CHAPTER 3 OUTLINE OF WATER DIVERSION FACILITY

The project facility to be proposed by the Kok-Ing-Nan water diversion plan is outlined as follows;

Facility	Dimension	Function
(1) Kok Diversion Dam		Water intake from Kok river
(2) Kok-Ing Diversion Channel	55 km	Convey Kok water to Ing river
(3) Ing Diversion Dam		Water intake from Ing river and regulation of water diverted/conveyed from Kok river
(4) Lao Diversion Canal	12 km	Convey Kok and Ing water to Ing-Yot tunnel
(5) Ing-Yot Tunnel	50 km	Transbasin water diversion tunnel from Ing to Yot river
(6) Yao Flood Control Dam		Control floods from upper Yao basin
(7) Yao River Training Works	40 km	Improve Yao river to let flow design discharge

3.1 Kok-Ing Water Diversion Facility

(1) Kok Diversion Dam

There are two alternative plans for the Kok diversion dam to take 125 cu.m/sec of Kok river water, namely use of the existing Chiang Rai weir constructed by DEDP and construction plan of new diversion dam at downstream of the existing weir. The plan of utilizing the existing weir will have the advantages of higher intake water level and not requiring construction cost. More detailed geological investigation will however be needed to finalize the selection of alternative plans, and both plans will be further studied in the feasibility study in association with selection of suitable route of the Kok-Ing diversion channel.

(2) Kok-Ing Diversion Channel

The diversion channel from the Kok river to the proposed Ing diversion dam is composed of the open canal or culvert to pass the paddy field in the kok basin, tunnel to penetrate mountains dividing the Kok and Ing basins and open canal to connect the tunnel outlet and the Ing diversion dam. There are five alternative plans for route selection as

briefed below;

- The A route plan proposed by the local consultants to connect new Kok diversion dam and the Ing diversion dam.
- The B route plan proposed also by the local consultant to connect the existing Chiang Rai weir and Ing diversion dam consisting of a long culvert and a short tunnel.
- The B-J route plan proposed by JICA based on the B route plan with intention to minimize the length of culvert by means of converting some section to open canal.
- The B-P route plan proposed by JICA on the basis of the B route plan to minimize the depth of canal and culvert by means of introducing a pumping system.
- The A-R route plan proposed by RID as a modification of the A route plan to minimize the length of tunnel.

These alternative plans of conceptual plan level will be further studied during the course of the feasibility study, because more detailed study based on newly prepared topo-maps and execution of geological investigation is required to arrive at the final conclusion. The study on environmental impact assessment will also be needed for all alternative routes since the paddy area wherein the canal and culvert are proposed is located near the Chiang Rai urban area and owned by the people's irrigation district which has a long history of irrigated agriculture. The outline of alternative route plans is given in Table-11.

3.2 Ing Diversion Dam and Lao Diversion Canal

(1) Ing Diversion Dam

The Ing diversion dam is planned on the Ing river at Thoeng with the intake capacity of 175 cu.m/sec to divert and regulate the Ing runoff together with the water diverted and conveyed from the Kok river. The study on dam facility at present stage is only of conceptual planning level, and more detailed study will be carried out in the feasibility study taking into account the regulating capacity of diversion dam reservoir, flood water level at damsite which is under influence of the Mekong back water during flood period, drainage system of the upper Ing basin, improvement of Lao river flowing into the Ing river, dam structure based on topographical and geological condition, etc.

(2) Lao Diversion Canal

The Lao diversion canal is planned to convey 175 cu.m/sec of the Ing water to the Ing-Yot tunnel with the total length of 12.4 km consisting of open canal section of 1.1 km, culvert section of 10.3 km and tunnel section of 1.0 km. The detailed study will also be made in the feasibility study in consideration of flood and water level conditions of Lao river, topographical and geological conditions along the canal route, etc.

3.3 Ing-Yot Tunnel

The Ing-Yot tunnel is planned to convey diverted water from the Lao diversion canal to the head of Yot river passing through high mountainous division between the Ing and Nan basins with a capacity of 175 cu.m/sec and a long distance of 50 km. Inclined adits of 17 km in total is required at 7 places, because of long length of tunnel construction. The hydraulic slope and sectional area of tunnel are designed at 1 to 2,500 and 73.4 sq.m respectively.

Two alternative tunnel routes, namely southern route and northern route, are proposed and studied by the local consultants. As a result of study, the southern route to pass the southern mountain area has been canceled due to the fact that very poor geological condition prevails over the proposed route and overburden depth is shallow which would cause serious construction problems such as rock fall, water leakage, need of strong reinforcement by steel supports, etc. On the other hand, the northern route is generally formed by hard and consolidated rock formation though having many fault zones which would force the tunnel to be designed and constructed classifying into the following tunnel types;

	B	C_1	C_2	D_1	D_2	E	Total
Length (km)	2.7	8.9	14.8	12.1	7.8	4.6	50.9
Steel Support	×	×	○	○	○	○	

Remark: ○=Steel support required, ×=not needed

3.4 Yao River Training

Diverted water of 175 cu.m/sec from the outlet of Ing-Yot tunnel is released to the Yot river and reaches the Sirikit reservoir through the Yao and Nan rivers. The nan river, having the flood releasing capacity of more than 2,000 cu.m/sec, can let the diverted water of 175 cu.m/sec flow without any problem, however, the Yao river with capacity of 200 cu.m/sec in its upper and 400 cu.m/sec in the lower reaches has no ability to flow smoothly 175 cu.m/sec in addition to its own flood from catchment throughout the river course, and therefore river training works including flood control plan is to be set up. The detailed river training plan will be formulated in the feasibility study taking into account hydrological and hydraulic conditions along the river and environmental impact to be caused throughout wet season by additional flow of 175 cu.m/sec.

(1) Yao Flood Control Dam

The Yao flood control dam is proposed in the upstream basin of Yao river near the outlet of the Ing-Yot tunnel at a site where drainage area is 370 sq.km and design flood capacity is 200 cu.m/sec. The dam is so designed approximately as to have the gross storage capacity of 35 MCM, dam height of 37 m and the maximum outflow capacity of 250 cu.m/sec.

(2) Improvement of Yao River

The river improvement works consisting of expansion of river width, weirs and drops to dissipate flow energy, village water supply facility, replacement and new installation of roads and bridges, etc will be required along the river course of about 40 km so that the designed flood of 200 to 300 cu.m/sec in upper and 300 to 400 cu.m/sec in lower reaches including 175 cu.m/sec of diverted water can be released safely and smoothly.

3.5 Project Cost

The project cost is estimated at 47,600 million Baht for the water allocation and utilization plans A and B and 55,600 million Baht for the plan C, as shown in Table-12. The plan A is set up so as to use developed water by the proposed project for second crops in the existing irrigated agricultural areas of Phitsanulok and Chao Phraya delta requiring no additional

investment to consolidate irrigation systems, while plan C intends to allocate some of water to 120,000 ha of the Phitsanulok Stage II area in addition to supply of water to the plan A and B areas requiring 800 million Baht of additional construction cost for irrigation system development.

CHAPTER 4 IMPLEMENTATION PROGRAM

4.1 Disbursement Schedule

The project is planned to be implemented in 8 years period taking the net construction period of 6.5 years for long distance tunnel into consideration. The construction of the Kok-Ing diversion dam and channel will take place first in order to contribute to levelling up of rural inhabitant's living standard in the Kok and Ing basins which would be influenced by the proposed project, by means of providing the Kok river water for irrigation and other uses in irrigable areas to be newly developed. Construction of remaining works such as Ing diversion dam, Ing-Yot tunnel, Yao river training, etc will be commenced 1.5 to 2 years afterwards. Accordingly, the annual amount of the project disbursement will be 6,000 to 7,000 million Baht on an average and 8,000 million Baht in the peak year.

4.2 Implementing Agency and Its Budget

The implementing agency of the project is RID which is the largest agency to implement water resources and irrigated agricultural development projects in Thailand holding employee of more than 50,000. The annual budget allocated is 43,700 million Baht in 1997, of which 25,800 million Baht is the budget for project implementation excluding the foreign aid amount. The annual disbursement amount of 8,000 million Baht in the peak year corresponds to about 30% of the current size of the project implementation budget. There will be few constraints on the project implementation from budgetary point of view, since the project implementation is expected in early 21 century when more expanded budget will be allocated to RID.

4.3 Implementation of Project in 8th National Development Plan

In accordance with the implementation list of water resources development projects in the 8th National Economic and Social Development Plan submitted by RID and approved by NESDB, the proposed Kok-Ing-Nan water diversion project is nominated as the project to be commenced in 2000 taking into account the period needed for feasibility study.

CHAPTER 5 PROJECT EVALUATION

5.1 Incremental Benefit of the Project

(1) Agricultural Incremental Benefit

Agricultural benefit is preliminarily studied based on projected production of second crops in dry season following the cropping plan proposed as given in Tables 9 and 10.

Plan A

- Beneficial Area: Existing irrigation area of 270,000 ha in total in Phitsanulok project area and Chao Phraya delta area
- Cropping Plan: Only second crops including upland crops, fruits, vegetables, etc without adoption of dry season paddy

Plan B

- Beneficial Area: Same as plan A, but with the total irrigable area of 224,000 ha
- Cropping Plan: Second crops same as the plan A but with adoption of some dry season paddy

Plan C

- Beneficial Area: New Phitsanulok Stage II area of 120,000 ha in addition to existing area as adopted in plans A and B with the total area of 335,000 ha
- Cropping Plan: Supplemental irrigation for Phitsanulok Stage II area and second crops for entire projected area

Aside from the above, agricultural benefit is also produced from the beneficial area of 32,000 ha in the Kok and Ing basins.

The project benefit is estimated on economical basis, derived from financial prices, as shown in Tables 13, 14 and 15, and as summarized below;

Basin	Plan A		Plan B		Plan C	
	Area (10^3ha)	Benefit (10^6Baht)	Area (10^3ha)	Benefit (10^6Baht)	Area (10^3ha)	Benefit (10^6Baht)
Nan & Chao Phraya Delta	270	5,588	224	3,639	335	4,762
Kok and Ing	32	673	32	673	32	673
Total	302	6,261	256	4,312	367	5,435

Plantation of second crops such as upland crops and vegetable does not require much irrigation water as compared with dry season paddy resulting that the irrigable area as well as project benefit for cropping plan without dry season paddy increase.

(2) Incremental Benefit in Municipal and Industrial Water Supply

The municipal and industrial water of 1,200 MCM per year can be supplied by the project to the lower Nan and Chao Phraya delta area. The benefit of water supply is estimated as below;

4.79 Baht/m3 x 1,200 MCM/year x 0.7 = 4,024 million Baht

where, 4.79 Baht is opportunity cost of urban water and 0.7 is loss factor of water supply

(3) Incremental Benefit in Hydro-Power Generation

The benefit from hydro-power generation at the Sirikit power plant by additional water through the proposed project is estimated as follows;

2,000 MCM x 1KWh/5.8m^3 x 1.12 x 0.85 = 328 million Baht

where, 1Kwh/5.8m^3 means that 5.8m^3 of water is consumed to produce 1Kwh of power energy, 1.12 Baht/Kwh is the opportunity cost of electricity, and 0.85 is the transmission loss coefficient

(4) Total Incremental Benefit

The total benefit is then summarized as below;

(Unit: million Baht)

Incremental Benefit	Plan A	Plan B	Plan C
Agriculture	6,261	4,312	5,435
Water Supply	4,024	4,024	4,024
Hydro-Power	328	328	328
Total	10,613	8,664	9,787

5.2 Economic Investment Cost

The economic investment costs for plans A, B and C are estimated based on the financial project cost as given below;

Item	Conversion Factor	Plans A and B		Plan C	
		Financial	Economic	Financial	Economic
1. Construction Cost	0.85	40,708	34,602	47,608	40,467
2. Engineering Fee	0.85	3,257	2,769	3,809	3,238
3. Administration Fee	0.94	2,035	1,913	2,380	2,237
4. Land Acquisition	0.94	1,000	940	1,200	1,128
5. O/M Equipment	0.85	106	90	124	105
6. Environmental Impact Mitigation	0.49	500	245	500	245
Total		47,606	40,558	55,621	47,420

5.3 Economic Evaluation

It is generally realized that some time will be needed for the farmers to be accustomed to the irrigated farming and thus to arrive at the projected benefits. It is therefore assumed that the realization of the benefits after the project is implemented will be 60% in the first year, 80% in the second year and 100% from the third year onward for the existing irrigable area where irrigated agriculture is being practiced by experienced farmers. In the newly developed area, however, the realization of the benefits after the project implementation is assumed to be 20% in the 1st year, 40% in the 2nd year, 60% in the 3rd year, 80% in the 4th year and 100% from the 5th year onward.

On-farm cost is considered in calculating benefits where such a cost is included in the economic input cost, however, the replacement cost is not taken into account because the facilities to be constructed are mostly civil engineering structures except some gate-related structures.

The result of economic evaluation based on the above economic benefit and investment cost is summarized as follows;

Item	Plan A	Plan B	Plan C
EIRR (%)	15.1	13.2	12.7
B/C	1.38	1.13	1.08

If additional supply of about 1,000 MCM of water become available in dry season to be possibly provided from the Kok hydro-power dam being studied, the project economy will be further upgraded showing the EIRR of exceeding 16%.

5.4 Necessity and Viability of Kok-Ing-Nan Water Diversion Project

Necessity and viability of the proposed Kok-Ing-Nan water diversion project is judged to be high as supported by the following reasons;

(1) Agricultural productivity, lives in urban area and activity of commercial and industrial sectors in the Chao Phraya river basin, especially in the delta area, will be largely restricted by the water shortage problems and as a result the socio-economic growth in Thailand will be stagnant in future.

As the study results of various alternative water resources development and transbasin water diversion projects ever proposed, it is judged at the present phase that the Kok-Ing-Nan water diversion project among these projects will have every possibility of realization for its implementation.

(2) The Thai Government has fully recognized details of the water shortage problems in the Chao Phraya basin and issued the Official Notice to commence the feasibility study on the Kok-Ing-Nan water diversion project to the Mekong Joint Committee where the

notification was greatly appreciated by three riparian countries, namely Lao PDR, Cambodia and Vietnam.

The Government has listed up the Kok-Ing-Nan water diversion project in the implementation program of water resources development projects in the 8th National Economic and Social Development Plan (1997-2001) in which the project is planned to be possibly commenced in the year 2000.

The Government has provided the large scale budget of 150 million Baht for the conceptual planning and feasibility studies of the proposed project in 1993, being carried out at present by RID.

(3) The proposed project is judged to be economically feasible with the EIRR value of 13%.

(4) RID is the largest agency in Thailand for implementation of water resources development projects having a number of capable staff, etc. RID is, with its budget size, considered to be the proper agency for smooth and successful implementation of the proposed project.

