For improvement of economic efficiency, cropping of high market price and high yield per land and at lowest cost are necessitated. Selection of crops of high market price will require forecasting of demands and supplies and control of production quantities. And for achievement of high yield and low cost, intensive and collective farming of the right crops in the right lands have to be practiced.

Upon achievement of the above-mentioned conditions, the most important party to play key roles is farmers, of course, and it therefore requires promotion and improvement of their farming technologies and social status for the smooth achievement. In order to educate farmers so as that they can technically manage high-return farming for improvement of their own living standards and to reinforce their social status especially in marketing of farm inputs and outputs, promotion, establishment and reinforcement of their cooperative organizations will necessarily elaborated. And without this the achievement will be much delayed.

4.2 Present Water Management System

4.2.1 Administrative Organizations on Water Management

Administration of water management has been conducted by many government agencies in the respective fields. However, the largest agency is the Royal Irrigation Department (RID) belonging to Ministry of Agriculture and Cooperatives and the Electricity Generating Authority of Thailand (EGAT). Other than these two major agencies, many ministries and departments take part in the water management and water resources development according to their respective duties and purposes. (See Figure 4-1)

RID has 12 Regional offices throughout the country and these regional offices control project offices which belong thereto. Each project area is divided into several sections, wherein a water

master is assigned. A number of zonemen and gate tenders are also assigned under a water master to report on crops conditions and to control irrigation facilities.

4.2.2 Water Allocation Procedure

Water requirements to secure minimum flow at specified points for domestic and industrial uses and minimum power generation other than irrigation use are also considered in water operation planning.

A mathematic simulation model was developed by RID with help of the ACRES INTERNATIONAL INC. of Canada so as to program water release from reservoirs and allocation to project areas. The program was designed to run by an IBM computer Model 1130 which was the sole computer available for RID at the time.

Judging from the current technologies, structure of the model, due to limited capacity and capabilities of the old computer system, is too complicated and consists of prolix program statements. And, the model requires too much volume of data collection and processing to run under the centralized processing system of RID.

In order to ease the above, supporting sub-programs for improvement/restructuring of the model has been developed by the Study Team to reform them to fit to the VAX 11/750 computer system. (See details in a seperated volume of the Program Manual)

4.2.3 Farmer's Organizations for Water Management

Water users' groups and irrigators' associations have been established for equitable water distribution and maintenance of facilities. Requests for water distribution in the areas are arranged based on the crop information provided by RID's zonemen, and common irrigators supervise actual water distribution after FTO.

Considering inactiveness and poor participation by the existing water users' organization, it may be said that the groups are not functioning efficiently.

4.3 Evaluation of Water Resources

4.3.1 Hydrological Characteristics

Annual run-off from the basin shows 150 to 400 mm out of annual rainfall of 1,000 to 1,200 mm indicating run-off percentages as 15 to 30%. Annual run-off at Sirikit Dam shows 440 mm, and at Bhumipol Dam shows 230 mm. Annual run-off yield at Bhumipol Dam has been decreasing. 80 - 90% of total run-off occurs in wet season from April to October.

Annual water flow at Nakhon Sawan amounts to about 24,000 MCM including 10,000 MCM of water release from the dams. Annual flow in Pasak river shows 2,100 MCM and mean yield is only 140 mm, which is the lowest in the Chao Phraya basins. Sideflow from sub-basins implies water losses along canal including consumptive use in the basin, during September to January, while it appears as run-off caused by rainfall during February to August.

4.3.2 Study on Dam Operation

(1) Water balance simulation model

A water balance simulation model has been built so as to examine water availability for demand and supply. For the water balance study, Chao Phraya basin is divided into fourteen sub-basins, as shown in Figure 4-2, and the study has been carried out as follows.

1) Hydrology data such as rainfall and stream flow at selected gauging stations and cropped area, crop growing stages are used in the model, as a input data.

2) In the balance model, control factors such as return flow rate and irrigation efficiency are assumed.

3) Water requirements and availability of side flow are quantified in each sub-basin.

4) After the computation, reservoir operation simulation is carried out considering functions of the both dams and minimum flow constraint in the river system.

Water balance calculation has been made on monthly basis for simulation period from 1978 to 1986. Simulated water flows have been compared with recorded ones at various points for verification of the model structure. Propriety of the model has consequently been proved.

(2) Study on dam operation

Dam operation has been examined by the above simulation model. It has been found that the simulated operation is almost same as the actual one by RID. The results are summarized as follows.

- As the dams being operated without at full storage in consecutive years, influence of excessive release from reservoirs contributes to long-term decrease of dry season cropping area. Especially, excessive release in wet season in 1981 and May to July in 1986 is one of causes of decreased dry season cropping area in the subsequent drought years.

- Dam storage was continuously decreased from wet season in 1979 till dry season in 1980. Side flow in this wet season account for 30% of that in normal year; equivalent to 20-year return period. Annual rainfall in the Chao Phraya Delta was about 800 mm as compared with 1,000 to 1,200 mm in the normal year. Therefore, wet season crop in 1979 was much more dependent upon the dam storage. Furthermore, a large volume of release was carried out to maintain 1.3 million rai in the dry season in 1980. It therefore becomes necessary to establish systems for annual cropping and release planning to prepare for such drought years.

4.3.3 Irrigation Water Use

Amount of annual water resources available in the Chao Phraya Delta during 1977 - 1986 is shown as follows.

Season	Amount of Water Resources (MCM)		
	Release from Dams	Side Flow*1	Available Water
Wet	3,800	14,700	18,500
Dry	6,200	1,200	7,400
Total	10,000	15,900	25,900

Note: *1 Side flow at Nakhon Sawan and Rama VI Barrage
Wet season from Jul. to Dec.
Dry season from Jan. to Jun.

Sideflows are not expected from January to April and most of irrigation water for this period is dependent on water release from the dams. Meanwhile, annual use of water resources as follows.

Season	Annual Release			Average Irrigated Area	Rainfall
	For Intake*1	Minimum Flow Constraint*2	Ineffective Release*3		
	(MCM)	(MCM)	(MCM)	(10^6 rai)	(MCM)
Wet	6,700	2,000	10,760	6.1	8,900
Dry	4,200	2,000	1,060	2.7	3,900

Note: *1 Actual intake for irrigation in the delta
*2 Minimum release for salinity control and other purpose, at the main regulators.
*3 Other releases

Amount of ineffective release is only 1,060 MCM during dry season. Meanwhile, intake of 4,200 MCM corresponds to 0.6 l/s/ha. It has been found that, in dry season, available water is strictly and effectively taken in at major regulators and water release from the dams and through regulators are neatly controlled.

From viewpoint of water management, however, establishment of

monitoring system to minimize ineffective release is important during wet season.

(unit: MCM)

Water Balance in the Delta (1977-1986)

Season	Estimated Consumptive Use for Crop	Estimated Effective Rainfall	Water*2 Requirement	Actual Intake	Estimated Storage*1 in Delta
Wet	8,632	4,477	4,185	6,703	+2,518
Dry	5,709	893	4,816	4,184	- 632

Note: *1 Including ineffective groundwater flow
*2 Not considering irrigation efficiency

Seen from the above, it may be said that the stored water in canal network and underground during wet season is consumed in the next dry season as a conserved water source.

Relation between intake water and irrigation area indicates that water intake for conservation area as 0.2 - 0.5 1/s/ha is far less than that for gravity area as 1.0 - 1.5 1/s/ha in dry season, though those in wet reason are 0.2 - 0.7 1/s/ha in both areas. Return flows from the upper area are effectively used in the lower area in dry season.

Judging from water intakes a long-term basis, it may be said that water diversion by regulators is well controlled.

4.3.4 Irrigation Water Supply and Production Yield

Water inputs including effective rainfall for six months are 1,826 m^3/rai and 1,850 m^3/rai in wet and dry seasons, respectively and supply sources of irrigation water are estimated as follows.

Crop	Irrigation Water Supply (m^3/rai/6 month) Effective Rainfall	Reservoir Release	Side Flow	Total
1st Cropping	751	283	792	1,826
2nd Cropping	330	1,260	260	1,850

Note: 1st cropping from Jul. to Dec.
2nd cropping from Jan. to Jun.

Furthermore, relation between water supply (excluding effective rainfall) and production yield is estimated as follows:

Crop	Water Supply per Yield (m^3/rai/6 month) Reservoir Release	Side Flow	Total
1st Paddy	0.81	2.28	3.09
2nd Paddy	2.15	0.44	2.59

Reservoir release for the first paddy is basically supplemental. In 1979, however, reservoir release of 2.14 m^3/kg for the first paddy was supplied. Release was extremely much in this drought year, and release operation during the wet season was under the same manners as those in usual dry season.

4.3.5 Examination on Available Water

Judging from the present situation of irrigation water use, it is necessary for effective use of water resources to ease water stress to the dams in dry season by making better use of side-flows in wet season and return flows in dry season.

Effective use of water resources, though the degree is much dependent on completeness of water management system, may be achieved by well equipped information management through improved monitoring/communication systems, which enables improved side-flow forecasting and easy and prompt understanding of water behaviors in project areas.

After the completion of improvement system, water use efficiency of side flow and within project area will be able to be raised by 5 to 10%, in accordance with extension of monitoring/communication system improvement until at main canal level from reservoir. Amount of availed water is estimated about 1,000 MCM, which enables additional some 80,000 ha of dry season irrigation. (See details in ANNEX-2)

4.4 Present Monitoring/Communication System

4.4.1 Observation and Monitoring of Hydrological Information

(1) Rainfall

Observation of rainfall is mainly performed by RID and Meteorology Department. The number of observation stations is 623 in Chao Phraya basin and a station covers the basin area of 260 km^2.

(2) Water level and discharge

Hydrology Division is responsible for observation of water level and discharge of natural rivers, while water levels and gate opening at regulators are observed by O/M Division. In most cases, water level is measured with staff gauges. Water discharge at regulator is calculated by calibration curve or table developed from hydraulic formula or direct flow measurements. Some H-Q curves or calibration tables, however, are sometimes doubtful in their reliability.

Observed records are hand-written by field staff in the designated forms and are sent by radio system or mail. Taking into account of wide coverage of the basin, observation frequency, number of stations and reliability are considered quite satisfactory.

(3) Cropping and field moisture conditions

Those are conducted by zoneman who patrols his own monitoring area on weekly basis.

It may be difficult for zoneman to report field moisture conditions because he judges by eyes and it involves inevitable personal errors.

(4) Water release from reservoirs

Water release and hydrological data at Bhumibol and Sirikit reservoirs are observed by EGAT. RID receives the data/information from the head office of EGAT by telephone.

4.4.2 Present Communication System

Collection and transfer of water management information/data are carried out by the following communication facilities. Present conditions are as follows.

(1) HF/SSB radio

HF/SSB radio is mainly used for long-distance communication. Out of five frequency bands for RID, four bands are applied in the Chao Phraya Basin. In the lower delta, three frequency bands are allocated for 27 stations. 20 - 30% of total communication volume is for water management. The current HF/SSB radio communication of RID is poor in quality and apt to cause mistransfer of the data and information. And, it has nearly come to the limit of capacity that it will not be able to stand for the future increase in communication volume, as a basic communication line among major offices.

(2) VHF/FM radio

This is used for short-range communication, and there are four frequency bands available in the lower delta and used at about 30 stations. Their performance is relatively under good conditions.

(3) Private wire telephone

Most of project offices are provided with this system as main media of their communication within their territory. Telephone is magnetic switchboard type and with bare wire. This telephone system

has been installed more than twenty years ago and has some unstable transmission performance depending on weather condition. This system is old type and has been deteriorated.

(4) Portable wireless telephone

About 70% of project offices are provided with VHF/FM radio station of fixed type. Radio equipment of portable type are not furnished in their monitoring area. A half of project areas, however, have private one for daily communication within the territory. Output power of the unit is 1 - 5 watt. This telephone has become very popular instead of the time-worned private wire telephone, and it is quite essential in the near future to ensure a powerful and good quality communication system so as to avoid confusion.

(5) Motorcycle and boat

Motorcycle is used by zoneman to visit and supervise the field and report to water master. Most of vehicle are private ones. Boats are also used to monitor the field in the low delta, however, use of boats is decreasing as development of road networks.

TOT public telephones are installed in many offices, however, they are not used for water management, except some offices adjacent to Bangkok. Current system is by operators in their reading and writing by voice communication. As a result, there may be misreading and miswriting through data transmission.

4.4.3 Data Processing, Arrangement and Distribution

Collected data are arranged on daily or weekly basis and water level/discharge and rainfall data are filed into daily/monthly reports. Those data are also used for decision-making of water allocation in the delta.

Instructions for water allocation are distributed by the aforesaid RID communication system or mail on the weekly basis to project offices.

Data/information of demands for water release from the two reservoirs worked out by RID and those of hydrology, operation and storage of the two observed by EGAT are exchanged by telephone communication.

O/M Division uses a small display board for their water allocation planning. Water level and discharge of 25-30 key stations in the basin are written on this board to facilitate decision-making of water allocation. Improvement of such display system is required for water allocation. (See details in ANNEX-4)

In order to improve the above conditions, display panel with indicators has been introduced by the Study Team and various data processing system on the panel has been developed. (See details in a separated volume of the Program Manual)

4.5 Current Data Management System

4.5.1 Data Collection and Data Transfer

Data for water management are categorized into the followings.

(1) Farming data (growing stage and acreage by each crop, etc.)

(2) Hydraulic/hydrological data (water level, flow, rainfall, water quality, underground water table, etc.)

(3) Water operation records (gate operation, instruction from upper-ordinate office, etc.)

(4) Construction/repair/rehabilitation records (canal, regulator, etc.)

Data of the above categories (1), (2) and (3) are collected by zonemen and water masters, while of (4) are occasionally recorded by the Project/Regional/Head Offices.

Farming activities are reported from project offices to the Head Office weekly in two different forms.

At the end of each season, project offices are required to report seasonal summary. Most of the Sectional Offices (Water Master's Offices) under project offices conduct seasonal or annual survey in advance on planned cropping area before it starts. This is used as acreage indices in the season.

Data items (2) at key sites are reported regularly once a day, from project offices to the Regional Office. Regional Offices transfer the reported data to the Head Office and file the data for occasional reference. Operational instructions are filed in the offices concerned, except in the Head Office. Operational activities are recorded and filed in Project Offices/Sectional Offices. Out of difficulties in data collection answered by Project Offices, "insufficient knowledge of staffs concerned" has been aware by the Head Office, consequently O&M Division and Training Division are jointly working to improve educational/training programs for the staffs-in-charge.

4.5.2 Data Compilation and Data Processing

In the current data management system, all of data processing and most of data compilation are concentrated in the Head Office. This is because computerized data processing had necessitated professional knowledge, and because social requirement had not been so tight when the current system was planned. The current computer program system for water management was an epoch-making one which fully availed of hardware/software resource of the IBM 1130 model.

However, the latest decade has required better system, and many of new methods introduced during the time have failed in meeting with dynamic changes of technologies. Decentralized (distributed) data processing/management can be a solution for the difficulties above. By application of a concept of decentralized system to the water management of the Chao Phraya River Basin, flexible and prompt water allocation/distribution can be realized and efficiency of water use can be higher to relieve conflict among water users.

4.5.3 Data Custody and Data Retrieval

Through the site surveys and the questionnaire surveys, it has been found that offices concerned have several difficulties in data custody and data retrieval. In short, difficulties are in (1) indexing/filling of data and (2) data storage space. Satisfactory measures to the above (1) and (2) will increase data availability not only to the direct Sections/Divisions but also to the other Sections/Divisions concerned.

4.5.4 Other Aspects of Data Management in RID

RID has respectable history in implementation of numerous important works, therefore each Section/Division/Office has acquired much knowledge and experience supported by accumulated large volume of data. However, difficulties are in retrieval (search and obtainment). These suggest necessity of well-designed information inventory system. RID has also exerted to improve environment of data retrieval. Some Divisions have their own computerized systems, such as a personnel data base system of the Personnel Division, a SSIP project information system of the Small Scale Project Construction Division and O&M Division. Moreover, hydrological data-base system and newly-built dam safety data-base system have been set-up by the Divisions concerned under orientation by IEC specialists.

4.6 Current Irrigation and Drainage System

4.6.1 Functions and Capacities

Major irrigation and drainage facilities in the Study Area are mostly those constructed in 1930's and before, and those in Chao Phraya Delta belong to the oldest group and still maintain the original figures when constructed. A number of problems of those in the Study Area as compared with in the others are seen.

Standard water duty for structural design employed by RID until the early 1970's were 0.81 l/s/ha (equivalent to 5 mm/day in net and 70% efficiency then 7 mm/day in gross) for canals and 0.91 l/s/ha for canal structures under which most of irrigation facilities are designed in the delta. This water duty is about 60% of that for dry season paddy of 1.4 l/s/ha and about a half of that in the neighboring Meklong area of 1.7 l/s/ha. As is the background, capacities of the facilities become insufficient for land preparation and in areas of good drain soils as are in the northern delta even in wet season or in areas for dry season paddy irrigation.

Canal network and on-farm facilities were designed for supplementary irrigation of wet season paddy that distribution of the limited available water efficiently with minimum losses has become more and more difficult due to diversified water uses developed after the construction such as dry season irrigation and crop diversification. Water regulating facilities are installed at key places in the canal networks, and their regulating precisions and number are therefore insufficient. Though efforts for the improvement are continued, such way of distribution is still in difficulties.

In addition the facts that systems of the facilities are already old-fashioned and manually operated for most of water

regulating structures, deterioration and/or loss of their functions and capacities are widely emerged that RID is continuously carrying out repair and improvement works in the emergency order.

4.6.2 Maintenance and Improvement

Repair, improvement, replacement and additional construction of superannuated, damaged and obsolete facilities are planned and carried out by RID-Regional Offices. At present, "Irrigation and Drainage System Improvement 5-Year Plan (1987-1991)" is on-going to improve large and medium scale irrigation project areas in the whole country as outlined below.

Table 4-2 IRR. & DRAIN. SYSTEM IMPROVEMENT 5-YR PLAN (1987-91)
PROGRAMED BUDGET ALLOCATION (as of Feb. 1988)
(Unit : Mill. Baht)

Reg.Off	1987	1988	1989	1990	1991	Total
1	25	27	40	49	58	199
2	25	38	40	46	60	203
3	39	48	75	63	75	300
4	33	60	60	67	73	293
5	51	59	74	60	66	310
6	68	50	60	66	72	316
7	70	88	148	170	172	648
8	95	86	105	180	187	653
9	90	65	85	93	99	432
10	34	33	70	63	86	286
11	26	28	40	44	47	185
12	47	42	40	46	57	232
Total	603	624	837	947	1,052	4,063

Table 4-3 IRR.& DRAIN. SYSTEM IMPROVEMENT 5-YR PLAN (1987-91)
WORK CONTENTS IN 25 PROJECTS IN THE DELTA
(as of Feb. 1988)
(Unit : Mill. Baht)

Work Item	Gravity Irr. Area	Water Conserv. Area	Total
Irr. canal & appt. st.	232 (32%)	6 (2%)	243 (21%)
Regulator	83 (11)	228 (53)	311 (26)
Drainage canal	124 (17)	26 (6)	150 (13)
Bridge	68 (9)	42 (10)	110 (9)
Dike and appt. st.	165 (22)	76 (18)	241 (21)
Others	67 (9)	49 (11)	116 (10)
Total	744 (100) (64%)	427 (100) (36%)	1,171 (100) (100%)

TABLE 4-4 IRR.& DRAIN. SYSTEM IMPROVEMENT 5-YR PLAN (1987-91)
WORK BREAKDOWNS IN 25 PROJECTS IN THE DELTA
(as of Feb. 1988)

(Unit : Mill. Baht)

Work Item	Gravity Irr. Area	Water Con serv Area	Total
Irr. canal lining	102	-	102
Rehabili. irr.canal & appt.st.	135	6	141
Rehabili. regulator	60	214	274
Improv. regulator	23	14	37
Rehabili. drain.canal.& appt.st.	2	-	2
Rehabili. drainage struc.	107	11	118
Improv. drainage struc.	15	15	30
Lining farm ditch	13	-	13
Improv. pumping station	13	-	13
Rehabili. bridge	68	42	110
Rehabili dike	165	76	241
Improv. gate structure	8	26	34
Scoring protection	10	5	15
Others	23	18	41
Total	744	427	1,171
(Per-rai cost in Baht)	(155)	(120)	(140)

Shown in Table 4-2, budget for the improvement for the component RID-regions of the Study Area as Nos. 1, 2, 3, 7 and 8 is about half of the total and that for Regions No. 7 and 8 is one-third to imply proportional allocation by irrigable area. However in the delta, budget for the gravity irrigation area is more given than in the water conservation area as shown in Table 4-4. Summary of the work contents are as shown in Table 4-3, which indicates that irrigation and drainage canals are major work components in the gravity irrigation area while regulators are those in the water conservation area to imply necessity for improvement of the work type and large work volumes.

