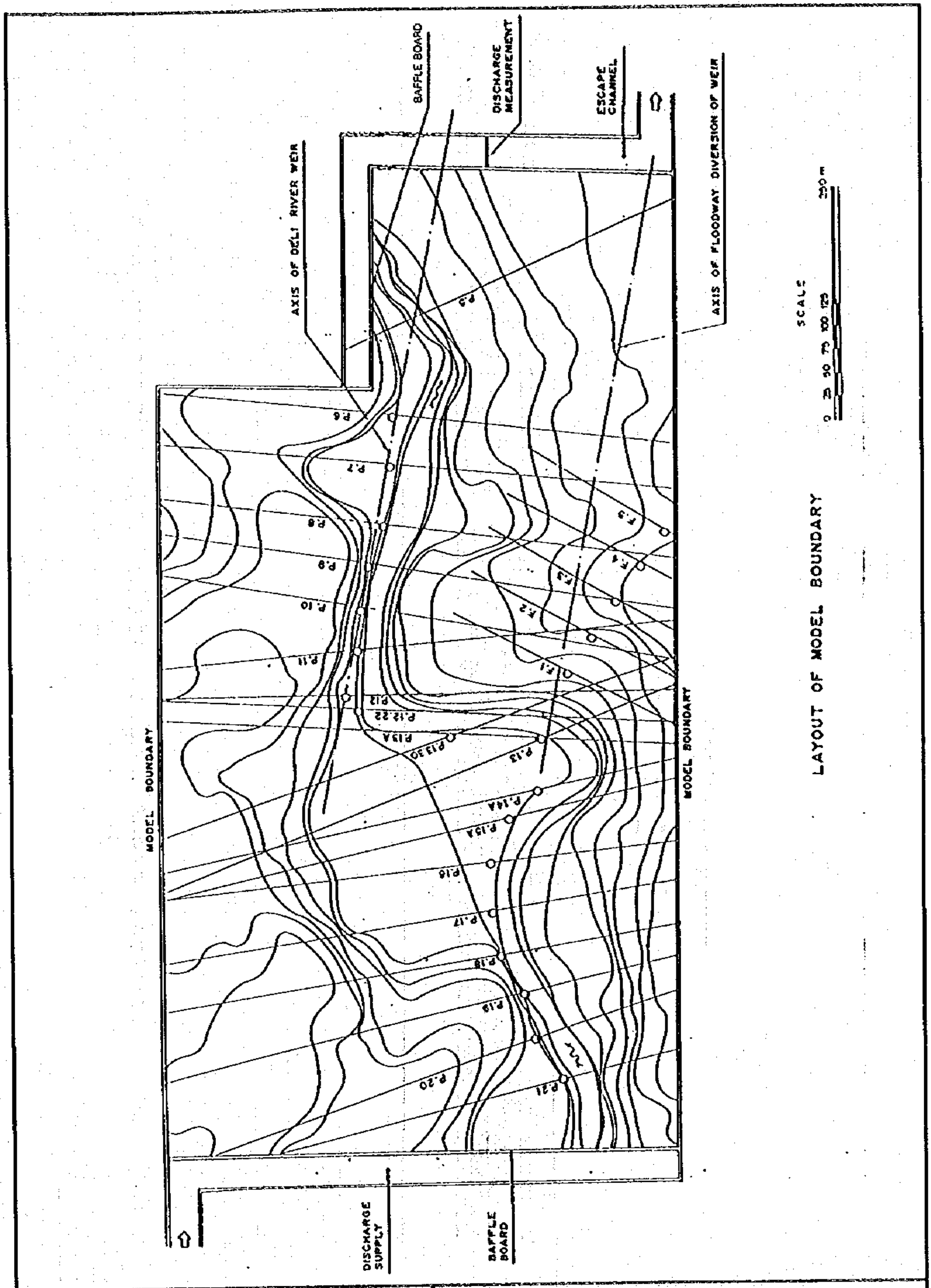
Fig. 3.3.15
EXISTING DRAINAGE AREA TO BE AFFECTED BY THE PROJECT



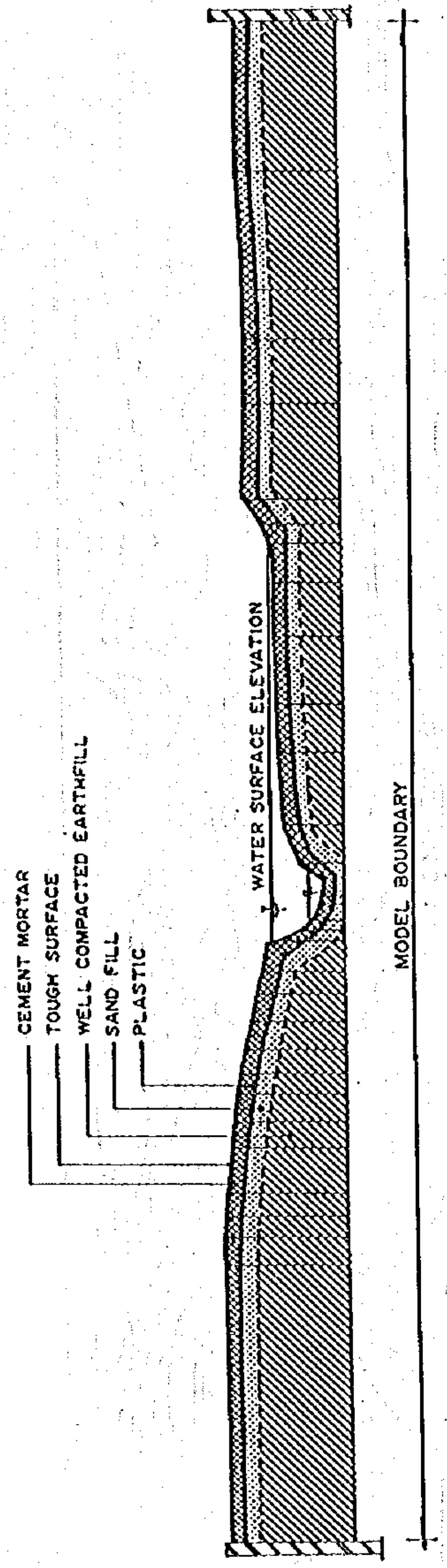
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.3.16 RESULT OF BATHYMETRIC SURVEY AND SAMPLING LOCATION
JAPAN INTERNATIONAL COOPERATION AGENCY	



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.3.17 SEABED PROFILE AROUND PERCUT RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	

