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## Water management in the upper East Bank of the Chao Phraya Delta

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**Abstract:** *Chao Phraya Delta of Thailand is one of greatest rice granary in Asian monsoon area. Its farming and water management has changed drastically by the Greater Chao Phraya Project. Recently, water shortage has become more serious by the decrease of runoff discharge upstream and increase in water demand. New modernized water management system corresponding to various changes is actually sought for.*

*This paper reviewed present situation, recent change of background, difficulties and existing problems on water management in the Chao Phraya Delta. Then, the importance of paddy field for natural resources conservation was referred. Finally, the strategies for more appropriate water management were discussed. The decision support system for water operation under preparation was also introduced. Main focus was given to the upper east bank of the delta.*

*It is essential to achieve stable water supply in dry season. Examples of strategies considered in this paper are as follows:*

*To construct regulating ponds.*

*To increase the number of monitoring on water operation and hydrology and improve accuracy.*

- 1. To promote the networking of information on water management, so as to find the common benefit among RID organizations and /or water users.*
- 2. To develop and use decision support system for water operation.*
- 3. To prepare some benefit for contribution of saving irrigation water.*
- 4. To promote participatory irrigation management cooperated by farmers' group.*
- 5. To examine crop calendar by locations for increasing the reuse opportunity of water.*

*It is difficult to evaluate the reasonableness of water allocation planning and practical water operation perfectly. Therefore, to have information in common and share the thinking process among RID and other authorities concerned are important to seek for more appropriate water management and bring up human resources.*

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# 1 Introduction

Chao Phraya Delta of Thailand is one of greatest rice granary in Asian monsoon area. Its farming and water management has changed drastically by the Greater Chao Phraya Project (van Beek, 1995). The original purpose of the project was supplementary irrigation in rainy season. At present, its function reached to irrigation in dry season and domestic water supply.

Recently, water shortage (Chaiwat, 1994, Roongrueng et al., 1996, Sanyu et al., 1999) has become more serious by the decrease of runoff discharge upstream and increase in water demand. The rice price hovered around low level. Under such circumstances, now is a turning point of paddy farming. New modernized water management system corresponding to the change is actually sought for.

In this paper, present situation, recent change of background, difficulties and existing problems on water management in the Chao Phraya Delta are reviewed. Then, the importance of paddy field for natural resources conservation is referred. Finally, the strategies for more appropriate water management are discussed. Main focus is given on the upper east bank of the delta.

## 2 Outline of the upper east bank of the Chao Phraya Delta

The Chao Phraya River basin has a catchment area of 162,000 km<sup>2</sup> including 1.4 million ha of the low-lying delta area. Main water resources in the basin are the Bhumiphol reservoir dam with storage capacity of 13,500 MCM (million cubic meter) and the Sirikit reservoir dam with storage capacity of 9,500 MCM. The Pasak reservoir dam with storage capacity of 960 MCM has just completed in 1999. The Chao Phraya diversion dam in the Chao Phraya River at Chainat enables to allocate water for the delta area. Location of main water operation facilities is shown in Figure 1. The area marked by diagonal line shows the upper east bank of the Chao Phraya Delta.

Total area of the upper east bank of the Chao Phraya Delta is 244,000 ha including 218,000 ha of irrigated area. The area is located in a part of Chai Nat, Nakhon Sawan, Lop Buri, Saraburi, Sing Buri, Ang Thon and Phra Nakhon Si Ayutthaya provinces. They get water resources from rainfall and the Chao Phraya River. Figure 2 shows main water operation facilities in the upper east bank of the delta and surrounding area. The Chainat-Pasak canal and Chainat-Ayutthaya canal are used to convey water from the Chao Phraya River throughout the Manorom regulator and the Maharaj regulator respectively. The maximum flow capacity of the Chainat Pasak canal is 210 m<sup>3</sup>/s and that of the Chainat-Ayutthaya canal is 75 m<sup>3</sup>/s. Those facilities were constructed under the Great Chao Phraya Project along with lateral distribution canal system and drainage system.

The land elevation in the irrigated area changes between 1 m and 19 m above mean sea level (MSL). Annual rainfall in the area changes between 1000mm and 1,600mm. Figure 3 shows the average monthly rainfall at Lopburi. Figure 4 shows the trend of annual rainfall. Rainy season starts from middle of April and ends late in October. At the beginning stage of the rainy season, it rains locally and within short period. Non-rain days sometimes continue

for quite a long period. The runoff ratio is difficult to calculate. However, it is estimated between 15 and 30% (Atthaporn, 1999). Tidal effect sometimes comes to Ang Thong. This area often suffers from water shortage and flooding. Therefore, water operation is essential for the prosperity of the area.

### 3 Present situation of water management

The Royal Irrigation Department (RID) is main organization to carry out water management. The east bank of the Chao Phraya delta is under the control of Regional Irrigation Office No.8 (RIO-8). There are five Operation and Maintenance (O/M) Project offices in the upper east bank of the delta, namely Manorom, Chong Khae, Khok Krathiam, Roeng Rang and Maharaj O/M projects. Their responsibilities are planning of water resources allocation, daily water operation including monitoring, flood protection and so on.

Figure 5 shows the organizations and flow of information on water management. Within RID, content of information in instructing direction is water allocation and facility operation at main water operation facilities. Content of information in reporting direction are daily rainfall, water level, discharge and condition of facility operation and weekly cultivation condition under the control of O/M Project offices. Table 1 shows example of data sheet at Khok Krathiam O/M Project. Information is prepared by hand writing. Facility operation at tertiary canal level is out of reporting.

In terms of field data, zonenmen and facility operators who belong to O/M Project Office collect most data. Data are reported to O/M Project Office by way of water master or directly. Facility operators are consisted of gate operator who is generally called gate tender, pump operator and canal operator who is generally called canal keeper. For example, there are two Water Master offices and sixteen Zonenman offices in Khok Krathiam O/M Project.

In the delta area, some O/M Project offices send their reports to both RID Head Office and their RIO, and others send them only to their RIO according to data communication conditions. Communication media used for information exchange are oral communication, voice radio communication, telephone, fax and so on. In the upper east bank of the delta, each O/M Project Office sends daily report to RIO-8, then RIO-8 sends them to RID Head Office. They usually use fax. According to the surprise inspection between on 15 December 1999 and 5 October 2000 for 13 times in total, 95% information arrived at RID H.O. on that day or within one-day delay.

Recently, RID is shifting the authority of daily water allocation from Head Office to RIO under the control. In normal water condition, RID Head Office orders only water operation at the Chao Phraya diversion dam and total water allocation for each RIO command area. RIO-8 determines water operation at main regulators such as Manorom, Chong Khae, Khok Krathiam, Roeng Rang and Maharaj regulators. RIO-8 also pays attention to main drainage regulators. Lateral and tertiary canal level is under the responsibility of each O/M Project.

RID Head Office estimates total water requirement based on collected information and makes water operation plan. Then, RID proposes the plan of release discharge from upstream reservoir dams weekly to Electricity Generating Authority of Thailand (EGAT). The

primary purpose of dam operation by EGAT is hydroelectric power generation. However, released water from dams is basically used effectively in most cases. If the water levels at the dams become higher than the designed upper rule curve, EGAT has to release excess water for protecting dams and flood mitigation.

