5.4 Irrigation Water Demand

5.4.1 Basic Parameters

Direct beneficial basins such as lower Nan and lower Chao Phraya, more particularly for the irrigation sub-projects/schemes directly served by the main rivers of the Nan and the Chao Phraya through a diversion by gravity or small-scale pumping are the target for due consideration. The study therefore covers the total irrigation service area of 8.4 million rai consisting of 7.34 million rai in the lower Chao Phraya basin and 1.06 million rai in the lower Nan basin, which are further divided into 0.67 million rai of existing area extending along the main stream of the Nan river including 0.39 million rai of DEDP pumping irrigation area. System expansion area of 500,000 rai on the left bank of the Nan river (Phitsanulok Stage 2 area) and 200,000 rai for DEDP pump irrigation are also considered. The RID's existing sub-projects in the Chao Phraya delta are examined at a block level such as Upper Delta and Lower Delta and/or West Bank and East Bank, while the DEDP pumping schemes are treated at a group level. In order to avoid useless complexity, the Thung Wat Sing sub-project area categorized under the RID MSIP with the irrigable area of 67,500 rai is excluded from the study. Irrigation systems and irrigable areas to be considered are, thus, summarized as follows;

Table 5.4.1 Irrigation Systems and Irrigable Areas

Irrigation System	Irrigable Area (10^3 rai)	
	Existing	Target
Chao Phraya Delta		
Existing Systems (Greater Chao Phraya Projects)	7,342	6,800
System Expansion	0	0
Sub-total	7,342	6,800
Lower Nan Basin		
Existing Systems		
Phitsanulok Irrigation Project, Stage 1	667.1	634.0
DEDP Pump Irrigation Projects	392.0	485.6
System Expansion		
Phitsanulok Irrigation Project, Stage 2	0.0	500.0
DEDP Pumping Project, up to 2006	0.0	100.0
DEDP Pumping Project, up to 2016	0.0	100.0
Sub-total	1,059.1	1,819.6
Total	8,401.1	8,619.6

5.4.2 Unit Irrigation Water Demand Analysis

Strict attention has been paid to the dry season irrigation where a serious shortage of water supply has been recognized; while there is no or less problem as a whole as to the water supply in wet season. In order to evaluate the irrigation water demand per unit area of irrigated farmland for various crops, records on discharges passed through irrigation canals at regulators and farmland areas irrigated by these amount of water are fully collected from O/M Division of RID.

Chao Phraya Delta

Discharge records are available, as shown in figures in the paragraph 5.4 of the Supporting Report, at almost all locations of regulators and intake structures where water is diverted from the Chao Phraya and other rivers or diverted water is distributed in the irrigated service area commanded under the Greater Chao Phraya Irrigation Project. Among those records, some are effective to estimate the unit area irrigation water consumption with the connection that the cropped area and amount of water used for irrigation can be directly presented. A simple water balance study has been made for this purpose, applying the following equations;

Table 5.4.2 Equation for Evaluation of Unit Area Water Consumption for Irrigation

Water Balance Equation	Irrigation Area Covered
Upper West Bank Area	
Thabot Reg. - Samchook Reg. =	Whole Samchook Sub-project Area
Samchook Reg. - Pho Phraya Reg. =	Whole Pho Phraya Sub-project Area
Borommathat Reg. - Channastr Reg. =	Whole Channastr Sub-project Area
Channastr Reg. - Yang Manee Reg. =	Whole Yang Manee Sub-project Area
Upper/Lower East Bank Area	
Manorom Reg. =	Whole Manorom/Downstream Area
Maharaj Reg. =	Whole Maharaj Sub-project Area
Lower East Bank Area	
Phra Thummaracha Syphon - Klong 13 Tail Reg. + Somboon Reg. + Klong 21 Reg. + Klong 20 Reg. + Klong 19 Reg. =	Whole Rangsit Tai Sub-project Area
Bang Kanak Reg. + Tha Khai Reg. + Tha Thua Reg. + Paktakhong Reg. + Cholahan Phichit Reg. + Klong 13 Tail Reg. =	Whole Khlong Dan + Phra Ong Chaiyanuchit Sub-project Areas
West Bank Area	
Borommathat Reg. + Phonlathep Reg. + Makamtao-Uthong Head Reg. + Noi Right Canal No.1 + Noi Left Canal No.2 + Nam Noi Left Canal No.1 + Khlong Thung Raharn + Right Land No.1 + Left Canal No.2 + Left Canal No.1 =	Whole West Bank Area
East Bank Area	
Manorom Reg. + Maharaj Reg. + Tham Moon Intake + Ban Lek Intake + Khao Kaew Intake =	Whole East Bank Area

The above analysis is detailed in the tables in the paragraph 5.4 of the Supporting Report indicating the following unit area water demand for irrigation;

Table 5.4.3 Unit Area Demand by Zone

Zone	Unit Area Demand (m^3/rai)
Upper West Bank	1,820
Upper/Lower East Bank	1,320
Lower East Bank	980
Whole West Bank	1,220
Whole East Bank	1,360

The above figures are given in terms of the diversion water requirement including all kinds of water losses after water is diverted. It would be judged from the above figures that overall diversion water requirement be around 1,800 m^3/rai for the upper part of the delta, 1,000 m^3/rai in the lower delta and 1,200 to 1,300 m^3/rai for the entire delta area.

Unit area irrigation requirements for various crops are referred to in the Interim Report of the Chao Phraya Basin Water Management Study undergone at present, since their figures seem to fit the actual achievement of the O/M activities in the delta area.

Table 5.4.4 Dry Season Irrigation Requirement by Crop

Zone	Unit	Dry Season Crops			Whole Year Crops		
		Rice	Field Crops	Vege-tables(*)	Sugar Cane	Fruit Trees	Fish Pond
Upper Delta Area	m^3/rai	1,850	1,300	550	1,300	2,000	1,450
Lower Delta Area	m^3/rai	1,000	900	400	875	1,250	925

Note: (*) Water demand for vegetable presents the amount of water for one crop per dry season. Under the assumption that two crops are usually cultivated during a season, amount of water is doubled in the water balance computation.

Above figures for various crops are then put into the actual cropped areas in each of the irrigation sub-project in order to calculate the average value of the unit area demand by zone. The study shows 1,740 m^3/rai for the Upper West, 1,000 m^3/rai for the Lower West, 1,310 m^3/rai for the whole West, 1,740 m^3/rai for the Upper East, 1,040 m^3/rai for the Lower East and 1,220 m^3/rai for the whole East area. In the delta area as a whole, 1,290 m^3/rai is obtained. All of these figures are reasonable when compared with the actual achievement in the delta area and therefore be acceptable.

The analysis made shows relatively low values of unit demand of water as compared with common figures of about 1,000 mm (10,000 m^3/ha or 1,600 m^3/rai) applied elsewhere in the southeastern asian countries. This is due to effective use of return flow within the irrigation systems to the maximum, and therefore it may be difficult to expect saving of irrigation water in particular in dry season even if water management system is rationalized.

Monthly pattern of the unit irrigation water demands for various dry season crops in the Chao Phraya delta are summarized below;

Table 5.4.5 Monthly Irrigation Water Requirement by Crop

(Unit: m³/rai)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
1. Upper Delta Area							
Dry Season Rice	241	422	519	511	146	11	1,850
Field Crops	143	359	483	292	23	0	1,300
Vegetables	44	255	251	0	0	0	550
Sugar Cane	210	210	220	220	220	220	1,300
Fruit Trees	333	333	334	334	333	333	2,000
Fish Pond	240	240	245	245	240	240	1,450
2. Lower Delta Area							
Dry Season Rice	130	228	281	276	79	6	1,000
Field Crops	99	248	334	202	17	0	900
Vegetables	38	182	180	0	0	0	400
Sugar Cane	145	146	146	146	146	146	875
Fruit Trees	208	208	209	209	208	208	1,250
Fish Pond	154	154	154	155	154	154	925

Lower Nan Area

Although the data collected from the Phitsanulok project area show relatively smaller values of irrigation water consumption as explained in paragraph 5.4 of the Supporting Report, the same figures as given to the upper banks of the delta are applied in this study for conservative or safety purpose.

Table 5.4.6 Dry Season Irrigation Requirement by Crop (Lower Nan Basin)

Zone	Unit	Dry Season Crops			Whole Year Crops		
		Rice	Field Crops	Vege-tables(*)	Sugar Cane	Fruit Trees	Fish Pond
Lower Nan Basin	m³/rai	1,850	1,300	550	1,300	2,000	1,450

Note: (*) Water demand for vegetable presents the amount of water for one crop per dry season. Under the assumption that two crops are usually cultivated during a season, amount of water is doubled in the water balance computation.

5.4.3 Evaluation of Current Water Demand and Shortage

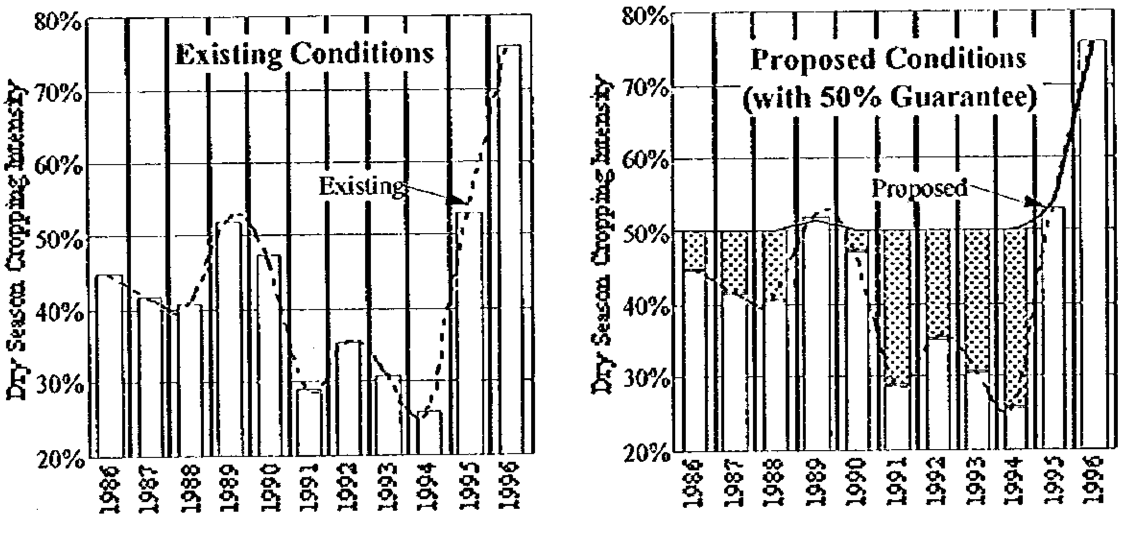
Under the current "Command and Control System" for irrigation practice in the Chao Phraya delta, cropped area in dry season is adjusted depending on the availability of water in the strategic reservoirs of Bhumibol and Sirikit at the end of previous wet season. The 61% of dry season cropping intensity (4,386,000 rai out of 7,192,000 rai) has been achieved in 1996 after receiving plenty of rainfall in 1995, however, in a dry year such as 1994, the intensity unavoidably lowered to 33% (2,380,000 rai) due to insufficient storage in the reservoirs. Under this situation, the amount of water actually used for irrigation does not have a direct relation with the demand of water for irrigation. In order to evaluate water demand for irrigation, it is therefore necessary to establish a guideline.

(1) Minimum Cropping Intensity to be Guaranteed

Water demand for irrigation is generally defined as the amount of water to be supplied to cover the cropped area under irrigation which satisfies a proposed magnitude of irrigation or cropping intensity. A guideline in terms of the "minimum cropping intensities to be guaranteed" is set up for this purpose in order to estimate water demand for dry season cropping and also to evaluate the present status of water shortage in the direct project beneficiary areas. The guideline allows for the irrigated area to receive additional water supply in order to achieve the minimum intensity proposed whenever the present intensity lowered it, while the present achievement is secured as it is when it already exceeds the minimum intensity.

It is, however, rather difficult to establish a fixed value of such an intensity since achievement of the proposed intensity largely depends on the availability of water in the strategic reservoirs of Bhumibol and Sirikit. A comparison study is therefore made giving various values of the minimum cropping intensities to be guaranteed within an acceptable range covering 20% to 90%. A conceptualized diagram showing a concept for water shortage evaluation is given in the following figure.

Figure 5.4.1 Concept for Water Shortage Evaluation (For a Case with 50% of Minimum Intensity to be Guaranteed)



(2) Present Status of Water Shortage

<u>Chao Phraya Delta</u>

For evaluation of the present conditions of water demand and shortage, the cropped area was taken as the average for the period from 1991 to 1996, and the monthly unit irrigation demand for dry season crops per rai in terms of diversion water requirement was applied. For reference, the present achievement of dry season irrigation is summarized as follows;

- Total Irrigable Area in the Delta 7,342,000 rai
- Average Cropping Intensity (1991-96) 40.2%
- Average Water Use for Irrigation 3,917 MCM

Computed results for various cases as given in Table 5.4.7 are further summarized as follows;

Table 5.4.8 Water Shortage for Dry Season Cropping in the Delta

Minimum Intensity to be Guaranteed (%)	Present Water Shortage (MCM)
20	252
30	546
40	1,063
50	1,754
60	2,594
70	3,535
80	4,563
90	5,633

Lower Nan Basin

The present features of irrigation in the direct beneficial areas in the Lower Nan basin are summarized as follows;

- Irrigable Area	Phitsanulok Stage 1 Area	667,100 rai
	DEDP Pump Project Area	392,000 rai
	Total	1,059,100 rai
- Irrigation Intensity	Phitsanulok Stage 1 Area	60.6%
	DEDP Pump Project Area	50.0%
	Total	56.7%
- Irrigation Water Use	Phitsanulok Stage 1 Area	737 MCM
	DEDP Pump Project Area	356 MCM
	Total	1,093 MCM

Computations for evaluation of the present water shortage are as per Table 5.4.9 and as summarized below;

Table 5.4.10 Present Water Shortage for Dry Season Cropping in Lower Nan

	Minimum Intensity to be Guaranteed (%)							
	20	30	40	50	60	70	80	90
Present Water Shortage (MCM)	0	0	1	41	163	304	467	652

Dry season cropping intensities in the Chao Phraya delta currently achieved by zone are summarized in Figure 5.4.2.

Table 5.4.11 Dry Season Cropping Intensities of 25 Irrigation Sub-Projects

Bank	Zone	Cropping Intensity (%)		
		1996	1991 - 1996	Difference
West Bank	Upper	75.9	41.5	34.4
	Lower	62.6	63.6	-1.0
	Total	70.8	50.0	20.8
East Bank	Upper	50.6	16.9	33.7
	Lower	46.2	41.2	5.0
	Total	48.2	30.0	18.2
Total Delta Area		59.7	40.2	19.5

When several sub-projects with those of lower intensities are excluded, the cropping intensities by zone are as below;

Table 5.4.12 Dry Season Cropping Intensities of 20 Irrigation Sub-Projects (Excepting Those*/ of Lower Intensity)

Bank	Zone	Cropping Intensity (%)		
		1996	1991 - 1996	Difference
West Bank	Upper	85.9	47.6	38.3
	Lower	69.0	70.2	-1.2
	Total	79.1	58.3	20.8
East Bank	Upper	57.0	19.2	37.8
	Lower	59.7	53.6	6.1
	Total	58.2	35.3	22.9
Total Delta Area		69.6	47.0	22.6

*/...... Upper West Bank (8) Yang Manee, (9) Phak Hai, Lower West Bank (10) Bang Ban, Upper East Bank (21) Nakhon Luang and Lower East Bank (24) Khlong Dan.

From the above figures, a standard to be set up to guarantee the irrigation water supply would be some 50%. A study made to evaluate the current status of water shortage, in terms of additional amount of water supply to guarantee the minimum level of cropping intensity, has revealed that about 1,800 MCM of dry season water would be in short at present to achieve a standard level of cropping intensity in the Chao Phraya delta.

5.4.4 Projection of Irrigation Water Demand

(1) Special Considerations to be Involved for Water Demand Projection

Projection of water demand for irrigation involves several important issues which affect the direction of agriculture and in turn estimation of water demand in future and hence need careful consideration. Such important issues include 1) need of dry season rice to support national economy of Thailand, 2) need of water supply in the delta especially for conservation area to prevent the area from salt intrusion, and 3) appropriated upper limit of crop diversification.

Necessity of Dry Season Rice Cropping in the Delta

Table 5.4.13 Supply and Demand Balance of Rice in Thailand

Items	Region				Country Total
	Central	North-East	North	South	
1. Population (1,000)	18,923	20,383	11,748	7,540	58,595
2. Rice Consumption (1,000 ton)					
Per Capita (kg/person/year)	101	162	143	109	131
Total Consumption	1,909	3,297	1,678	820	7,704
-do- (Paddy) (0.66)	2,892	4,996	2,542	1,242	11,672
3. Paddy Production (1,000 ton)					
Wet Season Paddy	3,844	7,835	4,453	883	17,016
Dry Season Paddy	1,937	169	678	49	2,831
Total	5,781	8,003	5,131	932	19,847
4. Paddy Balance (1,000 ton)	2,889	3,007	2,588	(-)310	8,175
5. Export (1,000 ton)					7,817

Rice production still keeps an important role over the economy of Thailand in terms of national food security and export earnings. The dry season rice of high quality shares a considerable part of rice production for export, and therefore the agricultural development strategy in the 8th 5-Year Plan of National Economic Development, although touching on the decreasing tendency of dry season rice cropping, envisages to maintain 3.0 million rai of dry season rice cropping in the whole country. Cultivation of dry season rice needs inevitably irrigation water supply, and actually about 70% in an ordinary year or more than 75% in a dry year of the national total dry season rice has been produced in the Chao Phraya delta where a large extension of irrigation system exists. In order to secure 3.0 million rai of dry season rice, about 2.1 million rai of farmland under irrigation have to be planted to paddy in dry season in the delta.

Importance of Water Supply in Delta Conservation Area

In order to grasp the importance of irrigation water supply in the conservation area which locates in the lower delta, the past records of irrigation practice in the Chao Phraya delta are summarized in a form shown below;

Table 5.4.14 Past Record of Irrigation Practice (Cropping Intensity in %)

	1991-1996 Average	1994 (Dry Year)
Gravity System (Upper Banks)	31.2	17.7
Conservation Area (Lower Banks)	53.1	52.0

The above figures indicate that, even in a critical dry year such as 1994, similar amount of water as compared with that in an average year has been supplied to the conservation area making a sacrifice of the upper zones. Besides the historical background that the conservation area has been developed much earlier than the upper zones, the above fact explains the importance of water supply throughout a year to the conservation area to prevent the area from intrusion by salt water, as can be learnt also from precepts of destruction of world-famous deltas in recent years due to salt damages. In the Chao Phraya delta in recent years, the overpumping of underground water mainly for industrial purpose has rapidly depleted the aquifer storage and outpaced the replenishment by rain water, as shown in Figure 5.4.3. It would cause a land collapse and soil degradation which would destroy the soil's ability to absorb water. Salinity of soil will be accumulated more and more if supply of fresh water in the delta is suspended inviting a total salt damage of the delta areas.

