TABLE D-13 NONG YAI RESERVOIR OPERATION (CASE: 2) (2/5)

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 530.0 TOTAL : 1200.0

YEAR : 1983

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	21.9	0.73	0.70	0.00	0.01	3.62	0.00
	2	6.5	0.64	0.88	0.00	0.01	3.37	0.00
	3	19.7	0.60	0.50	0.00	0.01	3.46	0.00
Feb	1	0.0	0.45	0.62	0.00	0.01	3.28	0.00
	2	9.4	0.36	0.35	0.00	0.01	3.29	0.00
	3	0.0	0.23	0.43	0.00	0.01	3.07	0.00
Mar	1	0.9	0.23	0.63	0.00	0.01	2.66	0.00
	2	0.0	0.18	0.65	0.00	0.01	2.17	0.00
	3	0.2	0.16	0.67	0.00	0.01	1.65	0.00
Apr	1	0.0	0.09	0.59	0.00	0.01	1.14	0.00
	2	0.0	0.04	0.59	0.00	0.01	0.57	0.00
	3	3.0	0.02	0.57	0.00	0.01	0.00	0.00
May	1	7.1	0.07	0.47	0.00	0.01	0.00	0.00
	2	0.0	0.29	0.54	0.00	0.01	0.00	0.00
	3	102.3	0.26	0.02	0.00	0.01	0.23	0.00
Jun	1	14.8	0.38	0.35	0.00	0.01	0.24	0.00
	2	12.3	0.52	0.37	0.00	0.01	0.38	0.00
	3	82.3	2.10	0.01	0.00	0.01	2.46	0.00
Jul	1	7.0	0.91	0.39	0.00	0.01	2.97	0.00
	2	63.9	1.49	0.01	0.00	0.01	3.90	0.54
	3	94.4	0.99	0.01	0.00	0.01	3.90	0.97
Aug	1	17.8	0.91	0.27	0.00	0.01	3.90	0.62
	2	36.9	3.40	0.11	0.00	0.01	3.90	3.28
	3	22.2	1.42	0.24	0.00	0.01	3.90	1.16
Sep	1	26.1	0.77	1.06	0.00	0.01	3.59	0.00
	2	61.4	0.99	0.71	0.00	0.01	3.87	0.00
	3	48.0	1.77	0.96	0.00	0.01	3.90	0.76
Oct	1	15.8	3.13	0.70	0.00	0.01	3.90	2.41
	2	61.9	2.32	0.09	0.00	0.01	3.90	2.22
	3	111.8	4.30	0.01	0.00	0.01	3.90	4.28
Nov	1	186.3	3.96	0.00	0.00	0.01	3.90	3.94
	2	224.0	5.83	0.00	0.00	0.01	3.90	5.82
	3	0.0	1.50	1.06	0.00	0.01	3.90	0.43
Dec	1	0.0	0.91	1.13	0.00	0.01	3.67	0.00
	2	14.8	0.70	0.86	0.00	0.01	3.50	0.00
	3	57.9	0.61	0.26	0.00	0.01	3.83	0.00
TOTAL		1330.6	43.26	16.81	0.04	0.42		26.43

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 530.0 TOTAL : 1200.0

YEAR : 1984

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	6.1	0.52	0.97	0.00	0.01	3.37	0.00
	2	0.0	0.35	0.99	0.00	0.01	2.72	0.00
	3	15.9	0.39	0.56	0.00	0.01	2.53	0.00
Feb	1	100.4	0.33	0.01	0.00	0.01	2.85	0.00
	2	0.9	0.36	0.43	0.00	0.01	2.77	0.00
	3	1.9	0.20	0.41	0.00	0.01	2.54	0.00
Mar	1	0.0	0.19	0.64	0.00	0.01	2.08	0.00
	2	0.0	0.13	0.65	0.00	0.01	1.54	0.00
	3	25.7	0.11	0.43	0.00	0.01	1.21	0.00
Apr	1	0.0	0.19	0.59	0.00	0.01	0.79	0.00
	2	11.2	0.17	0.49	0.00	0.01	0.46	0.00
	3	38.7	0.20	0.24	0.00	0.01	0.41	0.00
May	1	53.6	0.28	0.05	0.00	0.01	0.63	0.00
	2	18.5	0.50	0.37	0.00	0.01	0.75	0.00
	3	7.5	0.51	0.47	0.00	0.01	0.78	0.00
Jun	1	76.1	0.56	0.01	0.00	0.01	1.31	0.00
	2	71.6	0.89	0.01	0.00	0.01	2.18	0.00
	3	149.7	8.06	0.01	0.00	0.01	3.90	6.32
Jul	1	58.4	3.20	0.01	0.00	0.01	3.90	3.17
	2	3.4	2.04	0.40	0.00	0.01	3.90	1.62
	3	18.5	1.37	0.28	0.00	0.01	3.90	1.08
Aug	1	100.4	1.65	0.01	0.00	0.01	3.90	1.63
	2	109.9	9.01	0.01	0.00	0.01	3.90	8.99
	3	99.7	6.75	0.01	0.00	0.01	3.90	6.73
Sep	1	45.0	5.47	0.74	0.00	0.01	3.90	4.72
	2	104.3	4.63	0.43	0.00	0.01	3.90	4.18
	3	32.1	4.98	1.22	0.00	0.01	3.90	3.74
Oct	1	47.7	5.59	0.18	0.00	0.01	3.90	5.40
	2	26.0	3.80	0.57	0.00	0.01	3.90	3.22
	3	167.0	4.21	0.01	0.00	0.01	3.90	4.20
Nov	1	45.9	2.02	0.28	0.00	0.01	3.90	1.73
	2	82.1	1.54	0.00	0.00	0.01	3.90	1.53
	3	70.9	1.21	0.09	0.00	0.01	3.90	1.11
Dec	1	4.6	0.95	1.05	0.00	0.01	3.78	0.00
	2	14.1	0.84	0.87	0.00	0.01	3.73	0.00
	3	73.5	1.40	0.13	0.00	0.01	3.90	1.10
TOTAL		1681.3	74.60	13.60	0.04	0.42		60.46

TABLE D-13 NONG YAI RESERVOIR OPERATION (CASE: 2) (3/5)

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 530.0 TOTAL : 1200.0

YEAR : 1985

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	10.4	0.66	0.90	0.00	0.01	3.65	0.00
	2	0.8	0.55	0.98	0.00	0.01	3.20	0.00
	3	89.9	0.59	0.01	0.00	0.01	3.77	0.00
Feb	1	2.2	0.46	0.58	0.00	0.01	3.64	0.00
	2	0.0	0.37	0.44	0.00	0.01	3.55	0.00
	3	14.4	0.24	0.31	0.00	0.01	3.47	0.00
Mar	1	19.1	0.26	0.46	0.00	0.01	3.26	0.00
	2	63.0	0.34	0.15	0.00	0.01	3.44	0.00
	3	0.0	0.28	0.67	0.00	0.01	3.04	0.00
Apr	1	15.8	0.18	0.44	0.00	0.01	2.77	0.00
	2	17.5	0.14	0.43	0.00	0.01	2.46	0.00
	3	57.7	0.49	0.10	0.00	0.01	2.84	0.00
May	1	94.7	0.39	0.01	0.00	0.01	3.21	0.00
	2	155.3	1.59	0.01	0.00	0.01	3.90	0.87
	3	37.6	0.90	0.19	0.00	0.01	3.90	0.69
Jun	1	45.3	0.51	0.07	0.00	0.01	3.90	0.44
	2	130.1	3.43	0.01	0.00	0.01	3.90	3.41
	3	70.9	7.03	0.01	0.00	0.01	3.90	7.01
Jul	1	23.8	1.51	0.23	0.00	0.01	3.90	1.26
	2	51.2	0.99	0.01	0.00	0.01	3.90	0.97
	3	9.6	1.12	0.35	0.00	0.01	3.90	0.75
Aug	1	53.0	0.80	0.01	0.00	0.01	3.90	0.78
	2	80.6	3.05	0.01	0.00	0.01	3.90	3.03
	3	42.3	3.22	0.07	0.00	0.01	3.90	3.14
Sep	1	55.6	3.55	0.62	0.00	0.01	3.90	2.91
	2	32.3	1.98	1.09	0.00	0.01	3.90	0.88
	3	48.9	1.64	0.95	0.00	0.01	3.90	0.68
Oct	1	127.3	4.45	0.01	0.00	0.01	3.90	4.43
	2	56.5	3.01	0.14	0.00	0.01	3.90	2.86
	3	36.6	1.70	0.49	0.00	0.01	3.90	1.20
Nov	1	158.1	2.55	0.00	0.00	0.01	3.90	2.53
	2	76.3	6.65	0.03	0.00	0.01	3.90	6.60
	3	20.0	1.69	0.72	0.00	0.01	3.90	0.96
Dec	1	162.9	3.81	0.01	0.00	0.01	3.90	3.80
	2	26.5	0.93	0.65	0.00	0.01	3.90	0.26
	3	0.3	0.69	1.15	0.00	0.01	3.43	0.00
TOTAL		1886.5	61.75	12.29	0.04	0.42		49.46

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 530.0 TOTAL : 1200.0

YEAR : 1986

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	4.9	0.51	0.99	0.00	0.01	2.94	0.00
	2	0.0	0.39	0.99	0.00	0.01	2.32	0.00
	3	4.0	0.33	0.77	0.00	0.01	1.87	0.00
Feb	1	2.6	0.27	0.57	0.00	0.01	1.56	0.00
	2	0.0	0.22	0.44	0.00	0.01	1.32	0.00
	3	0.0	0.15	0.43	0.00	0.01	1.02	0.00
Mar	1	11.4	0.16	0.53	0.00	0.01	0.64	0.00
	2	0.0	0.12	0.65	0.00	0.01	0.09	0.00
	3	0.0	0.10	0.67	0.00	0.01	0.00	0.00
Apr	1	2.0	0.06	0.57	0.00	0.01	0.00	0.00
	2	0.0	0.34	0.59	0.00	0.01	0.00	0.00
	3	1.2	0.07	0.59	0.00	0.01	0.00	0.00
May	1	104.6	0.58	0.01	0.00	0.01	0.56	0.00
	2	74.8	2.08	0.03	0.00	0.01	2.59	0.00
	3	68.4	1.99	0.04	0.00	0.01	3.90	0.63
Jun	1	21.3	0.73	0.29	0.00	0.01	3.90	0.43
	2	66.5	0.63	0.01	0.00	0.01	3.90	0.61
	3	78.0	4.73	0.01	0.00	0.01	3.90	4.71
Jul	1	62.3	1.63	0.01	0.00	0.01	3.90	1.61
	2	158.0	10.29	0.01	0.00	0.01	3.90	10.27
	3	22.7	3.47	0.24	0.00	0.01	3.90	3.21
Aug	1	137.1	7.31	0.01	0.00	0.01	3.90	7.28
	2	86.9	19.06	0.01	0.00	0.01	3.90	19.04
	3	9.6	4.00	0.34	0.00	0.01	3.90	3.64
Sep	1	128.2	4.06	0.30	0.00	0.01	3.90	3.75
	2	31.2	4.69	1.11	0.00	0.01	3.90	3.57
	3	70.7	7.01	0.76	0.00	0.01	3.90	6.24
Oct	1	110.1	8.42	0.01	0.00	0.01	3.90	8.40
	2	17.5	4.05	0.71	0.00	0.01	3.90	3.33
	3	136.8	3.04	0.01	0.00	0.01	3.90	3.02
Nov	1	144.3	5.34	0.00	0.00	0.01	3.90	5.32
	2	2.0	2.13	1.02	0.00	0.01	3.90	1.10
	3	42.5	1.38	0.34	0.00	0.01	3.90	1.02
Dec	1	93.6	1.14	0.01	0.00	0.01	3.90	1.12
	2	12.0	0.94	0.90	0.00	0.01	3.90	0.02
	3	34.6	0.92	0.56	0.00	0.01	3.90	0.35
TOTAL		1739.8	102.31	14.54	0.04	0.42		88.66

TABLE D-13 NONG YAI RESERVOIR OPERATION (CASE: 2) (4/5)

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 530.0 TOTAL : 1200.0

YEAR : 1987

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	13.8	0.72	0.84	0.00	0.01	3.77	0.00
	2	1.9	0.61	0.96	0.00	0.01	3.41	0.00
	3	2.1	0.56	0.80	0.00	0.01	3.16	0.00
Feb	1	0.5	0.45	0.61	0.00	0.01	2.98	0.00
	2	0.0	0.40	0.44	0.00	0.01	2.92	0.00
	3	0.0	0.28	0.43	0.00	0.01	2.76	0.00
Mar	1	37.6	0.44	0.29	0.00	0.01	2.90	0.00
	2	0.0	0.29	0.65	0.00	0.01	2.52	0.00
	3	0.0	0.22	0.67	0.00	0.01	2.06	0.00
Apr	1	0.0	0.17	0.59	0.00	0.01	1.62	0.00
	2	3.4	0.20	0.56	0.00	0.01	1.24	0.00
	3	0.1	0.18	0.60	0.00	0.01	0.81	0.00
May	1	107.0	0.43	0.01	0.00	0.01	1.22	0.00
	2	7.2	0.36	0.47	0.00	0.01	1.10	0.00
	3	100.6	0.27	0.02	0.00	0.01	1.34	0.00
Jun	1	20.1	0.46	0.30	0.00	0.01	1.49	0.00
	2	135.3	2.52	0.01	0.00	0.01	3.90	0.09
	3	30.7	2.01	0.17	0.00	0.01	3.90	1.83
Jul	1	4.8	0.97	0.41	0.00	0.01	3.90	0.55
	2	3.9	0.59	0.40	0.00	0.01	3.90	0.18
	3	32.3	0.44	0.16	0.00	0.01	3.90	0.27
Aug	1	7.9	0.42	0.36	0.00	0.01	3.90	0.05
	2	28.9	0.89	0.18	0.00	0.01	3.90	0.69
	3	98.1	3.98	0.01	0.00	0.01	3.90	3.95
Sep	1	15.4	2.61	1.25	0.00	0.01	3.90	1.35
	2	30.6	2.58	1.12	0.00	0.01	3.90	1.45
	3	37.1	1.48	1.14	0.00	0.01	3.90	0.32
Oct	1	152.8	1.07	0.01	0.00	0.01	3.90	1.05
	2	9.7	1.48	0.85	0.00	0.01	3.90	0.62
	3	110.3	1.87	0.01	0.00	0.01	3.90	1.85
Nov	1	245.1	4.72	0.00	0.00	0.01	3.90	4.70
	2	43.1	5.06	0.32	0.00	0.01	3.90	4.72
	3	52.7	2.37	0.25	0.00	0.01	3.90	2.11
Dec	1	0.4	1.64	1.13	0.00	0.01	3.90	0.50
	2	2.5	0.85	1.07	0.00	0.01	3.68	0.00
	3	2.3	0.69	1.12	0.00	0.01	3.24	0.00
TOTAL		1338.2	44.27	18.17	0.04	0.42		26.29

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 530.0 TOTAL : 1200.0

YEAR : 1988

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	16.7	0.50	0.79	0.00	0.01	2.93	0.00
	2	1.8	0.37	0.96	0.00	0.01	2.33	0.00
	3	14.5	0.34	0.59	0.00	0.01	2.06	0.00
Feb	1	0.0	0.25	0.62	0.00	0.01	1.68	0.00
	2	13.4	0.24	0.31	0.00	0.01	1.60	0.00
	3	10.8	0.20	0.34	0.00	0.01	1.44	0.00
Mar	1	9.7	0.16	0.55	0.00	0.01	1.05	0.00
	2	0.0	0.18	0.65	0.00	0.01	0.56	0.00
	3	0.4	0.20	0.67	0.00	0.01	0.08	0.00
Apr	1	57.3	0.25	0.09	0.00	0.01	0.23	0.00
	2	67.1	0.24	0.08	0.00	0.01	0.38	0.00
	3	9.7	0.22	0.51	0.00	0.01	0.07	0.00
May	1	41.2	0.63	0.15	0.00	0.01	0.54	0.00
	2	55.8	0.60	0.04	0.00	0.01	1.08	0.00
	3	16.0	0.55	0.39	0.00	0.01	1.22	0.00
Jun	1	109.4	5.40	0.01	0.00	0.01	3.90	2.70
	2	98.3	3.87	0.01	0.00	0.01	3.90	3.85
	3	3.5	1.65	0.43	0.00	0.01	3.90	1.21
Jul	1	45.1	1.25	0.05	0.00	0.01	3.90	1.19
	2	50.6	3.22	0.01	0.00	0.01	3.90	3.20
	3	83.2	2.14	0.01	0.00	0.01	3.90	2.12
Aug	1	3.6	1.37	0.40	0.00	0.01	3.90	0.96
	2	32.5	1.13	0.15	0.00	0.01	3.90	0.97
	3	97.9	2.12	0.01	0.00	0.01	3.90	2.10
Sep	1	22.5	1.25	1.12	0.00	0.01	3.90	0.11
	2	66.0	1.48	0.67	0.00	0.01	3.90	0.80
	3	78.1	3.97	0.70	0.00	0.01	3.90	3.26
Oct	1	79.6	5.50	0.01	0.00	0.01	3.90	5.48
	2	77.1	7.13	0.01	0.00	0.01	3.90	7.11
	3	28.0	4.13	0.64	0.00	0.01	3.90	3.48
Nov	1	40.5	1.66	0.34	0.00	0.01	3.90	1.31
	2	187.3	7.14	0.00	0.00	0.01	3.90	7.13
	3	306.9	17.63	0.00	0.00	0.01	3.90	17.62
Dec	1	2.0	3.11	1.10	0.00	0.01	3.90	2.00
	2	0.9	1.85	1.09	0.00	0.01	3.90	0.74
	3	4.9	1.47	1.07	0.00	0.01	3.90	0.39
TOTAL		1732.3	83.39	14.55	0.04	0.42		67.72

TABLE D - 13 NONG YAI RESERVOIR OPERATION (CASE: 2) (5/5)

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 530.0 TOTAL : 1200.0

YEAR : 1989

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	9.3	1.05	0.92	0.00	0.01	3.90	0.12
	2	28.7	0.87	0.50	0.00	0.01	3.90	0.36
	3	137.1	1.00	0.01	0.00	0.01	3.90	0.98
Feb	1	0.6	0.66	0.61	0.00	0.01	3.90	0.04
	2	19.3	0.71	0.26	0.00	0.01	3.90	0.43
	3	0.7	0.41	0.42	0.00	0.01	3.87	0.00
Mar	1	142.8	1.33	0.11	0.00	0.01	3.90	1.19
	2	0.6	0.69	0.65	0.00	0.01	3.90	0.03
	3	14.9	0.47	0.53	0.00	0.01	3.82	0.00
Apr	1	35.2	0.56	0.26	0.00	0.01	3.90	0.21
	2	59.1	0.85	0.09	0.00	0.01	3.90	0.75
	3	0.0	0.44	0.60	0.00	0.01	3.72	0.00
May	1	88.8	0.51	0.02	0.00	0.01	3.90	0.31
	2	83.6	0.96	0.02	0.00	0.01	3.90	0.93
	3	100.1	7.40	0.02	0.00	0.01	3.90	7.36
Jun	1	67.1	2.11	0.02	0.00	0.01	3.90	2.08
	2	18.3	1.90	0.31	0.00	0.01	3.90	1.58
	3	108.7	6.77	0.01	0.00	0.01	3.90	6.75
Jul	1	5.5	2.17	0.40	0.00	0.01	3.90	1.76
	2	135.7	1.64	0.01	0.00	0.01	3.90	1.61
	3	109.6	7.81	0.01	0.00	0.01	3.90	7.79
Aug	1	101.2	3.79	0.01	0.00	0.01	3.90	3.77
	2	52.5	8.48	0.01	0.00	0.01	3.90	8.46
	3	50.6	9.22	0.01	0.00	0.01	3.90	9.20
Sep	1	88.7	5.41	0.34	0.00	0.01	3.90	5.06
	2	32.5	4.50	1.08	0.00	0.01	3.90	3.40
	3	44.8	5.38	1.01	0.00	0.01	3.90	4.36
Oct	1	23.4	3.43	0.57	0.00	0.01	3.90	2.85
	2	27.2	5.40	0.55	0.00	0.01	3.90	4.84
	3	91.5	3.71	0.01	0.00	0.01	3.90	3.69
Nov	1	288.3	19.12	0.00	0.00	0.01	3.90	19.10
	2	125.8	11.49	0.00	0.00	0.01	3.90	11.47
	3	21.8	3.94	0.69	0.00	0.01	3.90	3.24
Dec	1	0.0	2.63	1.13	0.00	0.01	3.90	1.48
	2	18.1	2.02	0.80	0.00	0.01	3.90	1.20
	3	10.3	1.82	0.98	0.00	0.01	3.90	0.82
TOTAL		2142.4	130.63	12.95	0.04	0.42		117.22

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 530.0 TOTAL : 1200.0

YEAR : 1990

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	5.6	1.44	0.98	0.00	0.01	3.90	0.45
	2	11.1	1.28	0.80	0.00	0.01	3.90	0.47
	3	9.9	1.24	0.67	0.00	0.01	3.90	0.56
Feb	1	10.9	1.00	0.43	0.00	0.01	3.90	0.56
	2	0.2	0.91	0.44	0.00	0.01	3.90	0.46
	3	0.0	0.61	0.43	0.00	0.01	3.90	0.17
Mar	1	0.6	0.71	0.63	0.00	0.01	3.90	0.06
	2	1.9	0.66	0.64	0.00	0.01	3.90	0.02
	3	0.0	0.69	0.67	0.00	0.01	3.90	0.00
Apr	1	4.8	0.54	0.54	0.00	0.01	3.88	0.00
	2	2.4	0.87	0.57	0.00	0.01	3.90	0.27
	3	36.8	0.76	0.26	0.00	0.01	3.90	0.50
May	1	4.9	0.65	0.49	0.00	0.01	3.90	0.14
	2	75.7	1.59	0.03	0.00	0.01	3.90	1.55
	3	85.2	2.59	0.02	0.00	0.01	3.90	2.56
Jun	1	84.5	2.13	0.01	0.00	0.01	3.90	2.11
	2	32.4	2.47	0.18	0.00	0.01	3.90	2.28
	3	21.5	1.81	0.26	0.00	0.01	3.90	1.53
Jul	1	14.0	1.74	0.32	0.00	0.01	3.90	1.41
	2	9.7	1.76	0.35	0.00	0.01	3.90	1.40
	3	21.9	1.93	0.25	0.00	0.01	3.90	1.67
Aug	1	15.1	1.40	0.30	0.00	0.01	3.90	1.09
	2	56.9	3.69	0.01	0.00	0.01	3.90	3.67
	3	123.6	9.26	0.01	0.00	0.01	3.90	9.23
Sep	1	19.6	5.22	1.17	0.00	0.01	3.90	4.04
	2	30.7	4.81	1.11	0.00	0.01	3.90	3.68
	3	50.5	5.99	0.94	0.00	0.01	3.90	5.04
Oct	1	71.0	9.27	0.01	0.00	0.01	3.90	9.25
	2	32.1	6.09	0.46	0.00	0.01	3.90	5.61
	3	243.2	8.88	0.01	0.00	0.01	3.90	8.86
Nov	1	224.1	13.23	0.00	0.00	0.01	3.90	13.21
	2	31.9	10.37	0.51	0.00	0.01	3.90	9.85
	3	97.7	6.72	0.00	0.00	0.01	3.90	6.71
Dec	1	20.7	2.31	0.78	0.00	0.01	3.90	1.52
	2	1.8	1.99	1.08	0.00	0.01	3.90	0.89
	3	14.3	1.77	0.91	0.00	0.01	3.90	0.84
TOTAL		1467.2	118.35	16.25	0.04	0.42		101.63

TABLE D-14 DESIGN CAPACITY OF IRRIGATION FACILITY (1/4)

WATER DUTY FOR IRRIGATION CANAL (BLOCK A)

MONTH	NET IRRIGATION REQUIREMENT (mm/10 days)				IRRIGABLE AREA (ha)				REQUIRED WATER
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 1	TYPE 2	TYPE 3	TYPE 4	
	0.55	0.55	0.50	0.50	60	6	17	20	(l/s)
	57.1	57.1	36.1	49.6	144.2	14.4	28.4	46.0	233.0
Jan.	49.6	49.6	36.1	49.6	125.3	12.5	28.4	45.9	212.1
	36.1	36.1	36.1	49.7	91.2	9.1	28.4	46.0	174.7
	16.4	16.4	36.7	50.5	41.4	4.1	28.9	46.8	121.3
Feb.	1.0	1.0	36.7	50.5	2.5	0.3	28.9	46.8	78.4
	0.0	0.0	36.8	50.6	0.0	0.0	29.0	46.9	75.8
	0.0	96.8	45.5	62.6	0.0	24.4	35.8	57.9	118.2
Mar.	0.0	110.8	45.5	62.6	0.0	28.0	35.8	58.0	121.8
	0.0	130.0	45.5	62.5	0.0	32.8	35.8	57.9	126.5
	0.0	68.3	44.0	60.5	0.0	17.2	34.6	56.0	107.9
Apr.	0.0	73.3	44.0	60.5	0.0	18.5	34.6	56.0	109.2
	0.0	78.2	44.0	60.5	0.0	19.7	34.6	56.0	110.4
	0.0	71.4	39.4	54.2	0.0	18.0	31.0	50.2	99.2
May	0.0	71.4	39.4	54.2	0.0	18.0	31.0	50.2	99.2
	0.0	75.9	39.4	54.2	0.0	19.2	31.0	50.2	100.4
	0.0	60.4	36.2	49.8	0.0	15.3	28.5	46.1	89.8
Jun.	0.0	52.3	36.2	49.8	0.0	13.2	28.5	46.1	87.8
	0.0	34.0	36.2	49.7	0.0	8.6	28.5	46.0	83.1
	0.0	15.3	37.1	51.0	0.0	3.9	29.2	47.3	80.3
Jul.	0.0	0.9	37.1	51.0	0.0	0.2	29.2	47.2	76.6
	0.0	0.0	37.2	51.1	0.0	0.0	29.3	47.3	76.6
	0.0	0.0	36.4	50.1	0.0	0.0	28.7	46.4	75.1
Aug.	0.0	0.0	36.4	50.1	0.0	0.0	28.6	46.4	75.0
	0.0	0.0	36.5	50.1	0.0	0.0	28.7	46.4	75.1
	95.6	95.6	35.4	48.7	241.4	24.1	27.9	45.1	338.5
Sep.	107.0	107.0	35.4	48.7	270.2	27.0	27.9	45.1	370.2
	118.8	118.8	35.4	48.6	300.0	30.0	27.9	45.0	402.9
	50.6	50.6	33.8	46.5	127.8	12.8	26.6	43.1	210.3
Oct.	53.9	53.9	33.8	46.5	136.1	13.6	26.6	43.1	219.4
	62.9	62.9	33.9	46.6	158.8	15.9	26.7	43.1	244.6
	58.0	58.0	31.4	43.2	146.5	14.6	24.7	40.0	225.8
Nov.	59.9	59.9	31.4	43.2	151.3	15.1	24.7	40.0	231.1
	60.7	60.7	31.4	43.1	153.3	15.3	24.7	39.9	233.2
	63.8	63.8	34.4	47.3	161.1	16.1	27.1	43.8	248.1
Dec.	61.7	61.7	34.4	47.3	155.8	15.6	27.1	43.8	242.3
	65.6	65.6	34.5	47.4	165.7	16.6	27.2	43.9	253.3
Total	1018.7	1957.7	1339.9	1842.1				Max	402.9