Water allocation in dry season (RID, 1998) is very important problems to prevent water conflict. Many regulations are done among organizations concerned including RID. The discussion starts from October of the previous year to determine water allocation between January and June (hereafter called WM dry season). The period of actual dry season and WM dry season is different. RID, EGAT and other related organizations collect information and estimate remaining water storage volume as of 1st January in main dams and reservoirs. After understanding available water resources in the six months, water allocation planning is discussed. It is generally understood that about 6,600 MCM is needed in WM dry season for irrigation, domestic and industry consumption, navigation, salinity control (Chaiwat, 1995). Of them, water supply for Bangkok is about 700 MCM. Domestic and industry consumption, salinity control, navigation in the delta area are 700 MCM, 600 MCM and 300 MCM respectively. The priority of water allocation changes year by year. The priority of irrigation becomes the last in case of serious water shortage. The allocated water resources for irrigation determines cultivation planning in WM dry season. General criteria are as follows:

- 1) When the remaining active storage volume at dams as of 1st January is more than 8,000 MCM, target cultivation area is recommended 480,000 ha.
- 2) When the remaining active storage volume at dams as of 1st January is between 5,000 MCM and 8,000 MCM, target cultivation area is recommended between 320,000 ha and 480,000 ha.
- 3) When the remaining active storage volume at dams as of 1st January is less than 5,000 MCM, cultivation planning will be canceled.
- 4) For the WM dry season of 2000, new methodology to determine the total release discharge from upstream dams was adopted. The inflow and demand of water for the following three years were estimated, then the most stable water supply planning was chosen.

The following priority was adopted to determine the location of cultivation area in WM dry season of 1998:

- 1) First priority: to allocate water for the paddy field where wet season's cultivation in 1997 was impossible.
- 2) Second priority: to allocate water for the farmer who had damage by violent natural calamity in 1997.
- 3) Third priority: to allocate water for the farmer who is planned to receive irrigation water in WM dry season of 1998 based on rotational rule.
- 4) The last priority: to allocate water for farmer who wants to cultivate for increase of income.

The followings are procedures within RID to determine the location of cultivation:

- 1) At first, RID Head Office informs RIOs about amount of available water resources between January and June and the plan of total amount of water allocated for each RIO.
- 2) RIO selects the command area where irrigation water is supplied based on rotation rule. The area is selected by lateral canal basis.
- 3) RIO informs the results to O/M Project offices.
- 4) O/M Project offices discuss with farmers and arrange the plan of cultivation area and daily water distribution.
- 5) O/M Project office make daily water allocation plan and report to RIO.
- 6) RIO arranges the collected information from O/M Project offices and reports to RID Head Office.

RID makes not only planning but also monitoring and report. Table 2 shows the comparison between planning and result in recent years. There are other water resource from the MaeKlong River basin and the Pasak reservoir dam. In 2000, water transfer from the MaeKlong river basin to the Tha Chin River was planned 1,000 MCM and actually 420 MCM were transferred. In terms of the Pasak reservoir dam, 534 MCM was planned to release, and actually 753 MCM was released. Table 3 shows the planning of water allocation for the upper east bank of the delta in WM dry season of 2000. RID and EGAT try to keep the planed water operation at dams and main regulators, namely release discharge from dams and intake from main regulators. However, those have to be modified by the influence of rainfall and unexpected water demand. Figure 6 shows the comparison between planning and results of intake discharge from the Manorom regulator. The planning of intake was 1,046 MCM. In case of WM dry season of 2000, the rain started earlier than normal season. The water level at the Sirikit reservoir dam became near to the upper rule curve from middle of May. EGAT released more water than the plan because of high demand of electricity. That caused the increase in discharge at the Chainat-Pasak canal. As a result of it, the practical intake became 1,666 MCM. In terms of total RIO-8 area, although the planning of water use was 1,735 MCM, but they actually received 2,387 MCM. The plan of the cultivated area in RIO-8 command area was 115,000 ha. The practical cultivation area became 197,000 ha that was almost maximum potential in dry season.

In the delta area, rice cultivation more than five times per two years is possible now where water condition is good. Historically, the rice cultivation in dry season started only about 30 years ago. In those days, farmers could get irrigation water every two years by rotation. It was new trial. Before that, only one crop in a year was possible. The rice cultivation area increased rapidly, but soon came to the limit because of available water resources and existing function of irrigation facilities (Virat, 1992, Water Operation Branch, 1999). The flow capacity of the system under the Great Chao Phraya Project is equivalent to about 7 mm/d for supplementary irrigation supply. It can meet about 60% of water requirement of paddy farming. After unsuccessful regulation of cultivated area with farmers, some farmers started rice cultivation by their own will. Farmers could cultivate rice any time they like if they can get water, because non-photosensitive variety was developed. It collapsed the order of water operation at on-farm level in some areas.

Some O/M Project areas shifted main rice cultivation from rainy season to dry season after the Greater Chao Phraya Project, because farmers there want to escape from flood disaster. Average crop intensity of dry season in the delta area is 30-40 % (Sanyu et al., 1999). There is much difference by locations as shown in Figure 7. The ratio of the upper east bank is relatively low. When we think about equality among O/M projects, we need to understand crop intensity throughout the year and historical background. However, to make a persuasive water allocation rule considering both priority and preference is not so easy.

Recent change of background on water management in the delta area can be summarized as follows:

- Amount of rainfall in the upstream of the Chao Phraya River basin tends to decrease. It causes the decrease of inflow discharge into the reservoir dams.
- Intake discharge at upstream of the delta area increased so much. It decreased the discharge at the Chao Phraya diversion dam where most irrigation water is delivered throughout main regulators. Figure 8 shows the change of discharge at Nakhon Sawan and Chainat in the Chao Phraya River. (The Nakhon Sawan point is about 94 km upstream or 50 km north of the Chao Phraya diversion dam, and the Chainat point is just downstream of the diversion dam.)
- Besides supplementary irrigation in rainy season, water allocation for domestic and industrial use, and flood control have been requested.
- Rice cropping calendar became different even within command area of some thousand ha.
- Situation of over cropping continues as shown in Table 2.
- Many gates or regulators have been constructed at the end of lateral canals, main drainage canals even in the gravity irrigation system area as well as the Lopburi river. Those increase the function of storing water in the area.
- Farmers tend to have their own pumps and ponds.
- Because floating rice area and deep water rice area decreased, it became difficult to convey excess flooding water into paddy fields.
- The Pasak reservoir dam contributes mitigation of water shortage and flood especially in the lower east bank of the delta.

## 4 Difficulties and problems of water management

Many researches and international cooperation projects have been implemented, and many proposals were given on water management. Their contribution is great. But, RID still has the following difficulties on practical water management in the delta area:

1. Water travelling time from upstream dams to the fields needs much time as long as 1-3 weeks.
2. Arrival discharge at the Chao Phraya diversion dam changes by the fluctuation of release discharge from upstream dams, because EGAT saves the release on holidays. Figure 9

shows the comparison between total release discharge from upstream dams (Bhumipol and Sirikit reservoir dams) and discharge at Nakhon Sawan in the Chao Phraya River.

3. It is difficult to estimate runoff discharge (side flow) from rainfall information accurately.
4. Much water is consumed in the upstream of the delta area beyond the control of RID. Sometimes, only half of released water from dams arrives at the Chao Phraya diversion dam. Other departments have installed many pumps there and regulation of water allocation at planning stage is not enough even now. This phenomenon can be estimated during WM dry season in Figure 9.
5. There is no regulating pond that enables released water from upstream dams to use more effectively during unexpected rainfall.
6. Water level in the main irrigation canal sometimes has to be kept high to send water for some lateral canals that intake sill elevations are relatively high compared with standard of minimum water level as shown in Figure 10. In such cases, not only discharge but also water level becomes important indicator for water operation.
7. It is difficult to use local rainfall more effectively under the present monitoring system and the number of staff.
8. Cooperation of farmers on maintenance of on-farm facility and keeping cultivation plan in dry season is not enough. Someone sometimes breaks on-farm facilities at lateral and tertiary canals.
9. When farmers start planting after small rain at the beginning of rainy season, but rain does not continue, a young rice plant would wither and die if irrigation water is not enough supplied. This weather condition is called dry spell. Farmers strongly ask irrigation water even though their paddy fields are out of irrigation schedule.
10. A third person sometimes gives pressure to RID on water allocation.

On the other hand, RID needs to resolve the following problems:

1. Accurate measurement of discharge at main regulators.
2. Frequent renewal of data on canal network and O/M facilities.
3. Close connection among O/M Project offices, RIOs and RID Head Office on inputting collected data into computers and their usage.
4. To make well-grounded water operation process with scientific analysis.