Sustainable supply of water for irrigation in dry season has thus made a great contribution to prolongation of life of the delta, and at least supply of dry season water at the present level is therefore necessary to avoid this crisis.

Appropriate Limit of Crop Diversification

Crop diversification program has been promoted under the current policy for agricultural development and areas planted to diversified crops have been increasing everywhere in the delta. Diversified crops however require stable supply of irrigation water throughout a year. There is a certain limit of areas for diversified crops from view points of land use, water usage, market demand and agro-industry requirement. Discussions were made with the Department of Agriculture regarding the appropriate upper limit of crop diversification and the possible decrease of irrigable area due to conversion to the other land uses with a conclusion as summarized previously in Table 5.3.3.

Table 5.4.15 Present and Proposed Cropping Areas for Diversified Crops

(Unit: 1,000rai)

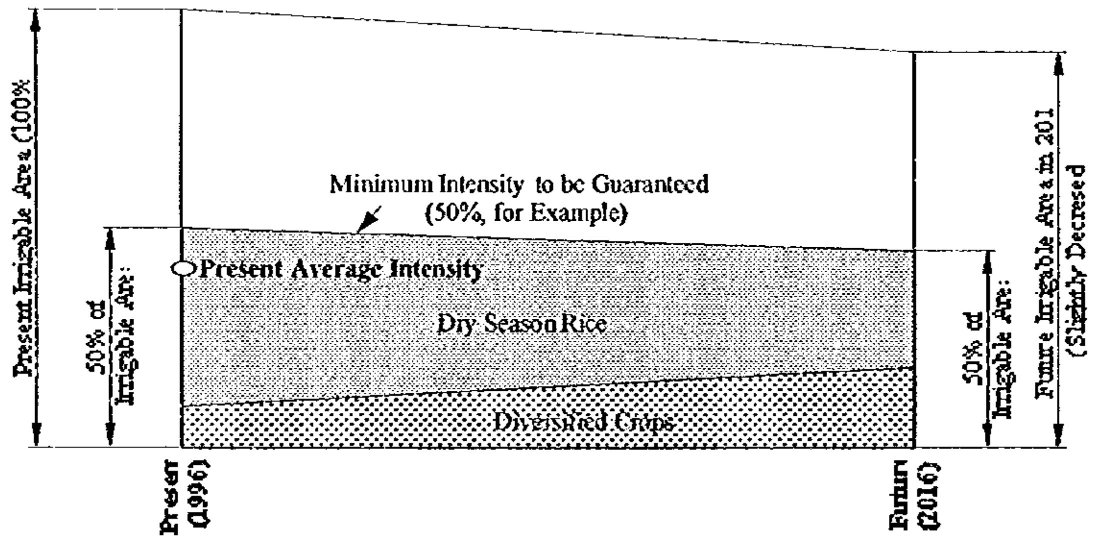
Area	Irrigable Area	Paddy	Sugar Cane	Field Crops	Vege-table	Fruit Trees	Fish Pond	Total
1. Present Conditions								
Delta	7,342.0	2,208.8	175.3	66.9	41.7	323.2	137.1	2,953.0
Lower Nan	1,059.0	491.4	0	25.3	5.1	0	0.4	522.2
Total	8,401.0	2,700.2	175.3	92.2	46.8	323.2	137.5	3,475.2
2. Proposed Condition								
Delta	6,800.0	2,407.2	290.4	181.0	85.2	531.3	190.9	3,686.0
Lower Nan	1,819.6	671.1	0	145.5	27.3	127.4	27.3	998.6
Total	8,619.6	3,078.3	290.4	326.5	112.5	658.7	218.2	4,684.6
3. Change (%)	102.6	114.0	165.7	354.1	240.4	203.8	158.7	134.8

(2) Water Demand Projection

Water demand for dry season irrigation in the project target year of 2016 is estimated in conformity with 1) probable decrease of irrigable area, 2) guideline to set up a minimum cropping intensity to be guaranteed, 3) potential growth of crop diversification and 4) cropped area for the dry season paddy which is adjustable between the proposed cropped area and area for diversified crops.

A concept for estimation of dry season irrigation water demand is as follows;

Figure 5.4.4 Method for Estimation of Irrigation Water Demand



Because many of the diversified crops consume lesser amount of water than paddy, water demand for irrigation would decrease as the promotion of crop diversification accelerates. Three degrees of crop diversification are thus considered to estimate water demand for irrigation in future.

Table 5.4.16 Three Degrees of Crop Diversification

Promotion of Crop Diversification	Degree of Crop Diversification	Water Consumption
Highly Promoted	120% of figures in Table 5.4.15	Lesser consumption
Normally Promoted	As proposed in Table 5.4.15	Medium consumption
Moderately Promoted	80% of figures in Table 5.4.15	Larger consumption

Water Demand in the Delta

Computation for estimation of water demand for irrigation in the year 2016 is presented in paragraph 5.4 of the Supporting Report. Estimated results for all of the cases are then summarized as given in Tables 5.4.17, 5.4.18 and 5.4.19 respectively for high, normal and moderate promotion cases of crop diversification.

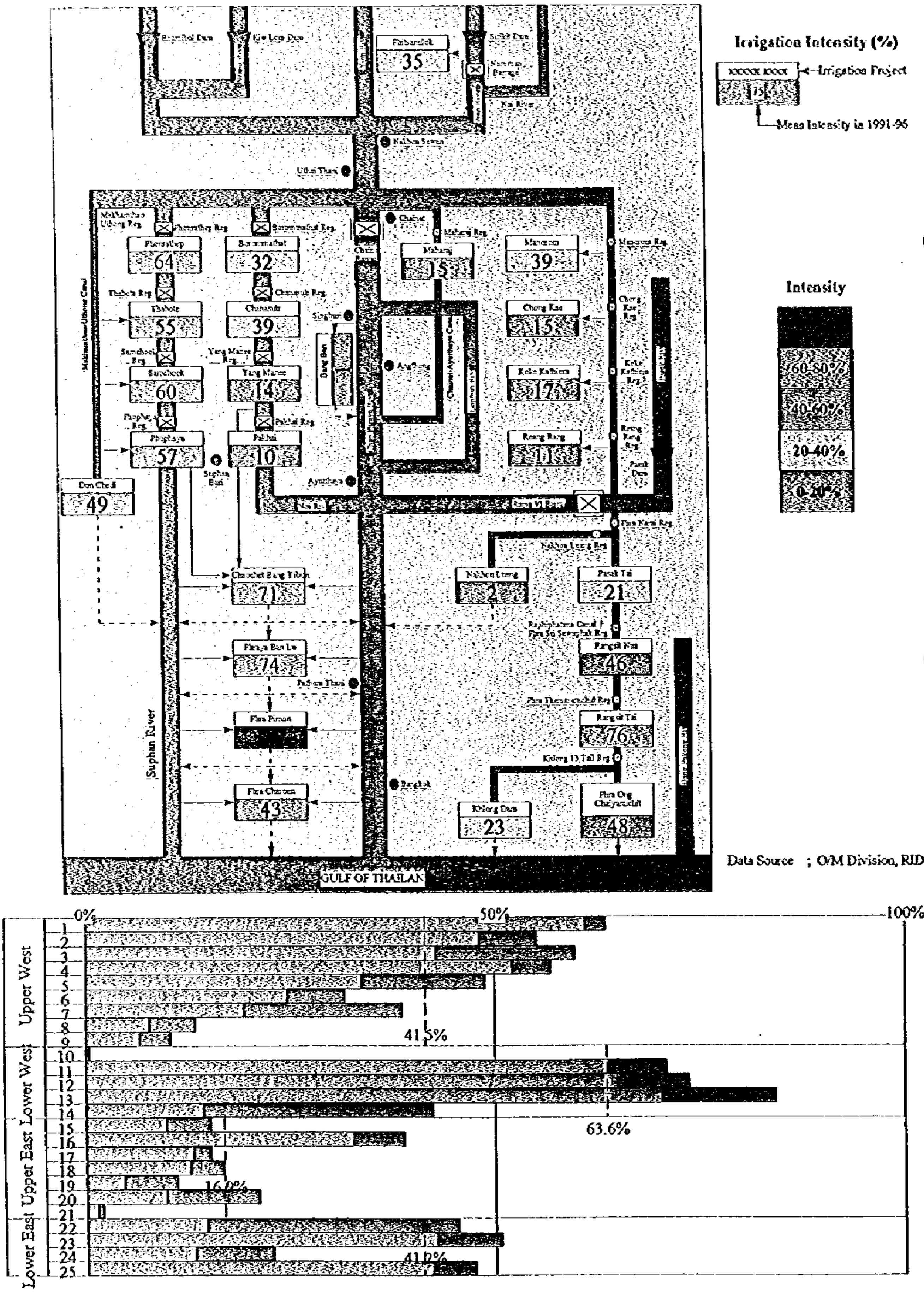
As is visualized in Figure 5.4.5, water demand for irrigation decreases for all cases of computation if the same level of cropping intensity is maintained. This is due to decrease of irrigable area as well as promotion of crop diversification program.

Lower Nan Area

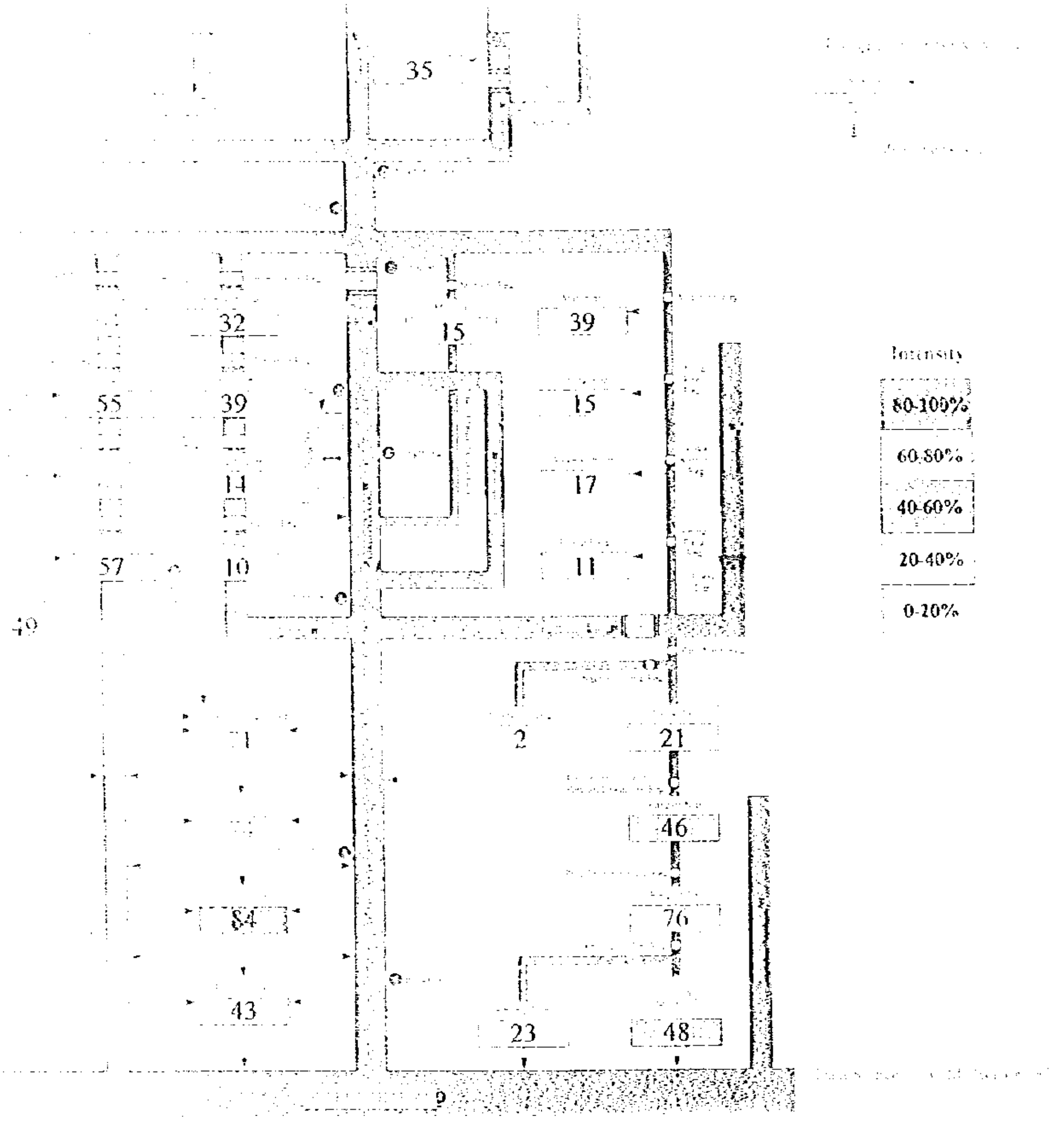
Computed results for the other cases are compiled in the Supporting Report. Estimated results for all of the cases are then summarized as given in Table 5.4.20 covering all of high, normal and moderate promotion cases of crop diversification.

Water demand for the system expansion area consisting of 500,000 rai for the Phitsanulok Stage 2 area and 200,000 rai for pump irrigation area is also considered in the estimation as shown in Table 5.4.21.

Figure 5.4.2 Dry Season Cropping Intensity in 25 Irrigation Projects in the Delta



Data Source ; O/M Division, RID


35
32
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39
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49
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84
76
43
23
48
Intensity
80-100%
60-80%
40-60%
20-40%
0-20%

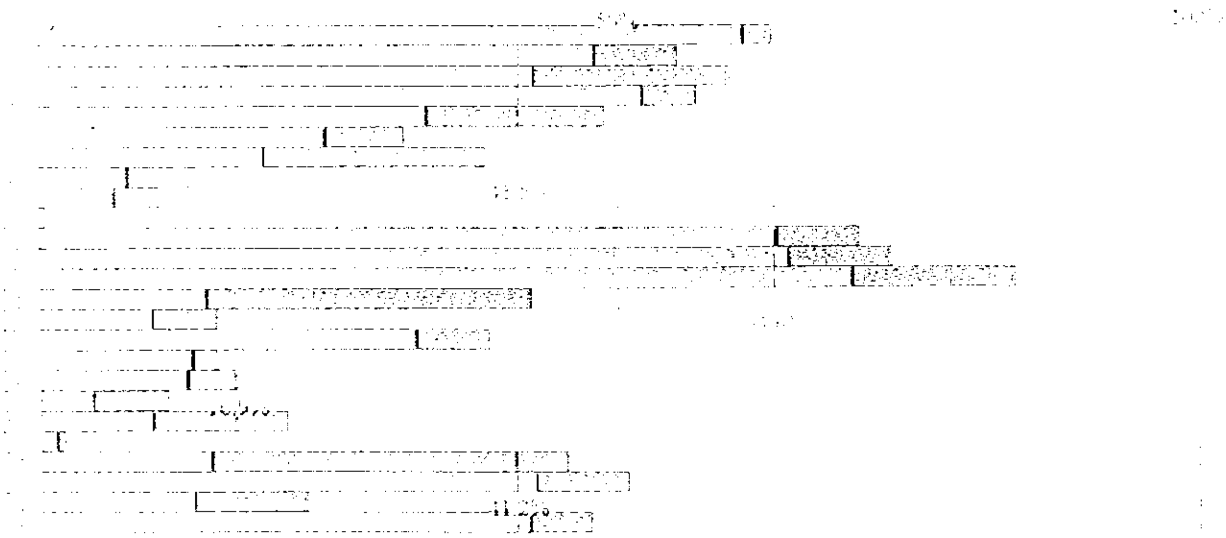
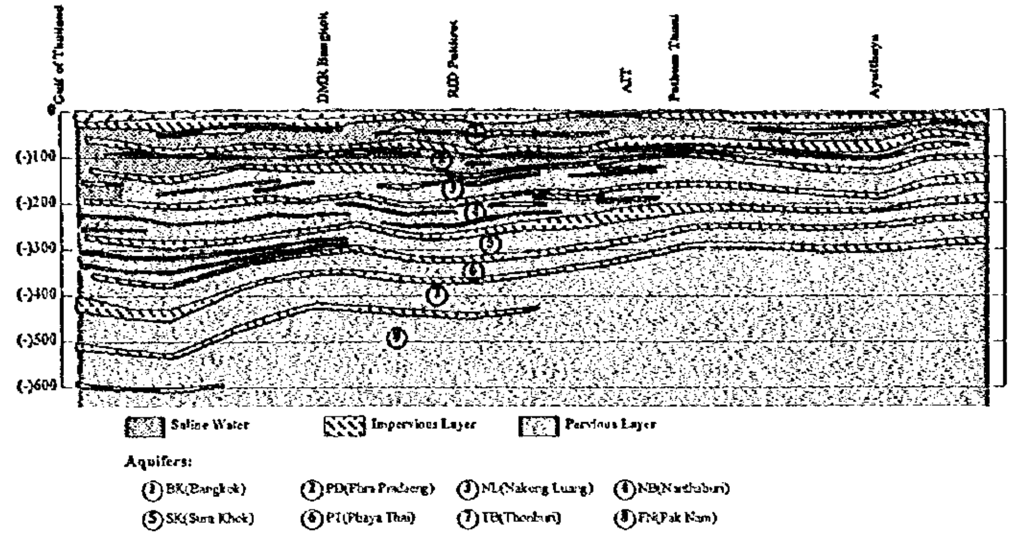