(5) Construction of the long distance tunnel, the most difficult work among the proposed project facilities, could be implemented by international competent contractors.

(6) Since there exist impacts on the natural environment on the diversion routes or at any local places to be caused by land acquisition, river training, borrow area and spoil bank, trans-basin water diversion, etc., environmental mitigation measures should be carefully planned and implemented taking into account the watershed management rules provided in Thailand. Compensation for the problem caused by the presence of the reservoir would however be relatively small for the proposed project. On the other hand, the irrigation development projects to be implemented in association with the proposed water diversion project will contribute to a great extent to the economic growth of the Kok and Ing river basins, and therefore it is necessary to make every effort to obtain the consent and participation of the rural inhabitant in the project area.

6 Recommendation and Conclusion

As explained in the previous paragraph 5.4, the proposed Kok-Ing-Nan water diversion project will make a large contribution to the sustainable socio-economic development of the Chao Phraya basin toward 21 century and it is hence judged from this conceptual planning study that this project is viable and it is recommended to proceed to the feasibility study. It is however necessary prior to the commencement of the feasibility study that RID, MOSTE and RFD arrive at a general consensus through mutual discussions on the conceptual planning of the proposed project which would be implemented in the watershed classification areas and national parks.

Table-1 Water and Farmland Resources in Thailand and Chao Phraya Basin

Basin	Area (103 sq.km)	1993 Population (million)	Water Resources			Farmland Resources		
			Volume (BCM)	Yield (mm)	Per Capita Volume (m3)	Area (106 ha)	Per Capita Area (ha)	Per ha Volume (m3/ha)
1. Whole Country								
Chao Phraya	157.9	21.7	32.9	210	1,500	5.9	0.27	5.6
North East	168.9	20.5	47.3	280	2,300	9.2	0.45	5.1
East	36.3	3.9	26.4	730	6,800	2.0	0.52	13.2
West	43.2	3.5	13.7	320	3,900	1.4	0.40	9.8
South	72.1	7.6	73.8	1,020	9,710	2.8	0.36	26.7
Kok/Ing etc.	34.7	2.0	18.2	520	9,200	0.6	0.27	9.2
Total	513.8	59.2	212.3	410	3,600	21.9	0.37	9.7
2. Chao Phraya Basin								
Nan	34.3	2.3	9.16	270	4,000	1.08	0.47	8.5
Yom	23.6	1.8	2.96	130	1,600	0.76	0.42	3.9
Wang	10.8	0.7	1.10	100	1,600	0.15	0.21	7.3
Ping	33.9	2.6	7.97	240	3,000	0.65	0.25	12.3
Sakae Krung	5.2	0.5	1.30	190	2,700	0.26	0.52	5.0
Pasak	16.3	1.6	2.98	180	1,900	0.91	0.57	3.3
Delta	33.8	12.2	7.43	220	610	2.07	0.17	3.6
Total	157.9	21.7	32.90	210	1,500	5.9	0.27	5.6

Remark: The above water volumes of Chao Phraya basin are estimated on the basis of observed data in past 20 years which are already reduced because of upstream water diversion for irrigation and other purposes. The potential water resources in the Chao Phraya basin would therefore be assumed at 42,000 MCM or 260 mm if about 9,000 MCM of upstream water diversion is taken into consideration.

Table-2 Runoff Characteristics of Major Rivers

Basin and Gaging Station		Drainage Area (km^2)	Mean Annual Runoff			Specific Runoff Yield (mm)	Maximum Annual Runoff (MCM)	Minimum Annual Runoff (MCM)	Discharge	
			Wet Season (MCM)	Dry Season (MCM)	Total (MCM)				Mean (m^3/sec)	Maximum (m^3/sec)
1. Kok;	(GN3) Myanmar Border	2,980	1,642	498	2,140	719	3,034	1,342	68	551
	(G2A) Diversion Damsite	6,053	2,892	696	3,588	593	5,686	2,034	114	953
	(GN1) River Mouth	10,300	4,208	982	5,190	504	7,266	3,430	165	874
2. Lao;	(GN15) Confluence of Kok	3,080	715	140	855	278	1,338	424	27	-
3. Ing;	(IN_2) Existing Wair	3,450	819	62	881	256	1,383	435	28	596
	(IN_1) A. Thoeng	5,700	1,733	149	1,882	331	3,926	823	60	1,250
4. Yao;	(N51) Confluence of Nan	774	323	57	380	491	606	199	12	380
5. Nan;	(N17) Upper Nan	1,156	577	149	726	628	1,096	452	23	1,843
	(N1) Nan City	4,609	2,320	224	2,544	552	4,748	1,342	81	2,800
	Sirikit Inflow	13,100	4,419	705	5,124	391	8,574	3,119	163	3,378
	Sirikit Outflow	13,100	2,131	2,721	4,852	370	7,284	2,405	154	1,963
	(N12A) Uttaradit	15,718	2,891	2,466	5,375	342	10,270	2,486	171	3,300
	(N5A) Phitsanulok	25,286	4,712	2,443	7,155	283	12,131	3,199	286	1,896
	(N7) Phicit	29,153	6,027	2,740	8,767	301	14,288	3,850	278	1,563
	(N14) Chung Saeng	33,197	6,838	2,348	9,186	277	15,874	3,562	292	1,448
6. Yom;	(Y14) Sukothai	12,131	2,323	204	2,527	209	5,092	840	81	-
7. Wang;	(W4A) Tak	10,507	965	412	1,077	147	2,104	408	100	445
8. Ping;	Buhmibol Inflow	26,386	4,559	686	5,245	199	8,804	2,562	167	-
	Buhmibol Outflow	26,386	1,917	3,021	4,938	188	7,620	2,790	157	-
	(P7A) Kamphaeng Phet	42,700	4,357	3,402	7,759	103	12,221	4,184	35	2,452
9. Chao Phraya;	(C_2) Nakhon Sawan	110,569	15,367	7,099	22,466	182	36,917	11,541	246	4,712
	(C_{13}) Chainat Inflow	119,000	16,028	6,381	22,409	188	38,771	8,587	711	4,360
	Chainat Outflow	119,000	8,595	2,196	10,791	91	26,055	2,650	343	-
	Chainat Diversion	119,000	7,433	4,185	11,618	98	14,577	5,937	369	-
10. Pasak;	Damsite	12,925	1,835	156	1,991	204	4,830	609	713	-
	Confluence of Chao Phraya	16,292	2,224	189	2,413	149	5,855	738	77	-
11. Mekong;	Chiang Saen	189,000	67,844	17,728	85,572	453	126,682	67,850	2,714	17,600
	Chiang Khong	204,000	75,993	19,508	95,501	468	129,696	75,328	3,029	18,000

Table-3 Summary of Sirikit Reservoir Operation in Wet and Dry Season

Year	Inflow into Reservoir			Outflow from Reservoir			Balance (Inflow-Outflow)		Storage at End of		Storage Space at End of	
	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	June	November	June	November
1974	3505.2	723.6	4228.8	2861.8	2328.8	5190.6	643.4	-1605.2	7352	7928	2158	1582
1975	7649.4	924.7	8574.1	3522.1	3697.4	7219.5	4127.3	-2772.7	6442	9345	3068	165
1976	5347.3	976.2	6323.5	3432.4	3789.7	7222.1	1914.9	-2813.5	5902	8113	3608	1397
1977	3434.1	706.2	4140.3	3290.3	1850.4	5140.7	143.8	-1144.2	4577	5189	4933	4321
1978	5792.9	727.6	6520.5	1675.0	3660.0	5335.0	4117.9	-2932.4	3919	7803	5591	1707
1979	3068.0	508.4	3576.4	3092.6	1579.6	4672.2	-24.6	-1071.2	4828	4635	4682	4875
1980	5734.8	882.3	6617.1	1317.2	3094.2	4411.4	4417.6	-2211.9	3578	7588	5932	1922
1981	6858.3	717.2	7575.5	3711.6	3572.9	7284.5	3146.7	-2855.7	4830	8216	4680	1294
1982	4614.5	694.6	5309.1	2147.5	3612.0	5759.5	2467.0	-2917.4	5073	7488	4437	2022
1983	4592.2	857.9	5450.1	1353.7	2734.7	4088.4	3238.5	-1876.8	4273	7562	5237	1948
1984	5640.8	770.9	6411.7	2666.3	3815.0	6481.3	2974.5	-3044.1	5494	8310	4016	1200
1985	4517.3	1169.9	5687.2	1164.2	3120.3	4284.5	3353.1	-1950.4	4891	8274	4619	1236
1986	3593.0	485.4	4078.4	3028.3	3102.2	6130.5	564.7	-2616.8	5777	6519	3733	2991
1987	2552.0	684.6	3236.6	1402.5	1570.4	2972.9	1149.5	-885.8	3629	4776	5881	4734
1988	3843.0	643.4	4486.4	822.1	2100.1	2922.2	3020.9	-1456.7	4012	6648	5498	2862
1989	3315.6	605.3	3920.9	1761.8	2644.2	4406.0	1553.8	-2038.9	5092	6448	4418	3062
1990	3476.1	552.1	4028.2	2271.7	2446.4	4718.1	1204.4	-1894.3	4202	5320	5308	4190
1991	2862.1	401.5	3263.6	1297.1	1966.5	3263.6	1565.0	-1565.0	3376	4746	6134	4764
1992	2555.4	563.2	3118.6	569.1	1835.9	2405.0	1986.3	-1272.7	2997	4927	6513	4583
1993	2743.2	583.0	3326.2	2301.2	1122.7	3423.9	442.0	-539.7	3402	3853	6108	5657
1994	7112.1	623.5	7735.6	1055.0	3504.4	4559.4	6057.1	-2880.9	3549	9108	5961	402
1995	8401.0			4021.7			4379.3		5739	9397	3771	113
Mean	4419.4	704.8	5124.2	2130.6	2721.3	4852.0	2288.8	-2016.5	4629	6800	4881	2710
Max.	7649.4	1169.9	8574.1	3711.6	3815.0	7284.5	6057.1	-539.7	7352	9345	6513	5657
Min	2552.0	401.5	3118.6	569.1	1122.7	2405.0	-24.6	-3044.1	2997	3853	2158	113

Note: (1) Wet season from June to November and dry season from December to next May. (2) The year 1995 was excluded from calculation of mean, maximum and minimum values. (3) Drainage area is 13,100 sqkm and gross capacity is 9,510 MCM.

Table-4 Summary of Bhumibol Reservoir Operation in Wet and Dry Season

Year	Inflow into Reservoir			Outflow from Reservoir			Balance (Inflow-Outflow)		Storage at End of		Storage Space at End of	
	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	June	November	June	November
1974	5427	1167	6594	2391	3123	5514	3036	-1956	8435	11687	5027	1775
1975	7654	1150	8804	3712	3908	7620	3942	-2758	9462	13366	4000	96
1976	4038	893	4931	3423	3874	7297	615	-2981	9610	10965	3852	2497
1977	4681	837	5518	3607	2966	6573	1074	-2129	7108	8806	6354	4656
1978	6379	470	6849	2055	3551	5606	4324	-3081	5955	10732	7507	2730
1979	2849	325	3174	3682	2020	5702	-833	-1695	7224	6480	6238	6982
1980	5596	652	6248	659	2995	3654	4937	-2343	4845	9475	8617	3987
1981	4599	878	5477	1578	3085	4663	3021	-2207	6773	10051	6689	3411
1982	4725	409	5134	2691	3582	6273	2034	-3173	7778	9588	5684	3874
1983	4538	675	5213	1063	2920	3983	3475	-2245	5808	9413	7654	4049
1984	3656	444	4100	1407	2494	3901	2249	-2050	7055	9040	6407	4422
1985	5124	1209	6333	874	2939	3813	4250	-1730	6801	10776	6661	2686
1986	3072	418	3490	2723	3321	6044	349	-2903	8415	8970	5047	4492
1987	4159	783	4942	1923	2854	4777	2236	-2071	5678	7933	7784	5529
1988	5429	740	6169	258	4323	4581	5171	-3583	6235	10611	7227	2851
1989	3803	622	4425	1921	3382	5303	1882	-2760	6812	8414	6650	5048
1990	3360	296	3656	2210	2277	4487	1150	-1981	5191	6404	8271	7058
1991	3948	312	4260	1003	2935	3938	2945	-2623	4254	6980	9208	6482
1992	3651	616	4267	429	2604	3033	3222	-1988	3902	7136	9560	6326
1993	2017	545	2562	1802	988	2790	215	-443	4507	5011	8955	8451
1994	7035	961	7996	848	3294	4142	6187	-2333	4822	10486	8640	2976
1995	5737			1360			4377		7415	12138	6047	1324
Mean	4559	686	5245	1917	3021	4938	2642	-2335	6508	9158	6954	4304
Max.	7654	1209	8804	3712	4323	7620	6187	-443	9610	13366	9560	8451
Min.	2017	296	2562	258	988	2790	-833	-3583	3902	5011	3852	96

Note: (1) Wet season from June to November and dry season from December to next May. (2) The year 1995 was excluded from calculation of mean, maximum and minimum values.
(3) Unit is given in MCM.

Table - 5 Summary of Projected Water Demand at Present and in Future

Item	Unit	Nan	Yom	Wang	Ping	Sakae Kurang	Pasak	Delta	Total
1. Basin Area									
Total Area	km^2	34,330	23,620	10,790	33,900	5,190	16,290	33,800	157,920
Farm Land Area	10^3 ha	1,080	760	150	650	260	910	2,070	5,880
2. Present Water Demand (1993)									
(1) Irrigation Area	10^3 ha	278	132	68	260	92	121	1,281	2,232
(2) Population	10^3	2,310	1,960	670	2,430	430	1,670	13,150	22,620
(3) Water Demand									
Irrigation Water	MCM	2,871	859	487	2,428	1,161	835	11,620	20,261
Domestic Water	MCM	66	54	20	76	8	72	-	296
Municipal Water	MCM	37	15	-	53	-	-	1,200	1,305
Industry/tourism	MCM	-	-	1	-	-	24	550	575
River Maintenance	MCM	-	-	-	-	-	-	2,860	2,860
Total	MCM	2,974	928	508	2,557	1,169	931	16,230	25,297
3. Future Water Demand (2016)									
(1) Irrigation Area	10^3 ha	437	285	138	482	126	179	1,315	2,962
(2) Population	10^3	3,110	2,410	850	3,980	690	2,210	13,420	26,670
(3) Water Demand									
Irrigation Water	MCM	4,360	2,066	813	4,344	1,161	1,114	13,500	27,358
Domestic Water	MCM	76	64	23	94	16	114	-	387
Municipal Water	MCM	57	28	-	90	-	-	1,860	2,035
Industry/tourism	MCM	6	1	3	6	-	34	1,100	1,150
River Maintenance	MCM	-	-	-	-	-	-	2,400	2,400
Total	MCM	4,499	2,159	839	4,534	1,177	1,262	18,860	33,330
4. Increment									
(1) Irrigation Area	10^3 ha	159	153	70	222	34	58	34	130
(2) Population	10^3	800	450	180	1,550	260	540	270	4,050
(3) Water Demand									
Irrigation	MCM	1,489	1,207	326	1,916	0	279	1,880	7,097
Others	MCM	36	24	5	61	8	52	750	936
Total	MCM	1,525	1,231	331	1,977	8	331	2,630	8,033

Remark : The above water demand in the Chao Phraya basin except the Delta area at present is summarized based on the study result of the water resources development for 25 basins. The water demand at present is summarized by the data of the diversion water at the Chainat Barrage issured by RID O/M Division.