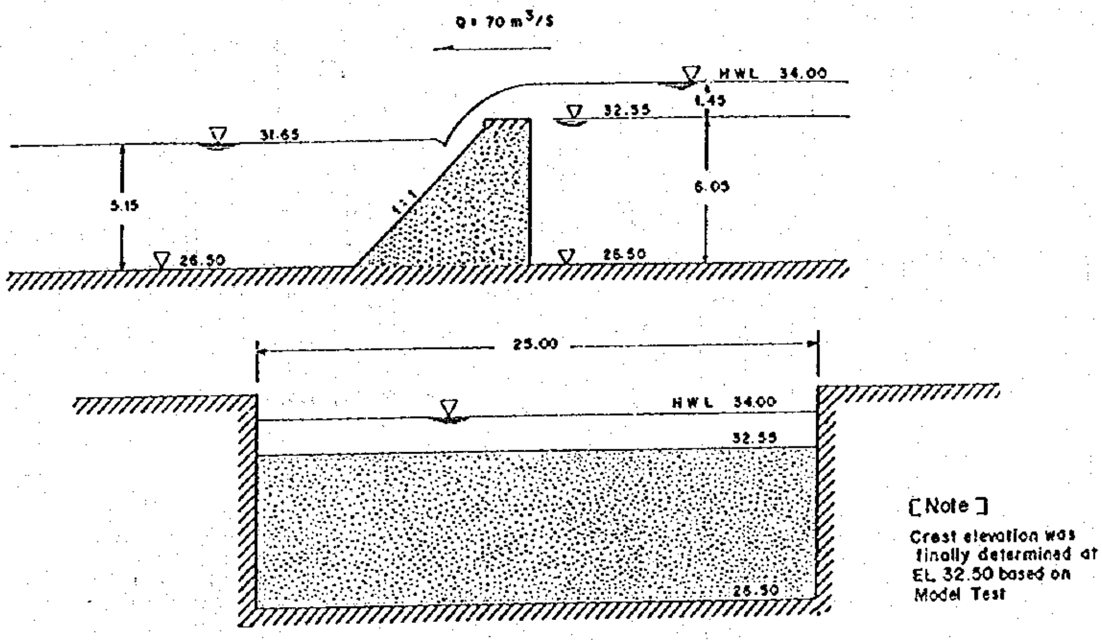


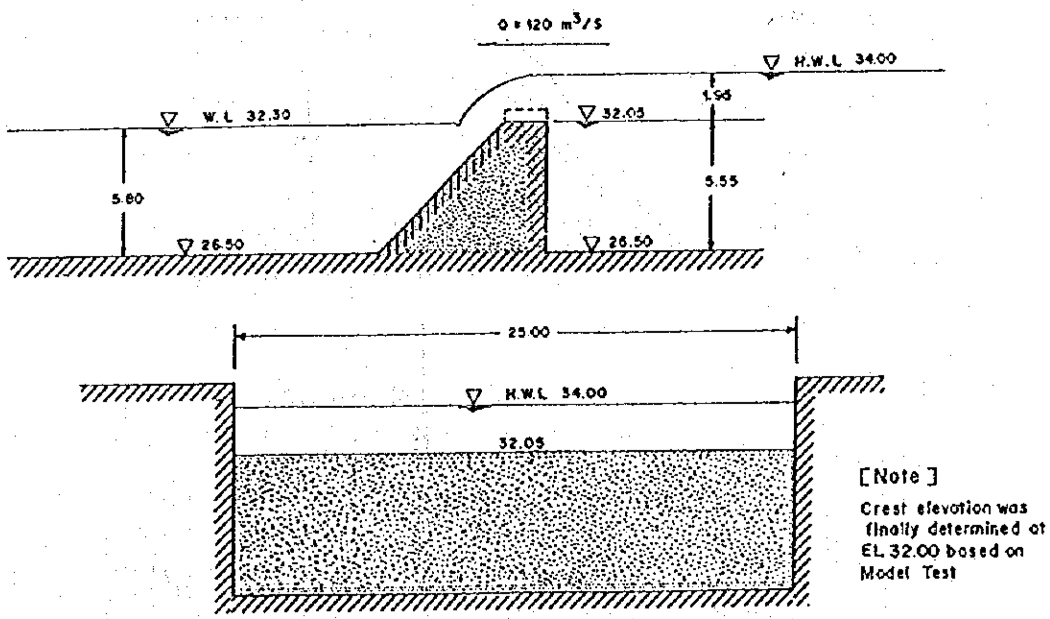
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 3.4.1 LAYOUT OF MODEL BOUNDARY



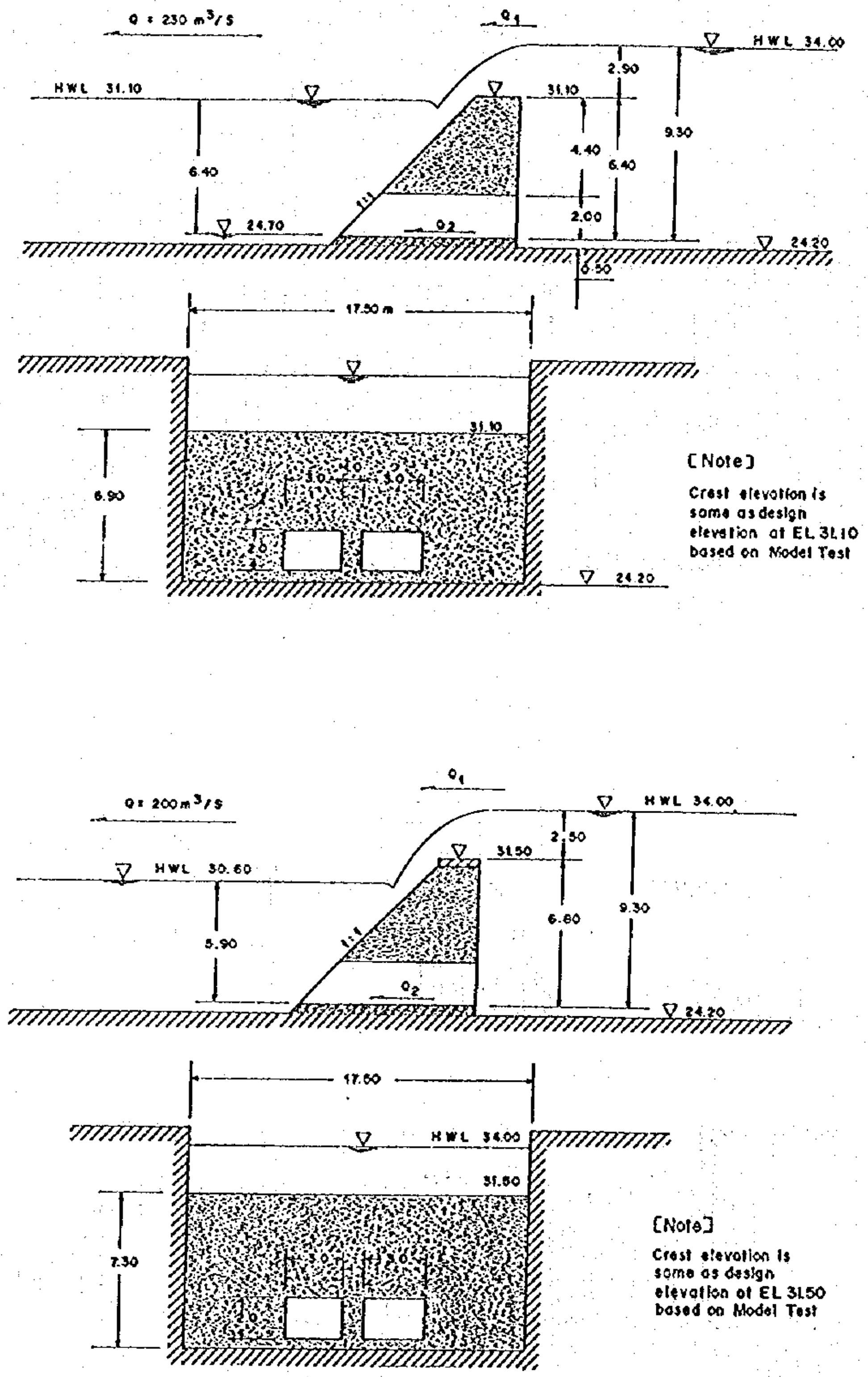
TYPICAL CROSS SECTION FOR RIVER AND FLOODWAY MODEL

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.4.2 TYPICAL CROSS SECTION FOR RIVER AND FLOODWAY MODEL
JAPAN INTERNATIONAL COOPERATION AGENCY	