Figure 5.4.3 Current Situation of Saninity Intrusion into Groundwater Aquifer



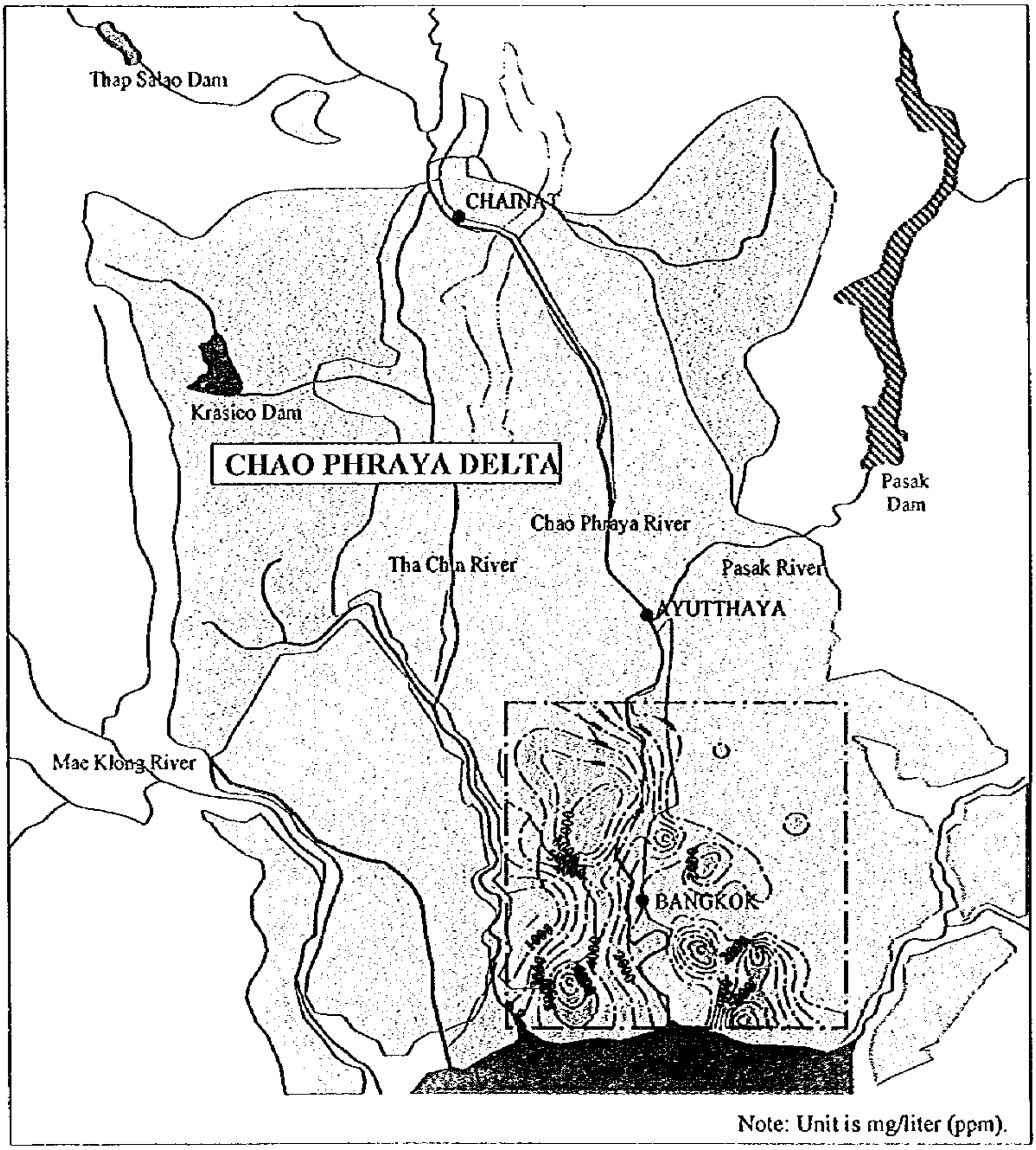


Figure 5.4.3 **Current Situation of Saninity Intrusion into Groundwater Aquifer**

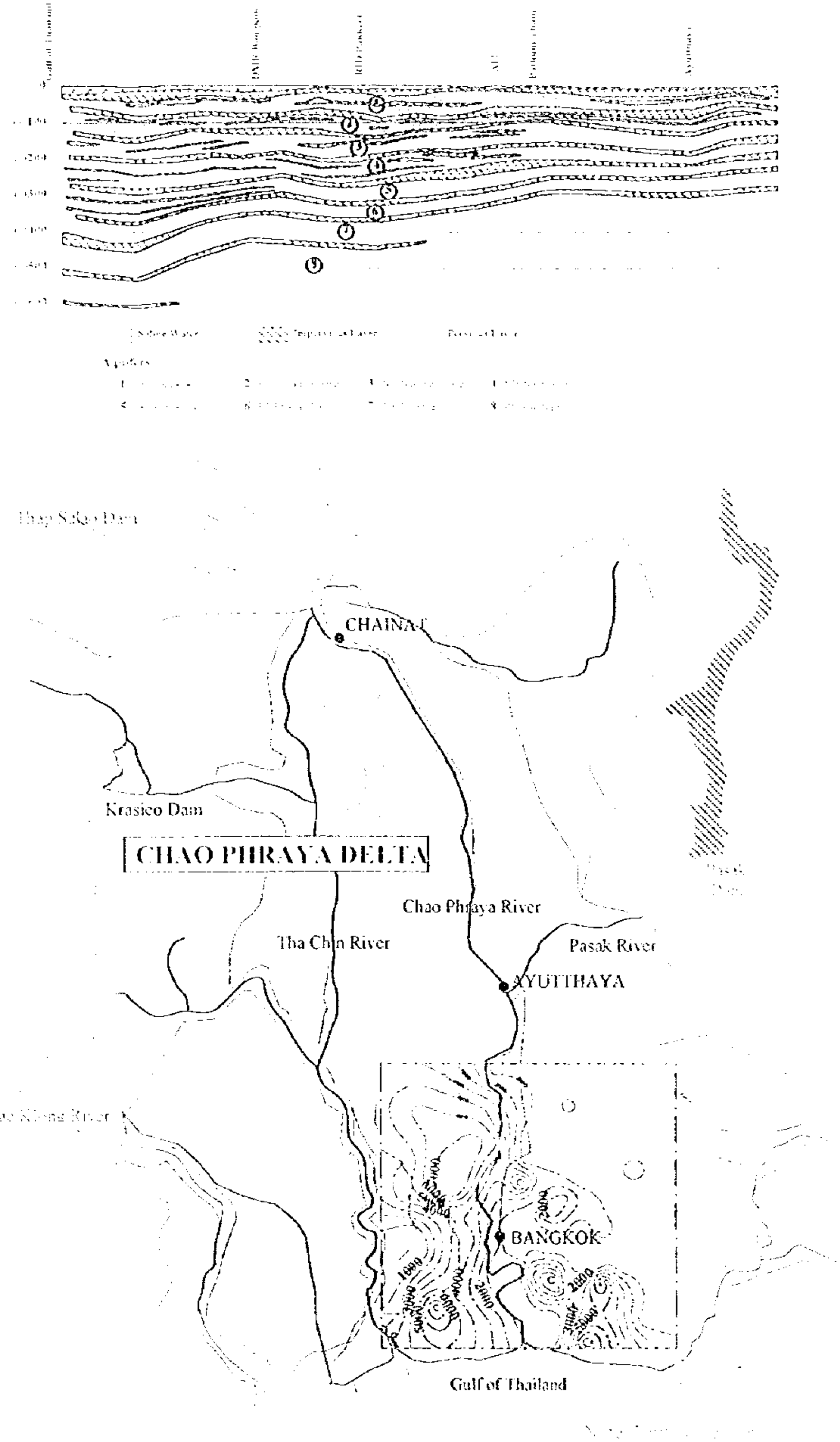


Figure 5.4.5 Irrigation Water Demand for Various Cases of Minimum Cropping Intensity to be Guaranteed (Chao Phraya Delta)

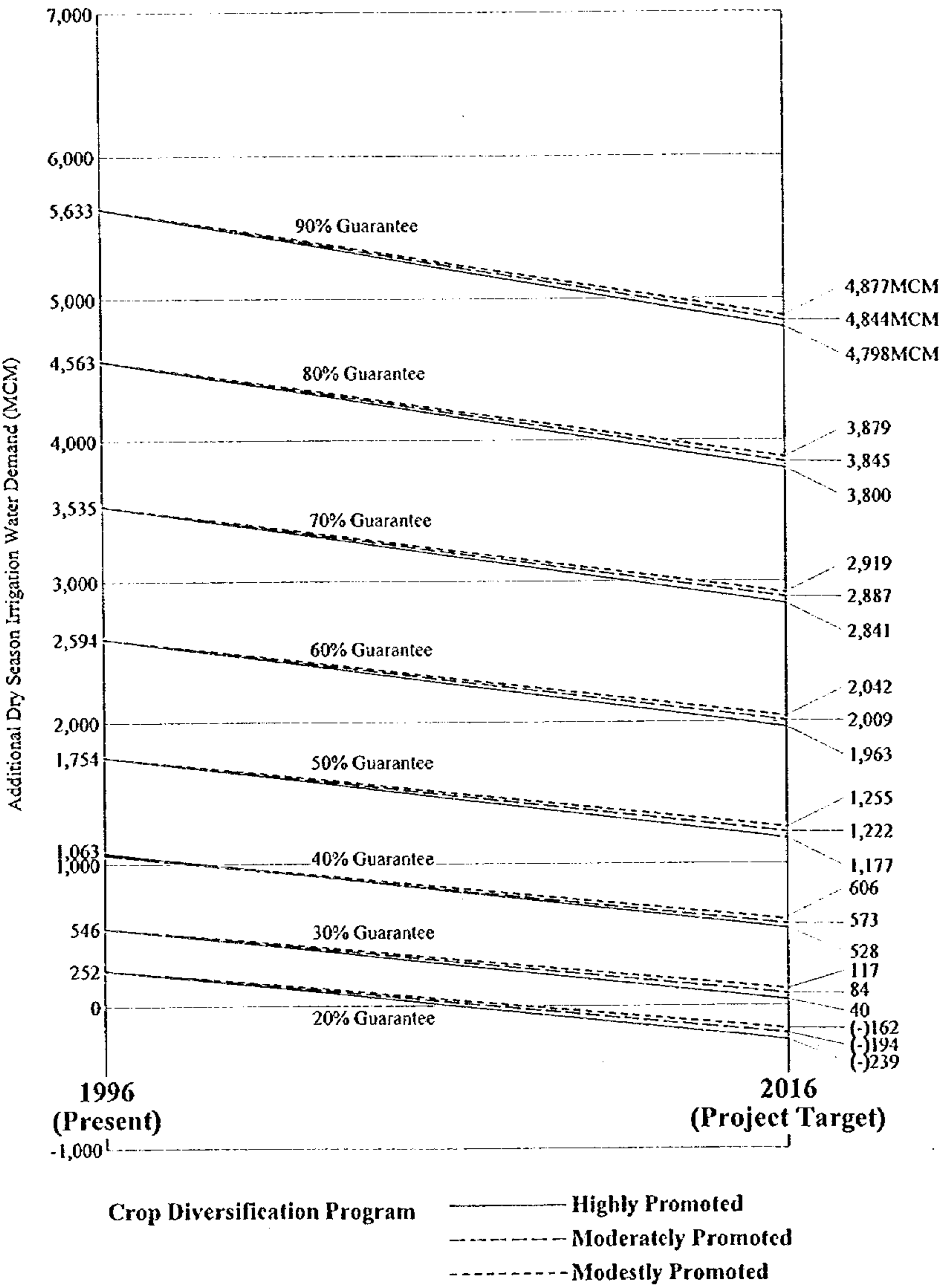


Table 5.4.7 Present Demand and Shortage of Water for Dry Season Irrigation in the Chao Phraya Delta

		Unit	West Bank			East Bank			Delta
			Upper	Lower	Total	Upper	Lower	Total	Total
1. Present Achievement of Irrigation Practice									
Irrigable Area		rai	2,299,000	1,447,000	3,746,000	1,657,000	1,939,000	3,596,000	7,342,000
Average Cropping Intensity		%	41.5	63.6	50.0	16.9	41.2	30.0	40.2
Average Amount of Water Used		MCM	1,662	934	2,596	489	832	1,321	3,917
2. Demand and Shortage of Water with a Minimum Cropping Intensity									
20%	Average Intensity	%	41.5	63.6	50.0	25.1	41.2	33.8	42.1
	Water Demand	MCM	1,662	934	2,596	741	832	1,573	4,169
	Shortage	MCM	0	0	0	252	0	252	252
30%	Average Intensity	%	42.4	63.6	50.6	33.4	41.2	37.6	44.2
	Water Demand	MCM	1,700	934	2,634	997	832	1,829	4,463
	Shortage	MCM	38	0	38	508	0	508	546
40%	Average Intensity	%	48.1	63.6	54.1	41.8	42.1	42.0	48.1
	Water Demand	MCM	1,942	934	2,876	1,252	851	2,103	4,979
	Shortage	MCM	281	0	281	763	19	782	1,063
50%	Average Intensity	%	54.8	63.6	58.2	50.1	50.0	50.0	54.2
	Water Demand	MCM	2,226	934	3,160	1,507	1003	2,510	5,670
	Shortage	MCM	564	0	564	1,019	171	1,190	1,754
60%	Average Intensity	%	62.7	64.1	63.2	60.0	60.0	60.0	61.7
	Water Demand	MCM	2,561	942	3,503	1,811	1,197	3,008	6,511
	Shortage	MCM	899	8	907	1,322	365	1,687	2,594
70%	Average Intensity	%	71.0	70.0	70.6	70.0	70.0	70.0	70.3
	Water Demand	MCM	2,915	1,027	3,942	2,117	1,391	3,508	7,450
	Shortage	MCM	1,254	93	1,347	1,629	559	2,188	3,535
80%	Average Intensity	%	80.0	80.0	80.0	80.0	80.0	80.0	80.0
	Water Demand	MCM	3,298	1,172	4,470	2,424	1,585	4,009	8,479
	Shortage	MCM	1,637	238	1,875	1,935	753	2,688	4,563
90%	Average Intensity	%	90.0	90.0	90.0	90.0	90.0	90.0	90.0
	Water Demand	MCM	3,724	1,316	5,040	2,731	1,779	4,510	9,550
	Shortage	MCM	2,062	382	2,444	2,242	947	3,189	5,633

WaterDemandSumModi.xls

Table 5.4.9 Present Demand and Shortage of Water for Dry Season Irrigation in the Lower Nan Basin

(Existing System)

		Unit	Lower Nan Basin (Existing System)		
			Phitsanulok, Stage 1	DEDP Pump Project	Total
1. Present Achievement of Irrigation Practice					
	Irrigable Area	rai	667,100	392,000	1,059,100
	Average Cropping Intensity	%	60.6	50.0	56.7
	Average Amount of Water Used	MCM	737	356	1,093
2. Demand and Shortage of Water with a Minimum Cropping Intensity					
20%	Average Intensity	%	60.6	50.0	56.7
	Water Demand	MCM	737	356	1,093
	Shortage	MCM	0	0	0
30%	Average Intensity	%	60.6	50.0	56.7
	Water Demand	MCM	737	356	1,093
	Shortage	MCM	0	0	0
40%	Average Intensity	%	60.7	50.0	56.7
	Water Demand	MCM	738	356	1,094
	Shortage	MCM	1	0	1
50%	Average Intensity	%	64.0	50.0	58.8
	Water Demand	MCM	778	356	1,134
	Shortage	MCM	41	0	41
60%	Average Intensity	%	68.0	60.0	65.0
	Water Demand	MCM	827	429	1,256
	Shortage	MCM	90	73	163
70%	Average Intensity	%	73.5	70.0	72.2
	Water Demand	MCM	896	501	1,397
	Shortage	MCM	159	145	304
80%	Average Intensity	%	80.8	80.0	80.5
	Water Demand	MCM	986	574	1,560
	Shortage	MCM	249	218	467
90%	Average Intensity	%	90.0	90.0	90.0
	Water Demand	MCM	1,099	646	1,746
	Shortage	MCM	362	290	652

WaterDemandSumModi.xls,ExstLowNan

Table 5.4.17 Water Demand and Additional Supply for Dry Season Irrigation in the Delta (Highly Promoted)

		Unit	West Bank			East Bank			Delta
			Upper	Lower	Total	Upper	Lower	Total	Total
20%	Average Intensity	%	41.5	63.6	49.8	25.1	41.2	33.6	41.9
	Water Demand	MCM	1,450	844	2,294	619	764	1,383	3,677
	Shortage	MCM	-211	-90	-301	130	-68	62	-239
30%	Average Intensity	%	42.4	63.6	50.3	33.4	41.2	37.5	44.1
	Water Demand	MCM	1,486	844	2,330	861	764	1,625	3,955
	Shortage	MCM	-175	-90	-265	373	-68	305	40
40%	Average Intensity	%	48.1	63.6	53.9	41.8	42.1	42.0	48.1
	Water Demand	MCM	1,717	844	2,561	1,103	781	1,884	4,445
	Shortage	MCM	55	-90	-35	615	-52	563	528
50%	Average Intensity	%	54.8	63.6	58.1	50.1	50.0	50.0	54.2
	Water Demand	MCM	1,985	844	2,829	1,345	918	2,263	5,092
	Shortage	MCM	324	-90	234	857	86	943	1177
60%	Average Intensity	%	62.7	64.1	63.2	60.0	60.0	60.0	61.6
	Water Demand	MCM	2,303	851	3,154	1,633	1,093	2,726	5,880
	Shortage	MCM	641	-83	558	1,144	261	1405	1963
70%	Average Intensity	%	71.0	70.0	70.6	70.0	70.0	70.0	70.3
	Water Demand	MCM	2,639	927	3,566	1,923	1,268	3,191	6,757
	Shortage	MCM	977	-7	970	1,435	436	1871	2841
80%	Average Intensity	%	80.0	80.0	80.0	80.0	80.0	80.0	80.0
	Water Demand	MCM	3,002	1,057	4,059	2,214	1,443	3,657	7,716
	Shortage	MCM	1,341	123	1464	1,725	611	2336	3800
90%	Average Intensity	%	90.0	90.0	90.0	90.0	90.0	90.0	90.0
	Water Demand	MCM	3,406	1,187	4,593	2,504	1,618	4,122	8,715
	Shortage	MCM	1,744	253	1997	2,015	786	2801	4798

WaterDemandSumModi.xls,SumHighDelta

Table 5.4.18 Water Demand and Additional Supply for Dry Season Irrigation in the Delta (Moderately Promoted)

		Unit	West Bank			East Bank			Delta Total
			Upper	Lower	Total	Upper	Lower	Total	
20%	Average Intensity	%	41.5	63.6	49.8	25.1	41.2	33.6	41.9
	Water Demand	MCM	1,488	841	2,329	638	757	1,395	3,724
	Shortage	MCM	-174	-93	-267	149	-76	73	-194
30%	Average Intensity	%	42.4	63.6	50.3	33.4	41.2	37.5	44.1
	Water Demand	MCM	1,524	841	2,365	880	757	1,637	4,002
	Shortage	MCM	-138	-93	-231	391	-76	315	84
40%	Average Intensity	%	48.1	63.6	53.9	41.8	42.1	42.0	48.1
	Water Demand	MCM	1,754	841	2,595	1,122	773	1,895	4,490
	Shortage	MCM	92	-93	-1	633	-59	574	573
50%	Average Intensity	%	54.8	63.6	58.1	50.1	50.0	50.0	54.2
	Water Demand	MCM	2,023	841	2,864	1,364	911	2,275	5,139
	Shortage	MCM	361	-93	268	875	79	954	1222
60%	Average Intensity	%	62.7	64.1	63.2	60.0	60.0	60.0	61.6
	Water Demand	MCM	2,340	848	3,188	1,651	1,086	2,737	5,925
	Shortage	MCM	679	-86	593	1,162	254	1416	2009
70%	Average Intensity	%	71.0	70.0	70.6	70.0	70.0	70.0	70.3
	Water Demand	MCM	2,676	924	3,600	1,942	1,261	3,203	6,803
	Shortage	MCM	1,015	-10	1005	1,453	429	1882	2887
80%	Average Intensity	%	80.0	80.0	80.0	80.0	80.0	80.0	80.0
	Water Demand	MCM	3,040	1,054	4,094	2,232	1,436	3,668	7,762
	Shortage	MCM	1,378	120	1498	1,743	604	2347	3845
90%	Average Intensity	%	90.0	90.0	90.0	90.0	90.0	90.0	90.0
	Water Demand	MCM	3,443	1,184	4,627	2,522	1,611	4,133	8,760
	Shortage	MCM	1,781	250	2031	2,034	779	2813	4844