Promotion of digitizing and networking will contribute to save time and personnel expenses in total. It makes the preparation of input data for analysis easy. Existing software such as AISP (Acres Irrigation Support Package)(ACRES, 1982, Choolit, 1999, Pal Consultant Co. Ltd. et al., 1999) should be used more widely. Establishment of information processing environment will be first step. On the other hand, to keep balance between experience and analysis is also important.

## 5 Function of paddy fields for natural resources conservation

Paddy farming in Asia monsoon area is strongly connected with rural social system. Good management of paddy field is essential for not only food production but also natural resources conservation. Paddy farming including related water management has been playing following important roles and function (Yuyama et al., 1996, Yuyama, 1999):

- 1) Flood mitigation as retarding basin
- 2) Water resources for downstream area as regulating pond
- 3) Water quality and ecosystem conservation
- 4) Protection of soil erosion
- 5) Production of oxygen
- 6) Provision for recreational opportunity

One of characteristics in the Chao Phraya Delta is floating rice farming. It can be summarized as low input and low yield but sustainable farming. Cultivated floating rice area decreased from 228,000 ha in 1987 to 114,000 ha in 1997 (CTI et al., 1999). The storage volume in the floating rice area in 1997 can be estimated 2,750 MCM by assuming that water depth is 2.5 meter. The volume would be almost as same as standing water in remaining paddy fields in rainy season if the water depth were assumed 0.3 meter. For reference, inundated volume in the flood of 1995 was estimated 15,900 MCM (CTI et al., 1999). Without paddy fields, to protect metropolitan Bangkok from flooding is impossible. The distribution of the floating rice area is shown in Figure 11. Floating rice area in the upper east bank of the delta in 1998 was 52,400 ha. Table 4 shows detail condition. Unit of floating rice area is from some thousand to ten thousand ha. Each unit has drainage regulator to control water level. The weight of artificial control of water increased even in floating rice area. Recently, newly constructed big roads function as embankment.

Floating rice can grow flexibly corresponding to irregular increase of water level. It grows just like rice grown in a dry field with weed at the beginning stage. Then, the stem increases between 2 m and 10 m according to water condition. It takes 7-9 months from planting to harvest. The harvest starts from December or January after the standing water is drained.

Released water from the floating rice area can also contribute to decrease salinity concentration at downstream area. EC (Electrical conductivity) in the irrigation and drainage canals of the upper east bank of the delta ranged between 15 and 30 mS/m. Those values are equivalent to TDS (Total dissolved solids) of 100-200 mg/L. Comparing from the EC standard for irrigation of 200 mS/m, measured values were relatively very low.

There is economic analysis to find suitable land use in terms of water consumption (Paul Consultant Co. Ltd. et. al, 1999, Apichart, 2000). Rice production came to low position under the indicator of the profit per specific water consumption (Baht/m<sup>3</sup>). However, when we discuss about land use change from paddy field to other usage, we need to consider the sustainability of activity and potential function of paddy farming. Otherwise, one countermeasure might cause negative impact to another problem. Performance of water use

in paddy farming differs by the level of spatial scale and time, because water consumption of paddy field is different by the growing stage and drained water can often be reused at downstream area. Return flow is actually difficult to estimate. Therefore, such kind of economic analysis should make clear of prerequisite conditions for the analysis.

## 6 Strategy for more appropriate water management

### 6.1 General Strategies

Recently, we need much regulation and time to construct large-scale dams or inter-basin water conveyance canals. On the other hand, we need to develop water resources to correspond increasing demands. More efforts have to be done at O/M side, too. To save irrigation water in rainy season is essential to achieve stable water supply in dry season. To promote crop diversification in dry season will also contribute to it. More close communication between supply side and demand side is needed. Field monitoring and analysis (Chalong, 1991, V.V.N. Murty et al., 1991, Pushpa et al., 1993, Apichai et al., 1994, Chatchai et al., 1993) should be emphasized for the delta level water allocation planning and operation.

Examples of strategies/countermeasures for more appropriate water management are as follows:

- 1) To construct regulating ponds.
- 2) To increase the density of check gate, field turn out (FTO), canal and road.
- 3) To increase the number of monitoring on water operation and hydrology and improve accuracy.
- 4) To promote the networking of information (Kobayashi et. al, 1994) on water management, so as to find the common benefit among RID organizations and/or water users.
- 5) To develop and use decision support system for water operation containing feedback of experience, databases, and analyses. Effective use of existing software (Choolit, 1999, Yoshino et al., 1997, Hayase et al., 1996) and databases is important.
- 6) To improve rules and regulations on water allocation including preparation of some benefit for contribution of saving irrigation water.
- 7) To establish technology and economic basis for promoting crop diversification in dry season more widely.
- 8) To strengthen a campaign of water saving for supplementary supply of irrigation water in rainy season.
- 9) To promote participatory irrigation management (PIM) cooperated by farmers' groups.
- 10) To examine dam operation rule curves with EGAT after reviewing proposed ideas (Sanyu et al., 1999, CTI et al., 1999, Horikawa, 1997).

- 12) To strengthen training courses that can contribute practical water operation.
- 13) To strengthen integrated watershed management in NWRC (National Water Resources Committee).
- 14) To examine crop calendars by locations for increasing reuse of water.
- 15) To examine automatic control type regulator when renewal is discussed.

Any one of them is not easy to implement. However, they are considered unavoidable problems. In terms of 1), many spatial levels of ponds can be considered. Purposes are peak cut of discharge during flood, storage of for early dry season or emergency, and minimizing travelling time lag of water between supply and demand (buffer function). In terms of 3) and 4), great progress is expected by the improvement of information technology. However, organization of maintenance team and renewal plan of facility and equipment are needed in advance especially for telemetering system. Information on drainage (Francois et al., 1997) will be more important for conservation of water resources. In terms of 7), the strengthening of drainage standard is needed, because vegetables are not so strong against inundation as paddy. In terms of 12), effort has already started to cope with flood, water shortage and environmental conservation. In terms of 13), more effective use of released water from the floating rice area should be discussed. Reuse of irrigation water will contribute water quality conservation (Yuyama et al., 1999).

Main information on water management and hydrology is opened to the public at homepage of RID (<http://www.rid.go.th>). RID organized the Office of Hydrology and Water Management in 1997. Collected data can be used more effectively and practically. To have information and process on water management in common will also contribute to have ownership and bring up capable person. Research achievements (Kasetsart University and ORSTOM, 1996, <http://www.ku.ac.th/delta>) are helpful to reconfirm existing condition and to pick up alternative countermeasures.

## 6.2 Proposal of decision support system for water operation in the upper east bank of Chao Phraya delta

The purpose of the system is to achieve more appropriate and fair water management. To monitor existing condition accurately and share summarized information in common is essential. The decision-maker and all responsible persons will be able to get latest summarized information easily. The target O/M Project is Manorom, Chong Khae, Khok Krathiam, Roeng Rang and Maharaj. To learn from the past trend, daily data from 1994 will be input. The concepts of the system are as follows:

- 1) Contribution to practical water operation throughout the year
- 2) Combination of monitoring, analysis and experience (improvement of man-machine interface)
- 3) Common ownership of water management process among RID Head Office, RIO-8 and five O/M Project offices (including establishment of information networking)
- 4) Seeking for stable water supply by water saving at every spatial and temporal levels

- 5) Effective use of existing software
- 6) Effective use of existing hydrological and water management databases and their strengthen in function
- 7) Input of daily information at lateral canal level and above
- 8) Paying more attention to drainage system

The system will be designed by Windows basis and connected with existing hydrological and water management databases. The support by Geographical Information System (GIS) and Remote Sensing (RS) technology will be helpful. The system is consisted of four sub-systems of monitoring, database, analysis, and reference information as shown in Table 5. Plan of data communication networking is arranged in Figure 12. Needed daily information on hydrology and water management is shown in Table 6.