4.6.3 Field Conditions of Facilities and Necessity for their Improvement

In order to identify field conditions of the existing facilities and opinions of field staff regarding O & M and system improvement, the Study Team conducted a questionnaire survey to all project managers and their all water masters in the delta

(questionnaire formats in ANNEX-5 Form 3-1). A number of considerable differences have thereby been found among those in the gravity irrigation and the water conservation areas. Followings are findings from answers of project managers.

- Service area per official staff: 2,700 rai in the gravity irrigation (hereinafter referred as GI) area while 3,100 rai in the water conservation area (hereinafter referred as WC) with a 10% difference.
- Service area per employee: 139 rai in GI area while 304 rai in WC area; about double.
- Danger on canal and canal structures: more in the WC area.
- Required inputs for satisfactory and efficient achievement of duties: in both area qualified staff, vehicles, communication and office equipment and staff training programs are strongly wanted.

Findings made from answers of water masters are given in the followings.

Service area per staff:	(GI Area)	(WC Area)
per water master	85,000 rai	124,000 rai
per zoneman	13,500	31,000
per gate tender	5,100	9,800

- Water shortage in dry season: 27 sections (47% of section in number) in GI area while 17 sections (60%) in WC area.
- Flood damage: 35 sections (60%) in GI area while 19 sections (68%) in WC area to imply wide-spread flood over the delta.
- Problem in water quality: none in GI area while 18 sections (64%) in WC area.

Various requirements for improvement and rehabilitation works wanted by the responsible field staff, who are supposed well aware of the above-mentioned, have been compiled and summarized. After some modifications due to some erroneous answers and settings of unit work costs, estimation of work volumes and costs have been made.

In GI area, totals of 4,500 km of canal including 65% and 71% of the existing irrigation and drainage canals respectively, 3,000 km of dikes and roads and 92% and 34% of regulators (Po-To-Ro) and pipe-regulators (To-Ro-Bo) respectively are wanted for some measures. In WC area, totals of 6,400 km of canals, 900 km of dikes and roads and 74% and 90% of regulators (Po-To-Ro) and pipe-regulators (To-Ro-Bo) are wanted for some measures. (See ANNEX-5, wherein Table 3-20 for the work volumes, Table 3-22 for cost conversion and Table 3-23 for modified costs.) Per-rai costs by project areas in the delta have grouped in to three, which are named "Intensive", "Moderate" and "Conservative" request for improvement, and their average per-rai cost has been worked out as standard per-rai cost for the groups and to interprete that into requested degree for improvement as shown below.

Table 4-5 ESTIMATED UNIT COST FOR IMPROVEMENT
(at water master level)

(Unit: Mil. Baht)

Degree of Request	Gravity Irr. Area	Water Conserv. Area
Intensive	1,200	1,700
Moderate	600	800
Conservative	270	550

The above unit costs are those for facilities at water master level and therefore employed as those for lateral level facilities. Unit costs at on-farm level and main canal, and definitions of levels and work volumes have been set-up (as shown in ANNEX-5, Table 5-3), and then total improvement costs of each of 25 project areas in the delta have been worked out by degree of request cases (as shown in ANNEX-5, Table 5-5). The summarized results as compared with the on-going" 5-year Plan (1987-1991)" are in the following table.

Table 4-6 ESTIMATED IMPROVEMENT COST WANTED IN 25 PROJECT AREAS IN THE DELTA AND BUDGET FOR ON-GOING IMPROVEMENT 5-YR PLAN

(Unit: Mill. Baht)

Imp. Cost/Budget	Gravity Irr. Area	Water Conserv. Area	Total	Remarks
(Wanted by Field Offices)				
Intensive request	14,760	12,690	27,451	(23 times)
Moderate request	7,368	6,177	13,545	(12)
Conservative request	3,948	3,648	7,596	(6.5)
Sus. Imp. 5-year Plan (Total of 5-year budget)	744	427	1,171	(1.00)

As shown above, the total budget for the 5-year plan is far less than that wanted by responsible field staff. For meeting with even the "Moderate" request, it requires the 5-year plan 6.5 times or more than 30 years if the present pace continues. The above accordingly suggests their keen concern and necessity for improvement.

4.6.4 Evaluation of Irrigation and Drainage Systems

Upon formulation and planning for improvement of functions and capacities of irrigation and drainage systems, programing of work subjects and their work order have to be made and require evaluation of some factors in each subject system. Figure 4-3 shows five evaluation factors and 9 indices herein proposed; the latter are independent variables to define the former as follows.

Values of indices have been converted into are those divided by the sample mean to yield 1.00 as a sample mean, and values of the evaluation factors are calculated by the following formula to yield zero-values as a sample mean.

(Evaluation factor value) = 1/3 ((+/-) (Index value - 1.00))

(N.B. (+/-): (+) for affirmative index to the factor
(-) for negative index to it

Evaluation of each factor of the systems of 25 project areas separately in GI area and WC area in the delta has been made, and an addition factor for integrated evaluation has been assumed to imply "Goodness" of systems by calculating an average value of 4 evaluation factors except "Degree of importance". The outcomes are shown in Table 4-7.

In right columns of the Table, an example application case for determining work implementation priority order is presented, wherein priority is assumed to be given to the project areas of (1) not satisfactory functioning, (2) not easy operation, (3) good economic justifiability and (4) not advanced farming. Therefore, an integrated evaluation factor of "Priority for implementation" is defined as follows.

(Priority for implementation) = 1/4 (Degree of functional satisfaction) x (-1) + (Operational easiness) x (-1) + (Economic justifiability) + (Degree of agri. advance.) x (-1))

Consequently, priority number in descending order of the evaluated values are given in the right column of the Table.

Figure 4-3 RELATION BETWEEN EVALUATION FACTOR AND INDEX

(EVALUATION FACTOR)	(RELATION)	(INDEX)
1. Degree of importance		1. Service area
2. Degree of agricultural advancement		2. Land consoli. rate
		3. Cropping intensity
3. Operational easiness		4. Crop diversifi. rate
4. Economic justifiability		5. Water behavior stability
		6. Oldness of facilities
5. Degree of functional satisfaction		7. Functional degree
		8. Necessity for improvement
		9. Cost for improve.

(N.B. See detail methods in Tables 4-1, and 4-2 of ANNEX-5)

Table 4-7 EVALUATED RESULTS OF SYSTEMS BY PROJECT AREA IN THE DELTA AND AN EXAMPLE OF DETERMINING IMPROVEMENT PRIORITY

	Evaluated Value						*	Example		*
Proj. Area	Impor tance	Funct. Satis	Opera. Easi.	Econo. Jusstif.	Agri. Advan.	System Goodns	*	Imp. Priori.	Pri- ority	*
(GRAVITY IRRIGATION AREA)										
PLTP	-0.44	-0.17	0.26	-0.43	-0.56	-0.23	*	0.01	10	*
TABT	-0.31	0.18	0.47	-0.21	-0.53	-0.02	*	-0.08	14	*
SAMC	1.67	0.12	-1.38	1.68	1.98	0.60	*	0.24	2	*
DONC	0.48	-0.00	-0.67	0.57	1.00	0.22	*	0.06	6	*
POPY	-0.20	-0.08	0.21	-0.17	0.09	-0.17	*	0.09	5	*
BORM	-0.15	0.16	0.32	-0.16	0.79	0.28	*	-0.36	17	*
CHAN	0.01	0.15	0.55	-0.03	0.46	0.28	*	-0.30	16	*
YANG	-0.43	0.08	0.35	-0.27	-0.72	-0.14	*	0.00	11	*
PAKH	-0.46	0.04	0.52	-0.42	-0.72	-0.15	*	-0.07	13	*
BANB	-0.54	-0.44	0.55	-0.80	-0.72	-0.35	*	-0.05	12	*
MANR	-0.34	0.28	0.29	-0.17	0.41	0.20	*	-0.29	15	*
CHNG	0.56	0.15	-0.56	0.73	0.89	0.30	*	0.06	6	*
KOKA	-0.42	-0.27	0.32	-0.51	-0.69	-0.29	*	0.03	9	*
RUNR	0.47	-0.27	-0.63	0.18	0.24	-0.12	*	0.21	3	*
MAHA	0.87	0.05	-0.74	0.67	0.27	0.06	*	0.27	1	*
PASK	-0.39	0.03	-0.06	-0.27	-0.69	-0.25	*	0.11	4	*
NKNL	-0.38	-0.01	0.21	-0.37	-0.72	-0.22	*	0.04	8	*
(WATER CONSERVATION AREA)										
CHBY	-0.44	0.02	0.35	-0.40	-0.43	-0.12	*	-0.08	7	*
PYBL	-0.09	-0.07	0.18	-0.11	-0.11	-0.03	*	-0.03	3	*
PYPM	-0.03	-0.13	-0.00	0.10	0.10	0.02	*	0.03	3	*
PASI	0.72	0.04	-0.91	0.95	0.89	0.24	*	0.23	1	*
RNUA	0.36	0.03	-0.39	0.28	0.33	0.07	*	0.08	2	*
RTAI	-0.16	-0.05	0.32	-0.38	-0.28	-0.10	*	-0.09	8	*
KDAN	-0.17	0.11	0.14	-0.29	-0.25	-0.07	*	-0.07	5	*
PRAO	-0.18	0.04	0.32	-0.16	-0.25	-0.01	*	-0.07	5	*

4.7 Interrelation among Water Management, Agricultural Production and Marketing System

4.7.1 Problems on Land Use in the Basin

In the past, efforts for increasing agricultural production have been made through mainly expanding cultivable land as well as providing irrigation facilities for the existing cultivated land. However, the former has generally caused destruction of the forest land, and the latter has brought availability of water resources more tight, especially during dry season. The ratio of forest land against total national land has lowered below 30% which is called as dangerous level in monsoon countries, and caused various adverse effects from viewpoints of environment and water management. For example, sometimes floods and ineffective release of river flow happen, because of shorter time span that rainfall flows down as river discharge, due to less holding capacity of water in the basin. Furthermore, there exist some fear that incremental sediment produced by soil erosion in the upper stream would shorten durable life of the existing storage dams. In the Chao Phraya river basin, there exists approximately 40% of forest land comparing the national average of 30%, but it has decreased by 2.7 million hectares, equivalent to annual decreasing rate of 2.46%. Therefore, it is considered inappropriate to expand cultivable land through conversion of the forest land any more.

According to the mosaic map arranged by a remote-sensing technique and the existing available data, land use in the Chao Phraya Delta can be summarized in the following. A soil type is basically formed by heavy clay, in which paddy is mostly grown. In addition, there exist a wide belt of acidic soil in the central part of Delta, including Ayutthaya, in which an important theme is how to properly maintain groundwater table. In the area adjacent to Bangkok Metropolis, farm land has rapidly sprawled by expansion of residential and industrial areas, and it has caused deterioration in

water quality for irrigation purpose. This phenomenon is obvious through that cultivators of flowers, mainly orchid, and aquaculturists are forced to move to other area, seeking good quality of water. In improving the present water management system, careful attention should be paid not only to secure quantity of water but also its quality.

4.7.2 Land Productivity and Water Management

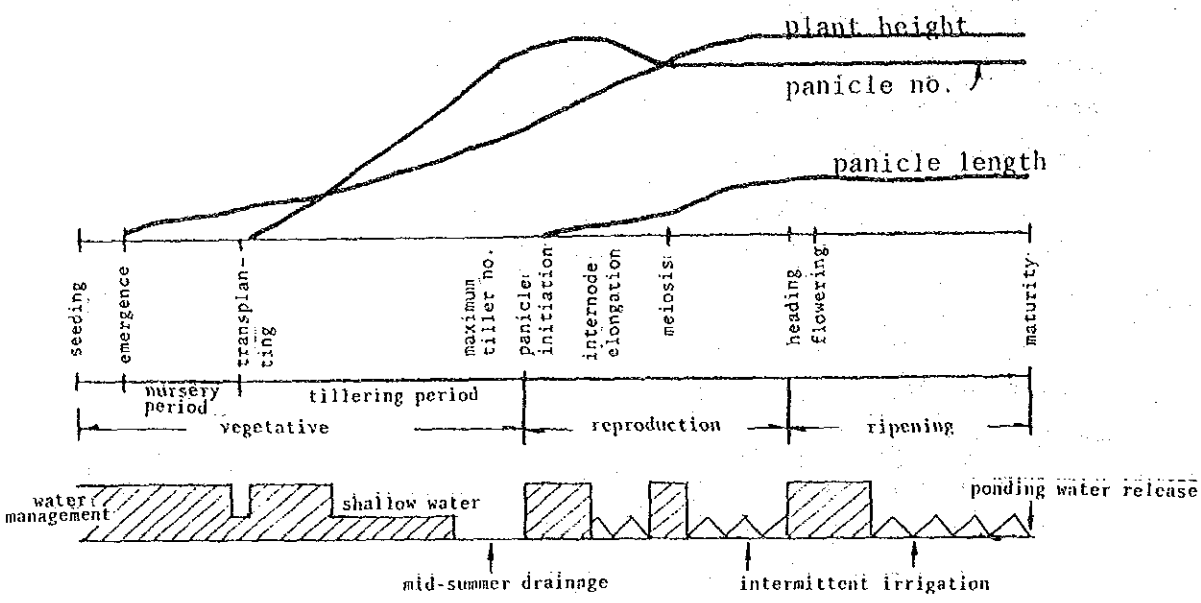
When there exists a limitation in expanding cultivable land, the way for the basin to follow is to increase a land productivity, in other words, to increase crop yield. The following shows comparison of paddy yield;

Comparison of Paddy Yield

(Unit: Kg/ha)

	Dry Season	Wet Season	Dry + Wet
Thailand			
- Chao Phraya Delta	3,830	3,310	3,472
- Whole Kingdom	3,519	1,813	1,913
Indonesia	n.a.	n.a.	4,050
Burma	n.a.	n.a.	3,200

Paddy yield in the Delta ranges from 2.1 to 4.4 tons per ha in wet season, 2.3 to 5.6 tons per ha in dry season. A basic factor to increase crop yield is that farmers shall make efforts to apply more dosage of input materials such as fertilizers, chemicals, etc. Specially in paddy farming as shown in the following figure, to maintain water depth suitable to each growing stages from nursery to harvesting, results in increasing yield as clarified through various kind of experiments. In case of irrigation for diversified crops, method and irrigation interval differ, depending upon field conditions (soil type and slope) and kind of crop grown. Thus, similar to paddy cropping, more sophisticated water management for the said crops would contribute to increase their yield.



For the purpose of realizing the said requirements, it is prerequisite to improve the water management system from viewpoints of soft- and hard-wares so as to timely supply proper amount of water as well as to give advise to farmers by extension workers, to manage proper supply of water by zonemen of RID, and to follow proper water management discipline on-farm level by farmers themselves.

4.7.3 Plot-to-Plot Irrigation

In Thailand, paddy field with land consolidation works is very limited, and thus a plot-to-plot irrigation method is commonly practised. In this method, paddy field along an irrigation canal can directly intake water from the canal, on the other hand, most of paddy fields are irrigated one plot to another from higher portion to lower one, because they are located far from the canals. Drainage is similarly practised as irrigation, which means that a

drainage water from one plot is used for an irrigation water of the next plot. In this system, the lower plot tends to have severe drought damages as well as inundation damages. Furthermore, it is difficult to adopt proper water management coping with plant growing stages as mentioned in the previous paragraph 4.7.1. In this regards, it is necessary to promote land consolidation works, of to carry out even and proper distribution of water among members in water users' organization and to reinforce such organization.

4.7.4 Gravity Irrigation and Conservation Irrigation

Regarding irrigation method, the Chao Phraya Delta may be divided into two, namely gravity irrigation area in the upper part and water conservation area in the lower part. Figure 4-4 shows change in paddy cropping in the both areas from 1974 to 1986, indicating that more cropped area in the gravity system during wet season and the reverse situation during dry season. Especially in the drought year of 1980, cropped area in the conservation system considerably exceeded that in the gravity system.

According to the field investigation concerning with irrigated area during dry season for both irrigation system, in the Gravity Area, dry season irrigation is evenly carried out through annual rotational irrigation by dividing the area into two, either upper area and lower area, or left bank area and right bank area. On the other hand, in the Conservation Area, only farm land along a canal is irrigable every year, resulted in occurrence of unequal distribution of farm income.

4.7.5 Water Management for Problematic Soils

Acid sulfate soils and saline soils occur very extensively in active and former tidal flats of the Southern Central Plain. They cover an area of about 900,000 ha and are main problem soils in Thailand. For utilization of these soils having potential acid soil layer at shallow depth, two approaches are possible.

(1) Limit pyrite oxidation and try to inactivate existing and potential acidity by maintain a suitable high water table.

(2) Drain intensively to achieve maximum oxidation of pyrite and try to remove the acidity by leaching.

The soils of the Chao Phraya Delta are very fine textured and have poor hydraulic conductivity. It is very difficult for these soils to drain intensively and to remove the acidity, if sufficient fresh water could be available. Therefore, (1) is preferred.

In the neighborhood of Bangkok, the soils artificially piled on ridges are used for cultivation of vegetables and fruits trees. In these soils groundwater table is maintained about 70 cm below the soil surface and the acids in the piled soils are leached by frequent irrigation with water from the ditches between the ridges. This land use technics is a wise method preventing the soil damage and using land efficiently, if economically possible.

4.7.6 Floating Rice

Near and around Ayutthaya, the ground level is comparatively low and three rivers of Lop Buri, Pasak and Noi join with the Chao Phraya River, therefore, the area suffers periodical and sever inundation which continues until December when water level in Chao Phraya River starts to decrease. In such area, a floating rice is grown, which stands coping with increase of water depth, and total cropped area of the rice reached to 228,300 ha in 1986/87. Although the floating rice occupies a field for long time (210- 220 days) and gives low yield (1.0 - 1.5 tons/ha), it is an important crop in the area where higher yielding variety could not be grown, as explained in the above. The inundation areas also have a function to retain flood discharges in the Chao Phraya River system and to protect Bangkok Metropolis from floods, and the role would not be changed until some concrete measures will be taken for flood protection as well as drainage system in the Chao Phraya River Basin.

4.7.7 Crop Diversification

Due to stagnation of rice price in the world market, not only profitability of paddy cropping at farmers' level has been deteriorated, but also share of rice in the Thai export earnings has been decreased. On the other hand, dry season paddy cropping acreage has been increasing in parallel with promotion of constructing irrigation facilities in the basin. Eventually, available water resources in the basin has become quite tight and marginal. In this regards, it is one of prerequisites to promote crop diversification introducing more field crops from viewpoints of efficient and equitable use of irrigation water.

At this moment, following constraints on promoting crop diversification in the Study Area are detected;

i) Soil condition in the delta (Heavy Clayey Soil)
ii) Existing irrigation facilities could not meet with introduction of furrow/sprinkler irrigation
iii) Non-existence of marketing channel for field crops
iv) Non-existence of farmers' attitude and know-how for field crops which are more risky than paddy.

On the other hand, cultivation of fruits and vegetables at the raised bed is intensively practised in the Rangsit Nua project area and the suburbs of Bangkok Metropolis. The raised bed cultivation method requires a quite big investment, but it is quite suitable in the lower delta, which controls groundwater table so as to prevent soil acidity, and keeps irrigation water in furrows for dry season. Therefore, introduction of the cultivation method has to be carefully studied in the frame of improved water management system in the basin, taking into consideration of the constraints as mentioned above.

4.7.8 Farmer Level Water Use Organization

(1) General

In connection with water use organization at farmer level, there exist the Water Users Group (WUG) in the large scale existing project and People's Irrigation in the upper basin, of which main objectives are equal distribution of water as well as proper maintenance of irrigation facilities. While the People's Irrigation has been well managed as an organization contributing to rural society with historical tradition, WUG is generally not well organized and operated, and further some of them had been dissolved already.

(2) Water users group (WUG)

One water users group covers about 1,000 rai (160 ha) and 20 to 30 farm households. A group of this kind is organized in the areas in which irrigation system is well consolidated as the Chao Phraya Delta; however, the group's activity is not so active due to negative collaboration among members and lack of understanding on efficient use of irrigation water, etc.