WaterDemandSumModi.xls,SumHighDelta

Table 5.4.19 Water Demand and Additional Supply for Dry Season Irrigation in the Delta (Modestly Promoted)

		Unit	West Bank			East Bank			Delta
			Upper	Lower	Total	Upper	Lower	Total	Total
20%	Average Intensity	%	41.5	63.6	49.8	25.1	41.2	33.6	41.9
	Water Demand	MCM	1,512	838	2,350	656	749	1,405	3,755
	Shortage	MCM	-150	-96	-246	167	-83	84	-162
30%	Average Intensity	%	42.4	63.6	50.3	33.4	41.2	37.5	44.1
	Water Demand	MCM	1,548	838	2,386	898	749	1,647	4,033
	Shortage	MCM	-113	-96	-209	409	-83	326	117
40%	Average Intensity	%	48.1	63.6	53.9	41.8	42.1	42.0	48.1
	Water Demand	MCM	1,778	838	2,616	1,140	766	1,906	4,522
	Shortage	MCM	117	-96	21	651	-66	585	606
50%	Average Intensity	%	54.8	63.6	58.1	50.1	50.0	50.0	54.2
	Water Demand	MCM	2,047	838	2,885	1,382	903	2,285	5,170
	Shortage	MCM	386	-96	290	893	72	965	1255
60%	Average Intensity	%	62.7	64.1	63.2	60.0	60.0	60.0	61.6
	Water Demand	MCM	2,365	845	3,210	1,670	1,079	2,749	5,959
	Shortage	MCM	703	-89	614	1,181	247	1428	2042
70%	Average Intensity	%	71.0	70.0	70.6	70.0	70.0	70.0	70.3
	Water Demand	MCM	2,701	921	3,622	1,960	1,254	3,214	6,836
	Shortage	MCM	1,039	-13	1026	1,471	422	1893	2919
80%	Average Intensity	%	80.0	80.0	80.0	80.0	80.0	80.0	80.0
	Water Demand	MCM	3,064	1,051	4,115	2,250	1,429	3,679	7,794
	Shortage	MCM	1,403	117	1520	1,762	597	2359	3879
90%	Average Intensity	%	90.0	90.0	90.0	90.0	90.0	90.0	90.0
	Water Demand	MCM	3,468	1,181	4,649	2,541	1,604	4,145	8,794
	Shortage	MCM	1,806	247	2053	2,052	772	2824	4877

WaterDemandSumModi.xls,SumHighDelta

Table 5.4.20(1) Water Demand and Additional Supply for Dry Season Irrigation in the Lower Nan Basin (Existing System) (1/2)

(Crop Diversification Highly Promoted Case)

		Unit	Lower Nan Basin (Existing System)		
			Phitsanulok, Stage 1	DEDP Pump Project	Total
20%	Average Intensity	%	60.6	50.0	56.0
	Water Demand	MCM	673	421	1,094
	Shortage	MCM	-64	65	1
30%	Average Intensity	%	60.6	50.0	56.0
	Water Demand	MCM	673	421	1,094
	Shortage	MCM	-64	65	1
40%	Average Intensity	%	60.7	50.0	56.1
	Water Demand	MCM	673	421	1,094
	Shortage	MCM	-64	65	1
50%	Average Intensity	%	64.0	50.0	57.9
	Water Demand	MCM	712	421	1,133
	Shortage	MCM	-25	65	40
60%	Average Intensity	%	68.0	60.0	64.5
	Water Demand	MCM	759	511	1,270
	Shortage	MCM	22	154	176
70%	Average Intensity	%	73.5	70.0	72.0
	Water Demand	MCM	824	600	1,424
	Shortage	MCM	87	244	331
80%	Average Intensity	%	80.8	80.0	80.5
	Water Demand	MCM	909	690	1,599
	Shortage	MCM	172	334	506
90%	Average Intensity	%	90.0	90.0	90.0
	Water Demand	MCM	1,017	780	1,797
	Shortage	MCM	280	424	704

(Crop Diversification Moderately Promoted Case)

		Unit	Lower Nan Basin (Existing System)		
			Phitsanulok, Stage 1	DEDP Pump Project	Total
20%	Average Intensity	%	60.6	50.0	56.0
	Water Demand	MCM	679	425	1,104
	Shortage	MCM	-58	69	11
30%	Average Intensity	%	60.6	50.0	56.0
	Water Demand	MCM	679	425	1,104
	Shortage	MCM	-58	69	11
40%	Average Intensity	%	60.7	50.0	56.1
	Water Demand	MCM	680	425	1,105
	Shortage	MCM	-57	69	12
50%	Average Intensity	%	64.0	50.0	57.9
	Water Demand	MCM	718	425	1,143
	Shortage	MCM	-19	69	50
60%	Average Intensity	%	68.0	60.0	64.5
	Water Demand	MCM	765	515	1,280
	Shortage	MCM	28	159	187
70%	Average Intensity	%	73.5	70.0	72.0
	Water Demand	MCM	830	605	1,435
	Shortage	MCM	94	249	343
80%	Average Intensity	%	80.8	80.0	80.5
	Water Demand	MCM	916	695	1,611
	Shortage	MCM	179	339	518
90%	Average Intensity	%	90.0	90.0	90.0
	Water Demand	MCM	1,024	785	1,809
	Shortage	MCM	287	429	716

Table 5.4.20(2) Water Demand and Additional Supply for Dry Season Irrigation in the Lower Nan Basin (Existing System) (2/2)

(Crop Diversification Modestly Promoted Case)

		Unit	Lower Nan Basin (Existing System)		
			Phitsanulok, Stage 1	DEDP Pump Project	Total
20%	Average Intensity	%	60.6	50.0	56.0
	Water Demand	MCM	686	430	1,116
	Shortage	MCM	-51	74	23
30%	Average Intensity	%	60.6	50.0	56.0
	Water Demand	MCM	686	430	1,116
	Shortage	MCM	-51	74	23
40%	Average Intensity	%	60.7	50.0	56.1
	Water Demand	MCM	686	430	1,116
	Shortage	MCM	-51	74	23
50%	Average Intensity	%	64.0	50.0	57.9
	Water Demand	MCM	725	430	1,155
	Shortage	MCM	-12	74	62
60%	Average Intensity	%	68.0	60.0	64.5
	Water Demand	MCM	772	520	1,292
	Shortage	MCM	35	164	199
70%	Average Intensity	%	73.5	70.0	72.0
	Water Demand	MCM	837	612	1,449
	Shortage	MCM	100	256	356
80%	Average Intensity	%	80.8	80.0	80.5
	Water Demand	MCM	922	701	1,623
	Shortage	MCM	185	344	529
90%	Average Intensity	%	90.0	90.0	90.0
	Water Demand	MCM	1,030	789	1,819
	Shortage	MCM	293	433	726

WaterDemandSumModi.xls,SumProjNan

Table 5.4.21(1) Water Demand and Additional Supply for Dry Season Irrigation in the Lower Nan Basin (Expanded System) (1/2)

(Crop Diversification Highly Promoted Case)

		Unit	Lower Nan Basin (Expanded System)		
			Phitsanulok, Stage 2	DEDP Pump Project	Total
20%	Average Intensity	%	20.0	20.0	20.0
	Water Demand	MCM	155	61	216
	Shortage	MCM	155	61	216
30%	Average Intensity	%	30.0	30.0	30.0
	Water Demand	MCM	247	98	345
	Shortage	MCM	247	98	345
40%	Average Intensity	%	40.0	40.0	40.0
	Water Demand	MCM	340	135	475
	Shortage	MCM	340	135	475
50%	Average Intensity	%	50.0	50.0	50.0
	Water Demand	MCM	432	172	604
	Shortage	MCM	432	172	604
60%	Average Intensity	%	60.0	60.0	60.0
	Water Demand	MCM	525	209	734
	Shortage	MCM	525	209	734
70%	Average Intensity	%	70.0	70.0	70.0
	Water Demand	MCM	617	246	863
	Shortage	MCM	617	246	863
80%	Average Intensity	%	80.0	80.0	80.0
	Water Demand	MCM	709	283	992
	Shortage	MCM	709	283	992
90%	Average Intensity	%	90.0	90.0	90.0
	Water Demand	MCM	802	320	1,122
	Shortage	MCM	802	320	1,122

(Crop Diversification Moderately Promoted Case)

		Unit	Lower Nan Basin (Expanded Sysrem)		
			Phitsanulok, Stage 2	DEDP Pump Project	Total
20%	Average Intensity	%	20.0	20.0	20.0
	Water Demand	MCM	160	63	223
	Shortage	MCM	160	63	223
30%	Average Intensity	%	30.0	30.0	30.0
	Water Demand	MCM	252	100	352
	Shortage	MCM	252	100	352
40%	Average Intensity	%	40.0	40.0	40.0
	Water Demand	MCM	345	137	482
	Shortage	MCM	345	137	482
50%	Average Intensity	%	50.0	50.0	50.0
	Water Demand	MCM	437	174	611
	Shortage	MCM	437	174	611
60%	Average Intensity	%	60.0	60.0	60.0
	Water Demand	MCM	530	211	741
	Shortage	MCM	530	211	741
70%	Average Intensity	%	70.0	70.0	70.0
	Water Demand	MCM	622	248	870
	Shortage	MCM	622	248	870
80%	Average Intensity	%	80.0	80.0	80.0
	Water Demand	MCM	715	285	1,000
	Shortage	MCM	715	285	1,000
90%	Average Intensity	%	90.0	90.0	90.0
	Water Demand	MCM	807	322	1,129
	Shortage	MCM	807	322	1,129

Table 5.4.21(2) Water Demand and Additional Supply for Dry Season Irrigation in the Lower Nan Basin (Expanded System) (2/2)

(Crop Diversification Modestly Promoted Case)

		Unit	Lower Nan Basin (Expanded System)		
			Phitsanulok, Stage 2	DEDP Pump Project	Total
20%	Average Intensity	%	20.0	20.0	20.0
	Water Demand	MCM	165	65	230
	Shortage	MCM	165	65	230
30%	Average Intensity	%	30.0	30.0	30.0
	Water Demand	MCM	257	102	359
	Shortage	MCM	257	102	359
40%	Average Intensity	%	40.0	103.0	58.0
	Water Demand	MCM	350	139	489
	Shortage	MCM	350	139	489
50%	Average Intensity	%	50.0	50.0	50.0
	Water Demand	MCM	442	176	618
	Shortage	MCM	442	176	618
60%	Average Intensity	%	60.0	60.0	60.0
	Water Demand	MCM	535	213	748
	Shortage	MCM	535	213	748
70%	Average Intensity	%	70.0	70.0	70.0
	Water Demand	MCM	627	250	877
	Shortage	MCM	627	250	877
80%	Average Intensity	%	80.0	80.0	80.0
	Water Demand	MCM	720	287	1,007
	Shortage	MCM	720	287	1,007
90%	Average Intensity	%	90.0	90.0	90.0
	Water Demand	MCM	812	324	1,136
	Shortage	MCM	812	324	1,136

WaterDemandSumModi.xls,SumProjNan

5.5 Projection of Water Demand for Non-Irrigation Sectors

In general, informations given for projection of water demand for non-irrigation sectors as compiled in the CPBWMS report are applied in order to maintain the consistency of development.

5.3.1 Domestic Water demand

Estimation of domestic demand is based on the analysis of population together with the estimated per capita water consumption.

Table 5.5.1 Population Projection (1,000 person)

Area	1996	2006	2016
Lower Chao Phraya including 1013 District	12,778	14,860	17,408

Table 5.5.2 Per Capita Domestic Consumption (liter/person/day)

District	1996	2006	2016
- Bangkok and Muang Districts in 5 Neighborhood Provinces of Bangkok	250	300	325
- Other Districts in 5 Neighborhood Provinces of Bangkok	200	250	275
- Muang Districts of Other Provinces	150	200	250
- Other Districts	100	150	200

Total domestic water demand is computed by multiplying the population number with the per capita water consumption. To split current estimated demand between surface and groundwater sources, data collected from PWA, MWA and DMR were used.

Table 5.5.3 Domestic Surface Water Demand (MCM/Year)

Area	1996	2006	2016
Lower Chao Phraya including 1013 District	712.1	1,120.2	1,545.8

The abstraction requirement is usually greater than the above figures representing consumer demand due to losses in the transmission and distribution systems. For surface water, current combined efficiency was taken to be rising from 50% to 65% by the year 2016.

Table 5.5.4 Combined Efficiency of Water Transmission and Distribution

	1996	2026
Efficiency	50%	65%

The result of applying these efficiencies gives the abstraction requirements for surface water as summarized below;

Table 5.5.5 Domestic Surface Water Abstraction Requirement (MCM/Year)

Area	1996	2006	2016
Lower Chao Phraya including 1013 District	1,424.2	2,036.6	2,576.3

5.5.2 Industrial Water Demand

Same procedures were taken to estimate water requirement for industrial uses including industry and heavy commercial uses such as depots, warehouses etc.

Table 5.5.6 Industrial Surface Water Demand (MCM/Year)

Area	1996	2006	2016
Lower Chao Phraya including 1013 District	178.2	367.8	650.7

Table 5.5.7 Combined Efficiency of Water Transmission and Distribution

	1996	2016
Efficiency	60%	70%

Table 5.5.8 Industrial Surface Water Abstraction Requirement (MCM/Year)

Area	1996	2006	2016
Lower Chao Phraya including 1013 District	297.0	567.3	929.6

5.5.3 Livestock Water Demand

Estimation of water demand for livestock is achieved by determining representative numbers of the most common livestock and multiplying these figures by approximate per capita consumption. Livestock numbers were obtained from statistics published by the Department of Livestock Development. Recent statistics confirm that numbers of most livestock are rising over the long term. Approximate numbers of livestock in the Chao Phraya basin in 1996 together with recent growth rates (annual percentage increase) were estimated as under;

Table 5.5.9 Number of Livestock and Recent Growth

Livestock	Number in 1996	Growth per Annum
Buffalo and Cattle	2,618,000	0.8%
Pigs	2,032,000	2.7%
Chickens and Ducks	52,955,000	5.0%

Per capita animal water consumption in terms of litres/head/day used in the estimate was taken from the Agricultural Compendium for Rural Development in the Tropics and Sub-tropics using the higher end of any ranges of figures given.

Table 5.5.10 Per Capita Water Consumption of Common Livestock

Livestock	Consumption (liter/Head/Day)
Buffalo and Cattle	40
Pigs	6
Chickens and Ducks	0.3

Table 5.5.11 Water Demand for Livestock

Area	1996	2006	2016
Lower Chao Phraya including 1013 District	18.31	21.82	26.71

5.5.4 Total Water Demand for Non-Irrigation Sectors

Total surface water abstraction for the normal case of water demand for non-irrigation sectors including domestic, industrial and livestock uses is summarized as follows;

Table 5.5.12 Normal Projection of Water Demand for Non-Irrigation Sectors (MCM)

Description	1996	2006	2016
1. Annual Demand			
Domestic	1,424.2	2,036.6	2,576.3
Industrial	297.0	567.3	927.6
Livestock	18.31	21.82	21.82
Total	1,739.51	2,625.72	3,532.61
2. Monthly Demand	144.96	218.81	294.38
3. Subtraction for 1013 District	-7.98	-13.54	-19.98
4. Monthly Demand Modified	136.98	205.27	274.40
5. Dry Season Demand	821.9	1,231.6	1,646.4

The above figures are further divided into zone-wise values;

Table 5.5.13 Non-Irrigation Water Demand in Zone (Normal Projection)

Zone	1996	2006	2016
Upper Chainat Area	5.94	7.56	9.60
Upper West Bank	13.38	16.98	21.84
Lower West Bank	531.48	793.50	1,055.70
Upper East bank	16.02	21.78	28.68
Lower East Bank	255.06	391.80	530.58
Total	821.88 (100%)	1,231.62 (150%)	1,646.40 (200%)
Increase	0	409.74	824.52

The above normal case of projection for non-irrigation sectors allows for 200% of water demand increase by the year 2016 mainly due to increase of population and per capita water consumption. Domestic and industrial sectors may have a priority to use water before irrigation, however, even so they have to aim to save water in order to cope with water shortage crisis that may occur more frequently in future.

A careful consideration should be paid for the recent depletion of underground water in the delta. According to the data from the Department of Mineral Resources, at present about 2.5 MCM/day of water has been abstracted from the groundwater aquifers. Natural water recharge can cover only 1.6 MCM of them, and accordingly 0.9 MCM/day of water, equivalent to 328.5 MCM per annum of water, has been lost from underground water resources. Water users without registration are not included in the record, and therefore actual water abstraction may be much more than officially announced. Assuming that the official records catch about 80% of the underground water users, actual consumption of underground water is estimated at 3.125 MCM (2.5 MCM /0.8=3.125 MCM). Artificial recharge of about 280 MCM/dry season may be required in order to maintain the current situation of the delta (3.125 MCM/day - 1.6 MCM/day x 365 days divided by 2, dry season only = 278 MCM).

In due consideration of the above, the study intends to establish a further "low growth" variant to future water use not allowing a rapid increase of per capita water consumption as predicted in the normal forecast for water demand. Under the assumption that necessary countermeasure would be taken to keep per capita consumption of domestic water at the current level and also to save water for industrial use, the future water demand for non-irrigation sector could be reduced to 85% of the normal forecast values.

As a further "high growth" variant, it is assumed that some of the current level of underground water abstraction in the Bangkok area would be shifted to surface water or additional surface water for artificial recharge of underground water would be required. To cope with this demand, the study concludes to add 278 MCM of water required for recharge of underground water for dry season use.

