4.5 Irrigation and Drainage Plan of Tonle Bati Area

4.5.1 Delineation of Irrigation Area

The area of irrigation development of the Tonle Bati Study area is delineated from the following basic considerations:

(1) Area to be commanded from Tonle Bati Lake and Existing Irrigation Canal System

Main and laterals have been re-constructed for an area of about 1,600 ha and tertiary canals have been provided for about 900 ha, although they are presently not well functioning. The canal system of overall irrigation development of Tonle Bati area will be based on the existing canal layout.

Irrigation water of the existing Tonle Bati area is served from Tonle Bati lake. Water levels of the lake to be kept for irrigation are limited with surrounding conditions. The high water level should be less than 7.8 m to avoid the inundation of pagoda locating on the south coast of the lake. Further, the lake is important resources for tourism and fisheries, then the low water level is to keep at least 5 to 6 m .

(2) Extent of Suitable Soils for Irrigation Development

Major parts of the Tonle Bati area belong to "moderately suitable" to "marginally suitable". Most of the Tonle Bati Study area, therefore, will be incorporated in the irrigation development area except the land subject to inundation around Cheung Loung lake. The area extending below the elevation of El. 5.3 m (LBTB) will be excluded from intensive irrigation development area.

On the basis of the above-mentioned condition, the area of 4,200 ha will be delineated as the suitable for irrigation development of Tonle Bati Study area. The extent of the area is as summarised below and the location is as shown in Fig. V-8.

Location	Irrigation area (ha)
1. Existing Irrigation area	1,600
2. Surrounding area	2,600
Total	4,200

4.5.2 Water Supply Plan

(1) Localised Reservoir Plan

The irrigation water source of the Tonle Bati area is the Tonle Bati river with lake storage, but it is quite limited in the dry seasons. To increase irrigation area of the Tonle Bati Study area, augmentation of irrigation water is inevitable.

The Department of Hydrology has prepared a multi-reservoir plan to augment irrigation water to the Tonle Bati area. The plan envisages the creation of a series of reservoirs consisting of Stung Toch, Saba and Kok Tel reservoirs, all of which are linked by a dike running between Kandal Stung and Kok Tel villages. The storage-water surface of them are as shown in Fig. V-11 and V-12. The gross storage volume was estimated to be 29 MCM, with a corresponding surface area of 1,400 ha at the same water level of 12.0 m. On the basis of this plan, some part of the dike from Saba to Kok Tel have been implemented, but the main dam embankment has been suspended.

The Department of Hydrology has made another reservoir plan, envisaging construction of Saba reservoir and rehabilitation of the connection canal (NS 78) to make a straight connection to Tonle Bati catchment with the Prek Thnot river through the Stung Toch river. This plan has advantages that construction of the canal is relatively easy and the soonest result will be realised on short time. Based on this plan, re-construction of the connection canal (NS 78) has been implemented.

In due consideration of the irrigation plan and environmental situation on the reservoir areas, the localised reservoir plans envisaged are conceived as follows.

i) Stung Toch Reservoir

The intake water level at Kompong Tuol regulator is set to be 11.5 m on account of avoiding inundation and/or ill-drainage of the areas locating upstream of the Kompong Tuol. A large part of the envisaged reservoir area lies on the ground levels of 10. to 11 m. Therefore, no possibility of the creation of Stung Toch reservoir is considered under the condition of a revised intake water level.

ii) Kok Tel Reservoir

The Kok Tel reservoir plan envisaged by the Department of Hydrology is to construct an earth dam across the Tonle Bati river which discharges water into Lake Tonle Bati. The reservoir level was set at 12.0 m with a gross storage volume of 18 MCM and a corresponding water surface area of about 700 ha. The dam crest was set to be 14.0 m in elevation with a maximum height of about 9 m. The embankment of a main dam of about 1,300 m remains uncompleted. According to the information obtained during the field survey, the following negative aspects on creation of the planned Kok Tel reservoir (reservoir water surface of 12.00) were considered.

a. Inundation of three villages, which require resettlement of villagers with about 120 families and provision of infrastructures in resettlement areas,

b. Inundation of about 400 ha paddy fields which requires additional farm land to the villagers,

c. Loss of living environment for villagers, such as good developed trees.

In order to avoid inundation of the villages as well as to reduce loss of farm land in the reservoir area, and further taking into account the revised water level of 11.5 at the Kompong Tuol regulator site, a Kok Tel reservoir water level should be lowered to 10.5 m.

The following alternatives will be conceived for the irrigation plan of the Tonle Bati Study area under without and with Prek Thnot reservoir cases:

Alternative Plan	Prek Thnot Reservoir	Localised Reservoir	Connection Canal
Plan -1a	Without Prek Thnot Reservoir	Without Kok Tel Reservoir	With connection canal
Plan -1b	Without Prek Thnot Reservoir	With Kok Tel Reservoir	With connection canal
Plan-2	With Prek Thnot Reservoir	Without Kok Tel Reservoir	With connection canal

The irrigable areas of the respective alternatives are described hereunder.

(2) Irrigation Area

The irrigable area of the Tonle Bati Study area is 4,200 ha which consists of (1) the area of 1,600 ha (the existing Tonle Bati area) where rehabilitation/construction of irrigation facilities was made, and (2) the area of 2,600 ha lying around the existing Tonle Bati irrigation area. In order to ensure reliable irrigation to the existing Tonle Bati area of 1,600 ha, irrigation plan for those area under without Prek Thnot reservoir case was examined. Water balance simulation of respective plans was carried out on the following conditions:

Description	Alternative Plan-1a	Alternative Plan-1b
Localised reservoir storage	Tonle Bati lake Storage : 16.7 MCM (at HWL 7.8 m in to Tonle Bati lake) : 5.9 MCM (at LWL 6.0 m in Tonle Bati lake)	Tonle Bati lake plus Kok Tel reservoir Storage: 26.0 MCM (at HWL 10.5 m in to Kok Tel Reservoir) : 16.7 MCM (at LWL 7.8 m in Tonle Bati lake)
Connection canal	Capacity of 7.0 m^3/sec	Capacity of 7.0 m^3/sec
Water requirement	For the proposed cropping pattern (1,600 ha), and For receding paddy cropping for 600 ha	For the proposed cropping pattern (1,600 ha), and For receding paddy cropping for 600 ha
Water loss from reservoir	Percolation loss of 2 mm/day plus evaporation	Percolation loss of 2 mm/day plus evaporation

i) Without Prek Thnot Reservoir Plan

Water balance simulation of Plan-1a indicates that this plan could ensure irrigation to an area of 1,600 ha as shown in Fig. V-13. Run-of-river water of the Prek Thnot reduces sharply from December, showing the minimum in March. The supply from the Prek Thnot river through the connection canal could not be expected during the dry season in some years. In the later stage of the second cropping and the beginning of the first cropping, i.e. January through May, lake water level goes down. It necessitates pumping-up irrigation for the dry season irrigation area. The irrigation area locating the main canal is flat, having the elevations of 7.0 to 7.5 m. In the period of the flow water, the pumping irrigation is inherently needed. The storage simulation indicates that irrigation water of 5.6 MCM is required to be lifted for 4.5 months, as shown in Fig.V-14.

The irrigation plan-1a requires pumping irrigation in the dry season. Storage simulation of Plan-1b shows that the gravity irrigation will be ensured throughout the year for an area of 1,600 ha, as also shown in Fig. V-14.

ii) With Prek Thnot Reservoir-Plan-2

Irrigation Plan-2 will ensure the sufficient irrigation of the whole area of 4,200 ha without Kok Tel reservoir according to the result of simulation (see Fig. V-15). Water requirements for the whole area 4,200 ha is as estimated in Table V-13. The irrigation plan-1a for 1,600 ha will be implemented prior to or at least at the same time. As mentioned above, in case of Plan-1b, the gravity irrigation can be ensured for the area of 1,600 ha. It means that Kok Tel dam contributes much to reducing O & M works. However, in case the Prek Thnot dam is realised on short time, the dam will not be justified. The implementation of Kok Tel dam is largely dependent upon the time span to the Prek Thnot dam construction.

The implementation schedule of the Prek Thnot Multipurpose Project is not formulated at the present time, ant it is not clear whether Prek Thnot reservoir becomes operational on short time or long time. In this situation, it is recommended that irrigation development of Tonle Bati Study area is implemented firstly with Plan-1a as the first phase; without Kok Tel dam by augmented water through the connection canal.

(3) Water Supply Plan

The design capacity of the Main Canal M1 is 9.8 m^3/sec which is sufficiently large to command the area located in the southern part of the Tonle Bati area. It is served with extension of the Main Canal M1. The eastern part of the area will be commanded with the extension of the Main Canal M3. The northern part of the area will be supplied from the Main Canal M1 with improvement of the main canal. The preliminary canal layout is as shown in Fig. V-16.

4.5.3 Drainage Plan

The drainage system of Tonle Bati area is broadly divided into three drainage systems. The eastern part of the Tonle Bati area is drained to Cheung Loung lake through the old Pol Pot canals running on east-west direction. The southern part will be drained to the Haknuman (NS 85) canal. While, the northern part is directly drained in the downstream of the Tonle Bati river.

The drainage canal system to be constructed consists of major drainage canals, tertiary and quaternary canals and their related structures. Major drainage canals will be constructed mainly by improvement of the old Pol Pot canals. The preliminary layout of drainage system of Tonle Bati area is as shown in Fig. V-16. The tertiary drainage canals within the tertiary blocks are improved/constructed together with the irrigation canals system.

4.5.4 General Features of Irrigation and Drainage Facilities

(1) General Design Consideration

The preliminary designs of irrigation and drainage facilities are prepared for development of the Tonle Bati area. The following are the general features of the Project facilities:

i) Irrigation Canals

a. Main canals

The existing main canal will be improved for the following:

- Slope protection by means of concrete lining, and sod facing,
- Re-shaping of canals cross sections with excavation of canal sections or earthfill for embankment,
- Provision of inspection road for main canal with gravel metalling.

b. Laterals and tertiary canals

- Re-shaping of canals cross sections with excavation of canal sections or earthfill for embankment,
- Provision of tertiary canals as to suit the appropriate tertiary block size.

c. Provision of quaternary canals

- Provision of the field ditch will be needed to ensure equitable water delivery in the tertiary service area.

d. Related structures
   - Installation of gates,
   - Repair of canals sections downstream of structures, and
   - Provision of required structures or structure parts where not provided yet.

ii) Activation of Tonle Bati Lake Related Structures

The water levels of Tonle Bati Lake will be lowered in the dry season even the irrigation water is augmented from the Prek Thnot through a connection canal. Lifting water from the lake will be required in the dry season to supplement the gravity irrigation supply. The pumping station will be improved. The intake will be provided with slide gates with improvement of the inlet and outlet structures. The following are the major required works for activation of Tonle Bati lake for the irrigation purpose.

a. Improvement of intake
b. Improvement of Pumping Station
c Improvement of Spillway of Tonle Bati Lake
d. Improvement of Lake Dike

iii) Improvement of Connection Canal (NS 78 canal)

In order to augment the storage water of the Tonle Bati lake, the following connection canal and its related facilities are needed to be rehabilitated.

a. Improvement of NS 78 Canal
b. Stung Toch Regulator
c. Kandal Stung Regulator

iv) Improvement of Drainage Canals and Related Structures

a. Clearing and reshaping of major drainage canals,
b. Reshaping of the tertiary drainage canals,
c. Additional tertiary canals,
d. Drainage structures where required.