(3) People's irrigation

In Chiang Mai valley, there exist traditional water use organization having nearly 700 years' history, which are organized by every weir or diversion structure. At present there are 2,000 of the organization, of which command area ranges from 3,000 to 5,000 rai (480 ha to 800 ha). For the chief, beneficial farmers contribute 7 to 20 kg of paddy per rai in case of achieving good yield in the irrigation command. Maintenance works for turn-outs and canals are obligatorily carried out by member farmers themselves, who traditionally compose rural society as well, and rules for water allocation and structure repairing have been historically established. In comparison with the WUG mentioned above, the People's Irrigation is being quite successfully operated and managed.

Table 4-1 CHRONOLOGICAL PERFORMANCE OF R. I. D.

Year	Events Related to Water Management in the Chao Phraya River Basin
1890	- Private enterprise(England) initiated swamp development in Rangsit
1903	- Canal Department established by King Som dej Phra Chula Chomklao (Rama V)
1914	- RID was established by King Rama V
1915-1924	Pasak Tai Project (Rapee Pat Canal, Rama VI Barrage) was established by King Som dej Phra Mong Kut Klao (Rama VI)
1923-1932	- Pho Phraya Project was established
1927	- RID name was changed to Water Resources Development Department by King Som dej Phra Pok Klao (Rama VII)
1929-1963	- Ma Kham Thao Project was established
1935-1955	- Samchook Project was established
1939-1963	- Tung Fang Tawan Tok was established
1949	- Ditch & Dike commenced (FAO)
1950	- Greater Chao Phraya Project commenced by IBRD loan
1957	* Chainat Dam completed
1964	* Bhumibol Dam completed
1969	- EGAT established (May 1)
1970	* Vajiralongkorn Dam completed
1972	* Sirikit Dam completed
1973	- On-farm development commenced under Land Consolidation Act
1976-1982	+ Chao Phraya Meklong Basin Study commenced by cooperation of Acres International
1977	- SSIP Project commenced
1979	- Water Management System commenced operation - Severe Drought over country - Government established Adhoc Drought Relief Committee
1980	- Job Creation Project started for Relief of Drought - Severe Flood around Bangkok - Big deduction of Dry Paddy Area in the Greater Chao Phraya Project * Srinagarind Dam completed
1983	- Severe Flood around Bangkok
1984	* Khao Laem Dam completed
1985	* Narusuan Dam completed - Irrigation Engineering Center opened (April)
1986	- Scope of Works on the Water Management Study agreed between RID and Japanese Side (May) - Irrigation Subsector Report (IBRD) issued.
1987-1989	+ Water Management Study commenced (January)
1987	- Severe Drought at early Wet Season in Chao Praya Basin
1988	- Severe Flood damaged Southern Region (November)

Notes
* : Completion of Large Scale Hydraulic Structures
+ : Commencement of Water Management Studies

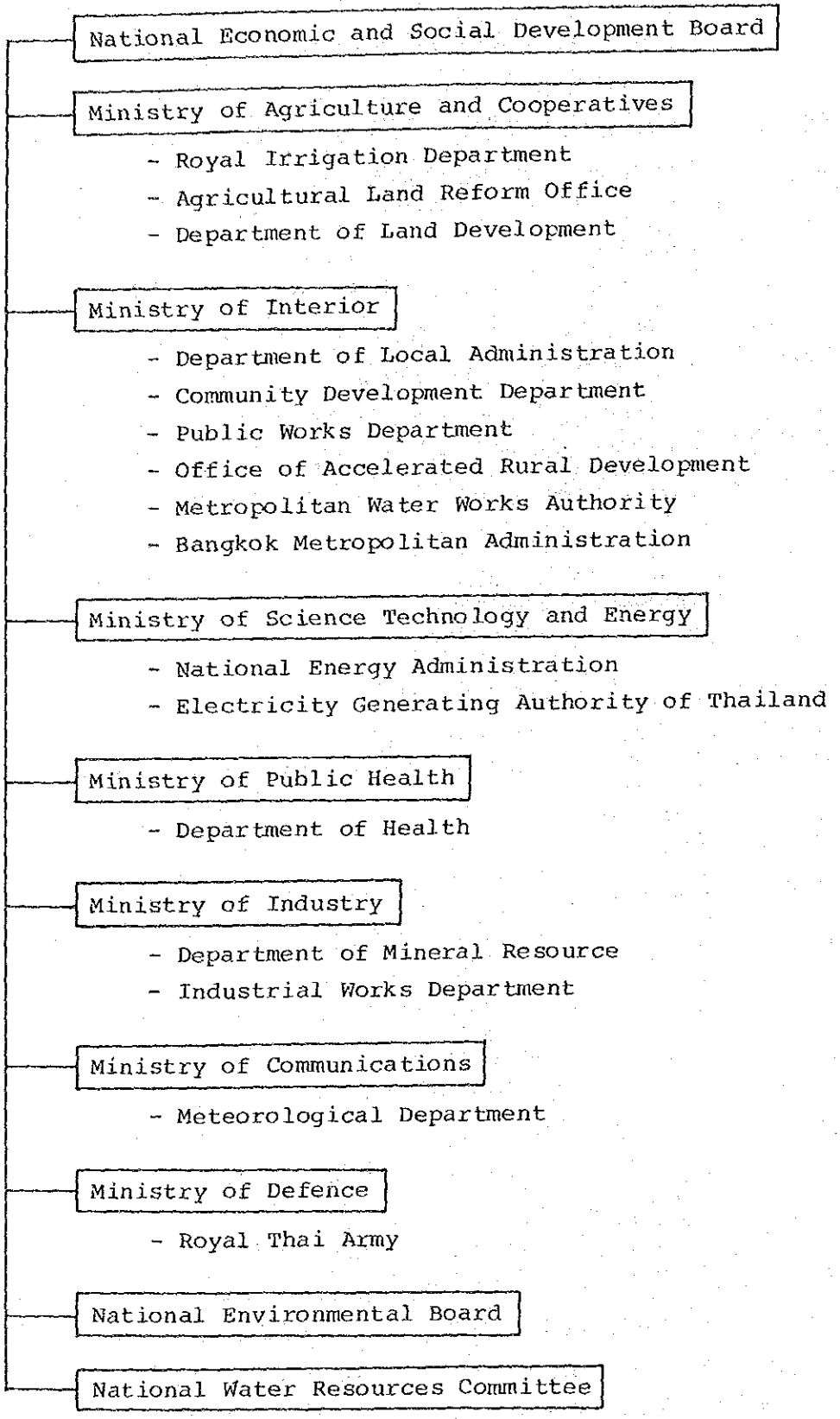


Figure 4-1 GOVERNMENTAL AGENCIES ON WATER RESOURCES DEVELOPMENT

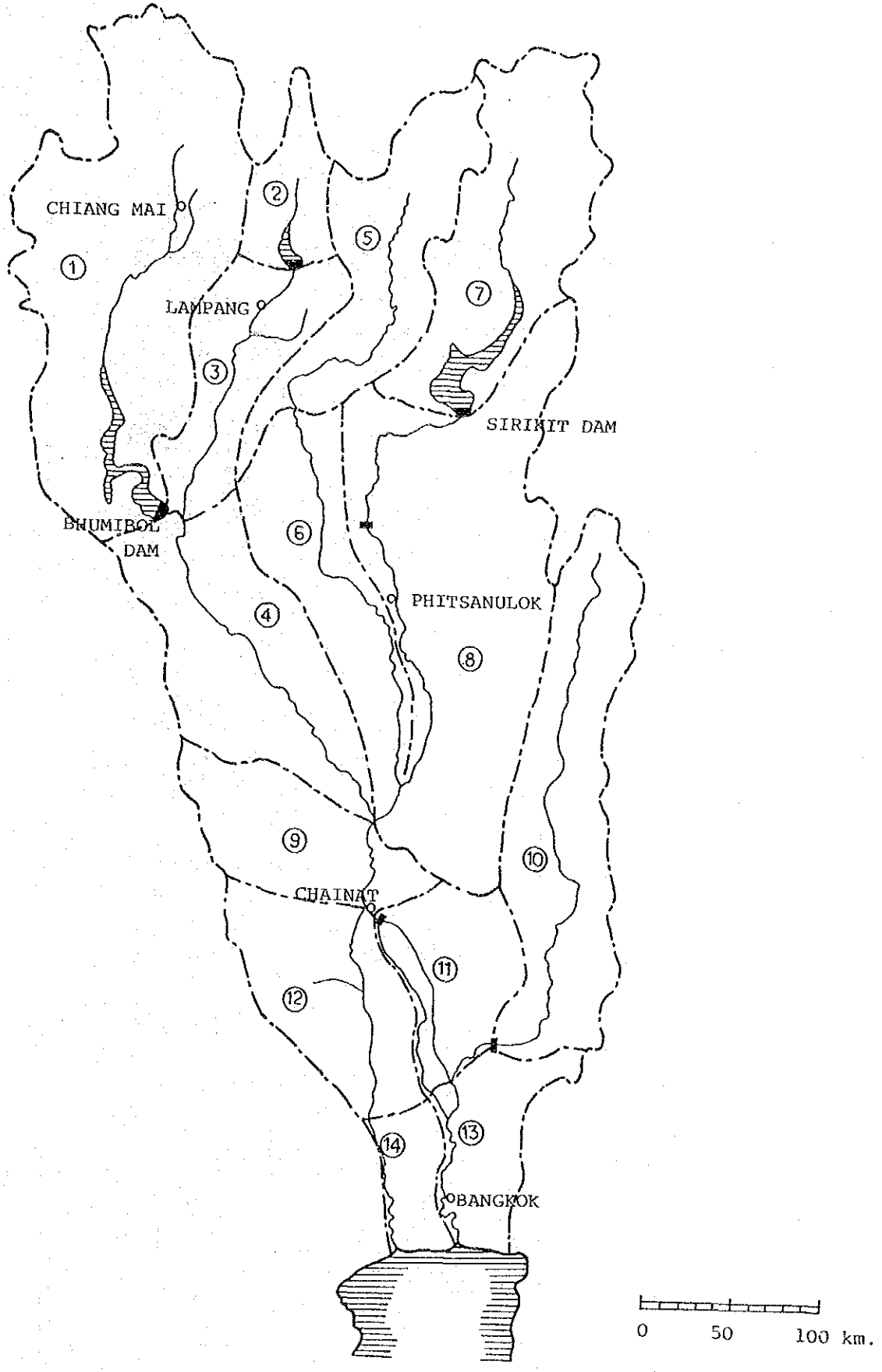


Figure 4-2 SCHEME OF SUB-BASIN IN CHAO PHRAYA RIVER

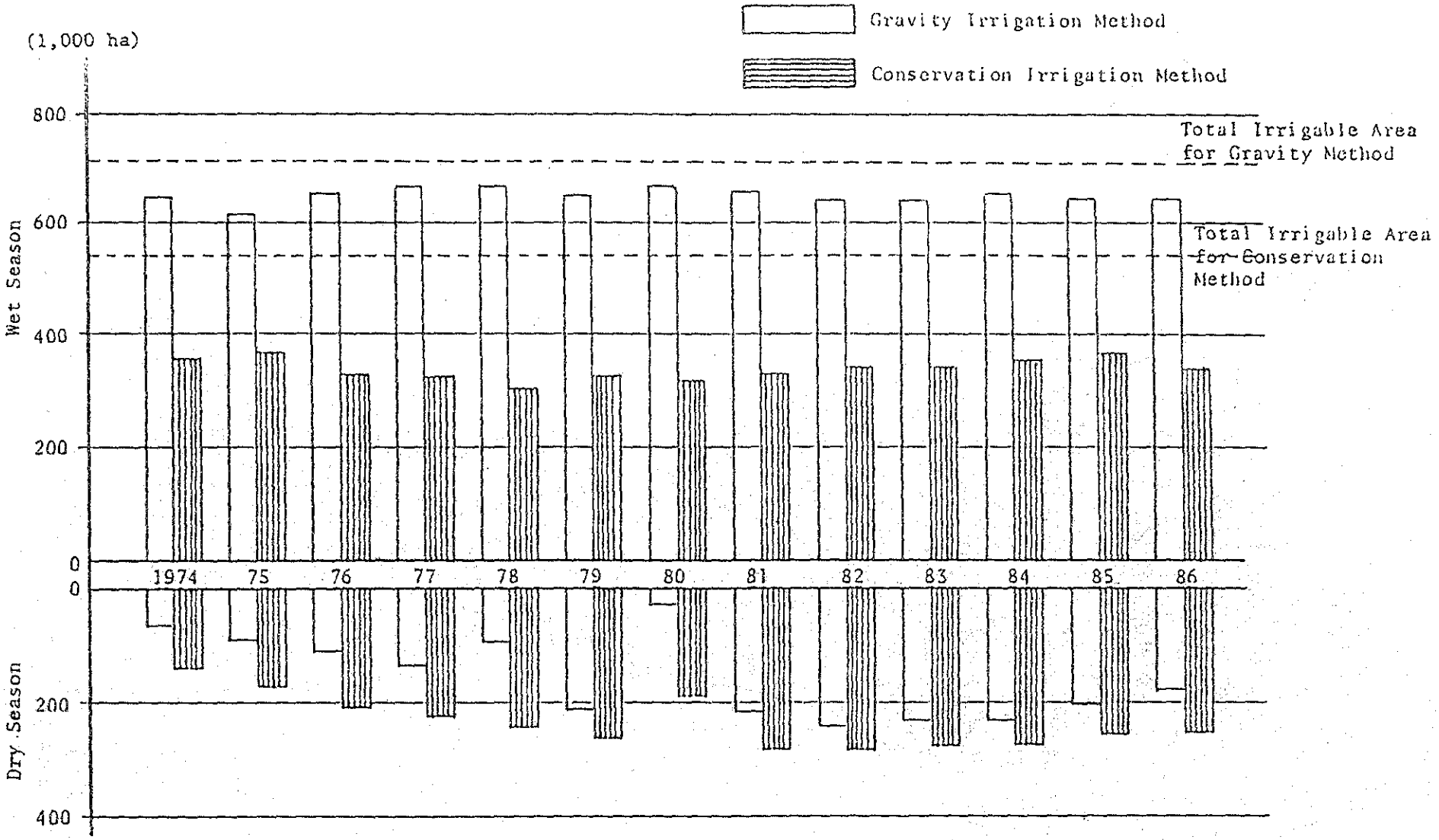


Figure 4-4 PLANTED AREA BY IRRIGATION METHOD

CHAPTER 5

PLAN FORMULATION AND PROJECT PLANNING

FOR

IMPROVEMENT OF WATER MANAGEMENT SYSTEM

CHAPTER 5 PLAN FORMULATION AND PROJECT PLANNING FOR IMPROVEMENT OF WATER MANAGEMENT SYSTEM

5.1 Concept of Basin Water Management

5.1.1 Water Management Problem

Water management problems identified during the Study can be summarized as follows. (See Tables 5-1 and 5-2)

(1) Tightness of water resources available
(2) Needs of measures for flood and drainage control
(3) Necessity of conserving environment and ecology system
(4) Problems in O&M with present water use facilities
(5) Difficulties in development of new water resources
(6) Continuous progress in fragility of function of the river basin (See Section 5.7.2)
(7) Legislation of water law (See Section 5.7.1)

5.1.2 Basic Thoughts of Water Law

Following basic thoughts of water law have been widely accepted as global rule for planning of water management system.

(1) Acceptance of hydrological cycle
(2) Public water use
(3) Water management by river basin
(4) Economy in water management
(5) Basin development planning with participation of local population
(6) Harmony with environment

5.1.3 Definition of Water Management

A term "water management" in this Study has been defined to be composed of the followings. (See Figure 5-1)

Water Management	(1) Water Resources Management (in planning) :	- Evaluation of resources and allocation
	(2) Water Operation Management (in operation)	- Management of water use facilities (hardware)
		- Information management (software)
		- Institutional management (humanware)

(1) Water resources management

In order to use the basin water in full, it is required to examine and evaluate the available water in the basin in terms of quantity, quality, timing and location. Volume of water available for additional exploitation can be quantified by deducting estimated water demand from volume of basin water endowed.

The supply and demand have to coincide in time and location. This is called a water allocation plan which provides the target or the norm for water operation.

(2) Water operation management

Water operation aims at realizing the norms imposed with the water allocation plan and to remove excessive water, based on monitored water information. Water operation, therefore, denotes the positive aspect of water management which consists of the following control activities in case of Chao Phraya River Basin.

1) Reservoir release
2) Diversion control
3) Distribution control on main canal system
4) Distribution control on lateral canal system
5) Soil moisture control on farm
6) Pumping control of creek water
7) Drainage water control
8) Water quality control

A basin-wise hydrological simulation has been conducted by employing a mathematical basin model developed by the Study Team. It has been confirmed that water operation had been managed quite satisfactorily by RID throughout the whole ten years examined with data and information made available. Site information indicated on the Display Panel have been fully employed during the course of the above analysis. Introduction of the panel enabled to facilitate the Study.

5.1.4 Water Management Level

A concept of "management level" has been introduced to define the level of improvement of hydraulic structures, information and organizations. This would enable not only flexible priority ordering for project implementation but also programing of prompt and varied countermeasures upon changes of conditions. (See Table 5-3, and Figures 5-2 and 5-3)

5.1.5 Concept of Scaling

Scales of subject areas for the Study vary from the whole basin till a farm plot in accordance with subject component of the Study. A scale concept has therefore been employed, generally corresponding to the management level. Figure 5-3 explains the scaling concept with relation to management level and zoning, wherein zoning scale varies along micro/macro direction.

5.1.6 Development of Computer Application Programs

(1) Outline of the ACRES System

RID, in cooperation with ACRES INTERNATIONAL LTD., had developed a system of mathematical simulation model for the Chao Phraya-Meklong Basin Water Management System, hereinafter referred to as the System, during 1976-1982. The System had been operated in 1982, 1983 and 1986 but it is under suspension at present.

The System aims to instruct flow adjustment at 23 regulators in the delta by dividing the entire irrigation areas of about 2 million hectares in the basin into 109 irrigation blocks. A spell of computation under the System had been undertaken once a week by the Water Operation Center of the RID Central Office employing data of daily rainfalls at 300 sites, river flows at 110 sites, cropped areas in 12 types and soil moisture in 3 types in each block collected through VHF wireless voice communication or by post.

The collected data are processed through 20,000 steps of FORTRAN programs using 64 files, and its operation takes 6 hours even by use of the VAX 11/750 system of IEC.

The spell of computation consists those 4 weeks; parameter verification for the week before, water allocation for the week, forecast of flows at regulators for the next week and required water release from reservoirs for the week after next.

It is required to give monthly evaporations, rates of effective rainfall, irrigation efficiencies and rates of return flow to each irrigation block for operation of the System. Number of parameters thus required amounts to about 4,000 and therefore the System has difficulties in practical application. Major outputs of the System are limited to flows at 23 regulators. Lower cost-performance to such heavy work loads has caused suspension of the system operation.

In order to lessen such drawbacks to possible extent, supporting sub-programs have been developed by the Study Team under the concept as shown in ANNEX-2. However, basic constraint itself can hardly overcome even though application of such supporting sub-programs.

(2) Computer programs under the improved system

Taking account of the said drawbacks, the improved water management system is proposed by putting particular stress on improvement of monitoring and communication system.

In addition, plans for development of the relevant computer programs are presented in Table 5-4. Some programs have already been developed by the Team and applied by RID staff.

However, following measures are necessary for further computer application to the improved system.

1. Undertaking of gate calibration for revision
2. Rearrangement of inventories of water use facilities
3. Preparation of land zoning by land use
4. Improvement of monitoring system
5. Establishment of data management guidelines

In this connection, fostering of system engineers of RID is one of basic requirements for operation of the proposed system, and therefore so expected for consideration by the RID management.

5.2 Improved Water Management System and Implementation Plan

5.2.1 Improved Water Management System

As materialization of the improvement of entire water management system requires huge investment and time, "Water

Management Model Project" is, therefore, proposed (1) to materialize the water management concept, (2) to train staff, (3) to demonstrate to relevant personnel concerned and (4) to select project components to be implemented in the subsequent future.

Along with this approaches, the Study Team proposes such projects/studies as shown in Figure 5-5. And their relations to water management problems are shown in Figure 5-6.