Table 5.5.14 High and Low Growth Variants of Non-Irrigation Water Demand (MCM)

Variant	Equation	Dry Season Water Use in 2016	
		Water Demand	Additional Demand
High Growth Forecast	Normal Forecast + 278 MCM	1,924.4	1,102.52
Normal Forecast	-	1,646.4	824.52
Low Growth Forecast	Normal Forecast x 85%	1,399.44	577.56

5.6 Overall Water Demand Involving Irrigation and Non-Irrigation Sectors

In order to avoid useless confusion, overall additional water demand for dry season uses involving all of water user sectors is summarized with the following combination of water demands for irrigation sector and non-irrigation sectors;

Table 5.6.1 Combination of Water Demand Scenarios among Sectors

Combination	Irrigation Sector	Non-Irrigation Sector
1	High Promotion of Crop Diversification	Low Growth Case
2	Normal Promotion of Crop Diversification	Normal Growth Case
3	Moderate Promotion of Crop Diversification	High Growth Case

The overall water demands for various cases of the minimum cropping intensity ranging from 20% to 90% are compiled in the following form;

Table 5.6.2 Total Additional Dry Season Water Demand (MCM/Season)

Minimum Cropping Intensity	Combination of Promotion of Crop Diversification Program with Growth Trend of Non-Irrigation Water Demand	Present Shortage of Water	System Expansion (Lower Nan Basin)	
			Excluded	Included
20%	High Promotion + Low Growth Normal Promotion + Normal Growth Moderate Promotion + High Growth	252	340 642 964	556 865 1,194
30%	High Promotion + Low Growth Normal Promotion + Normal Growth Moderate Promotion + High Growth	546	619 920 1,243	964 1,272 1,602
40%	High Promotion + Low Growth Normal Promotion + Normal Growth Moderate Promotion + High Growth	1,064	1,107 1,410 1,732	1,582 1,892 2,221
50%	High Promotion + Low Growth Normal Promotion + Normal Growth Moderate Promotion + High Growth	1,795	1,795 2,097 2,420	2,399 2,708 3,038
60%	High Promotion + Low Growth Normal Promotion + Normal Growth Moderate Promotion + High Growth	2,757	2,717 3,021 3,344	3,451 3,762 4,092
70%	High Promotion + Low Growth Normal Promotion + Normal Growth Moderate Promotion + High Growth	3,839	3,750 4,055 4,378	4,613 4,925 5,255
80%	High Promotion + Low Growth Normal Promotion + Normal Growth Moderate Promotion + High Growth	5,030	4,884 5,188 5,511	5,876 6,188 6,518
90%	High Promotion + Low Growth Normal Promotion + Normal Growth Moderate Promotion + High Growth	6,285	6,080 6,385 6,706	7,202 7,514 7,842

Table 5.6.3(1) Total Water Demand for 20% Minimum Dry Season Intensity Case

Case	Area	1996	2006	2016	Remarks
1. Water Demand for Irrigation in the Existing Beneficial Area					
Highly Promoted Case (1)	Chao Phraya Delta	252		-239	
	Lower Nan	0		1	
	Total	252		-238	
Moderately Promoted Case (2)	Chao Phraya Delta	252		-194	
	Lower Nan	0		11	
	Total	252		-183	
Modestly Promoted Case (3)	Chao Phraya Delta	252		-162	
	Lower Nan	0		23	
	Total	252		-139	
2. Water Demand for Non-Irrigation Sectors					
High Growth Case (4)		0		1,103	
Normal Growth Case (5)		0		825	
Low Growth Case (6)		0		578	
3. Water Demand for Irrigation in the System Expansion Area					
Highly Promoted Case (7)	Phitsanulok2, etc.	0		216	
Moderately Promoted Case (8)	do	0		223	
Modestly Promoted Case (9)	do	0		230	
4. Total Water Demand (Water Use in the Existing Beneficial Area Only)					
(1) + (6)	Delta+Phitsanulok1	252		340	
(2) + (5)	do	252		642	
(3) + (4)	do	252		964	
5. Total Water Demand (Water Use in the System Expansion Area Included)					
(1) + (6) + (7)	Delta+Phitsanulok1,2	252		556	
(2) + (5) + (8)	do	252		865	
(3) + (4) + (9)	do	252		1,194	

Table 5.6.3(2) Total Water Demand for 30% Minimum Dry Season Intensity Case

Case	Area	1996	2006	2016	Remarks
1. Water Demand for Irrigation in the Existing Beneficial Area					
Highly Promoted Case (1)	Chao Phraya Delta	546		40	
	Lower Nan	0		1	
	Total	546		41	
Moderately Promoted Case (2)	Chao Phraya Delta	546		84	
	Lower Nan	0		11	
	Total	546		95	
Modestly Promoted Case (3)	Chao Phraya Delta	546		117	
	Lower Nan	0		23	
	Total	546		140	
2. Water Demand for Non-Irrigation Sectors					
High Growth Case (4)		0		1,103	
Normal Growth Case (5)		0		825	
Low Growth Case (6)		0		578	
3. Water Demand for Irrigation in the System Expansion Area					
Highly Promoted Case (7)	Phitsanulok2, etc.	0		345	
Moderately Promoted Case (8)	do	0		352	
Modestly Promoted Case (9)	do	0		359	
4. Total Water Demand (Water Use in the Existing Beneficial Area Only)					
(1) + (6)	Delta+Phitsanulok1	546		619	
(2) + (5)	do	546		920	
(3) + (4)	do	546		1,243	
5. Total Water Demand (Water Use in the System Expansion Area Included)					
(1) + (6) + (7)	Delta+Phitsanulok1,2	546		964	
(2) + (5) + (8)	do	546		1,272	
(3) + (4) + (9)	do	546		1,602	

Table 5.6.3(3) Total Water Demand for 40% Minimum Dry Season Intensity Case

Case	Area	1996	2006	2016	Remarks
1. Water Demand for Irrigation in the Existing Beneficial Area					
Highly Promoted Case (1)	Chao Phraya Delta	1,063		528	
	Lower Nan	1		1	
	Total	1,064		529	
Moderately Promoted Case (2)	Chao Phraya Delta	1,063		573	
	Lower Nan	1		12	
	Total	1,064		585	
Modestly Promoted Case (3)	Chao Phraya Delta	1,063		606	
	Lower Nan	1		23	
	Total	1,064		629	
2. Water Demand for Non-Irrigation Sectors					
High Growth Case (4)		0		1,103	
Normal Growth Case (5)		0		825	
Low Growth Case (6)		0		578	
3. Water Demand for Irrigation in the System Expansion Area					
Highly Promoted Case (7)	Phitsanulok2, etc.	0		475	
Moderately Promoted Case (8)	do	0		482	
Modestly Promoted Case (9)	do	0		489	
4. Total Water Demand (Water Use in the Existing Beneficial Area Only)					
(1) + (6)	Delta+Phitsanulok1	1,064		1,107	
(2) + (5)	do	1,064		1,410	
(3) + (4)	do	1,064		1,732	
5. Total Water Demand (Water Use in the System Expansion Area Included)					
(1) + (6) + (7)	Delta+Phitsanulok1,2	1,064		1,582	
(2) + (5) + (8)	do	1,064		1,892	
(3) + (4) + (9)	do	1,064		2,221	

Table 5.6.3(4) Total Water Demand for 50% Minimum Dry Season Intensity Case

Case	Area	1996	2006	2016	Remarks
1. Water Demand for Irrigation in the Existing Beneficial Area					
Highly Promoted Case (1)	Chao Phraya Delta	1,754		1,177	
	Lower Nan	41		40	
	Total	1,795		1,217	
Moderately Promoted Case (2)	Chao Phraya Delta	1,754		1,222	
	Lower Nan	41		50	
	Total	1,795		1,272	
Modestly Promoted Case (3)	Chao Phraya Delta	1,754		1,255	
	Lower Nan	41		62	
	Total	1,795		1,317	
2. Water Demand for Non-Irrigation Sectors					
High Growth Case (4)		0		1,103	
Normal Growth Case (5)		0		825	
Low Growth Case (6)		0		578	
3. Water Demand for Irrigation in the System Expansion Area					
Highly Promoted Case (7)	Phitsanulok2, etc.	0		604	
Moderately Promoted Case (8)	do	0		611	
Modestly Promoted Case (9)	do	0		618	
4. Total Water Demand (Water Use in the Existing Beneficial Area Only)					
(1) + (6)	Delta+Phitsanulok1	1,795		1,795	
(2) + (5)	do	1,795		2,097	
(3) + (4)	do	1,795		2,420	
5. Total Water Demand (Water Use in the System Expansion Area Included)					
(1) + (6) + (7)	Delta+Phitsanulok1,2	1,795		2,399	
(2) + (5) + (8)	do	1,795		2,708	
(3) + (4) + (9)	do	1,795		3,038	

Table 5.6.3(5) Total Water Demand for 60% Minimum Dry Season Intensity Case

Case	Area	1996	2006	2016	Remarks
1. Water Demand for Irrigation in the Existing Beneficial Area					
Highly Promoted Case (1)	Chao Phraya Delta	2,594		1,963	
	Lower Nan	163		176	
	Total	2,757		2,139	
Moderately Promoted Case (2)	Chao Phraya Delta	2,594		2,009	
	Lower Nan	163		187	
	Total	2,757		2,196	
Modestly Promoted Case (3)	Chao Phraya Delta	2,594		2,042	
	Lower Nan	163		199	
	Total	2,757		2,241	
2. Water Demand for Non-Irrigation Sectors					
High Growth Case (4)		0		1,103	
Normal Growth Case (5)		0		825	
Low Growth Case (6)		0		578	
3. Water Demand for Irrigation in the System Expansion Area					
Highly Promoted Case (7)	Phitsanulok2, etc.	0		734	
Moderately Promoted Case (8)	do	0		741	
Modestly Promoted Case (9)	do	0		748	
4. Total Water Demand (Water Use in the Existing Beneficial Area Only)					
(1) + (6)	Delta+Phitsanulok1	2,757		2,717	
(2) + (5)	do	2,757		3,021	
(3) + (4)	do	2,757		3,344	
5. Total Water Demand (Water Use in the System Expansion Area Included)					
(1) + (6) + (7)	Delta+Phitsanulok1,2	2,757		3,451	
(2) + (5) + (8)	do	2,757		3,762	
(3) + (4) + (9)	do	2,757		4,092	

Table 5.6.3(6) Total Water Demand for 70% Minimum Dry Season Intensity Case

Case	Area	1996	2006	2016	Remarks
1. Water Demand for Irrigation in the Existing Beneficial Area					
Highly Promoted Case (1)	Chao Phraya Delta	3,535		2,841	
	Lower Nan	304		331	
	Total	3,839		3,172	
Moderately Promoted Case (2)	Chao Phraya Delta	3,535		2,887	
	Lower Nan	304		343	
	Total	3,839		3,230	
Modestly Promoted Case (3)	Chao Phraya Delta	3,535		2,919	
	Lower Nan	304		356	
	Total	3,839		3,275	
2. Water Demand for Non-Irrigation Sectors					
High Growth Case (4)		0		1,103	
Normal Growth Case (5)		0		825	
Low Growth Case (6)		0		578	
3. Water Demand for Irrigation in the System Expansion Area					
Highly Promoted Case (7)	Phitsanulok2, etc.	0		863	
Moderately Promoted Case (8)	do	0		870	
Modestly Promoted Case (9)	do	0		877	
4. Total Water Demand (Water Use in the Existing Beneficial Area Only)					
(1) + (6)	Delta+Phitsanulok1	3,839		3,750	
(2) + (5)	do	3,839		4,055	
(3) + (4)	do	3,839		4,378	
5. Total Water Demand (Water Use in the System Expansion Area Included)					
(1) + (6) + (7)	Delta+Phitsanulok1,2	3,839		4,613	
(2) + (5) + (8)	do	3,839		4,925	
(3) + (4) + (9)	do	3,839		5,255	

Table 5.6.3(7) Total Water Demand for 80% Minimum Dry Season Intensity Case

Case	Area	1996	2006	2016	Remarks
1. Water Demand for Irrigation in the Existing Beneficial Area					
Highly Promoted Case (1)	Chao Phraya Delta	4,563		3,800	
	Lower Nan	467		506	
	Total	5,030		4,306	
Moderately Promoted Case (2)	Chao Phraya Delta	4,563		3,845	
	Lower Nan	467		518	
	Total	5,030		4,363	
Modestly Promoted Case (3)	Chao Phraya Delta	4,563		3,879	
	Lower Nan	467		529	
	Total	5,030		4,408	
2. Water Demand for Non-Irrigation Sectors					
High Growth Case (4)		0		1,103	
Normal Growth Case (5)		0		825	
Low Growth Case (6)		0		578	
3. Water Demand for Irrigation in the System Expansion Area					
Highly Promoted Case (7)	Phitsanulok2, etc.	0		992	
Moderately Promoted Case (8)	do	0		1,000	
Modestly Promoted Case (9)	do	0		1,007	
4. Total Water Demand (Water Use in the Existing Beneficial Area Only)					
(1) + (6)	Delta+Phitsanulok1	5,030		4,884	
(2) + (5)	do	5,030		5,188	
(3) + (4)	do	5,030		5,511	
5. Total Water Demand (Water Use in the System Expansion Area Included)					
(1) + (6) + (7)	Delta+Phitsanulok1,2	5,030		5,876	
(2) + (5) + (8)	do	5,030		6,188	
(3) + (4) + (9)	do	5,030		6,518	

Table 5.6.3(8) Total Water Demand for 90% Minimum Dry Season Intensity Case

Case	Area	1996	2006	2016	Remarks
1. Water Demand for Irrigation in the Existing Beneficial Area					
Highly Promoted Case (1)	Chao Phraya Delta	5,633		4,798	
	Lower Nan	652		704	
	Total	6,285		5,502	
Moderately Promoted Case (2)	Chao Phraya Delta	5,633		4,844	
	Lower Nan	652		716	
	Total	6,285		5,560	
Modestly Promoted Case (3)	Chao Phraya Delta	5,633		4,877	
	Lower Nan	652		726	
	Total	6,285		5,603	
2. Water Demand for Non-Irrigation Sectors					
High Growth Case (4)		0		1,103	
Normal Growth Case (5)		0		825	
Low Growth Case (6)		0		578	
3. Water Demand for Irrigation in the System Expansion Area					
Highly Promoted Case (7)	Phitsanulok2, etc.	0		1,122	
Moderately Promoted Case (8)	do	0		1,129	
Modestly Promoted Case (9)	do	0		1,136	
4. Total Water Demand (Water Use in the Existing Beneficial Area Only)					
(1) + (6)	Delta+Phitsanulok1	6,285		6,080	
(2) + (5)	do	6,285		6,385	
(3) + (4)	do	6,285		6,706	
5. Total Water Demand (Water Use in the System Expansion Area Included)					
(1) + (6) + (7)	Delta+Phitsanulok1,2	6,285		7,202	
(2) + (5) + (8)	do	6,285		7,514	
(3) + (4) + (9)	do	6,285		7,842	

CHAPTER 6.

IDENTIFICATION OF KOK-ING-NAN PROJECT

CHAPTER 6. IDENTIFICATION OF KOK-ING-NAN PROJECT

6.1 Historical Background of Chao Phraya Basin Development

After the Second World War, the Thai government began to develop a large-scale gravity irrigation system. In 1950, the World Bank granted the first project loan for construction of the Chao Phraya dam on the Chao Phraya river at Chainat, which was completed in 1957 together with distribution systems to cover the total irrigation area of 7.5 million rai commanded by the Greater Chao Phraya Project. In 1958, the design and construction of the Bhumiphol dam was commenced under another World Bank loan in association with comprehensive development purposes including irrigation, drainage, flood control, power generation, navigation, etc., bringing the irrigable area at the end of 1959 stepped up to about 9.4 million rai. In early 1960, survey and design of the Sirikit multipurpose project to construct a large scale storage dam on the Nan river was commenced and it was completed in 1973. After completion of the Bhumiphol and Sirikit dams, about 25% of the Chao Phraya river runoff became under control.

Due to geographical constraint as well as limited development potential of water resources, it was considered at these stages that even all potential water resources available for development in the forthcoming 20 years were put for implementation, about 80% of farmlands could not be benefitted leaving majority of farmers still relying on rainfed condition. Water shortage during dry season in the remote rural area used to be poor situation because of absolute lack of water even for domestic use. Workable rural population used to seek for temporary migration in the urban area while only the minority and aged people continued to stay in the rural area. Accordingly, the economic development in the rural area has dropped far behind of that of the urban area. Unstable rural life and seasonal population concentration in the urban area have also caused major element for social insecurity.

Under aforementioned situation, the government launched in 1976 a policy to advance construction of small scale projects to meet the basic needs of the people in the rural areas. Under this policy, equal emphasis was given among the large, medium and small scale water resources development projects depending on the water resources availability and prevailing local conditions.

Supported by the governmental policy to promote water resources development, the national economy has rapidly grown together with increased irrigable area from the past years. The rapid and high growth of the economic development achieved in the country during this period were, however, associated with extensive exploitation and destruction of the natural resources such as land, forest and water. In parallel with such development activities, shortage of water was spread over most part of the country in recent years due to inconsistent rainfall and runoff pattern and duration. There were scarcity of flow in river systems and insufficient amount of water stored in the reservoirs together with rapid increase of water demand from all water user sectors. In addition, due to scarcity of proper site for dam/reservoir construction of large-scale as well as more restrictions from environmental conservation requirement, water resources development of a large-scale has become difficult and slowed down particularly after 1987.

Following the progress of development activities of water resources, there was a jump in increase of irrigated area in sub-basins of the Chao Phraya river as shown in Table 6.1.1.

Table 6.1.1 Increase of Irrigated Area in the Upper Chao Phraya Sub-Basins

Year	Ping	Wang	Yom	Nan	Total
1970	250	97	27	252	626 (100%)
1980	752	201	350	624	1,927 (308%)
1990	1,571	449	831	1,796	4,647 (742%)
1996	1,974	534	1,086	2,081	5,675 (907%)

Some important figures to explain water budget at present and in future in the upper Chao Phraya basin are extracted from the Table 4.1.11 "Irrigation Area and Water Demand of Existing and Future Project in Upper Chao Phraya" as follows;

Table 6.1.2 Wet Season Water Budget in Four Sub-Basins in Upper Chao Phraya Basin

Sub-basin	Nan	Ping	Wang	Yom	Total
(1) Water Resources	8,590	4,040	1,020	3,340	16,990
(2) Farm Area	6,840	4,140	950	4,800	16,730
(3) Existing Condition					
- Irrigable Area (10^3rai)	2,100	1,880	530	970	5,480
- Irrigation Intensity (%)	31	45	56	20	33
- Water Use (MCM)	2,430	2,220	630	1,150	6,430
- Surplus of Water (MCM)	6,160	1,820	390	2,190	10,560
(4) Full Development Condition					
- Irrigable Area (10^3rai)	4,140	3,190	880	1,870	10,080
- Irrigation Intensity (%)	61	77	93	39	60
- Water Demand (MCM)	4,810	3,790	1,040	2,220	11,860
- Surplus of Water (MCM)	4,780	250	0	1,120	5,150

Note: Water Resources = Present runoff (1985-96 average) + Present water use

Table 6.1.3 Dry Season Water Budget in Four Sub-Basins in Upper Chao Phraya Basin

Sub-basin	Nan	Ping	Wang	Yom	Total
(1) Water Resources	2,960	3,230	120	280	6,590
(2) Farm Area	6,840	4,140	950	4,800	16,730
(3) Existing Condition					
- Irrigable Area (10^3rai)	710	420	80	190	1,400
- Irrigation Intensity (%)	10	10	8	4	8
- Water Demand (MCM)	1,250	760	150	340	2,500
- Surplus of Water (MCM)	1,710	2,470	0	0	4,180
(4) Full Development Condition					
- Irrigable Area (10^3rai)	1,580	800	140	480	3,000
- Irrigation Intensity (%)	23	19	15	10	18
- Water Demand (MCM)	2,770	1,420	260	850	5,300
- Surplus of Water (MCM)	190	1,810	0	0	2,000

The followings can be summarized from the above tables;

- The surplus water from the upper Chao Phraya basin is the major source of water to be utilized in the lower Chao Phraya basin consisting mainly of the Delta area. At present, about 10,600 MCM and 4,200 MCM of wet and dry season water flows into the Chao Phraya river at the confluence with the Nan, Ping and Yom rivers. These amounts of water are further added by the Sakae Krang runoff and side-flow from the residual catchments downstream of the confluence, and 14,160 MCM of wet season water and 5,840 MCM of dry season water are available at the Chainat barrage.