Table-6 Outline of Existing Large and Medium Dams

Basin	Dam	Drainage Area (km^2)	Annual Runoff (MCM)	Active Capacity (MCM)	Irrigable Area (ha)
1. Large Scale					
Ping	Bhumibal	26,386	5,250	9,660	649,000
– Do –	Mae Ngat	1,281	290	243	4,800
– Do –	Mae Kuang	569	210	249	28,000
Wang	Kiu Lom	2,700	590	108	25,600
Nan	Sirikit	13,130	5,120	6,660	649,000
Sakae Krung	Tap Salao	534	200	152	23,000
Chao Phraya	Krasieo	1,200	170	201	20,800
Subtotal	7	45,800	11,830	17,273	1,400,000
2. Medium Scale					
Ping	Mae Tub	126	24.6	39	4,160
Wang	Mae Yao	35	3.2	3.5	960
– Do –	Mae Arb	35	4.4	7.5	640
– Do –	Mae Prik	45	5.5	4.2	620
Yom	Mae Kam Pong	–	13.9	2.6	960
– Do –	Mae Man	–	23.3	18.8	2,320
– Do –	Khlong Khang Nai	28	3.0	10.4	320
Nan	Huai Head	40	6.0	4.1	1,230
– Do –	Khlong Tron	265	38.0	10.4	3,740
– Do –	Nam Haeng	227	30.2	18.8	960
– Do –	7 Sub-Projects	–	–	41.7	1,230
Sakae Krung	7 Sub-Projects	–	–	–	15,700
Pasak	19 Sub-Projects	–	–	108.0	79,400
Chao Phraya	38 Sub-Projects	–	–	26.0	31,700
Subtotal	81	–	–	295.0	143,940
Total	88	–	–	17,568	1,544,140

Table-7 Outline of Proposed Large and Medium Dams

Basin	Dam	Drainage Area (km^2)	Annual Runoff (MCM)	Active Capacity (MCM)	Irrigable Area (ha)
1. Large Scale					
Ping	Mae Khan	1,085	181	165	3,200
Wang	Kiew Kho Ma	1,275	265	190	4,400
Yom	Kaeng Sua Ten	3,583	933	1,175	48,800
Nan	Khwae Noi	4,254	1,449	769	24,900
– Do –	Nam Khek	854	489	345	10,800
Sakae Krung	Mae Wong	615	221	250	46,700
Pasak	Pasak	12,929	2,100	785	37,000
Subtotal		24,595	5,638	3,679	175,800
2. Medium Scale					
Ping	Huai Mae Khon Reservoir	34	9.6	2.7	800
	Huai Mae Kon Reservoir	44	10.3	5.6	1,700
	Khlong Khayang Reservoir	20	6.7	4.6	600
	Khlong Prai Reservoir	51	17.1	13.0	600
	Nam Lai Reservoir	74	18.5	15.0	1,600
	Khlong Khlung Reservoir	95	20.6	18.0	1,800
Wang	Ban Lu Reservoir	–	–	24.5	2,700
Yom	Mae Song Reservoir	305	75.7	65.8	8,200
	Mae Tang Reservoir	120	29.8	30.6	3,500
	Huai Mae Song Reservoir	60	6.3	12.4	1,300
	Huai Ta Pae Reservoir	287	30.3	58.0	3,200
	Mae Mok Reservoir	728	85.0	96.0	8,500
	Wang Deang Reservoir	179	34.1	12.0	1,300
	Mae Sai Reservoir	177	43.9	24.3	3,700
	Huai Suang Reservoir	47	5.0	5.6	700
	Mae Khong Kai Reservoir	70	8.2	9.0	1,100
Nan	Mae Khaning Reservoir	229	34.0	62.0	2,400
	Huai Nam Klung Reservoir	184	63.2	12.4	4,500
	Khlong Chomphu Reservoir	364	63.5	13.0	5,900
	Mae Chaey Reservoir	18	6.8	4.3	600
Sakae Krung	Khlong Pho Reservoir	376	97.0	67.5	–
	Huai Nam Dung Reservoir	40	8.2	5.0	600
	Huai Kan Yao Reservoir	85	17.5	5.0	800
Subtotal		3,587	691.3	566.3	56,100
Total		28,182	6,329.3	4,245.3	231,900

Table-8 Case Study of Sirikit Reservoir Operation with Various Combination of Diversion Capacity

Ing-Nan Cap.	Kok-Ing Cap.	Carry-Over = 500MCM						Carry-Over = 1,000MCM						Carry-Over = 1,500MCM					
		Diversion		Usable Storage		Spill-age	Over URC	Diversion		Usable Storage		Spill-age	Over URC	Diversion		Usable Storage		Spill-age	Over URC
		Potent	Actual	Potent	Addit.			Potent	Actual	Potent	Addit.			Potent	Actual	Potent	Addit.		
150	75	1867	1803	5334	2238	0	0	1867	1741	5267	2171	26	1	1867	1631	5129	2033	459	2
	90	1956	1885	5414	2318	0	0	1956	1813	5336	2240	34	1	1956	1698	5193	2098	459	2
	105	2007	1930	5458	2362	0	0	2007	1852	5373	2278	37	1	2007	1735	5228	2132	459	2
	120	2030	1951	5477	2381	0	0	2030	1869	5389	2293	39	1	2030	1752	5243	2147	459	3
175	87	2071	1989	5520	2424	0	0	2071	1896	5416	2320	123	1	2071	1763	5258	2163	459	2
	105	2175	2077	5606	2510	0	0	2175	1970	5486	2391	133	1	2175	1838	5330	2235	459	3
	122	2230	2123	5649	2554	0	1	2230	2004	5517	2421	137	1	2230	1875	5365	2269	459	3
	140	2255	2142	5667	2572	0	1	2255	2018	5530	2434	140	1	2255	1889	5377	2281	459	3
200	100	2258	2137	5668	2573	0	0	2258	2026	5540	2444	210	1	2258	1880	5373	2277	459	4
	120	2367	2226	5753	2657	0	1	2367	2102	5610	2515	231	1	2367	1941	5430	2334	459	5
	140	2427	2271	5796	2700	0	1	2427	2148	5655	2559	237	2	2427	1974	5459	2364	459	5
	160	2450	2286	5810	2715	0	1	2450	2166	5671	2576	238	2	2450	2984	5468	2373	459	5

Note: (1) Carry-Over is the storage to be maintained at the end of dry season for unforeseen drought.
(2) Potential diversion is possible amount of diversion corresponding to capacity of diversion channel.
(3) Actual diversion is amount of water diverted after adjusted with the Sirikit storage.
(4) Potential usable storage is estimated at (November End Storage+Dry Season Inflow-Carryover).
(5) Additional usable storage is estimated at (Potential Usable Storage-Existing Water Use 3,095MCM).
(6) Spillage is the total amount of spillage during 20 years.
(7) Over URC means number of time when reservoir storage exceeds the upper rule curve.

Table - 9 Dry Season Cropping Pattern and Water Demand for Existing Area

Crops	Unit Irrigation Demand (m^3/ha)	Phitsanulok		Delta		Total	
		Area (ha)	Water Demand (MCM)	Area (ha)	Water Demand (MCM)	Area (ha)	Water Demand (MCM)
1. Plan A, Existing Irrigation Area without Dry Season Paddy							
Dry Maize	4,000	6,000	24.0	64,000	256.0	70,000	280
Dry Soybean	5,000	5,100	25.5	54,900	274.5	60,000	300
Dry Peanut	4,000	1,700	6.8	18,300	73.2	20,000	80
Sugar Cane	7,000	3,400	23.8	36,600	256.2	40,000	280
Orchard	11,000	3,400	37.4	36,600	402.6	40,000	440
Vegetable	6,000	900	5.4	9,100	54.6	10,000	60
Fish	12,000	2,600	31.2	27,400	328.8	30,000	360
Total	-	23,100	154.1	246,900	1,645.9	270,000	1,800
2. Plan B, Existing Irrigation Area with Dry Season Paddy							
Dry Paddy	10,000	6,000	60	85,000	850	91,000	910
Dry Maize	4,000	3,000	12	32,000	128	35,000	140
Dry Soybean	5,000	3,000	15	27,000	135	30,000	150
Dry Peanut	4,000	-	-	9,000	36	9,000	36
Sugar Cane	7,000	2,000	14	18,000	126	20,000	140
Orchard	11,000	2,000	22	18,000	198	20,000	220
Vegetable	6,000	-	-	4,000	24	4,000	24
Fish	12,000	1,000	12	14,000	168	15,000	180
Total	-	17,000	135	207,000	1,665	224,000	1,800

Remark: (1) Irrigable area at Phitsanulok and Delta is 108,000ha and 1,190,000ha respectively. Accordingly the increasing cropping intensity in dry season is 22% in the A plan but 17% in the B plan due to high water demand of dry season paddy.

Table-10 Plan C, Cropping Pattern and Water Demand for the Existing and New Area

Crops	Unit Irrigation Demand (m^3/ha)	Phitsanulok, Exist		Phitsanulok, New		Delta, Exist		Total	
		Area (ha)	Water Demand (MCM)	Area (ha)	Water Demand (MCM)	Area (ha)	Water Demand (MCM)	Area (ha)	Water Demand (MCM)
Wet Paddy	2,000	-	-	120,000	240	-	-	120,000	240
Dry Paddy	10,000	-	-	12,000	120	25,000	250	37,000	370
Dry Maize	4,000	3,000	12	4,000	16	39,000	156	46,000	184
Dry Soybean	5,000	3,000	15	3,000	15	33,000	165	39,000	195
Dry Peanut	4,000	1,000	4	1,000	4	11,000	44	13,000	52
Sugar Cane	7,000	2,000	14	2,000	14	22,000	154	26,000	182
Orchard	11,000	2,000	22	2,000	22	22,000	242	26,000	286
Vegetable	6,000	1,000	6	1,000	6	6,000	36	8,000	48
Fish	12,000	1,000	12	2,000	24	17,000	204	20,000	240
Total	-	13,000	85	147,000	461	175,000	1,251	335,000	1,797

Remark: (1) Phitsanulok new irrigation area is lying on the left bank of the Nan river and can get the water by Naresuan barrage.

(2) Supplemental irrigation water of 2,000 m^3/ha will be sufficient for wet season paddy plantation, because the wet season paddy can take sufficient irrigation water from the rich runoff in the Nan river from August to October and will requires only the water in June to July which has the less runoff in the Nan river and is covered with Sirikit outflow.

Table-11 Outline of Alternative Plans for Diversion Route between Kok and Ing

(Cost Unit : Baht million)

Item	Unit	A Plan		A-R Plan		B Plan		B-J Plan		B-P Plan	
		Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
1. Diversion Capacity	m^3/sec	125	-	125	-	125	-	125	-	125	-
2. Kok Diversion Dam Intake	m	385	-	385	-	389	-	389	-	389	-
Water Level											
Cost		-	536	-	536	-	160	-	160	-	160
3. Canal in Kok Basin											
Open Canal	m	13,746	513	15,112	631	14,063	723	18,589	800	23,507	1,135
Culvert	m	1,050	187	3,011	568	17,994	3,763	1,861	330	3,856	661
Nong Luang Reservoir	L,S	-	160	-	160	-	160	-	160	-	60
Pumping Station	L,S	-	-	-	-	-	-	-	-	-	1,600
4. Tunnel between Kok & Ing											
No.1 Tunnel	m	5,800	3,126	3,114	1,734	-	-	3,114	1,734	-	-
No.2 Tunnel	m	7,240	3,344	7,755	3,630	5,506	2,901	7,775	3,630	4,200	2,100
Regulating Pond	L,S	-	120	-	120	-	120	-	120	-	120
5. Canal in Ing Basin	m	21,750	922	21,750	922	21,750	922	21,750	922	21,750	922
6. Total	m	49,866	8,908	50,762	8,301	59,313	8,749	53,089	7,856	53,313	6,758

Remark:(1) Plan A and B are proposed by the local consultant and A-R by RID.

(2) B-J and B-P are proposed newly by JICA Team in order to minimize the cost for Plan A, B and A-R.

B-P plan is however set up by pumping and will not be recommendable when pumping operation cost is taken into consideration.

Table-12 Project Cost of Kok-Ing-Nan Water Diversion

(Unit 10^6Baht)

Item	Plan A and B	Plan C	Remark
1. Construction Cost			
(1) Diversion Dam and Canal between Kok and Ing	8,500	8,500	
(2) Ing Diversion Dam	354	354	
(3) Lao Diversion Canal	3,588	3,588	
(4) Ing-Yot Diversion Tunnel	20,604	20,604	
(5) Yot Flood Control Dam	182	182	
(6) Yao River Training	400	400	
(7) Irrigation Project in Kok & Ing Basin	1,600	1,600	32,000 ha
(8) Irrigation Project in Phitsanulok II	-	6,000	120,000 ha
(9) O/M Office, Quarters & Facility	170	170	
Subtotal	35,398	41,398	
2. Contingency	5,310	6,210	15% of subtotal
3. Total 1+2	40,708	47,608	
4. Others			
(1) Engineering Fee	3,257	3,809	8% of total 3
(2) Administrative Fee	2,035	2,380	5% of total 3
(3) Land Acquisition	1,000	1,200	
(4) O/M Equipment	106	124	0.3% of total 3
(5) Environmental Mitigation	500	500	
Total	6,898	8,013	
Grand Total	47,606 ≒47,600	55,621 ≒55,600	

Remark: (1) The beneficial area of the plan A and B is the existing irrigation area of the Phitsanulok I and Delta area, which will not require the construction cost for canal system.

(2) The beneficial area of the plan C includes the new irrigation area of the Phitsanulok II, which requires the construction cost of canal system.