5.2.2 Implementation Plan

Consequent on the entire Study, following implementation procedures are proposed. (See Table 5-5)

(1) Water Management Model Project ... short term project

(2) Monitoring/Communication System Improvement Project (until Level-2 .. short-term project); (until Level-3 .. medium-term project)

(3) Irrigation and Drainage System Improvement Project (until Level-2) ... medium-term project

(4) Comprehensive River Basin Development Study ... short-term study

(5) Crop Diversification Promotion Center Plan ... short-term study

(6) Data Management System Improvement Project:
The first part of the Data Management System Improvement Plan is to be implemented under (1) above, while remaining parts under medium-term project

(7) The remainders of the above (2) and (3) ... long-term project

5.3 Water Management Model Project

5.3.1 Background and Objectives

Present water management has various advantages though it still

contains some difficulties in management activities.

Thorough improvement of water management requires long time, a large amount of funds, sophisticated planning, training etc. Therefore, a concept of "management level" is introduced to specify/design corresponding target by level of improvement in this study. Targets at management levels for a project area have to be so set-up as to meet the local characteristic of the area, capability of management staff and social needs.

There are three approaches for improvement. They are improvement of hardware, software and humanware. Approach from hardware means improvement of monitoring/communication/data management and water use facilities including new installation/construction. That from software means improvement of technical capability for handling the hardware. That from humanware means improvement in quality of activities among management organizations for operation/maintenance. Those approaches should be well balanced under well-conceived implementation programs.

For early materialization of outcomes from this Master Plan Study, a model project is herein proposed, as a pilot project for improved water management system. Know-hows and experience acquired during the course of its implementation will gradually and steadily be extended and applied to others. The technical cooperation has room to be considered for smooth and efficient implementation of the Project.

(1) Implementation of a model project for developing operational practices and formation of project prototype.

(2) Setting-up and systematization of water management methods and standards to fit the local conditions.

(3) Demonstration and dissemination to/among all the concerned.

(4) Staff training and transfer of knowledges on water management system/project.

(5) Preparation of feasibility study reports for the subsequent project implementation and proposals on the implementation system.

5.3.2 Model Project Area and Project Activities

The following areas of the model project are selected taking into account the characteristics, existing facilities and organization of water management on the delta (See Figure 5-8).

Model Area/Office	Functions and Objectives
(1) RID Head Office	- Evaluation of water resources - Precise water allocation plan - Summarization of outcomes
(2) Region No. 7 Office, Chao Phraya Dam and Five head regulators	- Precise gate operation by use of real-time data by telemeters
(3) Region No. 8 Office & Koke Kathiem Project Area	- Precise water management in gravity irrigation area
(4) Rangsit Tai Project Office and the Area	- On-farm water management in diversified cropping area
(5) Phasi Charoen Project Office and the Area	- Water management in conservation irrigation area with urbanization
(6) Bang Ban Project Office and Area	- Pump Irrigation in polder

Project activities will be programed for each of selected model areas in accordance with their local characteristics. Those are summarized as follows. (See details in ANNEX-3)

(1) Issues relevant to water resources management

- Evaluation on development/conservation conditions of water resources

- Identification of projects for improved water management
- Examination of countermeasures for drought/flood
- Examination of annual cropping plan

(2) Issues relevant to water distribution

- Collection of monitored data by improved system
- Water allocation planning at each management level
- Monitoring of water flow and review of water allocation plan and actual operation
- Modification for improvement of water allocation planning methods

(3) Execution of field monitoring

- Water level/discharge, water qualities, groundwater and gate calibration

(4) Compilation of data

- Filing of field-monitored and collected data
- Preparation of irrigation/drainage system diagrams

(5) Development of software

- Design of data compilation formats
- Review of such hydrological patterns in the past as intake water and run-off discharge, etc.
- Development of computer application programs for data compilation and water allocation planning

(6) Training and education on water management activities

- Basic concepts of water management and activities
- Practice of water management at each management level
- Operation/maintenance of equipments and facilities for water management
- Computer programing

(7) Public information services

- Water use position in the basin
- Demonstration and dissemination of data and information to the agencies and groups concerned

5.3.3 Equipment and Facilities Required

(1) Monitoring/communication and data management facilities

- Telemeter: Water level observation stations with telemeter are to be set up at major regulators as shown in Figure 5-9. Observed water levels are automatically transmitted to the model project office.
- HF/SSB radio: HF/SSB radios are at water level observation stations in the middle Basin as shown in Figure 5-9. Observed data are promptly transferred to Region 7 Office and Water Management Center by voice communication.
- Portable wireless telephone and patrol vehicle are to be provided accordingly.
- Hydrology observation devices: Additional devices for gauging of rainfall, water level, water discharge, water quality and soil moisture are to be installed at selected sites.
- Data management facilities: Mini-computer and display devices are to be installed at an appropriate place for data processing, re-arrangement of observed data and training of staff.

(2) Civil works

- On-farm facilities: Improvement of on-farm facilities is subject to those in the selected area for practice/training /demonstration of on-farm activities.
- Gate structures: Such improvement of gate structures as electrification and automation is desired for precise operation.
- Others: Improvement of canal and pump facilities is also required for efficient and economical operation practice. (See details in ANNEX-3)

5.3.4 Implementation Plan

Implementation of model project may be divided into two stages; (1) construction of proposed equipments/facilities and civil works, and (2) establishment of improved water management activities.

(1) Construction stage

Construction work of proposed equipments and facilities is implemented in this stage. Considering the work volumes, construction work may be implemented in three phases. In the first phase, water management center is constructed. Construction works in Regional offices, and related areas and sites are carried out in the second phase. The works needed in other model areas are in the third phase. (Refer to Figure 5-10)

Implementation periods in each phase are supposed to be 1.0 year for construction preparation including detailed design and is 1.0 year for construction and installation of equipments and facilities.

Total construction period is 5.0 years in 3 phases (Refer to Figure 5-10). Construction costs of each phase are estimated to be 169.6, 203.0 and 227.4 million Baht, respectively, the total cost will amount to 600 million Baht (Refer to Table 5-6).

(2) Establishment stage of improved water management activities

A system of improved water management activities will be established through practices and experience in the field. Those activities are thought to be managed by some experts and RID's own staff by use of the introduced equipment and facilities, wherein transfer of technologies and training of the staff-in-charge will be contemplated. Long and short term qualified experts in each phase are required in different fields. And, each management activities

will be carried out by those qualified experts and RID's staff who are recruited from the related division in RID or the concerned agencies (Refert ot Figures 5-11 and 5-12).

It is necessary to set up an executive organization in RID for systemtic activities of this project. The proposed organization is consisted of seven sections under the Director of Water Management Model Project, as illustrated in Figure 5-13. Proposed activities will be carried out by some sections in which the recruited experts and RID's staff are assigned.

Total implementation period is 5.0 years, and the required cost for the three stages is estimated to be 186.0 million Baht. (Refer to Figure 5-10)

Stage-(2) may be implemented in parallel with Stage-(1) since some of proposed activities under Stage-(2) do not require new construction of facilities with Stage-(1).

5.3.5 Project Effect

Through practices and with findings during the course of implementation, know-hows thus accumulated enable step-wise application and intensification of the improved water management system to the other area as well.

5.3.6 Relevant Functions and Activities of IEC

IEC has been functioning for staff training and accumulation of technical know-hows and experiences in irrigation fields to play its roles as an engineering center during the past 4 years under close collaboration with RID staff. For implementation of the proposed Model Project, effective and efficient uses of the IEC's buildings, computer systems and other equipment appear to be beneficial.

5.4 Monitoring/Communication System Improvement Project

5.4.1 Outlines

Systems of data/information processing for water management consist of (1) monitoring system for better understanding of latest situation, (2) communication system for smooth transfer of information/data, and (3) data management system for easy processing and handling of collected data.

Present communication system suffer much from noise and unstable transmission performance because of aged equipment. Monitoring and data management systems are presently experiencing difficulties in timely data observation/collection and in their effective use.

An improvement plan has, therefore, been formulated by management level. Respective water management levels and their corresponding methods of data/information management are shown in Table 5-7.

5.4.2 Communication System Improvement Project

An improvement plan has been formulated by such levels of communication, as (1) trunk line (RID Head Off. - Regional Off.), (2) local circuit (Regional Off. - Project Off.) and (3) field circuit (within project area). Improvement of the system by management level are as follows.

Level-1: For quick contact and smooth coordination with neighboring project offices, current VHF/FM radio system of local circuit is to be improved by taking the current functional capability into account.

Level-2: In addition to the level-1, communication system between project offices is to be replaced by duplex communication system from one office after another. Most of local and field circuits are also to be improved.

Improvement at level-3 and 4 is the same as that of level-2 but to different extent.

(1) Improvement of trunk line

Considering increasing communication volume in the future, it is urgent to change the present system into a stable one. Multiplex radio system is therefore proposed to fulfil the requirement and to secure a good quality of communication.

For the trunk line system, (1) system of existing UHF line owned by TOT or satellite communication network by CAT and (2) system of private UHF line of RID may be considered as alternatives. As a result of careful examinations, the system with existing UHF line of TOT is proposed for the trunk line.

(2) Improvement plan of communication system (Level-1)

1) Improvement of VHF/FM radio system

VHF/FM radio system is to be improved, taking its present functions into account, as follows.

- VHF/FM radio system is to be introduced to project offices which are not provided with VHF/FM radio yet.
- Some facilities in the existing radio system such as antenna and tower may be utilized after examination of their current capability.
- Improved circuit is to be provided for direct communication between water management staff.
- VHF/FM radio system is to be located at all major regulators presently not equipped with proper radio system yet.

Consequently, the number of proposed VHF/FM radio station is as follows.

Improvement	Number of Station
1. All new set of radio facilities	22
2. Replacement of radio equipments and antenna (tower remains for use)	3
3. Replacement of radio equipments (tower and antenna remain for use)	16
Total	41

2) Improvement plan of local circuit (Level-2)

a) Improvement in Private Wire Telephone

Private wire telephone of about 15 km between Regional 7 office and neighboring project offices is to be improved.

b) Use of TOT Network

Eight project offices around Bangkok where TOT network may be used as local circuit, have been selected. Capacity of 3 - 9 channels will be needed in this system.

c) Introduction of Rural Radiophone System

Rural radiophone system is to be introduced except in some areas where improved private wire telephone and TOT telephone are available. Numbers of main and sub-stations to be built in this system are 5 and 15 in the delta, respectively. Junction circuits composed of either small capacity multiplex radio link or TOT leased private circuit, are to be installed in 3 stations.

d) Others

PABX (private automatic branch exchange) is to be installed in one project office after another.

Improvement plan of local circuits is shown in Figure 5-14.

3) Improvement of field circuits (Level-2)

Though replacement from private wire telephone to VHF/FM radio system appears to be most economical if the size of monitoring area and possible jamming/confusion are taken into account, a

communication system composed of VHF/FM radio and improved private wire telephone is proposed.

a) Improvement of Private Wire Telephone System

- Replacement from present open wire to cable line
- Rehabilitation of present magnetic telephone type

As a result of the study, improvement plan formulated is as follows.

Region	Telephone Line (km)	Number of Telephone (set)
Region No.7	763	640
Region No.8	617	465
Region No.9	33	40
Total	1,413	1,145

(The length of telephone lines to be improved is about 50% of 2,800 km of the total existing line)

b) Improvement in VHF/FM Radio System

- Fixed Radio Station: at 104 offices of water master and project offices
- Protable Wireless Telephone: for communication among project office, water master offices and zonemen; 401 sets in total.
- VHF/FM Mobile Station: one set of VHF/FM mobile radio for each project office; 27 sets.

(Proposed facilities by level are shown in Table 5-8)

(3) Improvement in the upper and middle basins

An improvement plan for the upper and middle basins has also been formulated, based on the same concepts as for the delta. In the plan, priority has been given to improvement of basic communication facilities.

(4) Cost estimates

Construction cost of the proposed facilities/equipments is as follows.

1) Construction cost (lower basin)

(unit: Million Baht)

Items	Level-1	Level-2	Level-3	Level-4
1. Construction of Facilities	18	368	368	368
2. Engineering Services	3	73	73	73
3. Contingency	2	44	44	44
Total	23	485	485	485

Note: Engineering services is 20% of the cost 1
Contingency is about 10% of the costs (1 and 2)

2) Construction cost (the upper and middle basins)

Construction cost is estimated at the amount of 33 million Baht for level-1 and 313 million Baht for the other levels.

(5) Maintenance

Maintenance of the introduced facilities is to be undertaken by the Communication Division. Maintenance costs for spare parts, consumables and rental fee of TOT line are required after the construction. Annual cost is estimated at the amount of 0.3, 9.2, 10.0 and 12.0 million Baht in level-1 to level-4.

(6) Project effect

Improvement of communication system will enable not only quick transmission of required data/information and smooth coordination among operation staff, but also systematic water management activities.

(7) Implementation

Implementation of the improvement upto the level-2 is herein proposed to achieve as the short-term target. (Refer to 5.4.3 (8))

5.4.3 Monitoring System Improvement Project

(1) Outlines

Improvement of monitoring system consists of (1) improvement of hydrological observation facilities in the Study area and the river system and (2) improvement of monitoring facilities in O&M offices. Degree of those improvement depends on the management level assumed. More construction/installation of facilities are required in some parts if quick response and accuracy of data/information are necessary even at the same management level.

(2) Hydrological observation

1) Water level at regulator

Total number of regulator sites to be monitored in the Delta is estimated at about 30,130, 1,500 and 7,900 stations at level-1 thru level-4 respectively. Level-1 places emphasis to observation at major regulators. Existing equipment may be used for observation, since high accuracy is not required at this level. At the other levels, however, automatic gauges will gradually be installed so as to quantify amount of water supply with more accuracy. In addition, telemeter equipment is to be furnished for exact monitoring of water levels and flows at major regulator sites which fluctuate widely, at level-3. These sites are those selected for indication on the display panel installed during this Study. At level-4, additional telemetering system is also to be introduced at some sites along main canal. (See Figure 5-15)

2) Water levels in the river system

Observation/collection methods are to be improved at some stations selected in the river system. Alternative methods for observation and data collection such as (1) present observation + newly installed wireless voice communication, (2) automatic recorder + improved voice communication and (3) telemeter system, have been examined, and locations and the methods have been planned at each management level. Number of locations thus planned is 7 at level-1 and 28 at level-4.

3) Rainfall

Rainfall observation will be continued with the same method as present. New gauging stations are to be installed at the same site as for water level observation at the same management level. Observed data are to be transmitted, together with water level records, by voice. At level-3 and level-4, some of them may be collected by telemetering system.

4) Field moisture content

Under the plan, installation of gauges is needed for observation of field moisture content so as to eliminate different judgement by each zoneman. Patrol vehicles and portable wireless telephones have been included in the plan for smooth data collection. Soil moisture gauges are only to be installed in level-3 and level-4.

5) Other hydrological observation

- Water quality and water flow observation
- Groundwater level observation

(3) Monitoring facilities

1) Display system

Display panels are to be installed in some key offices so as to display the latest situation of water flow in the command area and to review the water allocation and operation. In some project offices in the delta, monitoring system with display panel is to be installed at level-4.

2) Water operation room

Project office will execute water management with help of improved monitoring/communication and data management facilities at level-3 and level-4. For this, an operating room as large as 300 - 1,500 sq.m is to be constructed for installation of equipment and their operation.

(4) Facilities and equipment

Proposed facilities and equipment by level in the delta are summarized in Table 5-9. Improvement plan for the middle and upper basin has also been formulated under the same concepts as in the delta. Priority is given to the improvement in the command area and offices in the Region No.3 so as to keep balance with the management system in the delta.

(5) Cost estimates

1) Construction cost (lower basin)

(unit: Million Baht)

Items	Level-1	Level-2	Level-3	Level-4
1. Construction of Facilities	18	79	288	656
2. Engineering Services	3	15	57	131
3. Contingency	2	9	34	78
Total	23	103	379	865

Note: Engineering Services 20% of the cost 1
Contingency is about 10% of the cost (1 to 2)

2) Construction cost (upper and middle basins)

Construction cost is estimated at the amount of 8, 46, 81, 317 million Baht in level-1 to level-4, respectively.

(6) Maintenance

Maintenance will be undertaken by the O&M and Hydrology Divisions. Maintenance cost for spare parts and other miscellaneous expenses are required after construction. Annual maintenance cost is estimated at the amount of 1.3, 4.0 and 9.2 million Baht in level-2 to level-4, respectively.

(7) Project effect

Water operation will efficiently be carried out by better comprehension of the newest situations and by cross-examination of the monitored information with programed ones.

(8) Project implementation

Implementation of the improvement upto Level-2 is herein proposed in combination with communication system as shown in 5.4.2, as a short-term project. Proposed implementation schedule is shown in Figure 5-16. Implementation plan of Level-3 and Level-4 will be formulated incorporating the findings and outcomes of the Model Project.

5.5 Data Management System Improvement Plan

5.5.1 General Conception

Through review of the current data management system, there have been several points found for improvement. However, the improvement must be carefully planned in such ways as not to disturb its daily operations.

(1) Preparatory works

To avoid any conflict and/or overlapping among data and their handlings, the followings are found indispensable.

- Unification of data management system and data code system
- Improvement of data communication system
- Improvement of data processing system and data storage system
- Improvement of public information service system
- Examination of practical operation system

Data management system does not necessarily mean computerized data management, but it includes the system of rationalized information flow, data assortment, data custody and their administration.

(2) Information flow

When the importance of water management is increasingly realized, the centralized decision-making system for a vast area, such as Chao Phraya River Basin, not only gives more burden to the central office, but also tends to fail in satisfying local water requirements. Therefore, decentralized data processing/management is one of keywords for the improved water management system as in the Chao Phraya River Basin. On the other hand, frequent and prompt

information exchange is also one of important factors for unified basin management system. In other words, decentralized data management is also required for regulation of information flow. Information are transmitted through communication systems. Therefore, a concept of "Information Bus Line (IBL)" has been employed as shown in Figure 5-17. This concept is the key to realize the decentralized data processing/management. More significant merits of this concept are;

1) Concurrent utilization of information even at remote offices

2) Elimination of duplication/conflict of data

3) Prompt availability of information

4) Availability of data as common property

Radio via, RID's own channel and by TOT telephone, or postal service are being used for information communication at present. Until the provision of computerized information system, the inquiry and transfer will have to rely on the present system. Until such time will come, for unautomated offices, immediate upper-ordinate offices will have to act the roles of their subordinate offices.

Even if automated facilities are not equipped, 2) and 4) listed above will benefit RID substantially. Automated Information Bus Line (IBL), especially in case of computerization, needs on-line or off-line communication link. Though this concept might be realized even without computerized facilities, however, if any of automated facilities were made available, they would surely be helpful to service at their full capability.

(3) Data assortment

Information to be utilized by unspecified users need to be indexed by well-conceived criteria for assortment. For the sake of this, the following four are thought indispensable.

1) Categorization of users' requirements to save procedure for retrieval from intricacy.

2) Clarification of relation between data for systematic assortment/identification systematic and compact structuring.

3) Unification of data indexing systems to save coding form confusion and complication.

4) Simplification of indexing criteria to avoid misindexing.

This methodology can usefully be applied to any kinds of assortment, even to non-automated ones. However, when this method is applied to computer data assortment, it fully enpowers information retrieval.

(4) Data custody

For rational and economical management of voluminous data, the management system is planned to be decentralized one. Data communication/management system utilizing personal computer etc. may be introduced to some offices in needs. There must be less difficulties in handling these systems because RID has already utilized these modern system in data communication/management. In addition, data cabinet and air conditioner are to be equipped at offices concerned for protection of raw data from weathering by high humid and temperature.

(5) System administration

In the decentralized system organization, each system office shall take the same responsibility of data management as present one. The central system shall be responsible for administration of the whole system, and therefore regulates system operation and lead subordinate systems to follow the regulations. The central system shall be informed of condition of subordinate systems. Efficiency and security of the whole system shall be supervised by the central and sub-systems under some well-examined guidelines. Functions at each management level are shown in Table 5-10.

5.5.2 System Formulation and Installation Plan

Plan of installation from level-1 to level-4 is optional depending on the degree of necessity. Each level may be adjusted at the time of implementation. At any level, installation and introduction of equipment must not disturb daily services for water management. Therefore, step-by-step implementation need be undertaken in the way as follows.

The first step is for preparatory works consisting of (1) establishment of the system operation committee, (2)exchange of data inventory among offices, (3)data indexing, (4)design of data/survey forms and inquiry forms, (5)scheduling of installation, (6)planning of computer application softwares, etc.