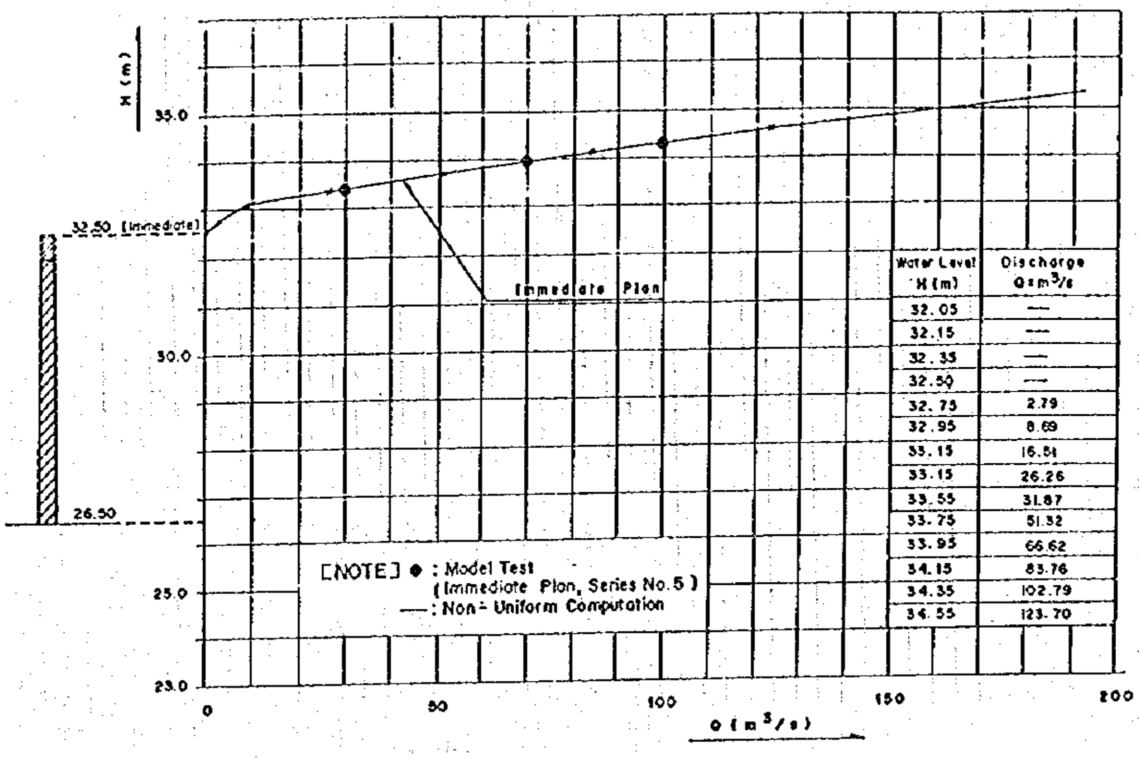




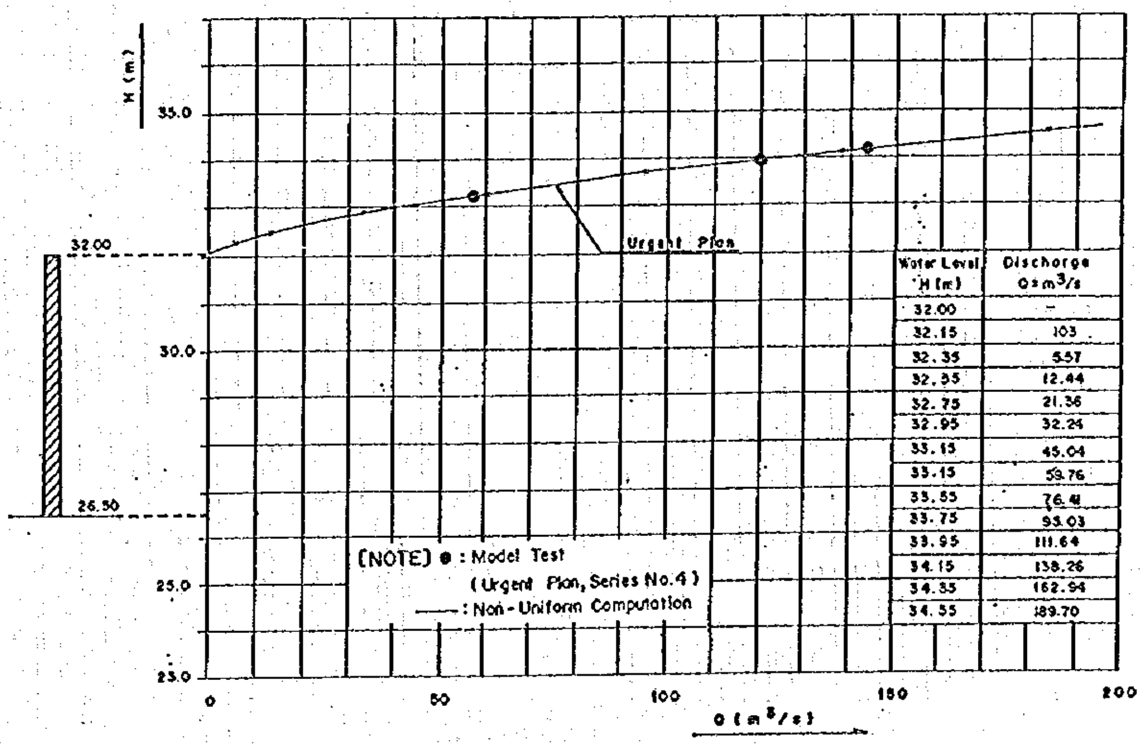
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.4.3 MODEL OF FLOODWAY WEIR
JAPAN INTERNATIONAL COOPERATION AGENCY	



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.4.4 MODEL OF DELI RIVER WEIR
JAPAN INTERNATIONAL COOPERATION AGENCY	