## 7 Conclusion

Farming and water management in the Chao Phraya Delta is changing rapidly now. Corresponding to changes in background, re-allocation of water resources, rehabilitation of aged facilities, construction of facility and examination of its operation for crop diversification, and promotion of PIM are actually sought for (Charoon et al., 1993, Siripong, 1997). In the eighth Agricultural Development Plan (MOAC, 1998), three strategies of 1) strengthening international competitiveness, 2) natural resources conservation and sustainable agricultural development, and 3) human resources and farmers organization development, were stated.

Modern technology and Thai custom need to be mixed well to search for sustainable agricultural system including water management and marketing. Not only preference in economics but also future prosperity in the delta area has to be discussed among all necessary stakeholders.

In this paper, present situation and problems of water management in the delta area was reviewed. Water operation seemed to become more complicated and difficult than before to satisfy new requirement. Many challenges are needed for stable supply of water in dry season.

In terms of the upper east bank of the delta, they received the benefit by the Greater Chao Phraya Project so much. The area has great potential of development and alternative possibilities (NESDB, 1990). It is up to national policy and agriculture policy. The development of the area has great impact on water use, flood fighting and water quality environment to the lower east bank of the delta including Bangkok.

It is difficult to evaluate the reasonableness of water allocation planning and practical water operation perfectly. Even when water operation is suitable in total, small complains will come from many water users. Every process of water operation can not be automatic. Therefore, we need decision support system as tool of man-machine interface or expert system to promote water management with accountability. To have information in common and share the thinking process among RID and other authorities concerned are important to seek for more appropriate water management and bring up human resources.

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TABLE 3 PLANNING OF WATER ALLOCATION IN WM DRY SEASON OF 2000(MCM)

|              | Manorom | C h o n g<br>Khae | K h o k<br>Krathiam | R o e n g<br>Rang | Maharaj |
|--------------|---------|-------------------|---------------------|-------------------|---------|
| Rice         | 80      | 115               | 100                 | 30                | 147     |
| Vegetable    | 0       | 14                | 8                   | 12                | 15      |
| Fruit        | 2       | 7                 | 4                   | 1                 | 0       |
| Fish pond    | 1       | 2                 | 1                   | 2                 | 0       |
| Domestic use | 12      | 1                 | 17                  | 5                 | 0       |
| Sum          | 95      | 145               | 130                 | 50                | 162     |

TABLE 4 CONDITION OF FLOATING RICE AREA IN THE UPPER EAST BANK OF THE DELTA (1998)

| O/M Project   | Area (ha) | Maximum water level (m.MSL) | Remarks   |
|---------------|-----------|-----------------------------|---|
| Chong Khae    | 720       | +1.20                       |   |
| Khok Krathiam | 18,076    | +5.95                       | Average water level                                     |
| Roeng Rang    | 4,480     | +6.00                       | Bang Khum regulator area                                |
|               | 4,320     | +5.00                       | Khor Lerng regulator area                               |
| Maharaj       | 480       | +10.20                      | Left bank of Chainat-Ayutthaya canal area (km. 21-26)   |
|               | 7,234     | +8.03                       | Chainat Pasak main drainage canal No.3 area (km. 18-27) |
|               | 10,298    | +5.50                       | 2L-8L lateral canal area                                |
|               | 6,785     | +4.16                       | End of Chainat-Ayutthaya canal area                     |

TABLE 5 : PLAN OF CONSTITUTION OF SUB-SYSTEM

|   |   |
|---|---|
| <p><b>&lt;Monitoring&gt;</b></p> <p>Storage and release of reservoir/dam<br/>           Rainfall<br/>           Water level<br/>           Discharge<br/>           Salinity<br/>           Cropping area and soil moisture<br/>           Inundation condition<br/>           Operational condition of facilities</p>          | <p><b>&lt;Database&gt;</b></p> <p>River and canal network<br/>           Hydrological database<br/>           Water management database<br/>           Facility database<br/>           V~h curve at block level<br/>           Basic material to calculate water Requirement by respective crop<br/>           List of important reports and papers</p>  |
| <p><b>&lt;Analysis&gt;</b></p> <p>Water requirement analysis<br/>           Runoff analysis<br/>           Calculation of discharge at regulator, gate, pump etc.<br/>           Flow analysis (non-uniform flow, Unsteady flow)<br/>           Water balance analysis<br/>           AISP, WASAM, MIKE Basin, MIKE 11 etc.</p> | <p><b>&lt;Reference information&gt;</b></p> <p>Flow of information on water operation<br/>           Organization and responsible persons related to water operation<br/>           Plan of cropping<br/>           Plan of water allocation<br/>           Weather forecast<br/>           Arrangement of problems (past, present and expected)<br/>           Alternative ideas for countermeasure or trouble solution<br/>           Question and Answer</p> |

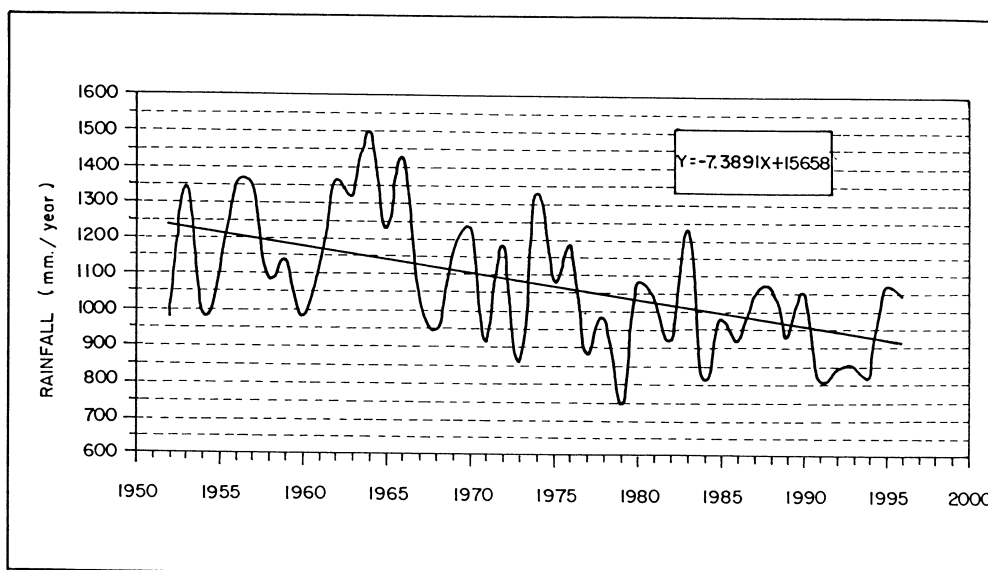
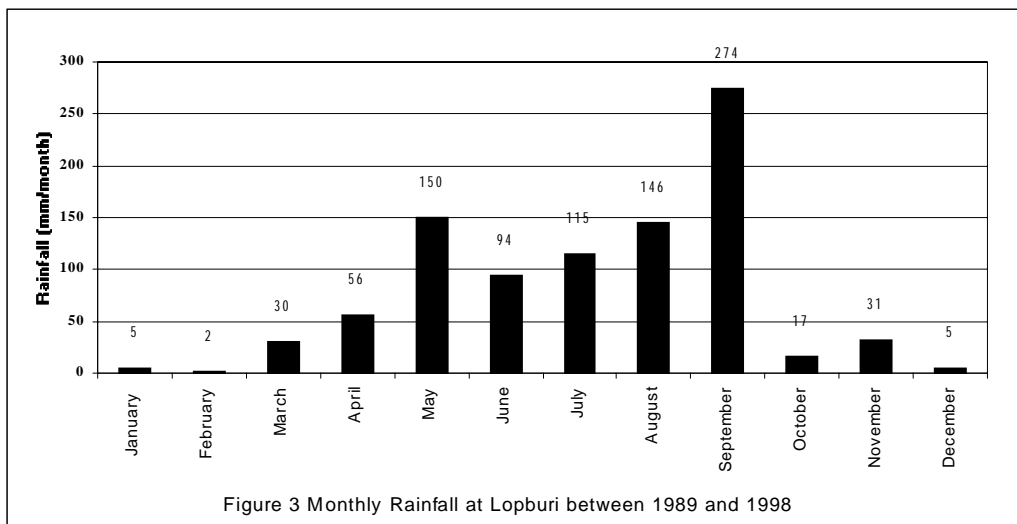
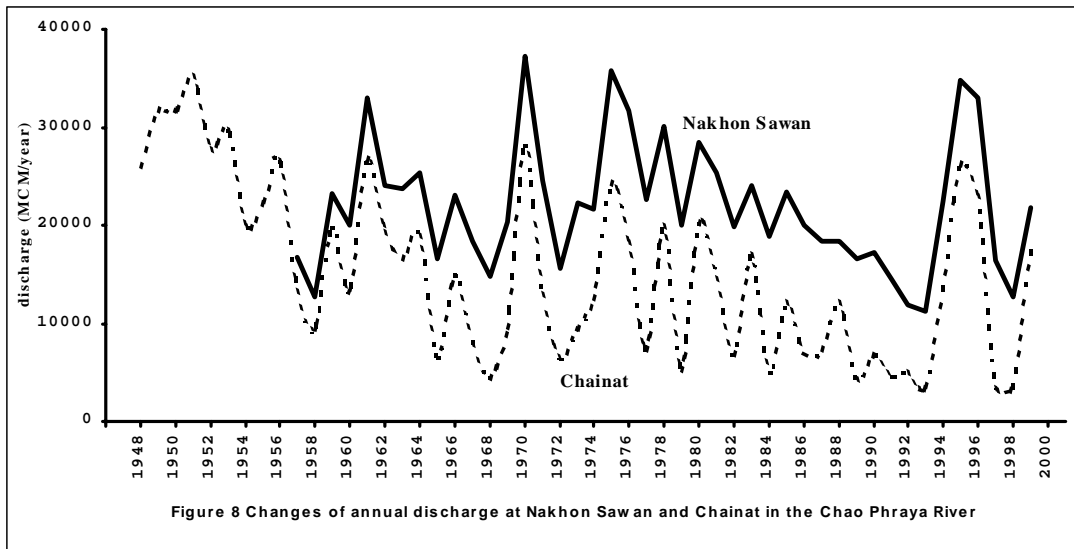
TABLE 6 : NEEDED DAILY INFORMATION ON HYDROLOGY AND WATER MANAGEMENT