NOTE: TYPE 1, 2, 3, 4: Q (l/s) = NET.R (mm/10days)* AREA (ha) / IEF / 43.2

WATER DUTY FOR IRRIGATION CANAL (BLOCK B)

MONTH	NET IRRIGATION REQUIREMENT (mm/10 days)				IRRIGABLE AREA (ha)				REQUIRED WATER
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 1	TYPE 2	TYPE 3	TYPE 4	
	0.55	0.55	0.50	0.50	96	10	36	10	(l/s)
	57.1	57.1	36.1	49.6	230.7	24.0	60.2	23.0	337.9
Jan.	49.6	49.6	36.1	49.6	200.4	20.9	60.2	23.0	304.4
	36.1	36.1	36.1	49.7	145.9	15.2	60.2	23.0	244.2
	16.4	16.4	36.7	50.5	66.3	6.9	61.2	23.4	157.8
Feb.	1.0	1.0	36.7	50.5	4.0	0.4	61.2	23.4	89.0
	0.0	0.0	36.8	50.6	0.0	0.0	61.3	23.4	84.8
	0.0	96.8	45.5	62.6	0.0	40.7	75.8	29.0	145.5
Mar.	0.0	110.8	45.5	62.6	0.0	46.6	75.8	29.0	151.4
	0.0	130.0	45.5	62.5	0.0	54.7	75.8	28.9	159.5
	0.0	68.3	44.0	60.5	0.0	28.7	73.3	28.0	130.1
Apr.	0.0	73.3	44.0	60.5	0.0	30.9	73.3	28.0	132.2
	0.0	78.2	44.0	60.5	0.0	32.9	73.3	28.0	134.3
	0.0	71.4	39.4	54.2	0.0	30.1	65.7	25.1	120.8
May	0.0	71.4	39.4	54.2	0.0	30.1	65.7	25.1	120.8
	0.0	75.9	39.4	54.2	0.0	31.9	65.7	25.1	122.7
	0.0	60.4	36.2	49.8	0.0	25.4	60.3	23.0	108.8
Jun.	0.0	52.3	36.2	49.8	0.0	22.0	60.3	23.1	105.4
	0.0	34.0	36.2	49.7	0.0	14.3	60.3	23.0	97.7
	0.0	15.3	37.1	51.0	0.0	6.4	61.9	23.6	92.0
Jul.	0.0	0.9	37.1	51.0	0.0	0.4	61.8	23.6	85.8
	0.0	0.0	37.2	51.1	0.0	0.0	62.0	23.7	85.7
	0.0	0.0	36.4	50.1	0.0	0.0	60.7	23.2	83.9
Aug.	0.0	0.0	36.4	50.1	0.0	0.0	60.7	23.2	83.9
	0.0	0.0	36.5	50.1	0.0	0.0	60.8	23.2	84.0
	95.6	95.6	35.4	48.7	386.3	40.2	59.0	22.5	508.0
Sep.	107.0	107.0	35.4	48.7	432.3	45.0	59.0	22.5	558.9
	118.8	118.8	35.4	48.6	480.0	50.0	59.0	22.5	611.5
	50.6	50.6	33.8	46.5	204.4	21.3	56.4	21.5	303.7
Oct.	53.9	53.9	33.8	46.5	217.8	22.7	56.3	21.5	318.3
	62.9	62.9	33.9	46.6	254.1	26.5	56.5	21.6	358.7
	58.0	58.0	31.4	43.2	234.3	24.4	52.3	20.0	331.1
Nov.	59.9	59.9	31.4	43.2	242.0	25.2	52.3	20.0	339.6
	60.7	60.7	31.4	43.1	245.3	25.5	52.3	20.0	343.1
	63.8	63.8	34.4	47.3	257.8	26.9	57.4	21.9	363.9
Dec.	61.7	61.7	34.4	47.3	249.3	26.0	57.3	21.9	354.5
	65.6	65.6	34.5	47.4	265.1	27.6	57.5	21.9	372.1
Total	1018.7	1957.7	1339.9	1842.1				Max	611.5

NOTE: TYPE 1, 2, 3, 4: Q (l/s) = NET.R (mm/10days)* AREA (ha) / IEF / 43.2

TABLE D - 14 DESIGN CAPACITY OF IRRIGATION FACILITY (2/4)

WATER DUTY FOR IRRIGATION CANAL (BLOCK C)

MONTH	NET IRRIGATION REQUIREMENT (mm/10 days)				IRRIGABLE AREA (ha)				REQUIRED
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 1	TYPE 2	TYPE 3	TYPE 4	WATER
	0.55	0.55	0.50	0.50	13	1	38	10	(l/s)
	57.1	57.1	36.1	49.6	31.2	2.4	63.5	23.0	120.1
Jan.	49.6	49.6	36.1	49.6	27.1	2.1	63.5	23.0	115.7
	36.1	36.1	36.1	49.7	19.8	1.5	63.5	23.0	107.8
	16.4	16.4	36.7	50.5	9.0	0.7	64.6	23.4	97.7
Feb.	1.0	1.0	36.7	50.5	0.5	0.0	64.6	23.4	88.5
	0.0	0.0	36.8	50.6	0.0	0.0	64.7	23.4	88.2
	0.0	96.8	45.5	62.6	0.0	4.1	80.0	29.0	113.1
Mar.	0.0	110.8	45.5	62.6	0.0	4.7	80.0	29.0	113.7
	0.0	130.0	45.5	62.5	0.0	5.5	80.0	28.9	114.5
	0.0	68.3	44.0	60.5	0.0	2.9	77.4	28.0	108.3
Apr.	0.0	73.3	44.0	60.5	0.0	3.1	77.4	28.0	108.5
	0.0	78.2	44.0	60.5	0.0	3.3	77.4	28.0	108.7
	0.0	71.4	39.4	54.2	0.0	3.0	69.3	25.1	97.4
May	0.0	71.4	39.4	54.2	0.0	3.0	69.3	25.1	97.4
	0.0	75.9	39.4	54.2	0.0	3.2	69.3	25.1	97.6
	0.0	60.4	36.2	49.8	0.0	2.5	63.7	23.0	89.3
Jun.	0.0	52.3	36.2	49.8	0.0	2.2	63.7	23.1	88.9
	0.0	34.0	36.2	49.7	0.0	1.4	63.7	23.0	88.1
	0.0	15.3	37.1	51.0	0.0	0.6	65.3	23.6	89.6
Jul.	0.0	0.9	37.1	51.0	0.0	0.0	65.3	23.6	88.9
	0.0	0.0	37.2	51.1	0.0	0.0	65.4	23.7	89.1
	0.0	0.0	36.4	50.1	0.0	0.0	64.1	23.2	87.3
Aug.	0.0	0.0	36.4	50.1	0.0	0.0	64.0	23.2	87.2
	0.0	0.0	36.5	50.1	0.0	0.0	64.2	23.2	87.4
	95.6	95.6	35.4	48.7	52.3	4.0	62.3	22.5	141.1
Sep.	107.0	107.0	35.4	48.7	58.5	4.5	62.3	22.5	147.9
	118.8	118.8	35.4	48.6	65.0	5.0	62.3	22.5	154.8
	50.6	50.6	33.8	46.5	27.7	2.1	59.5	21.5	110.9
Oct.	53.9	53.9	33.8	46.5	29.5	2.3	59.5	21.5	112.8
	62.9	62.9	33.9	46.6	34.4	2.6	59.6	21.6	118.3
	58.0	58.0	31.4	43.2	31.7	2.4	55.2	20.0	109.4
Nov.	59.9	59.9	31.4	43.2	32.8	2.5	55.2	20.0	110.5
	60.7	60.7	31.4	43.1	33.2	2.6	55.2	20.0	111.0
	63.8	63.8	34.4	47.3	34.9	2.7	60.6	21.9	120.1
Dec.	61.7	61.7	34.4	47.3	33.8	2.6	60.5	21.9	118.8
	65.6	65.6	34.5	47.4	35.9	2.8	60.7	21.9	121.3
Total	1018.7	1957.7	1339.9	1842.1				Max	154.8

NOTE: TYPE 1, 2, 3, 4: Q (l/s) = NET.R (mm/10days)* AREA (ha) / IEF / 43.2

WATER DUTY FOR IRRIGATION CANAL (BLOCK D)

MONTH	NET IRRIGATION REQUIREMENT (mm/10 days)				IRRIGABLE AREA (ha)				REQUIRED
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 1	TYPE 2	TYPE 3	TYPE 4	WATER
	0.55	0.55	0.50	0.50	17	2	57	0	(l/s)
	57.1	57.1	36.1	49.6	40.9	4.8	95.3	0.0	140.9
Jan.	49.6	49.6	36.1	49.6	35.5	4.2	95.3	0.0	134.9
	36.1	36.1	36.1	49.7	25.8	3.0	95.3	0.0	124.1
	16.4	16.4	36.7	50.5	11.7	1.4	96.9	0.0	110.0
Feb.	1.0	1.0	36.7	50.5	0.7	0.1	96.8	0.0	97.6
	0.0	0.0	36.8	50.6	0.0	0.0	97.1	0.0	97.1
	0.0	96.8	45.5	62.6	0.0	8.1	120.1	0.0	128.2
Mar.	0.0	110.8	45.5	62.6	0.0	9.3	120.1	0.0	129.4
	0.0	130.0	45.5	62.5	0.0	10.9	120.1	0.0	131.0
	0.0	68.3	44.0	60.5	0.0	5.7	116.1	0.0	121.9
Apr.	0.0	73.3	44.0	60.5	0.0	6.2	116.1	0.0	122.3
	0.0	78.2	44.0	60.5	0.0	6.6	116.1	0.0	122.7
	0.0	71.4	39.4	54.2	0.0	6.0	104.0	0.0	110.0
May	0.0	71.4	39.4	54.2	0.0	6.0	104.0	0.0	110.0
	0.0	75.9	39.4	54.2	0.0	6.4	104.0	0.0	110.4
	0.0	60.4	36.2	49.8	0.0	5.1	95.5	0.0	100.6
Jun.	0.0	52.3	36.2	49.8	0.0	4.4	95.5	0.0	99.9
	0.0	34.0	36.2	49.7	0.0	2.9	95.5	0.0	98.4
	0.0	15.3	37.1	51.0	0.0	1.3	98.0	0.0	99.3
Jul.	0.0	0.9	37.1	51.0	0.0	0.1	97.9	0.0	98.0
	0.0	0.0	37.2	51.1	0.0	0.0	98.2	0.0	98.2
	0.0	0.0	36.4	50.1	0.0	0.0	96.1	0.0	96.1
Aug.	0.0	0.0	36.4	50.1	0.0	0.0	96.1	0.0	96.1
	0.0	0.0	36.5	50.1	0.0	0.0	96.3	0.0	96.3
	95.6	95.6	35.4	48.7	68.4	8.0	93.4	0.0	169.9
Sep.	107.0	107.0	35.4	48.7	76.6	9.0	93.4	0.0	179.0
	118.8	118.8	35.4	48.6	85.0	10.0	93.4	0.0	188.4
	50.6	50.6	33.8	46.5	36.2	4.3	89.3	0.0	129.7
Oct.	53.9	53.9	33.8	46.5	38.6	4.5	89.2	0.0	132.3
	62.9	62.9	33.9	46.6	45.0	5.3	89.5	0.0	139.8
	58.0	58.0	31.4	43.2	41.5	4.9	82.9	0.0	129.2
Nov.	59.9	59.9	31.4	43.2	42.9	5.0	82.9	0.0	130.8
	60.7	60.7	31.4	43.1	43.4	5.1	82.9	0.0	131.4
	63.8	63.8	34.4	47.3	45.6	5.4	90.9	0.0	141.9
Dec.	61.7	61.7	34.4	47.3	44.1	5.2	90.8	0.0	140.1
	65.6	65.6	34.5	47.4	46.9	5.5	91.0	0.0	143.5
Total	1018.7	1957.7	1339.9	1842.1				Max	188.4

NOTE: TYPE 1, 2, 3, 4: Q (l/s) = NET.R (mm/10days)* AREA (ha) / IEF / 43.2

TABLE D-14 DESIGN CAPACITY OF IRRIGATION FACILITY (3/4)

WATER DUTY FOR IRRIGATION CANAL (BLOCK E)

MONTH	NET IRRIGATION REQUIREMENT (mm/10 days)				IRRIGABLE AREA (ha)				REQUIRED WATER
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 1	TYPE 2	TYPE 3	TYPE 4	
	0.55	0.55	0.50	0.50	72	8	19	0	(l/s)
	57.1	57.1	36.1	49.6	173.0	19.2	31.8	0.0	224.0
Jan.	49.6	49.6	36.1	49.6	150.3	16.7	31.8	0.0	198.8
	36.1	36.1	36.1	49.7	109.4	12.2	31.8	0.0	153.3
	16.4	16.4	36.7	50.5	49.7	5.5	32.3	0.0	87.5
Feb.	1.0	1.0	36.7	50.5	3.0	0.3	32.3	0.0	35.6
	0.0	0.0	36.8	50.6	0.0	0.0	32.4	0.0	32.4
	0.0	96.8	45.5	62.6	0.0	32.6	40.0	0.0	72.6
Mar.	0.0	110.8	45.5	62.6	0.0	37.3	40.0	0.0	77.3
	0.0	130.0	45.5	62.5	0.0	43.8	40.0	0.0	83.8
	0.0	68.3	44.0	60.5	0.0	23.0	38.7	0.0	61.7
Apr.	0.0	73.3	44.0	60.5	0.0	24.7	38.7	0.0	63.4
	0.0	78.2	44.0	60.5	0.0	26.3	38.7	0.0	65.0
	0.0	71.4	39.4	54.2	0.0	24.0	34.7	0.0	58.7
May	0.0	71.4	39.4	54.2	0.0	24.0	34.7	0.0	58.7
	0.0	75.9	39.4	54.2	0.0	25.6	34.7	0.0	60.2
	0.0	60.4	36.2	49.8	0.0	20.3	31.8	0.0	52.2
Jun.	0.0	52.3	36.2	49.8	0.0	17.6	31.8	0.0	49.5
	0.0	34.0	36.2	49.7	0.0	11.4	31.8	0.0	43.3
	0.0	15.3	37.1	51.0	0.0	5.2	32.7	0.0	37.8
Jul.	0.0	0.9	37.1	51.0	0.0	0.3	32.6	0.0	32.9
	0.0	0.0	37.2	51.1	0.0	0.0	32.7	0.0	32.7
	0.0	0.0	36.4	50.1	0.0	0.0	32.0	0.0	32.0
Aug.	0.0	0.0	36.4	50.1	0.0	0.0	32.0	0.0	32.0
	0.0	0.0	36.5	50.1	0.0	0.0	32.1	0.0	32.1
	95.6	95.6	35.4	48.7	289.7	32.2	31.1	0.0	353.0
Sep.	107.0	107.0	35.4	48.7	324.2	36.0	31.1	0.0	391.4
	118.8	118.8	35.4	48.6	360.0	40.0	31.1	0.0	431.1
	50.6	50.6	33.8	46.5	153.3	17.0	29.8	0.0	200.1
Oct.	53.9	53.9	33.8	46.5	163.3	18.1	29.7	0.0	211.2
	62.9	62.9	33.9	46.6	190.6	21.2	29.8	0.0	241.6
	58.0	58.0	31.4	43.2	175.8	19.5	27.6	0.0	222.9
Nov.	59.9	59.9	31.4	43.2	181.5	20.2	27.6	0.0	229.3
	60.7	60.7	31.4	43.1	183.9	20.4	27.6	0.0	232.0
	63.8	63.8	34.4	47.3	193.3	21.5	30.3	0.0	245.1
Dec.	61.7	61.7	34.4	47.3	187.0	20.8	30.3	0.0	238.0
	65.6	65.6	34.5	47.4	198.8	22.1	30.3	0.0	251.2
Total	1018.7	1957.7	1339.9	1842.1				Max	431.1

NOTE: TYPE 1, 2, 3, 4: Q (l/s) = NET.R (mm/10days)* AREA (ha) / IEF / 43.2

WATER DUTY FOR IRRIGATION CANAL (BLOCK F)

MONTH	NET IRRIGATION REQUIREMENT (mm/10 days)				IRRIGABLE AREA (ha)				REQUIRED WATER
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 1	TYPE 2	TYPE 3	TYPE 4	
	0.55	0.55	0.50	0.50	26	3	79	0	(l/s)
	57.1	57.1	36.1	49.6	62.5	7.2	132.0	0.0	201.7
Jan.	49.6	49.6	36.1	49.6	54.3	6.3	132.0	0.0	192.6
	36.1	36.1	36.1	49.7	39.5	4.6	132.0	0.0	176.1
	16.4	16.4	36.7	50.5	17.9	2.1	134.3	0.0	154.4
Feb.	1.0	1.0	36.7	50.5	1.1	0.1	134.2	0.0	135.4
	0.0	0.0	36.8	50.6	0.0	0.0	134.6	0.0	134.6
	0.0	96.8	45.5	62.6	0.0	12.2	166.4	0.0	178.6
Mar.	0.0	110.8	45.5	62.6	0.0	14.0	166.4	0.0	180.4
	0.0	130.0	45.5	62.5	0.0	16.4	166.4	0.0	182.8
	0.0	68.3	44.0	60.5	0.0	8.6	160.9	0.0	169.5
Apr.	0.0	73.3	44.0	60.5	0.0	9.3	160.9	0.0	170.2
	0.0	78.2	44.0	60.5	0.0	9.9	160.9	0.0	170.8
	0.0	71.4	39.4	54.2	0.0	9.0	144.1	0.0	153.1
May	0.0	71.4	39.4	54.2	0.0	9.0	144.1	0.0	153.1
	0.0	75.9	39.4	54.2	0.0	9.6	144.1	0.0	153.7
	0.0	60.4	36.2	49.8	0.0	7.6	132.4	0.0	140.0
Jun.	0.0	52.3	36.2	49.8	0.0	6.6	132.4	0.0	139.0
	0.0	34.0	36.2	49.7	0.0	4.3	132.4	0.0	136.7
	0.0	15.3	37.1	51.0	0.0	1.9	135.8	0.0	137.7
Jul.	0.0	0.9	37.1	51.0	0.0	0.1	135.7	0.0	135.8
	0.0	0.0	37.2	51.1	0.0	0.0	136.1	0.0	136.1
	0.0	0.0	36.4	50.1	0.0	0.0	133.3	0.0	133.3
Aug.	0.0	0.0	36.4	50.1	0.0	0.0	133.1	0.0	133.1
	0.0	0.0	36.5	50.1	0.0	0.0	133.5	0.0	133.5
	95.6	95.6	35.4	48.7	104.6	12.1	129.5	0.0	246.2
Sep.	107.0	107.0	35.4	48.7	117.1	13.5	129.5	0.0	260.1
	118.8	118.8	35.4	48.6	130.0	15.0	129.5	0.0	274.5
	50.6	50.6	33.8	46.5	55.4	6.4	123.7	0.0	185.5
Oct.	53.9	53.9	33.8	46.5	59.0	6.8	123.6	0.0	189.4
	62.9	62.9	33.9	46.6	68.8	7.9	124.0	0.0	200.8
	58.0	58.0	31.4	43.2	63.5	7.3	114.8	0.0	185.6
Nov.	59.9	59.9	31.4	43.2	65.5	7.6	114.8	0.0	188.0
	60.7	60.7	31.4	43.1	66.4	7.7	114.8	0.0	188.9
	63.8	63.8	34.4	47.3	69.8	8.1	125.9	0.0	203.8
Dec.	61.7	61.7	34.4	47.3	67.5	7.8	125.8	0.0	201.1
	65.6	65.6	34.5	47.4	71.8	8.3	126.2	0.0	206.2
Total	1018.7	1957.7	1339.9	1842.1				Max	274.5

NOTE: TYPE 1, 2, 3, 4,: Q (l/s) = NET.R (mm/10days)* AREA (ha) / IEF / 43.2

TABLE D - 14 DESIGN CAPACITY OF IRRIGATION FACILITY (4/4)

WATER DUTY FOR IRRIGATION CANAL (BLOCK G)

MONTH	NET IRRIGATION REQUIREMENT (mm/10 days)				IRRIGABLE AREA (ha)				REQUIRED WATER
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 1	TYPE 2	TYPE 3	TYPE 4	
	0.55	0.55	0.50	0.50	317	33	284	0	(l/s)
	57.1	57.1	36.1	49.6	380.9	39.7	474.6	0.0	895.2
Jan.	49.6	49.6	36.1	49.6	330.9	34.4	474.6	0.0	840.0
	36.1	36.1	36.1	49.7	240.8	25.1	474.6	0.0	740.5
	16.4	16.4	36.7	50.5	109.4	11.4	483.0	0.0	603.8
Feb.	1.0	1.0	36.7	50.5	6.7	0.7	482.5	0.0	489.9
	0.0	0.0	36.8	50.6	0.0	0.0	483.9	0.0	483.9
	0.0	96.8	45.5	62.6	0.0	67.2	598.2	0.0	665.5
Mar.	0.0	110.8	45.5	62.6	0.0	76.9	598.2	0.0	675.2
	0.0	130.0	45.5	62.5	0.0	90.3	598.2	0.0	688.5
	0.0	68.3	44.0	60.5	0.0	47.4	578.5	0.0	625.9
Apr.	0.0	73.3	44.0	60.5	0.0	50.9	578.5	0.0	629.4
	0.0	78.2	44.0	60.5	0.0	54.3	578.5	0.0	632.8
	0.0	71.4	39.4	54.2	0.0	49.6	518.0	0.0	567.6
May	0.0	71.4	39.4	54.2	0.0	49.6	518.0	0.0	567.6
	0.0	75.9	39.4	54.2	0.0	52.7	518.0	0.0	570.7
	0.0	60.4	36.2	49.8	0.0	41.9	476.0	0.0	517.9
Jun.	0.0	52.3	36.2	49.8	0.0	36.3	476.0	0.0	512.3
	0.0	34.0	36.2	49.7	0.0	23.6	476.0	0.0	499.6
	0.0	15.3	37.1	51.0	0.0	10.6	488.2	0.0	498.9
Jul.	0.0	0.9	37.1	51.0	0.0	0.6	487.8	0.0	488.4
	0.0	0.0	37.2	51.1	0.0	0.0	489.1	0.0	489.1
	0.0	0.0	36.4	50.1	0.0	0.0	479.0	0.0	479.0
Aug.	0.0	0.0	36.4	50.1	0.0	0.0	478.6	0.0	478.6
	0.0	0.0	36.5	50.1	0.0	0.0	479.9	0.0	479.9
	95.6	95.6	35.4	48.7	637.7	66.4	465.4	0.0	1169.6
Sep.	107.0	107.0	35.4	48.7	713.8	74.3	465.4	0.0	1253.5
	118.8	118.8	35.4	48.6	792.5	82.5	465.4	0.0	1340.4
	50.6	50.6	33.8	46.5	337.5	35.1	444.8	0.0	817.5
Oct.	53.9	53.9	33.8	46.5	359.6	37.4	444.4	0.0	841.4
	62.9	62.9	33.9	46.6	419.6	43.7	445.7	0.0	909.0
	58.0	58.0	31.4	43.2	386.9	40.3	412.9	0.0	840.0
Nov.	59.9	59.9	31.4	43.2	399.6	41.6	412.9	0.0	854.0
	60.7	60.7	31.4	43.1	404.9	42.2	412.9	0.0	859.9
	63.8	63.8	34.4	47.3	425.6	44.3	452.7	0.0	922.6
Dec.	61.7	61.7	34.4	47.3	411.6	42.8	452.3	0.0	906.7
	65.6	65.6	34.5	47.4	437.6	45.6	453.6	0.0	936.8
Total	1018.7	1957.7	1339.9	1842.1				Max	1340.4