(2) Proposed Project Works

The general features of the proposed project works of the irrigation and drainage system are as follows:

Description		First Stage Work	Second Stage Work
Main canal			
- Improvement of main canal	(km)	8.3	-
- Construction of main canal	(km)	-	-
Lateral			
- Improvement of existing Lateral	(km)	6.9	-
- Construction of Lateral	(km)	3.1	16.3
Tertiary canal			
- Improvement of existing tertiary canal	(km)	15.0	-
- Construction of tertiary canal	(km)	33.1	78.2
Quaternary canal system	(ha)	1,600	2,600
Improvement of Tonle Bati Lake Related Structures			
- Intake	(nos)	1	-
- Pumping Station	(nos)	1	-
- Spillway of Lake	(nos)	1	-
- Lake Dike	(km)	L.S	-
Improvement of Connection Canal			
- Connection canal	(km)	4.6	-
- Stung Toch Regulator	(nos)	1	-
- Kandal Stung Regulator	(nos)	1	-
Drainage works			
- Major drainage canals	(km)	24.1	39.2
- Tertiary canal	(km)	41.8	66.6

4.6 Selection of Priority Areas for Irrigation and Drainage Development

4.6.1 Basic Approach to Project Implementation

The irrigation and drainage development projects herein formulated are one of the important development components of the integrated agricultural and rural development project, which includes various schemes for development and consolidation of infrastructure facilities as well as for reinforcement and/or activation of supporting functions. In order to effectively implement the various components, and taking into account the technical and managerial capacity of the staff concerned, the implementation of the schemes should be made under the well designed stage-wise development. It could be divided into the following two stage:

(1) Priority Development

The first stage development aims to establish the technical and implementing base as a model area which will have to be the core to demonstrate the effects of the well managed irrigation and drainage system and function as the base for the future expansion to the whole area. Selection of the priority development areas as a model development can be made according to the physical and socio-economic conditions of the Study areas and the following selection criteria:

a. Benefit will accrue quickly with investment.

b. Priority area will function as a model exhibition to surrounding area.

c. Project components will be easily applied to other areas extensively.

d. Land productivity is high.

e. The area is located near a water source and it is possible in the area to realize double cropping as well as crop diversification in terms of irrigation water resources.

f. Accessibility of farm products to market is good.

g. Security condition is good.

(2) Second Stage Development

The remaining area will be covered in the second stage development. The implementation and operation of the model area would provide various information on intensive farming and life improvement measures, and chance for gaining experience for execution of the large-scale project implementation. On the basis of the accumulated result and institutional set-up during the first stage development, the second stage could successfully be implemented. Commencement of irrigation works, however, will be subject to the schedule of realization of the Prek Thnot multipurpose dam.

Whereas, the area belonging to the older terrace area is not suitable for intensive development as already suggested in the preceding chapter. For this area, pasture and fodder crops or fuelwood production are proposed without irrigation development.

4.6.2 Priority Development Projects

The irrigation and drainage development plan of the Study area revealed the irrigation development potential for the following two cases:

(1) Irrigation development without Prek Thnot reservoir

a. Kandal Stung area: 1,950 ha with cropping intensity of 173 %

b. Tonle Bati area: 1,600 ha with cropping intensity of 180 %

(2) Irrigation development with Prek Thnot reservoir

a. Kandal Stung area: 4,200 ha with cropping intensity of 200 %

b. Tonle Bati area: 4,200 ha with cropping intensity of 200 %

In order to establish a technical and implementing base as a model area for the integrated agricultural and rural development, the areas of 1,950 ha for Kandal Stung project area and 1,600 ha for Tonle Bati project area is selected as a priority development area, where reliable irrigation could be ensured under "without Prek Thnot reservoir condition" and the existing irrigation facilities are required to be improved.

5. PRELIMINARY DESIGN OF FACILITIES OF PRIORITY DEVELOPMENT AREAS

5.1 Kompong Tuol Irrigation Intake

5.1.1 General Design Consideration

In the design of the rehabilitation of Kompong Tuol irrigation intake consisting of Tuk Thla regulator, Kompong Tuol regulator, National road No. 3 dike and other related facilities, the following design consideration is taken into account:

(1) Uncertainty of Flood Flow Condition

The extreme floods of the Prek Thnot form a river channel flood flow and flood plain flow. The railway and road embankments located upstream of the Kompong Tuol intake hold back some flow, which is then released, increasing flood flow to the downstream due to overtopping or collapses. This uncertainty of flood flow condition should be considered in determination of the design flood.

(2) Design Flood Discharge without Prek Thnot Dam

The planned Prek Thnot reservoir has a flood control function. The implementation schedule of the Prek Thnot dam, however, is not determined yet. Then the works for Kompong Tuol intake has to be designed for the flood peak under without Prek Thnot reservoir.

(3) Flood and Normal Water Level at the Kompong Tuol regulator

The flood level in August 3, 1994 rose to 13.5 m (LBKS) at Tuk Thla regulator, when the flood waters overtopped the National Road No. 3 in many places. It is recommended to adopt 13.0 m for the design flood water level.

Normal water level for irrigation of 12.0 m (LBKS) was not accepted from the upstream villagers. Water level of 11.0 m, which was maintained under a closing condition of all gates of the Tuk Thla regulator in the dry season, occurred the lack of water in the Kandal Stung area. It is recommended to adopt 11.5 m for the normal water level.

(4) Levee along the Prek Thnot River

A flood dike along the right bank from Kandal Stung intake to the railway embankment was constructed during the Pol Pot regime to prevent floods flowing over the low-lying area. The floodwater in August 3, 1994 overtopped the dike and the paddy fields are inundated. Rehabilitation/heightening of the flood dike is prerequisite to Kompong Tuol irrigation intake works. The low-lying paddy fields on the left bank will be inundated under the normal operation water level of 11.5 m. It is also required to extend the existing embankment along the spillway channel.

5.1.2 Geological and Soil Mechanical Conditions at the Site

Geological conditions of the Tuk Thla regulator, the proposed Kompong Tuol regulator and road dike sites are summarized as follows:

(1) Tuk Thla Regulator Sites

There exist medium to fine dense sand layers up to the elevation of about 5 m. The sand layer is slightly permeable, and slightly dense having N-value of 20 to 30. Firm fine sandy layers underlies the pervious sand layers, which show N-values of 30 to 50.

(2) Kompong Tuol Regulator Site

The geology of the site consists of loose to soft sand layers with N-value of 5 to 20 and the sand layers are relatively high pervious. It exists above about +2.0 m in elevation. Firm sandy silt layers underlie the lose sand layers, having N-values of 30 to 50 and being less pervious. Thickness of the firm layer is about 3 m.

(3) National Road No. 3 Dike Site

This site is underlain by a firm to solid sandy silt layer (less pervious), a dense silty sand layer (highly pervious) and a soft to loose sand layer (highly pervious). The highly pervious sand layers are continuos from the upstream to the downstream at the proposed embankment site and are susceptible to piping under a raised water level condition. The soils available in the high water channel near the site are fine grained soils. Those soils are not suitable for embankment materials because of being highly dispersive, and less effective to compaction. So far as the result of the soil test on mixture of in-situ materials with the laterite or gravel soils is concerned, dispersiveness of the in-situ materials is not improved.

5.1.3 Preliminary Design of the Facilities

(1) Design Discharge and Water Levels

The design flood discharge and water levels for rehabilitation of Kompong Tuol intake is set as follows:

a. Flood Discharge at 100-year return period without Prek Thnot dam : 1,900 m^3/sec
b. Normal operation water level : EL. 11.50 m
c. Allowable maximum flood water level : EL. 13.00 m

(2) Tuk Thla Regulator

The gate portion will be replaced with a new structure. The existing bridge for the National Road No. 3 and stilling basin are used, with additional provision of downstream protection. Five (5) motor driven roller gates, 6 m width and 3 m height, will be provided. This regulator will share the release of 400 m^3/sec of the design flood discharge.

(3) Kompong Tuol Regulator

The outflow from the existing Kompong Tuol regulator is attacking the downstream road embankment, causing bank erosion. Seepage was observed on the outlet wall. The existing Kompong Tuol regulator will require much cost in the future to maintain the

structure in a good operational condition. The existing regulator will be demolished and replaced with embankment. The proposed site is selected near to the original river course where the river flow is concentrated. The proposed regulator will consist of five motor driven roller gates, 6 m width and 5 m height and the road crossing bridge. The piers and bridge are supported with concrete piles. The sheet piles under the piers will be needed against seepage. The base level of the gates is determined to be 6.6 m in elevation on the basis of the present river bed, which is 1 m below the bottom level of the existing Kompong Tuol regulator. This regulator will share the release of 650 m^3/sec of the design flood discharge.

(4) Overflow Type Spillway

This spillway will is provided to release the flood water exceeding the capacities of the two regulators. The required design capacity of the proposed spillway is 850 m^3/sec. The proposed spillway will be provided at the north side of the proposed Kompong Tuol regulator. The proposed cross section is of trapezoidal earth embankment covered with thin concrete and the sheet piling will be provided against seepage. The stilling basin will be provided downstream of the overflow section. Embankment will be constructed by selected soil materials to be transported from the outside.

Crest length	400.0 m	
Crest El.	11.5 m	
Crest width		
Total width	15.0 m	
Road portion	9.0 m	(concrete pavement)
Side slope	1:2.5	(thin concrete lining)

(5) National Road No. 3 Dike

High embankment between the Kompong Tuol regulator to the old river channel is liable for failure when the high reservoir levels are maintained. A new embankment is located slightly upstream from the existing route with the straight line. The sheet piling will be provided under the dike against seepage. Embankment will be constructed by selected soil materials to be transported from the outside.

Total width	15.0 m	
Net width	9.0 m	(asphalt pavement)
Crest El.	14.3 m	
Side slope	1:2.5	(sod facing)

(6) Flood Dikes along Upstream Right Bank and Left Bank

The present flood dike located on the right bank of the Prek Thnot river is improved through re-shaping of embankment with laterite covering. The left bank embankment will be extended to reach to the village road. The lowered crest portions will be provided for both dikes to lessen the flood damage in the areas.

	Right bank dike	Left bank dike
Crest width	4.0 m	4.0 m
Crest El.	13.5 ~ 14.6 m	13.5 m
Length	4.0 km	1.0 km
Side slope	1:2.0	1:2.0

(7) Radio Communication System

The present water management of the irrigation system including regulators on the Prek Thnot river was made by the respective provincial or district office. To make effective water management of the Prek Thnot river flow in the dry season as well as the flood season, the radio communication system will be installed. The station network is as follows:

a.	Main station	- Department of Agricultural Hydraulics and Hydrometeorology at Phnom Penh
b.	Branch station	- Water management Office of DAHHM
c.	Site station	- Kompong Speu provincial office of Hydrology (for Roleng Chrey regulator)
		- Kompong Tuol regulator office to be prepared

(8) Improvement of Related Facilities

The existing Kandal Stung regulator, locating west of the National Road No. 3 near to the Kandal Stung intake, will be replaced to function for regulating the discharge from the Prek Thnot river to the Stung Toch river.

5.1.4 General Features of Proposed Improvement Works

The general features of the rehabilitation of Kompong Tuol intake are as shown below. The general layout of rehabilitation works is as shown in Fig. V-17.

a)	Tuk Thla Regulator	Replacement of gates, (width 6 m x height 3 m x 5 sets)
b)	Kompong Tuol Regulator	Replacement of existing regulator, (gate: width 6m x height 5m x 5 sets, bridge: width 15 m)
c)	Spillway	Overflow type, 400 m in length
d)	Road Dike	Total width 15 m, asphalt pavement & width 9 m
e)	Flood Dike on Upstream Right Banks	Length of 4 km and 1 km for right and left banks dike crest width 4 m
f)	Radio Communication System	Main, branch and two site stations

During flood times, the floods less than design discharge (1,900 m^3/sec) will be able to be discharged downstream through the above two (2) regulators and the overflow type spillway. The flow capacities of two gates are depending upon the downstream water level. The following is the estimate of the flood discharge through the two gates under varied downstream water levels, under which no flowing over on the spillway is occurred.

Upstream WEL	Downstream WEL	Discharges
(m)	(m)	(cum/sec)
11.5	11.0	550
11.5	10.5	650
11.5	10.0	700

After the completion of the Prek Thnot dam, the floods will be regulated by the storage function of the dam and the probable flood in 100-year return period will be reduced to approximately 1,100 m^3/sec after the dam completion. In the case, most of floods will be released from the two regulators. The detailed operation manual has to be prepared at the implementation stage.

5.2 Kandal Stung Irrigation Project

5.2.1 General Design Considerations

In the design of the irrigation and drainage systems, the following design consideration will be taken into account :

(1) Available River Discharges to the Project Area

The Project area is located in the most downstream of the Prek Thnot Multipurpose Project area. The available discharges to the Project area at the Tuk Thla and Kompong Tuol regulators are estimated to be residual ones, after sharing the irrigation demands of irrigation schemes in the upstream.

(2) Intake Water Level

The water level at the head of the main canal is set to be 11.5 m in view of reducing the risk of inundation of the area in the upstream of Kompong Tuol intake as well as ensuring reliable water supply from the intake.

(3) Small Scale Pump-up Irrigation Area

The high-elevated area at the upstream end of the main canal was not served so far under the present irrigation practice. Farmers are using small scale pumps for paddy and vegetable cultivation. With the water level of 11.5 m, to serve the area, small scale pumps will be introduced in the project.

(4) Separate Irrigation and Drainage System

To promote equitable water supply and efficient water management, level-crossing of irrigation canals with Pol Pot canals (drainage canals) has to be neglected. Irrigation and drainage systems have to be separated in the canal system, except quaternary canals.