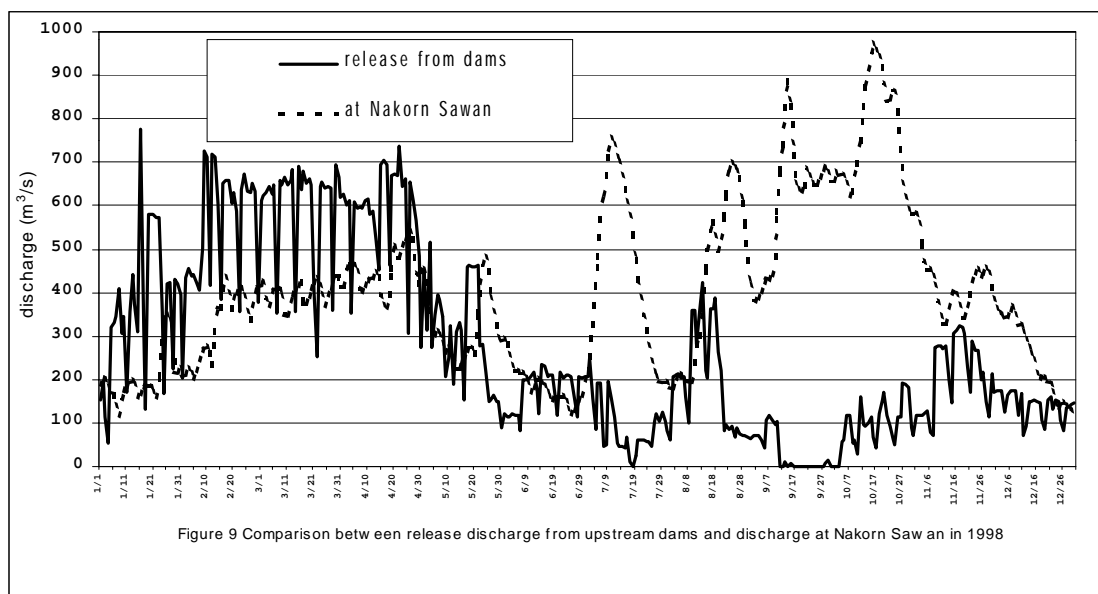
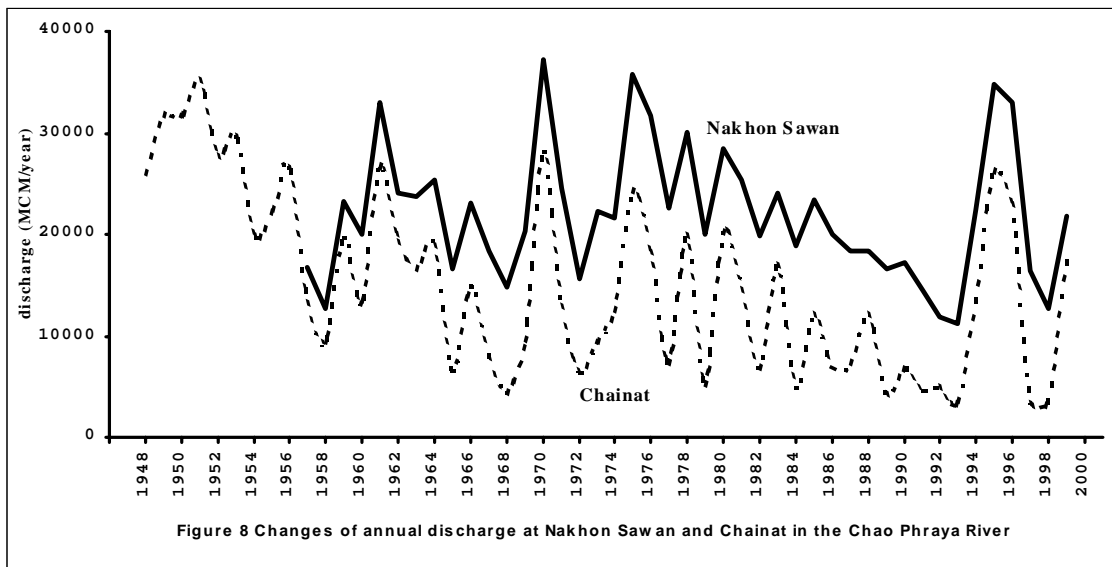
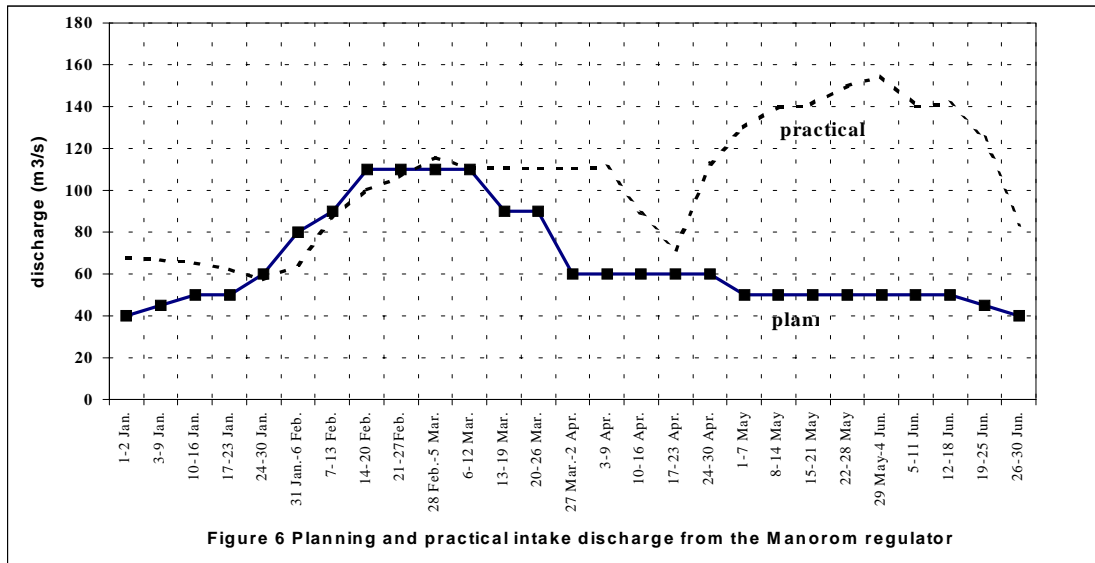
|  | Storage Volume | Water level | Discharge | Salinity | Operation |
|--|----------------|-------------|-----------|----------|-----------|
| <b>&lt;Reservoir dam&gt;</b>           |                |             |           |          |           |
| Bhumiphol                              | O              | O           | O         |          |           |
| Sirikit                                | O              | O           | O         |          |           |
| Pasak                                  | O              | O           | O         |          |           |
| <b>&lt;Chao Phraya river&gt;</b>       |                |             |           |          |           |
| Nakhon Sawan (C2)                      | -              | O           | O         |          |           |
| Chao Phraya Diversion Dam (C13)        | -              | O*          | O         |          | O         |
| Singburi (C3)                          | -              | O           | O         |          |           |
| Ang Thong (C7A)                        | -              | O           |           |          |           |
| Bangsai (C29)                          | -              | O           |           | O        |           |
| RID Pakkret (C22)                      | -              | O           |           | O        |           |
| RID H.O. (C12)                         | -              | O           |           | O        |           |
| Memorial Bridge (C4)                   | -              |             |           |          |           |
| River mouth                            |                |             |           |          |           |
| <b>&lt;Pasak river&gt;</b>             |                |             |           |          |           |
| Ban Muang Nua(S9)                      |                | O           | O         |          |           |
| Kaeng Khoi(S2)                         |                | O           | O         |          |           |
| Rama VI Diversion Dam (S 26)           |                | O*          | O         |          | O         |
| Panchama Thirat Uthit Hospital(S5)     |                | O           |           |          |           |
| <b>&lt;Lopburi river&gt;</b>           |                |             |           |          |           |
| Singburi regulator                     |                | O*          | O         |          | O         |
| Siphon Lopburi(L2A)                    |                | O*          | O         |          |           |
| Lopburi regulator                      |                | O*          | O         |          | O         |
| <b>&lt;Chainat Pasak Canal&gt;</b>     |                |             |           |          |           |
| Manorom regulator                      |                | O*          | O         |          | O         |
| Chong Khae regulator                   |                | O*          | O         |          | O         |
| Khok krathiam regulator                |                | O*          | O         |          | O         |
| Roeng Rang regulator                   |                | O*          | O         |          | O         |
| <b>&lt;Chainat Ayutthaya Canal&gt;</b> |                |             |           |          |           |
| Maharaj regulator                      |                | O*          | O         |          | O         |
| Ban Tuk regulator                      |                | O*          | O         |          | O         |
| Bang Chom Sri Siphon                   |                | O*          | O         |          | O         |
| <b>&lt;Drainage regulator&gt;</b>      |                |             |           |          |           |
| Bang Kharm (Chong Kae)                 |                | O*          | O         |          | O         |
| Wat Manee(Khok Krathiam)               |                | O*          | O         |          | O         |
| Klong Ta Mek(Khok Krathiam)            |                | O*          | O         |          | O         |
| Bang Chom Sri (Maharaj)                |                | O*          | O         |          | O         |
| Ban Rai (Maharaj)                      |                | O*          | O         |          | O         |
| Kao Chang (Maharaj)                    |                | O*          | O         |          | O         |
| Bang Khung (Maharaj)                   |                | O*          | O         |          | O         |
| <b>&lt;O/M&gt;</b>                     |                |             |           |          |           |
| Monorom O/M Project area               |                | O           | O         |          | O         |
| Chong Khae O/M Project area            |                | O           | O         |          | O         |
| Khok Krathiam O/M Project area         |                | O           | O         |          | O         |
| Roeng Rang O/M Project area            |                | O           | O         |          | O         |
| Maharaj O/M Project area               |                | O           | O         |          | O         |