Table - 13 Crop and Fish Benefit/ha (Economic)

Crop / Fish	Yield / ha ton / ha	Economic Price (Baht / ton)	Economic Gross Value per ha (Baht / ha)	Economic Input Cost per ha (Baht / ha)	Economic Net Value per ha (Baht / ha)
	A	B	C=A×B	D	E=C - D
Wet Paddy	1.8 ※	4,000	7,200	1,860※	5,340
Dry Paddy	4.5	4,300	19,350	9,320	10,030
Maize	3.5	3,000	10,500	6,195	4,305
Soybean	2.0	8,300	16,600	7,624	8,976
Peanut	1.8	11,400	20,520	9,410	11,110
Sugar Cane	43.3	460	19,918	12,078	7,840
Orchard	5.0	16,500	82,500	37,120	45,380
Vegetable	10.0	9,100	91,000	33,600	57,400
Fish	4.0	27,000	108,000	47,250	60,750

Remark : ※ The benefit of wet season paddy is estimated by difference of with project (irrigation) and without project (rainfed).

Table-14 Agricultural Increment Net Benefit (Economic) in Nan & Chao Phraya

Crop / Fish	Net Benefit /ha Baht/ha	Plan A		Plan B		Plan C	
		Area 10^3ha	Net Benefit 10^6 Baht	Area 10^3ha	Net Benefit 10^6 Baht	Area 10^3ha	Net Benefit 10^6 Baht
Wet Paddy	5,340	-	-	-	-	120	641
Dry Paddy	10,030	-	-	91	913	37	371
Maize	4,305	70	301	35	151	46	198
Soybean	8,976	60	539	30	269	39	350
Peanut	11,110	20	222	9	100	13	144
Sugar Cane	7,840	40	314	20	157	26	204
Orchard	45,380	40	1,815	20	908	26	1,180
Vegetable	57,400	10	574	4	230	8	459
Fish	60,750	30	1,823	15	911	20	1,215
計	-	270	5,588	224	3,639	335	4,762

Table-15 Agricultural Increment Net Benefit (Economic) in Project Area

Crop / Fish	Net Benefit /he Baht / ha	Area (10^3 ha)	Net Benefit 10^6 Baht
Maize	4,305	10	43
Soybean	8,976	6	54
Peanut	11,110	6	67
Orchard	45,380	6	272
Vegetable	57,400	2	115
Fish	60,750	2	122
計	-	32	673

Figure-1 Flow Diagram of Water Resources in Chao Phraya Basin (Average)

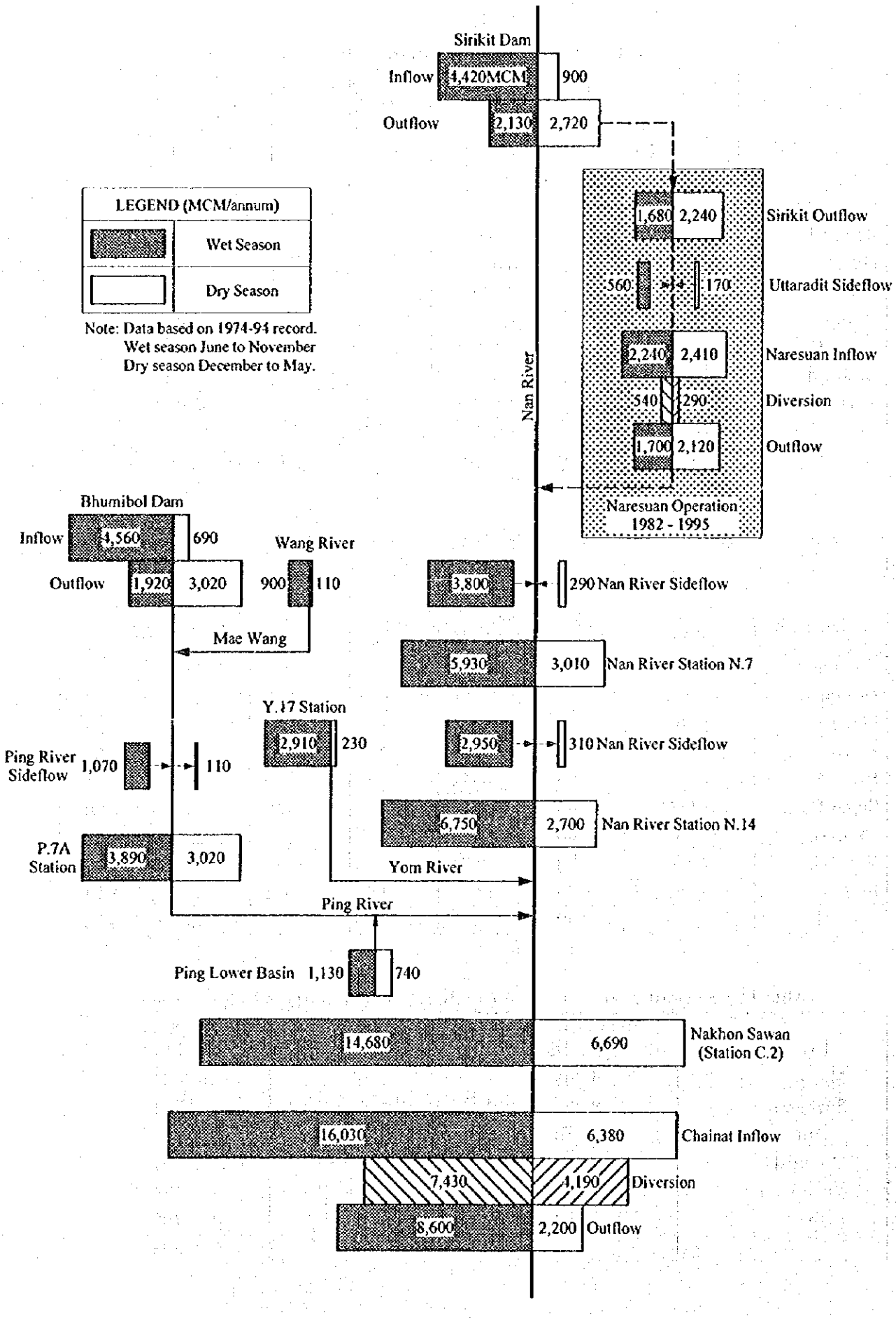


Figure-2 Flow Diagram of Water Resources in Chao Phraya Basin (Dry Years)