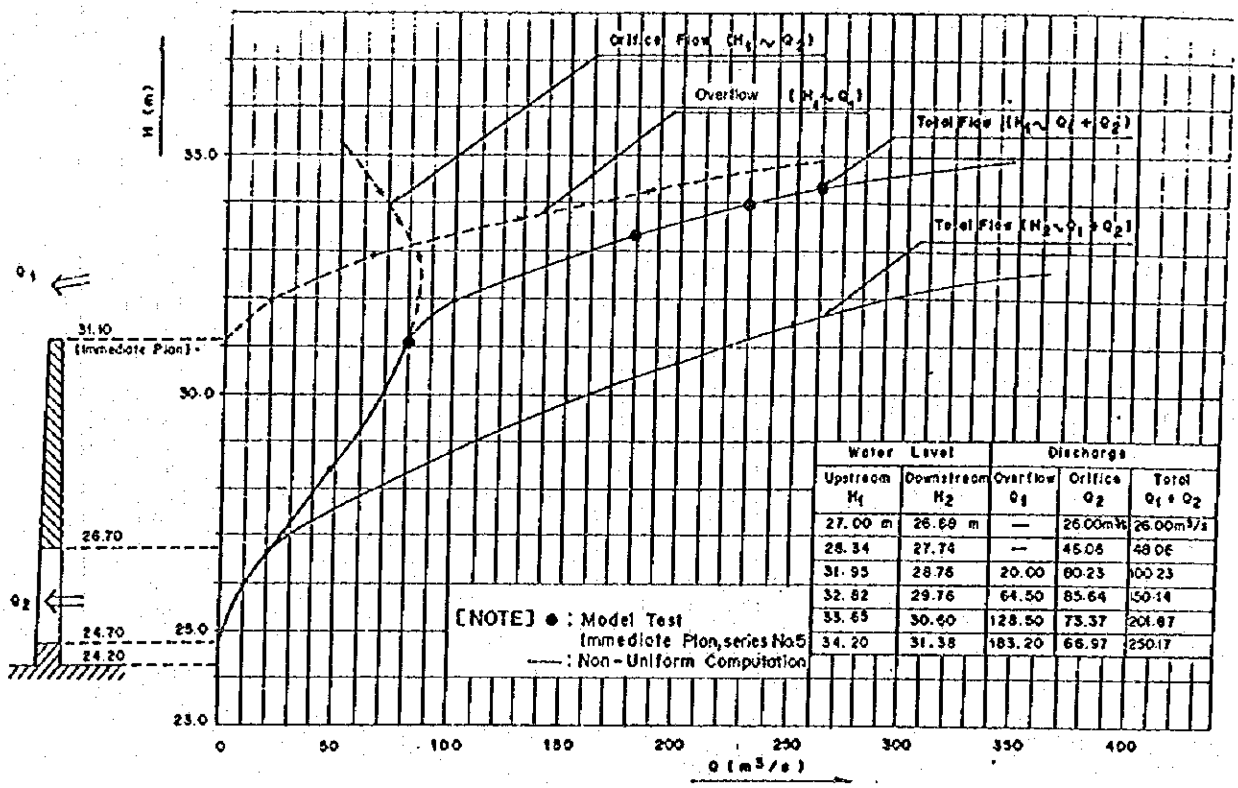


Water Level H (m)	Discharge Q m³/s
32.05	—
32.15	—
32.35	—
32.50	—
32.75	2.79
32.95	8.69
33.15	16.51
33.15	26.26
33.55	31.87
33.75	51.32
33.95	66.62
34.15	83.76
34.35	102.79
34.55	123.70

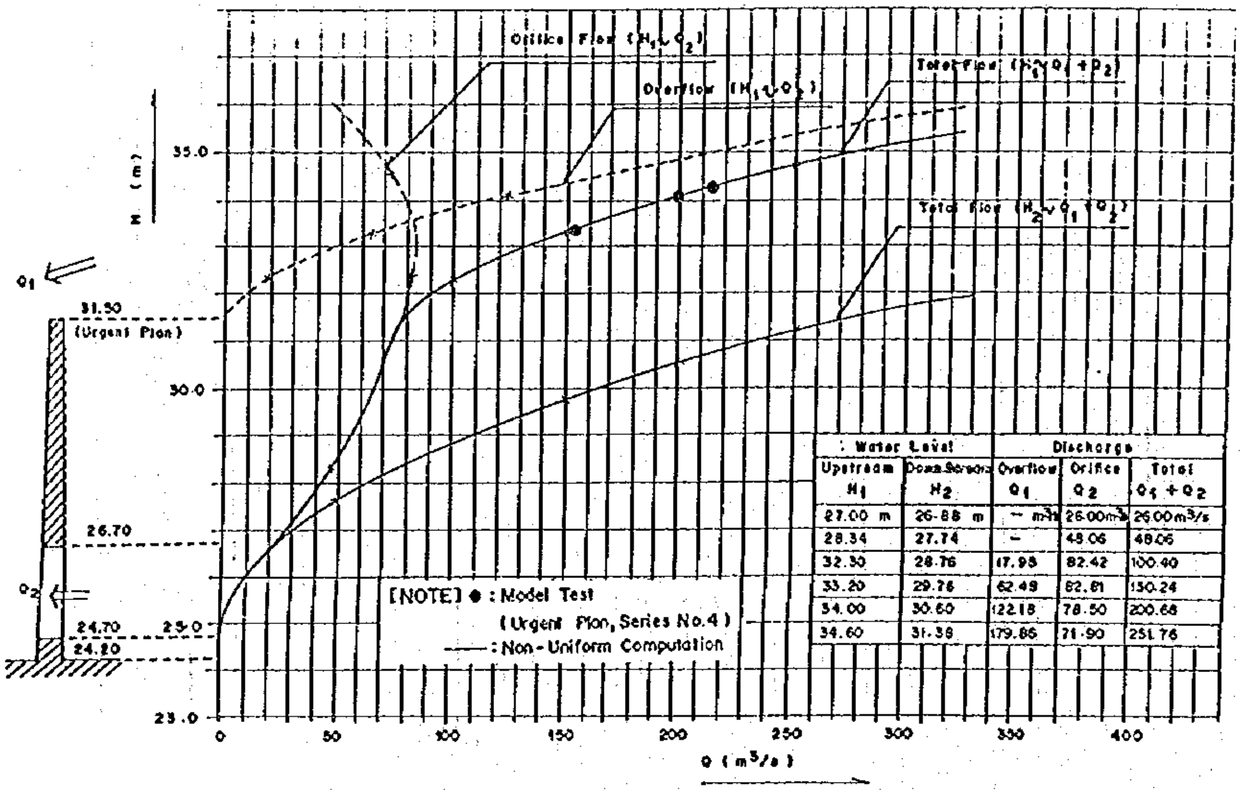


Water Level H (m)	Discharge Q m³/s
32.00	–
32.15	103
32.35	5.57
32.35	12.44
32.75	21.36
32.95	32.24
33.15	45.04
33.15	59.76
33.55	76.41
33.75	95.03
33.95	111.64
34.15	138.26
34.35	162.94
34.55	189.70

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 3.4.5 RATING CURVE OF FLOODWAY WEIR