(5) Future Development Area

Overall development of Kandal Stung area is divided into priority development and future development. Facilities for the priority development which relate to the future extension area include a head regulator, main canal, lateral canal and related structures. They have to be given the capacities for future development.

5.2.2 Irrigation Canals and Related Structures

(1) Irrigation System

The proposed irrigation and drainage systems are basically on the basis of the existing irrigation system with modification of canal layout, canal sections and discharge/water level control structures. The preliminary irrigation and drainage canal system layout is as shown in Fig.V-18. The irrigation diagrams thus prepared is as shown in Fig. V-19.

(2) Improvement of Canals

Canal sections of main canal to tertiary canals are in poor shape due to slope sliding and erosion. To prevent collapse of the canal embankment and to save the future O & M cost, canal slope protection will be needed. Most of canal embankments are also severely eroded

and eroded soils are silted-up on the canal berms. Canal reshaping by earthfill and removal of sediment will be necessary. The canal inspection roads are not well maintained and damaged due to erosion or breach of embankments. Laterite pavement will be provided for inspection road after re-shaping. The typical sections of irrigation canals are as shown in Fig. V-20. The following works are required for respective canals:

i) Main and Lateral Canals

a. Slope protection for the existing main canal by means of 2 phase concrete lining, and for the existing lateral by means of canal lining,

b. Sod facing for canal and embankment slopes,

c. Re-shaping of canals cross sections with removal of sediment and earthfill for embankment,

d. Improvement of inspection roads with laterite pavement.

ii) Related Structures

a. Installation of gates at check structures, diversion structures and turnouts,

b. Repair of canals sections downstream of structures slope protection,

c. Provision of required structures or structure parts where not provided yet,

d. Replacement of structures damaged severely.

(3) Basic Design Values

i) Design Discharge

The unit design discharges for the main and lateral canals, and tertiary canals are as follows:

Unit design discharges for the main and lateral canals	1.40 l/sec/ha
Unit design discharges for tertiary canals	1.72 l/sec/ha

ii) Velocity

The maximum permissible velocity in unlined canals is determined so as not to give the erosion. The minimum permissible velocity is determined so as not to induce the growth of aquatic plant and moss. Considering the characteristics of soil materials, the maximum and minimum permissible velocity are determined as follows:

Kind of canal	Minimum (m/sec)	Maximum (m/sec)
Earth canal	0.3	0.7
Lined canal	0.3	2.0

iii) Roughness Coefficient

The roughness coefficient of canals for determination of their hydraulic properties are as follows:

Canals	n value for Manning formula
Earth canal	
- Main and lateral canal	0.025
- Tertiary canal	0.030
Slope protection canal	0.020
Lined canal	0.015

(d) Side Slope

Canals	Side slope
Earth canal	
- Main and lateral canal	1.5
- Tertiary canal	1.0
Slope protection canal	1.5
Lined canal	1.5

5.2.3 Drainage Canals and Related Structures

(1) Drainage System

The drainage canal system consists of major drains, tertiary and quaternary drains. The function of the major drains is that major drains transport water from tertiary drains and flood water from surrounding areas to the disposal points. The proposed drainage layout is based on the Pol Pot canal system. The drainage canal layout is worked out based on the topographic maps at a scale of 1:5,000 which were prepared during this study period in 1994, supplemented by the canal layout prepared by the DOH. The drainage layout of the Project is shown in Fig.V-18. The drainage diagram is as shown in Fig.V-21.

The structures related to the drainage canals are bridges, culverts, closing bunds. The bridges are provided at the road crossing points.

(2) Basic Design Values

i) Design Discharge

The design discharge of the drainage canal at the respective cross sections is determined by the following basis:

Unit drainage water requirement	4.4 lit./sec/ha

ii) Canal Section

The drainage canal sections are designed on the following design criteria:

Type of canal	Trapezoidal earth canal
Permissible velocity	
- Maximum velocity	0.6 m/sec
- Minimum velocity	0.3 m/sec
Roughness coefficient for use of Manning formula	0.03
Side slope	1:1.0

5.2.4 Tertiary Development

The commanding area of the existing tertiary canal ranges from 30 to 100 ha, averaged to 65 ha. Tertiary canals are provided in parallel at intervals of 500 m to 800 m. To ensure equitable water delivery to the tail end of the main and lateral canal system, unification or division of the existing tertiary blocks is needed. According to the proposed main and lateral canal system layout, the tertiary block will command 50 ha on an average.

Tertiary development program aims at efficient water management by establishing well organized tertiary system and through refined rotational irrigation program. In order to distribute irrigation water equally and efficiently to all parts of the fields through more intensive water control, it is advisable to sub-divide the tertiary block into several quaternary blocks (basically 7 blocks). The quaternary block is served by respective quaternary canals. The recommended size of one quaternary block is 7 to 10 ha.

The quaternary canal is a terminal system. Irrigation water to be carried by this canal is distributed to fields directly. The end of a quaternary canal is connected to nearby a tertiary drainage canal so as to drain off excess water in the canal. The average interval of quaternary canal is 100 m. All the quaternary canals except the canal to be constructed in the highest position in respective areas are so designed as to have dual function; irrigation and drainage function, where possible.

The structures to be required in the tertiary block will be: division boxes, measuring devices such as Parshall flume type, culvert, etc.

5.2.5 Demonstration Farm

The demonstration farms is proposed to be established for the purpose to provide the demonstration effects of the improved irrigated agriculture and the base for further expansion of the development of the project area. The main objectives of the demonstration farm is as follows:

i) Establishment of water users associations and introduction of efficient on-farm water management

ii) Demonstration and Guidance on Cultivation Techniques

The location of the demonstration farm is selected at the following tertiary blocks in consideration of (a) reliable water supply, (b) high demonstration effect and (c) efficient extension services.

Tertiary canal	T.3.1.0	52 ha
Tertiary canal	T.3.2.0	63 ha
Tertiary canal	T.3.2.1	65 ha
Tertiary canal	T.3.3.0	85 ha
Total		265 ha

The demonstration farm will be provided with the tertiary canals and quaternary canal system with land levelling.

5.2.6 Proposed Irrigation and Drainage Works

The general features of the proposed project works of the irrigation and drainage system are as shown in Table V-14 and are summarized below.

Description		Work Quantity
Irrigation canal		
Main canal		
- Improvement of main canal	(km)	5.3
Lateral		
- improvement of existing lateral	(km)	8.2
- Construction of lateral	(km)	4.0
Tertiary canal	(km)	56.8
Quaternary canal system	(ha)	1,950
Drainage canals		
Main canal	(km)	18.1
Tertiary canal	(km)	64.6

5.3 Tonle Bati Irrigation Project

5.3.1 General Design Considerations

(1) Available River Discharges to the Study Area

The Tonle Bati lake water, the main water source of the Tonle Bati Irrigation Project, is insufficient for irrigation of the Project area. Augmentation of the water from the Prek Thnot river will be required.

(2) Tonle Bati Lake Water Level

The high water level of Tonle Bati lake is set to be 7.80 m in order to prevent Pagoda located on the southern coast of the lake from inundation by the high water of the lake. The low water level of the lake is set to be 5.50 m to preserve the water level for the recreation center.

(3) Pump Irrigation in Low Water Period

Even though the lake water is augmented from the Prek Thnot, the run-of-river water of the Prek Thnot is insufficient to preserve the lake water level to 7.80 m (without Prek Thnot reservoir condition). Then, the lake water levels go down. Supplemental pump irrigation is inevitable in the low water period.

(4) Priority Irrigation in the Elevated Area in the Dry Season

The central part of the project area is high-elevated, which will not be served by gravity flow. Pumping-up water in the dry season is given priority to such high-elevated area.

(5) Separate Irrigation and Drainage System

To promote equitable water supply and efficient water management, level-crossing of irrigation canals with Pol Pot canals (drainage canals) has to be neglected. Irrigation and drainage systems have to be separated in the canal system, except quaternary canals.

(6) Future Development Area

Overall development of Tonle Bati area is divided into priority development and future development. Facilities for the priority development include a head regulator, main canal,

and related structures which are related to the future extension area. They have to be given the capacities for future development.

5.3.2 Irrigation Canals and Related Structures

(1) Irrigation System

The proposed irrigation systems are basically on the basis of the existing irrigation system with modification of canal layout, canal sections and discharge/water level control structures. The preliminary irrigation canal system layout is as shown in Fig.V-22. The irrigation diagrams thus prepared are as shown in Fig.V-23.

(2) Canal and Related Structures

Canal sections of main canal to tertiary canals are in poor shape due to slope sliding and erosion. To prevent collapse of the canal embankment and to save the future O & M cost, canal slope protection will be needed. Most of canal embankments are also severely eroded and eroded soils are silted-up on the canal berms. Canal reshaping by earthfill and removal of sediment will be necessary. The canal inspection roads are not well maintained and damaged due to erosion or breach of embankments. Laterite pavement will be provided for inspection road after re-shaping. The typical section of irrigation canals are as shown in Fig.V-20. The following works are required for respective canals:

i) Main and Lateral Canals

a. Slope protection for the existing main canals by means of 2 phase concrete lining, and for the existing laterals by means of concrete lining,

b. Sod facing for canal and embankment slopes,

c. Re-shaping of canals cross sections with removal of sediment and earthfill for embankment,

d. Improvement/provision of inspection roads with gravel metalling.

ii) Related Structures

a. Installation of gates at check structures, diversion structures and turnouts,

b. Repair of canals sections downstream of structures slope protection,

c. Provision of required structures or structure parts where not provided yet,

d. Replacement of structures damaged severely.

(3) Basic Design Values

i) Design Discharge

The unit design discharges for the main and lateral canals, and tertiary canals are as follows:

Unit design discharges for the main and lateral canals	1.40 l/sec/ha
Unit design discharges for tertiary canals	1.72 l/sec/ha

ii) Velocity

The maximum permissible velocity in unlined canals is determined so as not to give the erosion. The minimum permissible velocity is determined so as not to induce the growth of aquatic plant and moss. Considering the characteristics of soil materials, the maximum and minimum permissible velocity are determined as follows:

Kind of canal	Minimum (m/sec)	Maximum (m/sec)
Earth canal	0.3	0.7
Lined canal	0.3	2.0

iii) Roughness Coefficient

The roughness coefficient of canals for determination of their hydraulic properties are as follows:

Canals	n value for Manning formula
Earth canal	
- Main and lateral canal	0.025
- Tertiary canal	0.030
Slope protection canal	0.020
Lined canal	0.015

(d) Side Slope

Canals	Side slope
Earth canal	
- Main and lateral canal	1.5
- Tertiary canal	1.0
Slope protection canal	1.5
Lined canal	1.5

(4) Activation of Tonle Bati Lake Related Structures

The water levels of Tonle Bati Lake will be lowered in the dry season even the irrigation water is augmented from the Prek Thnot through a connection canal. Lifting water from the lake will be required in the dry season to supplement the gravity irrigation supply. The required pumping-up water will be about 20 % of the annual irrigation demand as shown in Fig.V-24. The pumping station and intake will be improved. The intake will be provided with three slide gates with improvement of concrete structures.

i) Improvement of Intake

Three slide gates, 2.0 m wide and 2.0 m high, will be installed, to enable adjusting the discharges through the intake and to stop reverse flow from the canal to the lake during the pumping-up. The concrete structure will also be improved.

ii) Improvement of Pumping Station

Four sets (including one spare set) of horizontal volute type pump will be installed with capacity of 45 m^3/min, a total head of 4.5 m and 30kW each at the existing pumping station. For supplying power, a set of diesel generator will be also installed.

iii) Improvement of Spillway of Tonle Bati Lake

The bridge for the National Road No. 2, which is located immediately downstream of the spillway and is severely damaged, will be replaced.

iv) Improvement of Lake Dike

The existing dike surrounding the lake is insufficient in elevation and eroded at some location. Heightening and slope protection by sodding will be provided.