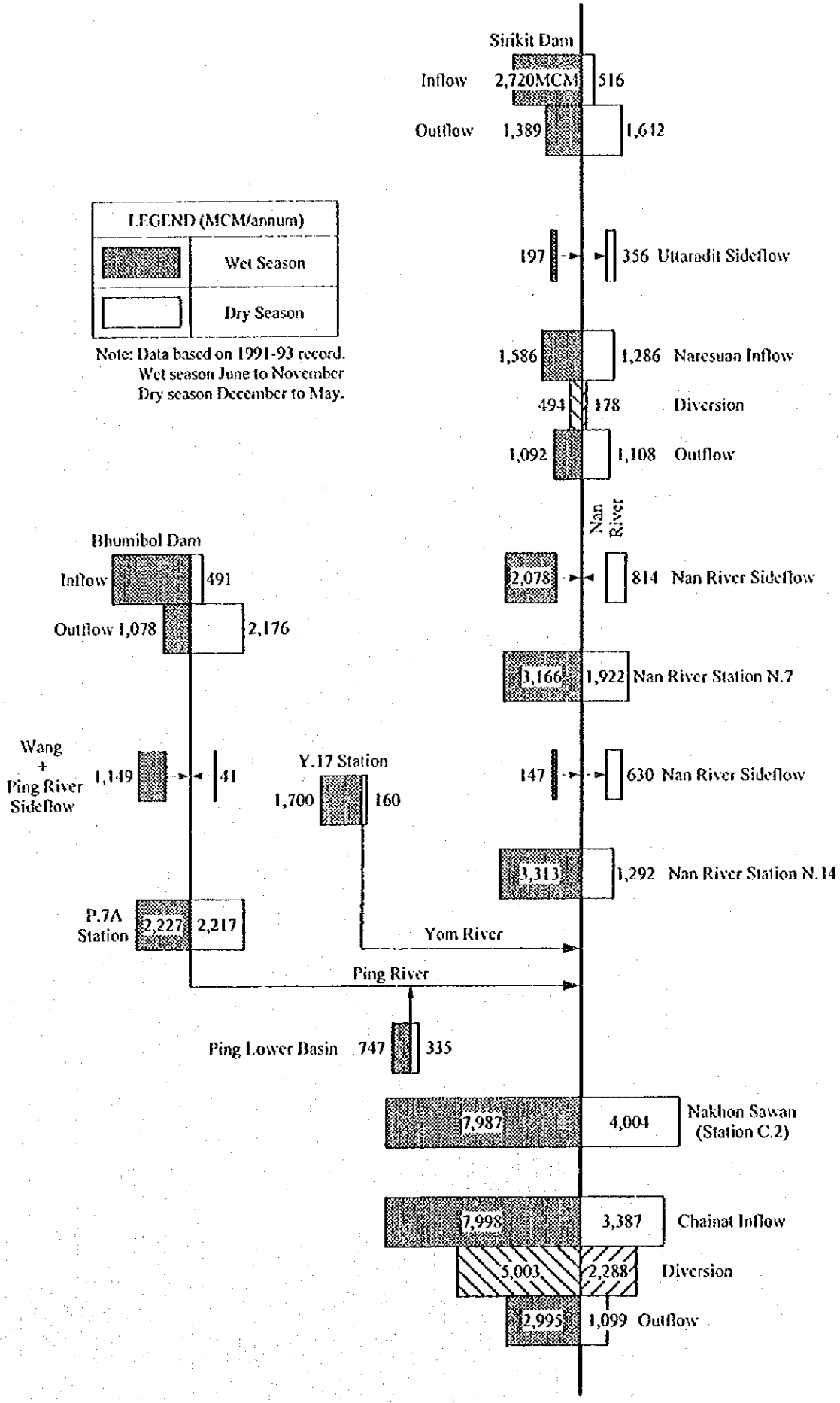


Figure-3 Sirikit Reservoir Operation Curve

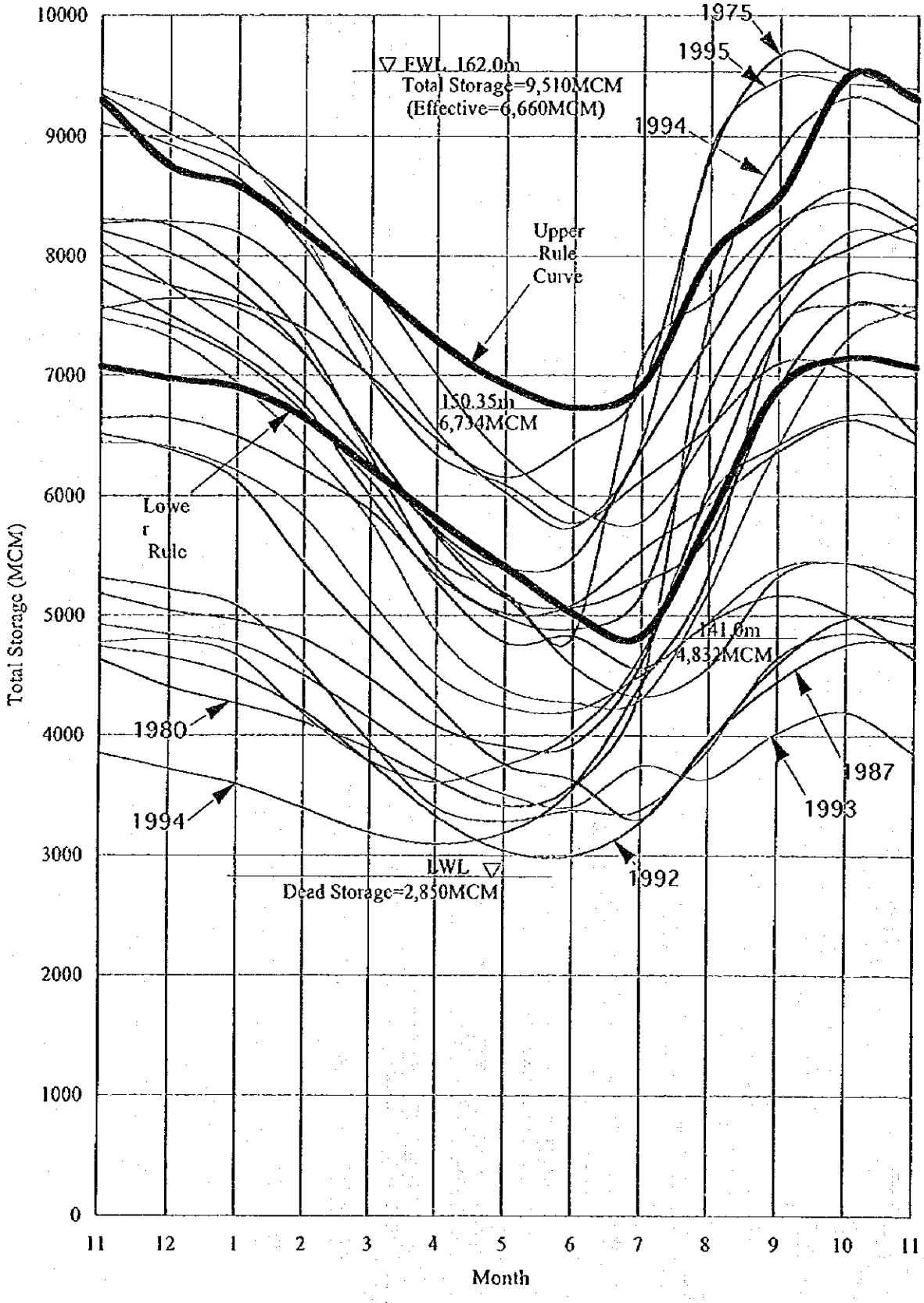


Figure-4 Bhumibol Reservoir Operation Curve

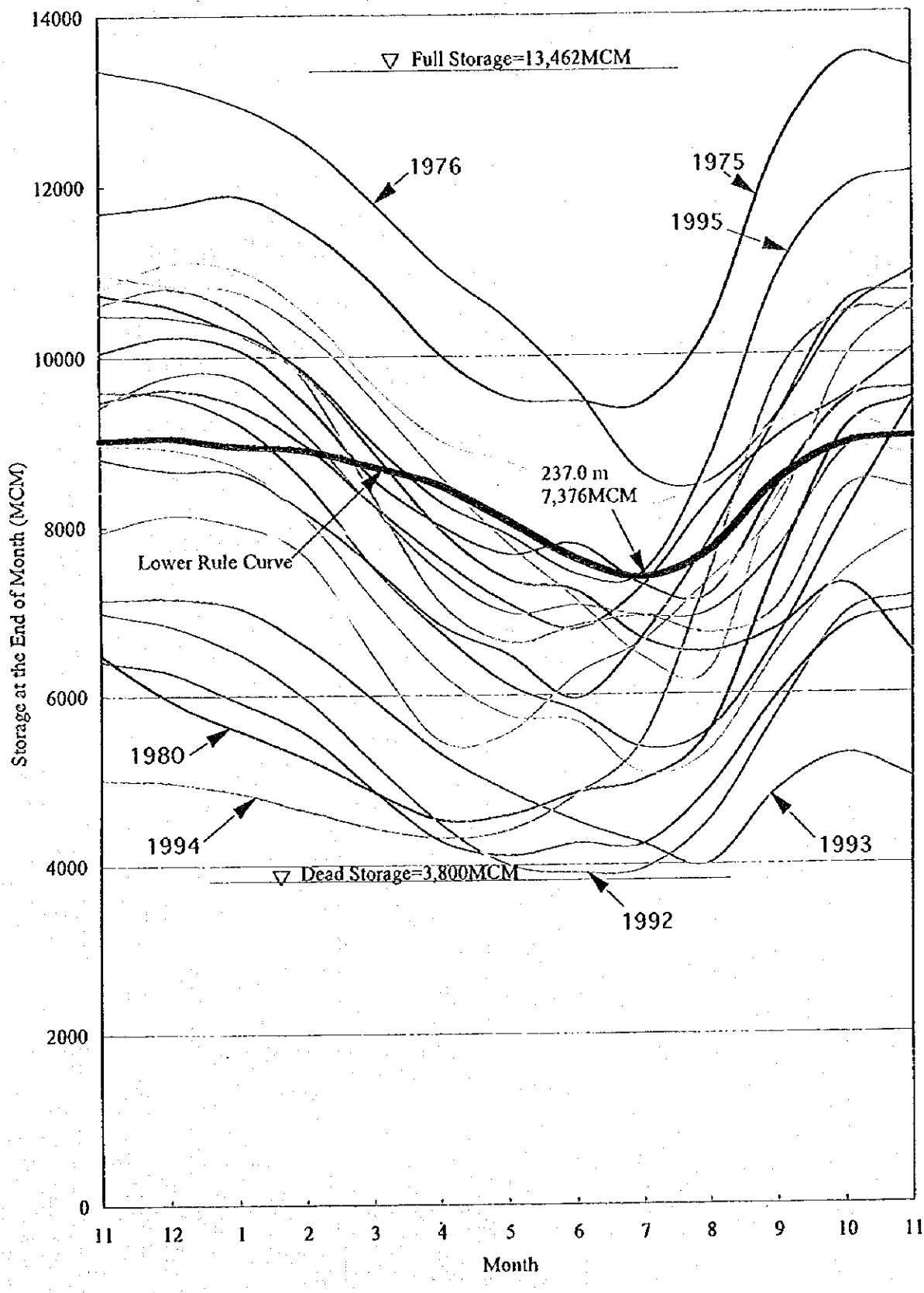


Figure-5 Cropping Area of Pitsanulok Project vs Naresuan Diversion/Sirikit Storage

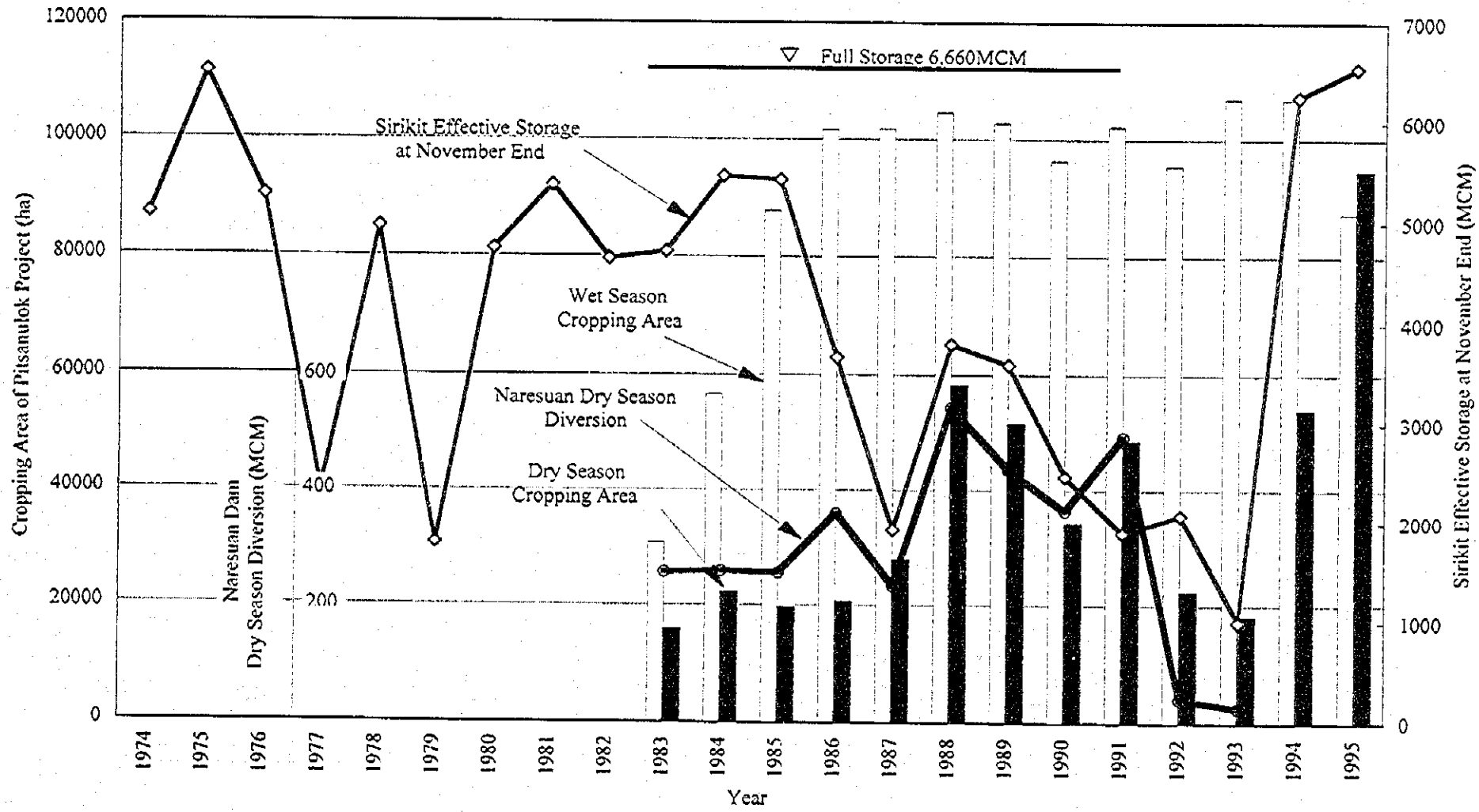


Figure-6 Cropping Area of Delta vs Chao Phraya Diversion/Sirikit Storage

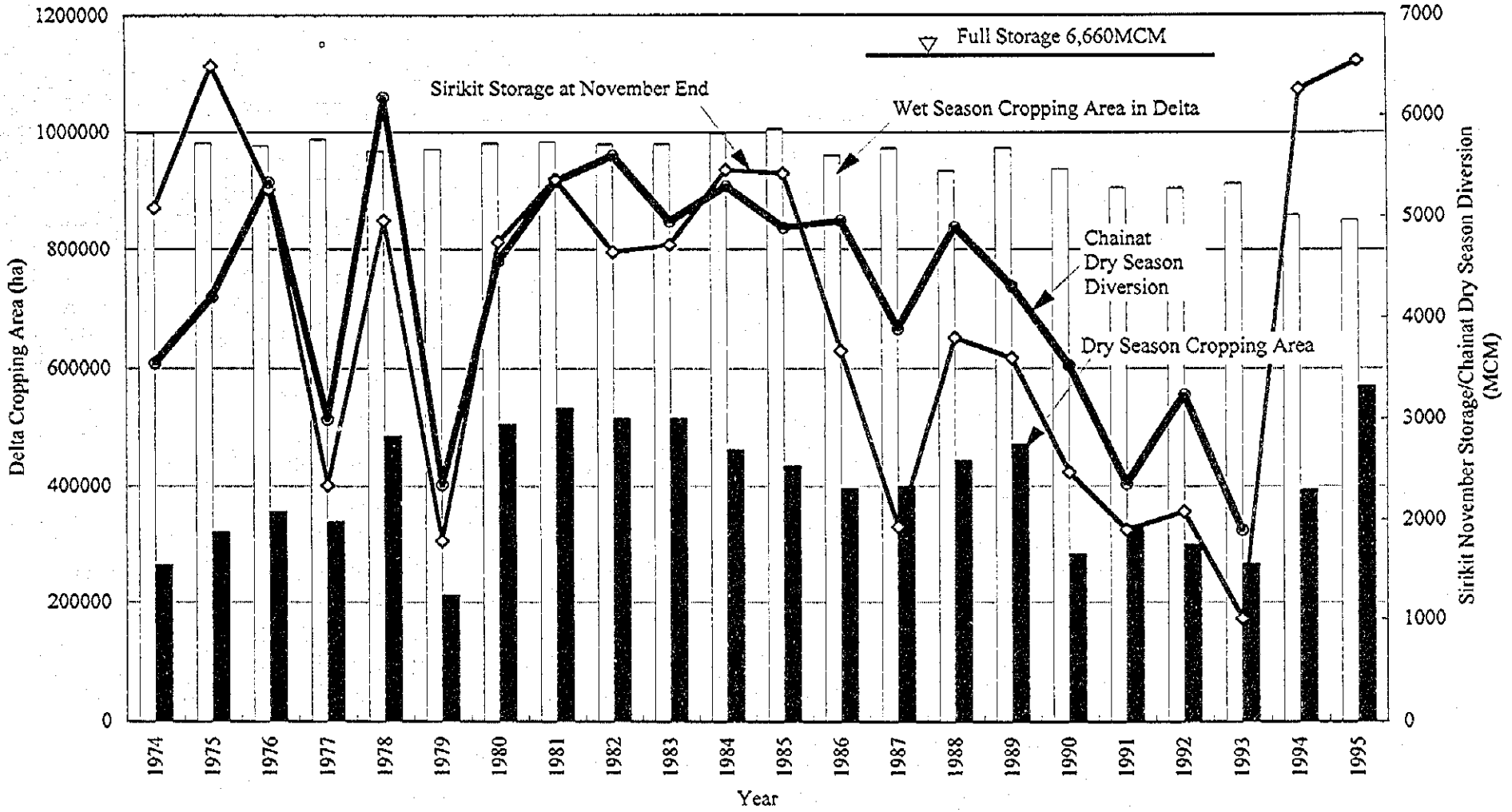


Figure-7 Downstream Release of Chao Phraya Dam

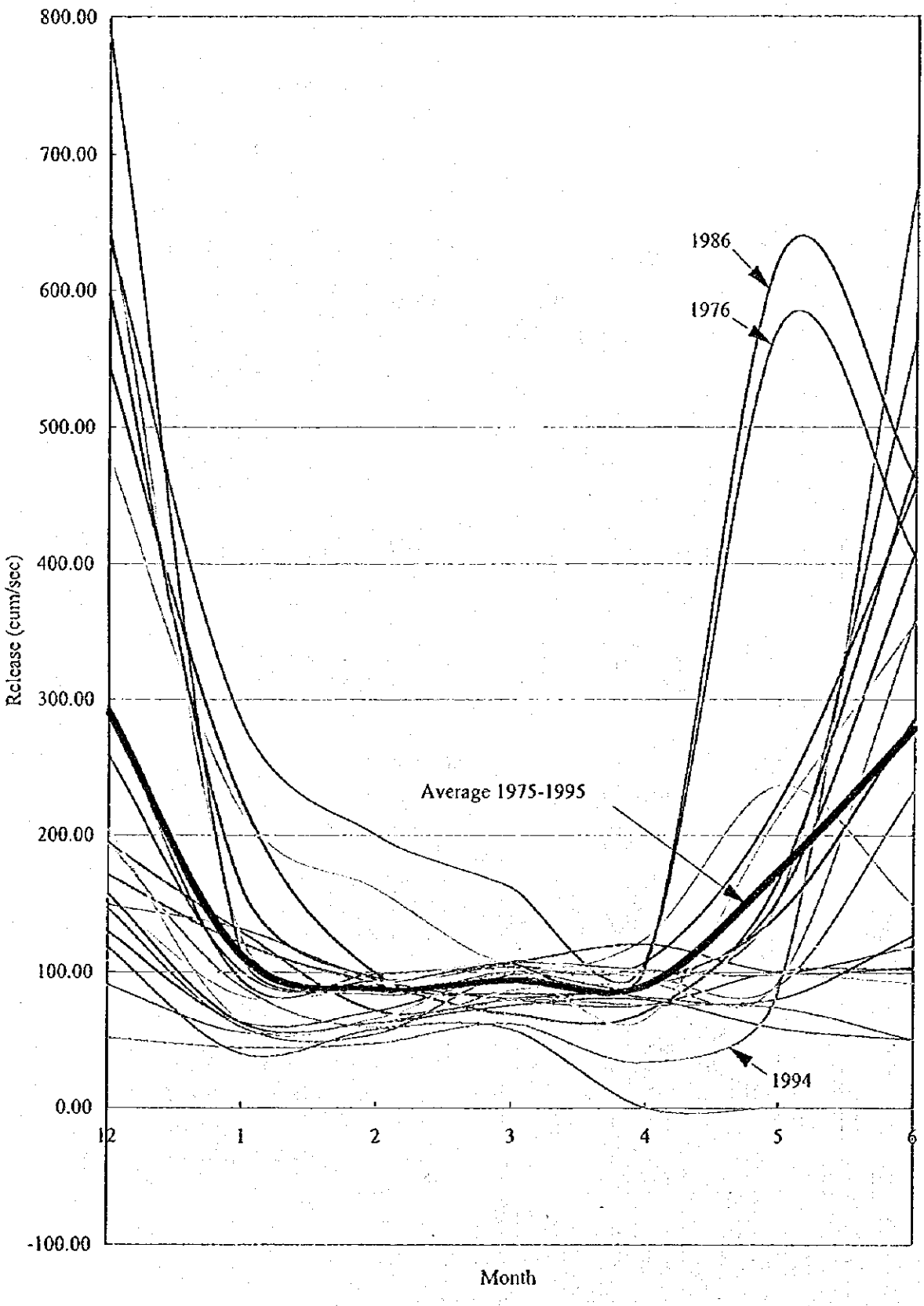
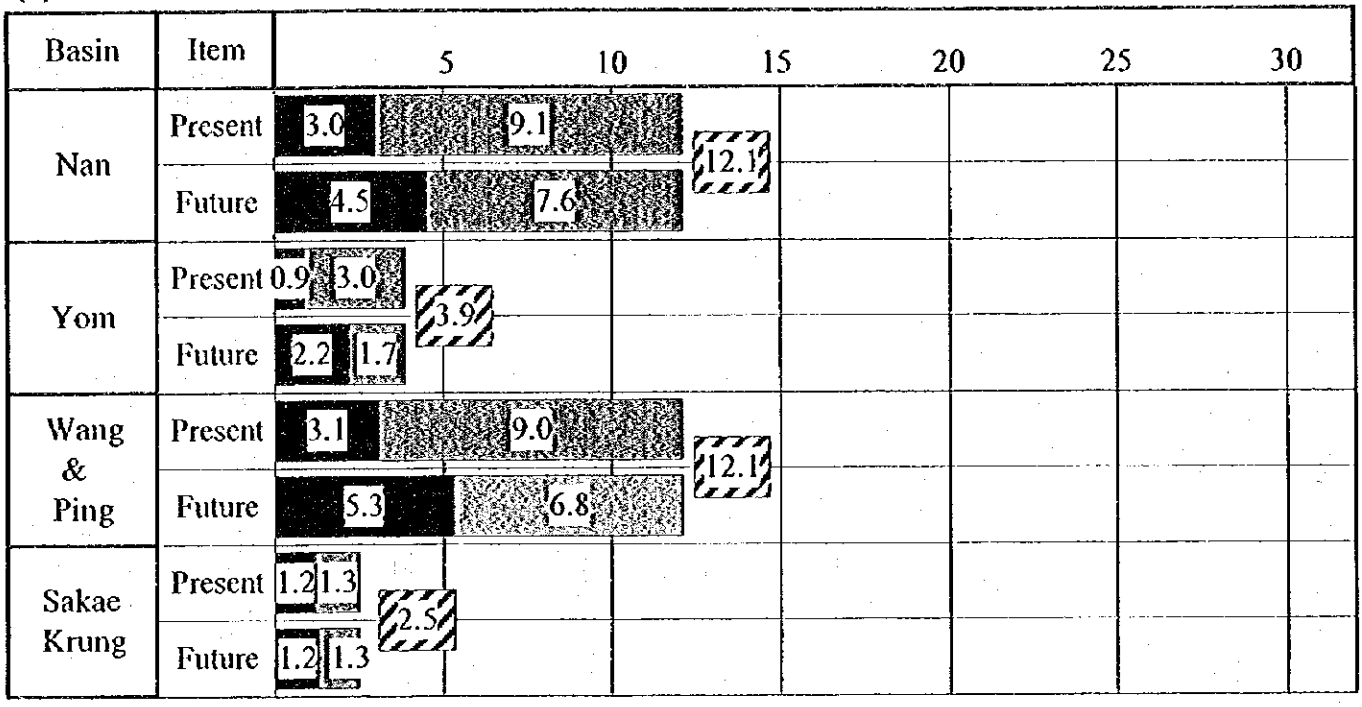