NOTE: TYPE1, 2: Q (l/s) NET. R (mm/10 days) * AREA (ha) / IEF / 86.4

NOTE: TYPE1, 2: Q (l/s) NET. R (mm/10 days) * AREA (ha) / IEF / 43.2

FIGURE D-1 MONTHLY RAINFALL AND EFFECTIVE RAINFALL

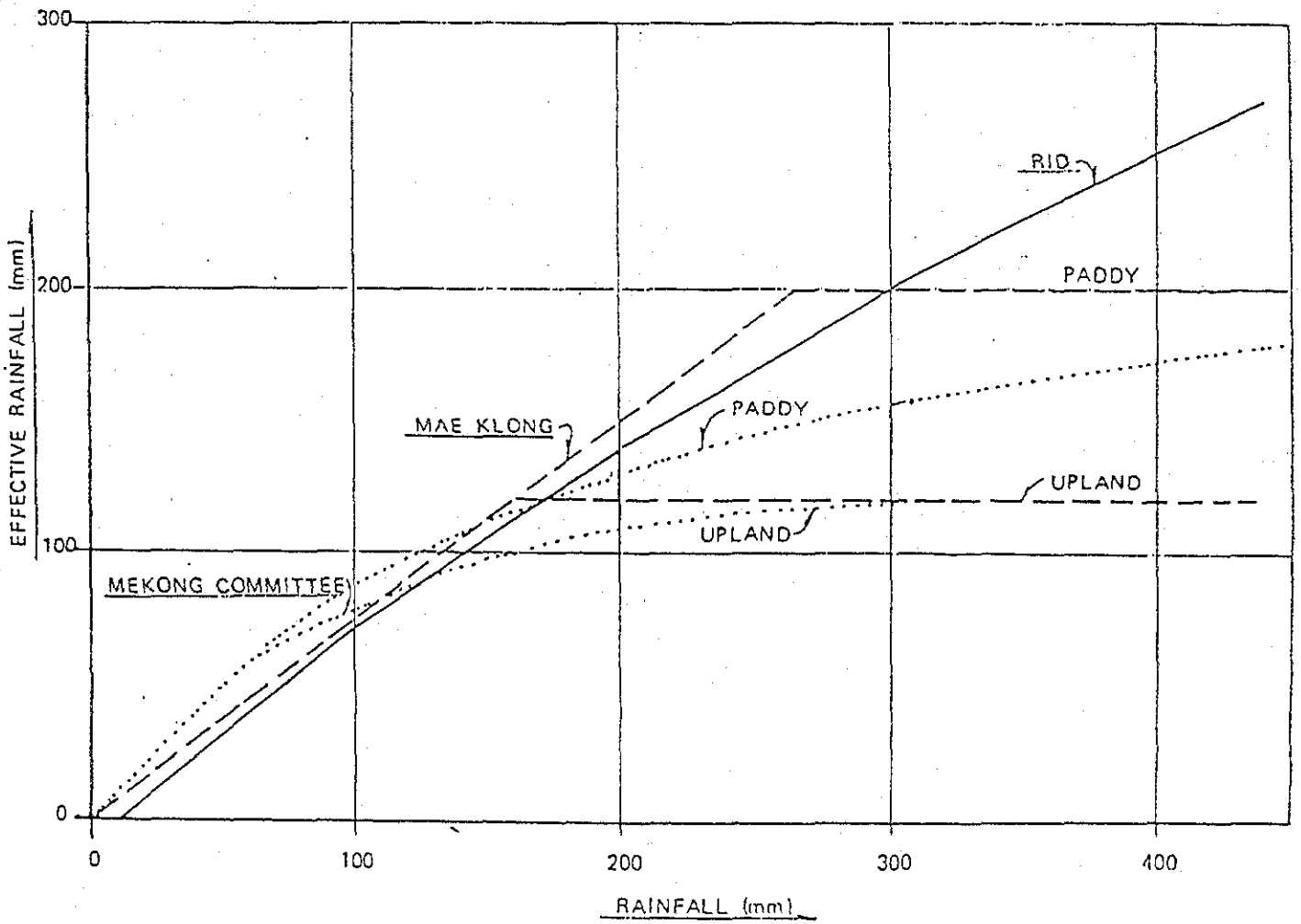
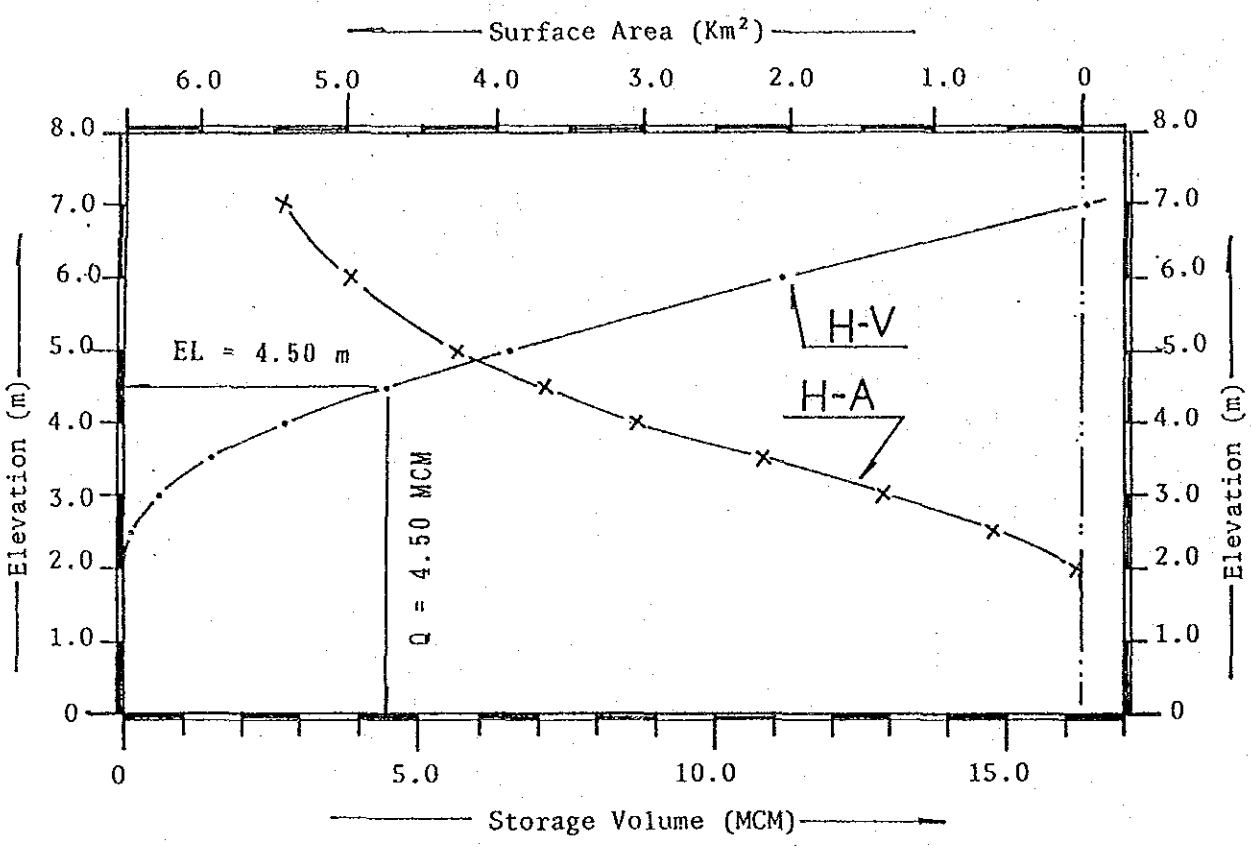


FIGURE D-2 AREA AND CAPACITY CURVE OF NONG YAI RESERVOIR



AREA AND CAPACITY OF NONG YAI RESERVOIR

EL(m)	D(m)	AREA(ha)	Av.A(ha)	V (1000m3)	AQ(1000m3)
0.50	0.00	0.0	0.00	0.0	0.0
1.00	0.50	0.2	0.10	0.5	0.5
2.00	1.00	2.8	1.50	15.0	15.5
2.50	0.50	59.1	30.95	154.8	170.3
3.00	0.50	135.1	97.10	485.5	655.8
3.50	0.50	218.6	176.85	884.3	1540.0
4.00	0.50	302.0	260.30	1301.5	2841.5
4.50	0.50	364.5	333.25	1666.3	4507.8
5.00	0.50	426.9	395.70	1978.5	6486.3
6.00	1.00	495.4	461.15	4611.5	11097.8
7.00	1.00	543.4	519.40	5194.0	16291.8

FIGURE D-3 RESERVOIR OPERATION STUDY (CASE: 1)

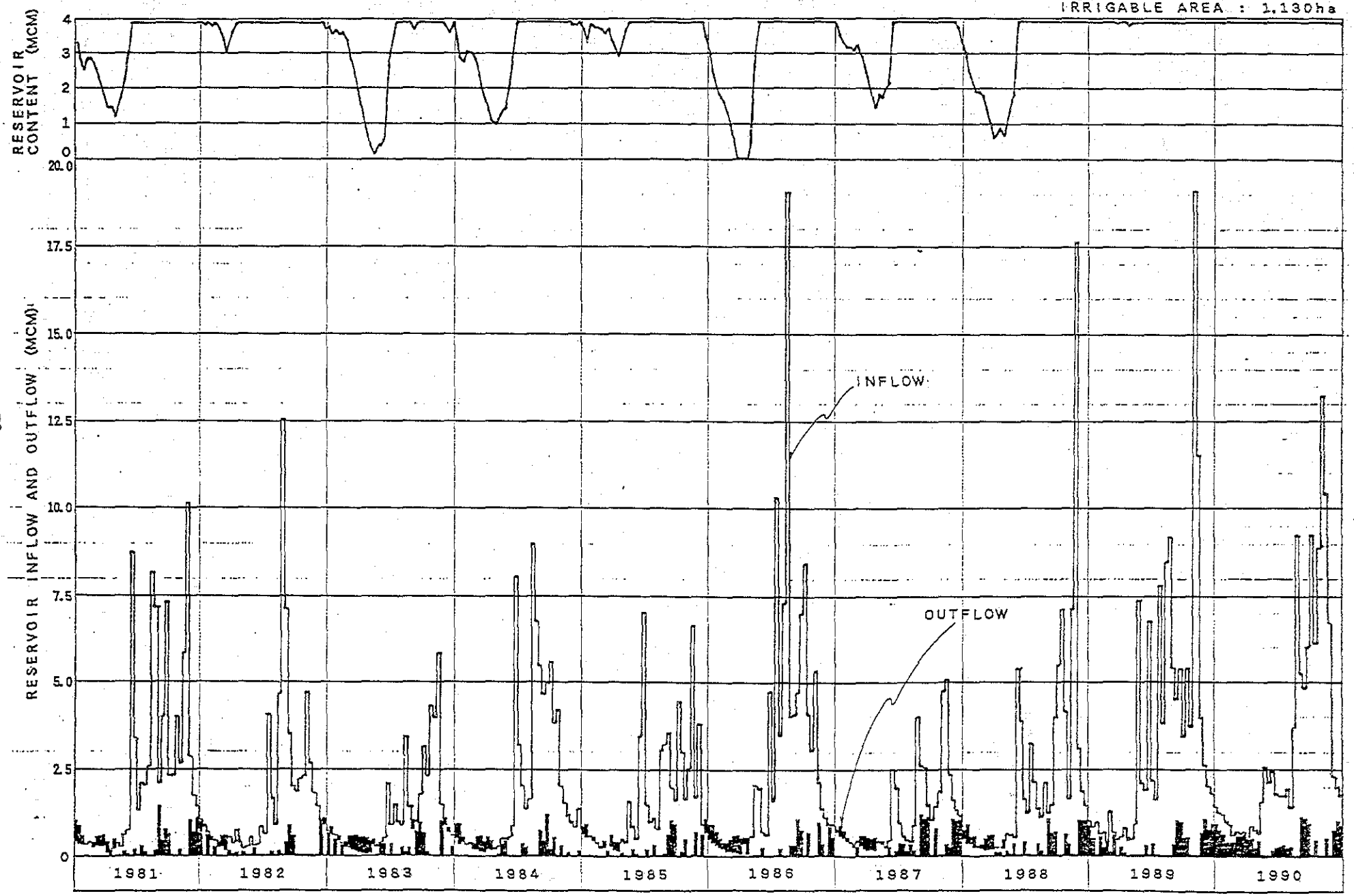
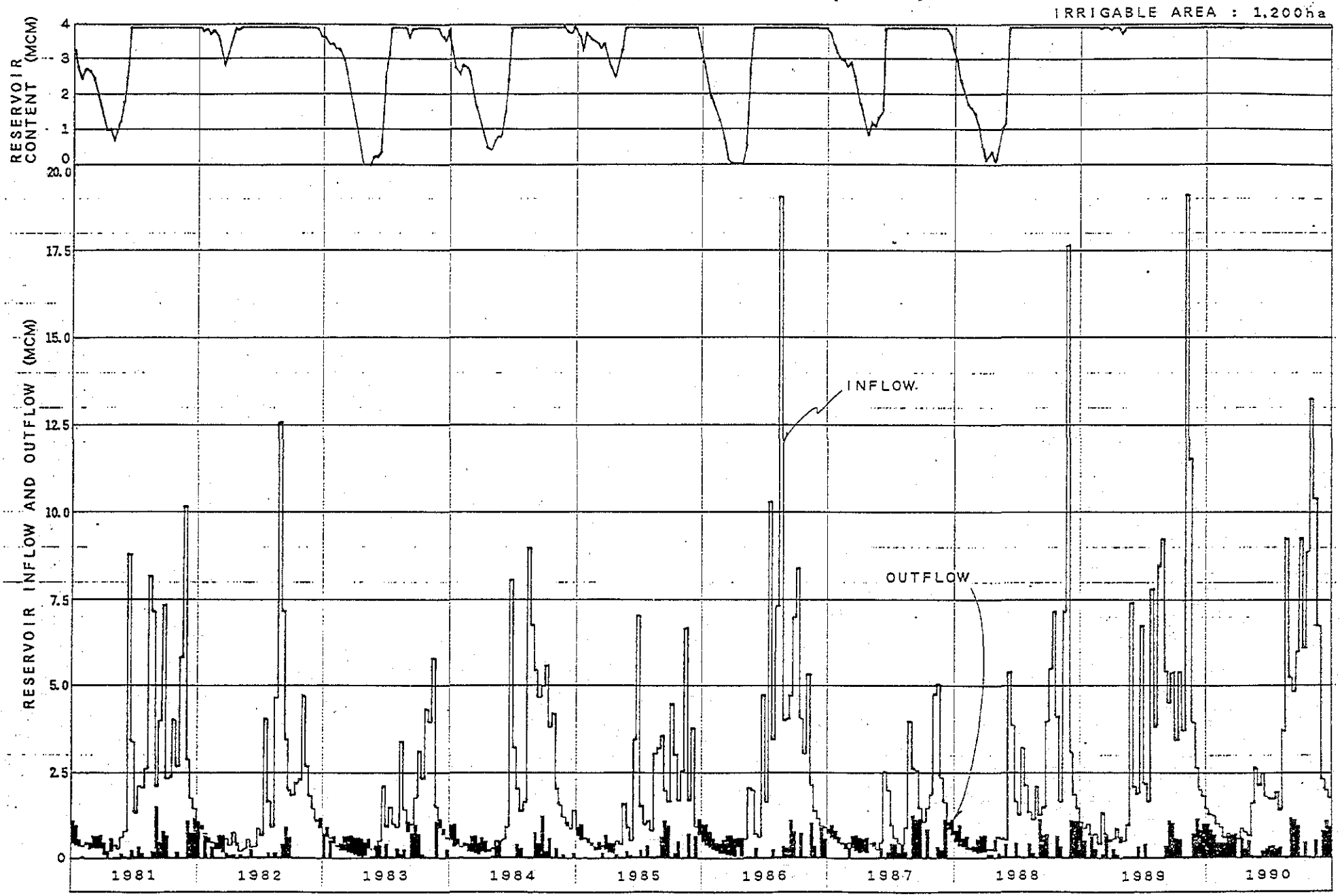


FIGURE D - 4 RESERVOIR OPERATION STUDY (CASE: 2)



APPENDIX E. FLOOD CONTROL

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APPENDIX E. FLOOD CONTROL

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APPENDIX E. FLOOD CONTROL

E - 1 FLOODS

E - 1 - 1 Flood Record

For 3 rivers of 4 major rivers in the Study Area, flood discharge records are available at 5 gauging stations; 3 stations of Phra Chao, Hat Som Pean and X46 for the Rap Ro river, 2 stations of Ta Ngo and X64 for the Tha Sae river and 1 station of X53 for the Khlong Chumphon. River discharge, however, is presently being observed by RID at only 3 stations of X46 station on the Rap Ro river, X64 station on the Tha Sae river and X53 station on the Khlong Chumphon. No river discharge is available for the Tha Taphao river. General information of the 6 gauging stations are given below:

RIVER DISCHARGE GAUGING STATIONS

River	Gauging Station	Catchment Area (sq.km)	Record Length
Rap Ro	Phra Chao	330	23 Years : 1965 - 1987
Rap Ro	Hat Som Peam	188	6 Years : 1983 - 1988
Rap ro	x46	751	13 Years : 1978 - 1990
Tha Sae	x64	957	17 Years : 1973 - 88, 1990
Tha Sae	Ta Ngo	352	6 Years : 1963 - 1968
Chumphon	x53	223	13 Years : 1978 - 1990

Table E-1 gives annual peak discharge records for 4 gauging stations with relatively long record length.

For the study purpose of flood control, annual peak discharges of the Tha Taphao river at X158 gauging station are estimated. X158 station with the catchment area of 1,819 sq.km is located on the Tha Taphao river 1 km downstream from the confluence of the Rap Ro river (803 sq.km) and Tha Sae river (1,016 sq.km). Estimates of the annual peak discharges at X158 station are based on the specific peak discharge expressed in terms of cu.m/sec per sq.km of the catchment area at 3 gauging stations of Phra Chao, X46 and X46. The estimated annual peak flood discharges are given as follows:

ESTIMATED ANNUAL PEAK DISCHARGE OF THA TAPHAO RIVER AT X158 STATION

- Unite: cu.m/sec -

Year	Discharge	Year	Discharge	Year	Discharge
1973	621	1979	1,127	1985	460
1974	885	1980	712	1986	932
1975	740	1981	554	1987	716
1976	1,177	1982	734	1988	1,320
1977	371	1983	344	1989	1,220 (*)
1978	1,054	1984	672	1990	647

Note: Estimated by RID

Based on the synthesized flood hydrographs, probable annual peak discharges are calculated by applying the Iwai method for various return periods as given below:

PROBABLE ANNUAL PEAK DISCHARGE OF THA TAPHAO RIVER AT X158 STATION

- Unite: cu.m/sec -

Return Period (year)	Discharge	Return Period (year)	Discharge
2	640	20	1,370
3	780	30	1,510
5	930	40	1,600
10	1,150	50	1,680

E - 1 - 2 TYPHOON GAY

(1) Rainfall

Typhoon Gay hit the Study Area on November 4, 1989 with the maximum wind speed of 120 km per hour near its center as shown in Figure E-8. Due to heavy rainfall caused by the typhoon, the Tha Taphao river was flooded for about 4 days from 4 to 7, November. Rainfall during the 4-day period is shown for 8 gauging stations in and around the Study Area in order of location from North to South as floows :

RAINFALL RECORD

Unite : mm

Gauging Station	Novemver, 1989					
	3rd	4th	5th	6th	7th	Total
Bang Saphan (*)	42	125	-	13	-	180
Yang Khwang - GT6 (*)	27	215	0	8	-	250
Amphoe Tha Sae	-	209	83	106	10	408
Ban Rap Ro-x46A	-	271	-	-	-	271
Sam Kaeo	66	92	12	3	-	173
A. Muang Chumphon	29	89	3	-	-	121
Amphoe Sawi (*)	32	41	5	-	-	78
Kra Buri (*)	18	60	-	-	-	78

Note : (*) shows the station located outside the Study Area.

The above table may suggest that heavy rains fell at Rap Ro and Tha Sae in the mountainous area, though rainfall was not recorded at Amphoe Pathiu and Ta Ngo, where are located on the center of the typhoon. The approximate return periods of daily rainfall on November 4th are 16 years for Amphoe Tha Sae (209 mm) and 25 years for Rap Ro.

(2) Floods of the Tha Taphao River

The water levels of the Tha Taphao river are observed at 3 gauging stations of X158, Sam Kaeo regulator and Amphoe Muang Chumphon; however, river discharges are not recorded. Figure E-1 shows the flood water levels observed by RID at the 3 stations, in which the bank elevation of Amphoe Muang Chumphon station is assumed to be 4.00 m above the mean sea level (MSL), basing on river cross section drawings surveyed by RID in 1991.

The water level at X158 station sharply rose on the afternoon of the 4th, November to reach its highest water level of 9.12 m MSL at 6 o'clock of the 5th, November. Overflows from the banks of the Tha Taphao river (El.7.5 m MSL) continued for about 50 hours. The highest water level at Sam Kaeo regulator that is located about 19 km downstream from X158 station was El. 5.95 m MSL at 18 o'clock of the 5th, being delayed for 12 hours. At Amphoe Muang Chumphon gauging station, the highest water level rose 1.16 m above the banks of the Tha Taphao river.

Flood discharges of the Rap Ro river were recorded at X46 gauging station with the catchment area of 751 sq.km; No flood discharge of the Tha Sae river was available because X64 gauging station with the catchment area of 957 sq.km was not functioning. The peak flood discharge of the Rap Ro river at X46 gauging station was 649.4 cu.m/sec, or 0.86 cu.m/sec/sq.km. The peak discharge of the Tha Taphao river at X158 station with a catchment area of 1,819 sq.km was estimated at 1,200 cu.m/sec by RID.

(3) Damage Caused by Typhoon

With destructive winds and floods, Typhoon Gay did considerable damage to the Study Area. According to the report prepared in December, 1989 by the Ministry of Interior, 42,927 households of 8 provinces were under the influence of the typhoon, and of 200 thousand populations suffered from the typhoon, 558 people were dead, 134 people were lost, 15,813 people were evacuated. In addition to damage to 46,958 of houses and 616 of ships, considerable damage was reported for roads, bridges, weirs, government buildings, farm land and others. Area of flooded farm lands amounted to about 150 thousand ha. The total damage was estimated by the Ministry of Interior to be Baht 11,647 million, of which Baht 11,257 million (or, equivalent to 97 percent of the total) was shared by Chumphon Province. Damage by province is presented on Table E-2.

E - 1 - 3 Flood Control

Flood control dam functions to release the flood water reducted with its peak discharge by storing the inflow flood partly or totally in the reservoir for certain time.

Rap Ro and Tha Sae reservoir having with flood control space of 120.1 MCM and 47.6 MCM respectively are planned to secure the flood control by providing flood way condit without gate.

The inflow hydrograph and outflow hydrograph after control of each reservoir, Rap Ro and Tha Sae by three hour interval are shown in Figure E-2 and E-3.

These figures indicate that a peak outflow discharge of 1,120 cu.m/sec is reduced to a peak outflow discharge of 409 cu.m/sec after control at the site of Rap Ro dam, and in case of Tha Sae dam, 530 cu.m/sec to 212 cu.m/sec.

The flood discharge at a subject point of down-stream is estimated by adding a flood discharge from the residual watershed (reservoir point to subject point) to the outflow discharge from the reservoir.

Figure E-4 and E-5 show the flood discharge of Rap Ro river and Tha Sae river respectively at the confluence point, furthermore Figure E-6 shows that of Tha Taphao river adding the both discharges of Rap Ro and Tha Sae river.

Consequently, each discharge of Rap Ro, Tha Sae and Tha Taphao river is given to 530,610 and 1,140 cu.m/sec respectively.

Since the present discharge capacity of Tha Taphao river is estimated to 430 cu.m/sec at the up-stream section between the confluence point and Sam Kaeo point, and 350 cu.m/sec at the down-stream section from the Sam Kaeo diversion point, Pak Phraek canal, Hua Wang Phanang Tuk canal, Sam Kaeo canal and improved Tha Taphao river jointly secure to release the flood of 1,150 cu.m/sec rounded from 1,140 cu.m/sec as shown in Figure E-7.

E - 1 - 4 Plan of Flood Control Storage

(1) Function of Flood Control Storage

In general, natural river flood increases accordingly its discharge hour by hour to reach the peak discharge, after that decreases the discharge gradually. As the flood discharge goes beyond the river flow capacity, the flood damages occur on the surrounding area of the river.

In order to treat the said flood problem, by providing reservoir(s) at certain proper site(s) on the river, the flood control-measure that stores the flood inflow into the reservoir(s) and releases a part of flood within the river flow capacity shall be taken, resulted to secure the downstream area from flood damages, as planned in this study.

There are three flood control methods, natural control method, constant discharge method, and constant rate and discharge method. In this study, the natural control method provided with conduit pipe is employed taking account of the following points;

1) The gate control method like the constant discharge method, and the constant rate and discharge method has a potentiality of occurrence of artificial flood damage by human error.
2) The gate control method requires high cost of operation and maintenance.

(2) Plan of Flood Control Storage

The flood control storage in the reservoir is the enclosed area Ⓐas shown in Figure - I between the inflow hydrograph and the outflow hydrograph at the dam site, while in Figure - II, the control storage corresponds to the area Ⓑ above N.W.S (effective storage).

Presently, it is situated that the flood forecasting is rather difficult theoretically, thus separation of flood control storage and water utilization storage is important in the reservoir plan. The flood control storage capacity is required to be empty establishing the conservation level (normal water level of utilization storage).

Although the regulating effect for flood is expected by retaining the water above the crest elevation of spill-way, the high water level of flood control storage is planned to be conformed to the crest elevation of emergency spill-way because the flow water over the spill-way crest are uncontrollable water and sometime exceed the safety river capacities in the downstream area, while the flow water through the outlet are controlled within the maximum design capacity. Therefore, the retention water capacity above the spill-way crest is not planned in the flood control storage capacity.