Remark-1: O\* means monitoring at both upstream and downstream. means estimated tidal level.

Remark-2: O/M information includes water level and discharge at intake of lateral canals, drainage canals, etc as exemplified in Table 1.)

- A. Reservoir Dam
- |     |   |                                  |  |                 |          |
|-----|---|----------------------------------|--|-----------------|----------|
| (1) | Bhumiphol Dam discharge (m <sup>3</sup> /d) | Storage volume (m <sup>3</sup> ) | Effective storage volume (m <sup>3</sup> ) | Water level (m) | Released |
| (2) | Sirikit Dam discharge (m <sup>3</sup> /d)   | Storage volume (m <sup>3</sup> ) | Effective storage volume (m <sup>3</sup> ) | Water level (m) | Released |
| (3) | Pasak Dam discharge (m <sup>3</sup> /d)     | Storage volume (m <sup>3</sup> ) | Effective storage volume (m <sup>3</sup> ) | Water level (m) | Released |
- B. Chao Phraya river
- |     |                                 |   |
|-----|---------------------------------|---|
| (1) | Nakhon Sawan (C2)               | Water level, discharge  |
| (2) | Chao Phraya Diversion Dam (C13) | Water level(upstream and downstream), released discharge, operational condition |
| (3) | Singburi (C3)                   | Water level   |
| (4) | Ang Thong (C7A)                 | Water level, discharge  |
| (5) | Bangsai (C29)                   | Water level   |
| (6) | RID Pakkret (C22)               | Water level, salinity   |
| (7) | RID H.O. (C12)                  | Water level, salinity   |
| (8) | Memorial Bridge (C4)            | Water level, salinity   |
- C. Pasak river
- |     |                                    |   |
|-----|------------------------------------|---|
|     | Ban Muang Nua(S9)                  | Water level, discharge  |
| (1) | Kaeng Khoi(S2)                     | Water level, discharge  |
| (2) | Rama VI Diversion Dam (S 26)       | Water Level (upstream and downstream), release discharge, operational condition |
| (3) | Panchama Thirat Uthit Hospital(S5) | Water level   |
- D. Lopburi river
- |     |                     |   |
|-----|---------------------|---|
| (1) | Singburi regulator  | Water Level (upstream and downstream), release discharge, operational condition |
| (2) | Siphon Lopburi(L2A) | Water level, discharge  |
| (3) | Lopburi regulator   | Water Level (upstream and downstream), release discharge, operational condition |
- E. Chainat Pasak Canal
- |     |                         |   |
|-----|-------------------------|---|
| (1) | Manorom regulator       | Water Level (upstream and downstream), release discharge, operational condition |
| (2) | Chong Khae regulator    | Water Level (upstream and downstream), release discharge, operational condition |
| (3) | Khok krathiam regulator | Water Level (upstream and downstream), release discharge, operational condition |
| (4) | Roeng Rang regulator    | Water Level (upstream and downstream), release discharge, operational condition |
- F. Chainat Ayutthaya Canal
- |     |                      |   |
|-----|----------------------|---|
| (1) | Maharaj regulator    | Water Level (upstream and downstream), release discharge, operational condition |
| (2) | Ban Tuk regulator    | Water Level (upstream and downstream), release discharge, operational condition |
| (3) | Bang Chom Sri Siphon | Water Level (upstream and downstream), release discharge, operational condition |
- G. Drainage system
- Water Level (upstream and downstream), release discharge, operational condition
- |     |                                       |
|-----|---------------------------------------|
| (1) | Bang Kharm regulator(Chong Kae)       |
| (2) | Wat Manee regulator(Khok Krathiam)    |
| (3) | Klong Ta Mek regulator(Khok Krathiam) |
| (4) | Bang Chom Sri regulator(Maharaj)      |
| (5) | Ban Rai regulator(Maharaj)            |
| (6) | Kao Chang regulator(Maharaj)          |
| (7) | Bang Kung regulator(Maharaj)          |
- H. Rainfall
- Information from Hydrology Center 5 and O/M Project offices
- I. O/M Information
- Water level and discharge at intake of lateral canal, water level and discharge at drainage canal, operational condition (There are overlapping information with other items.)
- |     |                                |
|-----|--------------------------------|
| (1) | Monorom O/M Project area       |
| (2) | Chong Khae O/M Project area    |
| (3) | Khok Krathiam O/M Project area |
| (4) | Roeng Rang O/M Project area    |
| (5) | Maharaj O/M Project area       |