Raising of existing dike/road	
Crest width	5.0 m
Crest El.	8.70 m
Location	3 location 2.0 km in total length
Construction of dike around Pagoda	
Crest width	4.0 m
Crest El.	8.70 m
Length	800 m
Related structure	
- Replacement of gates on Pol Pot drainage canals	1.s.
- Replacement of bridge on Tonle Bati river	1 nos

(5) Activation of Connection Canal (NS 78 canal)

i) Improvement of NS 78 Canal

In order to augment the storage water of the Tonle Bati lake, the connection canal is required to be rehabilitated. The capacity of the canal relates to the amount of the augmentation of water to Tonle Bati lake. It is determined to be 7 m^3/sec through storage simulation of lake water, in consideration of the future extension of the Tonle Bati area. The canal of 4.6 km up to the Tonle Bati river will be re-worked by means of additional excavation and improvement of spoil bank. The inspection road will be provided on the left bank with laterite surfacing . To prevent erosion of the damaged canal section in dispersive soils, self-retaining 2-phase canal lining will be provided, together with sodding.

ii) Stung Toch Regulator

In order to divert water in the Stung Toch which is conveyed from the Prek Thnot river, a regulator will be constructed in the Stung Toch river about 2 km downstream of a crossing point of National Road No. 3. A regulator is of a combined structure with a concrete weir and three gates. An intake for the connection canal to the Tonle Bati river will be constructed contiguously to the right bank wall with three slide gates . The total capacity of intake will be 7 m^3/sec.

5.3.3 Drainage Canals and Related Structures

(1) Drainage System

The drainage canal system consists of major drains and tertiary drains. The function of the major drains is that major drains transport water from tertiary drains and from surrounding areas to the Cheung Loung lake or the Pol Pot drainage canals. The proposed drainage layout is principally based on the Pol Pot canal system. The drainage canal layout is worked out based on the topographic maps at a scale of 1:10,000 which were prepared during this study period in 1993, supplemented by the canal layout prepared by the DOH. The structures related to the drainage canals are bridges, culverts, closing bunds. The drainage layout of the Project is shown in Fig.V-22. The drainage diagram is as shown in Fig. V-25.

(2) Basic Design Values

i) Design Discharge

The design discharge of the drainage canal at the respective cross sections is determined by the following basis:

Unit drainage water requirement	4.4 lit./sec/ha

ii) Canal Section

The drainage canal sections are designed on the following design criteria:

Type of canal	Trapezoidal earth canal
Permissible velocity	
- Maximum velocity	0.6 m/sec
- Minimum velocity	0.3 m/sec
Roughness coefficient for use of Manning formula	0.03
Side slope	1:1.0

ii) Canal Section

The drainage canal sections are designed on the following design criteria:

5.3.4 Tertiary Development

The commanding area of the existing tertiary canal ranges from 30 to 100 ha, averaged to 65 ha. Tertiary canals are provided in parallel at intervals of 500 m to 800 m. To ensure equitable water delivery to the tail end of the main and lateral canal system, unification or division of the existing tertiary blocks is needed According to the proposed main and lateral canal system layout, the tertiary block will command 47 ha on an average.

Tertiary development program aims at efficient water management by establishing well organized tertiary system and through refined rotational irrigation program. In order to distribute irrigation water equally and efficiently to all parts of the fields through more intensive water control, it is advisable to sub-divide the tertiary block into several quaternary blocks (basically 7 blocks). The quaternary block is served by respective quaternary canals. The recommended size of one quaternary block is 7 to 10 ha.

The quaternary canal is a terminal system. Irrigation water to be carried by this canal is distributed to fields directly. The end of a quaternary canal is connected to nearby a tertiary drainage canal so as to drain off excess water in the canal. The average interval of quaternary canal is 100 m. All the quaternary canals except the canal to be constructed in the highest position in respective areas are so designed as to have dual function; irrigation and drainage function, where possible.

The structures to be required in the tertiary block will be: division boxes, measuring devices such as Parshall flume type, culvert, etc.

5.3.5 Demonstration Farm

The demonstration farms is proposed to be established for the purpose to provide the demonstration effects of the improved irrigated agriculture and the base for further expansion

of the development of the project area. The main objectives of the demonstration farm is as follows:

i) Establishment of water users associations and introduction of efficient on-farm water management

ii) Demonstration and Guidance on Cultivation Techniques

The location of the demonstration farm is selected at the following tertiary blocks in consideration of (a) reliable water supply, (b) high demonstration effect and (c) efficient extension services.

Tertiary canal	T.3.6.0	31 ha
Tertiary canal	T.3.1.1	56 ha
Tertiary canal	T.3.2.1	48 ha
Tertiary canal	T.3.3.1	57 ha
Tertiary canal	T.3.4.1	43 ha
Tertiary canal	T.3.5.0	24 ha
	Total	259 ha

The demonstration farm will be provided with the tertiary canals and quaternary canal system with land levelling.

5.3.6 Proposed Irrigation and Drainage Works

The general features of the proposed project works of the irrigation and drainage system are as shown in Table V-14 and are summarized below.

Description		Project Work
Irrigation canals		
- Main Canal	(km)	8.3
- Lateral	(km)	10.0
- Tertiary Canal	(km)	48.1
- Quaternary canal system	(ha)	1,600
Improvement of Tonle Bati Lake Related Structures		
- Intake	(nos)	1
- Pumping Station	(nos)	1
- Spillway of Lake	(nos)	1
- Lake Dike	(km)	L.S.
Improvement of Connection Canal		
- Connection canal	(km)	4.6
- Stung Toch Regulator	(nos)	1
- Kandal Stung Regulator	(nos)	1
Drainage canals		
- Main and Lateral Canal	(km)	24.1
- Tertiary Canal	(km)	41.8

6. IMPLEMENTATION AND OPERATION AND MAINTENANCE PLAN

6.1 Organization and Management

6.1.1 Organization of the Project Implementation

The Department of Agricultural Hydraulics and Hydrometeorology (DOAHH), the Ministry of Agriculture, Forestry and Fisheries, would be the executing body for the Kandal Stung Irrigation Project and Tonle Bati Irrigation Project. DOAHH would be responsible for both the engineering works and the construction works of the Projects, and it would coordinate all activities of the relevant government agencies and regional administrative organizations in connection with the project execution.

The Construction Office under DOAHH would have the direct responsibility for the project execution. The Provincial Offices related to the respective Projects would coordinate the construction of the Projects at the provincial level on behalf of DOAHH.

To smoothly execute the project, the Project Offices for the Kandal Stung Irrigation Project and Tonle Bati Irrigation Project would be established. The Project Office would operate all the field works such as additional survey and investigation, land acquisition, the detailed design and construction supervision. The organization of the project execution is proposed as shown in Fig. V-26.

6.1.2 Organization of Operation and Maintenance

Irrigation and drainage system to be operated and maintained includes Tuk Thla and Kompong Tuol regulators, irrigation canal system and drainage system up to the outlet of the drainage canals.

Responsibilities for operation and maintenance of the irrigation and drainage systems will be divided broadly into two types of administrative bodies, government operation body responsible for the head regulator to lateral systems, and water users associations responsible for on-farm irrigation and drainage systems within tertiary blocks. The proposed O & M organization is as shown in Fig.V-27.

The government body will be divided into two; the central government and provincial government bodies. DOAHH will be responsible for operation and maintenance of Tuk Thla and Kompong Tuol regulators, and of Tonle Bati lake related facilities, and Provincial Offices of Agricultural Hydraulics and Hydrometeorology of Kandal and Takeo provinces will be responsible for main and lateral canal system in Kandal Stung irrigation system and Tonle Bati irrigation system, respectively.

The Water Management Office of DOAHH will carry out the O & M of the Kompong Tuol intake. The Kandal and Bati district offices will carry out O & M of main canal and lateral canal systems in their administrative areas. Each government offices will have to establish three units for the Project O & M; operation, maintenance and administration.

The operation unit will be responsible for operating the facilities and for delivering the water to their outlets in accordance with irrigation schedules. The maintenance unit will be responsible for maintaining the facilities, and maintenance works will be done in close coordination with operation schedule. The administrative unit will be responsible for applying the system regulations and for billing water charges.

The field staff will consist of irrigation supervisors and gate keepers with the following duties:

Irrigation supervisor: The irrigation supervisor is a technical staff who has a technical knowledge. They know the contents of the authorized irrigation schedule and they have to keep the enough communication channels with gate keepers and field O & M office. All irrigation supervisors are given motorcycles for their works. The working territory of one irrigation supervisor will be 10 to 15 km of the canal length and 500 to 1,000 ha of the irrigation area.

Gate keeper: The gate keepers will be nominated to the farmers who has sufficient knowledge for gate control and have sufficient communication channels with water users association and irrigation supervisors. The working distance is about 2 to 3 km from their homes. They will be given bicycles for gate operation.

Prior to implementation of the irrigation works, water users association will be organized in each tertiary block, averaging to its command area of 50 ha. The definitions and functions of water user's associations will be as follows:

i) The main functions of the water user's association are to manage water distribution, to operate and maintain irrigation and drainage canal system in a tertiary block and to manage contribution fee for the water user's association.

ii) The organisation of water user's association consists of a general assembly, board of the association and member farmers. Budget for all works is collected from the association members and paid by and for the association.

iii) Board of the association consists of a chief of the association, a secretary, treasury and water master.

At the provincial and district government levels, the provincial and district irrigation committees will be organised to co-ordinate smooth operation and maintenance of irrigation system and water management of the Project. They are constituted from the representatives of the provincial or district government offices, such as Agriculture office , Public Works office, rural development office, etc.

6.2 Implementation Plan

6.2.1 Overall Implementation Plan

The irrigation development project is one of the integrated agricultural and rural development project, which includes various schemes for development and consolidation of infrastructure facilities as well as for reinforcement and/or activation of supporting functions. In order to effectively implement the irrigation project together with other various components, and taking into account the technical and managerial capacity of the staff concerned, the implementation of the integrated schemes should be made under the well designed stage-wise development. It could be divided into two stage. The implementation schedule is as shown in Fig. V-28.

(1) Priority Development

The first stage development aims to establish the technical and implementing base as a model area which will have to be the core to demonstrate the effects of the integrated agricultural and rural development and function as the base for the future expansion to the whole area.

(2) Second Stage Development

The remaining area will be covered in the second stage development. The implementation and operation of the model area would provide various information on construction management of main civil works and on-farm works, organization of water user associations, and thus the chance for gaining experience for execution of the large-scale project implementation. On the basis of the accumulated result and institutional set-up during the first stage development, the second stage could successfully be implemented. Commencement of irrigation works, however, will be subject to the schedule of realization of the Prek Thnot multipurpose dam.

Whereas, the area belonging to the older terrace area is not suitable for intensive development as already suggested in the preceding chapter 6. For this area, pasture and fodder crops or fuelwood production are proposed. Thus the sufficient provision of extension support should be ensured as well as special measures to rural life improvement .

6.2.2 Implementation Schedule

The Project implementation plan is formulated on the following considerations:

The civil works to be executed by the Project are broadly classified into the main civil works and on-farm works. The main civil works consists of the Kompong Tuol irrigation intake, main, lateral and tertiary canals and drainage canals. The on-farm works include all the facilities below the tertiary outlets such as quaternary canals and related facilities. The Kompong Tuol irrigation intake, main and lateral canals, drains and their related structures would be executed by qualified civil work contractors with assistance of foreign technical services, which would be selected through competitive bidding, and the tertiary canals and drains by the local contractors. The quaternary canal networks in the tertiary systems would be constructed by water users associations to be organized under the guidance of the local government.

As the civil works of the Project include a large volume of earth works, the mechanized construction will be introduced in the main civil works. In order to increase the employment opportunity in and around the Project area, however, the manpower construction will be adopted as much as possible. The large scale civil works such as Kompong Tuol irrigation intake, main and lateral canals and major drains will be carried out mainly by heavy construction machinery. The tertiary and quaternary canal works will be carried out by manpower with minor construction equipment.

Taking into account the large scale of the civil works, the project works will be divided into three stages: i) detailed design and investigation of the main project facilities, ii) construction of main project facilities and iii) detailed design and construction of on-farm development works. The on-farm development works will be implemented simultaneously with the main project facilities works, so that upon completion of the main works, immediate benefits can be envisaged.

The implementation schedule of the priority development Projects is as shown in Fig. V-29.

6.3 Operation and Maintenance Plan

6.3.1 Water Supply Plan

(1) Irrigation Schedule

O & M section will prepare seasonal water distribution schedule including rotational blocks for dry season and rainy season cropping, respectively. It will submit the prepared irrigation schedule to the chairman of the Irrigation Committee for its approval. After the approval, the irrigation schedule will be announced to the water user' association before starting crop cultivation. Based on the final irrigation schedule, the O & M Office starts water release to the Project canals.

(2) Water Distribution

Continuous water distribution is employed at the peak requirement period in the Project canal. Two irrigation rotation blocks and 15-day time lag will be adopted in a seasonal irrigation schedule for early rice cropping and local rice variety cropping, respectively. Four rotational blocks will be applied at the fully cropped season. The rotational system is effective to reduce irrigation peak demand of the main canal system at the start of cropping especially for a land preparation period. Gate operation with an interval on half month basis will be made by gate keepers principally in accordance with the irrigation schedule, and sometimes with adjustment on the basis of the rainfall conditions. Irrigation supervisors of O & M Office will check gate operation at the field.