The second step is composed of (1)installation of equipment, (2)installation of basic computer softwares (such as operating system), (3)design and development of computer application softwares, (4)test runs and (5)staff training.

The third step, which is a step during operation, is the expansion of the second step, operation and maintenance of the system and training.

5.5.3 Equipment and Implementation Cost

Improvement plan of facilities in offices concerned in the delta is summarized as shown Tables 5-11 and 5-12.

Establishment of data management system inevitably involves improvement of softwares and hardwares. The system improvement project will, therefore, be implemented by use of outcomes of the proposed Model Project.

TABLE 5-11 EQUIPMENT FOR IMPROVED DATA MANAGEMENT

Equipment	Unit	Level-1	Level-2	Level-3	Level-4
Computer System					
- Personal Computer	1 set	4	10	19	41
- Personal Computer W/X-Y Plotter	"	1	4	6	16
- Work Station	"	1	2	5	7
Air Conditioner	"	4	8	13	31
Steel Cabinet	"	20	32	50	101
Facsimile	"	3	7	31	34
Video Projector	"	-	-	1	3

TABLE 5-12 COST FOR IMPROVED DATA MANAGEMENT

Equipment	Level-1	Level-2	Level-3	Level-4
1. Construction/Installation	14	36	77	151
2. Design and S/V*	3	7	15	30
3. Contingency	2	4	9	18
Total	19	47	101	199

Note: * ... Cost for Design and S/V is 20% of 1, Contingency is 10% of (1 + 2)

5.6 Irrigation and Drainage System Improvement Project

5.6.1 Objectives and Basic Concepts

For the existing irrigation and drainage systems which have difficulties, because of various reasons, in meeting with the present and/or anticipated requirement for water uses and/or in making highly effective use of available but limited water resources, the "Irrigation and Drainage System Improvement Project (temporary named)" is herein proposed for implementation to secure (1)efficient and safe water use without loss, (2)precise and easy water control, and (3)satisfactory functioning and capacities

for the present and anticipated future requirements under the following three basic concepts.

(1) A project to be implemented as appropriate engineering measures for acquirement and continuation of necessary functioning and capacities to have the component civil work structures and the appurtenances.

(2) A project to be continuously and strategically implemented in the most effective ways from long-term viewpoints.

(3) A project under which due methodologies, means and targets of improvement are established with due considerations in social, economic and technical constraints in the localities, and at the same time in keeping sound balance with the level of water operation and management softwares.

5.6.2 Proposed Criteria for Project Formulation/Identification

(1) Areal criteria for formulation/identification

- Large and medium scale irrigation project under control of RID in the whole country.
- Project with service area over 1,000 ha
- Project which have promising social and/or economic return.
- Project constructed in 1970 or before, or those constructed in 1970's with considerable functional deficiencies.

(N.B. Those meeting the above criteria are 108 project areas and 10.6 mill. rai in total.)

(2) Selection criteria

1) Economic criteria: improvement cost to be met with;

- Assured long-term reproduction

- Prevention of anticipated damages
- Increased production benefits
- Saving in O & M costs in long-term

ii) Social criteria: improvement is to be significant for;

- Improvement and reinforcement of social infrastructures
- Prevention of losses and protection of benefits from present or future environmental changes
- Equitable benefits among water users
- Promotion and expansion of farmers participation in O&M

iii) Engineering criteria: improvement works are those to be for;

- Recovery of deteriorated facilities in functions, by rehabilitation and/or replacement
- Renovation of obsolete facilities, with functions of the current engineering design and modern standards
- Employment and application of modern technologies for achievement of precise and more economic water operation and system maintenance

5.6.3 Improvement terms and Estimated Cost

(1) Subject structures

Subject structures are water use facilities and the appurtenances at lateral, main and basin levels under RID's control and at on-farm level. Those structures are;

i) Water source facilities: storage dam, diversion dam, pumping station, swamp, pond, farm pond, well, etc.

ii) Irrigation and drainage facilities: canal in general, regulator (intake, diversion, check, FTO, drainage, etc), siphon, wasteway, culvert, flume, chute, pipe bridge, drop, pumping station, on-farm structures, etc.

iii) Other: canal-crossing structures, road, dike, navigation lock, office, house, water measuring/observation structures, safety structures, etc.

(N.B. Those constructed by private entities or organizations with little public significance and specialized objectives, such as highly-intensive orchard plantation or fish ponds, are to be excluded.)

(2) Standard for structural improvement

Standards for structural improvement needs to be carefully formulated for each category of structure so as to meet its role such as purpose, function, dimensions/capacity, etc., as integral component of a huge system complex. For application in practice, however, the standards are to be flexible enough to cope with the social, economic and engineering constraints. It will be practical if some standard conditions which fit with each category of structures are firstly defined and then adjust the standard in flexible ways. Examples of defined standards for some typical structures such as regulator, open canal, siphon, dike, pumping station and bridge are presented in ANNEX-5, FORM 5-1 to 5-7 for reference.

(3) Privileged application area

The principle herein presented can be applicable over the whole country. However, in the early periods, the center of implementation shall be limited in Chao Phraya Delta only, and then gradually be expanded to other areas. In water conservation area of the delta, due to drainage problems in and around the Metropolis and the area of poor soil conditions for crops other than paddy, improvement of drainage systems and relevant infrastructures is to be given high priority. While in the gravity irrigation area, the improvement is to be stressed on irrigation systems in lands favorable for upland crops.

(4) Estimated project cost

Estimation of costs for improvement in the delta has been made at the levels of basin, main lateral and on-farm systems. Work volumes and unit costs are set as shown in Table 5-13, based on the results of survey on requirements for improvement wanted by the field staff and past accomplishment works. For an assumed case of "Moderate request" as the initial target for implementation, the estimated project cost for the delta and projected cost for entire basin are shown in Table 5-14.

Table 5-14 ESTIMATED COST FOR PROPOSED IRR. & DRAIN. SYSTEM IMPROVEMENT PROJECT

(Unit: Mil. Baht)

System Level	in Chao Phraya Delta				Whole Country
	Gravity Irr. Area	Water Conserv. Area	Total	(Baht/rai)	
Basin	*	*	20	*	*
Main Canal	812	103	915	(100)	*
Lateral Canal	2,662	2,699	5,361	(700)	*
On-farm	3,894	3,375	7,269	(950)	*
Total	7,368	6,177	13,565 (75%)	(1,700)	18,000 (100%)

N.B. * not calculated

5.6.4 Proposed Implementation Program

(1) Preparation

Before starting the Project implementation, some fundamental preparatory works are required. Among them, complement, compilation, updating and data-base-systematization of inventories of structures and other facilities are the most fundamental ones, to be followed by setting-up of standard for structural improvement. By cross-examining the both, selection of subject systems and of subject facilities for improvement can be correctly and easily made.

Besides, based on long-term development policies at both national and local levels on water resources, water utilities, drainage, land use, agriculture, etc., water use and land use plans at each level of trunk, main, lateral and on-farm systems are to be formulated so as that required functions and capacities of individual facilities can be determined for improvement.

(2) Implementation programming

If one assumes the Project with a total project cost 18,000 mill. Baht is implemented in 20 years, the annual outlay required will be 900 mill. Baht/year. Meanwhile, under the on-going 5-year plan, annual budget allocated to RID is 800 mill. Baht. Assuming 60% of the budget is for the areas within this Project, it seems realistic for RID to allocate 400 mill. Baht of its budget for this Project annually. Another 400 mill. Baht appears better to, therefore, be financed from RID's additional budget or by foreign sources.

A 20-year term of the Project implementation had better be divided into several phases. By setting targets in each phase, accomplishments may be assured in comparison therewith. In keeping same pace with other various but popular 5-year plans in Thailand, a 5-year term for each phase and 4 phases in the 20 years appear to be reasonable. Subject area per phase then becomes 2.6 mill. rai (420,000 ha). Allocation of the Project cost to each region, in proportion to subject service area, will be 8% for the Northern, 9% for the Northeastern, 80% for the Central (34% for Reg. 7, 28% for Reg. 8, 13% in Reg. 9 and 10.5% for Reg. 10) and 3% for the Southern regions.

(3) Implementation management

1) Management organization

Following offices and staff are proposed for assignment.

- Project Director: appointed in RID Head Office to direct the overall Project implementation
- Project Head Office: placed in O & M Diversion of RID Head Office represented by Project Manager who administrates and supervise overall Project activities
- Regional Project Office: placed in each subject RID-Regional office represented by Regional Project Engineer who manage the Project implementation under supervision of the Director of the region
- Field Project Office: placed in each subject project O & M office represented by Field Project Engineer to implement the Project under supervision of project manager of the O & M office

2) Operational management

- Project director represents the Project and direct its overall implementation
- Implementation planning and plan formulation are to be made through coordination among planning Div., O & M Div., Design Div. and Regional Offices.
- Survey and design works are to be carried out by Survey Div. and Design Div. in cooperation with Regional Offices.
- Construction is to be implemented by Regional Offices either through force account or through contract work, while Regional Project Engineer supervise and inspect the construction and its accomplishments.
- Project Head Office performs administration and coordination works necessary for the Project implementation. And it closely monitor progresses and gives instructions whenever necessary.

5.7 Comprehensive River Basin Development Study

5.7.1 Water Management under Water Law

Such international agencies as FAO, ESCAP and International Association of Water Law has been studying legal and social aspects of water management under global concept. Water law refers basically (1) flood control, (2) water use, (3) water quality and (4) environmental conservation. It covers overall implication and relationship between water and human beings society.

Following basic doctrines have been widely accepted as its global rule for planning of water management system.

Water Law Doctrine

(1) acceptance of hydrological cycle
(2) public water use
(3) water management by river basin
(4) economy in water management
(5) basin development planning with participation of local population
(6) harmony with environment

5.7.2 Water Resources Development and Conservation Plan

(1) Water resources development

Development of water resources in the Study Area has long time been implemented in the upper and middle basins and a large number of reservoirs and diversion dams/barrages have been constructed, while development of groundwater has been implemented in the middle basin to a certain extent.

Though water demands are steadily increasing, it may be said

that potential sites for construction of reservoir with substantial storage volume are quite limited and hardly satisfy the demands. Nevertheless, construction of new reservoirs is still profitable if the sites are not in watershed areas of Bhumipol, Sirikit and Kiu Lom Dams, because new reservoirs upstream those dams will decrease annual inflow to downstream reservoirs.

On the other hand, construction of new reservoirs downstream watersheds of the 3 dams and upstream of Chao Phraya Dam and upstream of Rama VI Barrage function in two ways; reduction of flood runoff and increase of dry season runoff into the Delta. Therefore construction of reservoirs shall be focussed into following watersheds.

- Watershed of the Ping lower than Bhumipol Dam
- Watershed of the Wang lower than Kiu Lom Dam
- Watershed of the Yom
- Watershed of the Nan lower than Sirikit Dam
- Watershed of the Chao Phraya upper than Chao Phraya Dam
- Watershed of the Pasak upper than Rama VI Barrage

Reservoir can avail irrigation in both seasons in combination with diversion dams, meanwhile independent diversion dams can also avail wet season irrigation to supplement rainfall. Construction of independent diversion dams may also be planned in the above-mentioned watersheds.

Further development of surface water resources are rather limited, however potentiality for groundwater development is abundant especially in flood plains of the middle basin and in Chao Phraya Delta. Development of groundwater requires rather small initial investment per project but high operation cost.

Due to small initial investment, groundwater development plans may flexibly be formulated for implementation by taking account of

various constraints of the locality. However due to height operation cost, share of O&M costs may cause some conflicts between beneficial farmers and the executing agency.

Nevertheless, development of groundwater shall be promoted in the aforementioned areas and O&M cost shall be shared with beneficial farmers.

(2) Water resources conservation

Conservation of water resources in the Study Area may be planned and implemented in two ways. Conservation of vegetation cover in the watershed is the most important measure. Conservation of forest is the key measure, since it can retain rainfall in ground and will contribute to stable and reliable stream runoff whole year round.

Once forest is destroyed, soils are washed away by rainfalls, resulting in low retention capacity. Washed soil may deposit in reservoirs, thus shortening the reservoir life-time. It takes long time to recover the forest once it has been destroyed. Therefore, forest destruction shall be strictly prevented.

Another way of conservation is conservation of natural swamps of large scale in the middle and lower basins. They also contribute to stable and reliable runoff whole year round, because of their water retention function.

In case some larger swamps are to be developed for irrigation or any other purposes, the plan should be so formulated that no sacrifice of their water retention capacity is needed.

5.7.3 Study on Comprehensive River Basin Development Plan

The average annual rainfall in the Chao Phraya River Basin is 1200 mm, while the gross domestic product (GDP) in the basin accounts for 62 % of the national GDP (see Table 3-3). GDP per unit rainfall in the basin accordingly exceeds twice of the national figure. Thus, the expansion and growth of social and economic activities in the basin has caused tight and severe availability of water in recent years.

The limited amount of water resources in the basin constrains the social and economic activities and it has caused the need that planning methodologies of water resources in the basin has to be restructured, combining and coordinating the development of micro-macro concepts. The microscopic plans implies the conventional individual development planning, while the macroscopic plan is here defined as the basin-wise planning consisting of water resources utilization plan and water operation plan. Micro and macro plans have, therefore, to maintain good harmony among them.

Preparation of a well-examined basin-wise inventory of projects, comprising microscopic plans under unified planning criteria will enable reasonable project selection and subsequent implementation. It is expected that such an inventory will make it possible to remote external uneconomic factors among them and will contribute to overall improvement of the basin productivity and for creation of national wealth. The existing individual development plans which correspond to the microscopic plans in the basin are listed as below. (See Figure 5-18 for their location.)

List of Comprehensive River Basin Study

(1) Bang Pakong River Basin development Plan

(2) Upper Pasak River Basin Development Plan

(3) Groundwater Development Plan in the vicinity to Phichit and Sukhothai

(4) Kwai Noi River Basin Development Plan

(5) Yom River Basin Development Plan

(6) Kok-Ing-Yom-Nan Diversion Project Plan

(7) Salween River Basin Development Plan

(8) Sakaekrang River Basin Development Plan

(9) Wang Thong River Basin Development Plan

(10) Meklong-Chao Phraya Diversion Plan

(11) Lower Ping River Basin Development Plan
(Tak-Kamphaeng Phet Area Development Plan)

(12) Other Related Development Plans

5.8 Method of Project Evaluation for Water Management System

5.8.1 Basic Concept

A project plan and/or a system is, normally, composed of three components, namely, facility/structure, information and organizational/human factor. Such a plan aiming at improvement of operational system as this Master Plan Study, put more significance on information component. Therefore, it is necessary to introduce a probability and/or a forecast concept (Degree of Uncertainty), when computing benefit and cost which are the basis of project evaluation. The overall frame and/or structure of the planning and the system are to be taken into consideration in this process. The cost and benefit can be treated as variables by dividing them into the said three components, and an optimum investment can be figured out on the basis of the interrelation among the three above.

Secondly, since the study area covers a vast area and extends over the area of around 1.3 million hectares, even if main beneficial area, the Chao Phraya Delta only is taken, it is possible to formulate optional project plans, by establishing several management levels (ex. Level-0 thru Level-4) and combining them with the district division (zoning). This approach would make it easier to work out a solution given by the "Parato Optimum", as well as to determine priority on the identified project(s).

The relation between the objectives and the effects of RID water management system improvement can be summarized in the following: (a) the increment in cropping area through saving irrigation losses, (b) the increase in crop yield through improved reliability in irrigation water supply, and (c) the intensification of cropping through crop diversification (See Figure 5-19). Input data for the cost are obtainable by a technical/engineering information data-base (through implementation of the "Water Management Model Project"), and those of benefit from facilities by use of the method ordinarily employed. The

benefit arising from the information one could be estimated by introduction of the concept of probability and/or forecast, but no data on the component is presently available in the entire basin. Therefore, available data obtained with other projects/areas, will provisionally be adopted. In this context, it is prerequisite to immediately commence the proposed model project, to obtain the necessary data and information applicable to the analysis of entire river basin.

5.8.2 Project Evaluation

The relation among the water management level, the identified projects/studies and the development target is summarized in the following;

PROJECT & STUDIES IN THE IMPROVED WATER MANAGEMENT SYSTEM

Project / Study	Manage. Level	Imple. Term
(1) Water Management Model Project	until Level-4	short-term
(2) Monitoring/Communication System Improve. Project	until Level-2	short-term
	until Level-3	medium-term
	until Level-4	long-term
(3) Data Management System Improvement Plan	(to be formulated during/after imple. of the Model Project)	
(4) Irrigation and Drainage System Improve. Project	until Level-2	medium-term
	after Level-2	long-term
(5) Study on Comprehensive River Basin Development Plan		short-term
(6) Study on Crop Diversification Promotion Center		short-term

N.B. Short-term implies 5-7 years, while medium-term 8-15 years and long-term over 15 years.

(1) Short-term projects/studies

Out of the short-term projects/study listed above, "(5) Study on Comprehensive River Basin Development Plan" and "(6) Study on Crop Diversification Promotion Center" are those to be carried out for investigating the possibility of realizing any component which

is a part of the improved water management system. Therefore, it does not appear necessary to quantitatively evaluate the benefits arising from these studies, at this moment.

On the other hand, having the characteristics of a pilot project for the improved water management system (IWMS) in mind, the proposed water management model project is to proposed for implementation for the sake of experimentally implementing the pioneering part of IWMS, and obtaining and preparing the necessary data and information for the realization of the entire IWMS. Therefore, it is, similar to the above two studies, rather difficult to quantitatively evaluate the benefits. However, it would put forward the future image of the IWMS, as well as to increase the income of participating farmers and to make farming practices more efficient, when the agencies and farmers concerned will make their efforts to positively cooperate for the implementation of the project.

By implementation of the monitoring/communication system improvement project (until Level-2), it is expected that the efficiency of water resources utilization in the entire basin would increase by 5 - 10 percent, including effective use of side flows. The incremental amount is estimated to be about 1,000 MCM with which about 80,000 ha of paddy field could be additionally irrigated in the dry season (See Chapter 4, para. 4.3.5 of this report) if the side inflow is efficiently utilized. On the basis of these figures, a preliminary project evaluation has been made for two cases; (1) planting paddy only, and (2) planting paddy and upland crops (soybean as representative) in half.

Preliminary Project Evaluation for
Monitoring/Communication Improvement (Level-2)

Item	Unit	Paddy only	Paddy + Upland
- Investment Cost	฿ million	947.0	947.0
- Implementation Period	year	4	4
- O & M Cost	฿ million	10.5	10.5
- Project Benefit	- ditto -	258.2	284.5
- I.R.R.	%	17.4	18.9

Although the above result is preliminary in native and further in-depth analysis is required, it became obvious that more efficient improvement of the water management system could be achieved by implementing this monitoring/communication improvement project which includes the least possible large scale civil works. Consequently, it appears necessary, in this connection, that all the necessary measures are to be taken to promote the realization of the improved water management system for the entire basin, including the proposed water management model project.

(2) Middle-term project

The items and costs of those projects listed as middle-term project are summarized in the following;

Name of Project	Management Level	Project Cost (฿ million)
- Monitoring/Communication System Improvement	until Level-3	1,258
- Data Management System Improvement	-	107
- Irrigation and Drainage System Improvement	until Level-2	1,050

At this moment, it is rather difficult to evaluate these medium-term projects with economical indicators such as EIRR, it

could be expected that these projects bring about increase of dry season cropping area as would be realized in the short-term projects as well as the replacement effect in the main water use facilities. In order to obtain basic data to be required for calculation of such benefits/effects, it is inevitable to implement the proposed model project as early as possible.

(3) Long-term project

The projects included in the long-term are (1) Monitoring/Communication System improvement (until Level-4), (2) Data Management System Improvement (until Level-4) and (3) Irrigation and Drainage System Improvement (after Level-3). Through implementation of these long-term projects, the improved water management system would be established in the entire Chao Phraya River Basin, and furthermore such benefits/effects could be expected as prosperous expansion of the basin agriculture, increase in farmers income, improvement and stabilization of living standard of inhabitants in the basin. Therefore, these projects should be promoted aiming at realization of the improved water management system for the entire Chao Phraya River Basin, taking into consideration the results to be made available by the short- and middle-term projects and the financial conditions.