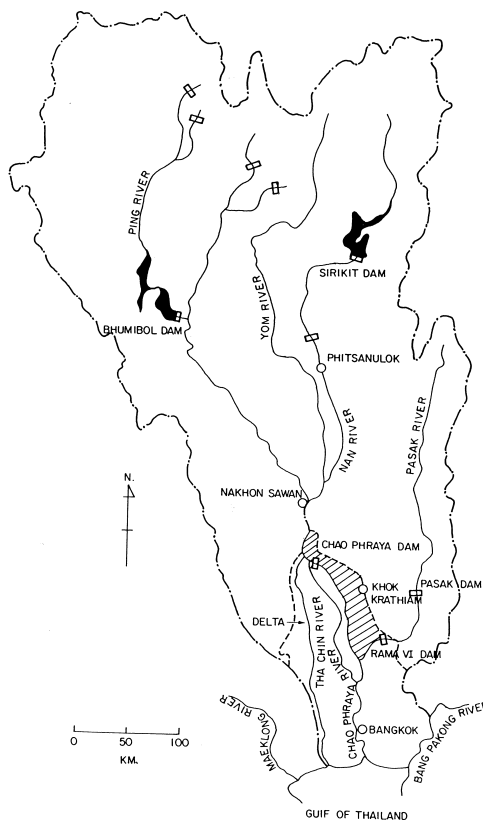


Fig 1

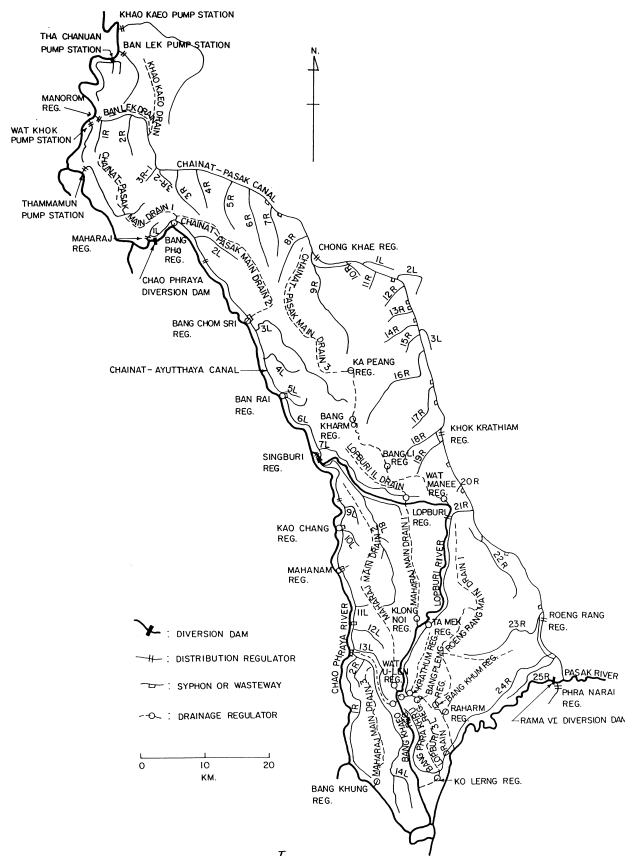


Fig. 2

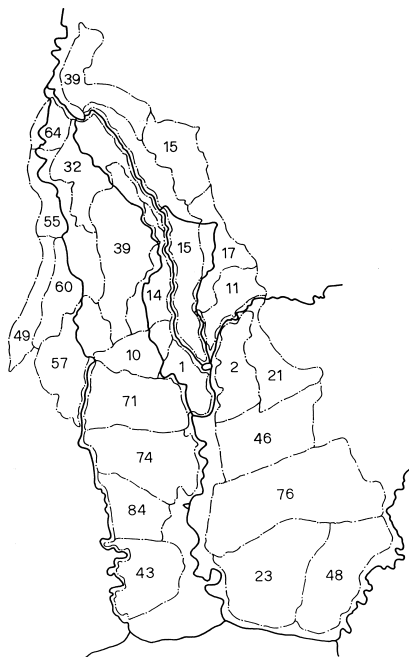


Fig. 7

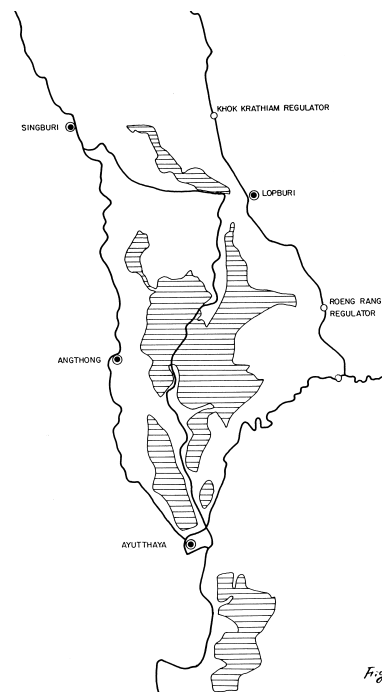


Fig 11

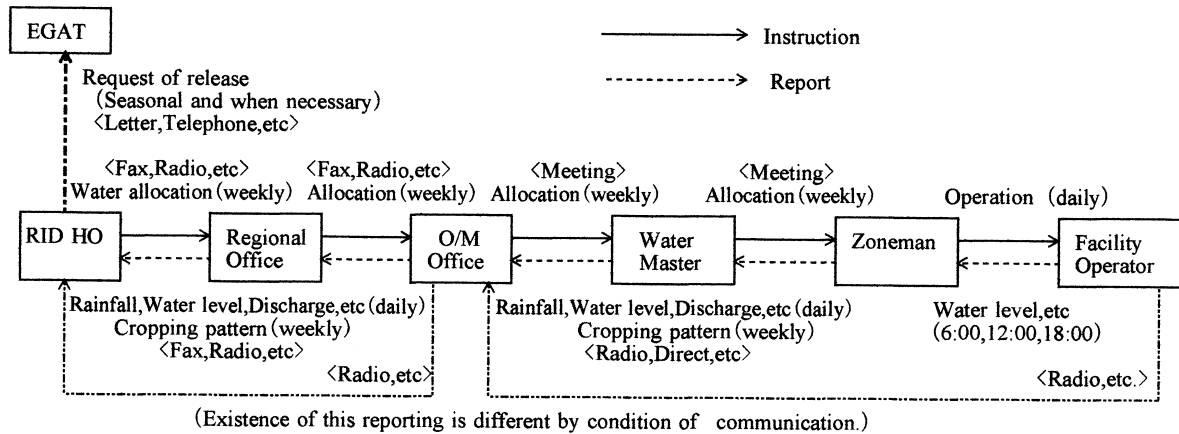
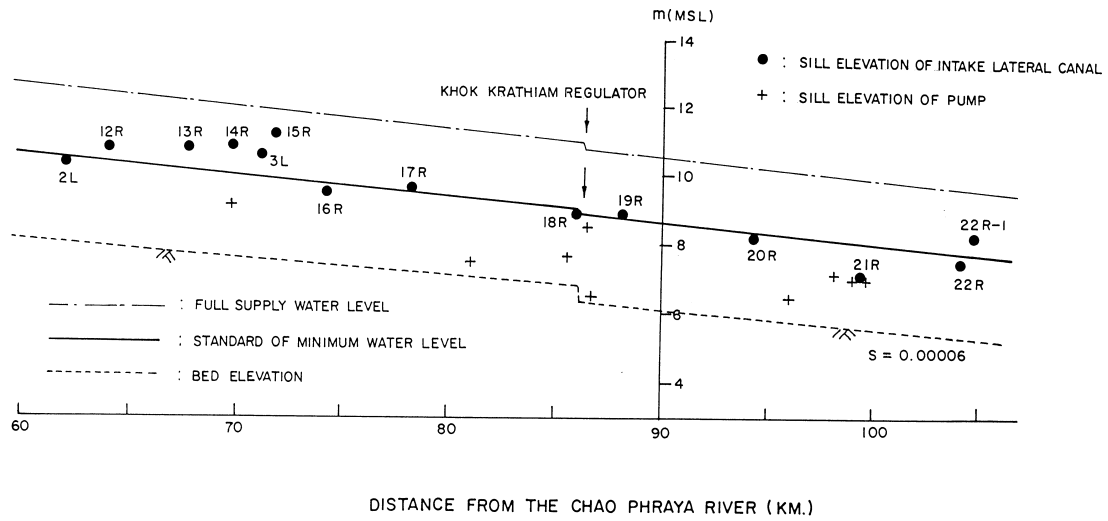