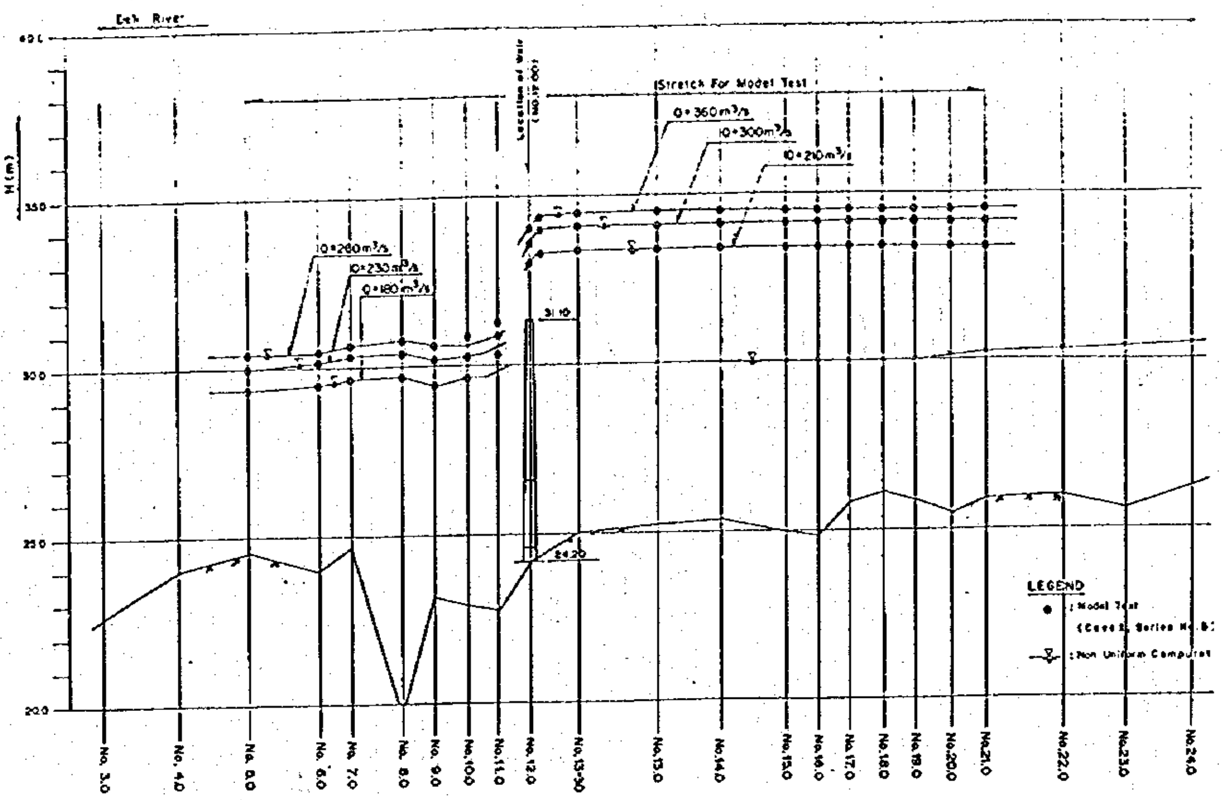


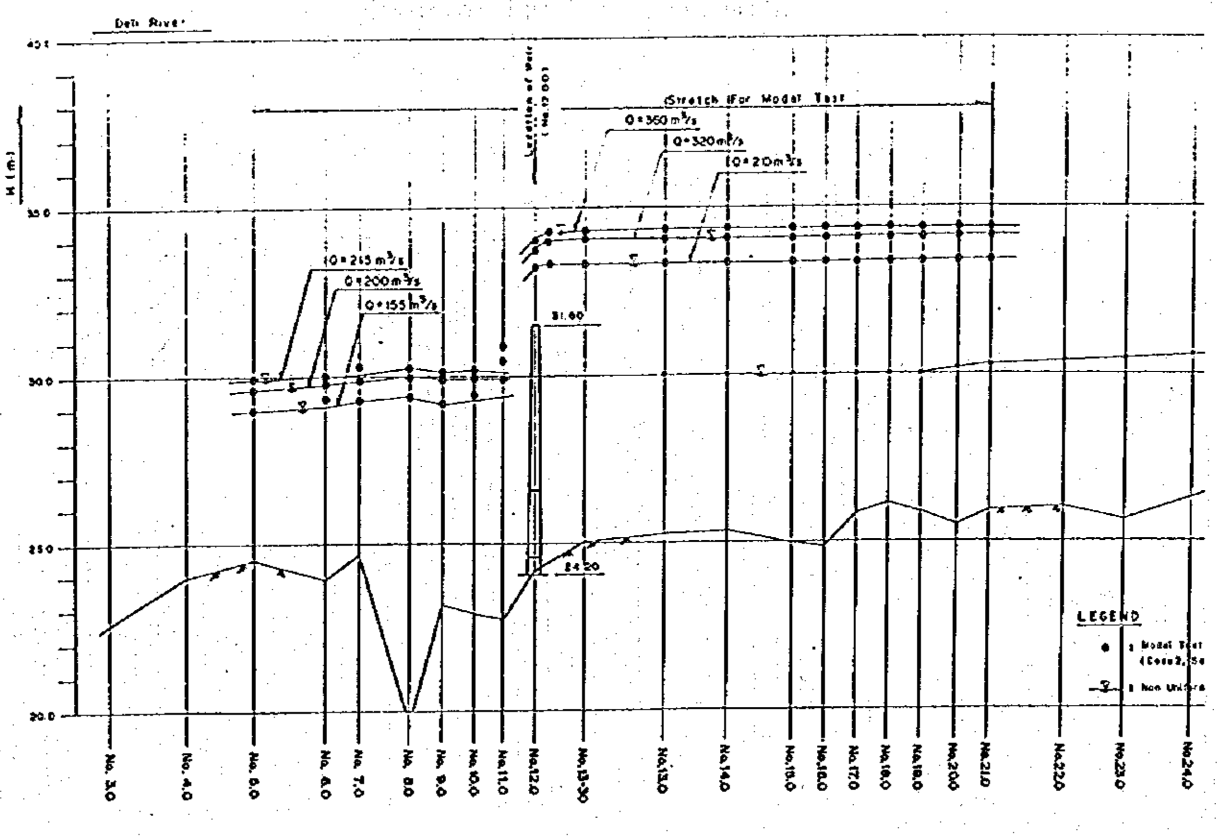
Water Level		Discharge		
Upstream H_1	Downstream H_2	Overflow Q_1	Orifice Q_2	Total $Q_1 + Q_2$
27.00 m	26.88 m	—	26.00m³/s	26.00m³/s
28.34	27.74	—	45.06	48.06
31.95	28.76	20.00	80.23	100.23
32.82	29.76	64.50	85.64	150.14
33.65	30.60	128.50	73.37	201.87
34.20	31.38	183.20	66.97	250.17



Water Level		Discharge		
Upstream H_1	Down Stream H_2	Overflow Q_1	Orifice Q_2	Total $Q_1 + Q_2$
27.00 m	26.88 m	— m³/s	26.00m³/s	26.00m³/s
28.34	27.74	—	48.06	48.06
32.30	28.76	17.98	82.42	100.40
33.20	29.76	62.49	82.81	150.24
34.00	30.60	122.18	78.50	200.68
34.60	31.38	179.86	71.90	251.76