The water management with in the tertiary block is proposed as follows: A water master will be responsible for overall O & M of tertiary block. Under the water master, a quaternary block chief assists the water master for O & M in the quaternary block. A seasonal irrigation schedule will be informed to the representatives of WUAs by the O & M staff in the meeting to be held before every cropping season, and then the irrigation schedule is further informed to respective farmers. The water supply in the tertiary system will be made principally on the rotational basis.

(3) Monitoring and Communication

The meteorological equipment including a rain gauge were installed in the Tonle Bati Center. Rainfall data will be used for O & M in making irrigation schedule and water delivery schedule.

Real time water management is prerequisite for even distribution of irrigation water to the existing irrigation schemes located in the Prek Thnot river basin. The water level measurement of the Prek Thnot river will be made at the water level gauging stations which were installed during the study period in December 1993. Measurement of water levels at the gauging stations which are located in the Kompong Speu and Kandal provinces will be measured by the staff of the respective Provincial Hydrology Offices under the administration of DOAHH. Water level measurement data will be transferred to the DOAHH through the telecommunication system to be installed. In the Project area, diversion discharges at intake and diversion structures will be measured. The diversion discharges at the respective sites will be recorded by gate keepers and reported to the O & M Office.

6.3.2 Maintenance Plan

Maintenance works of the irrigation system will be divided into two categories, i.e. routine maintenance and periodical maintenance. Routine maintenance works will be made within a short interval and in a small scale throughout a year. Periodical maintenance will be made rather intensively in a large scale during a water cut period. The water cut will be made

from the end of irrigation for the second cropping to the irrigation start of the rainy season cropping.

First immediately after irrigation cut, the staff of O & M section will inspect the actual condition of the canals and structures under water, and judge the necessity of repairing. Based on the result of the inspection, a periodic maintenance work program will be prepared, together with the budget estimate. The major periodical maintenance work will be desilting works for canals and structures, canal embankment repairs, structure and gate repairs, greasing of gates, etc. Routine maintenance works to be required will be simple minor works such as grass cutting, desilting work of the small structures. Those periodical and routine maintenance works will be carried out directly or with hired labour under the supervision of the O & M section.

The urgent repair may be required when canal system faces a serious damage or likely to lead to system failure to be caused by an unexpected forces

6.3.3 Training of O & M Staff

Training of O & M staff and water users is important for attaining equitable water supply in the irrigation canal system and within tertiary blocks. Programmes of water use training will be implemented prior to and continuously after completion of the irrigation works. For those purposes, workshops, seminars and regular training courses will be programmed for respective classes of officers and staff by the DOAHH. Representatives of water users associations will be trained by the irrigation supervisors of the O & M office on the water management within the tertiary block. The main items required for training are as follows:

i) To set up basic idea for the water use among the concerned government agencies in water management of the river water, government canal systems and within the tertiary blocks.

ii) To promote function of the irrigation committee and water users associations to be organized.

iii) To promote the establishment and improvement of water resources regulations.

iv) To promote the improvement of the skill, knowledge and behaviour of water users in irrigation management.

Tables

Table V-1 Estimate of Flow Capacity of Tuk Thla Regulator

(Flood Water on August 3, 1994)

Gate No. from the left	hg	Elg	Eltg	hgo	Orifice flow	Over flow
	(m)	(m)	(m)	(m)	(m3/sec)	(m3/sec)
1	0.64	11.52	13.92	2.91	7.7	0.0
2	0.56	11.44	13.84	2.83	7.5	0.0
3	1.34	12.22	14.62	3.61	9.6	0.0
4	0.85	11.73	14.13	3.12	8.3	0.0
5	0.46	11.34	13.74	2.73	7.2	0.0
6	0.41	11.29	13.69	2.68	7.1	0.0
7	0.51	11.39	13.79	2.78	7.4	0.0
8	-0.74	10.14	12.54	1.53	4.1	1.1
9	0.69	11.57	13.97	2.96	7.9	0.0
10	0.78	11.66	14.06	3.05	8.1	0.0
11	0.40	11.28	13.68	2.67	7.1	0.0
12	0.56	11.44	13.84	2.83	7.5	0.0
13	0.67	11.55	13.95	2.94	7.8	0.0
14	0.37	11.25	13.65	2.64	7.0	0.0
15	0.23	11.11	13.51	2.50	6.6	0.0
16	0.35	11.23	13.63	2.62	7.0	0.0
17	0.47	11.35	13.75	2.74	7.3	0.0
18	0.34	11.22	13.62	2.61	6.9	0.0
19	0.34	11.22	13.62	2.61	6.9	0.0
20	-0.37	10.51	12.91	1.90	5.0	0.5
21	-1.75	9.13	11.53	0.52	1.4	3.3
22	0.42	11.30	13.70	2.69	7.1	0.0
23	-0.51	10.37	12.77	1.76	4.7	0.8
24	0.36	11.24	13.64	2.63	7.0	0.0
25	0.39	11.27	13.67	2.66	7.1	0.0
		Total			171.2	5.8
		Grand Total				177.0

Discharge calculation

$$Q = C * b * d * (2g (h1-h2))^{1/2} \quad (m3/sec)$$

C : 0.60

b : effective width , bo-0.04*2*h1=0.71 m

d : hgo

h1 : 4.89 m

h2 : 2.91 m

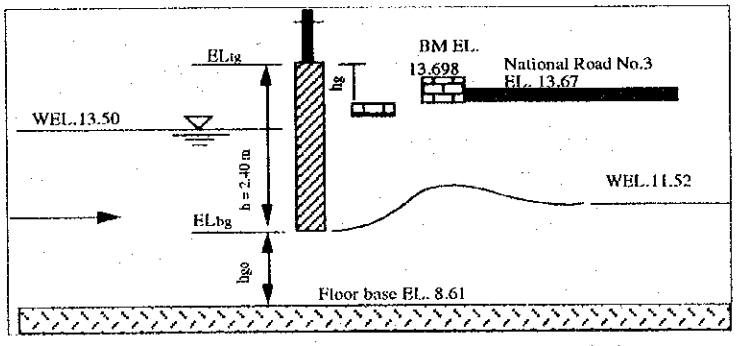


Table V-2 List of Existing Irrigation Canals of Kandal Stung Irrigation Project Area

No.	Canal	Abbre-viation	Length	Canal property at head								Construction	Improvement/ New
				Q	v	i	B	H	b1	b2	h		
			(m)	(m3/sec)	(m/sec)		(m)	(m)	(m)	(m)	(m)		
1.	Main canal	M	5,300	NA	NA	NA	NA	NA	NA	NA	NA		Imp
		Sub-total	5,300										
2.	Lateral												
2.1	Lateral 1	L1	4,000	NA	NA	NA	NA	NA	NA	NA	NA		New
2.2	Lateral 2	L2	500	NA	NA	NA	NA	NA	NA	NA	NA		Imp
2.3	Lateral 3	L3	850	NA	NA	NA	NA	NA	NA	NA	1.20		Imp
2.4	Lateral 4	L4	1,520	1.316	0.56	0.0005	1.50	2.00	1.00	1.00	1.23	MCC	New
	Lateral 4	L4	3,240	1.316	0.56	0.0005	1.50	1.75	1.00	1.00	1.07	MCC	Imp
2.5	Lateral 5	L5	855	1.084	0.44	0.0002	1.50	1.57	1.00	1.00	1.02	MCC	New
	Lateral 5	L5	2,260	1.084	0.39	0.0002	1.50	1.57	1.00	1.00	-	MCC	Imp
		Sub-total	13,225										
3.	Tertiary canal										0.35		
3.1	Tertiary 1.0	T1.0	900	0.079	0.22	0.0003	0.50	0.60	0.50	0.50	0.65	MCC	New
3.2	Tertiary 1.1.0	T1.0	1,000	0.294	0.31	0.0003	0.50	1.00	0.50	0.50	0.58	1990MCC	New
3.3	Tertiary 1.2.1	T1.1.0	1,000	0.294	0.29	0.0003	0.50	0.93	0.50	0.50	0.54	1990MCC	New
3.4	Tertiary 1.2.2	T1.2.2	1,000	0.196	0.28	0.0003	0.50	0.84	0.50	0.50	-	1990MCC	New
3.5	Tertiary 1.3.1	T1.3.1				not constructed yet							
3.6	Tertiary 1.4	T1.4	1,000	0.089	0.23	0.0003	0.50	0.68	0.50	0.50	0.57	MCC	New
3.7	Tertiary 1.5	T1.5	1,200	0.220	0.28	0.0003	0.50	0.87	0.50	0.50	0.54	1990MCC	New
3.8	Tertiary 2.1.0	T2.1.0	994	0.193	0.28	0.0003	0.50	0.84	0.50	0.50	0.51	1990MCC	Imp
3.9	Tertiary 2.2.0	T2.2.0	1,264	0.164	0.26	0.0004	0.50	0.81	0.50	0.50	0.53	1990MCC	Imp
3.10	Tertiary 2.3.0	T2.3.0	1,416	0.185	0.27	0.0002	0.50	0.83	0.50	0.50	0.53	1990MCC	New
3.11	Tertiary 2.4.0	T2.4.0	1,480	0.188	0.27	0.0003	0.50	0.83	0.50	0.50	-	1990MCC	Imp
3.12	Tertiary 3.1.0	T3.1.0				not constructed yet							
3.13	Tertiary 3.2.0	T3.2.0	850	0.156	0.26	0.0002	0.50	0.79	0.50	0.50	0.63	1989MCC	Imp
3.14	Tertiary 3.3.0	T3.3.0	1,900	0.269	0.30	0.0002	0.50	0.98	0.50	0.50	0.61	1989MCC	Imp
3.15	Tertiary 3.4.0	T3.4.0	1,900	0.260	0.30	0.0003	0.50	0.96	0.50	0.50	0.70	1989MCC	New
3.16	Tertiary 3.5.0	T3.5.0	1,900	0.339	0.32	0.0002	0.50	1.05	0.50	0.50	0.36	1989MCC	Imp
3.17	Tertiary 4.1.1	T4.1.1	600	0.081	0.22	0.0003	0.50	0.61	0.50	0.50	-	1990MCC	Imp
3.18	Tertiary 4.1.2	T4.1.2				not constructed yet							
3.19	Tertiary 4.2.1	T4.2.1	600	0.069	0.21	0.0003	0.50	0.58	0.50	0.50	0.38	1990MCC	New
3.20	Tertiary 4.2.2	T4.2.2	800	0.089	0.23	0.0003	0.50	0.68	0.50	0.50	0.29	1990MCC	New
3.21	Tertiary 4.3.1	T4.3.1	600	0.051	0.20	0.0003	0.50	0.54	0.50	0.50	0.38	1990MCC	Imp
3.22	Tertiary 4.3.2	T4.3.2	900	0.089	0.23	0.0002	0.50	0.68	0.50	0.50	0.32	1990MCC	Imp
3.23	Tertiary 4.4	T4.4	600	0.690	0.23	0.0003	0.50	0.57	0.50	0.50	0.35	1990MCC	Imp
3.24	Tertiary 4.5.1	T4.5.1	600	0.075	0.22	0.0003	0.50	0.60	0.50	0.50	0.40	1990MCC	New
3.25	Tertiary 4.5.2	T4.5.2	942	0.098	0.23	0.0002	0.50	0.70	0.50	0.50	0.35	1990MCC	New
3.26	Tertiary 4.6.1	T4.61	600	0.075	0.22	0.0003	0.50	0.60	0.50	0.50	0.44	1990MCC	Imp
3.27	Tertiary 4.6.2	T4.6.2	1,000	0.125	0.24	0.0002	0.50	0.74	0.50	0.50	0.53	1990MCC	Imp
3.28	Tertiary 5.1.1	T5.1.1	1,350	0.187	0.27	0.0003	0.50	0.83	0.50	0.50	0.30	1990MCC	Imp
3.29	Tertiary 5.1.2	T4.1.2	585	0.063	0.24	0.0003	0.50	0.55	0.50	0.50	0.42	1990MCC	Imp
3.30	Tertiary 5.2.1	T5.2.1	900	0.111	0.24	0.0002	0.50	0.72	0.50	0.50	0.33	1990MCC	New
3.31	Tertiary 5.2.2	T5.2.2	900	0.066	0.21	0.0002	0.50	0.58	0.50	0.50	0.43	1990MCC	New
3.32	Tertiary 5.3.1	T5.3.1	1,000	0.117	0.24	0.0002	0.50	0.73	0.50	0.50	0.37	1990MCC	Imp
3.33	Tertiary 5.3.2	T5.3.2	1,000	0.084	0.23	0.0003	0.50	0.62	0.50	0.50	0.42	1990MCC	Imp
3.34	Tertiary 5.4.1	T5.4.1	1,000	0.110	0.24	0.0003	0.50	0.72	0.50	0.50	0.34	1990MCC	Imp
3.35	Tertiary 5.4.2	T5.4.2	900	0.072	0.21	0.0002	0.50	0.59	0.50	0.50	0.31	1990MCC	Imp
3.36	Tertiary 5.5.1	T5.5.1	950	0.058	0.20	0.0002	0.50	0.56	0.50	0.50	0.42	1990MCC	New
3.37	Tertiary 5.5.2	T5.2.2	900	0.115	0.24	0.0003	0.50	0.72	0.50	0.50	-	1990MCC	New
3.38	Tertiary 5.6	T5.6				not constructed yet							
3.39	Tertiary 6.0	T6.0	3,502	0.468	0.32	0.0002	0.50	1.14	0.50	0.50		1989MCC	New
		Sub-total	38,033										