Table 5-1 BACKGROUND OF WATER MANAGEMENT STUDY

1. Tight and Severe Water Supply Situation

(1) Increasing Water Demand for:

① Dry season paddy and diversified crops

② Fish/shrimp pond and horticulture

③ City water and industrial water

(2) Necessity for Environment/Ecology System Conservation:

① Sea water intrusion/salinity control

② Surface/ground water contamination

③ Land subsidence

④ Green resources and aqua/wild life conservation

2. Removal of Excessive Water

① Flood Control/Mitigation

② Drainage or Sewage Treatment

3. Difficulty in Coordination among Agencies Concerned

① Royal Irrigation Department ——— Irrigation ; Flood Control

② Electricity Generating Authority of Thailand —— Hydro-Power Generation

③ Harbour Department ——— Navigation

④ Fishery Department ——— Fisheries

⑤ Forestry Department ——— Wild-life

⑥ Bangkok Metropolitan Administration ——— City Water; Sewage

⑦ Public Works Department ——— Water Supply

⑧ Industry Work ——— Industrial Water

⑨ National Environmental Board ——— Environmental Control

⑪ National Economic and Social Development Board —— Water Policy

4. Constraints to Promotion of New Project

(1) Cost-Effective/ Financial Tightness

(2) Difficulty in Acquisition of Right-of-Way or Coordination among Agencies

(3) Complexity in Planning Technology or Project Justification

5. Proposed Basic Frame to Overcome Above Problems

(1) Establishment of Water Use Technology (Software or Information Management)

(2) Modernization of Existing Facilities (Hardware or Facilities Management)

(3) Institutional Vitalization (Humanware or Institution Management)

(4) Project Study for New Water Resources Development and Crop/Marketing System

Table 5-2 PROBLEMS IN THE PRESENT WATER MANAGEMENT

1. Operation Plan

(1) Water shortage/drought in dry season

(2) Water shortage in wet season

(3) Drainage/flood in wet season

(4) Low check-up water level

(5) Unstable water level

2. Communication and Monitoring

(1) Insufficient equipment

(2) Insufficient patrol vehicles

3. New Construction

(1) Outdated irrigation system

(2) Insufficient No. of intake structures

(3) Short of regulating/retarding ponds

(4) Short of drainage pumps

(5) Insufficient farm ditch/ turn-out

4. Rehabilitation

(1) Deteriorated functions of structures

(2) Damaged structures

(3) Repair/rehabilitation

(4) Low bank crest

(5) Low dike crest

(6) Insufficient cross-section of canal

(7) Damage on side slope of canal

(8) Need of canal re-dredging

(9) Leakage from canal

(10) Subsidence of syphon/ regulator foundation

(11) Damage on gate hoist

(12) Insufficient No. of bridges and service roads

5. Personnel/Organization

(1) Shortage of budget

(2) Shortage of manpower

(3) Insufficient experience of staff

6. Environment

(1) Salt water intrusion

(2) Acid soil

(3) Water pollution

(4) Water weeds

(5) Land subsidence

7. Social Problems

(1) Illegal gate operation

(2) Illegal structures in canal

(3) Littering

(4) Illegal intake by cutting canal dike

Table 5-3 CONCEPT OF WATER MANAGEMENT LEVEL

Management Level	Subject Facilities	Management		Command Area	Improvement Subjects		Remarks
		Office	In-Charge		Information F.	Water Use Facil.	
Level 1	Major Facilities in Major River System	RID Head Office RID Region Office (EGAT) (BMA)	D.G. Regional Director	16,000㎢ ～ 172,000 ㎢	Communication System (Trunk line)	Auto-gate control of Chao Phraya Dam and Rama VI Barrage	(ex.) - Bhumipol Dam - Sirikit Dam - Chao Phraya Dam
Level 2	Main Canal System and Major Regulators	Project Office	Project Manager	15,000 ha ～ 100,000 ha	Communication System (Rural Radio, RID Telephone)	Rehabilitation/Modernization of gates, canal, appartenat structures	(ex.) - Chainat-Pasak Canal - Manorom Reg.
Level 3	Lateral Canal System and Other Regulators down to FTo	Section Office	Water Master/Zone Man	10,000 ha ～ 15,000 ha	Monitoring System (Telemeter)	- ditto -	
Level 4	On-Farm Facilities after FTo	Water User' Group	Farmers	50 ha ～ 100 ha	- ditto -	Land Consolidation (Extensive/ Intensive)	

Table 5-4 STEP-WISE DEVELOPMENT PLAN OF APPLICATION PROGRAM

LEVEL	DESCRIPTION	PROGRAM NAME
Level-0	Improvement of Acres Program	**ACRES(F)
Level-1	① Monitored Data Arrangement for Display Panel ② Basin-Wise Water Balance Model	**PANEL(L) **BASIN(F)
Level-2	① Estimated Irrigation Demand by Project Area ② Estimated Regulator Flow in Main Canal System ③ Monitored Regulator Flow in Main Canal System ④ Monitored River Flow in Basin System ⑤ Reservoir Operation for Annual Cropping Plan	*DEMAND-M(F) *ES-CANAL-M(F) **MO-CANAL-M(L) **MO-RIVER(L) **RES-OP-CR(F)
Level-3	① Estimated Irrigation Demand by Section/Zone ② Estimated/Monitored Regulator Flow in Lateral Canal System ③ Estimated/Monitored Water Level along Major River Course/Drainage System ④ Reservoir Operation Model with Hydro-Power Generation Output	DEMAND-L ES/MO-CANAL-L ES/MO-RIVER-H RES-OP-PG
Level-4 (Tentative)	① Water Operation System (Integration of Level-1 to Level-3) ② Water Resources Development Planning System ③ Forecasting System ④ Data Management System ⑤ Verification System ⑥ Overall Water Operation System (Integration of above ① to ⑤ by Knowledge-Base Concept) ⑦ Overall Maintenance System ⑧ Overall Evaluation System ⑨ Flood Control System	

Notes: * Computer Program Available; (F) FORTRAN;
** -Ditto- Manual Available ; (L) LOTUS ;

Table 5-5 ESTIMATED PROJECT COST BY MANAGEMENT LEVEL

(Unit: Million Baht)

Management Level	Subject Facilities	Basin	Information Improvement				Facilities Improvement			Institutional Management (Person-In-Charge)
			Communication	Monitoring	Data Management	Total	Gravity Irri. Area	Conserva'n Irri. Area	Total	
Level 1	Major Facilities in Major River System	U-M.	33	8	-	41	-	-	-	RID Head Office RID Regional Office (D.G.) (Regional Director)
		L.	23	23	19	65	40	-	40	
		T'tl	56	31	19	106	40	-	40	
Until Level 2	Main Canal System and Major Regulators	U-M.	313	46	3	362	85	10	95	Project Office (Project Manager)
		L.	485	103	47	635	852	103	955	
		T'tl	798	149	50	997	937	113	1,050	
Until Level 3	Lateral Canal System and Other Regulators down to FTo	U-M.	313	81	6	400	350	282	632	Section Office (Water Master) (Zone Man)
		L.	485	379	101	965	5,496	2,820	6,316	
		T'tl	798	460	107	1,365	3,846	3,102	6,948	
Until Level 4	On-Farm Facilities after FTo	U-M.	313	317	14	644	741	618	1,359	Water User's Group (Farmers)
		L.	485	865	199	1,549	7,408	6,177	13,585	
		T'tl	798	1,182	213	2,193	8,149	6,795	14,944	

Notes: U-M.: Upper and Middle Basins, L.: Lower Basin, T'tl: Total

All figures indicate the cumulative value until the respective management level

Figures for "Facilities Improvement" are those of "Moderate Case"

Short-term Target

Middle-term Target

Long-term Target

Table 5-6 COST ESTIMATION OF MODEL PROJECT

(Unit ; Million Baht)

Cost Items \ Phase, Project site	Unit	Project Total		Phase-1		Phase-2				Phase-3					
				W. M. Center		Reginal 7 off.		Regional 8 off.		Rangsit-Tai		Phasi-Charoen		Bang Ban	
		Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
I. Construction Stage															
(1) Monitoring Facilities															
- Telemeter	site	20	52.4	8	21.0	-	-	3	8.0	3	7.8	4	10.8	2	4.8
- HF/SSB radio	〃	9	6.4	8	5.6	-	-	1	0.8	-	-	-	-	-	-
- Hydrology devices	set	120	31.2	-	-	-	-	30	7.8	30	7.8	30	7.8	30	7.8
- Motor cycle/radio	unit	50	5.0	-	-	6	0.6	14	1.4	10	1.0	10	1.0	10	1.0
- Patrol car	〃	15	9.0	3	1.8	3	1.8	3	1.8	2	1.2	2	1.2	2	1.2
Sub-total			(104.0)		(28.4)		(2.4)		(19.8)		(17.8)		(20.8)		(14.8)
(2) Data management Facilities	set	6	132.0	1	53.6	1	22.4	1	22.4	1	11.2	1	11.2	1	11.2
Sub-total (1 to 2)			(236.0)		(82.0)		(24.8)		(42.2)		(29.0)		(32.0)		(26.0)
(3) Building	site	6	160.0	1	60.0	1	32.0	1	32.0	1	12.0	1	12.0	1	12.0
(4) Civil works	site	4	105.2	-	-	-	-	1	38.2	1	12.6	1	11.2	1	43.2
Sub-total (1 to 4)			(501.2)		(142.0)		(56.8)		(112.4)		(53.6)		(55.2)		(81.2)
(5) Engineering services	set	3	98.8	1	27.6	1	11.4	1	22.4	1	10.6	1	10.8	1	16.0
Sub-total (1 to 5)			(600.0)		(169.6)		(68.2)		(134.8)		(64.2)		(66.0)		(97.2)
Total			(600.0)		(169.6)		(203.0)				(227.4)				
II. Establishment Stage	set	3	186.0		60.0		63.0				63.0				
Grand total (I to II)			(786.0)		(229.6)		(266.0)				(290.4)				

Table 5-7 WATER MANAGEMENT LEVEL AND INFORMATION MANAGEMENT

Subject	Level-1	Level-2	Level-3	Level-4
Management site and area	River system at major regulator	Until at main canal including level-1	Until at FTO level including level-2	Until at on-farm level including level-3
Hydrology Observation -Measuring method	Visual, Manual (ex. staffgauge)	Visual, Automatic gauge	Visual, Automatic gauge, Telemeter	Automatic gauge, Telemeter, Visual
-Network(density)	Low ⟶			High
Monitoring of field condition	Visual judgement, Motorcycle	Visual/measuring, Motorcycle	Visual/measuring at FTO level, Motorcycle and patrol car	Visual/measuring at on-farm level, Motorcycle and patrol car
Distribution Management -Data collection/ distribution	Mail, Memo, Voice communication	Voice communication Mail, Memo, Facsimile	Voice communication Telemeter, Facsimile	Voice communication Telemeter, Facsimile
-Filing	Manual file	Manual file Computer file	Computer file Manual file	Computer file Data base
-Processing	Manual, Chart, Basic computer program	Manual, Chart, Basic computer program	Basic computer program	Packaged application programs
-Monitoring	Voice	Voice, Display panel	Display panel, Voice	Panel, Projector

Table 5-8 REQUIRED COMMUNICATION FACILITIES BY MANAGEMENT LEVEL (LOWER BASIN)

Required Facilities	Unit	Level-1	Level-2	Level-3	Level-4
Communication Facilities of Local Circuit					
VHF/FM radio system					
- New installation	set	8	8	8	8
- Replacement of radio equipment and antenna	"	3	3	3	3
- Replacement of radio equipment	"	16	16	16	16
- New ones at major regulator	"	14	14	14	14
Private wire telephone cable	km	-	20.3	20.3	20.3
Low capacity multiplex radio	set	-	2	2	2
Rural radiotelephone					
- Main station (1)	"	-	2	2	2
- Main station (2)	"	-	3	3	3
- Sub station	"	-	15	15	15
Private automatic branch exchange	"	-	26	26	26
Antenna tower	"	-	1	1	1
Communication Facilities of Field Circuit					
Private wire telephone					
- Communication cable	km	-	1,413	1,413	1,413
- Telephone set	set	-	1,145	1,145	1,145
VHF/FM radio system					
- New installation	"	-	36	36	36
- Removal	"	-	21	21	21
- Land mobile	"	-	27	27	27
- Portable wireless telephone	"	-	401	401	401

Table 5-9 REQUIRED MONITORING FACILITIES BY MANAGEMENT LEVEL (LOWER BASIN)

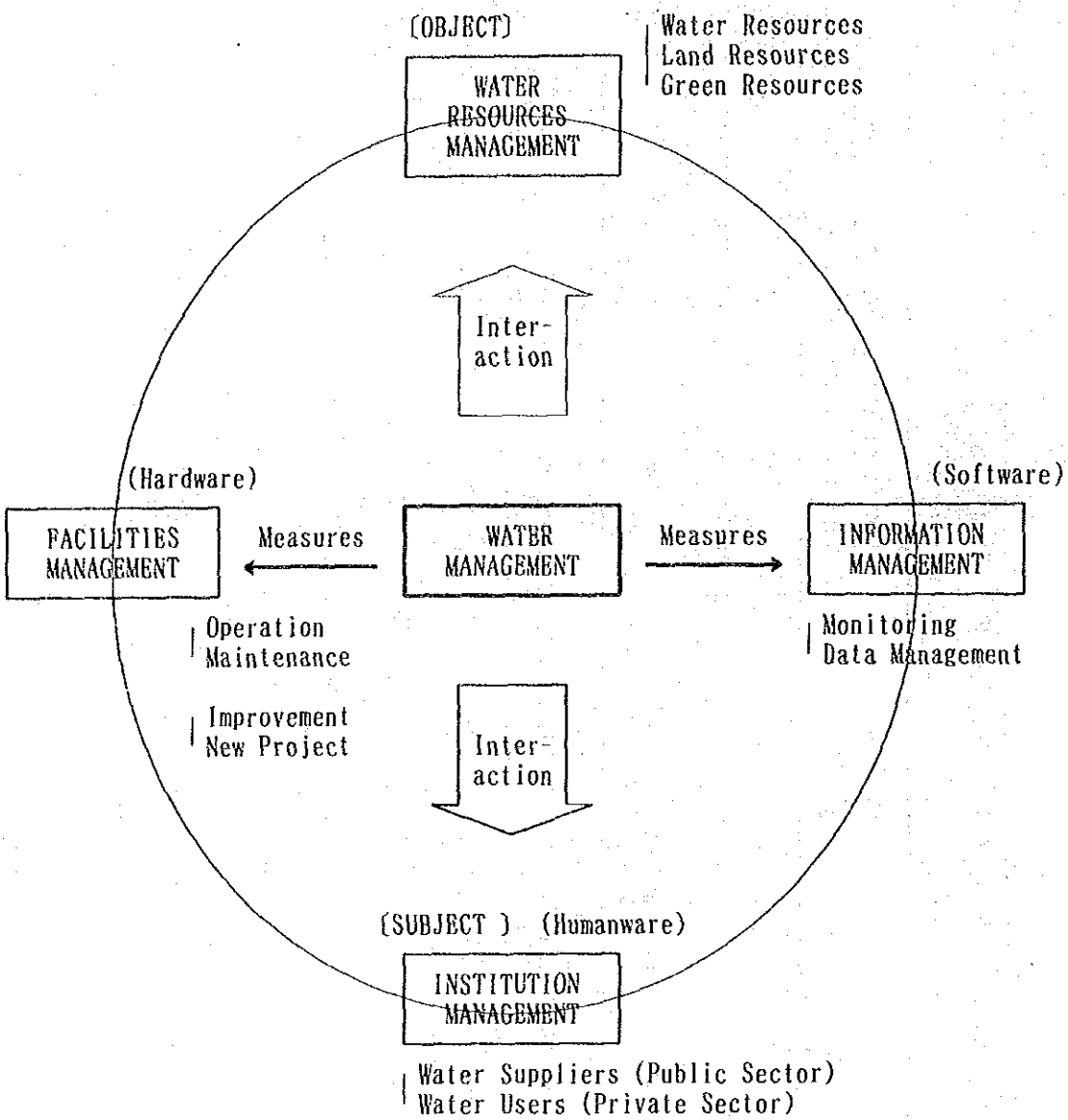
Required Facilities	Unit	Level-1	Level-2	Level-3	Level-4
Observation Facilities of Project Area					
Staff gauge	set	301	-	-	-
Automatic water level gauge	"	-	100	148	328
Reserving rainfall gauge	"	22	-	-	-
Automatic rainfall gauge	"	-	25	25	79
Water level/rainfall with telemeter equipment	"	-	-	36	66
Water quality meter (portable)	"	-	8	12	35
Water quality meter (fixed)	"	-	-	6	12
Soil moisture meter	"	-	-	32	64
Groundwater level gauge	"	-	-	-	50
Current meter (portable)	"	-	-	25	104
Monitoring Facilities in office					
Display panel (offline)	set	-	2	2	7
Telemetering equipment	site	-	-	1	8
Operating room	"	-	-	28	28
Monitoring Vehicle in Project Area					
Motorcycle	set	-	79	104	158
Patrol car	"	-	27	28	28
Maintenance vehicle	"	-	-	1	3
Observation Facilities in River System					
Radio facilities with housing	set	7	10	2	2
Automatic water level gauge	"	-	1	5	3
Automatic water level/rainfall gauge	"	-	-	-	3
Automatic water level gauge with ratio facilities	"	-	1	5	1
Automatic water level/rainfall gauge with radio facilities	"	-	3	6	-
Water level gauge with telemeter equipment	"	-	-	4	10
Water level/rainfall gauge with telemeter equipment	"	-	-	1	9
Automatic water quality meter	"	-	-	-	3

Table 5-10 ROLES AT DATA MANAGEMENT SYSTEM LEVELS

Function	Operational Authority	Roles
Central System	Head Office	(1) Standardization/Regularization of system operation (2) Software design and supervision of software development (3) Supervision/Back-up of operation in the central system and sub-systems (4) Public information service (5) Data entry into the central storage (6) Data compilation/processing (7) Data transfer to/from subordinate systems (8) Maintenance of the central system (9) Staff training for the central and sub-systems
Sub-System	Regional Offices, Hydrological Regional Offices, Divisions in Head/Regional Offices	(1) Supervision/Back-up of operation in the sub-system and subordinate terminal systems (2) Public information service for the sub-system and subordinate terminal systems (3) Data entry into the sub-system storage (4) Data compilation/processing (5) Data transfer to/from the central system and subordinate terminal systems (6) Maintenance of the sub-system (7) Staff training for the sub-system and subordinate terminal systems
Terminal System	Project Offices	(1) Data collection at sites (2) Data entry into the terminal system (3) Data compilation/processing (4) Data transfer to/from other systems (5) Maintenance of the terminal system

Table 5-13 UNIT COST AND WORK VOLUME FOR IMPROVEMENT BY SYSTEM LEVEL

System Level and Components	Specification	Modernization Alternative Case		
		Intensive	Moderate	Conservative
(Basin System)		MB	MB	MB
Bhumibol Dam, Naresuan Dam, Yom Weir		not needed	not needed	not needed
Sirikit Dam, Kiu Lom Dam		not needed	not needed	not needed
Rama VI Barrage	auto-gate control	L.S. 20	L.S. 20	L.S. 20
Chao Phraya Dam	auto-gate control	L.S. 20	L.S. 20	L.S. 20
(Main System)		MB	MB	MB
- Irrigation canal and appurtenant structures with design capacity over 10 CMS (capacity : Q in CMS, Length : L in km)	10 < Q =< 30 CMS, 263 km	.05*Q*L	.025*Q*L	.025*Q*L
	30 < Q =< 100 CMS, 179 km	.04*Q*L	.020*Q*L	.020*Q*L
	100 < Q CMS, 167 km	.03*Q*L	.015*Q*L	.015*Q*L
- Regulator (Po-To-Ro) with total width over 10 m (total width : W in m)	Irrig. Regulator, 19 plc	.45*W	.225*W	.225*W
	Drain. Regulator, 23 plc	.30*W	.15*W	.15*W
(Lateral System)		B/rai	B/rai	B/rai
- Irrigation canal and appurtenant structures with design capacity below 10 CMS till FTO	Gravity irri. area 4.44 Mill.rai	1,200	600	270
- Drainage, navigation and natural river system structures	Wat. conserv. area 3.37 Mill.rai	1,700	800	550
- Regulators with total width below 10 m				
(On-farm System)	Mill.rai	B/rai	B/rai	B/rai
- Overall on-farm irrigation and drainage facilities	Not consolidated 7.39	2,000	1,000	500
	Extensively consoli. 0.07	1,000	300	0
	Intensively consoli. 0.35	0	0	0



GOAL OF WATER MANAGEMENT :