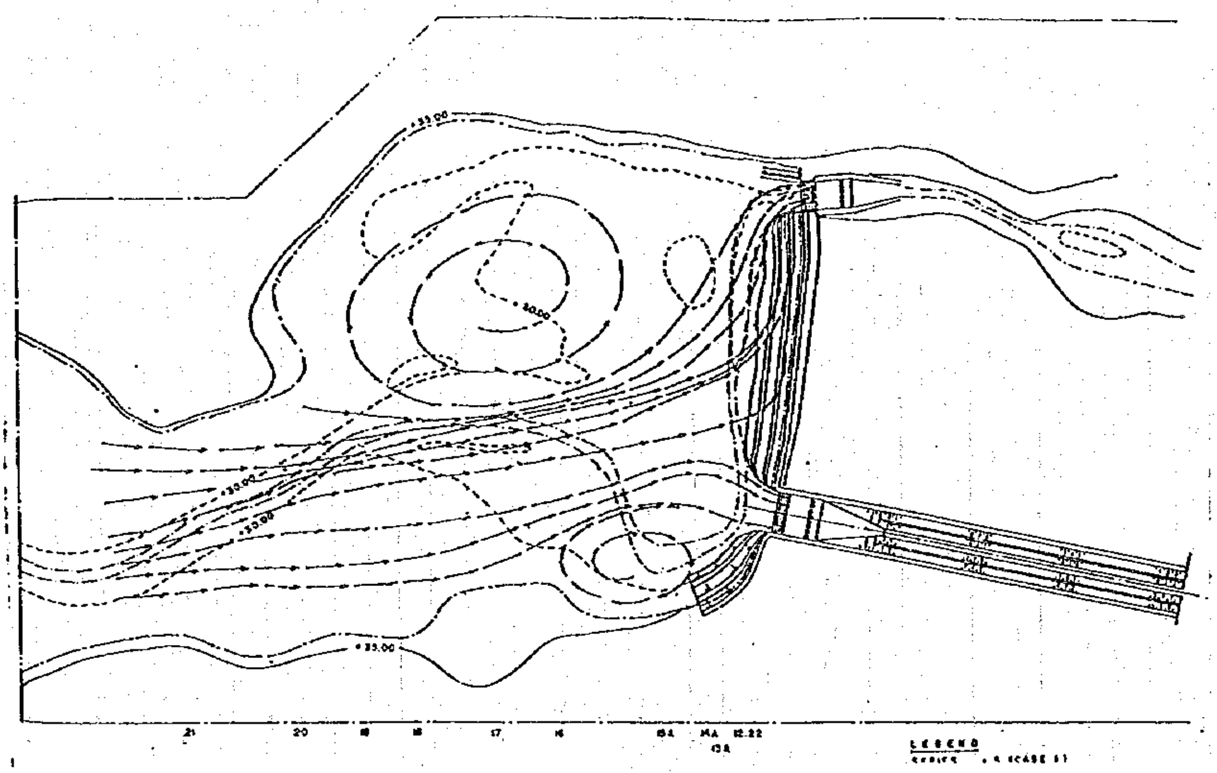
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.4.6 RATING CURVE OF DELI RIVER WEIR
JAPAN INTERNATIONAL COOPERATION AGENCY	



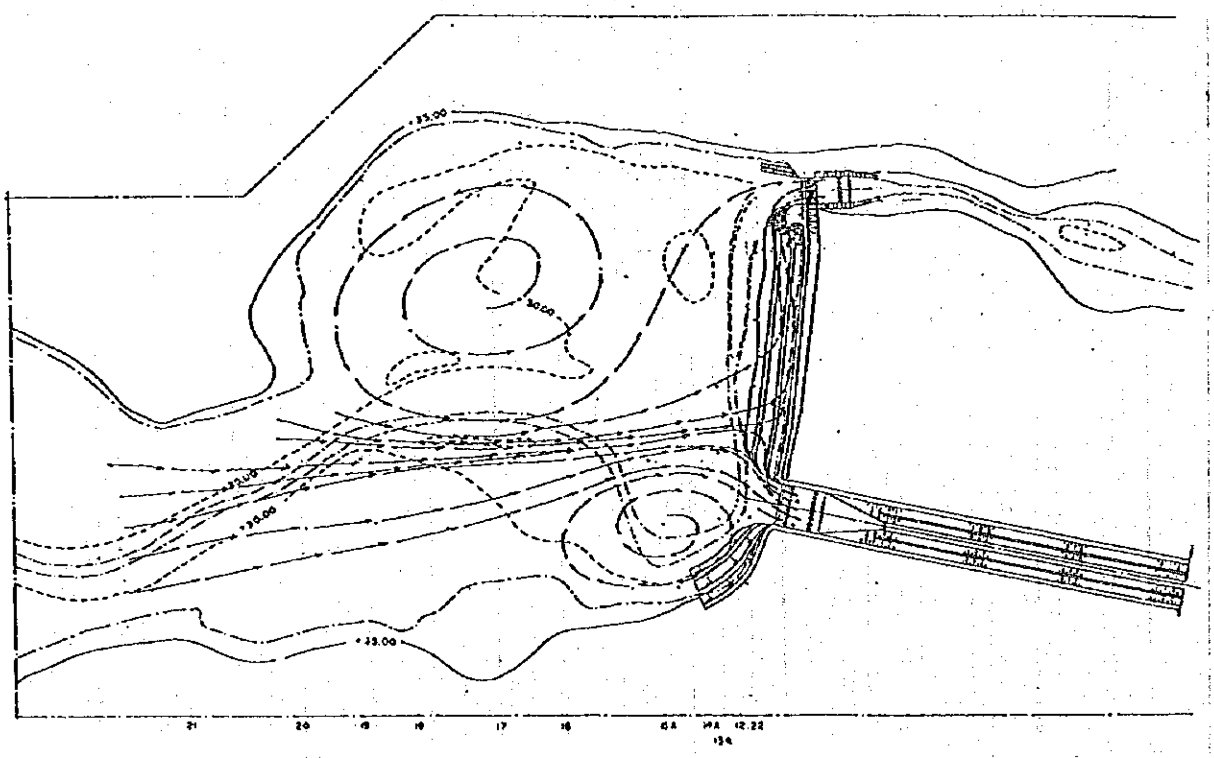


DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.4.7 WATER LEVEL PROFILE AT/AROUND DELI RIVER WIER
JAPAN INTERNATIONAL COOPERATION AGENCY	

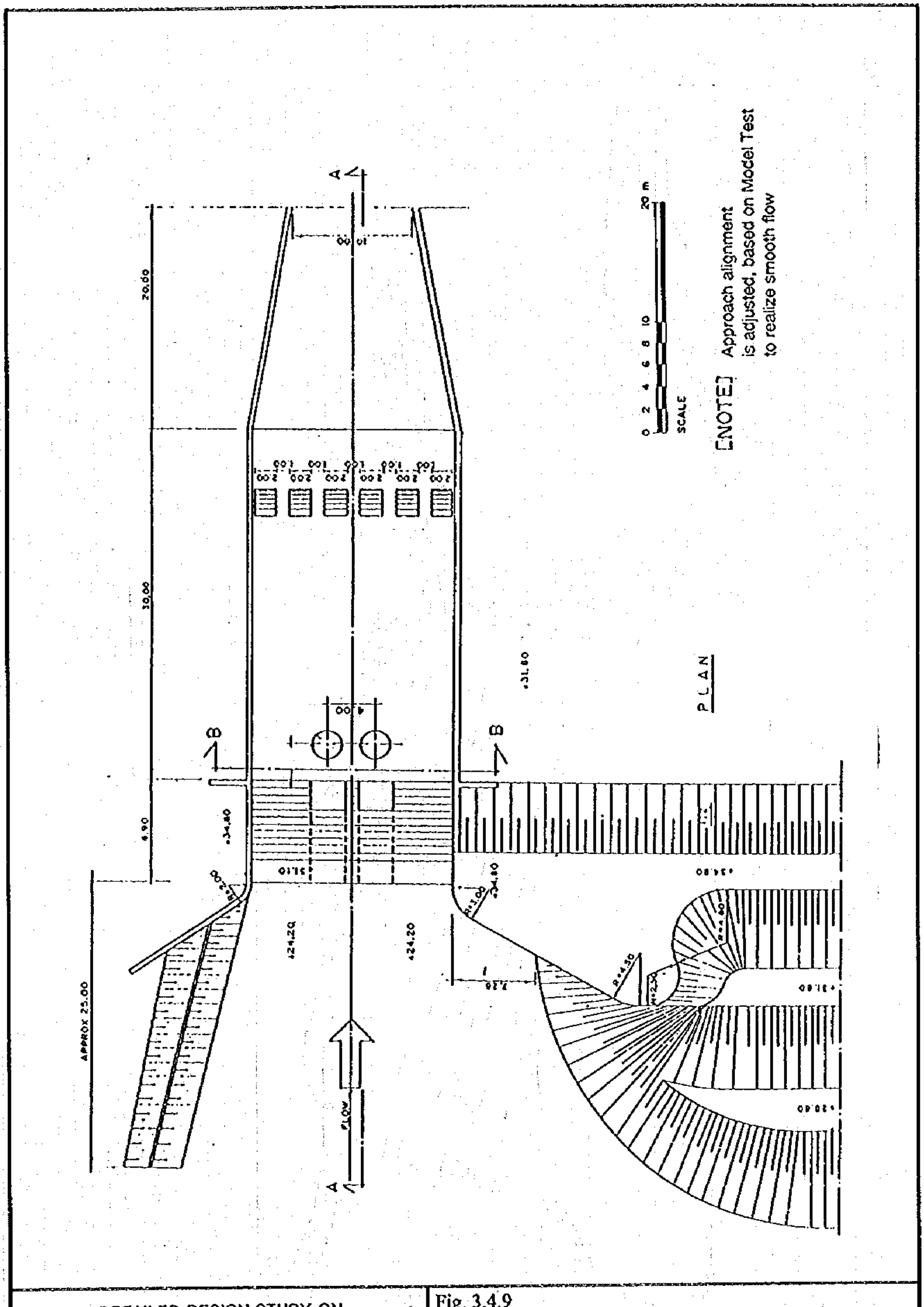
FLOW PATTERN (IMMEDIATE PLAN) – $Q = 300\ m^3/s$ –