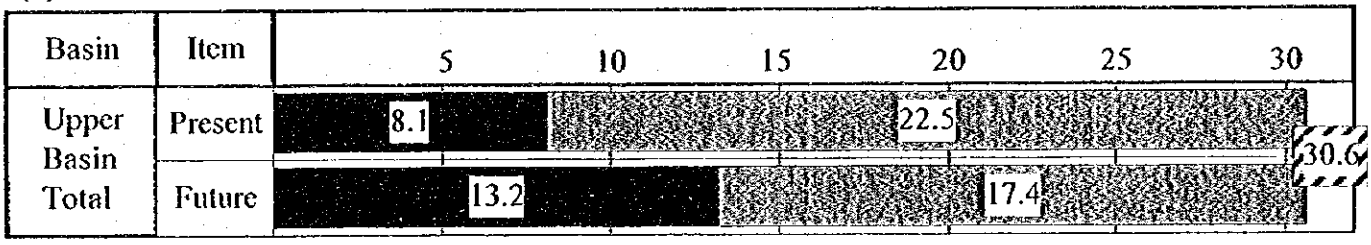
Figure-8 Water Balance of Upper and Lower Chao Phraya Basin

(1) Water Balance of Sub-Basins in the Upper Chao Phraya Basin



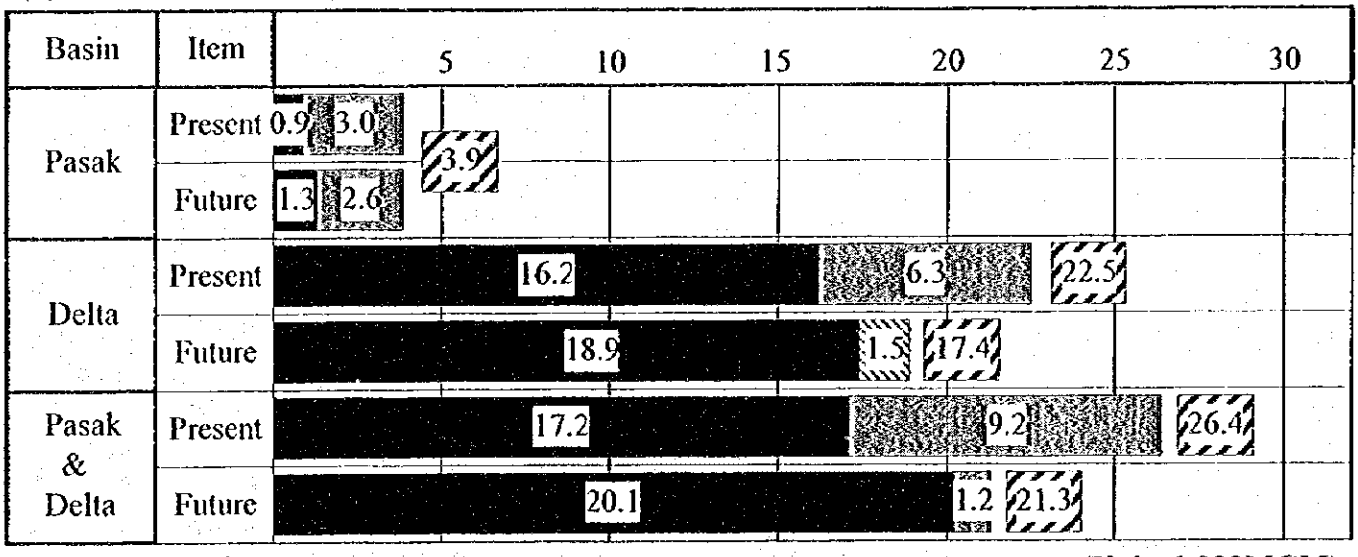
(Unit: 1,000MCM)

(2) Water Balance of the Upper Chao Phraya Basin



(Unit: 1,000MCM)

(3) Water Balance of the Lower Chao Phraya Basin



(Unit: 1,000MCM)

Average Annual Volume of Water Resources

Water Demand

Surplus Water

Water Deficit

PART II

INITIAL ENVIRONMENTAL EXAMINATION

EXECUTIVE SUMMARY

SUMMARY

The objective of the Project is to divert surplus water available in the Kok and Ing rivers flowing in the Northern Thailand, both of them being tributaries of the Mekong River, through several facilities such as open canal, culvert, tunnel, etc., to the Nan river and finally to the Sirikit Dam to meet the water demand in the Chao Phraya Delta. The volume of the diverted water is estimated at about 2 billion m^3 per annum, which corresponds to 175 m^3/sec, mainly used for agriculture, industrial and domestic purposes.

The Project is designed to utilize efficiently and effectively the existing facility of " Sirikit Dam " to store the diverted water of 2 billion m^3. Therefore, no significant resettlement problems will take place in spite of the storage of water as large as 2 billion $m^3$and the diversion route running over a length of about 160 km, because any large-scale dam is not required. However, a regulating dam with a height of about 35 m is required to be constructed on the upstream Yao river, for regulating the diverted water, protecting the downstream villages from flooding and supplying the stored water to the surrounding villages for agricultural purposes. In association with constructing the regulating dam, any resettlement is not envisaged.

The Project is planned to minimize resettlement problem of the local community as much as possible, especially in selecting the diversion route which inevitably passes through the village communities. However, about 20 households will be required to be relocated in the route near the Kok diversion dam. In addition to the resettlement problem, more attention should be paid to the issue of People's Irrigation, representing the traditional irrigation system in Northern Thailand. It will be unavoidable for the diversion route to pass, more or less, through the canal network of People's Irrigation. This issue may be vital to the implementation of the project, because this area is a starting point of the Project. In this respect, the activities of public relations should be concentrated on this matter with a full support of Chiang Rai Province at the beginning of the next stage of the study.

Concerning the Ing Diversion Dam which is planned to be constructed 2 km upstream of the Thoeng road bridge, consisting of concrete weir and polder dyke with a height of 5 m, its roles and impacts, such as influence on wetland, effect of flood mitigation, availability of irrigation water in the dry season, etc. should be well informed to and discussed with the village community when more concrete plan on this scheme be clarified. In this connection, people's participation, from the planning stage, in rural development will be highly recommended to be promoted under the initiative of village community with a full support of Chiang Rai Province.

The tunnel runs underground in the mountain/conservation areas mostly represented by National Forest Reserve (C)/National Park under establishment and designated as "Watershed Classification (1A)" as well. According to the regulation set up by OEPP, no development activities are allowed in the

forest areas classified as Watershed Classification (1A). In association with the tunnel construction, tunnel shafts are planned to be located at seven places along the route. In order to avoid the environmental impact, the entrance, exit and all the inlet portions of shafts are located outside of the Watershed Classification (1A).

However, the prior permission to proceed to the next study should be obtained through discussion/ consultation among RID, RFD and OEPP. In addition, their joint site inspection is highly advised to be carried out at the earliest possible date to clarify the present situation of the inlet and the outlet portions of the tunnel and the shafts, focusing on the forest resources, the watershed conservation, the access road (reinstatement after the operation and/or proper protection measures to prevent illegal logging), impacts of portals on slope stability, social environment of the surrounding villages, etc..

In addition, in association with the tunnel construction which is estimated to produce quarried rock of around 7 - 8 million m^3, much attention should be paid to safety of construction, and disposal /efficient utilization of such a huge amount of quarried rock . On this matter, sufficient discussion be highly recommended to be made about construction contracts, including unit price of quarried rock and designated disposal area, among RID, RFD and Chiang Rai/Phayao Provinces.

As mitigation measures in association with construction of the tunnel shafts and the access roads., adequate reforestation plans are advised to be established under the "Village Reforestation" concept.

Finally, in order to flow the diverted water of 175 m^3/sec., the Yao river will be inevitably required to be improved along the river stream stretching over a length of 40 km. Along the river, thirteen (13) villages, consisting of about 1,700 households equal to about 7,000 population, are distributed. The social impacts on these 13 villages should be studied/discussed among RID, Nan Province, affected village communities (chief of villages, chief of women's association, etc.), environmental experts of the third party (NGOs included). The ecological impacts should be examined as well.

The RID study showed that important water-related disease prevailing in the study was malaria whereas encephalitis and hemorrhagic fever were not present in the record. But encephalitis is reported to have occurred in the Project Area.

More comprehensive public health survey is needed to grasp current problems and to foresee health impact which will be brought by the water resources development project. Especially, the study on present situation of sanitation and hygiene such as types of drinking water and latrine is necessary in the 13 villages along the Yao river, the area of the Ing Diversion Dam and the vicinity of Nong Luang wetland. Most of the health impact studies show that improved access to water in terms of quantity, not quality, brought a significant reduction in diarrheal disease.

In the next stage of Environmental Impact Assessment (EIA) followed by IEE, the followings including the above items, are advised to be studied in more details.

Impacts on Ecosystem in the Mekong

The amount of diverted water from the Kok and Ing rivers is estimated at 1 to 3% of the average runoff of 129,370 MCM at Chiang Khong. The reduction of this volume itself has, more or less, some impacts on the Mekong river, but seems to be not significant. Supposing that, similar projects which reduce the runoff in the Mekong river, be implemented in near future at random or even in order in riparian countries in the Mekong basin, the impacts of the Project on the ecosystem in the Mekong basin might be not small.

The Kok-Ing-Nan Water Diversion Project could be, in other terms, a pilot project which has, more or less, some impacts on the ecosystem in the Mekong basin. Taking this opportunity, the RID will be advised to carry out some study or collect data concerning the cumulative impact of the Project.

Impacts on Aquatic Ecology from One Watershed to Other Watershed

The impacts on aquatic ecology from one watershed to other watershed has been examined based on captured species for Kok, Ing, Nan rivers and concerned tributaries. At this preliminary stage, it has been concluded that the impacts on distribution of fish from one watershed to other watershed is expected to be small because the preliminary result of the study (RID study) indicated that there are minor differences in families and species of fish found in each watershed.

This conclusion should be reconfirmed by more samplings/analyses and more precise examination in the subsequent study. And the impact analysis will be required to be continuously made in the monitoring stage after the implementation of the project.

Deep Excavation in Culvert

The canal passing near the community villages, is designed to be of culvert type. The excavation is, in some parts, down to a depth of 20-30 m from the ground. Therefore, the open space during construction is as wide as 100 m or more in the deepest section. Besides disposal of large amount of excavated soils, estimated at 18 million m^3, this might possibly induce safety problems such as accidents during construction, safety hazards to small children, etc.. Therefore, the design of such a deep excavation is strongly advised to be reviewed.

Ethnic Hilltribe

Villages of hilltribe (Yao tribe) are scattered around the entrance of Tunnel No. 4 shaft. Thus this area would need more attention than other areas, before and during the construction. And the Public Relation activities will have to be executed (for instance, at the time when the route of an access road be clarified.) in a close collaboration with NGOs for this special region earlier than the other regions.

Regulating Dam in the Yao River

The regulating dam will play a very important role not only in preventing the villages scattered along the Yao river from being flooded in a wet season, but also in providing the paddy field with stored water in a dry season. The water stored in the reservoir can be also used, for example, for nursery bed of valuable trees, medical plant, fishery, etc. In this connection, the enhancement programs are recommended to be promoted for the rural development under people's participation.

Yao River Training

In order to flow the diverted water of 175 m^3/sec., the Yao river will be inevitably required to be improved along the river stream stretching over a length of 40 km. Along the river, thirteen (13) villages, consisting of about 1,700 households equal to about 7,000 population, are distributed. The social impacts on these 13 villages should be examined/discussed among RID, Nan Province, affected village communities (chief of villages, chief of women's association, etc.), environmental experts of the third party (NGOs included). The ecological impacts should be examined as well.

The plan should have a minimal impact upon river flow, and minimize the affects of agricultural, fishery and pastoral activities, and minimize loss of biological diversity. However, if the plan is unavoidable, all efforts should be made not only to minimise loss of biological diversity but also to create more of biological diversity than its loss. The following programs are recommended to be implemented;

- create moderate slope of banks for the aquatic plant growth, which will contribute to produce natural detritus food for the fish
- plant riparian vegetation along the water's edge to conserve and create biological diversity
- pay attention to the habitat for wildlife and the morphology of the river

Recommendations

Finally, it will be concluded that the Environmental Impact Assessment (EIA) be indispensable in the next stage of the study. In the EIA study, the activities of the public relations in association with social environmental impacts induced by the Project and the proposal of the enhancement/mitigation programs to facilitate rural development under people's participation, both of which are closely related to each other, should be given high priority.