FIGURE I; HYDROGRAPH OF INFLOW AND OUTFLOW

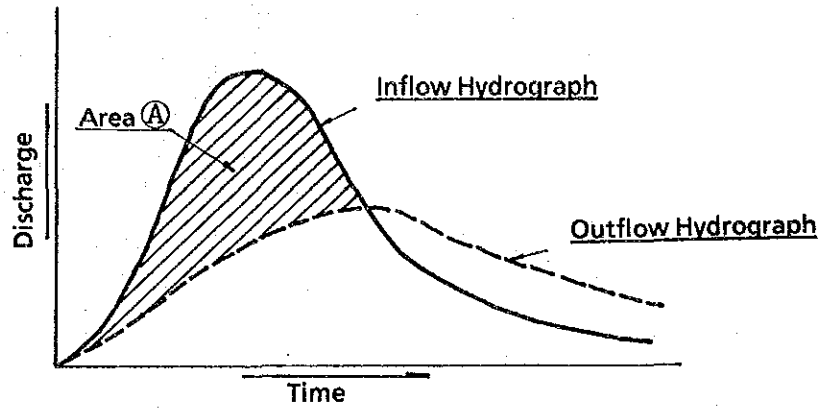
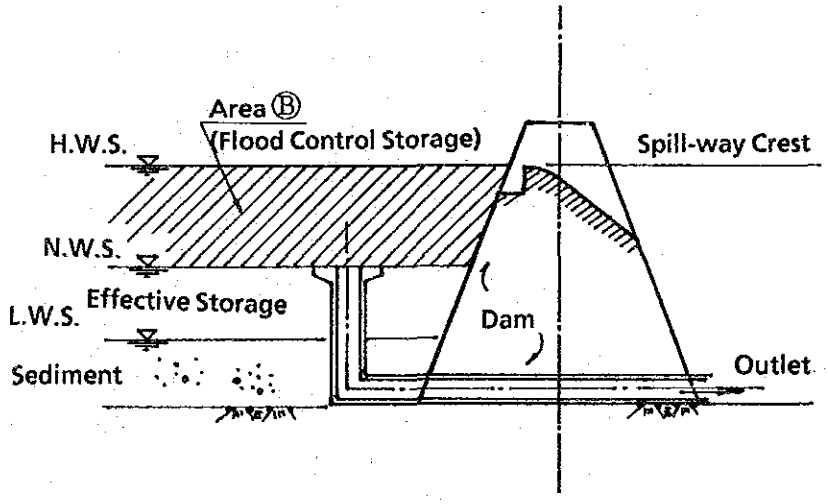


FIGURE II; STORAGE DIAGRAM



E-2 FLOOD CONTROL BENEFITS

E-2-1 General

The preliminary estimates of probable flood damages are based on the direct losses of the following :

① Crops
- Paddy
- Upland Crops
- Vegetables
- Fruits and tree Crops

② Shrimp Culture

③ Livestock

④ Roads and Bridges
- Privet Property
- Industrial Property

In estimation of damages, the following data and information are useful;

1970 flood : NEA report on Rub Roh Project
- Flooded area by land use
- Relation of flood to flooded area

1988 flood : Data prepared by Chumphon province
- Damage of farm lands, roads and bridges, weirs, public facilities and houses
- Damages of roads in the municipality of Chumphon
- Damages of paddy, fruits, tree crops, upland crops, and vegetables on the Amphoe basis

1989 flood : Data prepared by Chumphon province and provincial offices of agriculture
- Damages of Crops on the Tambon basis

- Damages of roads and bridges on the Tambon basis
- Damages of weirs on the Tambon basis

The present land use within the flooding area is based on the present land use maps prepared by DLD. There are about 5,000ha, 700ha, 800ha and 13,000ha of paddy fields, upland crop fields, mixed vegetable farms, and fruits and tree crops. Numbers and area (2,280ha), of shrimp culture ponds are derived from the NRD-2C data on the village basis, and locations of large scale ponds are confirmed by interpretation of the Landsat photos taken in 1990. The NDR-2C data presents the number of livestock and houses on the villages basis ; there are 4,800 houses in the municipality of Chumphon and 12,700 houses in the rural area. Damages of roads and bridges are based on the data of the provincial office.

All information is plotted on the topographic maps with the scale of 1:50,000 with the contour intervals of 20m and some spot elevations, and the relation of flood discharge and flooding area is obtained to estimate flood damages as shown in Figure E-9.

E - 2 - 2 Flood Damage in November 1989

It is reported that large scale damages were caused by flood in 1970, 1988 and 1989; however, flood damage records are available only for flood of November 1989 (Typhoon Gay) and 1988. During the field survey periods, flood damage records of Tha Taphao river basin (including lower reaches of Tha Sae river basin) were collected from the government offices concerned as given as follows:

(1) Crops

About 24,000 ha (150,000 rai) of lands were flooded in November 1989, of which crops of 17,800 ha (111,300 rai) were damaged amounting to 687.8 million Baht of damage, as summarized below:

CROP DAMAGE

(unit: ha)

Amphoe	Paddy	Upland Crops	Tree Crops	Fruits and Others	Total	Damage Amount (M฿)
Muang	3,212	107	5,834	287	9,440	227.7
Tha Sae	930	530	6,440	460	8,360	460.1
Total	4,142	637	12,274	747	17,800	687.8

(refer to Table E - 8 and E - 9)

(2) Bridges and Roads

Repairing costs of damaged bridges and roads amounted to 81.35 million Baht.

DAMAGES TO BRIDGES AND ROADS

(unit: Million Baht for damage)

Amphoe	Bridge		Roads		Total Damages
	Nos.	Damage	Nos.	Damage	
Muang	24	9.87	157	43.27	53.14
Tha Sae	28	14.81	98	13.40	28.21
Total	52	24.68	255	56.67	81.35

(refer to Table E - 10 and E - 11)

(3) Irrigation Facilities

The following damages are reported:

- 11 weirs damaged
- repairing costs of 2.39 million Baht

(4) Shrimp Ponds

According to information from the Provincial Office of Local Administration, damages to shrimp ponds were estimated at 57.61 million Baht as given below:

- Nos. of shrimp ponds damaged : 612
- Pond area damaged : 142 ha (890 rai)
- Estimated damage : 57.61 million Baht

(5) Public Buildings

78 public buildings including government offices, schools, temples and others were damaged; repairing costs amounted to 11.36 million Baht (Ministry of Interior).

(6) Others

According to data of the Ministry of Interior, 14,894 houses in Amphoe Muang were damaged; however, damage values are not available.

Losses of livestock were recorded by the Provincial Office of Local Administration as follows:

- Cattle	:	118
- Buffalo	:	92
- Swine	:	975
- Duck and chicken:		39,200

(7) Total Damage

As far as data collected are concerned, the flood damage of November 1989 amounts to 840.6 million Baht as below:

Crops	:	687.8 m Baht
Bridges and roads	:	81.4 m Baht
Irrigation facilities	:	2.4 m Baht
Shrimp ponds	:	57.6 m Baht
Public buildings	:	11.4 m Baht
Total		840.6 m Baht

E - 2 - 3 Probable Flood without Project

Probable peak flood discharge at X158 station of Tha Taphao river is estimated as given below:

PROBABLE FLOOD DISCHARGE

Return Period (Year)	Probable Flood Discharge (cu.m/sec)
2	640
3	780
5	930
10	1,150 *
20	1,370
30	1,510
40	1,600
50	1,680

* Flood with the return period of 10 years means that flood with the discharge of 1,150 cu.m/sec will not occur more than once in 10 years.

E - 2 - 4 Properties in Flood Area

(1) Flood Area

Estimates of flood area are based on topographic maps (1 : 50,000, 10 meter contour intervals with spot elevation), topographic maps of the priority area (1 : 10,000, 1.0 meter contour intervals), and statistic data of government offices.

About 27,400 ha (171,000 rai) of lands are subject to flooding when a flood with the return period of 50 years occurs.

(2) Inventory of Properties

a) Crops

There are 21,600 ha (135,000 rai) of farm lands, of which 20,000 ha (125,100 rai) of farm lands are cropped in the rainy season.

CROPPING AREA

(unit: ha)

Crops	Total Farmland	Rainy Season Cropping Area
Paddy	6,460	4,880
Upland Crops	730	730
Vegetables	820	820
Fruits/Tree Crops	13,590	13,590
Total	21,600	20,020

Estimated losses:

- Paddy : 2.0 ton/ha × 3,975 Baht/ton = 7,950 Baht/ha
- Upland crops : (Maize)
  3.5 ton/ha × 1,500 Baht/ton = 5,250 Baht/ha
- Vegetable : (Ginger)
  18.75 ton/ha × 5,000 Baht/ton = 93,750 Baht/ha
  (Pepper)
  1.5 ton/ha × 20,000 Baht/ton = 30,000 Baht/ha
  ∴ Average (93,750 + 30,000)/2 = 61,875 Baht/ha
- Fruits/Tree crops: (Coconut)
  3,600 fruits/ha × 4.0 Baht/fruit = 14,400 Baht/ha
  (Durian)
  4.4 ton/ha × 18,280 Baht/ton = 80,432 Baht/ha
  (Mangosteen)
  2.2 ton/ha × 8,490 Baht/ton = 18,678 Baht/ha
  ∴ Average (14,400 + 80,432 + 18,678)/3 = 37,837 Baht/ha

b) Shrimp Ponds

There are 2,730 ha of shrimp ponds in 2 river basins of Tha Taphao and Chumphon of which 760 ha of ponds are being operated for shrimp culture in Tha Taphao river basin. Estimated losses are: 4.56 ton/ha × 150,000 Baht/ton = 684,000 Baht/ha

c) Livestock

Numbers of livestock raised in Tha Taphao river basin are available from the NRD-2C data as below:

LIVESTOCK

Nos. of Livestock			Estimated Loss
Cattle	:	1,800	6,280 Baht/head
Buffalo	:	2,000	5,000 Baht/head
Swine	:	8,500	3,000 Baht/head
Poultry	:	150,000	20 Baht/unit

d) Irrigation Facilities and Farmland

The Sam Kaeo canal project is only one existing project in the Tha Taphao river basin for irrigation of 4,800 ha (30,000 rai) of paddy fields. In November 1989, 3,212 ha of paddy fields were flooded, and repairing costs of weirs and canals were 2.39 million Baht, or 744 Baht/ha of flooded paddy fields. Damage costs of irrigation facilities will be estimated at a rate of 800 Baht/ha of flooded paddy fields.

Saving costs for rehabilitation of flooded farmlands is a benefit from flood mitigation. On the assumption that an average depth of mud and dirt is 0.03 meter (300 cu.m/ha), rehabilitation costs are estimated at 6,000 Baht/ha (or, 2 persons × 100 Baht/day × 30 days) for flooded farm lands.

e) Bridges and Roads

Repairing costs are estimated based on experiences of Amphoe Offices in November 1989 as follows:

Bridges	:	543 thousand Baht/location
Roads	:	244 thousand Baht/location

f) Houses and Private Properties

In the flooding area of Tha Taphao river basin, there are 17, 500 houses; 4,800 houses in urban area and 12,700 houses in village areas. The present values of houses with properties are estimated as follows:

House in urban area : 0.8 million Baht
House in village area : 0.2 million Baht

g) Factories

There are 81 factories in the flooding area of Tha Taphao river basin (Provincial Office of Industry) as given as follows:

FACTORIES

Kinds of Factories	Nos.	Investment (Million Baht)
Processing of shrimp/crab	2	9.50
Dried shrimp	2	0.67
Coconut/palm oil	6	26.94
Rice mills	55	6.46
Noodle	4	1.70
Instant coffee	1	0.26
Fish meat	6	16.35
Cold storage	5	45.40
Total	81	107.28

Average investment : 1.32 million Baht
Estimated present value : 1.1 million Baht

E - 2 - 5 Probable Annual Average Flood Damage

Based on the topographic maps and hydraulic information at ×158 station, Sam Kaeo regulator and Chumphon bridge, correlation of flood discharge with flooding area is drawn. Potential flood damage costs are calculated for floods with the return periods from 2 to 50 years as summarized as follows:

SUMMARY OF FLOOD DAMAGE

(unit: Million Baht)

Return Period (Year)	Discharge (cu.m/sec)	Flood Damage
2	640	100.7
3	780	225.1
5	930	680.7
10	1,150	2,058.1
20	1,370	2,760.9
30	1,510	2,821.4
40	1,600	3,479.1
50	1,680	4,147.1

From the above table, probable annual average losses (without project) is calculated at 462.1 million Baht (refer to Table E-12 and E-13).

E - 2 - 6 Flood Benefits

With the implementation of drainage improvement works of Tha Taphao river system, the flood discharge of 1,150 cu.m/sec at the control point of ×158 with a return period of 10 years will be prevented from its damages.

The probable annual flood damage loss without any proposed flood control projects is estimated amounting to Baht 462.1 million approximately (refer to table E - 13).

When the said works are implemented, the damages such as 17,600 ha of farmland, 16,600 houses in the both of urban and village areas, 760 ha of shrimp farm, livestock, roads, bridges, so on will be prevented.

The probable annual flood damage loss is estimated at Baht 160.8 million (refer to table E - 14), thus the annual benefits of flood control amount to Baht 301.3 million.

While, accomplishment of such construction works as multipurpose reservoirs and improvement of Tha Taphao river system will be able to prevent the floods within the return period 30 years from occurrence so as to eradicate approximately the damages of 19,000 ha of farmland, 17,300 houses inclusive of the municipality of Chumphon 760 ha of shrimp farm, livestock, roads, bridges, etc., amounting to annual average 393.8 million Baht. (refer to table E - 15)

E - 3 SURVEY AND INVESTIGATION FOR RIVER MOUTH CLOSING

Before preparing the prevention plan of river mouth closing on Tha Taphao river, the survey and investigation works shall be conducted regarding the items as described below:

(1) Present Conditions

a) Land affected by river mouth closing
   - Farm land and others
   - Topography and geology
   - Damaged area

b) Physical conditions of river mouth closing
   - Season (time) and frequency (number) of closing
   - Sedimentation condition at river mouth
   - Flow route at river mouth deposit

(2) Meteology and Hydrology Data

a) Wind (Velocity and direction by 10 minutes)
   - Monthly data
   - Typhoon and depression data

b) Rainfall

c) Hydrology
   - Watershed
   - River run-off and sedimentation
   - River cross section and bed slope
   - Property of deposit and sediment materials
   - Tidal condition

(3) Oceanology Data

a) Wave (Normal and Typhoon)

b) Sea level

c) Nearshore current

d) River flow at river mouth

(4) Littoral Drift

a) Variation of shore
   - Seasonal tendency
   - Variance by flood and typhoon
   - Affection by coast structure

b) Survey of shore and beach level
   - Seasonal tendency
   - Variance by flood and typhoon
   - Affection by coast structure

c) Sedimentation at river mouth

d) Soil property of beach and sea bottom

e) Resources of littoral drift

TABLE E - 1 ANNUAL PEAK DISCHARGE

- Unit: cu.m/sec -

Year	Rap Ro River				Tha Sae River		Chumphon River	
	Phra Chao (330 sq.km)		X46 (751 sq.km)		X64 (957 sq.km)		X53 (223 sq.km)	
	Discharge	Date	Discharge	Date	Discharge	Date	Discharge	Date
1965	179.0	19, Oct.						
1966	132.0	31, Oct.						
1967	169.0	2, Aug.						
1968	95.2	5, Aug.						
1969	132.0	5, Nov.						
1970	496.0	30, Nov.						
1971	266.0	3, Nov.						
1972	170.0	5, Dec.						
1973	134.0	9, Jul.			278.0	10, Jul.		
1974	211.0	9, Jan.			351.0	9, Jan.		
1975	140.4	15, Aug.			431.1	5, Nov.		
1976	242.0	28, May			554.0	28, May		
1977	201.5	20, Aug.			211.0	12, Nov.		
1978	128.0	1, Oct.	589.1	14, May	400.6	14, May	259.0	22, Aug.
1979	227.0	6, Jul.	726.8	6, Jul.	388.0	6, Aug.	437.7	9, Aug.
1980	136.0	29, Aug.	562.1	29, Aug	155.5	2, Dec.	138.1	31, Aug.
1981	94.4	15, Jun.	232.4	23, Nov.	303.0	16, Jun.	164.9	23, Nov.
1982	124.0	25, Aug.	436.2	25, Aug.	253.2	26, Aug.	209.0	25, Aug.
1983	74.4	10, Nov.	151.2	28, Oct.	234.5	16, Nov.	145.4	15, Nov.
1984	132.0	29, Jun.	402.2	29, Jun.	229.2	30, Jun.	276.1	11, Aug.
1985	102.0	13, Nov.	239.0	14, Nov.	192.6	14, Nov.	179.1	20, Jun.
1986	233.0	11, Aug.	474.0	11, Aug.	401.0	12, Aug.	296.9	11, Aug.
1987	96.4	11, Nov.	175.7	12, Nov.	549.0	10, Nov.	107.8	8, Nov.
1988	-	-	541.0	24, Nov.	698.8	24, Nov.	263.5	16, Nov.
1989	-	-	649.4	5, Nov.	n.a	n.a	225.0	5, Nov.
1990	-	-	440.0	10, Nov.	321.5	2, Nov.	235.6	30, Oct.

Note: (1) Source: Hydrology Division, RID for X46, X64 and X53 ; NEA for Phra Chao
(2) Catchment area of ×46 : 617 sq.km from 1978 - 1984
751 sq.km from 1985

TABLE E-2 DAMAGE CAUSED BY TYPHOON GAY

Province	Human Affected					
	Households	Person	Evacuated	Dead	Lost	Injured
Chumphon	36,649	171,672	15,813	446	-	154
Prachuap Khiri Khan	3,292	15,550	-	19	84	13
Surat Thani	18	85	-	66	-	-
Ranong	2,780	12,415	-	21	-	-
Pattani	-	67	-	2	-	16
Rayong	188	-	-	3	50	-
Phetchaburi	-	-	-	1	-	-
Trat	-	452	-	-	-	1
Total	42,927	200,241	15,813	558	134	184

Province	Public Facilities					
	Roads	Bridges	Weirs	Offices	Schools	Temples
Chumphon	579	131	49	92	168	99
Prachuap Khiri Khan	367	39	10	8	38	24
Surat Thani	29	2	1	2	1	1
Ranong	21	20	-	37	9	2
Pattani	-	-	-	-	-	-
Rayong	12	-	1	-	-	-
Phetchaburi	4	1	-	-	-	-
Trat	1	1	4	3	-	-
Total	1,013	194	65	142	216	126

Province	Property and Agriculture			
	Houses	Ships	Farm Land (ha)	Temples
Chumphon	41,208	391	142,400	83,430
Prachuap Khiri Khan	3,258	99	3,870	3,490
Surat Thani	70	36	365	200
Ranong	2,106	4	3,760	1,320
Pattani	-	58	-	-
Rayong	188	26	-	-
Phetchaburi	-	2	135	-
Trat	128	-	-	-
Total	46,958	616	150,530	88,440

TABLE E-3 TROPICAL CYCLONES OVER STUDY AREA DURING 30-YEAR PERIOD (1951-1981)

Year	Month	Day	Note
1956	November	14	tropical depression
1958	October	20	- do -
1963	November	5	- do -
1964	November	18	- do -
1965	September	16	- do -
1967	October	5	- do -
1968	October	22	- do -
1970	November	30	tropical storm
1972	December	5	- do -
1973	October	5	tropical depression
1973	November	18	- do -

Source : Meteorological Department, MOC

TABLE E-4 FARM LAND DAMAGED BY FLOOD IN NOVEMBER, 1988

- Unit : rai -

Farm Land	Amphoe Muang		Amphoe Tha Sae		Total	
	Flooded	Damaged	Flooded	Damaged	Flooded	Damaged
Paddy	27,400	6,700	20,000	13,159	47,400	19,859
Fruit	741	135	3,300	1,338	4,041	1,473
Tree Crops	583	237	18,419	9,922	19,002	10,159
Upland Crops	15	15	3,172	1,603	3,187	1,618
Vegetables	1,485	1,485	209	111	1,694	1,596
Total	30,224	8,572	45,100	26,133	75,324	34,705

Source : Annual Report, Provincial Office of Agriculture, Chumphon.

TABLE E-5 FLOOD DAMAGED IN NOVEMBER, 1988

Item	Amphoe Muang		Amphoe Tha Sae		Total	
	Q'ty	฿ 1,000	Q'ty	฿ 1,000	Q'ty	฿ 1,000
Farm Land (rai)	7,550	5,800	15,000	30,000	22,550	35,800
Road	96	22,500	91	3,200	187	25,700
Weir	5	750	5	530	10	1,280
Bridge	14	5,500	38	8,900	52	14,400
Public Building	87	10,560	2	50	89	10,610
Houses	42	4,920	5	500	47	5,420
Livestock (head)	7,730	1,300	-	-	7,730	1,300
Fish Ponds		75,350	-	-		75,350
Total		126,680		43,180		169,860

Source : Provincial Office of Local Administration, Chumphon.

TABLE E-6 ROAD DAMAGED IN MUNICIPALITY OF CHUMPHON BY FLOOD IN NOVEMBER, 1988

Road	Damage (Baht 1,000)
Saladang	3,592
Paramin Makka	7,524
Pracha Utit	3,263
Pisit Payaban	277
Tavi Sinka	423
Krom Luang Chumphon	308
Suk Samen	175
Tha Taphao	114
Rach Vitee Krang	54
Pinij Kadee	44
Trai Rat	19
Total	15,793

Source : Provincial Office of Local Administration, Chumphon.

TABLE E-7 FARM LAND DAMAGED BY TYPHOON GAY IN 1989

- Unit : ha -

Amphoe/Tambon	Paddy	Upland Crop	Para Rubber	Tree Crops	Coconut	Coffee	Oil Palm	Others	Total	Damage (฿ M)
Muang Chumphon										
- Tak Dad	679	8	4	24	644	30	-	38	1,427	30.77
- Tayang	240	-	-	1	527	-	-	2	770	15.07
- Na Tung	208	2	-	12	465	1	-	74	762	22.62
- Bang Luak	471	24	43	51	716	27	-	105	1,437	39.67
- Bang Mark	1,081	-	-	5	701	7	4	14	1,812	28.33
- Wangphai	431	16	-	248	23	676	34	44	1,472	47.51
- Hadpankrai	442	39	50	25	677	44	7	21	1,305	31.33
- Na Cha Ung	128	18	32	3	1,101	1	-	19	1,302	32.19
Sub-total	3,680	107	129	369	4,854	786	45	317	10,287	247.49
Tha Sae										
- Tha Sae	1,018	952	-	-	6,165	-	-	135	8,270	404.18
- Ku Ring	358	243	-	-	5,689	-	-	886	7,176	399.49
- Takkam	362	183	-	-	4,622	-	-	152	5,319	332.45
- Nakra Tam	1,041	35	-	-	2,559	-	-	55	3,690	238.24
Sub-total	2,779	1,413	-	-	19,035	-	-	1,228	24,455	1,374.36
Total	6,459	1,520	129	369	23,889	786	45	1,545	34,742	1,612.85

Source : Provincial Office of Agriculture, Chumphon.

TABLE E-8 FARM LAND DAMAGED BY FLOOD BY NOVEMBER, 1989

- Unit : ha -

Tambon	Paddy	Upland Crops	Tree Crops	Fruits and Others	Total
Muang Chumphon					
Tak Dad	340	8	352	20	720
Tayang	240	-	528	2	770
Na Tung	208	2	477	75	762
Bang Luak	471	24	837	105	1,437
Bang Mark	1,081	-	717	14	1,812
Wangphai	302	16	983	31	1,332
Hadpankrai	442	39	803	21	1,305
Na Cha Ung	128	18	1,137	19	1,302
Sub-total	3,212	107	5,834	287	9,440
Tha Sae					
Tha Sae	410	380	2,470	50	3,310
Ku Ring	140	100	2,280	360	2,880
Takkam	70	40	920	30	1,060
Nakra Tam	310	10	770	20	1,110
Sub-total	930	530	6,440	460	8,360
Total	4,142	637	12,274	747	17,800

Source : Provincial Office of Agriculture, Chumphon.

TABLE E-9 CROP DAMAGE BY TYPHOON GAY IN 1989

Tambon	Damaged Area (ha)	Average Damage per ha (฿ 1,000)	Total Damage (฿ M)
Muang Chumphon			
Tak Dad	720	21.56	15.5
Tayang	770	19.57	15.1
Na Tung	762	29.69	22.6
Bang Luak	1,437	27.61	39.7
Ban Mark	1,812	15.63	28.3
Wangphai	1,332	32.28	43.0
Hadpankrai	1,305	24.01	31.3
Na Cha Ung	1,302	24.72	32.2
Sub-total	9,440		227.7
Tha Sae			
Tha Sae	3,310	48.87	161.8
Ku Ring	2,880	55.67	160.3
Takkam	1,060	62.50	66.3
Nakra Tam	1,110	64.56	71.7
Sub-total	8,360		460.1
Total	17,800		687.8

Notes : (1) Average damage per ha is calculated based on data of Provincial Office of Agriculture.

(2) Damage value includes losses caused by floods and winds.

TABLE E-10 ROADS AND BRIDGES DAMAGED BY FLOOD IN NOVEMBER, 1989 (AMPHOE THA SAE)

- Unit : Baht 1,000 -

Tambon	Road		Bridge		Total Damage
	Q'ty	Damage	Q'ty	Damage	
Tha Sae	27	3,973	6	2,623	6,596
Ku Ring	24	2,918	4	3,977	6,895
Takkam	32	4,657	15	6,736	11,393
Nakra Tam	15	1,847	3	1,470	3,317
Total	98	13,395	28	14,806	28,201

Source : Amphoe Office of Tha Sae.

TABLE E-11 ROADS AND BRIDGES DAMAGED BY FLOOD IN NOVEMBER, 1989 (AMPHOE CHUMPHON)

Tambon	Road	Bridge
Tak Dad	25	3
Tayang	10	-
Na Tung	14	2
Bang Luak	13	4
Bang Mark	27	2
Wangphai	25	5
Hadpankrai	7	3
Na Cha Ung	16	1
Pak Nam	-	1
Wang Phai	20	3
Total	157	24

Source : Provincial Office of Local Administration, Chumphon Province.