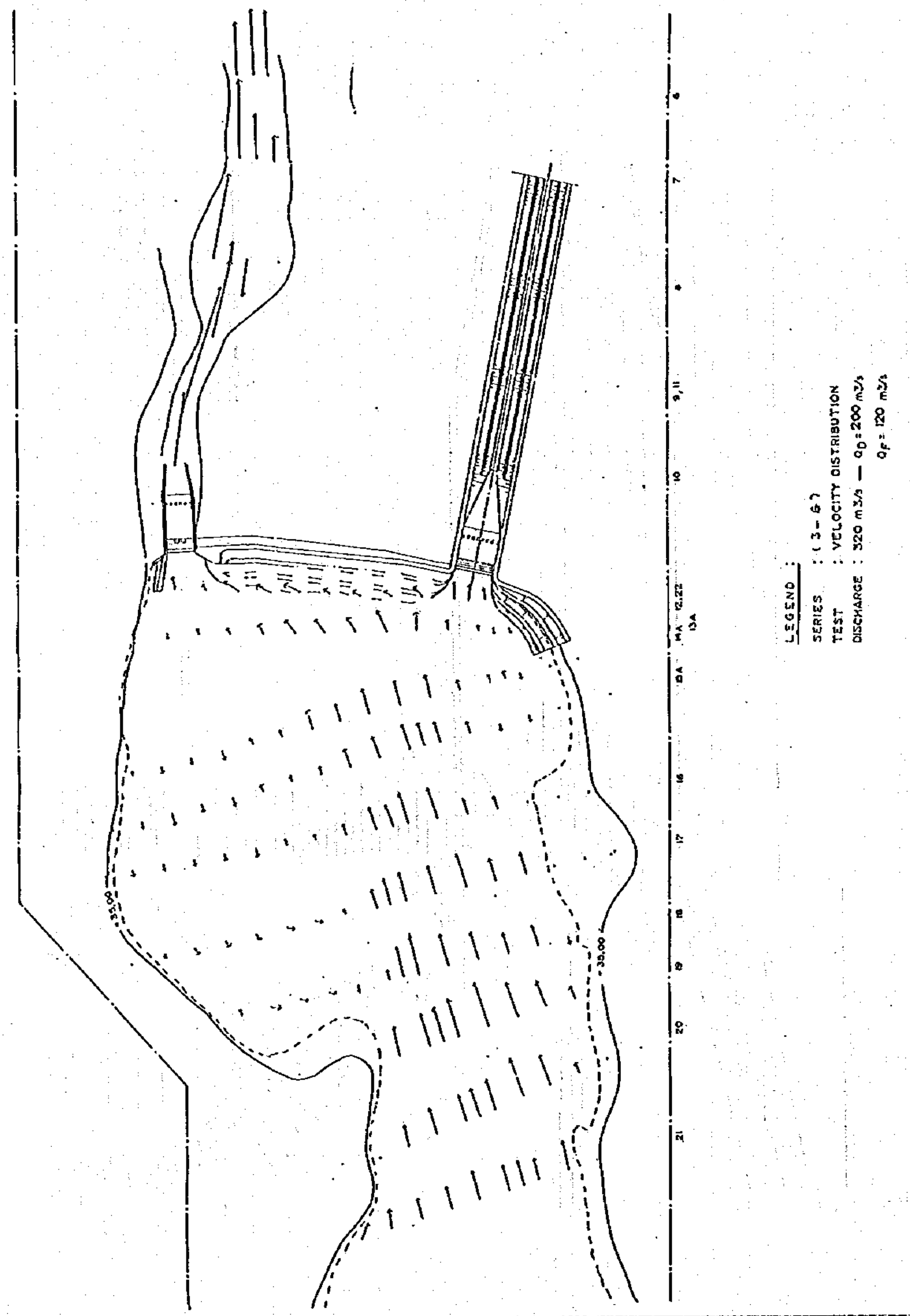
FLOW PATTERN (URGENT PLAN) – $Q = 320\ m^3/s$ –



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.4.8 FLOW PATTERN AT DIVERSION WEIRS
JAPAN INTERNATIONAL COOPERATION AGENCY	



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.4.9 FINAL APPROACH ALIGNMENT OF DELI RIVER WEIR
JAPAN INTERNATIONAL COOPERATION AGENCY	



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	Fig. 3.4 10 VELOCITY DISTRIBUTION IN UPSTREAM AREA OF WEIRS
JAPAN INTERNATIONAL COOPERATION AGENCY	

CHAPTER 4

FORMULATION OF DEFINITIVE PLAN

CHAPTER 4. FORMULATION OF DEFINITIVE PLAN

4.1 Formulation of Basic Plan

4.1.1 Flood Control Scale

Probable Flood Discharge

Through the hydrological analysis with the additionally observed rainfall for six years from 1989 to 1994 mentioned in Section 3.3 of CHAPTER 3, probable flood discharges were re-analyzed resulting in decreased values of flood discharge compared with the B-P Study results. Some of these discharges are as shown below.

(Unit: m³/s)

Return Period (Year)	Deli River (Helvetia)		Percut River (Tembung)	
	B-P Study	D/D Study	B-P Study	D/D Study
5	384	369	187	183
10	453	437	223	215
20	529	502	258	249
30	567	540	279	267
50	617	589	300	293
100	689	655	340	326

When these flood discharges obtained in both studies are upgraded, the recurrence probability could be as given below.