- In the average year conditions as mentioned above, about 4,000 MCM of water in dry season is diverted at the Chainat barrage for irrigation purpose including some amount of water for local domestic use and 2,000 MCM is released downstream for water supply to the Bangkok Metropolitan area as well as for river maintenance uses such as navigation and salt water exclusion.

- In a dry year, however, river flow in dry season decreases to some 3,400 MCM, from which necessary amount of water are withdrawn for priority sectors such as domestic and industrial purposes, and limited amount of water is allocated to crop cultivation in the Delta (Command and Control System).

- In future at the full development stage, irrigable area will increase from 5.48 million rai in 1996 to 10.08 million rai in 2016 and increased water use for irrigated agriculture will reduce to a great extent the surplus water from the upper Chao Phraya basin decreasing to the order of 2,000 MCM in an average year. This amount of dry season water at Chainat barrage corresponds to the current driest year condition, while water demand for domestic and industrial uses would increase year by year according to the growth of population and change of living standard.

- As a consequence water allocation to irrigated agriculture is unavoidable to be cut down in future. Since water allocation for the perennial crops such as fruit trees is indispensable throughout a year, a scale-down of irrigation practice is directly linked to reduction of dry season rice production which in turn induces a serious impact on the national food security and export earnings.

The above situation is visualized in Figures 6.1.1 and 6.1.2.

6.2 Necessity of Additional Water Supply in Chao Phraya Delta

6.2.1 Current Shortage of Water for Irrigation

In order to evaluate the current situation of water shortage in the Chao Phraya delta area, a standard to guarantee the irrigation water supply was set up in Chapter 5 of this report at around 50%. A study showed the current status of water shortage in terms of additional amount of water supply to guarantee the minimum level of cropping intensity and revealed that about 1,800 MCM of dry season water would be in short at present to achieve a standard level of cropping intensity in the Chao Phraya delta. Various levels of minimum cropping intensities to be guaranteed were also put into an alternative study in order to evaluate various stages of water shortage, or in other word, additional supply of water currently required in the Delta. The study results are summarized as follows;

Table 6.2.1 Present Water Shortage in the Delta Area (Unit = MCM/year)

District/Zone	Existing Situation (%)	Minimum Cropping Intensity to be Guaranteed			
		40%	50%	60%	70%
Upper West	41.5	281	564	899	1,254
Lower West	63.6	0	0	8	93
West Bank Total	50.0	281	564	907	1,347
Upper East	16.9	763	1,019	1,322	1,629
Lower East	41.2	19	171	365	559
East Bank Total	30.0	782	1,190	1,687	2,188
Delta Area Total	40.2	1,063	1,754	2,594	3,535

Note: Figures are given as an average in the recent 6 years from 1991 to 1996.

The above order of the present shortage of water for the irrigated agriculture in the Delta will inevitably be accelerated in future resulted from promotion of the water resources development in the upper sub-basins together with increase of domestic, industrial and other water demand in the Delta.

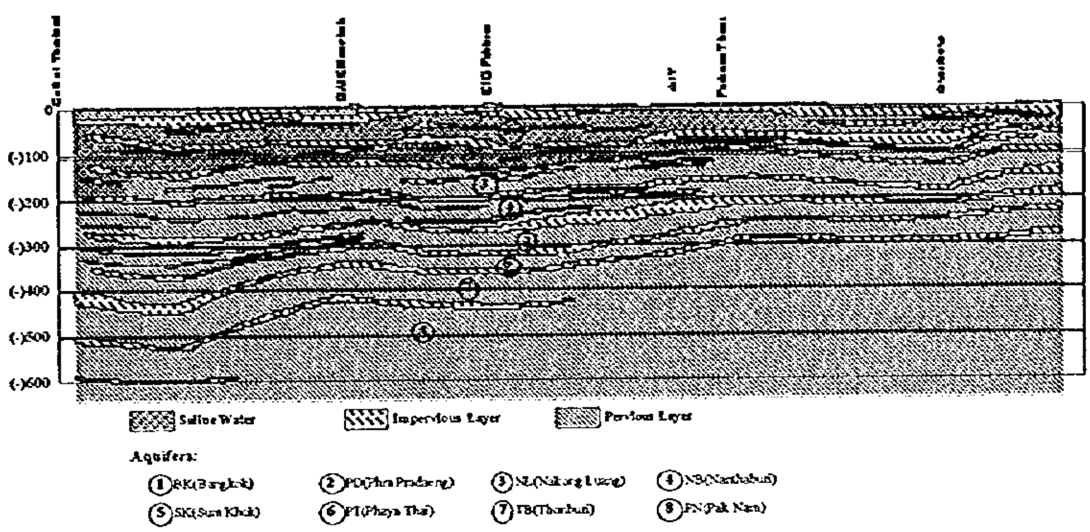
6.2.2 Necessity of Dry Season Rice Cropping in the Delta

As shown in Table 5.4.13 in the paragraph 5.4, Chapter 5, rice production still keeps an important role over the economy of Thailand in terms of national food security and export earnings sharing a considerable part of rice production for export. The agricultural development strategy in the 8th 5-Year Plan therefore, envisages to maintain 3.0 million rai of dry season rice cropping in the whole country. Cultivation of dry season rice needs inevitably irrigation water supply, and actually about 70% in an ordinary year or more than 75% in a dry year of the national total dry season rice has been produced in the Chao Phraya delta where a large extension of irrigation system exists. In order to secure 3.0 million rai of dry season rice, about 2.1 million rai of farmland under irrigation have to be planted to paddy in the dry season in the delta.

6.2.3 Importance of Water Supply in Delta Conservation Area

The lower zones of the Chao Phraya delta is called as the "Conservation Area" where importance of irrigation water supply throughout a year in both wet and dry seasons has been deeply recognized. In the actual irrigation practice under the current "Control and Command" system, even in a critical dry year such as 1994, similar amount of water as compared with that in an average year has been supplied to the conservation area making a sacrifice of the upper zones, as presented in Table 5.4.14 of Chapter 5. This fact explains that the stable water supply throughout a year in the conservation area is much important to prevent the area from damaged by salt water intrusion, as can be learnt also from precepts of destruction of world-famous deltas in recent years due to salt damages. In the Chao Phraya delta in recent years, the overpumping of underground water mainly for industrial purpose has rapidly depleted the aquifer storage and outpaced the replenishment by rain water, as shown below. It would cause a land collapse and soil degradation which would destroy the soil's ability to absorb water. Salinity of soil will be accumulated more and more if supply of fresh water in the delta is suspended inviting a total salt damage of the delta areas.

Figure 6.2.1 Salinity Intrusion into the Delta Aquifer



Sustainable supply of water for irrigation in dry season has thus made a great contribution to prolongation of life of the delta, and at least supply of dry season water at the present level is therefore necessary to avoid this crisis.

6.2.4 Necessity of Stable Water Supply for Diversified Crops

Crop diversification program has been promoted under the current policy for agricultural development and areas planted to diversified crops have been increasing everywhere in the delta. Diversified crops however require stable supply of irrigation water throughout a year. There is a certain limit of areas for diversified crops from view points of land use, water usage, market demand and agro-industry requirement, as concluded previously in Table 5.3.3. To guarantee stable supply of irrigation water for these diversified crops, at least 2,560 MCM of irrigation water is to be supplied in dry season even in a critically dry year as shown in Table 6.2.2. This figure reveals the fact that, under the current situation, without development of additional water resources and even if all of water is used for irrigation purpose only, the Chao Phraya flow in the dry season falls below the requirement in a critically dry year such as the year 1993.

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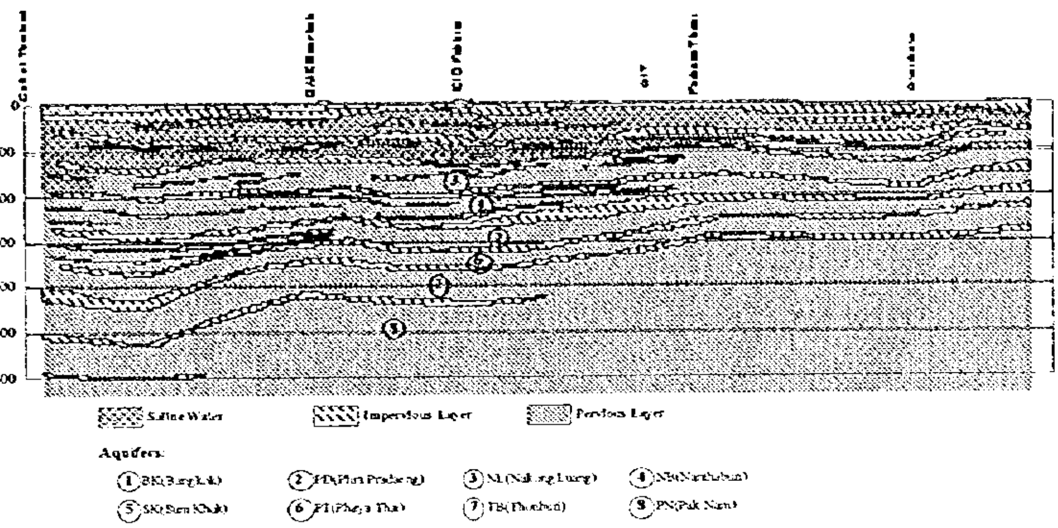

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Table 6.2.2 Necessity of Stable Water Supply for Diversified Crops

(Unit: 1,000rai)

Area	Irrigable Area	Sugar Cane	Field Crops	Vege-table	Fruit Trees	Fish Pond	Total
Water Consumption(m^3/rai)		1,300	1,300	1,100	2,000	1,450	
1. Present Conditions							
Cropped Area (1,000rai)	8,401.0	175.3	92.2	46.8	323.2	137.5	3,475.2
Water Demand (MCM)		228	120	51	646	199	1,244
2. Proposed Condition							
Cropped Area (1,000rai)	8,619.6	290.4	326.5	112.5	658.7	218.2	4,684.6
Water Demand (MCM)		378	424	124	1,317	316	2,559
3. Water Demand Increase		150	304	73	671	117	1,315

Note: Area for diversified crops covers the Chao Phraya delta and lower Nan basin.

6.3 Alternative Transbasin Water Diversion Plans

6.3.1 Limit of Water Resources Development in Upper Chao Phraya Basin

(1) Present Water Resources Development

Numbers of large, medium and small scale dams have been constructed and under operation in the upper Chao Phraya basin mainly for irrigation purpose. Among these dams, only Sirikit and Bhumibol dams can release water for uses in the Delta area.

Total effective storage capacity of such dams is estimated at 17,600 MCM, of which 93% is occupied by the capacities of Bhumibol and Sirikit reservoirs. The reservoir inflow of both dams, however, is about 10,000 MCM, providing the major reason why 7,000 MCM of large empty space of storage exist in both reservoirs at the end of wet season. As a consequence, river runoffs regulated by these existing dams in the upper Chao Phraya basin accounts for 11,000 MCM or 50% of the total runoff in the basin.

All dams except Bhumibol and Sirikit have no function or contribution to supply excess water in response to the demand in the Delta, being utilized for irrigation and other purposes in their own tributary sub-basins. The available waters to be supplied in dry season to the Delta are thus limited to 6,000 MCM in normal years and 3,400 MCM in dry years, all of which are supplied only from Bhumibol and Sirikit dams.

(2) Future Water Resources Development

RID and other governmental agencies in Thailand have set up the future water resources development plan in the Chao Phraya basin since 1980 with the intention of storing more water in wet season and utilizing it during dry season. Implementation of such large/medium scale dams has, however, been delayed due to social and environmental constraints such as resettlement problem in the reservoir area and construction of reservoirs in the watershed classification areas.

The notable large dams nominated for future implementation are the Kaen Sua Ten dam with the effective storage capacity of 1,200 MCM and the Pasak dam with 800 MCM capacity, both of which are relatively small scale when compared with the Bhumibol and Sirikit dams. The total effective storage capacity of all of the proposed dams is more or less 4,000 MCM, which would be much smaller to regulate sufficiently wet season runoff in the Chao Phraya basin. Furthermore, the reservoir water will be used mostly for supplemental irrigation of wet season paddy, not allocated to second crops because of large existence of rainfed area for wet season paddy, insufficient inflow into reservoirs and others. Such waters stored in the proposed reservoirs will thus be supplied to irrigable areas in the tributary basins, and no contribution to the Chao Phraya delta area will be expected.

6.3.2 Alternative Transbasin Water Diversion Plans Studied in the Past

Numbers of studies in various levels have been made. The most possible method is to divert the water transbasin to the Chao Phraya basin from the Salawin and its tributaries such as Moei and Pai rivers, and from the Mekong river and its tributaries such as Kok and Ing rivers. Since the both Salawin and Mekong are international rivers, the utilization of boundary waters requires the international water agreement among riparian countries.

Among the existing large scale dams constructed in the Chao Phraya basin, the Bhumibol and Sirikit dams are proud of their outstanding storage capacities. Their capacities are however not fully utilized due to absolute lack of inflow into reservoirs. One of the best solution would be to fully utilize their empty capacities by means of introducing water diverted transbasin from other basins where excess water is wasted unutilized.

In total, 18 alternative transbasin water diversion plans have been formulated up to present with various phases of study by various agencies concerned such as RID, DEDP, EGAT, MRC and others, for solving the water shortage problems in the Chao Phraya basin. Such transbasin water diversion plans, whose projected features are summarized in Table 6.3.1 and locations are shown in Figure 6.3.1, are classified into the following two categories;

- Water diversion from the Salawin river and tributaries
- Water diversion from the Mekong river and tributaries

Each category comprises several alternatives for water resources development, as explained below.

(1) Water Diversion from the Salawin River and Tributaries

The Salawin river, originated deep in the Himalayas, flows down for a distance of 2,200 km mostly in the territory of China and Myanmar, and it forms a part of the border between Thailand and Myanmar. It finally empties into Andaman Sea at Martaban of Myanmar. The two countries have been deep and long concerned regarding the utilization of water resources of the Salawin river mainly for hydro-power generation and irrigation. In particular since the oil crisis of 1978, urgent necessity for developing the border rivers has become realized between the two countries, and it has been seriously discussed with the objective of providing supply sources of water and electric power, demands of which are increasing with a high economic growth in Thailand.

- **Salawin-Bhumibol Diversion Plan**

The so-called Salawin Project studied individually by DEDP and EGAT consists of a single dam at about 10 km upstream of the confluence of the Salawin and Moei rivers (DEDP), or two dams, an upper dam planned about 76 km upstream and a lower dam at 1 km upstream of the confluence (EGAT). The major purpose of the dams is hydroelectric power generation. It is however expected as the associated scheme to also serve for the purposes of flood control and irrigation in the downstream area.The projected outline of these dams are as follows;

Table 6.3.2 Feature of Salawin Project

Feature	DEDP Dam	EGAT Upper Dam	EGAT Lower Dam
Drainage Area (km²)	295,000	293,100	295,000
Runoff (MCM/yr)	119,200	118,600	119,200
Dam Height (m)	209	170	43
High Water Level (m)	200	220	86
Gross Storage (MCM)		21,000	740

According to the paper prepared by DEDP; Development of Hydropower on Rivers Bordering Thailand-Burma in 1988, irrigable areas are estimated as below;

Table 6.3.3 Irrigable Area by the Salawin Project

	Thailand	Myanmar	Total
Irrigable Area in ha	0	1,600,000	1,600,000

Apart from original development plans prepared by either DEDP or EGAT and although study is not made in any phase, it may not be impossible to divert the Salawin water into the Bhumiphol reservoir by means of constructing diversion canals and tunnels. Based on a desk study, the length of diversion canal/tunnel is estimated at some 90 km, and this idea will have advantages and disadvantages as summarized below;

<u>Advantages</u>

- The diversion route will be shorter than those for the Mekong Diversion Projects, as mentioned later, and monitoring control of diversion water by riparian rights will be easy because that the diversion route will be mostly consisting of tunnel works.
- Myanmar is the only riparian country concerned
- Irrigation areas will be provided in two countries, Thailand and Myanmar

- Both banks of Salawin river locate in high mountainous areas, causing no serious problem due to flood from reservoir impoundment

Disadvantages

- According to the original development plan by DEDP, irrigation areas are extended only within Myanmar territory where water use is advantageous from topographical point of view, while Thailand will obtain only benefit from power generation.
- The riparian countries who mutually use the boundary water shall have to make agreement in advance of commencement of the project, but Myanmar still not join declaration as specified by the Helsinki Rules.
- Pump lifting of the diversion water with a head of about 90 m will be required to divert Salawin water to the Chao Phraya basin through the Bhumiphol reservoir.
- There are minority groups in the project areas which may cause inconvenience in field works and other activities.
- Diversion plan itself is only of desk study level.

- **Moei-Huai Khanaeng Dam-Bhumibol Diversion Plan**
- **Salawin-Mae Lama Luang Dam-Bhumibol Diversion Plan**

The Moei river, which flows towards the northwest through Thailand territory, passes Mae Sot, Mae Ramat and Tha Song Yang, and joins the Salawin river at Ban Kho Puai after adding the Yuam river, is also the bordering river between Thailand and Myanmar. The feasibility study was conducted in 1995 to formulate so-called Moei-Salawin Diversion Project. The project aims to divert the Moei river water to Chao Phraya basin through the Bhumiphol dam. In total, five alternative plans were studied under prefeasibility study level by DEDP, and two possible alternative plans, the second route through Huai Khanaeng dam and third diversion route through Mae Lama Luang dam, were extracted from the study for comparison.

Table 6.3.4 Some Comparison on Alternative Route 2 and 3

	Alternative Route 2	Alternative Route 3
Diversion Route	Moei - Huai Kanang Dam - Bhumiphol Dam	Salawin - Mae Lamalung Dam - Bhumiphol Dam
Possible Diversion Water	2,450 MCM/annum	1,090 MCM/annum
Diversion Tunnel	7.5 m(D)x81.9 km	7.5 m(D)x15.9 km
Total Lifting Head Required	329 m	188 m
Internal Rate of Return	11.9%	15.4%
Water Cost in Baht	1.86	1.38

From the comparative table, the alternative route 3 will be the most feasible from both engineering and economic points of view. However, the possible amount of diversion water of 1,090 MCM as an annual average, determined in consideration of practical water right for wet and dry season irrigation, will be insufficient to meet water shortage in the

Chao Phraya basin. Moreover, dam and reservoir areas and other structure sites are located mostly in the Mae Lamao national reserved forest area. In addition, major structure sites for the alternative plan 2 also locate in the Ta Song Yang national reserved forest area.

- **Nam Ngao-Bhumibol Diversion Plan**

This plan aims at developing downstream areas of the Ngao basin and alleviating the water shortage problem in the Chao Phraya basin by means of diverting surplus water of about 500 MCM/annum through the Ngao dam and Mae Tun river finally into the Bhumibol reservoir. This plan requires 235 m of pump lifting, only 65% of which can be recovered at the Bhumibol power plant. Moreover 500 MCM/year of water is not sufficient to restore the empty capacity of the Bhumibol reservoir.