TABLE E-12 SUMMARY OF FLOOD DAMAGE

(unit : Baht Million)

Return Period (Year)	Flood Discharge (cu.m/sec)	Crops	Shrimp	Livestock	Facilities Farm Land	Total (1)
2	640	27.1	-	-	39.1	66.2
3	780	44.3	-	-	66.2	110.5
5	930	61.9	-	3.0	93.0	157.9
10	1,150	69.4	519.8	10.4	108.9	708.5
20	1,370	72.1	519.8	24.1	114.0	730.0
30	1,510	112.5	519.8	26.4	117.0	775.7
40	1,600	121.4	519.8	26.4	118.5	786.1
50	1,680	125.4	519.8	26.4	124.0	795.6

Return Period (Year)	Flood Discharge (cu.m/sec)	Bridge, Road	House	Factory	Total (2)	Grand Total
2	640	34.5	-	-	34.5	100.7
3	780	53.4	60.8	0.4	114.6	225.1
5	930	72.4	444.0	6.4	522.8	680.7
10	1,150	85.8	1,240.0	23.8	1,349.6	2,058.1
20	1,370	99.3	1,896.0	35.6	2,030.9	2,760.9
30	1,510	108.1	1,902.0	35.6	2,045.7	2,821.4
40	1,600	113.4	2,544.0	35.6	2,693.0	3,479.1
50	1,680	116.9	3,190.0	44.6	3,351.5	4,147.1

TABLE E-13 PROBABLE ANNUAL AVERAGE LOSSES

(unit: Baht Million)

Return Period (Year)	Flood Discharge (cu.m/sec)	Probability		Actual Losses	Average Losses	Probable Average Losses
2	640	0.500	0.500	101	51	25.5
3	780	0.333	0.167	225	163	27.2
5	930	0.200	0.133	681	453	60.2
10	1,150	0.100	0.100	2,058	1,370	137.0
20	1,370	0.050	0.050	2,761	2,410	120.5
30	1,510	0.033	0.017	2,821	2,791	47.4
40	1,600	0.025	0.008	3,479	3,150	25.2
50	1,680	0.020	0.005	4,147	3,813	19.1
Total						462.1

TABLE E-14 ROBABLE ANNUAL AVERAGE LOSSES (IN CASE OF PROTECTION OF 1/10 YEARS FREQUENCY FLOOD)

(unit: Baht Million)

Return Period (Year)	Flood Discharge (cu.m/sec)	Probability		Actual Losses	Average Losses	Probable Average Losses
2	640	0.500	0.500	-	-	-
3	780	0.333	0.167	-	-	-
5	930	0.200	0.133	-	-	-
10	1,150	0.100	0.100	-	-	-
20	1,370	0.050	0.050	2,761	1,381	69.1
30	1,510	0.033	0.017	2,821	2,791	47.4
40	1,600	0.025	0.008	3,479	3,150	25.2
50	1,680	0.020	0.005	4,147	3,813	19.1
Total						160.8

TABLE E-15 PROBABLE ANNUAL AVERAGE LOSSES IN CASE OF PROTECTION OF 1/30 YEARS FREQUENCY FLOOD)

(unit: Baht Million)

Return Period (Year)	Flood Discharge (cu.m/sec)	Probability		Actual Losses	Average Losses	Probable Average Losses
2	640	0.500	0.500	-	-	-
3	780	0.333	0.167	-	-	-
5	930	0.200	0.133	-	-	-
10	1,150	0.100	0.100	-	-	-
20	1,370	0.050	0.050	-	-	-
30	1,510	0.033	0.017	2,821	1,411	24.0
40	1,600	0.025	0.008	3,479	3,150	25.2
50	1,680	0.020	0.005	4,147	3,813	19.1
Total						68.3

TABLE E-16 FLOOD DAMAGE TO PADDY

Return Period (Year)	Flood Discharge (cu.m/sec)	Area (ha)	Damage Rate	Losses (฿ M)
2	640	1,250	0.20	1.99
3	780	2,100	0.20	3.34
5	930	3,000	0.40	9.54
10	1,150	4,150	0.40	13.20
20	1,370	4,400	0.40	13.99
30	1,510	4,600	0.50	18.29
40	1,600	4,700	0.50	18.68
50	1,680	4,880	0.50	19.40

GPV = ฿7,950/ha

TABLE E-17 FLOOD DAMAGE TO UPLAND CROPS

Return Period (Year)	Flood Discharge (cu.m/sec)	Area (ha)	Damage Rate	Losses (฿ M)
2	640	160	0.30	0.25
3	780	260	0.30	0.41
5	930	390	0.40	0.82
10	1,150	610	0.40	1.28
20	1,370	660	0.40	1.39
30	1,510	690	0.50	1.81
40	1,600	720	1.00	3.78
50	1,680	730	1.00	3.83

GPV = ฿5,250/ha

TABLE E-18 FLOOD DAMAGE TO VEGETABLES

Return Period (Year)	Flood Discharge (cu.m/sec)	Area (ha)	Damage Rate	Losses (฿ M)
2	640	440	0.60	16.34
3	780	700	0.60	25.99
5	930	710	0.70	30.75
10	1,150	740	0.70	32.05
20	1,370	760	0.70	32.92
30	1,510	790	0.90	43.99
40	1,600	810	1.00	50.12
50	1,680	820	1.00	50.74

GPV = ฿61,875/ha

TABLE E-19 FLOOD DAMAGE TO FRUIT/TREE CROPS

Return Period (Year)	Flood Discharge (cu.m/sec)	Area (ha)	Damage Rate	Losses (฿ M)
2	640	4,500	0.05	8.51
3	780	7,700	0.05	14.57
5	930	11,000	0.05	20.81
10	1,150	12,100	0.05	22.89
20	1,370	12,600	0.05	23.84
30	1,510	12,800	0.10	48.43
40	1,600	12,900	0.10	48.81
50	1,680	13,590	0.10	51.42

GPV = ฿37,837/ha

TABLE E-20 FLOOD DAMAGE TO CROPS

(unit: Baht Million)

Return Period (Year)	Flood Discharge (cu.m/sec)	Paddy	Upland Crops	Vegetables	Fruits, Tree	Total
2	640	1.99	0.25	16.34	8.51	27.09
3	780	3.34	0.41	25.99	14.57	44.31
5	930	9.54	0.82	30.75	20.81	61.92
10	1,150	13.20	1.28	32.05	22.89	69.42
20	1,370	13.99	1.39	32.92	23.84	72.14
30	1,510	18.29	1.81	43.99	48.43	112.52
40	1,600	18.68	3.78	50.12	48.81	121.39
50	1,680	19.40	3.83	50.74	51.42	125.39

TABLE E-21 FLOOD DAMAGE TO SHRIMP POND

Return Period (Year)	Flood Discharge (cu.m/sec)	Pond Area (ha)	Damage Rate	Losses (฿ M)
2	640	-	-	-
3	780	-	-	-
5	930	-	-	-
10	1,150	760	1.00	519.84
20	1,370	760	1.00	519.84
30	1,510	760	1.00	519.84
40	1,600	760	1.00	519.84
50	1,680	760	1.00	519.84

GPV = ฿ 684,000/ha

TABLE E-22 FLOOD DAMAGE TO LIVESTOCK

Return Period (Year)	Flood Discharge (cu.m/sec)	Cattle			Buffaloe		
		Nos.	Damage Rate	Losses (฿ M)	Nos.	Damage Rate	Losses (฿ M)
2	640	-	-	-	-	-	-
3	780	-	-	-	-	-	-
5	930	360	0.3	0.68	420	0.3	0.63
10	1,150	1,200	0.3	2.26	1,380	0.3	2.07
20	1,370	1,670	0.5	5.24	1,800	0.5	4.50
30	1,510	1,800	0.5	5.65	2,000	0.5	5.00
40	1,600	1,800	0.5	5.65	2,000	0.5	5.00
50	1,680	1,800	0.5	5.65	2,000	0.5	5.00

GPV: Cattle = ฿6,280/head
Buffaloe = ฿5,000/head

Return Period (Year)	Flood Discharge (cu.m/sec)	Swine			Poultry		
		Nos.	Damage Rate	Losses (฿ M)	Nos.	Damage Rate	Losses (฿ M)
2	640	-	-	-	-	-	-
3	780	-	-	-	-	-	-
5	930	1,600	0.3	1.44	25,000	0.5	0.25
10	1,150	5,600	0.3	5.04	100,000	0.5	1.00
20	1,370	7,700	0.5	11.55	138,000	1.0	2.76
30	1,510	8,500	0.5	12.75	150,000	1.0	3.00
40	1,600	8,500	0.5	12.75	150,000	1.0	3.00
50	1,680	8,500	0.5	12.75	150,000	1.0	3.00

GPV: Swine = ฿3,000/head
Poulty = ฿20/unit

TABLE E-23 TOTAL FLOOD DAMAGE TO LIVESTOCK

(Unit : Baht Million)

Return Period (Year)	Flood Discharge (cu.m/sec)	Cattle	Buffaloe	Swine	Poultry	Total
2	640	-	-	-	-	-
3	780	-	-	-	-	-
5	930	0.68	0.63	1.44	0.25	3.00
10	1,150	2.26	2.07	5.04	1.00	10.37
20	1,370	5.24	4.50	11.55	2.76	24.05
30	1,510	5.65	5.00	12.75	3.00	26.40
40	1,600	5.65	5.00	12.75	3.00	26.40
50	1,680	5.65	5.00	12.75	3.00	26.40

TABLE E-24 FLOOD DAMAGE TO IRRIGATION FACILITIES AND FARM LAND

Return Period (Year)	Flood Discharge (cu.m/sec)	Irrigation Facilities		Farm Land		Total Losses (฿ M)
		Area (ha)	Losses (฿ M)	Area (ha)	Losses (฿ M)	
2	640	1,250	1.00	6,350	38.10	39.10
3	780	2,100	1.68	10,760	64.56	66.24
5	930	3,000	2.40	15,100	90.60	93.00
10	1,150	4,150	3.32	17,600	105.60	108.92
20	1,370	4,400	3.52	18,420	110.52	114.04
30	1,510	4,600	3.68	18,880	113.28	116.96
40	1,600	4,700	3.76	19,130	114.78	118.54
50	1,680	4,880	3.90	20,020	120.12	124.02

TABLE E-25 FLOOD DAMAGE TO BRIDGE AND ROAD

Return Period (Year)	Flood Discharge (cu.m/sec)	Bridge		Road		Total Losses (฿ M)
		Nos.	Losses (฿ M)	Nos.	Losses (฿ M)	
2	640	23	12.49	90	21.96	34.45
3	780	37	16.83	150	36.60	53.43
5	930	39	21.18	210	51.24	72.42
10	1,150	48	26.06	245	59.78	85.84
20	1,370	57	30.95	280	68.32	99.27
30	1,510	62	33.67	305	74.42	108.09
40	1,600	65	35.30	320	78.08	113.38
50	1,680	67	36.38	330	80.52	116.90

Losses : Bridge = ฿ 543,000 / location
Road = ฿ 244,000 / location

TABLE E-26 FLOOD DAMAGE TO HOUSE IN URBAN AREA

Return Period (Year)	Flood Discharge (cu.m/sec)	Urban Area		
		Nos.	Damage Rate	Losses (฿ M)
2	640	-	-	-
3	780	700	0.03	16.8
5	930	3,600	0.10	288.0
10	1,150	4,800	0.20	768.0
20	1,370	4,800	0.30	1,152.0
30	1,510	4,800	0.30	1,152.0
40	1,600	4,800	0.40	1,536.0
50	1,680	4,800	0.50	1,920.0

Losses : ฿ 0.8 million / house

TABLE E-27 FLOOD DAMAGE TO HOUSE IN VILLAGE

Return Period (Year)	Flood Discharge (cu.m/sec)	Nos.	Damage Rate	Losses (฿ M)
2	640	-	-	-
3	780	2,200	0.10	44.0
5	930	7,800	0.10	156.0
10	1,150	11,800	0.20	472.0
20	1,370	12,400	0.30	744.0
30	1,510	12,500	0.30	750.0
40	1,600	12,600	0.40	1,008.0
50	1,680	12,700	0.50	1,270.0

Losses : ฿ 0.2 million / house

TABLE E-28 TOTAL FLOOD DAMAGE TO HOUSE

(Unit : Baht Million)

Return Period (Year)	Flood Discharge (cu.m/sec)	Urban Area	Village Area	Total
2	640	-	-	-
3	780	16.8	44.0	60.8
5	930	288.0	156.0	444.0
10	1,150	768.0	472.0	1,240.0
20	1,370	1,152.0	744.0	1,896.0
30	1,510	1,152.0	750.0	1,902.0
40	1,600	1,536.0	1,008.0	2,544.0
50	1,680	1,920.0	1,270.0	3,190.0

TABLE E-29 FLOOD DAMAGE TO FACTORY

Return Period (Year)	Flood Discharge (cu.m/sec)	Nos.	Damage Rate	Losses (฿ M)
2	640	-	-	-
3	780	12	0.03	0.40
5	930	29	0.20	6.38
10	1,150	72	0.30	23.76
20	1,370	81	0.40	35.64
30	1,510	81	0.40	35.64
40	1,600	81	0.40	35.64
50	1,680	81	0.50	44.55

฿ 1.1 million / factory

FIGURE E-1 FLOOD WATER LEVEL OF THA TAPHAO RIVER IN 1989

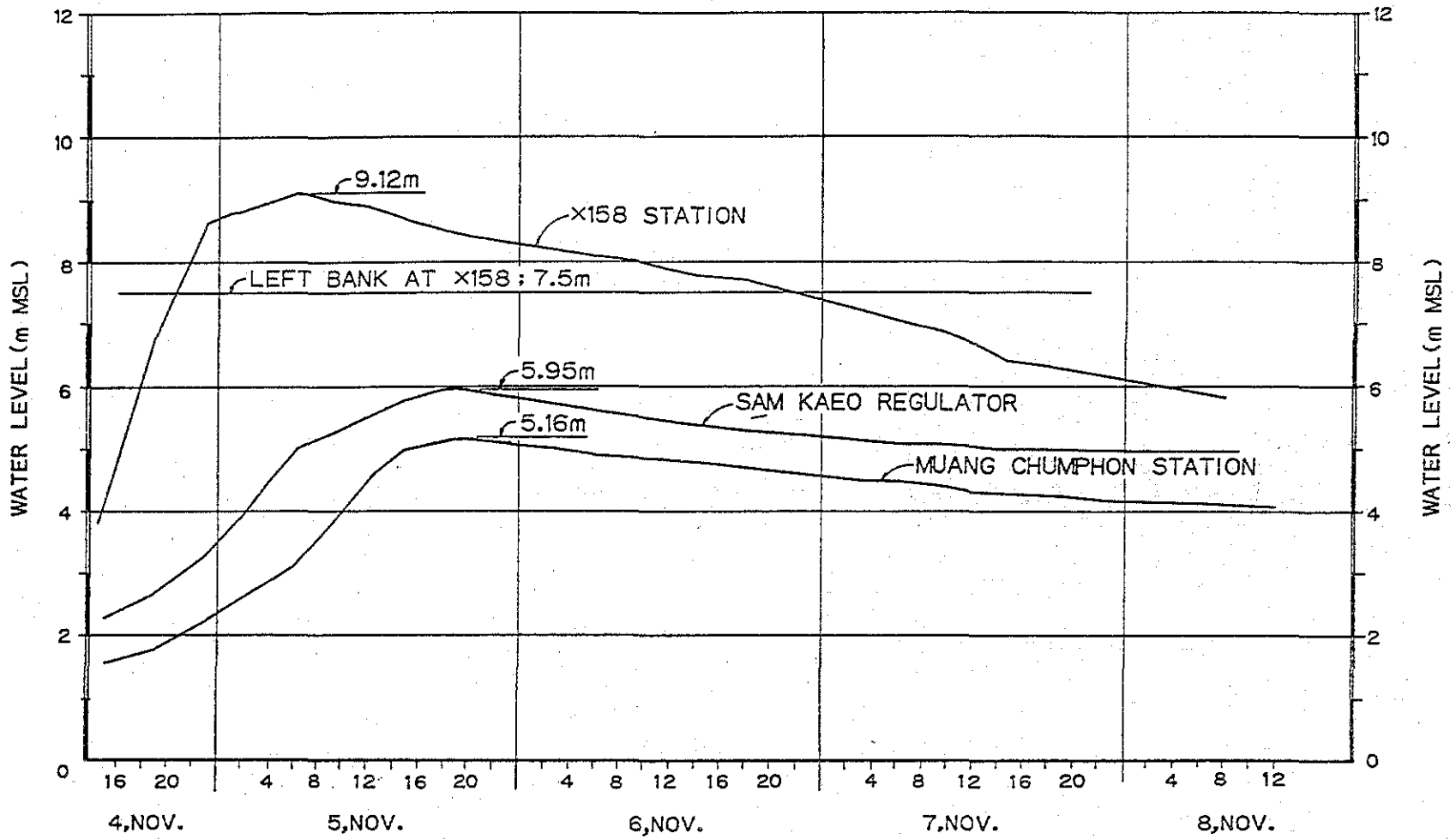


FIGURE E-2 FLOOD CONTROL BY RAP RO RESERVOIR

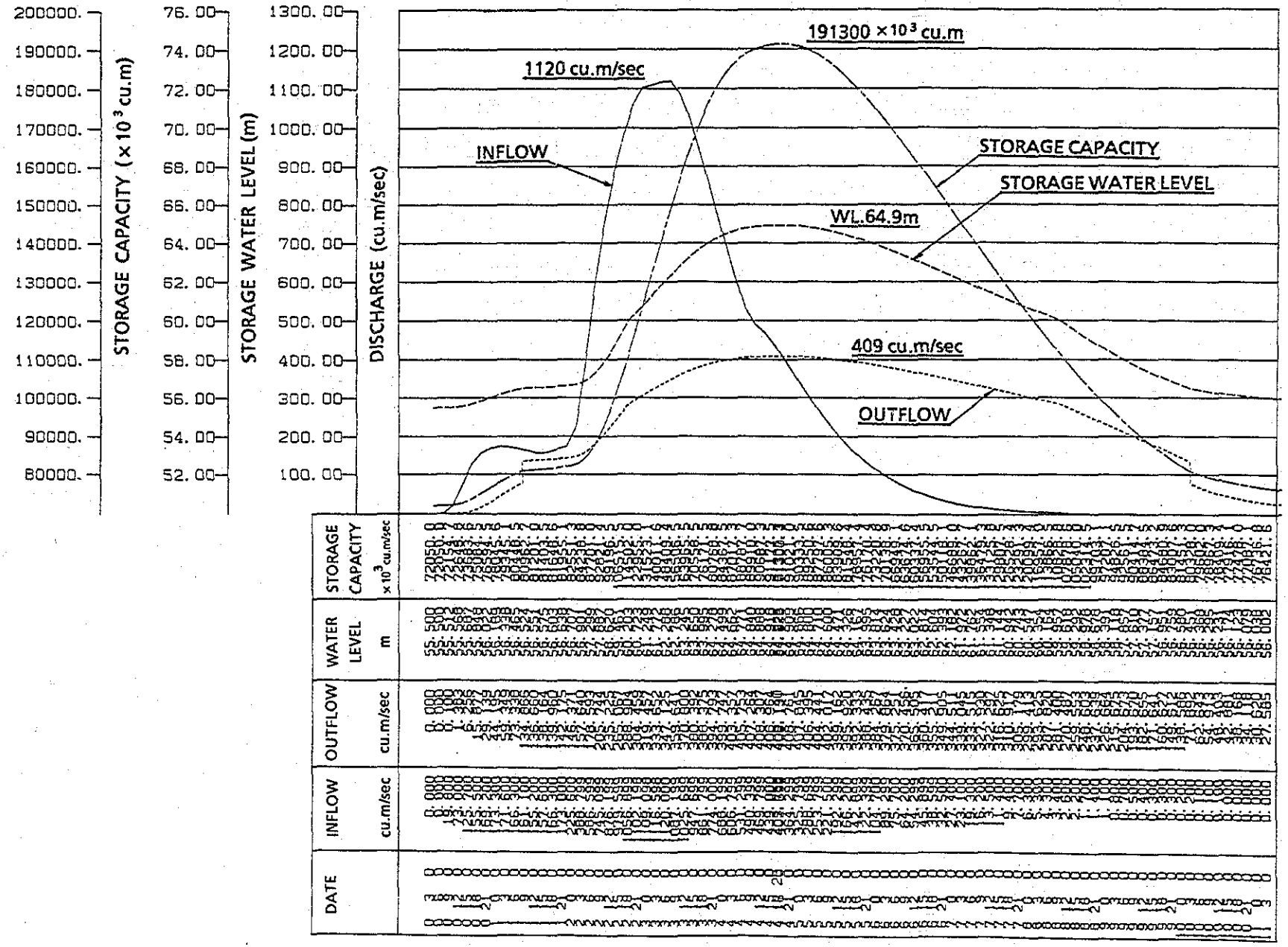


FIGURE E-3 FLOOD CONTROL BY THA SAE RESERVOIR

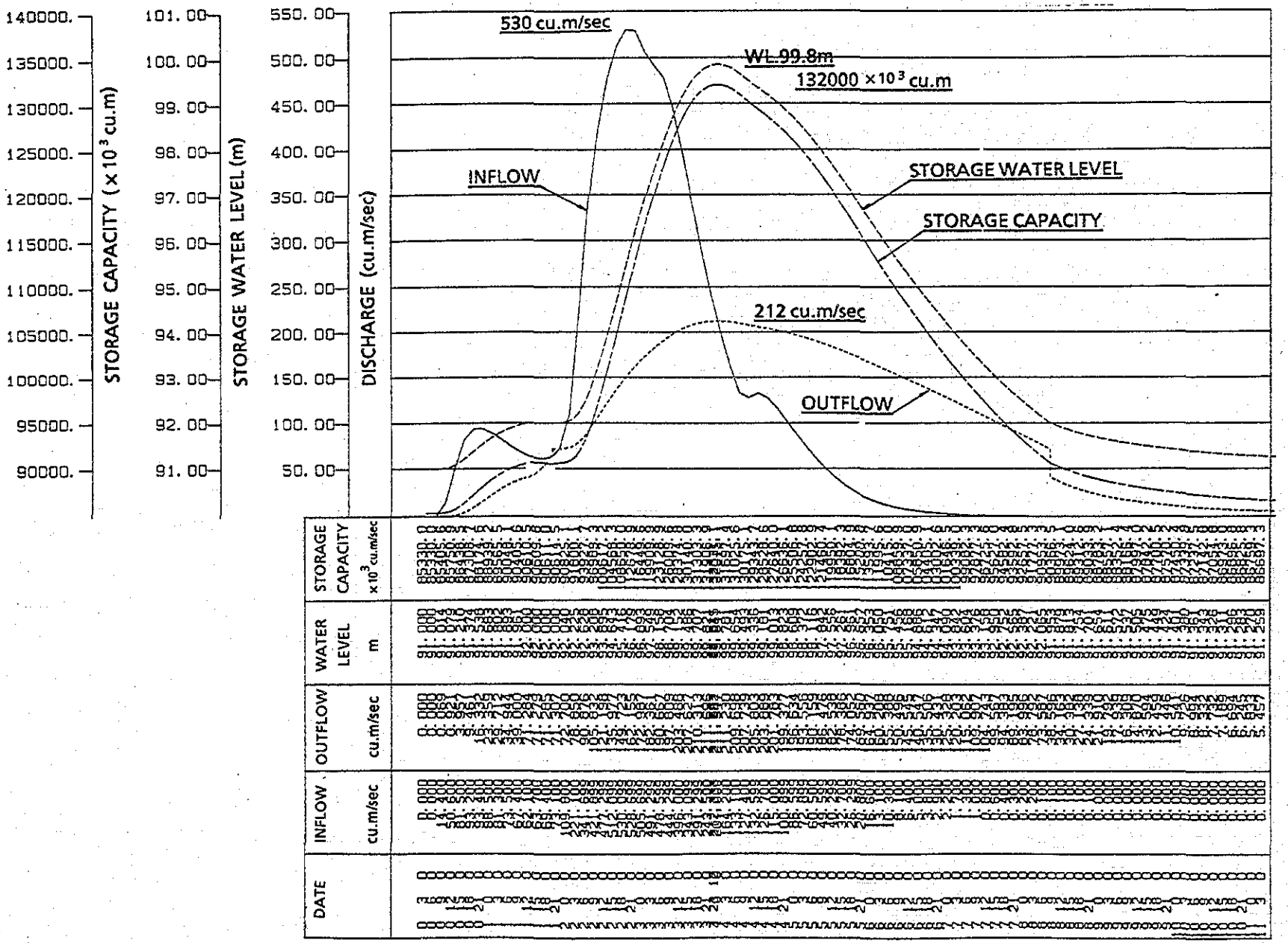


FIGURE E-4 FLOOD HYDROGRAPH OF RAP RO BASIN

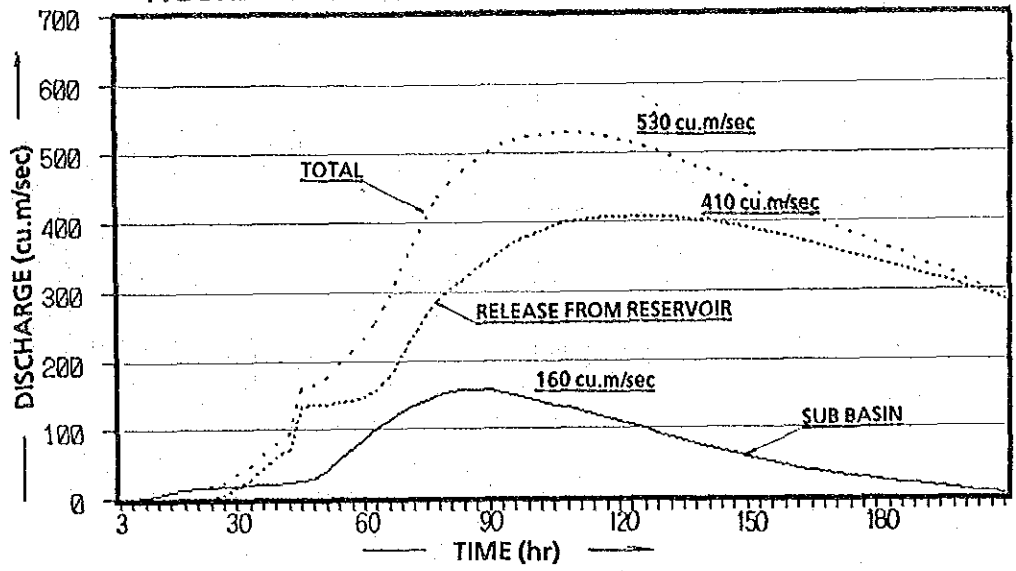


FIGURE E-5 FLOOD HYDROGRAPH OF THA SAE BASIN

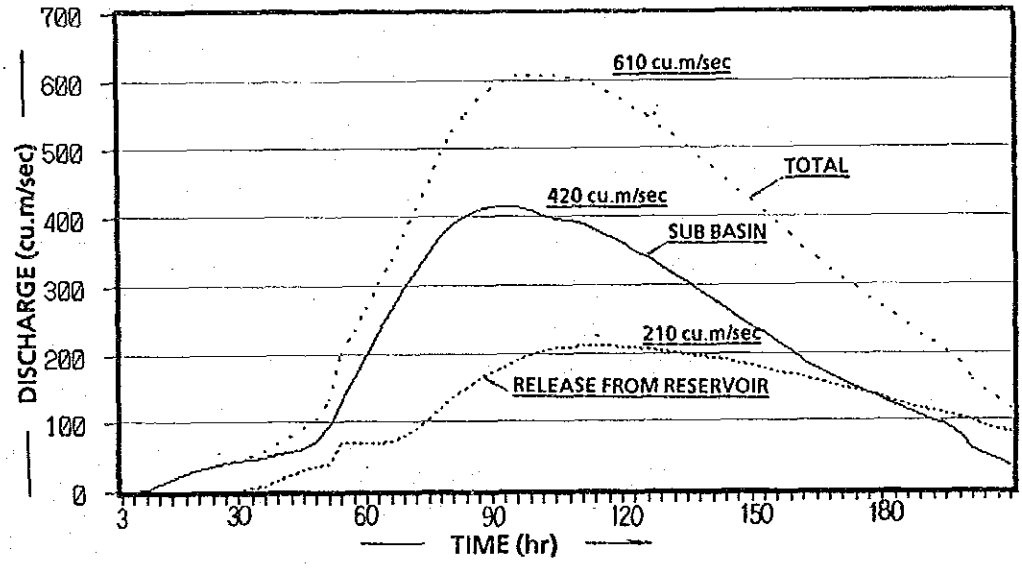


FIGURE E-6 FLOOD HYDROGRAPH OF THA TAPHAO RIVER (X.158)