The Kok-Ing-Nan Water Diversion Plan should be really a strategic development plan. Therefore, the Project should be planned and implemented to meet the development concepts of NESDB, that is, to maximise the benefit of the people affected/people related and facilitate people's participation

in the whole project cycle of planning, implementation, monitoring and evaluation. Furthermore, to secure the sustainable environmental development, the co-operation /collaboration among government agencies concerned and provincial governments will be strongly required and be indispensable.

INITIAL ENVIRONMENTAL EXAMINATION

The Study on the Kok-Ing-Nan Water Diversion Project

Part II (Summary .....Initial Environmental Examination)

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CHAPTER 1 INITIAL ENVIRONMENTAL EXAMINATION

1.1 Executive Summary

The prime objective of an Initial Environmental Examination (IEE) is to reach a decision on whether a full-scale examination of environmental impacts, i.e., an Environmental Impact Assessment (EIA), is required or not. The purpose of conducting the IEE for the Kok-Ing-Nan Water Diversion Project is to identify various environmental parameters affected by a project implementation for the proposed alternatives. The impact on these environmental parameters for the selected optimum water diversion route will be reviewed and carefully examined in the next stage of the EIA.

The preparation of an IEE is an iterative assessment process that begins at the earliest phase of a project development and, running concurrently with project development, constitutes an integrated feedback loop with project planning, implementation, and operation.

The impact assessment, whether it is IEE or EIA, should be regarded as an iterative assessment process that retains its importance in project authorization (or denial) but also becomes a central tool for (1) monitoring and managing predicted impacts from the time of land acquisition and the management process through construction, operational, and maintenance phases; and (2) refining project development on discovery of impacts previously overlooked or changes in project design that may be required during the actual implementation.

The objective of the Project is to divert surplus water available in the Kok and Ing rivers flowing in the Northern Thailand, both of them being tributaries of the Mekong River, through several facilities such as open canal, culvert, tunnel, etc., to the Nan river and finally to the Sirikit Dam to meet the water demand in the Chao Phraya Delta. The volume of the diverted water is estimated at about 2 billion m^3 per annum, which corresponds to 175 m^3/sec, mainly used for agriculture, industrial and domestic purposes.

In light of the development concept focusing on the human resources development addressed in the 8th National Economic and Social Development Plan (1997-2001), the following points are stressed;

(1) The people should benefit the most from the development plan,

(2) Sustainable environmental development to support the improvement of quality of life, and participation of people in the national development plan,

(3) Adjustment of the administration of the government to such as environment where NGOs, private sector, community and people are allowed to participate more in the national

development plan, even in an initial stage of determining a strategic development plan and in a later stage of monitoring and evaluation.

The Kok-Ing-Nan Water Diversion Plan should be really a strategic development plan. Therefore, the Project should be planned and implemented to meet the above development concepts, that is, to maximise the benefit of the people affected/people related and facilitate people's participation in the whole project cycle of planning, implementation, monitoring and evaluation. Furthermore, to secure the sustainable environmental development, the co-operation /collaboration among government agencies concerned and provincial governments will be strongly required and be indispensable.

The statistical data on

- Annual average income distribution
- Planting rate and water resources in a dry season
- Land utilization rate
- Working location and period, and
- Immigration rate and type of work

have clearly indicated that most social problems in the rural communities are closely related to wage and job opportunities. Judging from the correlation among three significant indicators such as household income, land utilization rate and emigration rate, a vicious circle of the problems is found, which the rural communities are now facing.

The vicious circle is represented as follows;

Water shortage → Low rate of land utilization → Low income → Emmigration to urban area, due to lack of job opportunities in rural community → Socio-economic problems

In this respect, the provision of irrigation water in a dry season by the Project and its associated projects will be expected to contribute to sever this vicious cycle. In due consideration of the national development principles and the problems faced by the rural communities, the matters seemingly vital to the project implementation are discussed below in association with the environmental study, but not limited to environmental problems.

The Project is designed to utilize efficiently and effectively the existing facility of " Sirikit Dam " to store the diverted water of 2 billion m^3. Therefore, no significant resettlement/relocation will take place in spite of the storage of water as large as 2 billion $m^3$and the diversion route running over a length of about 160 km, because any large-scale dam is not required. However, a regulating dam with a height of about 35 m is required to be constructed on the upstream Yao river, for regulating the diverted water,

protecting the downstream villages from flooding and supplying the stored water to the surrounding villages for agricultural purposes. In association with constructing the regulating dam, any resettlement/relocation is not envisaged.

The Project has to be planned to minimize relocation of local communities as much as possible, especially in selecting the diversion route which inevitably passes through the village communities. However, about 20 households will be required to be relocated in the route near the Kok diversion dam. In addition to the resettlement problem, more attention should be paid to the issue of People's Irrigation, called " Muang Fai ", representing the traditional irrigation system in Northern Thailand. It will be unavoidable for the diversion route to pass, more or less, through the canal network of People's Irrigation. This issue may be vital to the implementation of the project, because this area is a starting point of the Project. In this respect, the activities of public relations should be concentrated on this matter with a full support of Chiang Rai Province at the beginning of the next stage of the study.

The Ing Diversion Dam, which is planned to be constructed 2 km upstream of the Thoeng road bridge, consists of concrete weir and polder dyke with a height of 5 m. The roles of and impacts by the Dam, such as influence on wetland, effect of flood mitigation, availability of irrigation water in the dry season, etc. should be well informed to and discussed with the village community when more concrete plan on this scheme be clarified. In this connection, people's participation, from the planning stage, in rural development will be highly recommended to be promoted under the initiative of village community with a full support of Chiang Rai Province.

In the preliminary study, of two (2) routes for Ing - Yot tunnel selected for comparison, the northern route has been judged to be more advantageous than the southern route , based on the past consultant's experiences, in taking into account engineering factors such as topographical and geological conditions and construction cost estimated for tunnel. According to the preliminary engineering study, the cost of tunnel construction for the southern route has been estimated at about 30,400 million Baht which is about 1.4 times as high as 21,100 million Baht for the northern route.

The tunnel runs underground in the mountain/conservation areas mostly represented by National Forest Reserve (C)/National Park under establishment and designated as "Watershed Classification (1A)" as well. According to the regulation set up by OEPP, no development activities are allowed in the forest areas classified as Watershed Classification (1A). In association with the tunnel construction, tunnel shafts are planned to be located at seven places along the route. In order to avoid the environmental impact, the entrance, exit and all the inlet portions of shafts are located outside of the Watershed Classification (1A).

From the ecological viewpoints of forest conservation, any significantly adverse impacts of the tunnel construction on forest resources may not be expected. There exist some projects planned/implemented in the area designated as Watershed Classification (1A), one of which was that an

underground headrace tunnel had been planned, in part, under the designated area (1A) for the "LAMTAKONG Hydroelectric Power Project ".

However, the prior permission to proceed to the next study should be obtained through discussion/ consultation among RID, RFD and OEPP. In addition, their joint site inspection is highly advised to be carried out at the earliest possible date to clarify the present situation of the inlet and the outlet portions of the tunnel and the shafts, focusing on the forest resources, the watershed conservation, the access road (reinstatement after the operation and/or proper protection measures to prevent illegal logging), impacts of portals on slope stability, social environment of the surrounding villages, etc..

In addition, in association with the tunnel construction which is estimated to produce quarried rock of around 7 - 8 million m3, much attention should be paid to safety of construction, and disposal /efficient utilization of such a huge amount of quarried rock . On this matter, sufficient discussion be highly recommended to be made about construction contracts, including unit price of quarried rock and designated disposal area, among RID, RFD and Chiang Rai/Phayao Provinces.

Finally, in order to flow the diverted water of 175 m^3/sec., the Yao river will be inevitably required to be improved along the river stream stretching over a length of 40 km. Along the river, thirteen (13) villages, consisting of about 1,700 households equal to about 7,000 population, are distributed. The social impacts on these 13 villages should be discussed among RID, Nan Province, affected village communities (chief of villages, chief of women's association, etc.), environmental experts of the third party (NGOs included). The ecological impacts should be examined as well.
In this discussion, the situation of the river before and after the implementation of the Project should be precisely and schematically explained so as to make village chiefs easily understand the merits and demerits. In addition to that, the enhancement programs in which the water available due to this project may be used for the villages' economic activities, should be accelerated under people's participation in rural development with a positive support of Nan Province and other governmental agencies.

Major items including the above-mentioned matters, revealed by this study of IEE, are described as below, that is, "Overall Impacts"(A - E) and "Individual Impacts"(1 - 15).

1.2 Overall Impacts

A. Change in Run-off in the Rivers

The project is planned to divert surplus water estimated at 2.0 billion m^3 available in total, 1.1 billion m^3 in the Kok river and 0.9 billion m^3 in the Ing river, to the Nan river in the other basin, as shown on Chart 1.

The surplus water, principally taken in the wet season, will contribute to mitigation of flood-induced disaster in the paddy field spreading in the lower Kok and Ing rivers. Especially, the Ing Diversion dam planned on the Ing river will contribute to flood mitigation in Amphoe Thoeng and the paddy field occurring in the lower basin of the Ing river. The diverted water flowing in the open canal and temporarily stored in the regulating pond/Ing Diversion Dam could be used for agricultural purpose through pumping-up by the surrounding villages and be supplied as well to Nong Luang Wetland on the way.

The change in water volume in the lower basins of Kok and Ing rivers will be alleviated to some extent due to inflow of back-water from the Mekong River.

B. Impacts on Ecosystem in the Mekong

The amount of diverted water from the Kok and Ing rivers is estimated at 1 to 3% of the average runoff of 129,370 MCM at Chiang Khong as shown on Chart 2. The reduction of this volume itself has, more or less, some impacts on the Mekong river, but seems to be not significant. Supposing that, similar projects which reduce the runoff in the Mekong river, be implemented in near future at random or even in order in riparian countries in the Mekong basin, the impacts of the Project on the ecosystem in the Mekong basin might be not small.

Each individual project results in direct and indirect impacts. Cumulative impacts are the aggregates of direct and indirect impacts resulting from two or more projects in the same area or region. Assessment of cumulative impact is important, considering the impact on the future ecosystem of the Mekong, whereas relatively small amount of water taken from the tributary of the Mekong may not be environmentally significant on a per project basis, the cumulative amount of water taken in the future may be highly significant.

Generally, environmental impact assessment has focused on those impacts that result from single projects. However, the growing concern for the global environment is likely to underscore the importance of assessing impacts in terms of whole developmental programs as well as individual projects. In this respect, the Project should be regarded as a part of the whole developmental programs associated with

the watershed development of the Mekong River Basin, with which the riparian countries as well as international institutions/organization are concerned.

The Kok-Ing-Nan Water Diversion Project could be, in other terms, a pilot project which has, more or less, some impacts on the ecosystem in the Mekong basin. Taking this opportunity, the RID will be advised to carry out some study or collect data concerning the cumulative impact of the Project. The location for this study is recommended to be "Nongbongkai Wildlife Restriction Area (NWRA) near Chiang Saen, which was declared as a Non-Hunting Area in 1985. The river or stream originated in NWRA is connected to the Ing river about 10 km from the river mouth to the Mekong River.
The tentative items for monitoring in a dry season and a wet season are as follows;

- Observation of bio-diversity
- Water level in NWRA
- Rice productivity, fish capture, cultivation area
- Population density
- Meteorological data
- Observation of acquatic plant, including weed
- Type and population of wildlife
- pH, BOD, SS and water level at the mouth of the Ing river
- pH, BOD, SS and water level in the center of the swamp

C. Back-water from Mekong River

The water level of the Mekong River at the mouth of the Ing river is recorded at 350 m max. and 340 m min., indicating that the fluctuation of water be ranged within 10 m around. The highest water level is observed in October to November and the lowest in April. The river gradient of the Ing river is very gentle, being approximately 1/5,000, from Thoeng to the mouth to the Mekong, so that the back-water comes up to about 50 km upstream from the mouth, but not to Amphoe Thoeng.

D. Impacts on Aquatic Ecology from One Watershed to Other Watershed

The impacts on aquatic ecology from one watershed to other watershed have been examined based on captured species for Kok, Ing, Nan rivers and concerned tributaries. At this preliminary stage, it has been concluded that the impacts on distribution of fish from one watershed to other watershed is expected to be low because the preliminary result of the study (RID study) indicated that there are minor differences in families and species of fish found in each watershed.

This conclusion should be reconfirmed by more samplings/analyses and more precise examination in the subsequent study. And the impact analysis will be required to be continuously made in the monitoring stage after the implementation of the project.

E. Public Health

In Thailand, diarrhea is by far the highest cause of morbidity. Diarrhea and food poisoning have not been reduced due to lack of water supply, hygienic latrine and food sanitation.

The implementation of water resources development project could cause both positive or negative health impacts. Therefore, it is necessary to study the present public health condition before project implementation, so that careful analysis of causes and problems could be done in the next study.

The RID (TEAM J/V) study showed that important water-related disease found in the study was malaria whereas encephalitis and hemorrhagic fever were not present in the record. But encephalitis is reported to have occurred in the Project Area. Common malnutrition problems were goitre and anemia. Particularly in the construction stage, the main problem is likely to be the outbreak of malaria among labors and communities in areas around the tunnel outlet and shaft construction sites. Besides, the spread of AIDS and diarrhea might be possibly found among workers.

More comprehensive public health survey is desirable to understand existing problems and to foresee health impact which will be brought by the water resources development project. Especially, the study on present situation of sanitation and hygiene such as types of drinking water and latrine is necessary in the 13 villages along the Yao river, the area of the Ing Diversion Dam and the vicinity of Nong Luang wetland.

Most of the health impact studies show that improved access to water in terms of quantity, not quality, brought a significant reduction in diarrheal disease. Furthermore, the health education for people in communities is useful to change inadequate health behavior. In this connection, it is recommended that in the early stage of the project, the health education programs be applied to these areas as a part of enhancement programs of the Project, to ensure that the available water is fully used for hygienic purposes, and to minimize fecal contamination of the environment.

Individual impacts along the diversion route from the starting point of the intake site in the Kok river are summarized below. The summary is shown on Chart 3 covering the whole route and the precise impacts on several alternative routes limited to the area between the intake in the Kok river and the Ing Diversion Dam is shown on Chart 4.