- **Mae Lamao-Bhumibol Diversion Plan**

This plan aims at developing downstream areas of the Mae Lamao basin and alleviating the water shortage problem in the Chao Phraya basin by means of diverting surplus water of about 360 MCM/annum through the Mae Lamao dam and Mae Tun river finally into the Bhumibol reservoir. This plan requires 48 m of pump lifting and most part of underground tunnel (15 km out of 23.5 km) passes through the watershed classified 1A area. Moreover 380 MCM/year of water is not sufficient to restore the empty capacity of the Bhumibol reservoir.

- **Mae Charao-Mae Tun Diversion Plan**

This plan is to supplement water from Moei river at Mae Charao pumping station and to divert about 500 MCM/year of water into Mae Lamao dam which will flow through Mae Tun into the Bhumibol reservoir. The plan requires in total 85 m of pump lifting.

- **Upper Pai-Mae Taeng Diversion Plan**
- **Upper Pai-Mae Khan Diversion Plan**
- **Upper Pai-Mae Sa-Mae Taeng Diversion Plan**
- **Lower Pai-Mae Chaem Diversion Plan**

The Upper Pai-Mae Taeng plan intends to divert about 500 MCM of annual water from the proposed Upper Pai dam with pump lifting of 65 m. The diverted water flows into Mae Taeng, a tributary of the Ping river, through a diversion tunnel of 3.3 m diameter and 27 km long. The Upper Pai-Mae Khan plan consists of two dams of 40 m high, whose reservoirs are connected by feeder canal. Some 300 to 500 MCM per annum of water are pumped up from the middle dam at the elevation 480 m, MSL to the regulating reservoir at the elevation of 860 m, MSL, thus requiring a pumping head of 380 m and consuming 132 MW of energy. The Upper Pai-Mae Sa-Mae Taeng diversion plan also consists of two dams of 40 m and 35 m high. A diversion tunnel of 3.8 m diameter and 43 km long will conducts 420 MCM of water annually under gravity. The lower Pai-Mae Chaem diversion plan will divert some 500 MCM of excess water from downstream area of the Lower Pai dam to Mae Chaem which flows into the Bhumibol reservoir. A pumping lift of 500 m is required consuming 512 MW of energy, not more than 20% of which can be recovered at the Bhumibol power plant.

Most of above plans can divert some 500 MCM or less water annually and consume huge energy of out of sense. Moreover, some parts of the project sites locate in the national reserved forest area and watershed areas of class 1A and 1B.

(2) Water Diversion from the Mekong River and Tributaries

Being the largest in Southeast Asia, the Mekong river is another source whose runoff is not utilized since long ago. There are some preliminary studies to make use of the Mekong runoff such as the Pamong project, in the light of the present political situation, however, it can not be imagined how far the plan would be implemented. The Mekong river has the average annual runoff of about 101 billion cu.m and in March the minimum average monthly runoff of 2,090 MCM at the confluence with the Ing river.

In the preliminary study report on the Analysis of Mekong Water Diversion Schemes for Thailand prepared by MRC in 1979, various diversion projects from the mainstream of the Mekong river were taken into consideration. Among those, the projects directly related to Mekong - Chao Phraya diversion are extracted as below;

- Mekong - Pasak Diversion Project
- Mekong - Sirikit Diversion Project

Besides, DEDP has a plan to study on the Diversion Plan from the Mekong River to Sirikit Reservoir, while EGAT summarized the possibilities of diversion projects for the followings;

- Mekong-Mae Ping diversion plan
- Mekong-Mae Ngat diversion plan
- Nam Man diversion plan
- Nam San diversion plan
- Kok-Ing-Yom-Nan diversion plan

- Mekong-Pasak Diversion Plan

The Mekong-Pasak diversion project is a pumping project in which waters are taken from the mainstream of the Mekong river at Ban Tha Dae Mae, Changwat Nong Khai, lifted about 35 m by pumps and then conducted through diversion canal of 11 km long and tunnel of 99 km long into the Pasak river near Amphoe Lom Sak.

- Mekong-Sirikit Diversion Plan

The Mekong-Sirikit project is a diversion project in which waters are taken from the mainstream of the Mekong river at Ban Pak Man in Laos by a gravity tunnel system of 60.5 km long into the Sirikit reservoir near Amphoe Na Noi.

For either of the above projects, pumping and canal capacity was taken at 50 m^3/sec to irrigate 162,500 rai (26,000 ha) of farmland. The Committee concluded that the both projects were less feasible because of their low benefits.

Table 6.3.5 Comparison of Mekong-Pasak and Mekong-Sirikit Diversion Plans

	Mekong-Pasak Project	Mekong-Sirikit Project
B/C Ratio	0.18	0.6
Internal Rate of Return (%)	0.5	4.7
Water Cost (Bahts/m^3)	2.09	1.09

- **Mekong-Sirikit Diversion Plan (DEDP)**

The DEDP proposed a study for external finance entitled the Diversion Plan from Mekong River to Sirikit Reservoir. The concept of the project is to divert part of the excess Mekong river water during wet season, mainly flood flow, to the Sirikit multipurpose reservoir by gravity to improve the stored water availability for use for irrigation and urban water supply in the Chao Phraya basin in the dry season and for power generation without any additional cost for storage and distribution of water. The division of Mekong river water during flood flow will contribute to reduce the magnitude of flood in the downstream area. A conceptual study called "Report of Diversion from Mekong and Mae Pai to Upper Chao Phraya River Basin" was prepared in March 1993. The intake area of the proposed diversion is assumed on the right bank of the Mekong river upstream of Chiang Khan in Lao PDR. The diverted water will flow under gravity in open channel and mainly in large tunnel across the mountains to the Sirikit reservoir. About 40% of the diversion route will be located in Lao PDR and 60% in Thailand. The administrative and legal aspects of cooperation between the two countries Thailand and Lao PDR is inevitably needed.

- **Mekong-Mae Ping Diversion Plan**

The Mekong-Mae Ping diversion plan is such a plan in which waters are taken from the mainstream of the Mekong river at the Kok river mouth and conveyed by gravity through a diversion tunnel of 185 km long into the Ping river near Changwat Chiangmai.

- **Mekong-Mae Ngat Diversion Plan**

The Mekong-Mae Ngat diversion plan is a pumping project in which waters are taken from the mainstream of the Mekong river at the Kok river mouth and conveyed through a diversion canal of 120 km long with a series of pumping lifts and a tunnel of 7 km long into the Mae Ngat reservoir at an elevation of 360 m.

- **Nam Man Diversion Plan**

The Nam Man dam, with a storage capacity of 235 MCM, is proposed to be constructed on the Nam Man, which is a tributary of Nam Heung flowing into Mekong river. This dam will irrigate 120,000 rai of cropland and generate an annual energy of 67 GWh. An excess water of 88 MCM per annum is diverted transbasin into the head of the Pasak river by gravity. Some 560 households are however required to be resettled.

- **Nam San Diversion Plan**

The Nam San dam with a storage capacity of 101 MCM is proposed to be constructed on the Nam San, which is a tributary of Nam Heung flowing into Mekong river. This dam will irrigate 37,500 rai of cropland and generate an annual energy of 62 GWh. An excess water of 128 MCM per annum is diverted transbasin into the head of the Pasak river by gravity. Some 280 households are however to be resettled.

- **Kok-Ing-Yom-Nan Diversion Project**

Originated in the mountainous terrain in Myanmar at an elevation of 1,600 m, the Kok river flows southward through Thai/Myanmar border to its confluence with the Mekong river near Chiang Saen. Its drainage area is about 10,800 km^2 of which 2,980 km^2 is in Myanmar territory. The average annual runoff flowing into the Mekong river is about 5,280 MCM.

The Ing river starts from Kwan Phayao, the common pond for several small streams originating from mountain ridges, and flows in the northeastern direction to merge with the Mekong river ar Ban Sop Ing in Amphoe Chiang Khong. The average annual runoff flowing into the Mekong river is estimated at 1,940 MCM. Being located in the northern-most region of the country, the Ing basin shares the common drainage boundary with Chao Phraya basin. The Ing river basin is the one whose runoff is left unutilized at present.

Considerations were given firstly to storage possibilities in the Yom basin which is unregulated at present. A prefeasibility study was undertaken in 1980 by EGAT to evaluate alternative damsites at Kaeng Sua Ten or Huai Sak. Soon after, investigations were carried out to examine alternatives for diverting water by pumping from the Ing and ultimately from the Mekong into the head of the Yom catchment, which forms a part of the Chao Phraya river system. A prefeasibility study of the Ing-Yom-Nan Diversion Project was undertaken in 1981 by EGAT.

The results from the study on economic terms showed that the optimum diversion capacity from the Ing and Mekong was in excess of 500 m^3/sec. The Huai Sak dam was shown to be more economical than Kaeng Sua Ten for storage less than 2,750 MCM, the optimum diversion capacity to the Nan would be 400 m^3/sec and the best intermediate stage development of the Ing diversion would be 220 m^3/sec.

During the reconnaissance for this study, it was recognized that a possible additional source or alternative to the Ing-Yom diversion might be to divert water from the Kok river. Flows in the Kok tributaries could also be intercepted and diverted. A prefeasibility study to examine diversion from the Kok was undertaken by EGAT in 1982. The main elements of the scheme are to construct a dam on the Kok river some 10 km west of Chiangrai, to generate hydro-power and to divert water into an earth canal of 105 km by gravity which would reach the Ing-Yom canal alignment at an elevation of 400 m. No pumping would be required in this scheme. During the course of the study, a decision to divert the Kok water would bring a canal geographically closer to the Mekong than in the Ing-Yom scheme. Consideration at reconnaissance level was therefore given to the possibility of diversion of Mekong water from Ban Sop Kok.

The Kok-Ing-Yom-Nan diversion project is thus a pumping project in which waters are taken from (1) the Ing river with a pumping lift of 43 m, (2) the Kok river by gravity, and (3) mainstream of the Mekong river at Sop Kok (Kok river mouth) with a pumping lift of 42 m, and then conveyed into the Yom basin where three dams, namely Pong No.1, 2 and 3 dam, are constructed to regulate flow, and finally waters are diverted into the Kaeng Sua Ten dam to be constructed with a storage capacity of 4,550 MCM. From the Kaeng Sua Ten dam water can be diverted to the Sirikit dam. According to the EGAT study, the total length of the diversion canal is 260 km and the tunnel is 32 km long. The project components therefore comprise the following five sub-projects;

- Mekong Diversion Sub-Project
- Ing-Yom Diversion Sub-Project
- Kok-Yom Diversion Sub-project
- Kaeng Sua Ten Multipurpose Dam Sub-Project
- Yom-Nan Diversion Sub-Project

The feasibility studies were undertaken for Ing-Yom diversion sub-project as well as for Kaeng Sua Ten multipurpose dam sub-project both by EGAT, and reports were issued in early 1984.

The EGAT concluded in the Summary Report of Kok-Ing-Yom-Nan Diversion Project issued in 1984 that the project which would be economically and socially feasible and could be developed to be a large scale, after comparison of all possible diversion projects, was the Kok-Ing-Yom-Nan diversion project.

(3) Progress of Kok-Ing-Yom-Nan Diversion Project

In consideration of existing political situation of utilizing the Mekong mainstream water, EGAT decided to exclude as the first stage Mekong diversion and Yom-Nan diversion sub-projects from their original plan, as stated in the Memorandum dated 7 June 1984 subjected on Summary of the Result Study on Kok-Ing-Yom-Nan Diversion Project, submitted to the Minister of MOAC and Secretary of NESDB.

(a) Kaeng Sua Ten Dam Project (Multi-purpose)

The first main objective of the feasibility study for the proposed Kaeng Sua Ten multi-purpose dam was to determine the size and type of dam required at Kaeng Sua Ten in the upper Yom basin in order to store water from the catchment itself as a first stage followed by the size of the dam required for the diversion of flows from the rivers in northern catchments for later stages. Studies were undertaken for the following staged project as below;

- Stage 1 (Yom only catchment with no diversion)
  To construct Kaeng Sua Ten dam of 82 m high with normal high water level of 270 m, capacity of 2,250 MCM and power-plant of 65 MW

- Stage 2 (Yom with Ing diversion from Thoeng)
  To construct Ing-Yom diversion channel of 120 m3/sec capacity, two pumping stations with capacity of 69 MW and Nam Phae and Rieng dams with power-plant of 102 MW, to raise the Kaeng Sua Ten dam for 14 m with normal high level of 284 m and capacity of 4,550 MCM, to add install capacity of power-plant with 65 MW, and to construct Yom/Phae and Yom/Sukothai irrigation system.

- Stage 3 (Yom with Kok and Ing diversion)
  To construct Kok dam at 50 m high, normal water level 445 m, capacity 570 MCM, 48 MW power-plant and Kok-Yom diversion channel of 150 m3/sec capacity, to add installed capacity of 100 MW at Kaeng Sua Ten and 30 MW at Rieng.

- Stage 4 (Final)
  To construct Mae Kok/Mae Lao irrigation system and to construct Pong No.2 dam and power-plant with capacity of 96 MW

(b) Kaeng Sua Ten Dam Project (Agricultural Dam)

The above study also revealed that although Stage 1 of the project was shown to be economically attractive as a multi-purpose project, power alone was only marginally economic. From EGAT's point of view, there are other hydro-power projects which might be considered more favorable. It is only in Stage 2 when diversion from northern catchment rivers are brought in, that hydro-power becomes much more attractive. Another major disadvantage of the Stage 1 project as originally conceived was the need for resettlement of some 3,390 families within the reservoir area, especially the town of Chiang Muan.

To overcome these two major constraints of large resettlement and marginally economic power, it became necessary to reconsider the concept of the Kaeng Sua Ten dam as a single purpose dam to satisfy the demand of water for agriculture only, as opposed to the multi-purpose concept set out for the feasibility study. By removing operating level constraints for hydro-power generation, reservoir levels could be drawn down much lower, thereby making more efficient use of storage. Consequently, a smaller dam could create the same agricultural benefits as a larger dam under hydro-power operating rules. The Kaeng Sua Ten dam feasibility study-Alternative Stage 1-Agricultural Dam was conducted under the revised concept by EGAT in 1985.

Table 6.3.6 Major Features of Kaeng Sua Ten Agricultural Dam

Feature	Dimension
Catchment Area	3,583 km2
Average Annual Runoff	933 MCM
Dam	Rockfill of 72 m high, 695 m long
Water Retention Level	258 m
Capacity at Retention Level	1,175 MCM
Projected Irrigation Area	48,800 ha
Resettlement Families	620 families

Responsible agency for overall activities of study and project implementation of the Kaeng Sua Ten dam was transferred from EGAT to RID since December 1985.

(c) Mae Kok Multipurpose Project

In 1986, EGAT undertook a prefeasibility study of the Mae Kok multipurpose project. The study analyzed the possibility to divert water from the proposed Kok dam into the Yom catchment by gravity, either instead of or in addition to the Ing to Yom diversion where pumping of all water is required. However, the feasibility study on the Kok Diversion Project, which would complete a series of diversion studies and would be the basis for formulating the overall Kok-Ing-Yom-Nan Diversion Scheme, has been delayed since 1986.

In 1989, a joint proposal by EGAT and RID to upgrade the diversion project to the feasibility study level was submitted to be financed by EEC. The study was never carried out due to different views of both agencies on the consultant selection process, and it has been delayed since then.

Water shortages in the Chao Phraya basin have steadily been aggravated by rapid economic development activities. Strong environmental movements to protect the Kok and Yom rivers from construction of any major storage dams have prompted RID to search for better alternatives of diversion scheme.

(4) Kok-Ing-Nan Diversion Project

The Kok-Ing-Nan development scheme is proposed as one of the possible option to divert surplus water in wet season trans-basin from the river basins where runoff is abundant to the one where water is needed. The scheme as envisaged would first divert the water from the Kok river at the existing barrage already constructed by DEDP near the city of Chiang Rai. This would minimize environmental impact to the upper Kok basin since no large storage dam and reservoir is required. The diverted water would then be transported by gravity to the Ing and Nan catchments through a series of canal and tunnel systems to meet the requirement of water in the Ing and Nan valleys as well as in the Chao Phraya basin after once stored in the Sirikit reservoir.

The conceptual plan study of this project has just started in March 1996 by RID. The project will primarily be composed of two major project components, namely Kok-Ing diversion scheme and Ing-Nan diversion scheme.

Since the latter half of 1980s, social and environmental problems for construction of large and medium dam/reservoirs have become serious. Even construction of the Kaeng Sua Ten agricultural dam with the cabinet's approval has been suspended because of strong resistance of local inhabitants and activists against ecological changes and resettlement problem. It will not be realistic to expect implementation of the further stages of the Kok-Ing-Yom-Nan diversion project if a great number of inundated families within the reservoir area is taken into consideration. Moreover, it will not meet the water requirement in the Chao Phraya basin if implementation of the stage-I alone of the Kok-Ing-Yom-Nan diversion project has been achieved.

Meanwhile, the Kok-Ing-Nan diversion project is not a reservoir type project as a result bringing no or less problems concerning encroachment of watershed and forestry resources, people resettlement, land expropriation and others. The project in principle requires no pumping. Diverted water of some 2,000 MCM per annum will meet the existing space for additional storage in the Sirikit reservoir, and will fulfill the requirement in the Nan and Chao Phraya basins when a proper rule of the Sirikit reservoir operation is accompanied. Although the Kok and Ing rivers are the tributaries of the Mekong river, agreements for exploiting the water diversion within local rivers have already been achieved among riparian countries in 1995.

From every aspects as considered above, the Kok-Ing-Nan diversion project will be the one which can meet the water requirement and can be implemented in near future.

6.3.3 Water Agreement and Other Important Issues

(1) Water Agreement

The Governments of the Kingdom of Cambodia, the Lao People's Democratic Republic, the Kingdom of Thailand and the Socialist Republic of Vietnam, being equally desirous of continuing to cooperate in a constructive and mutually beneficial manner for sustainable development, utilization, conservation and management of the Mekong river basin water and related sources, have resolved to conclude an agreement on The Cooperation For The Sustainable Development Of The Mekong River Basin at the Fifth and Final Meeting of The Mekong' Working Group held on November 28-29 1994 in Hanoi, Vietnam.

Since the initiation of the proposed Kok-Ing-Nan Water Diversion Project in 1993, RID negotiated with the Mekong River Committee (MRC) to rectify Article 5 "Reasonable and Equitable Utilization in the Rights of Water Usage" in the Agreement on "Cooperation for the Sustainable Development of the Mekong River Basin" signed by four riparian countries in April 1995. The negotiations were successful and Article 5 was rectified allowing for every countries in the Mekong river basin to make use of the water in the basins of the Mekong river's tributaries in their own countries. More details are given in the Supporting Report.

(2) Notification of Two Tributaries Projects in Thailand

At the Joint Committee held on November 20-21 1995 in Ho Chi Minh city of Vietnam, Dr. Prathes Sutabutr, Head of the Thai Delegation, on the basis of Article 5 of the Agreement and in a spirit of goodwill and cooperation, notified the Joint Committee on two tributary projects being implemented by Thailand, namely, the Kok-Ing-Nan and Lamtakhong. The former is a feasibility study project involving a diversion plan of water to the Chao Phraya river basin. The latter is a hydropower project on the Lamtakhong river, a tributary of the Mun river, involving the use of water from the existing Lamtakhong reservoir for generating electricity by means of pump-storage. The Joint Committee acknowledged the notification by Thailand with great appreciation.