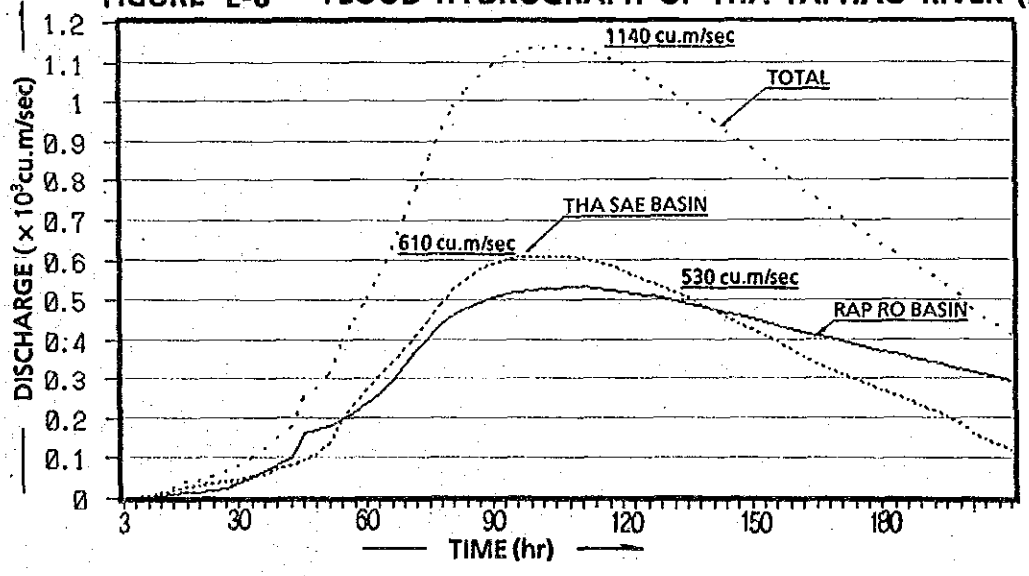
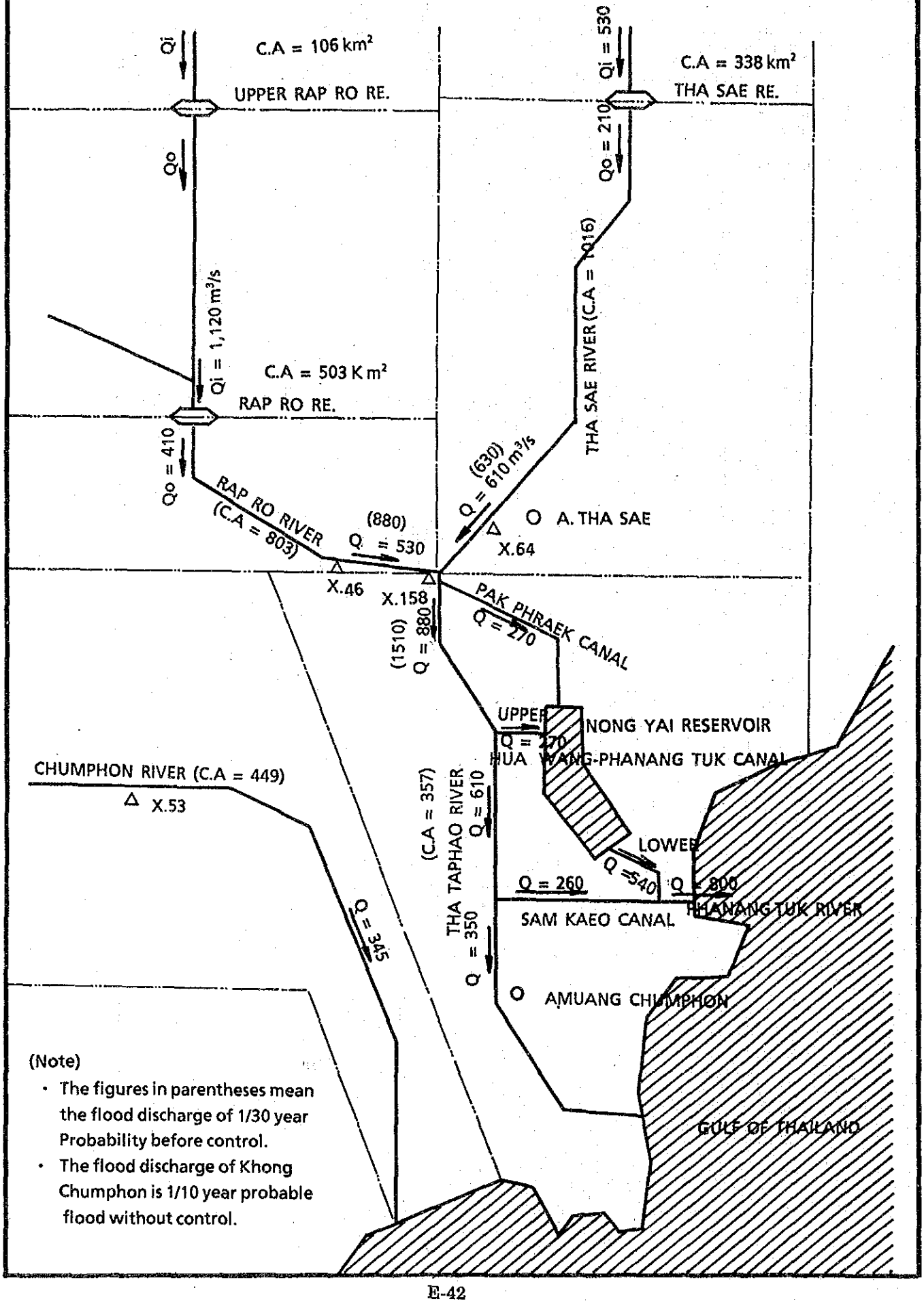


FIGURE E-7 DISTRIBUTION OF FLOOD DISCHARGE



(Note)

- The figures in parentheses mean the flood discharge of 1/30 year Probability before control.
- The flood discharge of Khong Chumphon is 1/10 year probable flood without control.

FIGURE E-8 TRACK OF GAY

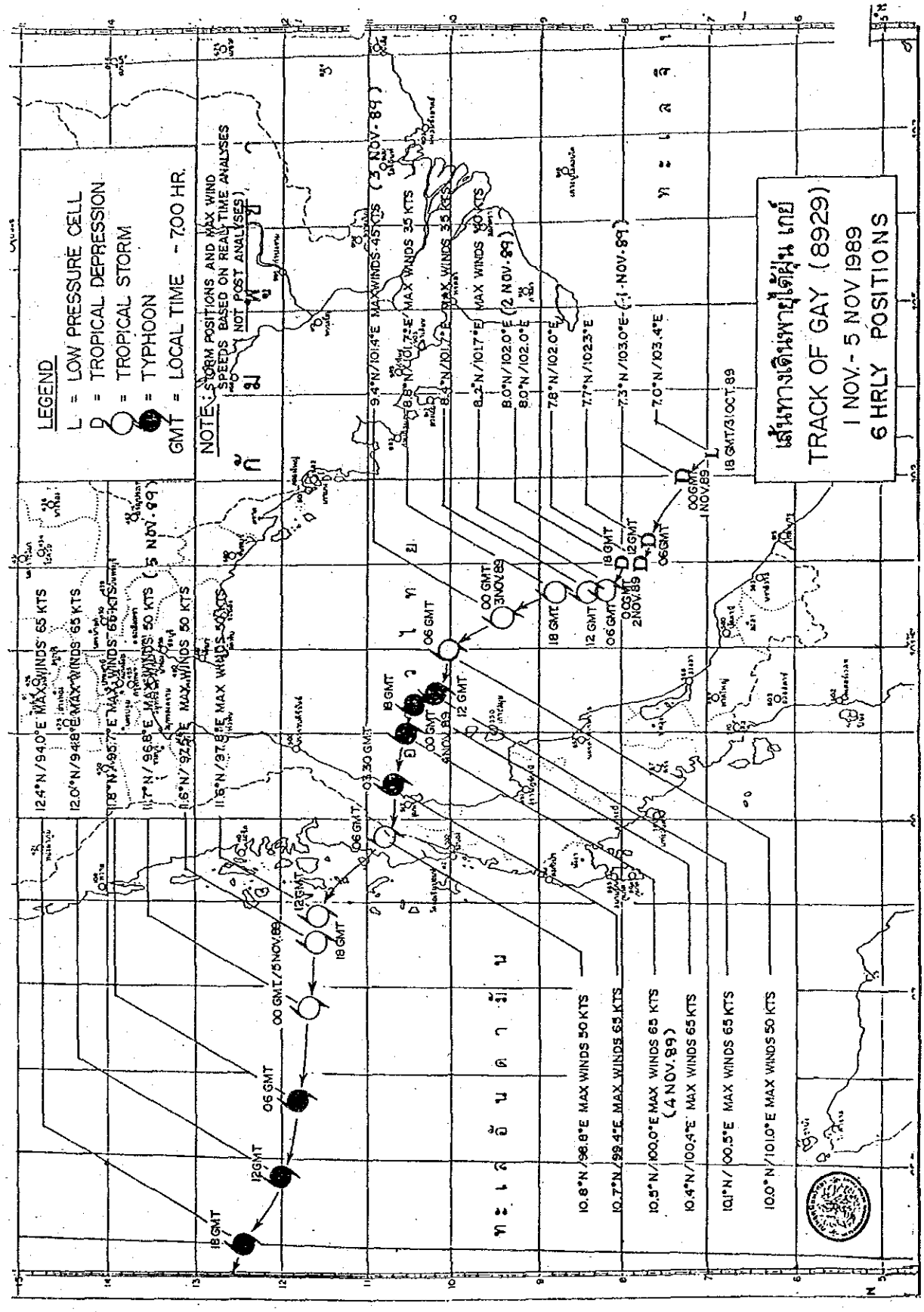
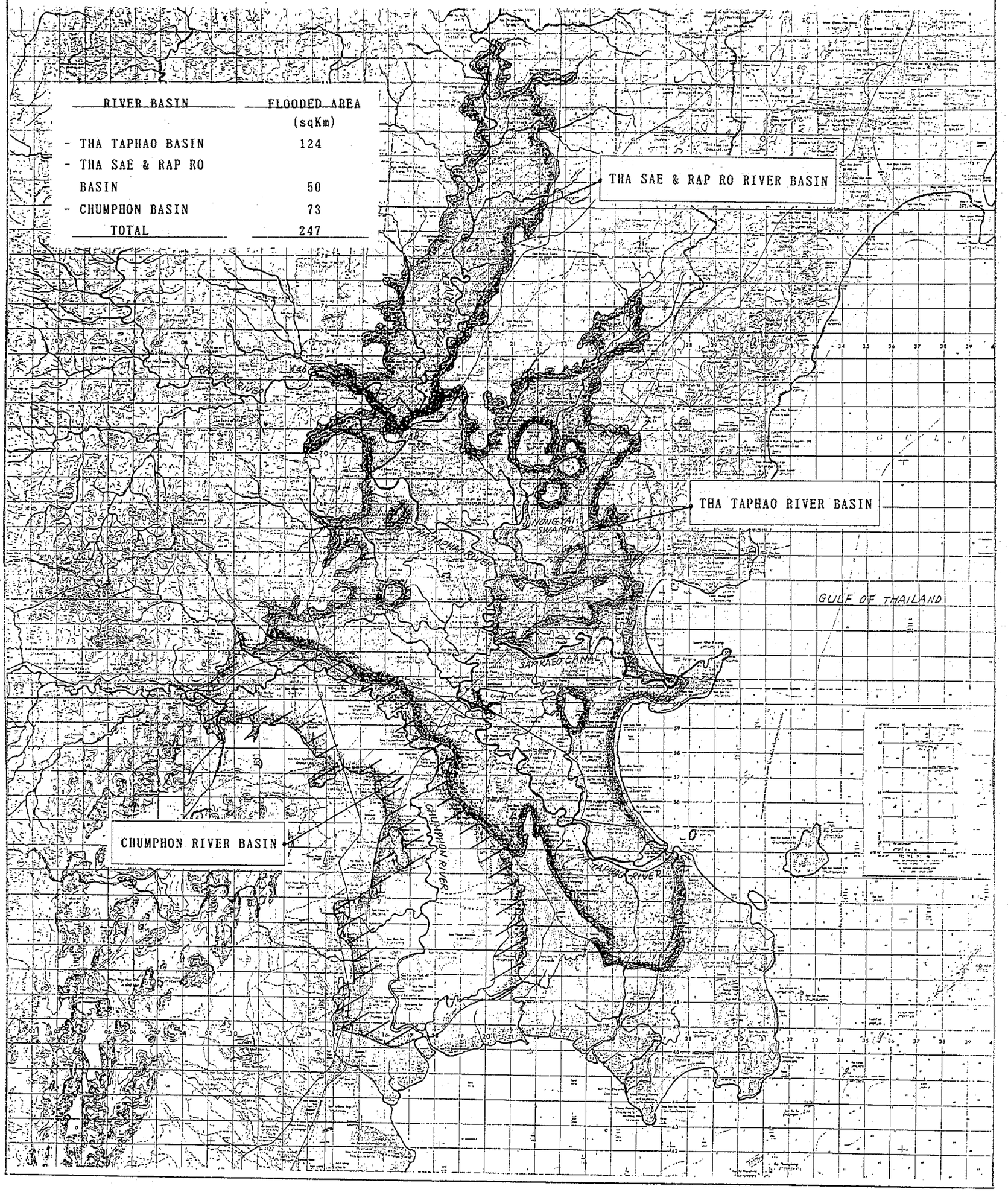


FIGURE E-9 FLOOD AREA MAP

RIVER BASIN	FLOODED AREA (sqKm)
- THA TAPHAO BASIN	124
- THA SAE & RAP RO BASIN	50
- CHUMPHON BASIN	73
TOTAL	247



APPENDIX F. PROJECT FACILITIES AND PROJECT COST

CONTENTS

APPENDIX F. PROJECT FACILITIES AND PROJECT COST

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APPENDIX F. PROJECT FACILITIES AND PROJECT COST

F-1 PROJECT FACILITIES

F-1-1 Storage Dams

Storage capacities and embankment volumes of the potential six reservoirs were preliminary estimated based on the topo-maps scaled 1 : 50,000 with the contour of 20 meters.

The typical section of those dams were preliminary designed with the up-stream slope of 1 : 3.00 and down-stream slope of 1 : 2.50 by file-type dam.

The storage water level ~ storage capacity and allocation of reservoir storage for main two reservoirs, Rap Ro and Tha Sae reservoir are shown in Figure F-1-1~1-4.

F-1-2 Hydraulic Design of Canal and River

(1) Coefficient of Roughness of River

The roughness coefficient of river was estimated applying a uniform flow formula based on the rating curve observed in 1990 at X158 gauging station of Tha Taphao river.

For a subject discharge as $Q = 200$ cu.m/sec

then, from the rating curve,

water depth is $H = 3.90$ m
flow area is $A = 184.0$ sq.m
wetted perimeter is $P = 68.0$ m

and, hydraulic radius is $R = A/P = 2.71$ m

While,

river bed slope is given as $i = 1/3{,}000$

and, flow velocity is as $V = Q/A = 1.09$ m/sec

Accordingly, from Manning's formula,

Coeff. of Roughness is thus derived as

$$n = \frac{1}{V} \cdot R^{2/3} \cdot i^{1/2} = \frac{1}{1.09} \times 2.71^{2/3} \times \left(\frac{1}{3000}\right)^{1/2}$$

$$= 0.033$$

For hydraulic calculation for planning and design purpose, the value of $n = 0.035$ is herein employed by taking some safety allowance into account.

(2) Initial Water Levels for Hydraulic Calculation

Water levels along the river course can only be worked out from downstream end to upstream in stepwise way giving initial water levels at the river mouth. Tidal levels at the river mouth of Tha Taphao river have been observed as follows;

DATA OF TIDE LEVEL AT KO MATTAPHON

Tidal Level in MSL	1987	1989	1990	Remarks	
Annual Highest tide	1.38	1.58	1.52	Recorded Max.	1.58
Mean high tide	0.56	0.52	0.51	Mean	0.53
Mean low tide	- 0.62	- 0.67	- 0.65	Mean	- 0.65
Annual lowest tide	- 1.41	- 1.46	- 1.43	Recorded Min.	- 1.46

It may be justified to employ mean tidal levels for planning and design of hydraulic structures, since a peak flood flow hardly coincides with high tide and, even so, the duration is only a short time. Accordingly,

$$WL = 1/2\,(0.53 - 0.65)$$

$$= - 0.06 \text{ MSL} - \text{m}$$

(3) Flow Capacity of Tha Taphao River

a) Sam Kaeo Section

The both banks of Tha Taphao river within the city of A. Muang Chumphon are much crowded by houses, and, therefore, improvement of the channel cross-section is hardly possible. Flow capacity in this section is accordingly planned in ways not to overflow the present channel cross-section. Consequently, the present flow capacity of the lower section of Tha Taphao river from the diversion point of Sam Kaeo canal is estimated as;

$$Q = 350 \text{ cu.m/sec}$$

b) The confluence (X158) to Sam Kaeo Diversion Point

Upon the flow capacity of the river along the section between the confluence (X158) to the diversion point of Sam Kaeo canal, some increased capacity may easily be attained only by some additional embanking along the both banks whereat necessary. Longitudinal profile of the channel and the water levels along the section are as shown in Figure F-1-8. Flow capacity of the section is consequently estimated as ;

$$Q = 430 \text{ cu.m/sec}$$

(4) River Improvement Plan

Design discharges of the rivers have been planned based on the flood analysis and flood control plans of Tha Sae and Rap Ro reservoir. The design discharges of rivers at the confluence (X158 gauging station) are as follows ;

Tha Sae river	Q1 = 610 cu.m/sec
Rap Ro river	Q2 = 530 cu.m/sec
Tha Taphao river	Q3 = 1,140 ≒ 1,150 cu.m/sec

Meanwhile, stochastic flood flow of 10 year return period in the Tha Taphao river at X158 indicates 1,150 cu.m/sec in case of no flood control by the reservoirs. The stochastic flow has accordingly been employed for the channel

improvement in the Tha Taphao river. On the other hand, flow capacities in the river at present are;

Beginning point (BP) of Tha Taphao River - Sam Kaeo	Q = 430 cu.m/sec
Sam Kaeo - Estuary	Q = 350 cu.m/sec

Flow capacities in the present channel do not satisfy the flood flow requirement, so that following river channel improvement are planned.

- Elevating/construction of dikes for increased capacity
- Short cut of river for smooth flow
- New construction of a floodway for flood diversion

Flood diversion by a floodway for the Tha Taphao river is planned as presented in Figure F-1-5.

a) Floodway Plan

Flood flows in each section of the course are given as;

- Beginning point of Tha Taphao river -	Inlet of Upper Hua Wang Phanang Tuk canal	Q 3 = 880 cu.m/sec
- Pak Phraek canal		Q 4 = 270 〃
- Upper Hua Wang Phanang Tuk canal		Q 5 = 270 〃
- Inlet of Upper Hua Wang Phanang Tuk canal -	Inlet of Sam Kaeo canal	Q 6 = 610 〃
- Sam Kaeo canal		Q 7 = 260 〃
- Lower Tha Taphao river from diversion point of Sam Kaeo canal		Q 8 = 350 〃
- Lower Hua Wang Phanang Tuk canal		Q 9 = 540 〃
- Phanang Tuk river		Q10 = 800 〃

The hydraulic design for such canals as Upper Hua Wang Phanang Tuk, Lower Hua Wang Phanang Tuk and Pak Phraek canal was made by applying non-uniform flow formula with the conditions of 2.0 m/sec of

maximum flow velocity and 0.025 of roughness coefficient, resulting as shown in Figure F-1-17, F-1-18 and F-1-19.

b) Flood Dike Plan

Some flood dikes are planned for construction whereat both banks of the channel may be overtopped by flood water. By taking embankment materials and difficulties in equitable construction into consideration, cross-section of the dike is planned as shown in Figure F-1-9, while the crest is as wide as 6.0 m to serve for O & M and traffic by the local residents. Design discharge and river length for the dike construction are found as follows;

	Design Capacity (cu.m/sec)	River Length (km)
Tha Sae river	610	21.0
Rap Ro river	530	17.0
Tha Taphao river		
(confluence - Hua Wang Phanang Tuk)	880	11.3
(Hua Wang Phanang Tuk - Sam Kaeo)	610	6.0
(Sam Kaeo - Estuary)	350	17.0
Phanang Tuk river	800	6.2
Chumphon river (10 year flood X53)	345	35.0
Nong Sai river	51.3	8.0

Dimensions of the dikes are determined from the results of non-uniform flow analysis of the flood flows and 1.0 m of freeboard. (refer to Figure F-1-10, F-1-11, F-1-12, F-1-13, F-1-14, F-1-15 and F-1-16)

F - 1 - 3 Structural Design of Canal

(1) Weir Structure of Hua Wang Phanang Tuk Canal

a) General

The Hua Wang Phanang Tuk canal shall provide weirs and gates at the following two sites.

Upper Canal

A fixed weir is constructed to divert the design discharge at flooding in the Tha Taphao river. Besides, an intake gate for irrigation water is provided so as to make emergency water supply against drawdown of the Nong Yai reservoir in the drought. And this weir is hereinafter called Head Weir.

Lower Canal

A fixed weir is constructed to retain the water level with 4.5 m for storage of irrigation water in the Nong Yai reservoir. Besides, two movable weirs are provided so as to give operation and maintenance services for the reservoir, canal and intake works for irrigation. This weir is hereinafter called Tail Weir.

b) Design Conditions

Items	Head Weir	Tail Weir
Design Flood Discharge	Q=270 cu.m/s	Q=540 cu.m/s
Design Canal Width	B=50 m	B=80 m
Maintenance Water Level at Nong Yai Reservoir	N.W.S. 4.5 m	N.W.S. 4.5 m
Minimum Water Level in Nong Yai Reservoir	L.W.S. 3.0 m	L.W.S. 3.0 m
Design High Water Level	H.W.S. 7.05 m (*1)	H.W.S. 6.00 m
Downstream Water Level at Flooding	WL. 6.20 m (*2)	WL. 3.61 m (*3)
Highest High - Water Level	-	WL. 1.58 m (*4)

(*1) Result of hydraulic computation of the Tha Taphao river (Survey Point : No.30+734)

(*2) Flood water level in the Nong Yai reservoir

(*3) Result of hydraulic computation of the Hua Wang Phanang Tuk canal

(*4) Taking place in 1989 at Ko Mattaphon

c) Design of Flood Sluiceway

i) Type of Fixed Weir

The proposed fixed weir shall be of type to ensure the necessary water level for intake and to secure water flow as smooth as possible for discharging flood water.

The cross section of the weir body shall be of trapezoidal shape with upstream face upright, while downstream face in gentle slope and with crest wide. The crest elevation shall be EL. 4.6 m as design water intake level including 10 cm free boad against waves and hydraulic abrasion at the crest.

ii) Type of Movable Weir

The sill height and span length of the movable weirs at the canal shall be as follows;

Movable Weir - 1 : EL.3.0 m (Lowest water level at Nong Yai reservoir) L=20 m

Movable Weir - 2 : EL.0.0 m (Canal Bed elevation) L=13 m

iii) Study on Weir length

The weir length shall be properly determined so that the design flood can flow down below the design discharge water level.