Note:
NA : No data

Canal	Improvement	New	Total	Number
	(m)	(m)	(m)	(m)
Main canal	5,300	0	5,300	1
Lateral	6,850	6,375	13,225	5
Tertiary canal	19,939	18,094	38,033	35
Total	32,089	24,469	56,558	-

Table V-3 Present Conditions of Canal Related Structures of Kandal Stung Irrigation Project Area

No.	Structure	Abbreviation	Constructed (year)	Constructed (by)	Present condition	
	Main canal					
1.	Control	COM-M1	1989	MCC	leakage from gate	
2.	Divisor	DIV-M2	1987	-	no gate	riprup : damaged
3.	Check	CI-M3.1	1989	-	no gate	wing wall : damaged
4.	Check	CI-M3.2	Pre .existing	1978	no gate	riprup : damaged
5.	Check	CI-M3.3	1989		no gate	riprup : damaged
6.	Divisor	DIV-M3.4	1987	-	no gate	riprup : damaged
	Lateral L1					
7.	Intake	I-L1.0	1989	MCC	no gate	
8.	Crossing	X-1.0	1989	-		riprup : damaged
9.	Check	CI-L1.1	1989	-	no gate	
10.	Check	CI-L1.3	1990	-	no gate	riprup : damaged
11.	Check	CI-L1.4	Pre . existing	1978	no gate	
12.	Check	CI-L1.5	1990	1992	no gate	
	Lateral L4					
13.	Check	C-L4.2	1988	MCC	no gate	riprup : damaged
14.	Check	CDI-L4.2	1988	-	no gate	
15.	Check	CDI-L4.3	1988	-	no gate	
16.	Check	CI-L4.4	1990		no gate	riprup : damaged
17.	Check	CDI-L4.6	1990		no gate	riprup : damaged
18.	Check	CT-L4.7.1	1990	-	no gate	
19.	Check	CT-L4.7.2	1990	-	no gate	
	Lateral L4					
20.	Check	CD-L5.1	1988	MCC	no gate	
21.	Check	CDI-L5.1	1988	-	no gate	
22.	Drop	D-L5.2	1988	-	no gate	
23.	Check	CDI-L5.2	1988	-	no gate	
24.	Check	CI-L5.3	1988	-	no gate	
25.	Check	CI-L5.4	1988	-	no gate	riprup : damaged
26.	Check	CI-L5.5	1988	-	no gate	riprup : damaged
27.	Check	CI-L5.6	Pre. existing		no gate	
	Drain					
28.	Check	CI-D3	Pre . existing		no gate	

No.	Structure	Abbreviation	Constructed (year)	Constructed (by)	Present condition	
	Block 1					
1.	Turnout	T1.0	1990	MCC	filled by farmers	
2.	Turnout	T1.1		-	no gate	
3.	Turnout	T1.2.1	1990	-	no gate	
4.	Turnout	T1.2.2	1990	-	no gate	
5.	Turnout	T1.3	not constructed yet			
6.	Turnout	T1.5	not constructed yet			
	Block 2					
7.	Turnout	T2.1.0	Pre.existing	1977	no gate	
8.	Turnout	T2.2.0	1990	-	no gate	
9.	Turnout	T2.3.0	1990	-	no gate	
10.	Turnout	T2.4.0	1990	-	no gate	
	Block 3					
11.	Turnout	T3.1.0			no gate	
12.	Turnout	T3.2.0	1990	MCC	no gate	
13.	Turnout	T3.3.0	1990	-	no gate	
14.	Turnout	T3.4.0	1990	-	no gate	
15.	Turnout	T3.5.0	1990	-	no gate	
	Block 4					
16.	Turnout	T4.1.1	n.a.	MCC	no gate	
17.	Turnout	T4.1.2	n.a.	-	no gate	
18.	Turnout	T4.2.1	1988	-	no gate	inlet crest : damaged
19.	Turnout	T4.2.2	1988	-	no gate	inlet crest : damaged
20.	Turnout	T4.3.1	1988	-	no gate	
21.	Turnout	T4.3.2	1988	-	no gate	inlet crest : damaged
22.	Turnout	T4.4	1990	-	no gate	inlet crest : damaged
23.	Turnout	T4.5.1	1990	-	no gate	inlet crest : damaged
24.	Turnout	T4.5.2	1990	-	no gate	inlet crest : damaged
25.	Turnout	T4.6.1	1990	-	no gate	
26.	Turnout	T4.6.2	1990	-	no gate	
	Block 5					
27.	Turnout	T5.1.1	1988	MCC	no gate	inlet crest : damaged
28.	Turnout	T5.1.2	1988	-	no gate	wing wall : damaged
29.	Turnout	T5.2.1	1988	-	no gate	
30.	Turnout	T5.2.2	1988	-	no gate	
31.	Turnout	T5.3.1	1988	-	no gate	
32.	Turnout	T5.3.2	1988	-	no gate	
33.	Turnout	T5.4.1	1988	-	no gate	
34.	Turnout	T5.4.2	1988	-	no gate	
35.	Turnout	T5.5.1	1988	-	no gate	
36.	Turnout	T.5.5.2	1988	-	no gate	riprup : damaged
37.	Turnout	T5.6		-	no gate	inlet crest : damaged
	Block 6					
38.	Turnout	T6.0	1989	MCC	no gate	

Table V-4 List of Existing Irrigation Canals of Tonle Bati Irrigation Project Area

No.	Canal	Abbre-viation	Length	Canal property at head								Construction	Improvement/ New
				Q	v	i	B	H	b1	b2	h		
			(m)	(m3/sec)	(m/sec)		(m)	(m)	(m)	(m)	(m)		
1.	Haknuman canal		2,800	NA	NA	NA	NA	NA	NA	NA	NA		Imp
		Sub-total	2,800										
2.	Main canal	M1	3,500	9.780	NA	0.00020	3.50	4.00	3.80	3.80	3.50	1990 DOH	New
	Main canal	M2	550	NA	NA	NA	NA	NA	NA	NA	NA	1987 WCC	New
	Main canal	M3	2,850	NA	NA	NA	2.00	2.44	3.50	2.00	NA	1987 WCC	Imp
		Sub-total	6,900										
3.	Lateral	L											
3.1	Lateral 1	L1	1,000	2.500	0.41	0.00010	2.00	1.75	3.50	1.50	1.45	1987 WCC	New
3.2	Lateral 2	L2	1,650	0.350	0.24	0.00010	1.00	1.38	2.50	0.40	0.98	1987 WCC	New
3.3	Lateral 3	L3	960	1.600	0.30	0.00010	1.50	1.85	2.00	3.00	1.45	1988 WCC	New
		L3	590	0.36	NA	0.00010	1.00	1.29	2.00	2.00	0.99	1988 WCC	Imp
3.4	Lateral 4	L4	775	0.720	0.21	0.00010	1.25	1.45	3.00	1.00	1.14	1988 WCC	New
3.5	Lateral 5	L5	1,030	NA	NA	0.00030	5.80	1.84	2.40	2.40	1.42	1989 DOH	Imp
3.6	Lateral 5.5	L55	1,250	0.166	NA	0.00020	0.60	1.65	2.40	1.20	1.15	1990 DOH	New
3.7	Lateral 7	L7	1,850	0.521	NA	0.00030	2.00	1.41	3.80	2.40	0.79	1990 DOH	Imp
		Sub-total	9,105										
4	Tertiary canal												
4.1	Tertiary 3.1	T3.1.0	1,450	0.225	0.14	0.00010	0.85	1.20	0.40	0.40	0.90	1988 WCC	New
4.2	Tertiary 3.2	T3.2.0	650	0.090	0.10	0.00010	0.85	0.90	0.40	0.40	0.60	1988 WCC	New
4.3	Tertiary 3.3	T3.3.0	800	0.180	0.13	0.00010	0.85	1.10	0.40	0.40	0.80	1988 WCC	New
3.9	Tertiary 3.4	T3.4.0	1,300	0.225	0.14	0.00010	0.85	1.20	0.40	0.40	0.90	1988 WCC	New
4.50	Tertiary 3.5	T3.5.0	1,050	0.135	0.12	0.00010	0.85	1.00	0.40	0.40	0.70	1988 WCC	New
4.60	Tertiary 3.6	T3.6.0	1,000	0.180	0.13	0.00010	0.85	1.10	0.40	0.40	0.80	1988 WCC	New
4.70	Tertiary 3.7	T3.7.0	600	0.180	0.13	0.00010	0.85	1.10	0.40	0.40	0.80	1988 WCC	New
4.80	Tertiary 3.8	T3.8.0	975	0.135	0.10	0.00010	0.85	1.10	0.40	0.40	0.79	1988 WCC	New
4.90	Tertiary 3.9	T3.9.0	1,000	0.090	0.11	0.00010	0.70	0.90	0.40	0.40	0.80	1988 WCC	New
4.10	Tertiary 3.10	T3.10.0	975	0.135	0.12	0.00010	0.85	1.00	0.40	0.40	0.60	1988 WCC	New
4.11	Tertiary 4.C	T4.0	1,450	0.315	NA	NA	1.00	1.51	0.40	0.40	1.19	1988 WCC	Imp
4.12	Tertiary 4.1	T4.1.0	1,250	0.225	0.13	0.00010	0.85	1.20	0.40	0.40	0.87	1988 WCC	New
4.13	Tertiary 4.2	T4.2.0	1250	0.180	0.12	0.00010	0.40	1.15	0.40	0.40	0.84	1988 WCC	New
4.14	Tertiary 5.1	T5.1.0	800	NA	NA	0.00020	0.40	1.31	2.40	3.00	0.79	1989 DOH	New
4.15	Tertiary 5.2	T5.2.0	1,050	NA	NA	0.00020	0.40	1.48	1.20	2.40	1.01	1989 DOH	New
4.16	Tertiary 5.3	T5.3.0	800	NA	NA	0.00020	0.40	1.26	2.40	1.20	0.76	1989 DOH	New
4.17	Tertiary 5.4	T5.4.0	1,050	NA	NA	0.00020	0.40	1.41	2.40	2.40	0.65	1989 DOH	New
4.18	Tertiary 55.1	T55.1.0	300	0.038	NA	0.00020	0.40	1.33	2.40	1.20	0.83	1990 DOH	New
4.19	Tertiary 55.2	T55.2.0	600	0.037	NA	0.00020	0.40	1.27	2.40	1.20	0.75	1990 DOH	New
4.20	Tertiary 55.3	T55.3.0	750	0.042	NA	0.00020	0.40	1.40	2.40	1.20	0.90	1990 DOH	New
4.21	Tertiary 55.4	T55.4.0	900	0.049	NA	0.00020	NA	1.36	2.40	1.20	0.87	1990 DOH	New
4.22	Tertiary 7.1	T7.1.0				not constructed yet							
4.23	Tertiary 7.2	T7.2.0				not constructed yet							
4.24	Tertiary 7.3	T7.3.0				not constructed yet							
4.25	Tertiary 7.4	T7.4.0				not constructed yet							
4.26	Tertiary 7.5	T7.5.0				not constructed yet							
4.27	Tertiary 7.6	T7.6.0				not constructed yet							
		Sub-total	20,000										

Note:

NA : No data

Canal	Improvement	New	Total	Number
	(m)	(m)	(m)	(m)
Haknuman canal	2,800	0	2,800	1
Main canal	2,850	4,050	6,900	3
Lateral	3,470	5,635	9,105	7
Tertiary canal	1,450	18,550	20,000	21
Total	10,570	28,235	38,805	-