Deli River			Percut River		
Discharge (m^3/s)	Return Period (Year)		Discharge (m^3/s)	Return Period (Year)	
	B-P Study	D/D Study		B-P Study	D/D Study
460	10	12	230	10	12
530	20	25	260	20	25
570	30	40	280	30	40
620	50	70	300	50	70
690	100	110	340	100	110

Flood Control Works in Deli-Percut River Basin

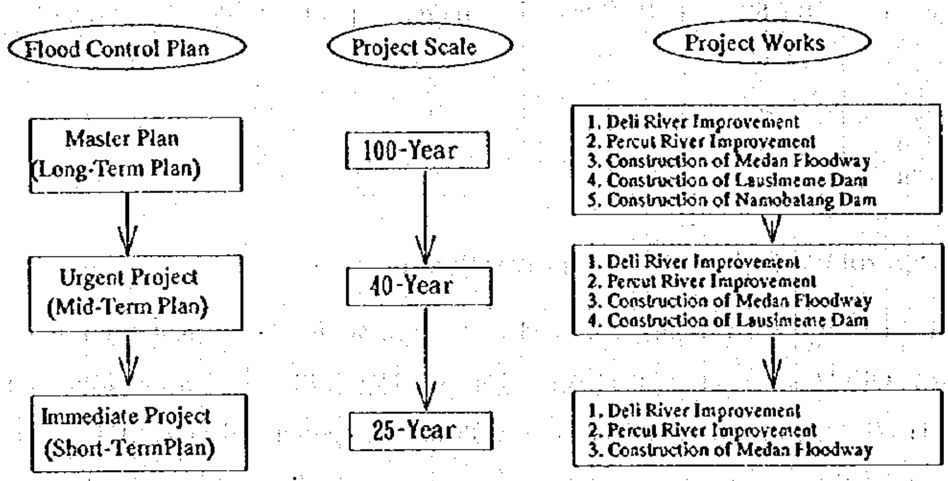
As figured out in the B-P Study, the flood control scheme for Deli-Percut River Basin is composed of the Master Plan and the Urgent Plan. The Urgent Plan is further divided into two stages. The first phase, named as the Immediate Plan, is composed of the project works of the Urgent Plan without the Lausimeme Dam in the upstream of Percut River, and the second phase consists of the construction of Lausimeme Dam.

Through the review and analysis of hydrology and flood control works undertaken, the project scales proposed are 100-year return period for the Master Plan and 40-year return period for the Urgent Plan. The Master Plan includes the construction of Namobatang Dam which is proposed in the upstream of Deli River; while, the Urgent Plan consists of only (1) the Percut River Improvement Works, (2) the construction of Medan Floodway, and (3) the construction of Lausimeme Dam, because the Deli River Improvement Works are already being carried out under the Second Medan Urban Development Project (MUDP II) on the project scale of some 10 to 15-year return period.

However, the "Flood Control Manual" (MPW/CIDA, 1993), which could be a guideline for flood control works in Indonesia, requires that the scale of flood control works in medium and big cities should not be smaller than a 25-year return period and, accordingly, all ongoing and proposed flood control projects in North Sumatra Province are designed on the project scale of more than a 25-year return period. Since the Deli River Improvement Project now being constructed under MUDP II and originally scheduled for completion by the end of 1995 is designed on the scale of a 10 to 15-year return period according to the hydrological analysis in this D/D Study, the flood control of Deli River under the Medan Flood Control Project should be assured at more than a 25-year return period. In accordance with the above, therefore, the flood control scale of the Immediate Plan is proposed to be a 25-year return period.

The configuration of the flood control scheme for the Deli-Percut River is as shown below.

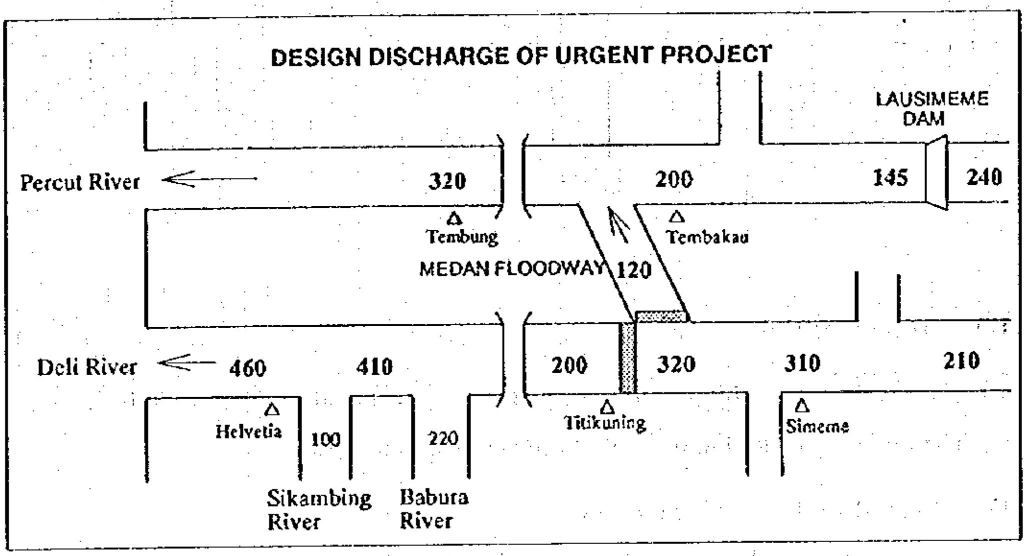
FLOOD CONTROL SCHEME



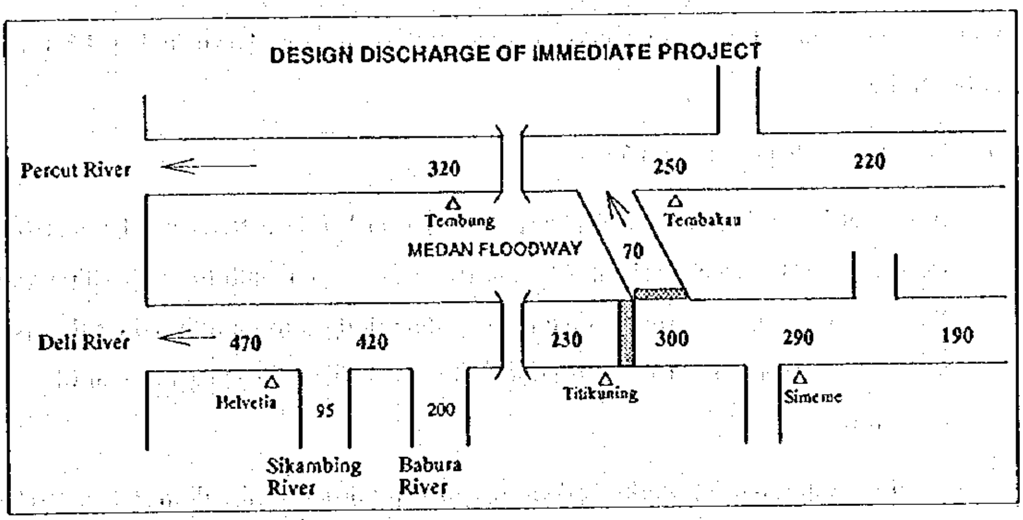
4.1.2 Design Discharge

In accordance with the newly proposed flood control scale as well as the updated probable flood discharges, the design discharges for the Urgent and Immediate projects have been estimated as graphically shown below.

For the Urgent Project:



For the Immediate Project:



Based on the design discharges for the Urgent Project, the design discharges for the Master Plan have also been figured out as shown below to attain a smooth development of the flood control plan in the area.