1.3 Individual Impacts along the Diversion Route

1. Intake from the Kok River

As an intake site, two alternatives are proposed, an upstream one and a downstream one of the existing diversion dam administered by DEDP. The downstream one (A route) is that a new intake facility is planned to be constructed about 4 km downstream of the Kok Diversion Dam (existing). In this case, the RID is able to administer the water under his control, but the canal will inevitably pass, in most parts, through the irrigation canal network under the DEDP control. On the other hand, the upstream one (B route) is planned to take directly the water at the location about 2 km upstream of the existing dam, but is not able to administer the water under his control.

In any case, mutual understanding and close co-operation between RID and DEDP will be highly required to promote the project. It should be noted by both governmental agencies through the process of site selection that the project be implemented to contribute to the economic development in the local community, in which the role the Chiang Rai Province is expected to play is not small, but rather large and vital to the project implementation.

2. Land Acquisition and People's Irrigation

The Kok Diversion Dam (existing) and the subsequent canal route are the starting point of the Project. The land acquisition for these areas located within the economic zone of Chiang Rai city, may be more sensitive than that for other areas.

The Project has to be planned to minimize resettlement/relocation of local communities as much as possible, especially in selecting the diversion route which inevitably passes through the village communities, resulting in that about 20 households be required to be relocated in the route near the Kok diversion dam. In addition to the resettlement problem, more attention should be paid to the issue of People's Irrigation, called " Muang Fai ", representing the traditional irrigation system in Northern Thailand.

The traditional People's Irrigation system, called as " Muang Fai ", not only controls the rivers and streams but defines the social fabric of thousands villages, welding communities together to share resources to ensure mutual prosperity. However, now village cohesion is weakening, and with it the willingness to co-operate. One of the reasons is that the new settlers refuse to pay for the water; old farmers, seeing the newcomers receiving free water, become reluctant to pay, resulting in most distressing to "Muang Fai administrators". Particularly, when water supplies are scarce during the dry season, the potential for conflict escalates and the problem becomes more serious.

It will be unavoidable for the diversion route to pass, more or less, through the canal network of People's Irrigation. This issue may be vital to the implementation of the project, because this area is the

starting point of the Project. In this respect, the activities of public relations and the social study on People's Irrigation should be concentrated on this matter with a full support of Chiang Rai Province in the next stage of the study.

In case of Route A, about 20 households will be required to be relocated as mentioned above. On the other hand, in case of Route B, no resettlement problems may be expected to take place at this moment, but some households may be possibly affected in the future due to expansion of the urban development in Chiang Rai city. Furthermore, in the route selection, it will be necessary to take into consideration the hike of land price with progress of urbanization.

3. <u>Ecosystem of Wetland</u> (Nong Luang) for Routes "B" and "B-P"

The wetland of Nong Luang is dried up in a dry season. The wetland presently plays an important role not only in feeding and breeding for birds and wildlife but also in aquaculture in the rural economy.

The canal route is to pass through Nong Luang, resulting in, more or less, having some adverse effects on the wetland ecosystem. However, the introduction of water from the canal in a dry season into the wetland is expected to contribute more to the rural economy, in meeeting the needs of local communities. In this respect, the conservation of the wetland in Nong Luang, or more positive utilization of the wetland, is closely related to enhancement programs under people's participation to be recommended with a full support of RID, RFD and DOF.

Despite the wide ranges of resources and services provided through wetlands in the region, they have not likely been properly protected or managed on a sustainable basis. In Southeast Asia, major threats come from mining, and unsustainable forestry conversion to agricultural or urban land. If these systems are to continue to support the region's biodiversity and the people who depend upon their resources, urgent attention needs to be given to improving their management. Governments and non-governmental organizations (NGOs) have been paying increasing attention to this issue in recent years, and Vietnam and Indonesia both joined the Ramsar Convention in the late 1980s.

Before that, understanding of wetlands, that is, understanding the full value of wetland ecosystems and the role that their sustainable use can play in achieving social and economic goals, needs to be built at all levels of society, firstly among government departments concerned such as RID, DOF, RFD, provincial government, etc..

4. <u>Deep Excavation in Culvert</u> (Route "B")

The canal passes through a paddy field and a small hill after coming out of the Nong Luang, and again run through a paddy field along which several villages, namely Ban Thung Khong and Ban Mua Luk, are situated several hundred meters away, and finally comes to a regulating pond planned with an area of 200 ha.

The pond plays a role in regulating diverted water temporarily, from which the diversion main canal goes out and another canal goes out as well to supply the water to the area on the left bank of the Hong Khua river, a tributary of the Ing river.

The canal passing near the above-mentioned villages, is designed to be of culvert type. The excavation is, in some parts, down to a depth of 20-30 m from the ground. Therefore, the open space during construction is as wide as 100 m or more in the deepest section. Besides disposal of large amount of excavated soils, estimated at 18 million m^3, this might possibly induce several safety problems such as accidents during construction, safety hazards to small children, etc.. The design of such a deep excavation is strongly advised to be reviewed. If it is unavoidable, the construction will be required to take the following measures in due consideration of anticipated adverse impacts on the environment;

- Safety measures against excavated slope collapse and slope sliding during construction,
- Safety measure against access to the excavated open space during construction (setting up the fence along the shoulder of the open space, preventing village people form approaching the site),
- Proper treatment of dewatering during the excavation work,
- Proper treatment of excavated materials (utilization of organic top soil and disposal of 18 million m^3 excavated soils), and
- Correct information about the construction to the local community.

5. Ing Diversion Dam

The construction of the polder dyke will contribute to close off a paddy filed from the flood and to alleviate potential damage to infrastructure. On the other hand, farmers will lose a benefit from the fertilizing role of the flood when the water recedes, but the benefits of the flood are not altogether lost. Generally, the dry season drawdown speeds up aerobic decomposition of accumulated organic matter, releasing nutrients that, on reflooding, support a wet-season bloom in productivity. The life histories of many organisms are intimately coupled to this periodicity. The volume of water discharges in rivers and other water bodies such as swamp and pond, principally dominates the distribution and the abundance of aquatic organisms. Therefore, the shortage of water supply has a significant influence on the activities of fishing and aquaculture.

The change of environment after the construction of the dykes is represented by longer periods of flood condition, 3 to 4 months, compared with the current flood, 2 to 3 weeks. It should be noted that the fluctuation in water level caused by change in water discharge after the project implementation is less than that due to seasonal change, a dry season and a wet season. Therefore, the impacts of the Project on the aquatic ecology are rather small. Plants and wildlife living there may adapt themselves to such environmental change of alternate periods of longer flooding and shorter drying.

In maintaining the function of the wetland, the periodicity of flow pattern is quite important. Although the flood pattern itself is to be changed by the Project, the periodicity will be secured. Therefore, productivity in aquaculture, growth cycle in aquatic plant and habitat/migration for wildlife will be less affected.

Here, it should be noted that the reservoir formed by the dyke helps farmers living there to utilize water even in a dry season for paddy/crop cultivation and aquaculture. Available water of 300 MCM in a dry season will be used for associated projects, that is, Lower Ing Irrigation project (5,000 ha), upper Ing Irrigation project (3,000 ha) and Inland Fishery project (2,000 ha in water surface area).

Principally, at each stage of the project implementation, such as planning, construction and operation, intensive and frequent consultation among local communities, representatives of Theong, RFD, RID, etc. will be advisable to be held for mutual understanding in the next stage of the study.

6. Tunnel Under Watershed Classification and National Forest Reserves

Although the impacts on forest resources are expected to be of low magnitude, there are important issues about environment-related regulations to be clarified before proceeding to the next stage of the study, that is, Watershed Classification and National Forest Reserves. According to the regulation set up by OEPP, no development activities are allowed in the forest areas classified as Watershed Classification (1A).

A major objective of watershed classification is to formulate land use plan for conservation of natural resources, in particular, water and forest resource from the viewpoint of their sustainable use. From the ecological viewpoints of forest conservation, any significantly adverse impacts of the tunnel construction on forest resources may not be expected. However, the prior permission to proceed to the next study should be obtained through discussion/ consultation among RID, RFD and OEPP at the earliest possible date.

In addition, no data on the vegetation around the Phu Sang Waterfall in the National Park are available. So, the survey on vegetation will be required to be made in the next stage of the study.

In the tunnel construction, the major issues related to watershed conservation will be the behavior of the groundwater/the surface water which may affect, more or less, the vegetation and forest resources occurring on the surface above the tunnel/shafts. The longitudinal sections of the tunnel/shafts are shown on Database Map. From the watershed conservation aspects, the investigation items are provisionally listed in Chart - 5 for the impacts likely induced by tunnel construction.

7. Safety Measures in Tunnel Construction

The tunnel construction will be required to take the following measures in due consideration of anticipated adverse impacts on the environment;

- Safty measures against the collapse of the wall and the ceiling,
- Proper treatment of polluted water,
- Proper treatment of excavated rock, and
- Reforestation of the areas affected such as inlet and outlet portions of tunnel and shafts,

and access road from existing roads to the shafts.

8. Reforestation Plan in the Inlet Portions of Shafts and along the Access Road

Some forest resources will be inevitably affected by construction of the tunnel shafts and the access roads. As mitigation measures, adequate reforestation plans are advised to be established under the "Village Reforestation" concept. Seedles for forest planting should be provided from RFD' Seedling Centre. Principally, the area for reforestation should be more than that affected by the construction. In the preparation stage of the reforestation plan, the co-operation/ collaboration among RID,RFD and village communities will be indispensable.

9. Utilization of Quarried Rock from Tunnel Construction

In connection to the proper treatment of excavated rock, it will be well advised to prepare the plan for utilizing the quarried rock from the tunnel excavation, the volume of which is estimated to be as large as 6 to 7 million m^3 in-situ.

The quarried rock can be used for several purposes, not only for the project but also for other purposes, depending on wethering degree.

For the project, and associated projects	coarse aggregates for concrete, rock material for river bank protection and construction materials for dam and dyke
For other purposes	coarse aggregates for local sale and construction materials for local sale

Particularly, in association with utilisation of quarried rock related to the tunnel construction, it is advised that not only the provincial government, under the initiative of community villages, participate positively in the development project, but also private sectors will be invited to join the project in a more positive manner.

For instance, a special purpose company in which a private sector and an affiliated entity of the provincial government take an equity participation, will be possibly established to produce and sell construction materials such as concrete aggregates, etc., in using quarried rock from tunnel excavation. The location for the spoil bank where the above excavated materials be disposed, shall be designated by the provincial government. In case of disposing such excavated materials at the designated site, the contractor shall pay at the price agreed among the parties concerned to the provincial government.
First of all, it is necessary to formulate a framework in which all the parties concerned, fairly and equally, share together the benefits and the risks coming from the Project.

In the background of this concept, the destruction of forest resources could be avoided in other areas where the quarried rock is necessitated for rural development purposes.

10. Aquatic Ecology and Fish Migration in Tunnel

Concerning the migration of fishes through the tunnel with a length of 50 km, most of the fishes have enough swimming capability so that no significant impacts are expected to be envisaged. But at the inlet portion of the tunnel, some measures are recommended to be considered for reducing the flow velocity, for instance, installing a resting place.

The lack of oxygen in the tunnel will be avoided, because the oxygen will be supplied into the water as far as the movement of atmospheric air occurs and the steady flow is present even under no sunlight condition like the night time. Furthermore, the temperature of the underground, about 1,000 m below the ground surface at the deepest, is almost the same as the annual average temperature of the atmosphere in the respective region, so that the difference in temperature is expected to be minor throughout the tunnel. Fishes could adapt themselves to change in temperature in the tunnel.

11. Ethnic Hilltribe

Villages of hilltribe (Yao tribe) are scattered around the entrance of Tunnel No. 4 shaft. Thus this area would need more attention than other areas, before and during the construction. And the Public Relation activities will have to be executed (for instance, at the time when the route of an access road be clarified.) in a close collaboration with NGOs for this special region earlier than the other regions.

12. Regulating Dam in the Yao River

The regulating dam is planned to be located out of the National Forest Reserve but its reservoir enters in parts into the National Forest Reserve covered with degraded forests. Any village is not directly affected, but pasture will be affected at limited places. The regulating dam will play a very important role not only in preventing the villages scattered along the Yao river from being flooded in a wet season, but also in providing the paddy field with stored water in a dry season. The water stored in the reservoir can be also used, for example, for nursery bed of valuable trees, medical plant, fishery, etc. In this connection, the enhancement programs are recommended to be promoted for the rural development under people's participation.

13. Yao River Training

In order to flow the diverted water of 175 m^3/sec., the Yao river will be inevitably required to be improved along the river stream stretching over a length of 40 km. Along the river, thirteen (13) villages, consisting of about 1,700 households equal to about 7,000 population, are distributed as shown on Chart 6. The social impacts on these 13 villages should be examined/discussed among RID, Nan Province, affected village communities (chief of villages, chief of women's association, etc.), environmental experts of the third party (NGOs included). The ecological impacts should be examined as well.

The plan should have a minimal impact upon river flow, and minimize the affects of agricultural, fishery and pastoral activities, and minimize loss of biological diversity. However, if the plan is unavoidable, all efforts should be made not only to minimise loss of biological diversity but also to create more of biological diversity than its loss. The following programs are recommended to be implemented;

- create moderate slope of banks for the aquatic plant growth, which will contribute to produce natural detritus food for the fish,
- plant riparian vegetation along the water's edge to conserve and create biological diversity, and
- pay attention to the habitat for wildlife and the morphology of the river

Vegetation can stabilize shorelines by reducing the energy of waves, currents or other erosive forces. At the same time, the roots of plants hold the bottom sediment in place, preventing the erosion of the river bank.

In this connection, taking the opportunities to utilise water available in a dry season, rural development projects are strongly recommended to be promoted for the dry season cultivation eagerly needed in the Yao river basin. In addition, the Lower Yao Irrigation project (2,000 ha) is planned as associated project. These projects should be implemented at the tambon level under the intiative of village people. There, village people themselves assess the present conditions of livelihood and resources potential such as land use, labour force, credit/fund sources, and propose their development plan to the Tambon Council, which undertakes coordination, cooperation and information dissemination.

14. Impact on the Sirikit Dam

The volume of diverted water of 2,000 MCM will be stored additionally in the Sirikit Dam, which is the final destination of the Project.

This raises and keeps the water level of the Sirikit reservoir to H.W.L. in a wet season, which eventually has some environmental impacts on the ecosystems of the reservoir in a different manner from the case without project.

- Riparian habitat and riparian vegetation
- Aquatic habitat and aquatic plant/aquatic organisms
- Fish nursery and spawning
- Siltation
- Eutrophication
- Weed habitat
- Freshwater aquaculture and fishing

15. Minor Impacts on Wildlife

Only small size wildlife such as rat, snake, lizard, frog, etc. is present in most of the project area. The small size wildlife moves only within 50 m of his habitat. Most of the wildlife species present in the project area can adapt themselves to the change of the environment caused by the project. Most of the mid-size wildlife such as deer, wild pig, etc. have gone to the forest area. So the impacts on the mid-size wildlife appears to be minor.