Description	Head Weir	Tail Weir
Condition for Free Overflow	Water depth at upstream : d1 (*1) Water depth at downstream : d2 (*2) d1 = H.W.S. 7.05m - EL.4.60m = 2.45 m d2 = WL.6.20m - EL.4.60m = 1.60 m d2/d1 = 1.60/2.45 = 0.65 < 2/3 = 0.67 ···· OK	Fixed Weir d1 = H.W.S. 6.00m - EL.4.60m = 1.40 m d2 = WL.3.61m - EL.4.60m = - 0.99 m d2/d1 < 2/3 ···· OK
		Movable Weir - 1 d1 = H.W.S. 6.00m - EL.3.00m = 3.00 m d2 = WL.3.61m - EL.3.00m = 0.61 m d2/d1 = 0.61/3 < 2/3 ···· OK
		Movable Weir - 2 d1 = H.W.S. 6.00m - EL.0.0m = 6.00 m d2 = WL.3.61m - EL.0.0m = 3.61 m d2/d1 = 3.61 / 6.00 = 1.81 / 3.00 < 2/3 ···· OK

Description	Head Weir	Tail Weir
Overflow discharge	$Q = K * B * H^{3/2}$ $= 1.7 * 45.0 * 2.45^{3/2}$ $= 293$ cu.m/s > 270 cu.m/s ···· OK	Fixed Weir $Q1 = K * B * H^{3/2}$ $= 1.7 * 45.0 * 1.40^{3/2}$ $= 127$ cu.m/s
		Movable Weir - 1 $Q2 = Cf * K * B * H^{3/2}$ (*3) $= 0.9 * 1.7 * 20.0 * 3.0^{3/2}$ $= 159$ cu.m/s
		Movable Weir - 2 $Q3 = Cf * K * B * H^{3/2}$ $= 0.9 * 1.7 * 13.0 * 6.0^{3/2}$ $= 292$ cu.m/s
		Total Overflow $Q = Q1 + Q2 + Q3$ $= 127 + 159 + 292$ $= 578$ cu.m/s > 540 cu.m/s ···· OK

(*1) Water depth at up-and downstream is measured from the crest

(*2) K : Overflow coefficient (Trapezoidal weir)
B : Weir length
H : Waterhead at upstream of the weir
≒ Water depth at upstream

(*3) Cf : Vena contract factor of weir piers

Therefore, the weir length shall be determined as follows ;

Head Weir ..... Fixed Weir Length B = 15.0 * 3 = 45.0 m

Tail Weir ..... Fixed Weir Length B = 15.0 * 3 = 45.0 m
Movable Weir Length 20.0 m and 13.0 m

iv) Study on Creep Length

The appropriate creep length shall be secured to protect the creeping route of the weir foundation from piping. The necessary creep length can be secured by Bligh method.

$$L > C * H$$

Where,

L : Creep length measured along the weir foundation. (m)
C : Coefficient difference by kinds geological survey. C = 15
H : Water level difference between up and down stream.

In order to ensure the creep length given by the above formula, a cut-off wall shall be provided in addition to the creeping route along the flow direction by weir body and downstream apron.

Description	Head Weir	Tail Weir
Creep Coefficient	15.0	15.0
Maximum water level difference between up and down stream H	Flooding H.W.S. 7.05m - H.W.S. 6.2m = 0.85 m Normal flow WL.4.60m - L.W.S. 3.00 m =1.60 m Therefore H = 1.60 m	 H.W.S. 6.0m - WL. 3.61m = 2.39 m WL.4.60m - EL. - 0.95 m =5.55 m H = 5.55 m
Required creep length L (m)	15.0 * 1.60 = 24.0 m	15.0 * 5.55 = 83.3 m
Length of weir and apron cut-off wall length ℓ (m)	31.5 m	46.5 m
Cut-off wall length ℓ' (m)	Unnecessary because of $\ell > L$	L - ℓ (*1) = 83.3 - 46.5 = 36.8 m

(*1) Although the computation has resulted in the depth of the cut-off wall as deep as about 19 m. The borehole drilling survey clarified that there extends an impervious layers found deeper than EL.-5.0 m. Under the conditions, the design value shall be taken by 1.5 times as deep as the normal water level differences.

$$\ell = 4.5 * 1.5$$
$$= 6.75 \doteq 7.0 \text{ m}$$

v) Study on Canal Bed Protection

The extent of the construction works shall be decided with Bligh's Formula.

$$L = LB - \ell a$$
$$LB = 0.67 * C * (Ha * q)^{0.5} * f$$

Where :

L : Length of riprap (m)

LB : Total length of protection works (m) in adding apron length (ℓa) to riprap length (L)

Ha : Distance between weir crest and water surface elevation in the downstream in droughty conditions.

q : Design flood discharge per unit width.

f : Safety ratio 1.0

C : Bligh's coefficient 15.0

Item	Head Weir	Tail Weir
Ha (m)	EL. 4.60m - L.W.S. 3.0m = 1.60 m	EL. 4.60m - E.L. 0.0m = 4.60 m
q (cu.m/s)	270.0 / 45.0 = 6.0	540.0 / 78.0 = 6.92
LB (m)	31.1	56.7
ℓa (m)	16.8	20.0
L (m)	14.3 ≒ 15	36.7 ≒ 40

d) Design of Intake Works

i) Location

The intake works for Block G (A = 600 ha, Intake amount Q=1.340 cu.m/s) in the southern part of the benefitial area shall be located on the right bank close by the upstream of the tail gate.

ii) Study on Type

Sill height of intake ;

The sill height of the intake shall become 1.5 m higher elevation than the bed of sand sluiceway (movable weir - 2) so that inflow of sand into the canal can be prevented. And the higher sill elevation allows a settling basin not to be constructed in particular.

EL = EL.0.0 m + 1.5 m = EL. 1.50 m

Intake Flow Velocity and Canal Width ;

The intake flow velocity at the intake sill is considered reasonably by V=0.6~1.0 m/s in general for preventing sand materials from inflowing and hydro-plants from growing in the main canal.

In taking the intake canal width as

$$B = Q / (H * V)$$

Where :

Q : Design maximum intake amount 1.34 cu.m/s

H : Intake water depth

$$H = \text{L.W.S.3.00 m} = \text{EL. 1.50 m} = 1.50 \text{ m}$$

$$B = 1.34 / (1.50 * 0.8) = 1.12 \text{ m}$$

Consequently, the canal width shall be

$$B = 1.5 \text{ m}$$

Appurtenant Facilities ;

Screen

Screens shall be provided at the inlets so as to prevent suspended matters from flowing into the canal. Bars of the screens shall have interval at 200 mm and thickness of 12 mm, respectively. The screens also shall be inclined with slope of 1 to 0.3 for easy clean of trash.

Gates

Gates shall be provided at the both sides of the embankment.

River side .... Water tight leaf sluice gate for water control

Inside ..... Stand-by gate

(2) Structure Analysis on Pak Phraek Canal

a) General

A fixed weir shall be provided at the inlet of the canal, which shall function to divert flood water for releasing into the Bay of Thailand through Nong Yai reservoir when the discharge of the Tha Taphao river increases.

b) Design Conditions

Design Flood Discharge	Q = 270 cu.m/s
Design Canal Width	B = 50 m
Design Flood Water Level	H.W.S. 11.60 m (by the result of non-uniform flow analysis on the Tha Taphao river.)
Flood Water Level at close by the downstream the water	WL. 8.50 m (by the result of non-uniform flow analysis of the Pak Phraek canal)

c) Structure Analysis

Weir Length (L) ;

The relationship of weir length L, overflow depth H, and overflow amount Q is expressed in the following formula :

$$Q = K * L * H^{3/2}$$

Where ;

K : Overflow Coefficient 1.70

In taking overflow depth by H=2.5 m, the crest elevation is obtained as follows to make a free overflow.

EL = H.W.S. 11.6 m - 2.5 m = EL. 9.10 > WL. 8.50 m

When the weir length is to be L = 42.0 m,

$$Q = 1.7 * 42.0 * 2.5^{3/2}$$
$$= 282 \text{ cu.m/s} > 270$$

and the conditions can be fulfilled and the weir length shall be L = 42.0.

Creep Length (L) ;

Creep length is determined in the same way of Bligh's method to have been taken for that of the Hua Wang Phanang Tuk canal.

$$L > C * H$$
$$= 15.0 * (\text{EL.9.10} - \text{EL.5.80})$$
$$= 49.5$$
$$\fallingdotseq 50 \text{ m}$$

The weir and apron length is ℓa = 31.0 m, and the cut-off wall length ℓ' is to be determined as follows ;

$$\ell' = L - \ell a$$
$$= 50.0 - 31.0$$
$$\fallingdotseq 19.0 \text{ m}$$

In other respect by the geology, the deeper parts than EL.7.0 m is found as clayer impervious layers, and the creep length in these layers shall be taken 1.5 times as large as the water level difference between up - and downstream.

Creep length can be obtained as follows ;

$$\ell' = 3.3 \text{ m} * 1.5$$
$$= 4.95$$
$$\fallingdotseq 5.0 \text{ m}$$

Canal Bed Protection Works (L)

$$L = 0.67 * C * (Ha * q)^{0.5} * f - \ell a$$
$$= 0.67 * 15.0 * ((\text{EL.9.10} - \text{EL.6.0}) * 6.43)^{0.5} * 1.0 - 13.0$$
$$= 31.87$$
$$\fallingdotseq 32 \text{ m}$$

Where ;

$q = 270.0 \text{ cu.m/s}/42.0 = 6.43 \text{ cu.m/s/m}$

d) Foundation Analysis

i) General

The geological survey revealed that the N value at the foundation of the tail gate is as low as 5 and below, and soft foundation reaches deeper place to require pile foundation. In sampling out a heavier block, a computation shall be made on the allowable bearing capacity along the pile center so as to determine rough size of piles to be used. And, in considering the fact of the piles as long as 25 m to be required, steel piles shall be applied for easy transportation and handling.

ii) Design Conditions

Proposed Piling Sites

Movable Weir - 2, 1 Block Width 15 * 19 m

Type of Foundation Works

Placing method with steel piles of 500 mm dia. (SKK400)
Pile thickness of T = 12.0 mm
Corrosion margin = 2.0 mm

Forces out of Design

Vertical force	:	W = 2500 t
Concrete body	:	W = 2350 t
Gates and others	:	W = 40 t
Bridge and others	:	W = 110 t

Survey boring to be applied : DH3

iii) Pile Design

Allowable bearing capacity determined by ground conditions :
Ultimate bearing capacity (Ru)

$$Ru = qd * A + U * \Sigma li * fi$$

Where,

qd : Ultimate bearing capacity at pile tip (tf/m^2)

$N = (N1 + N2) / 2$ ($N \leqq 40$)

N1 : N value of the point at pile top (tf/m^2)

$N1 = 37$

N2 : Average N value in the area 4 times distance upwards from the type of the pile

$N2 = (37 + 30 + 28) / 3 = 32$

$N = (37 + 32) / 2 = 34$

Approximate penetration length $\ell = 1.4$ m

Penetration Conversin Rate for Bearing Layer

$\ell / D = 1.4 / 0.5 = 2.8$

$qd / N = 6 * 2.8 = 16.8$

$qd = 16.8 * 34 = 571.2\ tf/m^2$

A : Area of pile top $0.196\ m^2$

U : Circumference of pile 1.571 m

ℓi : i layer thickness in considering friction by pile circumference area (m)

fi : Maximum friction of i layer in considering circumference surface friction

$fi = N / 5$

Table for Circumference Surface Resistivity of Pile

No. of layers	Depth (m)	Layer thickness ℓi (m)	Kinds of soils	Average of N values (N)	Friction of Circumference Surface	$\ell i * fi$
1	2.2 - 11.0	8.8	Sand and Gravel	4	0.825	7.26
2	11.0 - 20.6	9.6	Clay	24	23.6	226.56
3	20.6 - 28.2	7.6	Sand and Gravel	28	5.6	42.56
Total		26.0				276.38

Therefore, Ultimate bearing capacity (Ru) is as follows ;

$$Ru = 571.2 * 0.196 + 1.571 * 276.38$$
$$= 546.15 \text{ tf}$$

Allowable beating capacity to driving force Ra :

$$Ra = K * Ru/n$$

n : Safety ratio 3

K : Correction factor of safety ratio 1.0

$$Ra = 546.15/3 = 182.05 \text{ tf}$$

Number of piles n ;

$$n = W / Ra$$
$$= 2500 / 182$$
$$= 13.7$$

Therefore, the steel piles are arranged under the weir as follows ;

$$4 * 4 = 16 \text{ piles}$$

F - 1 - 4 Irrigation Facilities

(1) Canal Section

Main irrigation canals are designed with lined canal shaping trapezoidal section,taking maintenance cost of canal and decreasing seepage loss into account.

Figure F-1-23 shows the major dimensions of each main canal.

(2) Selection of Motive Power for Irrigation Pump

Irrigation pumps planned can be motived by diesel engine or electric motor, of which selection is made through a economic comparison study as described below.

The economic comparison study on the matter is conducted in case of the pump to be installed to "A" irrigation block representative among a total of 6 blocks, "A" to "F" block because of middle scale of pump.

a) Design Conditions

Specification of Pump ;

- Double suction volute pump ø 350×300×2 units
- Design discharge Q=24.18 m^3/min
  (Q=12.1 m^3/min per unit)

Annual average operation time ;

- Annual average pumping water volume V=1.258 MCM
- Operation time H=1.258×10^6/12.1×60=1,733 hr

Unit price of fuel (Diesel) ; 8.5 Baht/ℓ

Electric charge

- Consumption 1.23 Baht/kwH
- Basic cost 167 Baht/kw/month

b) Comparison Study

i) Initial Cost

The initial costs for both of electric power and diesel engine power pump are estimated as follows ;

Item	Electric Power Pump (30 KW × 2)	Diesel Engine Pump (45 PS/1,800 rpm×2)
	('000 ฿)	('000 ฿)
- Pump	714	714
- Motive power	771	1,373
- Electric line	297	-
Sub-total	1,782	2,087

ii) Annual Operation Cost

Electric power pump ;

- Basic cost	167 ฿/KW/M × 30 KW × 2 × 12 M	= 120.24	('000 ฿)
- Consumption	1.23 ฿/KWH×30 KW×0.5×1,733 H	= 31.97	(〃)
Sub-total		152.21	(〃)

Diesel engine pump ;

- Fuel	8.5 ฿/ℓ × 45 PS × 0.23 × 1,733 H	= 152.46	('000 ฿)
- Lubricant and others	(20 %)	30.49	(〃)
Sub-total		182.95	(〃)

The results of the above study indicate that the case of electric power pump is economical than the diesel engine pump in both of initial cost and operation cost so as to plan the electric power pump.

F - 2 PROJECT IMPLEMENTATION

F - 2 - 1 Project Organization

RID is an executing agency responsible for implementation of the Nong Yai Integrated Agriculture Development Project. The project is comprised of three sub-projects, River Improvement project, Canal project and Nong Yai Irrigation project. Therefore, Nong Yai Integrated Agriculture Development Project Office which has responsibilities for promoting the project and organizing, coordinating and directing sub-projects will be set up for smooth execution of the project.

Each sub-project office under the project office will be established for securing smooth execution of the works during the construction stage. The organization chart for project implementation is shown in Figure F-2-1.

The sub-project offices will consist of the administrative division and the engineering division. The administrative division will consist of administrative and accounting section, and land acquisition section responsible for budgeting, accounting personnel matters, negotiation of land acquisition and other miscellaneous matters. The engineering division will consist of engineering, laboratory and mechanical sections responsible for supervision of construction works and various testing of soil and concrete from the view points of quality control.

F - 2 - 2 Implementation Mode and Schedule

(1) Implementation Mode

The project has considerably huge works consisted of canal project (14.8 km of canal length), river improvement project (48.5 km of improving river length) and Nong Yai irrigation project (543 ha of reservoir and 1,200 ha of irrigable area), and its construction is scheduled to be completed until the end of 1996, quite tight schedule particularly in construction of canal project.

There are two implementation modes on execution of the construction works, force account basis by RID and contract basis by private companies.

However, considering procurement of huge amount of construction materials and equipment, and mobilization of a number of labor force prior to commencement of the works, and maintenance of equipment and employment of labor after completion of the works, it is recommendable that the major works shall be carried out on a contract basis.

(2) Implementation Schedule

Implementation of the project is scheduled to be done for five years from 1992 to 1996.

Detailed design works included preparation of tender documents for such urgent construction works as Sam Kaeo canal, Hua Wang Phanang Tuk canal, Nong Yai reservoir and improvement of Tha Taphao river will be undertaken within 1993, and the construction of the Hua Wang Phanang Tuk canal and improvement of Tha Taphao river will be completed for three years after the detailed design stage, and the other construction works be for two years.

Furthermore, the detailed design for Pak Phraek canal, Nong Yai irrigation facilities and improvement of Nong Sai river will be undertaken within 1994 and the construction of those works will be completed for two years after tendering.

Therefore, the project benefits of irrigation and flood protection will be obtained from 1997.

Implementation schedule of the project is shown in Figure F-2-2.

F - 2 - 3 Recommendation for Detailed Design

Before and/or during the detail design stage of the Nong Yai - Tha Taphao Development project, the following subjects shall be attended.

(1) Topo-survey Works

The following survey works are recommended to be carried out.

a) Nong Yai Irrigation Project

i) Topographic map (S = 1/4,000)
- Nong Yai irrigation area : 3,400 ha

ii) Profile (S = 1/2,000) and cross section (S = 1/200, @100 m)
- Reservoir's dike and road : 14.0 km
- Irrigation canal and pipe line : 25.0 km
- Drainage canal : 14.0 km

b) Canal Project

i) Profile (S = 1/2,000) and cross section (S = 1/200, @100 m)
- Hua Wang-Phanang Tuk canal : 5.0 km
- Pak Phraek canal : 6.0 km

c) River Improvement Project

i) Profile (S = 1/2,000) and cross section (S = 1/200, @100 m)
- Proposed five short cuts of Tha Taphao river : 7.0 km

(2) Geological Investigation Works

The following geological investigation works are recommended to be carried out.

a) Boring Investigation (ø 66 m/m)

Site	Drilling Length (m)	W/S.P.T	W/P.T
i) Nong Yai reservoir (Bridge sites)	5 sites × 3-holes × 20 m = 300 m	○	
ii) Hua Wang Phanang Tuk Canal			
- Weir site	3 holes × 30 m = 90 m	○	○
- Bridge and others	2 sites × 3 holes × 20 m = 120 m	○	
iii) Pak Phraek canal			
- Weir site	3 holes × 20 m = 60 m	○	○
- Bridge and others	4 sites × 3 holes × 20 m = 240 m	○	
iv) Tha Taphao river			
- Bridge, sluiceway and others	20 holes × 15 m = 300 m	○	

Note: S.P.T : Standard Penetration Test
P.T : Permeability Test

(3) Installation of Gauging Stations

There are no-gauging stations of rainfall and stream flow within the Nong Yai drainage area of 102 km^2. In order to measure and analyze the inflow from the basin and the effective rainfall in the irrigable area, at least one rainfall and one stream flow gauging stations are recommended to be installed at the places as shown in Drawing 1.5 "Location Map of Meteorology & Hydrology Gauging Stations for Flood Warning System".

(4) Estimation of Sediment Volume in the Nong Yai Reservoir

The floods from the Nong Yai basin with 102 km^2 of watershed and from the Tha Taphao river through the Hua Wang Phanang Tuk canal and the Pak Phraek canal enter into the Nong Yai reservoir, causing the sedimentation problem in the reservoir.

The estimation of sediment volume from the Nong Yai basin may be possible based on the data of suspended load on the Tha Taphao and Tha Sae rivers measured by RID, however, that from the Tha Taphao river is quite difficult due to a lack of available data so as to recommend conduction of the following matters.

- Estimation of inflow water from the Tha Taphao river to the reservoir at least for 10-years duration
- Measurement of content of suspended materials in flowing water by each degree of flood.

F - 3 PROJECT COST

F - 3 - 1 Composition of Project Cost

Construction of the major works of canals, reservoir and irrigation system will be carried out by the contractor under supervision of RID with assistance of the consultants.

The following condition and methodology of cost estimate are applied.

(1) Unit Rate for Major Works

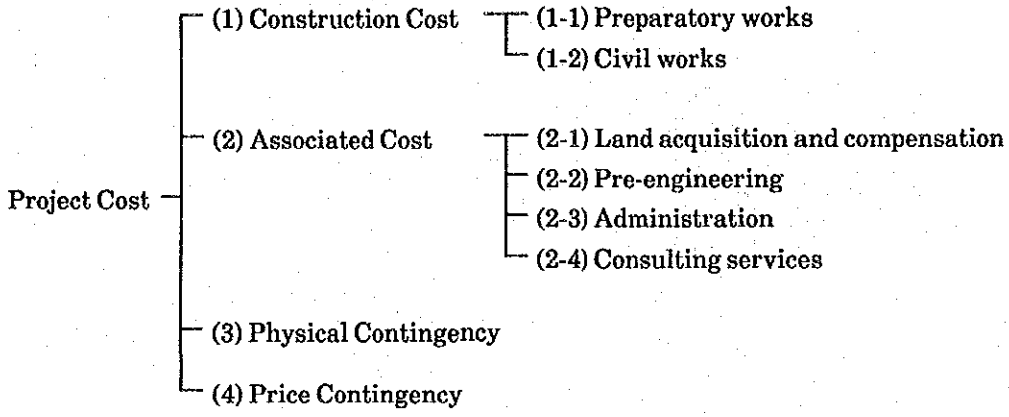
Basic unit prices of major labors and construction materials, and unit construction costs of major works are adopted from the current unit prices and costs of RID as of January 1991 on the contract basis and shown in Table F-2-1 and F-2-2 respectively.

Foreign and local currency portions for the basis are estimated, based on the prevailing percentage in the international fund agency, as follows ;

Description	Percentage	
	F/C	L/C
Cement	60	40
Reinforcement	70	30
Fuel and Oil	80	20
Timber	20	80
Explosive	80	20
Depreciation for Equipment	70	30
Repair for Equipment	80	20
labour	0	100

(2) Composition of Project Cost

The project cost is estimated with the following components;



a) Preparatory work cost

The cost for preparation works is consisted of costs for project offices and camps furnished with equipment, furniture, stationaries, etc.

b) Civil work cost

The civil work costs are contained with costs for construction works of facilities, temporary works and over-head for the works.

The costs for construction works of facilities are estimated based on the quantities calculated from the preliminary design and the unit costs, comprising such necessary costs for building and installation of the facilities and devices as labours, construction materials, fuel, depreciation of equipment, etc.

The costs for temporary works mean necessary costs for temporary facilities (diversion canals, access roads, electric wiring, contractor's camp facilities, drainage facilities, etc.), transportation of construction equipment, preparation of shop drawings, laboratory test, etc.

The cost for over-head which covers overhead, profit and taxes for the works is estimated with 15 % of the total construction cost of facilities included with temporary works costs, applying the current percentage of RID, as follows;

Description	Rate (%)
1. Overhead	3.5 % of material and wage costs
2. Profit	6.5 % of material and wage costs
3. Taxes	4.1 % of (material and wage costs + 1.+ 2.)

Note : Material and wage cost is over 100 million Baht.

c) Land acquisition and compensation cost

The costs for land acquirement of the facilities and reservoir, and resettlement works are estimated in this item.

d) Pre-engineering cost

The pre-engineering cost means necessary costs for topo-survey, meteorological and hydrological observation, geological investigation, etc. to be conducted prior and/or during the detail design stage. Referring to the similar agriculture development project in Thailand, the pre-engineering cost is estimated with 3 % of the total construction cost.

e) Administration cost

The administration cost contains salaries and wages of officers, miscellaneous costs for administration, fuel and light expenses, water charge, etc. during the implementation term. 5 % of the total construction cost is estimated as the administration cost.

f) Consulting service cost

5 % of the total construction cost is estimated as the consulting service cost for detail design and supervision.

g) Physical contingency

The physical contingency is estimated with 10 % of the base cost which is the sum of construction cost and associated cost.

h) Price contingency

The price escalation is estimated at 1 % per annum for the foreign currency portion, and 5 % per annum before 1995 and 4 % per annum after 1995 for the local currency portion.

F - 3 - 2 Project Cost

The project cost based on the above estimation is summarized in Table F-2-3 and F-2-5~2-7.

F - 3 - 3 Disbursement Schedule of Project Cost

The disbursement schedule of project cost is estimated in Table F-2-4, based on the project implementation program as shown in Figure F-2-2.

F - 3 - 4 Cost of Operation and Maintenance

The operation and maintenance costs mean costs for operation and maintenance of facilities constructed, which include salaries and wages of operators and maintenance men, operation costs of devices and pumps, maintenance cost of offices, vehicles for O & M use, replacement of irrigation pumps, etc.