(1) Efficient Use of Water Resources

(2) High Quality Services to Water Users

(3) No Negative Impact to Environment/Ecology System

(4) Equity and Fairness in Resources Allocation; and

(5) Conformity with Economy Principle

Figure 5-1 BASIC FRAME OF WATER MANAGEMENT

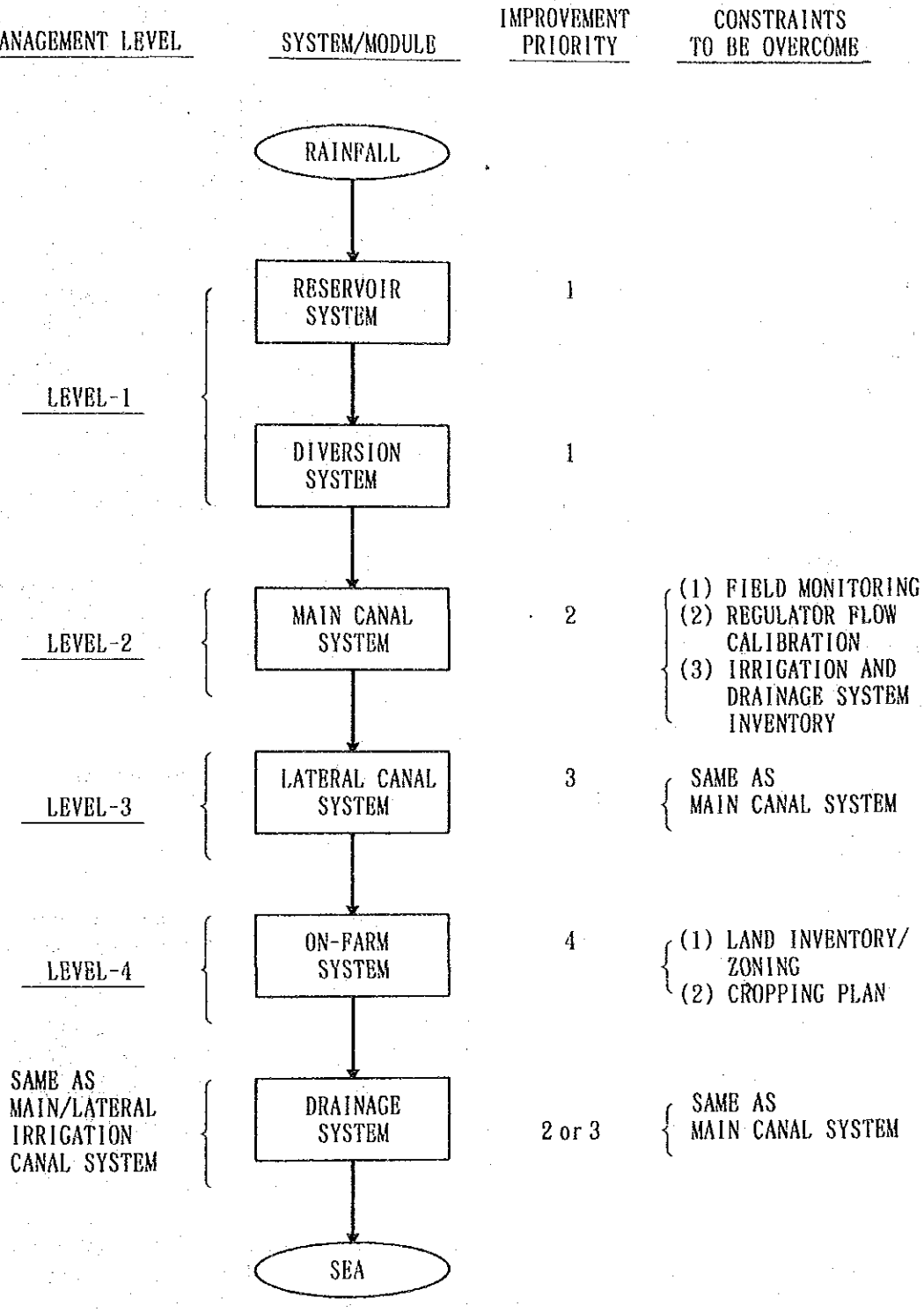
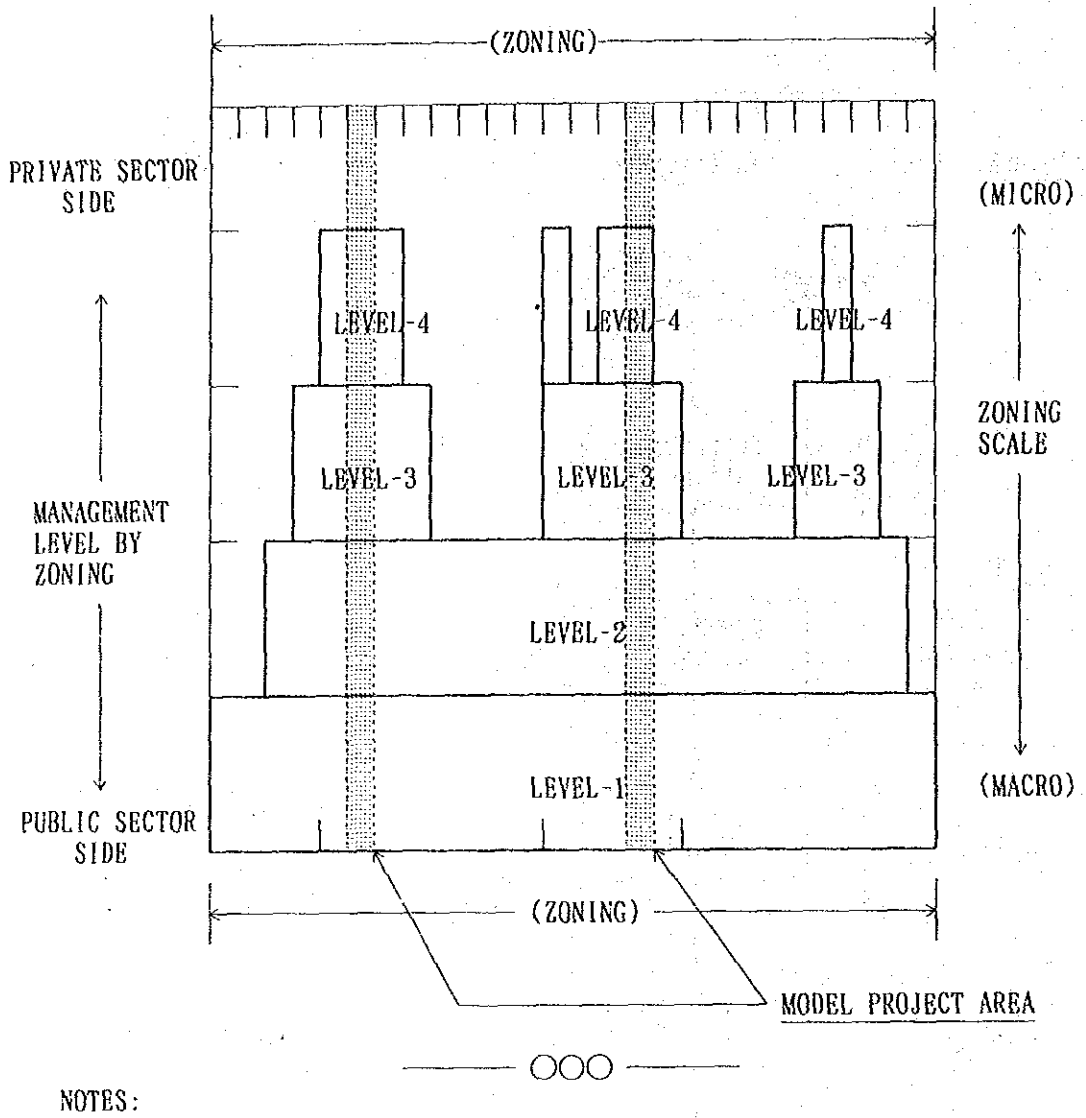


Figure 5-2 SYSTEM COMPONENTS OF THE BASIN WATER MANAGEMENT



NOTES:

(1) Lower the level, more public/infrastructual in nature; step-wise implementation from lower level to higher level would be orthodox approach.

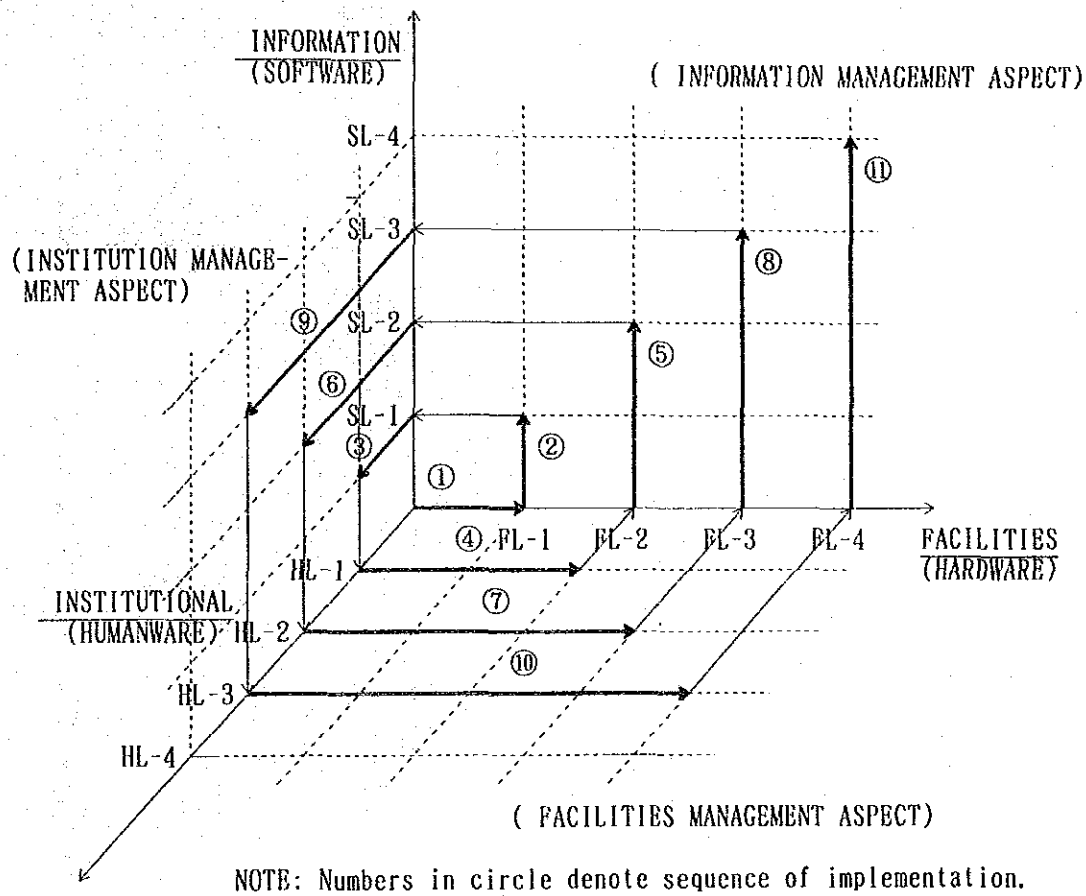
(2) Higher the level, more private/market-oriented in nature; required scale of zoning must be more precise and in detail. Intensive and profitable farming under private sector or group activities will be practiced in such zone.

(3) Horizontal direction denotes social equality, while vertical direction economic efficiency; it is required to maintain a moderate balance between both directions throughout the implementation course.

(4) The Model Project would materialize various management levels by providing various project components in prototype forms for farmers' understanding of the concept and selection of the project components.

(5) Goal of water management thus expected would be an appropriate water resources allocation to each zone to maximize overall benefits.

Figure 5-3 CONCEPT OF MANAGEMENT LEVEL



NOTE: Numbers in circle denote sequence of implementation.

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EXPLANATION

(1) Three aspects of Management should be well balanced, in principle.
(2) Extent of improvement corresponds to an increment of the Management Level and may differ according to characteristics of respective zone.
(3) *Field Monitoring, Gate Calibration, Zoning* and Facility Inventory Arrangement are prerequisite condition for materialization of the the above concept.