Table V-5 List of Existing Drainage Canals of Tonle Bati Irrigation Project Area

No.	Canal	Abbre-viation	Length	Canal property at head							Construction	Improvement/ New
				Q	v	i	B	H	b1	b2	h		
			(m)	(m3/sec)	(m/sec)		(m)	(m)	(m)	(m)	(m)		
Tertiary drainage canal													
1. Block 1						not constructed yet							
2. Block 2						not constructed yet							
3. Block 3													
3.1	DT3.1.0		1,300			0.0003	0.40	0.99	2.00	0.30	0.53	1988 WCC	New
3.2	DT3.2.0		800			0.0003	0.40	1.05	0.30	2.00	0.35	1988 WCC	New
3.3	DT3.3.0		1,050			0.0003	0.40	1.08	0.30	2.00	0.50	1988 WCC	New
3.4	DT3.4.0		1,000			0.0003	0.40	1.19	2.00	0.30	0.60	1988 WCC	New
3.5	DT3.5.0		1,200			0.0003	0.40	0.81	0.30	2.00	0.40	1988 WCC	New
3.6	DT3.6.0		1,075				2.00	0.75	2.00	0.30	0.20	1988 WCC	Imp
3.7	DT3.7.0		975			0.0003	0.40	1.09	2.00	0.30	0.50	1988 WCC	New
3.8	DT3.8.0		950			0.0003	0.40	1.04	0.30	2.00	0.42	1988 WCC	New
4. Block 4													
4.1	DT4.0		1,250			0.0003	0.40	1.24	2.00	0.30	0.50	1988 WCC	New
4.2	DT4.1		1250			0.0003	0.40	0.81	2.00	0.30	0.43	1988 WCC	New
5. Block 5													
5.1	DT5.1.0		800			0.0002	0.40	1.71	2.40	1.20	0.75	1988 WCC	New
		Sub-total	11,650										

Note:

NA : No data

Canal	Improvement	New	Total	Number
	(m)	(m)	(m)	(m)
Existing Drainage Canal	1,075	10,575	11,650	11
Total	1,075	10,575	11,650	-

Table V-6 Present Conditions of Canal Related Structures of Tonle Bati Irrigation Project Area

No.	Structure	Abbreviation	Constructed (year)	Constructed (by)	Present condition	
	Main canal					
1.	concrete bri	C.B.M1	1991	DOH		
2.	concrete bri	C.B.M2	1991	DOH		
	Lateral L1					
3.	check	CI-L1	1987	WCC	no gate	riprup : damaged
	Lateral L2					
4.	crossing	X-2-0	1987	WCC		riprup : damaged
	Lateral L3					
5.	intake	I-L3	1988	WCC	no gate	riprup : damaged
6.	check	CI-L3-1	1988	WCC	no gate	riprup : damaged
7.	check	CI-L3-2	1988	WCC	no gate	riprup : damaged
8.	check	CI-L3-3	1988	WCC	no gate	riprup : damaged
9.	check	CI-L3-4	1988	WCC	no gate	riprup : damaged
10.	check	CI-L3-5	1988	WCC	no gate	riprup : damaged
11.	wooden brid	W-B-L3	1988	WCC	no gate	riprup : damaged
	Lateral L4					
12.	intake	I-L4	1988	WCC		
13.	check	CI-L4	1988	WCC		
14.	Wooden bri	W-B-L4	1988	WCC		
	Lateral L5					
15.	intake	I-L5	1989	DOH	no gate	riprup : damaged
16.	check	CI-L5	1989	DOH	no gate	riprup : damaged
	Lateral L55					
17.	intake	I-L55		DOH	no gate	riprup : damaged
	Lateral L6					
18.	intake	I-L6				
	Lateral L7					
19.	check	CI-L7		DOH		

No.	Structure	Abbreviation	Constructed (year)	Constructed (by)	Present condition	
	Block 1					
	no related structure					
	Block 2					
	no related structure					
	Block 3					
1.	Turnout	T3.2.0	1988	WCC	no gate	riprup : damaged
2.	Turnout	T3.3.0	1988	WCC	no gate	riprup : damaged
3.	Turnout	T3.4.0	1988	WCC	no gate	
4.	Turnout	T3.5.0	1988	WCC	no gate	riprup : damaged
5.	Turnout	T3.6.0	1988	WCC	no gate	riprup : damaged
6.	Turnout	T3.7.0	1988	WCC	no gate	
7.	Turnout	T3.8.0	1988	WCC	no gate	
8.	Turnout	T3.9.0	1988	WCC	no gate	
9.	Turnout	T3.10.0	1988	WCC	no gate	
	Block 4					
10.	Turnout	T4.0	1988	WCC		
11.	Turnout	T4.1.0	1988	WCC		
12.	Turnout	T4.2.0	1988	WCC		
	Block 5					
13.	Turnout	T5.1.0	1989	DOH	no gate	
14.	Turnout	T5.2.0	1989	DOH	no gate	
15.	Turnout	T5.3.0		DOH	no gate	
	Block 55					
16.	Turnout	T55.1.0	1990	DOH	no gate	
17.	Turnout	T55.2.0			no gate	
	Block 7					
18.	Turnout	T7.2.0		DOH	no gate	
19.	Turnout	T7.3.0		DOH	no gate	
20.	Turnout	T7.4.0		DOH	no gate	
21.	Turnout	T7.5.0		DOH	no gate	
22.	Turnout	T7.6.0		DOH	no gate	

Table V-7 Water Requirement for Kandal Stung Irrigation Project

(1) Crop coefficient

	Crop growing stage (15 days)							
	1	2	3	4	5	6	7	8
Nursery	1.05	1.05						
Paddy (HY)	1.20	1.29	1.34	1.35	1.33	1.18		
Paddy (Local)	1.13	1.15	1.15	1.14	1.12	1.08	1.03	1.00
Maize	0.34	0.50	0.82	1.08	1.17	1.17	1.13	
Vegetables	0.33	0.48	0.79	1.05	1.11	1.00		

(2) Unit diversion water requirement (Sample Intermediate Output in 1969)

Unit : mm

Crop	Jan		Feb		Mar		Apr		May		Jun	
	1-15	16-ed	1-15	16-ed	1-15	16-ed	1-15	16-ed	1-15	16-ed	1-15	16-ed
1 Paddy (Nursary)	0.0	0.0	0.0	0.0	0.0	0.0	58.0	158.0	150.3	58.3	0.0	0.0
2 Paddy (HY)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.0	152.0	140.9	127.2
1 Paddy (Nursary)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 Paddy (HY)	79.2	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 Paddy (Nursary)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.0	137.7	130.6
3 Paddy (Local)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.0
5 Spring Maize	132.1	149.9	170.4	144.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 Spring Vegetable	94.8	133.5	161.0	126.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Crop	Jul		Aug		Sep		Oct		Nov		Dec	
	1-15	16-ed	1-15	16-ed	1-15	16-ed	1-15	16-ed	1-15	16-ed	1-15	16-ed
1 Paddy (Nursary)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 Paddy (HY)	163.0	155.4	95.1	19.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 Paddy (Nursary)	0.0	0.0	0.0	58.0	115.8	48.7	0.0	0.0	0.0	0.0	0.0	0.0
2 Paddy (HY)	0.0	0.0	0.0	0.0	0.0	58.0	113.5	71.6	137.9	163.8	165.7	167.2
1 Paddy (Nursary)	67.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 Paddy (Local)	150.8	156.9	83.5	68.1	7.0	0.0	0.0	0.0	52.6	5.8	0.0	0.0
5 Spring Maize	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.8	63.5	113.0
9 Spring Vegetable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.9	66.1

(3) Diversion water erquirement for each crop (Sample Intermediate Output in 1969)

Unit : MCM

Crop	Jan		Feb		Mar		Apr		May		Jun	
	1-15	16-ed	1-15	16-ed	1-15	16-ed	1-15	16-ed	1-15	16-ed	1-15	16-ed
1 Paddy (Nursary)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
2 Paddy (HY)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.5	1.4	1.2
1 Paddy (Nursary)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 Paddy (HY)	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 Paddy (Nursary)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
3 Paddy (Local)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
5 Spring Maize	0.4	0.4	0.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 Spring Vegetable	0.3	0.4	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.3	0.8	0.9	0.7	0.0	0.0	0.0	0.1	0.6	1.5	1.4	1.9

Crop	Jul		Aug		Sep		Oct		Nov		Dec	
	1-15	16-ed	1-15	16-ed	1-15	16-ed	1-15	16-ed	1-15	16-ed	1-15	16-ed
1 Paddy (Nursary)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 Paddy (HY)	1.6	1.5	0.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 Paddy (Nursary)	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 Paddy (HY)	0.0	0.0	0.0	0.0	0.0	0.5	1.0	0.6	1.2	1.5	1.5	1.5
1 Paddy (Nursary)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 Paddy (Local)	1.5	1.5	0.8	0.7	0.1	0.0	0.0	0.0	0.5	0.1	0.0	0.0
5 Spring Maize	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3
9 Spring Vegetable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
Total	3.1	3.0	1.7	0.9	0.1	0.5	1.0	0.6	1.8	1.6	1.7	2.0

Table V-8 Diversion Water Requirement for Kandal Stung Irrigation Project (Total Area : 1950 ha)

1. Diversion Water Requirement

(Unit : MCM)

Year	Jan		Feb		Mar		Apr		May		Jun	
Period	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end
1961	1.38	0.86	0.94	0.74	0.00	0.00	0.03	0.08	0.63	1.47	0.93	1.38
1962	1.39	0.89	1.00	0.81	0.00	0.00	0.03	0.07	0.61	1.41	1.67	2.28
1963	1.39	0.90	1.00	0.81	0.00	0.00	0.03	0.08	0.64	1.38	1.73	1.38
1964	1.40	0.90	0.96	0.83	0.00	0.00	0.03	0.08	0.60	1.27	1.61	1.53
1965	1.40	0.90	0.88	0.78	0.00	0.00	0.03	0.08	0.61	1.38	1.46	2.10
1966	1.40	0.88	0.96	0.78	0.00	0.00	0.03	0.08	0.60	1.42	1.29	0.80
1967	1.39	0.88	0.96	0.82	0.00	0.00	0.03	0.08	0.62	1.54	1.50	0.58
1968	1.40	0.90	0.96	0.84	0.00	0.00	0.03	0.07	0.63	1.50	1.23	1.72
1969	1.33	0.81	0.86	0.76	0.00	0.00	0.03	0.08	0.64	1.54	1.44	1.87
1970	1.39	0.89	0.96	0.84	0.00	0.00	0.03	0.08	0.63	1.25	1.40	2.00
Average	1.39	0.88	0.95	0.80	0.00	0.00	0.03	0.08	0.62	1.42	1.42	1.56

(Unit : MCM)

Year	Jul		Aug		Sep		Oct		Nov		Dec		Ave.
Period	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	
1961	2.91	3.53	2.53	1.80	0.85	1.12	1.05	0.93	1.03	1.12	1.51	1.90	1.20
1962	2.77	2.81	2.43	1.34	0.05	0.54	0.99	0.55	1.04	1.32	1.72	1.99	1.15
1963	2.79	2.20	1.11	0.54	0.74	0.93	0.92	1.97	0.05	1.11	1.72	1.99	1.06
1964	1.85	2.05	2.45	1.18	0.62	0.55	2.27	0.62	0.20	1.20	1.48	1.99	1.07
1965	2.01	2.94	2.53	0.06	0.05	0.53	1.49	0.60	1.23	0.92	1.07	1.44	1.02
1966	2.39	1.16	0.87	1.36	0.05	0.99	1.07	1.17	1.84	0.42	1.28	1.81	0.94
1967	2.69	0.86	2.09	1.32	0.56	0.54	1.06	2.44	1.64	1.59	1.72	1.99	1.12
1968	2.61	1.95	1.98	2.03	0.71	0.84	1.06	0.70	2.06	1.53	1.72	1.99	1.19
1969	3.09	3.04	1.74	0.88	0.12	0.54	1.02	0.64	1.75	1.59	1.72	1.99	1.15
1970	2.95	3.19	0.20	0.91	1.45	0.81	0.97	0.50	0.26	1.06	0.19	1.72	0.99
Average	2.61	2.37	1.79	1.14	0.52	0.74	1.19	1.01	1.11	1.19	1.41	1.88	1.09

2. Irrigation System Capacity

(1) Main System

- Water supply : continuous flow at the peak requirement period
- Design year with 80 % dependability : 1969
- Maximum diversion water requirement