Referring to the costs of similar projects in Thailand, the operation and maintenance costs are estimated as below ;

Tha Taphao River System
Improvement Project
- O & M cost ; 9,577 ('000 Baht)

Nong Yai Irrigation Project
- Replacement cost of pumps : 19,476 ('000 Baht)
- O & M cost : 4,845 (〃)

TABLE F-2-1 LIST OF BASIC UNIT PRICE

(Unit : Baht)

(1) Labour Price

Labour	Rates per day	Remarks
- Labour	103	Carpenter, Mason, Steel man
- Foreman	127	Head carpenter, Head mason Head steel man, Welder, Mecanician, Electrician,
- Driver	116	
- Operator for heavy equipment	175	
- Master Mechanician	157	

(2) Material Price

Material	Unit	Unit Price	Remarks
- Cement	ton	1,800	Portland cement
- Sand	cu.m	140	
- Crushed Stone	cu.m	320	
- Steel bar			
SR 24 ø 15	ton	11,355	
SR 24 ø 19	ton	10,904	
SR 24 ø 25	ton	11,679	
SR 30 ø 25	ton	11,400	
- Hard PVC Pipe			
ø 200 mm	4.0 m	2,160	
ø 300 mm	4.0 m	4,460	
- Fuel (Diesel)	ℓ	8.5	
- Fuel (Gasoline)	ℓ	9.0	
- Electric charge			
Consumption	KWH	1.23	
Basic cost	KW/month	167	

Data Source : RID Construction Div. as of December 1991

TABLE F-2-2 LIST OF UNIT COST

(Unit : Baht)

Description of Works	Unit	Unit Cost	F/C	L/C
1) Earth Works				
- Stripping (by Bulldozer)	cu.m	11.0	7.0	4.0
- Soil Excavation (by Man Power)	cu.m	50.0	-	50.0
- Excavation (Common soil)	cu.m	17.0	12.0	5.0
- Excavation (Hard soil)	cu.m	21.0	15.0	6.0
- Backfill (by Man Power)	cu.m	100.0	-	100.0
- Embankment (D>=95%)	cu.m	39.0	28.0	11.0
- Embankment (D>=85%)	cu.m	32.0	23.0	9.0
- Laterite Pavement	cu.m	100.0	22.0	78.0
- Sand Filling	cu.m	240.0	72.0	168.0
- Riprap	cu.m	589.0	176.0	413.0
- Dumping Riprap	cu.m	403.0	121.0	282.0
- Sodding	sq.m	17.0	-	17.0
- Spoil Bank (L=5km) excluding excavation cost	cu.m	20.0	14.0	6.0
- Spoil Bank (L=10km) excluding excavation cost	cu.m	25.0	17.0	8.0
2) Concrete Works				
- Lean Concrete	cu.m	1,144.0	400.0	744.0
- Plain Concrete	cu.m	1,389.0	486.0	903.0
- Reinforced Concrete (steel bar 100 kg/cu.m)	cu.m	3,186.0	1,434.0	1,752.0
- Reinforced Concrete (steel bar 125 kg/cu.m)	cu.m	3,580.0	1,611.0	1,969.0
- Reinforced Concrete (steel bar 150 kg/cu.m)	cu.m	3,975.0	1,788.0	2,187.0
- Lining Concrete	cu.m	1,700.0	595.0	1,105.0
- Masonry	cu.m	1,264.0	379.0	885.0
- Stone pitching	cu.m	680.0	204.0	476.0

Data Source : " Unit Cost for 2534 Thai fiscal year " prepared by RID

TABLE F-2-3 SUMMARY OF PROJECT COST

(1) River Improvement Project

Description of Works	Total Cost ('000 Baht)		
	Total	F/C	L/C
1. Construction Cost			
1.1 Preparatory Works	3,800	1,440	2,360
1.2 Tha Taphao river	250,099	131,425	118,674
1.3 Nong Sai river	47,792	22,407	25,385
1.4 Phanang Tuk river	33,724	14,640	19,084
Sub-Total	335,415	169,912	165,503
2. Associated Cost			
2.1 Land Acquisition & Compensation	95,285	0	95,285
2.2 Pre-engineering (3%)	10,062	0	10,062
2.3 Administration (5%)	16,771	0	16,771
2.4 Consulting Services (5%)	16,771	0	16,771
Sub-Total	138,889	0	138,889
Base Cost	474,304	169,912	304,392
3. Physical Contingencies (10%)	47,430	16,991	30,439
Total	521,734	186,903	334,831
4. Price Contingency	20,089	1,928	18,161
Project Cost	541,823	188,831	352,992

(2) Canal Project

Description of Works	Total Cost ('000 Baht)		
	Total	F/C	L/C
1. Construction Cost			
1.1 Preparatory Works	1,900	720	1,180
1.2 Sam Kaeo canal	314,008	163,893	150,115
1.3 Hua Wang Phanang Tuk canal	303,979	159,656	144,323
1.4 Pak Phraek canal	132,969	71,272	61,697
Sub-Total	752,856	395,541	357,315
2. Associated Cost			
2.1 Land Acquisition & Compensation	112,880	0	112,880
2.2 Pre-engineering (3%)	22,586	0	22,586
2.3 Administration (5%)	37,643	0	37,643
2.4 Consulting Services (5%)	37,643	0	37,643
Sub-Total	210,751	0	210,751
Base Cost	963,607	395,541	568,066
3. Physical Contingencies (10%)	96,361	39,554	56,807
Total	1,059,968	435,095	624,873
4. Price Contingency	38,403	4,468	33,936
Project Cost	1,098,371	439,563	658,809

(3) Nong Yai Irrigation Project

Description of Works	Total Cost ('000 Baht)		
	Total	F/C	L/C
1. Construction Cost			
1.1 Preparatory Works	1,900	720	1,180
1.2 Nong Yai reservoir	101,721	46,854	54,867
1.3 Irrigation & Drainage System	111,330	67,644	43,686
1.4 Agricultural Development Facilities	5,497	2,498	2,999
Sub-Total	220,448	117,716	102,732
2. Associated Cost			
2.1 Land Acquisition & Compensation	45,824	0	45,824
2.2 Pre-engineering (3%)	6,613	0	6,613
2.3 Administration (5%)	11,022	0	11,022
2.4 Consulting Services (5%)	11,022	0	11,022
Sub-Total	74,482	0	74,482
Base Cost	294,930	117,716	177,214
3. Physical Contingencies (10%)	29,493	11,772	17,721
Total	324,423	129,488	194,935
4. Price Contingency	12,006	1,336	10,670
Project Cost	336,429	130,824	205,605
Grand Total	1,906,125	751,486	1,154,639
Grand Project Cost	1,976,623	759,217	1,217,406

TABLE F-2-4 DISBURSEMENT SCHEDULE OF TOTAL PROJECT COST

PROJECT COST OF RIVER IMPROVEMENT

Description of Works		Total Cost ('000 Baht)			1992 Y ('000 Baht)			1993 Y ('000 Baht)			1994 Y ('000 Baht)			1995 Y ('000 Baht)			1996 Y ('000 Baht)		
		Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C
1. Construction Cost																			
1.1 Preparatory Works		3800	1440	2360	0	0	0	0	0	0	3800	1440	2360	0	0	0	0	0	0
1.2 Tha Taphao river		250099	131425	118674	0	0	0	0	0	0	75030	39428	35602	100040	52570	47470	75030	39428	35602
1.3 Nong Sai river		47792	22407	25385	0	0	0	0	0	0	0	0	0	21506	10083	11423	26286	12324	13962
1.4 Phanang Tuk river		33724	14640	19084	0	0	0	0	0	0	0	0	0	15176	6588	8588	18548	8052	10496
Sub-total		335415	169912	165503	0	0	0	0	0	0	78830	40868	37962	136722	69241	67481	119864	59803	60060
2. Associated Cost																			
2.1 Land Acquisition & Compensation		95285	0	95285	0	0	0	31762	0	31762	31762	0	31762	31762	0	31762	0	0	0
2.2 Pre-engineering	(3%)	10062	0	10062	0	0	0	5031	0	5031	5031	0	5031	0	0	0	0	0	0
2.3 Administration	(5%)	16771	0	16771	0	0	0	0	0	0	3941	0	3941	6836	0	6836	5993	0	5993
2.4 Consulting Services	(5%)	16771	0	16771	0	0	0	5031	0	5031	5031	0	5031	3354	0	3354	3354	0	3354
Sub-total		138889	0	138889	0	0	0	41824	0	41824	45766	0	45766	41952	0	41952	9347	0	9347
Base Cost		474304	169912	304392	0	0	0	41824	0	41824	124595	40868	83728	178674	69241	109433	129211	59803	69407
3. Physical Contingencies	(10%)	47430	16991	30439	0	0	0	0	0	0	11147	4087	7060	19334	6924	12409	16950	5980	10969
Total		521734	186903	334831	0	0	0	41824	0	41824	135742	44954	90788	198007	76165	121842	146160	65784	80377
4. Price Contingency		20089	1928	18161	0	0	0	2196	0	2196	5463	459	5005	7837	785	7052	4592	685	3908
Project Cost		541823	188831	352992	0	0	0	44020	0	44020	141206	45413	95793	205844	76950	128894	150753	66468	84285

PROJECT COST OF CANAL PROJECT

Description of Works		Total Cost ('000 Baht)			1992 Y ('000 Baht)			1993 Y ('000 Baht)			1994 Y ('000 Baht)			1995 Y ('000 Baht)			1996 Y ('000 Baht)		
		Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C
1. Construction Cost																			
1.1 Preparatory Works		1900	720	1180	0	0	0	0	0	0	1900	720	1180	0	0	0	0	0	0
1.2 Sam Kaeo canal		314008	163893	150115	14042	10434	3608	88553	46823	41730	106331	59003	47328	105082	47633	57449	0	0	0
1.3 Hua Wang Phanang Tuk canal		303979	159656	144323	0	0	0	0	0	0	91194	47897	43297	106393	55880	50513	106393	55880	50513
1.4 Pak Phraek canal		132969	71272	61697	0	0	0	0	0	0	0	0	0	59836	32072	27764	73133	39200	33933
Sub-total		752856	395541	357315	14042	10434	3608	88553	46823	41730	199425	107620	91805	271311	135585	135726	179526	95079	84446
2. Associated Cost																			
2.1 Land Acquisition & Compensation		112880	0	112880	11288	0	11288	33864	0	33864	33864	0	33864	33864	0	33864	0	0	0
2.2 Pre-engineering	(3%)	22586	0	22586	0	0	0	6776	0	6776	6776	0	6776	4517	0	4517	4517	0	4517
2.3 Administration	(5%)	37643	0	37643	702	0	702	4428	0	4428	9971	0	9971	13566	0	13566	8976	0	8976
2.4 Consulting Services	(5%)	37643	0	37643	702	0	702	4428	0	4428	9971	0	9971	13566	0	13566	8976	0	8976
Sub-total		210751	0	210751	12692	0	12692	49495	0	49495	60582	0	60582	65512	0	65512	22470	0	22470
Base Cost		963607	395541	568066	26734	10434	16300	138048	46823	91225	260007	107620	152387	336823	135585	201238	201995	95079	106916
3. Physical Contingencies	(10%)	96361	39554	56807	2673	1043	1630	13805	4682	9123	26001	10762	15239	33682	13559	20124	20200	9508	10692
Total		1059968	435095	624873	29408	11477	17930	151853	51505	100348	286008	118382	167626	370505	149144	221362	222195	104587	117608
4. Price Contingency		38403	4468	33936	1011	115	897	5788	520	5268	10448	1208	9240	14349	1537	12813	6806	1088	5718
Project Cost		1098371	439563	658809	30419	11592	18827	157641	52026	105616	296456	119589	176866	384855	150680	234174	229001	105675	123326

PROJECT COST OF NONG YAI PROJECT

Description of Works		Total Cost ('000 Baht)			1992 Y ('000 Baht)			1993 Y ('000 Baht)			1994 Y ('000 Baht)			1995 Y ('000 Baht)			1996 Y ('000 Baht)		
		Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C
1. Construction Cost																			
1.1 Preparatory Works		1900	720	1180	0	0	0	0	0	0	1900	720	1180	0	0	0	0	0	0
1.2 Nong Yai reservoir		101721	46854	54867	0	0	0	0	0	0	45774	21084	24690	55947	25770	30177	0	0	0
1.3 Irrigation & Drainage System		111330	67644	43686	0	0	0	0	0	0	0	0	0	50099	30440	19659	61232	37204	24027
1.4 Agricultural Development Facilities		5497	2498	2999	0	0	0	0	0	0	0	0	0	0	0	0	5497	2498	2999
Sub-total		220448	117716	102732	0	0	0	0	0	0	47674	21804	25870	106045	56210	49836	66729	39702	27026
2. Associated Cost																			
2.1 Land Acquisition & Compensation		45824	0	45824	0	0	0	15274	0	15274	15274	0	15274	15276	0	15276	0	0	0
2.2 Pre-engineering	(3%)	6613	0	6613	0	0	0	3307	0	3307	3306	0	3306	0	0	0	0	0	0
2.3 Administration	(5%)	11022	0	11022	0	0	0	0	0	0	2384	0	2384	5302	0	5302	3336	0	3336
2.4 Consulting Services	(5%)	11022	0	11022	0	0	0	3307	0	3307	3306	0	3306	2204	0	2204	2205	0	2205
Sub-total		74482	0	74482	0	0	0	21888	0	21888	24270	0	24270	22782	0	22782	5542	0	5542
Base Cost		294930	117716	177214	0	0	0	21888	0	21888	71944	21804	50140	128827	56210	72617	72271	39702	32569
3. Physical Contingencies	(10%)	29493	11772	17721	0	0	0	2189	0	2189	7194	2180	5014	12883	5621	7262	7227	3970	3257
Total		324423	129488	194935	0	0	0	24077	0	24077	79139	23985	55154	141709	61830	79879	79498	43672	35825
4. Price Contingency		12006	1336	10670	0	0	0	1264	0	1264	3285	245	3040	5261	637	4623	2196	454	1742
Project Cost		336429	130824	205605	0	0	0	25341	0	25341	82424	24229	58194	146970	62467	84503	81694	44127	37567
Grand Total		1906125	751486	1154639	29408	11477	17930	217754	51505	166248	500889	187321	313568	710222	287139	423083	447853	214043	233810
Grand Project Cost		1976623	759217	1217406	30419	11592	18827	227002	52026	174976	520085	189232	330853	737669	290098	447571	461448	216271	245178

TABLE F-2-5 CONSTRUCTION COST OF RIVER IMPROVEMENT PROJECT

Description of Works	Unit	Quantity	Total Cost unit rate (Baht)	Total Cost amount ('000 B)	Foreign Currency unit rate (Baht)	Foreign Currency amount ('000 B)	Local Currency unit rate (Baht)	Local Currency amount ('000 B)
1. THA TAPHAO RIVER								
(1) Temporary Works	L.S			10356		5442		4914
(2) Earth Works								
- Excavation Common Soil	cu.m	2658000	21.0	55818	15.0	39870	6.0	15948
- Embankment	cu.m	758000	45.0	34110	32.0	24256	13.0	9854
- Sodding	sq.m	237000	17.0	4029	0.0	0	17.0	4029
- Riprap	cu.m	71000	589.0	41819	176.0	12496	413.0	29323
- Pavement (Laterite)	cu.m	78000	100.0	7800	22.0	1716	78.0	6084
(3) Concrete Works								
- Reinforced Concrete	cu.m	2200	3580.0	7876	1611.0	3544	1969.0	4332
- Bridge	sq.m	2100	16000.0	33600	7200.0	15120	8800.0	18480
- Steel Pile (ϕ500,l=15m)	pile	60	54000.0	3240	32400.0	1944	21600.0	1296
(4) Miscellanous Works	L.S			18829		9895		8935
Over-head (15%)	L.S			32622		17142		15479
Total	L.S			250099		131425		118674
2. NONG SAI RIVER								
(1) Temporary Works	L.S			1979		928		1051
(2) Earth Works								
- Excavation Common Soil	cu.m	72000	21.0	1512	15.0	1080	6.0	432
- Embankment	cu.m	290000	45.0	13050	32.0	9280	13.0	3770
- Sodding	sq.m	54000	17.0	918	0.0	0	17.0	918
- Riprap	cu.m	27000	589.0	15903	176.0	4752	413.0	11151
- Pavement (Laterite)	cu.m	16000	100.0	1600	22.0	352	78.0	1248
(3) Miscellanous Works	L.S	1		6597		3093		3504
Over-head (15%)	L.S			6234		2923		3311
Total	L.S			47792		22407		25385
4. PHANANG TUK RIVER								
(1) Temporary Works	L.S			1396		606		790
(2) Earth Works								
- Stripping	cu.m	37000	11.0	407	7.0	259	4.0	148
- Embankment	cu.m	269000	32.0	8608	23.0	6187	9.0	2421
- Sodding	sq.m	50000	17.0	850	0.0	0	17.0	850
- Riprap	cu.m	25000	589.0	14725	176.0	4400	413.0	10325
- Pavement (Laterite)	cu.m	8000	100.0	800	22.0	176	78.0	624
(3) Miscellanous Works	L.S	1		2539		1102		1437
Over-head (15%)	L.S			4399		1910		2489
Total	L.S			33724		14640		19084
Grand Total				331615		168473		163143

TABLE F-2-6 CONSTRUCTION COST OF CANAL PROJECT

Description of Works	Unit	Quantity	Total Cost unit rate (Baht)	Total Cost amount ('000 B)	Foreign Currency unit rate (Baht)	Foreign Currency amount ('000 B)	Local Currency unit rate (Baht)	Local Currency amount ('000 B)
1. SAM KAEO CANAL								
1.1 New Regulator	L.S			96900		58140		38760
1.2 Concrete Works	L.S			7000		3150		3850
1.3 Equipment	L.S			15250		12200		3050
1.4 Topo-survey	L.S			1000		0		1000
1.5 Dike and Appertnant Structure	L.S			141340		63603		77737
1.6 Short Cut								
- Excavation Common Soil	cu.m	153200	21.0	3217	15.0	2298	6.0	919
- Embankment	cu.m	50900	32.0	1629	23.0	1171	9.0	458
- Riprap	cu.m	11100	589.0	6538	176.0	1954	413.0	4584
- Sodding	sq.m	10400	17.0	177	0.0	0	17.0	177
1.7 Over-head (15%)	L.S			40958		21377		19580
Total				314008		163893		150116
2. HUA WANG PHANANG TUK CANAL								
2.1 Upper Hua Wang Phanang Tuk Canal								
(1) Temporary Works	L.S			1904		863		1041
(2) Earth Works								
- Stripping	cu.m	4000	11.0	44	7.0	28	4.0	16
- Excavation Common Soil	cu.m	142000	21.0	2982	15.0	2130	6.0	852
- Embankment	cu.m	15000	32.0	480	23.0	345	9.0	135
- Sodding	sq.m	5200	17.0	88	0.0	0	17.0	88
- Riprap	cu.m	8400	589.0	4948	176.0	1478	413.0	3469
- Pavement (Laterite)	cu.m	1500	100.0	150	22.0	33	78.0	117
(3) Concrete Works								
- Reinforced Concrete	cu.m	5600	3580.0	20048	1611.0	9022	1969.0	11026
- Stone Pitching	cu.m	100	680.0	68	204.0	20	476.0	48
- Bridge	sq.m	360	16000.0	5760	7200.0	2592	8800.0	3168
- Slide Gate (1,500 × 2,500)	unit	1	55100.0	55	38570.0	39	2040.0	17
(4) Miscellanous Works	L.S			3462		1569		1894
Over-head (15%)	L.S			5998		2718		3281
Sub-total	L.S			45988		20836		25152
2.2 Lower Hua Wang Phanang Tuk Canal								
(1) Temporary Works	L.S			10683		5750		4873
(2) Earth Works								
- Stripping	cu.m	27000	11.0	297	7.0	189	4.0	108
- Excavation Common Soil	cu.m	2416000	21.0	50736	15.0	36240	6.0	14496
- Embankment	cu.m	131000	32.0	4192	23.0	3013	9.0	1179
- Sodding	sq.m	50500	17.0	859	0.0	0	17.0	859
- Riprap	cu.m	58500	589.0	34457	176.0	10296	413.0	24161
- Pavement (Laterite)	cu.m	10800	100.0	1080	22.0	238	78.0	842
(3) Concrete Works								
- Reinforced Concrete	cu.m	10700	3580.0	38306	1611.0	17238	1969.0	21068
- Stone Pitching	cu.m	600	680.0	408	204.0	122	476.0	286
- Bridge	sq.m	1200	16000.0	19200	7200.0	8640	8800.0	10560
- Roller Gate								
(1,600 × 20,000)	unit	1		11000		7700		3300
(4,600 × 13,000)	unit	1		14300		10010		4290
- Steel Pile (φ500mm)	m	3100	3600.0	11160	2160.0	6696	1440.0	4464
- Steel Sheet Pile	sq.m	800	2300.0	1840	1380.0	1104	920.0	736
(4) Railway Bridge	L.S	1		6400		3480		2560
(5) Miscellanous Works	L.S	1		19423		10038		8561
Over-head (15%)	L.S			33651		18113		15351
Sub-total	L.S			257991		138867		117694
Total				303979		159703		142846
3. PAK PHRAEK CANAL								
(1) Temporary Works	L.S			5506		2951		2555
(2) Earth Works								
- Stripping	cu.m	20000	11.0	220	7.0	140	4.0	80
- Excavation Common Soil	cu.m	1887000	21.0	39627	15.0	28305	6.0	11322
- Embankment	cu.m	168000	32.0	5376	23.0	3864	9.0	1512
- Sodding	sq.m	7000	17.0	119	0.0	0	17.0	119
- Riprap	cu.m	34840	589.0	20521	176.0	6132	413.0	14389
- Pavement (Laterite)	cu.m	12000	100.0	1200	22.0	264	78.0	936
(3) Concrete Works								
- Reinforced Concrete	cu.m	9000	3580.0	32220	1611.0	14499	1969.0	17721
- Stone Pitching	cu.m	200	680.0	136	204.0	41	476.0	95
- Steel Sheet Pile	sq.m	300	2300.0	690	1380.0	414	920.0	276
(3) Miscellanous Works	L.S	1		10011		5366		4645
Over-head (15%)	L.S			17344		9296		8047
Total	L.S			132969		71272		61697
Grand Total				750957		394868		354659

TABLE F-2-7 CONSTRUCTION COST OF NONG YAI IRRIGATION PROJECT (1/3)

Description of Works	Unit	Quantity	Total Cost unit rate (Baht)	Total Cost amount ('000 B)	Foreign Currency unit rate (Baht)	Foreign Currency amount ('000 B)	Local Currency unit rate (Baht)	Local Currency amount ('000 B)
1. NONG YAI RESERVOIR								
1.1 Temporary Works	L.S			4212		1940		2272
1.2 Earth Works								
- Excavation Common Soil	cu.m	70000	21.0	1470	15.0	1050	6.0	420
- Embankment	cu.m	330000	45.0	14850	32.0	10560	13.0	4290
- Riprap	cu.m	30000	589.0	17670	176.0	5280	413.0	12390
- Sodding	sq.m	55000	17.0	935	0.0	0	17.0	935
- Pavement (Laterite)	cu.m	19000	100.0	1900	22.0	418	78.0	1482
1.3 Concrete Works								
- Reinforced Concrete	cu.m	2000	3186.0	6372	1434.0	2868	1752.0	3504
- Bridge (B=6.0m, 4 places)	sq.m	1800	16000.0	28800	7200.0	12960	8800.0	15840
- Steel Pile (φ500,l=15m)	pile	44	54000.0	2376	32400.0	1426	21600.0	950
- Stone Pitching (t=0.3m)	sq.m	3000	680.0	2040	204.0	612	476.0	1428
- Slide Gate (1,000×1,000)	gate	11	15400.0	169	9240.0	102	6160.0	68
- Miscellanous Works	L.S			7658		3528		4131
Sub-total				88453		40743		47710
1.4 Over-head (15%)	L.S			13268		6111		7156
Total				101721		46854		54866
2. IRRIGATION AND DRAINAGE SYSTEM								
2.1 Irrigation Facilities								
2.1.1 Block A								
(1) Temporary Works	L.S			462		290		171
(2) Earth Works								
- Stripping	cu.m	5000	11.0	55	7.0	35	4.0	20
- Excavation Common Soil	cu.m	2000	17.0	34	12.0	24	5.0	10
- Embankment	cu.m	14000	38.0	532	27.0	378	11.0	154
- Sodding	sq.m	14000	17.0	238	0.0	0	17.0	238
- Pavement (Laterite)	cu.m	1700	100.0	170	22.0	37	78.0	133
(3) Concrete Works								
- Lining Concrete	cu.m	250	1700.0	425	595.0	149	1105.0	276
- Reinforced Concrete	cu.m	30	3580.0	107	1611.0	48	1969.0	59
- Slide Gate (1,000×1,000)	gate	2	15400.0	31	9240.0	18	6160.0	12
(4) Pump Station								
- Excavation Common Soil	cu.m	7000	17.0	119	12.0	84	5.0	35
- Backfill	cu.m	1000	32.0	32	23.0	23	9.0	9
- Reinforced Concrete	cu.m	300	3580.0	1074	1611.0	483	1969.0	591
- Pump (φ350×φ300)	unit	1	3260000.0	3260	2608000.0	2608	652000.0	652
- Steel Pipe (φ800mm)	m	18	8200.0	148	4920.0	89	3280.0	59
- Steel Pipe (φ600mm)	m	350	6200.0	2170	3720.0	1302	2480.0	868
(5) Miscellanous Works	L.S			839		528		312
Over-head (15%)	L.S			1454		915		540
Sub-total	L.S			11150		7012		4139
2.1.2 Block B								
(1) Temporary Works	L.S			703		443		260
(2) Earth Works								
- Stripping	cu.m	8000	11.0	88	7.0	56	4.0	32
- Excavation Common Soil	cu.m	26000	17.0	442	12.0	312	5.0	130
- Embankment	cu.m	38000	38.0	1482	27.0	1053	11.0	429
- Sodding	sq.m	37000	17.0	629	0.0	0	17.0	629
- Pavement (Laterite)	cu.m	4600	100.0	460	22.0	101	78.0	359
(3) Concrete Works								
- Lining Concrete	cu.m	450	1700.0	765	595.0	268	1105.0	497
- Reinforced Concrete	cu.m	60	3580.0	215	1611.0	97	1969.0	118
- Slide Gate (1,000×1,000)	gate	4	15400.0	62	9240.0	37	6160.0	25
(4) Pump Station								
- Excavation Common Soil	cu.m	29000	17.0	493	12.0	348	5.0	145
- Backfill	cu.m	1000	32.0	32	23.0	23	9.0	9
- Reinforced Concrete	cu.m	300	3580.0	1074	1611.0	483	1969.0	591
- Pump (φ450×φ350)	unit	1	5260000.0	5260	4208000.0	4208	1052000.0	1052
- Steel Pipe (φ800mm)	m	18	8200.0	148	4920.0	89	3280.0	59
- Steel Pipe (φ800mm)	m	200	8200.0	1640	4920.0	984	3280.0	656
(5) Miscellanous Works	L.S	1		1279		806		473
Over-head (15%)	L.S			2216		1396		820
Sub-total	L.S			16987		10704		6283
2.1.3 Block C								
(1) Temporary Works	L.S			348		211		137
(2) Pipe Line Works								
- Exacavation Common Soil	cu.m	3000	17.0	51	12.0	36	5.0	15
- Backfill	cu.m	3000	32.0	96	23.0	69	9.0	27
- Sandbed	cu.m	100	240.0	24	72.0	7	168.0	17
- PVC (φ300mm)	m	650	1230.0	800	615.0	400	615.0	400
- PVC (φ400mm)	m	450	2400.0	1080	1200.0	540	1200.0	540
- Sluice Gate (φ300mm)	gate	1	3500.0	4	2100.0	2	1400.0	1
- Sluice Gate (φ400mm)	gate	1	3600.0	4	2160.0	2	1440.0	1
(3) Pump Station								
- Excavation Common Soil	cu.m	19000	17.0	323	12.0	228	5.0	95
- Backfill	cu.m	1000	32.0	32	23.0	23	9.0	9
- Reinforced Concrete	cu.m	300	3580.0	1074	1611.0	483	1969.0	591
- Pump (φ200×φ150)	unit	1	1700000.0	1700	1360000.0	1360	340000.0	340
- Steel Pipe (φ800mm)	m	18	8200.0	148	4920.0	89	3280.0	59
- Steel Pipe (φ400mm)	m	250	4000.0	1000	2400.0	600	1600.0	400
(4) Miscellanous Works	L.S			633		384		250
Over-head (15%)	L.S			1097		665		432
Sub-total	L.S			8413		5099		3314