Figure 5 Flow of Information for Water Management

TABLE 2: PLANNING AND PRACTICAL WATER ALLOCATION IN THE CHAO PHRAYA RIVER BASIN

(MCM)

|   |                            | 1993  | 1994  | 1995   | 1996   | 1997   | 1998  | 1999  | 2000    |
|---|----------------------------|-------|-------|--------|--------|--------|-------|-------|---------|
| Active Storage on 1 <sup>st</sup> January |                            | 5,357 | 2,048 | 12,733 | 14,582 | 12,107 | 8,239 | 3,879 | 11,930  |
| 1. Consumption for domestic & Industry    |                            | 550   | 700   | 1,100  | 1,800  | 1,650  | 1,600 | 550   | (1,600) |
|   | -North of Nakorn Sawan     | 250   | 300   | 500    | 900    | 800    | 800   | 150   | (800)   |
|   | -Great Chao Phraya Project | 300   | 400   | 600    | 900    | 850    | 800   | 400   | (800)   |
| 2. Dry season cultivation                 |                            | 2,100 | 500   | 3,300  | 4,950  | 4,200  | 3,400 | 2,050 | (3,000) |
| 3. Navigation                             |                            | 300   | 0     | 300    | 400    | 300    | 300   | 0     | 300     |
| 4. MWA                                    |                            | 650   | 550   | 700    | 750    | 750    | 750   | 650   | 750     |
| 5. Salinity Control                       |                            | 400   | 250   | 600    | 600    | 500    | 450   | 350   | 350     |
| Sum of 1-5                                | Plan                       | 4,000 | 2,000 | 6,000  | 8,500  | 7,400  | 6,500 | 3,600 | 6,000   |
|   | Actual                     | 4,610 | 1,894 | 7,216  | 9,643  | 8,556  | 6,656 | 2,575 | 6,500   |
| 6. Paddy field area (million rai)         | Plan                       | 1.50  | 0     | 2.80   | 3.50   | 3.30   | 2.70  | 1.90  | 3.10    |
|   | Actual                     | 1.96  | 1.77  | 3.19   | 4.15   | 4.06   | 3.79  | 3.49  | 4.42    |

- 1) Water allocation plan in dry season between January and June was arranged. Side flow is not taken into account.
- 2) Active storage is effective storage at both Bhumibol and Sirikit reservoir dams.
- 3) MWA: Metropolitan Waterworks Authority
- 4) Paddy field area is sum of irrigated area. (1.0 rai = 0.16 ha)
- 5) RID changed the format of planning from 2000. The values inside ( ) in 2000 were assumed to fit the format of previous years.

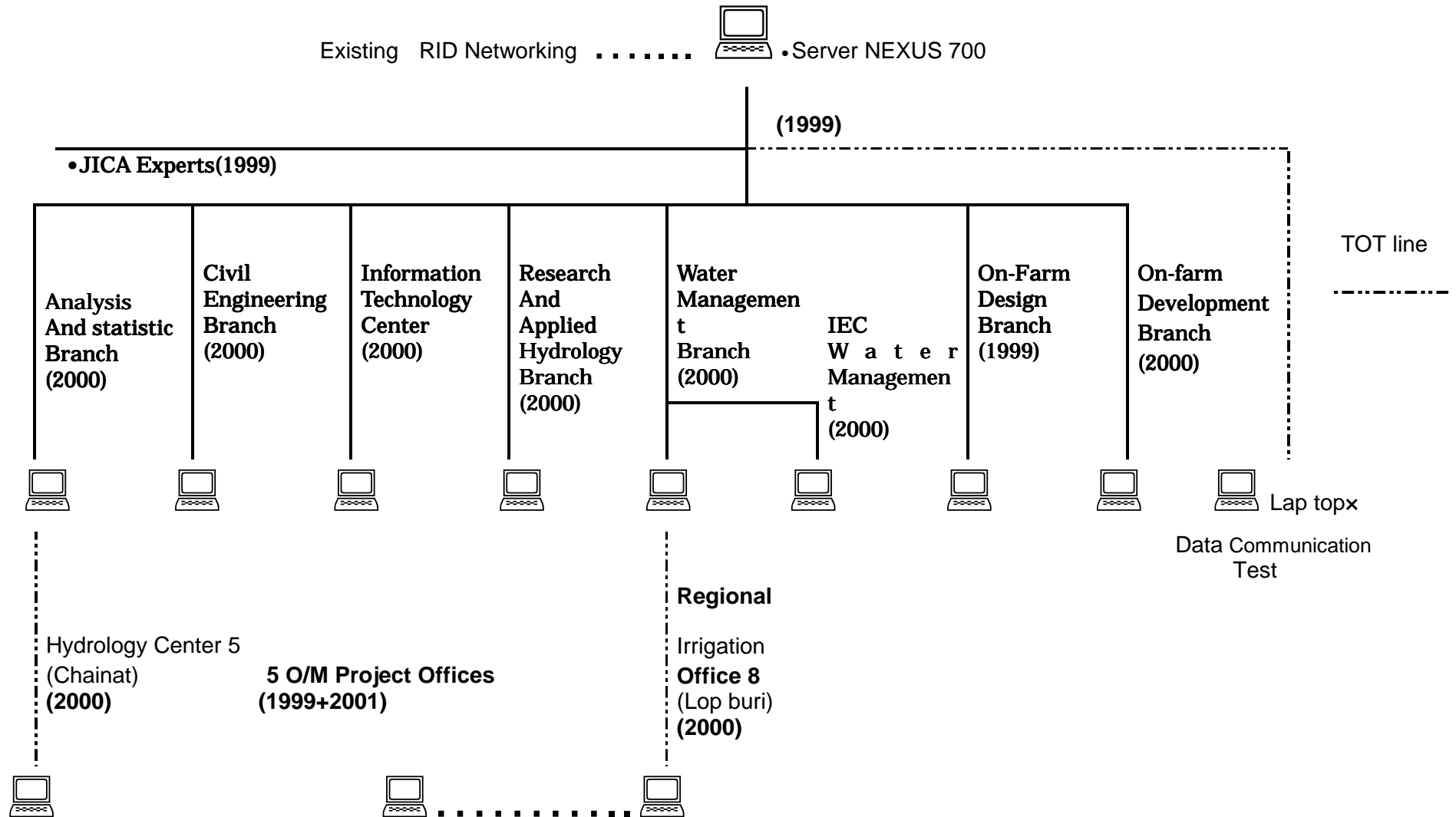


Figure 12: Plan of data communication networking