Figure 5-4 STEP-WISE IMPLEMENTATION OF IMPROVED SYSTEM

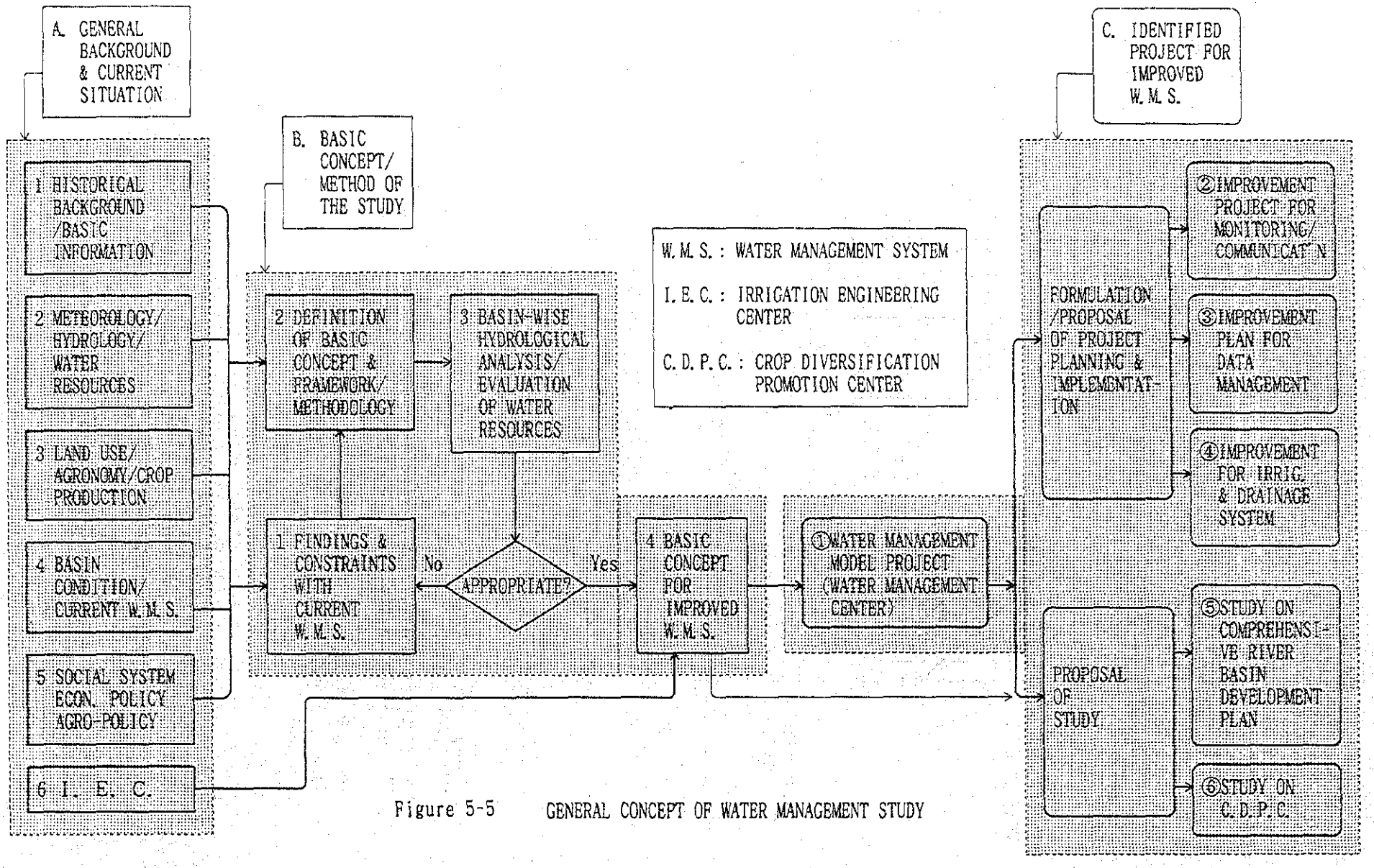


Figure 5-5 GENERAL CONCEPT OF WATER MANAGEMENT STUDY

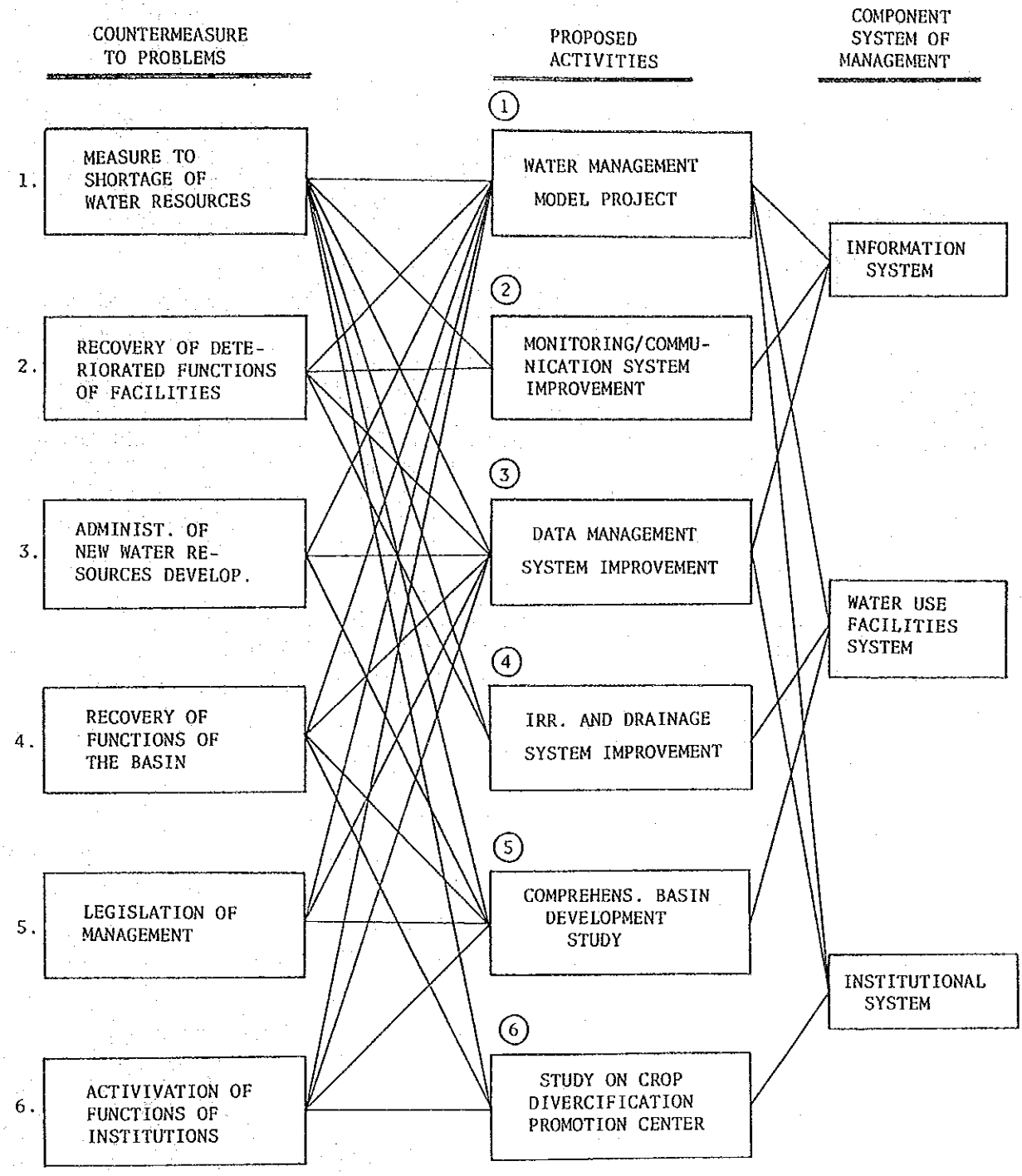


Figure 5-6 BASE PLAN FOR WATER MANAGEMENT SYSTEM IMPROVEMENT

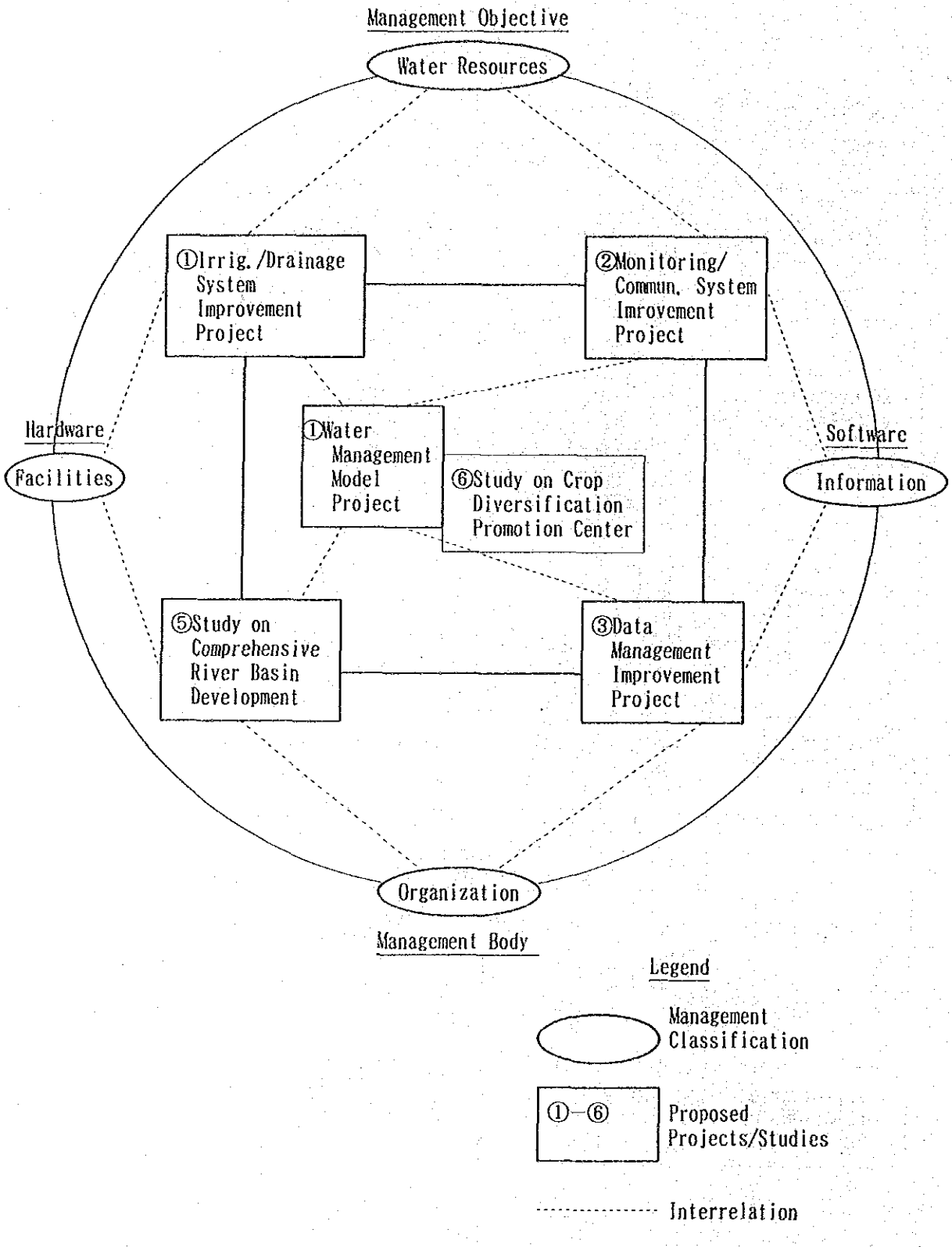


Figure 5-7 INTERRELATION BETWEEN MANAGEMENT CLASSIFICATION AND PROPOSED PROJECTS/STUDIES

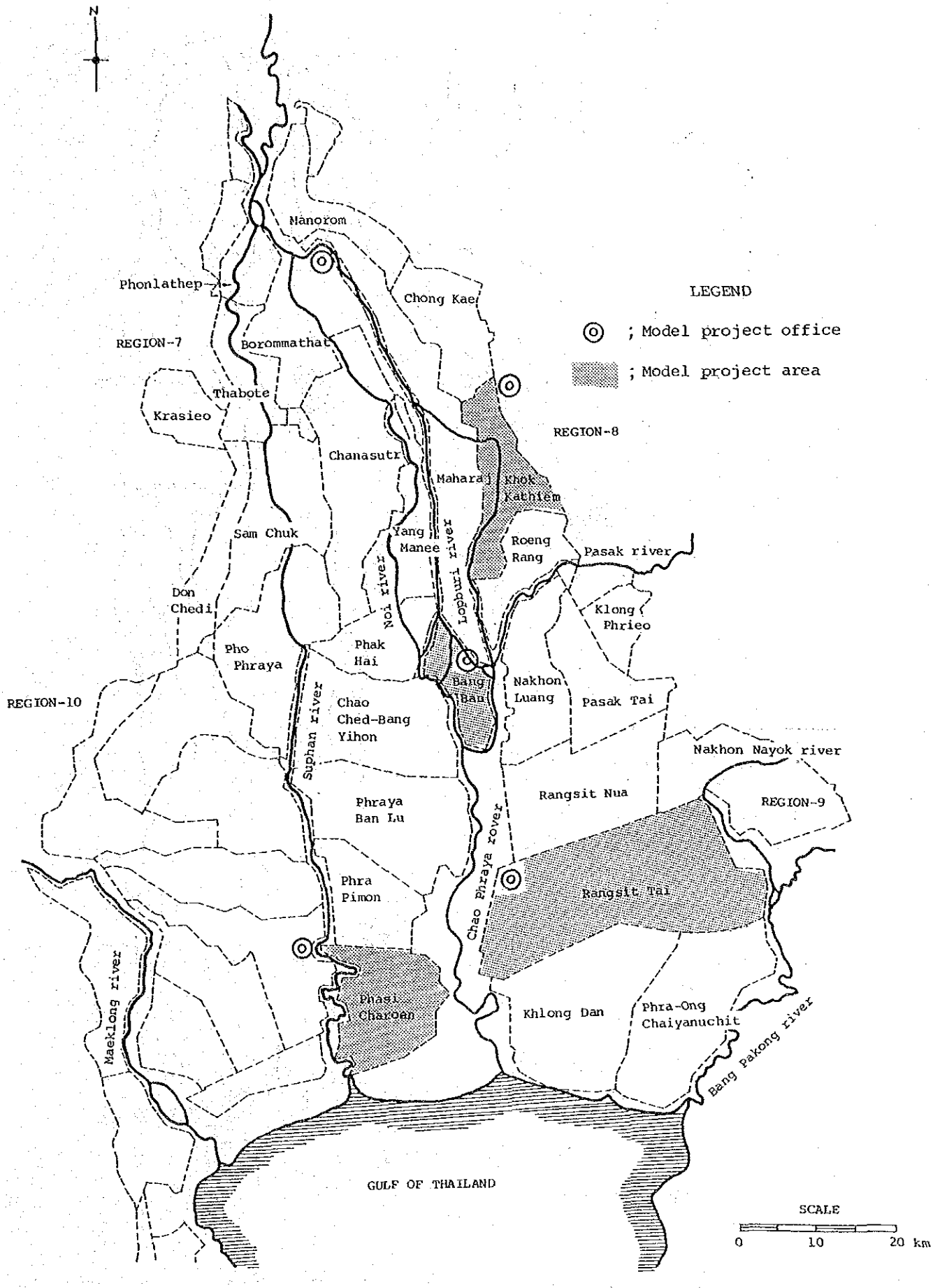


Figure 5-8 LOCATION OF MODEL PROJECT AREA

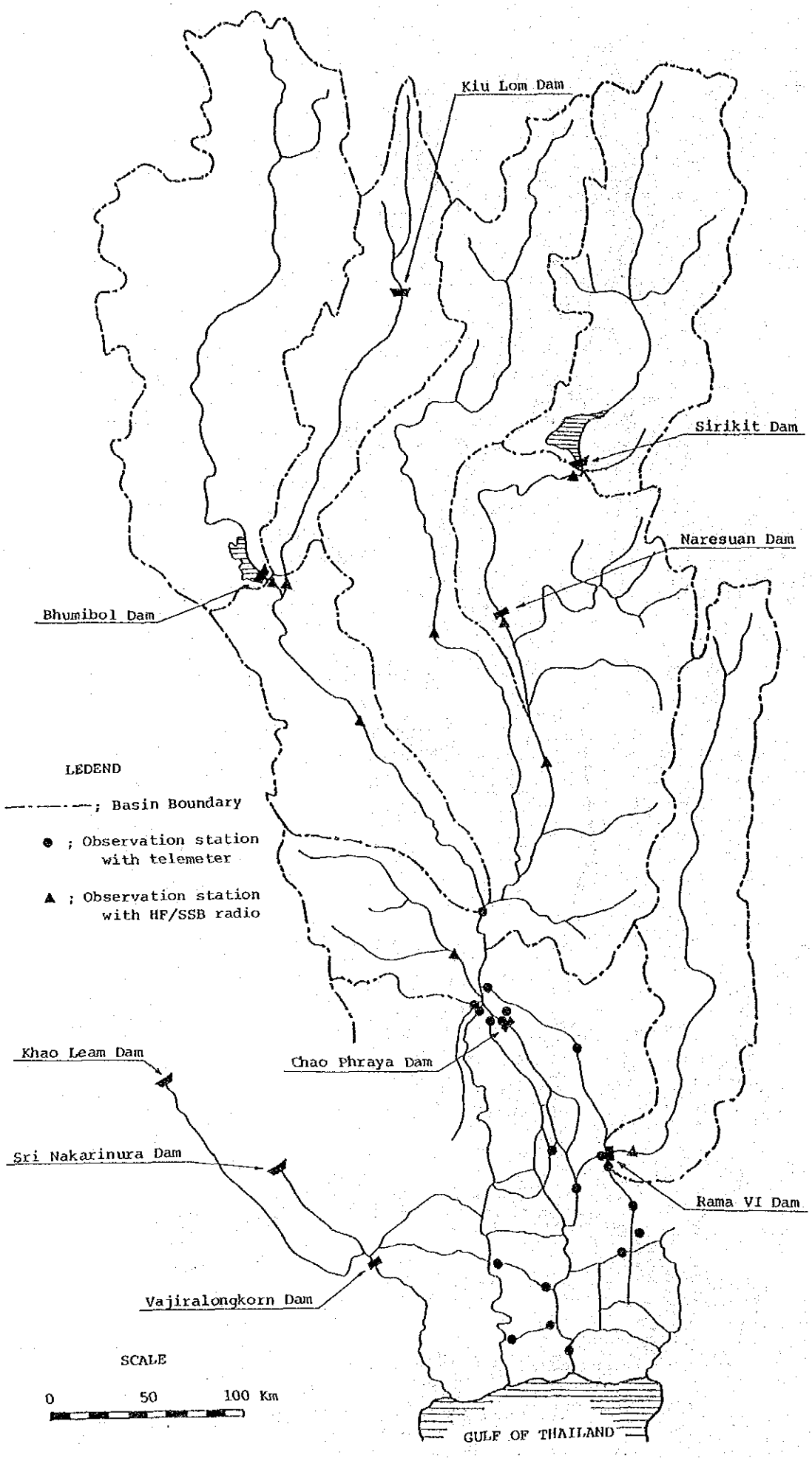
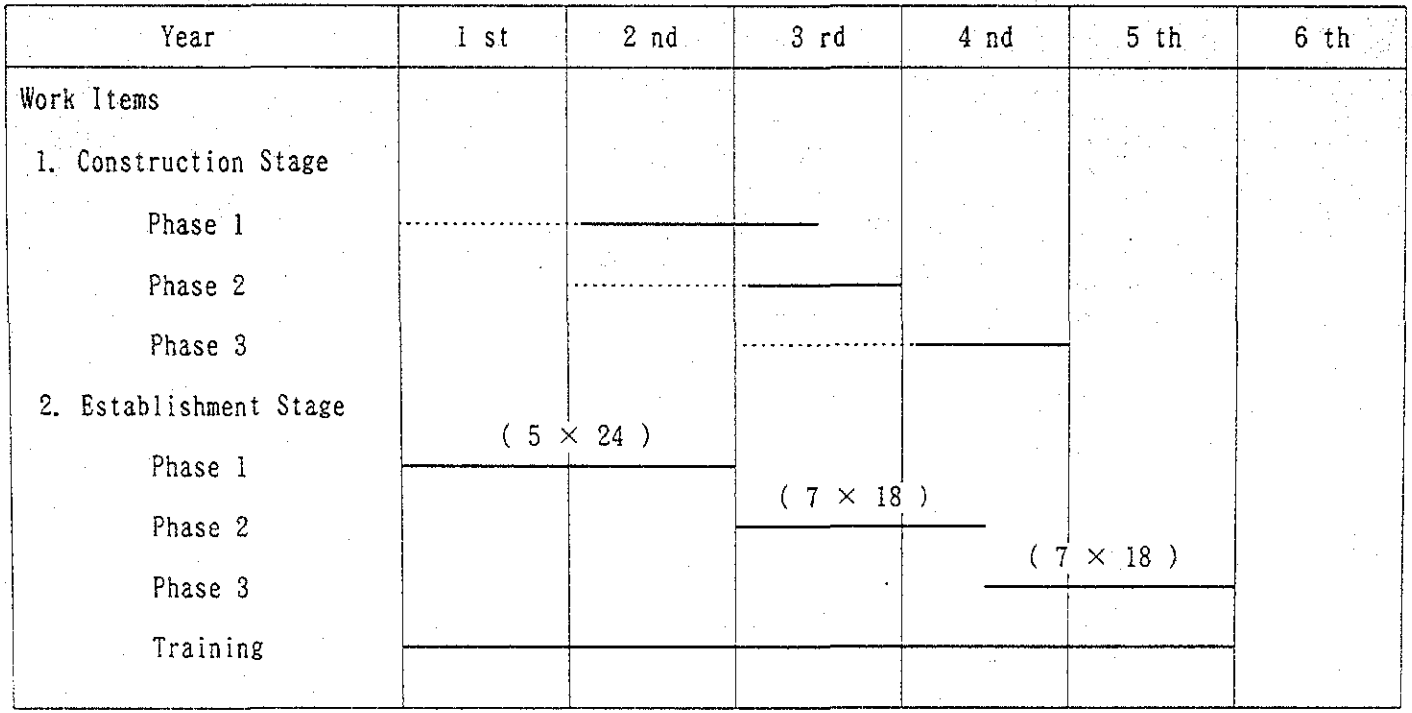


Figure 5-9 WATER LEVEL OBSERVATION STATIONS IN RIVER SYSTEM

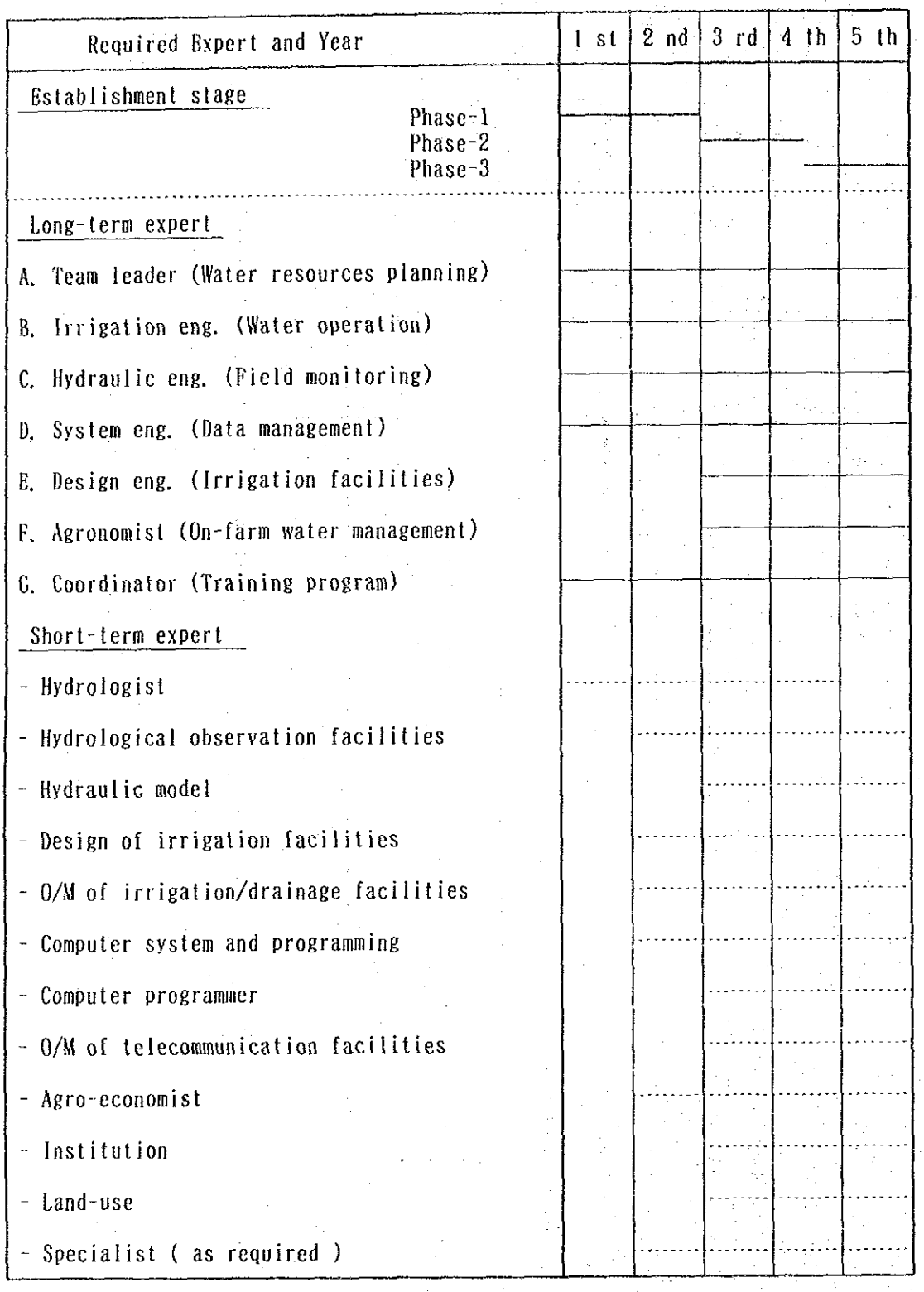


Note ····· ; Preparation for construction stage, detailed design and other necessary works.

( ) ; Expert (man-months)

Figure 5-10 IMPLEMENTATION SCHEDULE OF MODEL PROJECT

Figure 5-11 REQUIRED EXPERT AND WORK SCHEDULE



Note ; Long-term experts are stationed at the model project areas during the implementation of model project.
Short-term experts are employed at required times for specific fields necessitated in water management practices by the above long-term experts.

Figure 5-12 PROJECT ACTIVITIES BY MODEL PROJECT AREA AND EXPERT (1)

Project Activities	Model Project Area						Long-term Expert						
	①	②	③	④	⑤	⑥	A	B	C	D	E	F	G
1. Management of Water Resources Planning													
- General coordination of project activities	○						○						
- Planning/evaluation on water resources	○						○	△					
- Countermeasures for drought/flood	○	○	○				○	△			△	△	
- Examination on annual cropping plan	○						○	△				△	
2. Practice of Water Distribution													
- Water allocation plan to irrigation area	○	○	○	○	○	○	△	○					
- Release plan from reservoirs	○						△	○					
- Monitoring of water level/flow	○	○	○	○	○	○		○	△				
- Review of water allocation plan and actual operation	○	○	○	○	○	○		○	△			△	
- Modification of water allocation planning	○	○	○	○	○	○		○	△			△	
3. Practice of Gate Operation													
- Monitoring of water level by telemeter	○	○	○	○	○	○			○	△			
- Monitoring of water level/quality by manual			○	○	○	○			○			△	
- Monitoring of water flow/field condition			○	○	○	○		△	○			△	
- Monitoring of water flow by display panel	○	○	○	○	○	○			△	○			
- Practice of proper gate operation		○							○		△		
- Practice of proper pump operation						○			○		△		
4. Execution of Field Monitoring													
- Water level/discharge, gate calibration Ground water level		○	○	○	○	○			○		△		

Note ① ; Water management center. ② ; Reginal 7 office, Chao Phraya Dam and Five head regulators.
③ ; Reginal 8 office, Koke Kathiem project area. ④ ; Rangsit Tai project.
⑤ ; Phasi Charoen project. ⑥ ; Bang Ban project.
A ; Team leader (Water resources planning). B ; Irrigation eng. (Water operation).
C ; Hydraulic eng. (Field monitoring). D ; System eng. (Data management). E ; Design eng. (Irrigation facility). F ; Agronomist(On-farm management). G ; Coordinator(Training program).
○ ; Main-assignment. △ ; Sub-assignment.
Short-term experts are also required in accordance with each activity, if necessary.