The minutes of the special session of the said Joint Committee is also compiled in the Supporting Report.

(3) Position in the National Economic and Social Development Plan

RID finally concluded in 1996 a master plan for the medium and large scale construction projects to be listed up in the 8th National Economic and Social Development Plan (1997-2001). According to the master plan, the proposed Kok-Ing-Nan water diversion plan is nominated as the large scale irrigation project of which detailed design works has been scheduled for the year 2000.

A national-level committee to (1) control the feasibility study and investment plan for the Kok-Ing-Nan Water Diversion Project conforming to the governmental policy and maximum benefit to the agricultural development, (2) consider the study result, steer and phase the implementation and (3) nominate sub-committee or working group as necessary, has been set up since February, 1998, nominating the committee members consisting of the Deputy Minister of the Ministry of Agriculture and Cooperatives (MOAC) as a chairman, and as a member, the Under Secretary of Ministry of Interior, the Under Secretary of Ministry of Science, Technology and Environment, the Secretary General of NESDB, the Secretary General of Budget Bureau, the Deputy Under Secretary of MOAC, the Director General of RID, the Director General of DTEC, the Secretary General of Office of Financial Economy, Dr. Apichart Anukulampai, Dr. Surapol Sudara, and as a member cum secretary the Deputy DG for Engineering of RID, and a member cum assistant secretary the Director of PPD, RID.

6.4 Necessity of Kok-Ing-Nan Water Diversion Project

The necessity of the proposed Kok-Ing-Nan water diversion project is summarized as in the followings;

- The socio-economic and agricultural developments toward 21 century in the Chao Phraya basin, especially in the Delta area holding a large irrigated farmland of 7.3 million rai, expanded urban area involving the Bangkok Metropolis with dense population of exceeding 12.0 million and developed industrial zone achieving successful growth has faced a strong anxiety of stagnancy because the area will face the critical water shortage problem due to limited water resources and increasing water demand in particular in dry season. This increasing tendency of water demand mainly for irrigation in the upper Chao Phraya basin will continue more and more in future, since the new Constitution of Thailand amended in 1997 authorizes the local government and community to manage the natural resources within their territory and the rural areas are still left undeveloped under unequal economic situation as compared with the urban areas. This trend of rural development particularly in water resources in the past years resulted a rapid decrease of the runoff of Chao Phraya river which provides the major source of water to the lower Chao Phraya basin. It is inevitably necessary to introduce additional water to the Chao Phraya basin to solve water shortage problem and to achieve sustainable development of the area in 21 century.

- The Thai Government has studied numbers of water resources development projects in the Chao Phraya river basin since the early 1980s intending to implement feasible projects to cope with water shortage problems at present and in future. Many of these projects are however confronted with difficulties mainly from social and environmental restricts. In addition, even if all of these projects have been implemented, the total volume of water resources to be developed in future by such large and medium scale storage dam projects are however limited to less than 4,000 MCM, and it will be consumed mostly for supplemental irrigation of wet season paddy in the tributary sub-basins where dams/reservoirs are constructed, meaning that there is no allowance at all to supply excess water in dry season to the Chao Phraya delta area.

- The Thai Government has studied as well a number of alternative plans of transbasin water diversion from the Salawin and Mekong rivers to the Chao Phraya basin since the 1980s. Many of such plans have, however, been judged to be no or less viable for project implementation due to difficulty of diverting water from international rivers which needs water agreement among riparian countries, long distance tunnel and high pumping head which require high construction and operation costs, no availability of suitable construction site of large scale dam/reservoir to regulate the bulk amount of wet season runoff as well as large environmental impact such as peoples resettlement to be induced by dam construction, etc.

- Under this situation, in early 1990's the RID initiated the transbasin water diversion plan from the Kok and Ing rivers to the existing Sirikit dam by means of construction of long diversion channels and tunnels crossing the mountain ridge which divides the Ing and Nan watershed areas. The plan was considered to be viable at the preliminary stage of the study made by RID because of lesser environmental impact than other trans-basin diversion plans and substantial volume of both excess amount of water to be diverted and available storage capacity of the Sirikit reservoir. The Conceptual Planning Study including the IEE and the

Feasibility Study together with the EIA made on Thai-side's initiative supported by JICA proved the necessity, viability, technical, engineering and economic feasibility of the project, as described later in this report.

- The proposed Kok-Ing-Nan Water Diversion Project intends to divert about 2,000 MCM of water from the Kok and Ing rivers during wet season. The diverted water is then transported through long-distance canal and tunnel to the head of the Nan river and stored once in the Sirikit reservoir for use in dry season. Improvement of the Sirikit reservoir operation would produce additional 800 MCM of dry season water. The Study explains the significance of the project to cope with the present and future shortage of water in dry season in the Chao Phraya basin, however, at the same time explicated the fact that the proposed Kok-Ing-Nan Project alone is not sufficient to fulfill the entire demand of water in future when the progress of water resources development and increasing demand in the upper Chao Phraya basin are taken into consideration. Another water diversion project, transbasin from the Salawin river and its tributaries to the existing Bhumibol dam will be the next target.

Figure 6.1.1 Existing and Future Development in the Upper Chao Phraya Sub-Basins

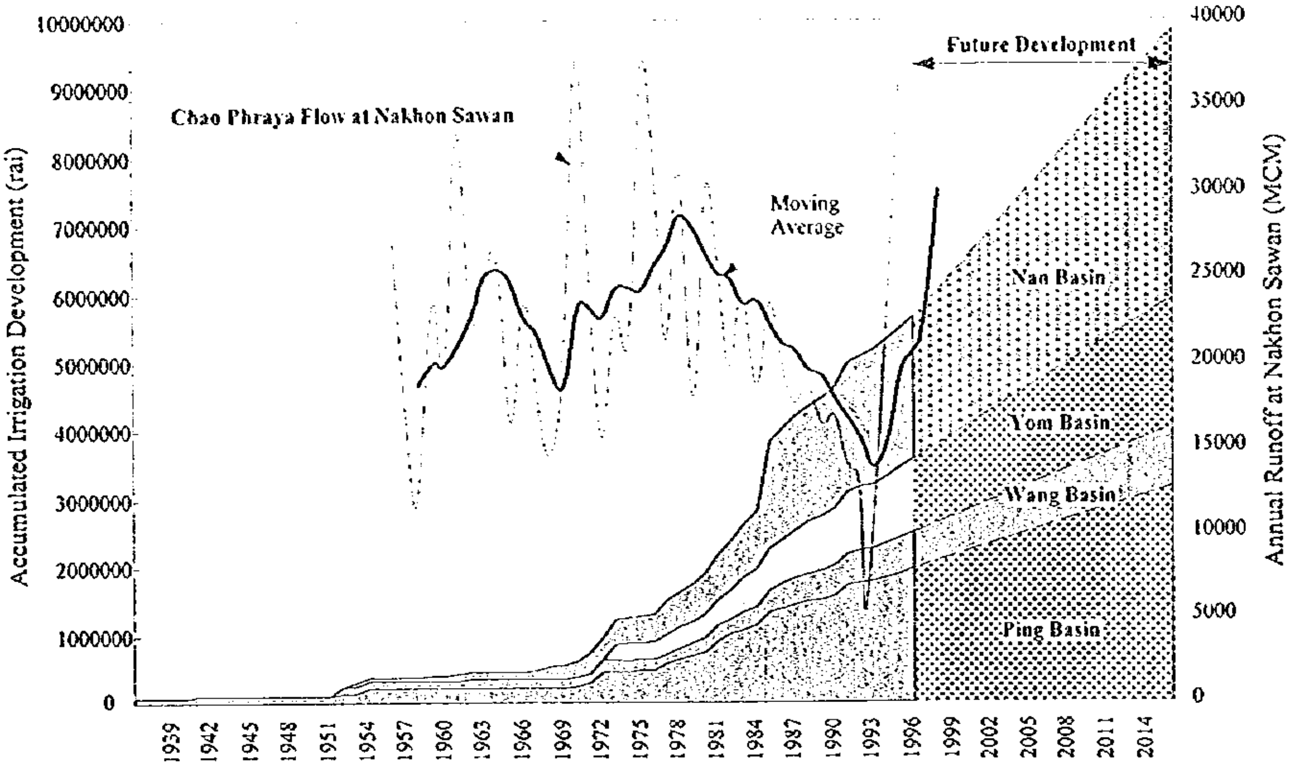

Figure 6.1.2 Past, Recent and Future Flow of Chao Phraya River at Major Stations

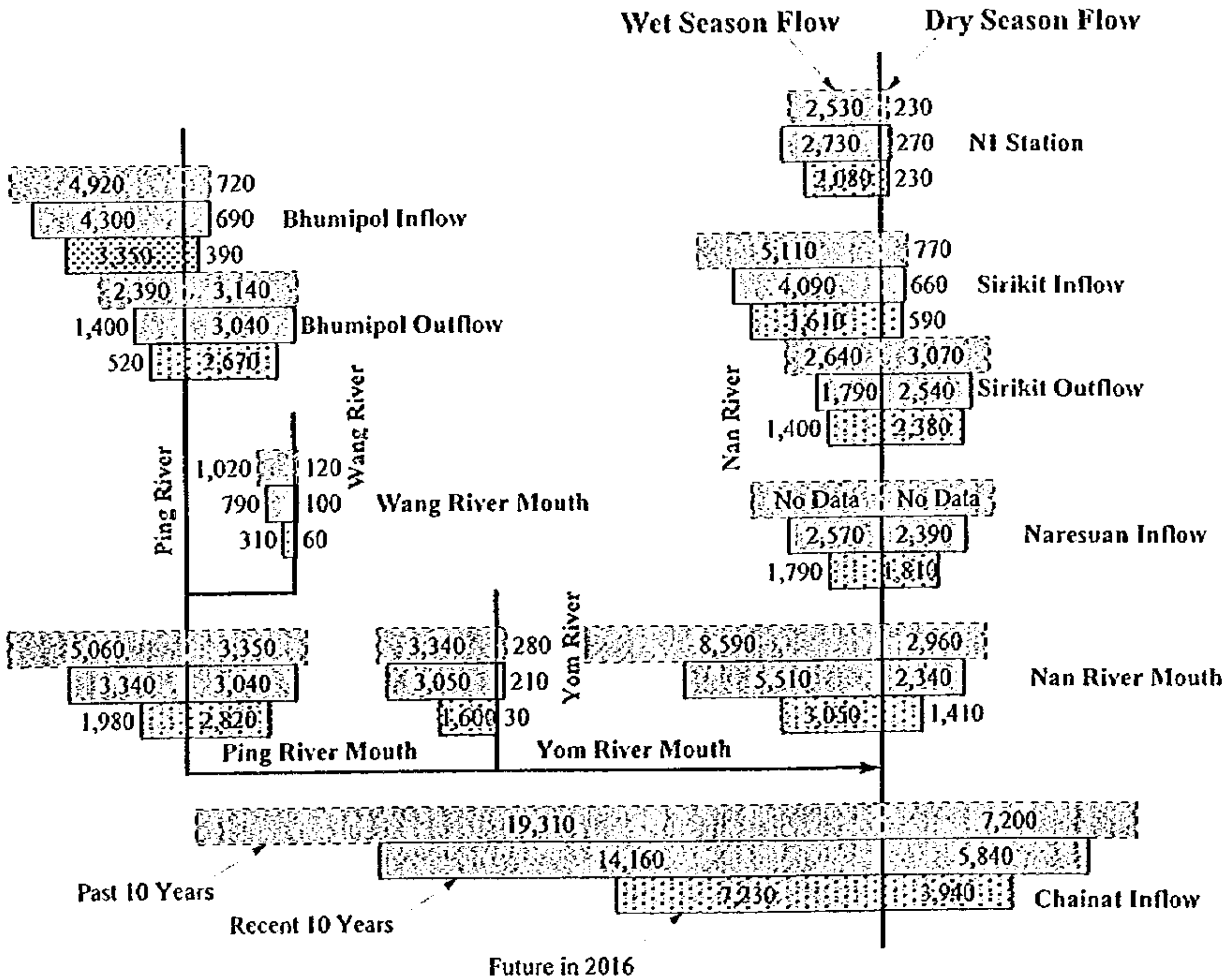

Figure 6.3.1 Location of Alternative Water Diversion Plan

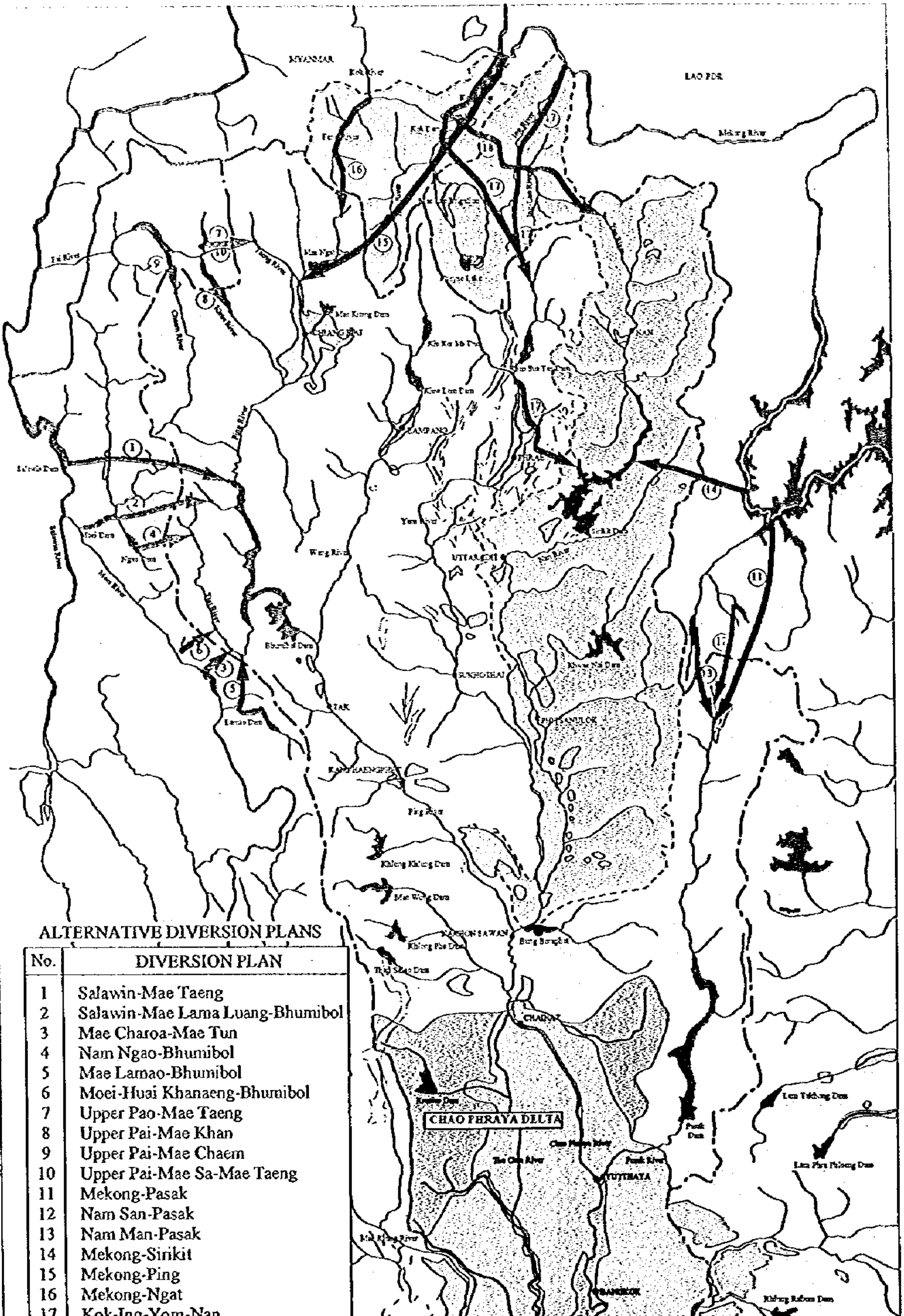

Table 6.3.1 Alternative Transbasin Water Diversion Plans

No	Alternative Diversion Project/Plan	Phase of Study	Agen-cy	Dam/Reservoir NHWL m,MSL	Dam/Reservoir Height m	Dam/Reservoir Storage MCM	Pump Head m	Canal/Tunnel Size m	Canal/Tunnel Length km	Annual Diversion m	Irrigation Area (ha)	Remark
1	Salaween-Bhumipol	Desk Study	EGAT	400	-	-			32/88	10,000	1,600,000	# International river, long tunnel
2	Salaween-Mae Lama Luang-Bhumibol	Pre-F/S	DEDP	155	100	344.0	329	Ø7.5	82	2,450	-	# National reserved forest
3	Mae Charoa-Mae Tun	Preliminary	DEDP	-	-	-	85	4.5	13	500	-	# National reserved forest # Watershed class 1A, 1B # Less irrigable area # Hard accessibility
4	Nam Ngao-Bhumibol	F/S	EGAT	270	80	-	235	Ø3.7	35.4	500	-	
5	Mae Lamao-Bhumibol	F/S	EGAT	255	60	94.3	48	Ø4.2	23.5	360	2,900	
6	Moei-Huai Khanaeng-Bhumibol	Pre-F/S F/S	DEDP EGAT	189	41	10.8	188	Ø7.5	18.5	1,100	-	# National reserved forest
7	Upper Pai-Mae Taeng	Preliminary Preliminary	EGAT DEDP	480	40 80	136	65 32.3	Ø4.4 3.3	27.3 27.2	500 368	- -	# National reserved forest # Watershed class 1A, 1B # Less irrigable area # Hard accessibility
8	Upper Pai-Mae Khan	Preliminary	EGAT	480	40	-	380	Ø4.4	15	300-500	-	
9	Lower Pai-Mae Chaem	Master Plan	DEDP	400			500	Ø3.5	15.5	500	-	
10	Upper Pai-Mae Sa-Mae Taeng	Preliminary	DEDP	475	40		non	3.8	42.8	416	-	
11	Mekong-Pasak	Preliminary	MRC		-	-	35		110	50cms	26,000	# Diversion from Laos # Low benefit
14	Mekong-Sirikit	Preliminary	MRC		-	-	-		60.5	50cms	26,000	
12	Nam San-Pasak	F/S	EGAT	686	-	235.0	non	2.5	3.6	88.5	4,040	# Resettlement problem
13	Nam Man-Pasak	F/S	EGAT	600	-	100.7	non	4.0	13.5	127.5	5,990	
15	Mekong-Ping	Desk Plan							185			# Ideal desk plan only
16	Mekong-Ngat	Desk Plan							127			
17	Kok-Ing-Yom-Nan	F/S	EGAT	284	96	4,450	85	17.8		3,237	34,280	# Resettlement problem
18	Kok-Ing-Nan	Under F/S	RID	-	-	-	non		110	2,000	200,000	