1961	3.53 (MCM/15 days)
1962	2.81
1963	2.79
1964	2.45
1965	2.94
1966	2.39
1967	2.69
1968	2.61
1969	3.09
1970	3.19

- Design Unit Water Requirement for main system
  MCM/(days x sec x ha) x 1.15
  = 3.09 / (15 x 86,400 x 1,950) x 1.15 1_/
  = **1.40 lit./sec/ha**
  1_/ : allowance for fluctuation of the Prek Thnot river water supply and future possible change of cropping

(2) Tertiary System

- Water supply : continuous flow at the puddling water supply period (peak period)
- Puddling water supply : puddling water supply for 1 tertiary block for 2 weeks
- Design Unit Water Requirement for tertiary canal
  mm x 10^4 / (2 weeks x sec) / irri. efficiency (appl.effi. x tert. canal effi.)
  = 150 x 10^4 / (14 x 86,400) / (0.85 x 0.85)
  = **1.72 lit./sec/ha**

Table V-9 Diversion Water Requirement of Tonle Bati Irrigation Project (Total Area : 1,600 ha)

(Unit : MCM)

Period	Jan		Feb		Mar		Apr		May		Jun	
	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end
1961	1.23	0.77	0.84	0.66	0.00	0.00	0.02	0.06	0.52	1.21	0.76	1.13
1962	1.24	0.79	0.89	0.72	0.00	0.00	0.02	0.06	0.50	1.16	1.37	1.87
1963	1.24	0.80	0.89	0.72	0.00	0.00	0.02	0.06	0.53	1.14	1.42	1.13
1964	1.24	0.80	0.86	0.74	0.00	0.00	0.02	0.06	0.50	1.04	1.32	1.26
1965	1.24	0.80	0.78	0.69	0.00	0.00	0.02	0.06	0.50	1.13	1.20	1.72
1966	1.24	0.78	0.85	0.69	0.00	0.00	0.02	0.06	0.49	1.17	1.06	0.66
1967	1.23	0.78	0.86	0.73	0.00	0.00	0.02	0.06	0.51	1.26	1.23	0.48
1968	1.24	0.80	0.86	0.75	0.00	0.00	0.02	0.06	0.52	1.23	1.01	1.41
1969	1.18	0.72	0.77	0.68	0.00	0.00	0.02	0.06	0.52	1.26	1.18	1.53
1970	1.24	0.79	0.86	0.75	0.00	0.00	0.02	0.06	0.52	1.02	1.15	1.64
Average	1.23	0.78	0.85	0.71	0.00	0.00	0.02	0.06	0.51	1.16	1.17	1.28

(Unit : MCM)

Period	Jul		Aug		Sep		Oct		Nov		Dec		Average
	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	
1961	2.39	2.89	2.08	1.48	0.70	0.96	0.93	0.82	0.90	1.00	1.35	1.69	1.02
1962	2.27	2.31	1.99	1.10	0.04	0.48	0.88	0.49	0.91	1.17	1.53	1.77	0.98
1963	2.29	1.80	0.91	0.45	0.62	0.80	0.82	1.70	0.05	0.99	1.53	1.77	0.90
1964	1.51	1.68	2.01	0.97	0.51	0.48	1.95	0.55	0.17	1.07	1.31	1.77	0.91
1965	1.65	2.41	2.08	0.05	0.04	0.48	1.30	0.53	1.07	0.82	0.95	1.28	0.87
1966	1.96	0.95	0.72	1.12	0.05	0.85	0.95	1.02	1.60	0.37	1.14	1.61	0.81
1967	2.21	0.70	1.71	1.09	0.46	0.48	0.94	2.09	1.42	1.41	1.53	1.77	0.96
1968	2.14	1.60	1.63	1.67	0.59	0.73	0.94	0.62	1.79	1.36	1.53	1.77	1.01
1969	2.54	2.50	1.43	0.72	0.10	0.48	0.91	0.57	1.52	1.41	1.53	1.77	0.98
1970	2.42	2.61	0.16	0.75	1.20	0.70	0.86	0.45	0.23	0.95	0.17	1.53	0.84
Average	2.14	1.95	1.47	0.94	0.43	0.64	1.05	0.88	0.97	1.06	1.26	1.67	0.93

Table V-10 General Features of Alternatives of Improvement of Kompong Tuol Irrigation Intake

Case-1

(1) Tuk Thla Regulator:
The existing 25 wooden slide gates are replaced with 5 steel roller gates having 6.0 m in width and 3.0 m in height. The flow capacity will be increased to 400 m3/sec. The existing bridge is utilized as it is.

(2) Kompong Tuol Regulator:
The existing 6 wooden slide gates are replaced with 6 steel gates, having 3.9 m in height and 1.5 m in width. The flow capacity will be increased to 150 m^3/sec. The existing concrete structure is utilized as it is.

(3) Additional Overflow Type Spillway:
Required design capacity of the proposed spillway is 1,350 m^3/sec. The net required length of the proposed spillway is calculated to be 680 m. From a view-point of the river morphology, two new spillways will be provided on the both side of the existing Kompong Tuol Regulator. One with 500-m length will be on the southern side of the regulator and the other with 290-m length will be on the northern side of the regulator. A bridge will be provided over the top of the northern-side spillway in order to secure gate operation of the Kompong Tuol Regulator at any time. Total design length for these two new spillway and existing Kompong Tuol Regulator will be 810 m and removal of existing houses and existing by-pass road will be required in this case.

(4) Route National No. 3 :
Existing National Route No.3 will be banked up to EL 14.3 m and the proposed road width is 15.0 m with 9-m asphalt pavement. The required length of the proposed upgrading works is approximately 1,420 m in total. General dimensions are given below :

Case-2

(1) Tuk Thla Regulator:
The improvement works same as *Case-1* will be carried out in this Case-2.

(2) Kompong Tuol Regulator:
Existing Kompong Tuol regulator will not be used.

(3) Additional Overflow Type Spillway:
Required design capacity of the proposed spillway is 1,500 m^3/sec. The proposed spillway has the same hydraulic section as that in Case-1, but the required net length of the spillway is 760 m. From a view-point of the river morphology, the proposed spillway will start at Point-A to north direction for about 840 m in total including the portion of existing Kompong Tuol Regulator. Total design length for the new spillway and existing Kompong Tuol Regulator will be 840 m and removal of existing houses and existing by-pass road will be required in this case.

(4) Route National No. 3 :
The proposed section has the same section as that in *Case-1*, but the required length of the proposed upgrading works is approximately 1,390 m in total.

Case-3

(1) Tuk Thla Regulator:
Theimprovement works same as *Case-1* will be carried out .

(2) Kompong Tuol Regulator:
Existing Kompong Tuol Regulator will be demolished and replaced with a new regulator which is almost same type of the proposed Tuk Thla regulator. The proposed Kompong Tuol Regulator consists of a gate portion and a bridge portion. Five sets of steel roller gates will be provided to the gate portion, having 6.0 m in width and 5.0 m in height each. The gate will be operated with electric motor supported by generator. The flow capacity of the new regulator is 650 m^3/sec. The bridge on the regulator will have 15 m wide.

(3) Overflow Type Spillway:
Required design capacity of the proposed spillway is 850 m^3/sec. The proposed spillway has the same hydraulic section as that in Case-1, but the required length of the spillway is 400 m . The proposed spillway will be provided at the north side of new Kompong Toul regulator.

(4) Route National No. 3 :
The proposed section is the same section as that in *Case-1*, but the required length is approximately 1,700 m in total.

Case-4

(1) Tuk Thla Regulator:
The improvement works same as *Case-1* will be carried out.

(2) Kompong Tuol Regulator:
Existing Kompong Tuol regulator will be not used.

(3) Additional Overflow Type Regulator with Rubber Dam:
Required design capacity of the proposed regulator is 1,500 m^3/sec. Required length of the regulator is 140 m in net and about 230 m in gross. The regulator consists of the rubber-made dam portion and the bridge portion over the dam. The proposed regulator will be constructed at the center of the main stream. The rubber-made dam will be installed on the concrete floor. The proposed dam is 2.5 m in height, 22.0 m in top width and 14.0 m in bottom width. Ten (10) sets of the dam in total will be provided to the regulator. A bridge consisting of 10 spans will be provided over the dam with width of 15.0 m.

(4) Route National No. 3 :
The proposed section has the same section as that in *Case-1*, and the required length is approximately 2,000 m in total

Table V-11 Available Discharges to the Study Area (1/2)

(Unit : MCM)

Year	Month		Prek Thnot Basin		Available Discharges to the Study Area		
			dam site	tributaries	Stung Toch	Stung Tonle Bati	Prek Thnot river
1961	Jan	1	6.2	0.5	0.0	0.1	5.2
		2	8.0	0.7	0.1	0.1	8.0
	Feb	1	5.6	0.1	0.0	0.0	5.6
		2	5.0	0.1	0.0	0.0	5.1
	Mar	1	4.0	0.0	0.0	0.0	4.0
		2	4.6	0.0	0.0	0.0	4.6
	Apr	1	4.4	0.0	0.0	0.0	3.3
		2	8.9	0.0	0.0	0.0	6.7
	May	1	23.8	0.0	0.0	0.0	20.9
		2	30.5	0.0	0.0	0.0	28.3
	Jun	1	33.9	1.2	0.0	0.0	34.6
		2	46.4	1.6	0.0	0.0	47.1
	Jul	1	83.6	8.1	0.0	0.0	89.4
		2	96.2	9.3	0.0	0.0	102.9
	Aug	1	70.3	7.1	0.5	0.6	75.1
		2	82.8	8.4	0.6	0.8	89.0
	Sep	1	113.6	13.7	1.2	1.7	125.1
		2	138.0	16.6	1.5	2.1	152.4
	Oct	1	218.3	28.8	3.8	5.3	245.4
		2	179.1	23.6	3.1	4.3	201.3
	Nov	1	93.2	12.9	1.7	2.3	105.1
		2	58.2	8.0	1.0	1.4	64.9
	Dec	1	30.8	3.8	0.5	0.6	32.4
		2	16.6	2.0	0.3	0.3	16.3
1962	Jan	1	7.1	0.6	0.1	0.1	6.1
		2	2.7	0.2	0.0	0.0	2.2
	Feb	1	2.3	0.0	0.0	0.0	2.4
		2	1.7	0.0	0.0	0.0	1.7
	Mar	1	1.8	0.0	0.0	0.0	1.8
		2	2.0	0.0	0.0	0.0	2.0
	Apr	1	2.0	0.0	0.0	0.0	0.9
		2	4.0	0.0	0.0	0.0	1.8
	May	1	10.1	0.0	0.0	0.0	7.4
		2	13.0	0.0	0.0	0.0	11.4
	Jun	1	0.0	0.0	0.0	0.0	0.0
		2	35.7	1.2	0.0	0.0	35.7
	Jul	1	161.6	15.6	0.0	0.0	176.7
		2	218.7	21.1	0.0	0.0	239.0
	Aug	1	46.3	4.7	0.3	0.4	49.4
		2	106.8	10.8	0.7	1.0	115.8
	Sep	1	239.7	28.8	2.6	3.6	266.4
		2	290.8	35.0	3.2	4.4	323.5
	Oct	1	222.0	29.3	3.9	5.4	250.2
		2	175.4	23.1	3.1	4.2	198.5
	Nov	1	50.4	7.0	0.9	1.2	55.9
		2	13.8	1.9	0.2	0.3	13.7
	Dec	1	18.1	2.2	0.3	0.4	17.8
		2	13.9	1.7	0.2	0.3	13.2
1963	Jan	1	12.0	1.0	0.1	0.1	11.4
		2	10.2	0.8	0.1	0.1	10.3
	Feb	1	7.3	0.1	0.0	0.0	7.4
		2	6.4	0.1	0.0	0.0	6.5
	Mar	1	7.4	0.0	0.0	0.0	7.4
		2	7.3	0.0	0.0	0.0	7.3
	Apr	1	6.1	0.0	0.0	0.0	5.0
		2	7.6	0.0	0.0	0.0	5.3
	May	1	12.8	0.0	0.0	0.0	9.8
		2	14.1	0.0	0.0	0.0	11.8
	Jun	1	13.6	0.5	0.0	0.0	12.0
		2	13.4	0.5	0.0	0.0	11.7
	Jul	1	9.6	0.9	0.0	0.0	8.7
		2	15.5	1.5	0.0	0.0	15.3
	Aug	1	35.5	3.6	0.2	0.3	37.8
		2	45.9	4.7	0.3	0.4	49.0
	Sep	1	60.4	7.3	0.7	0.9	65.5
		2	69.2	8.3	0.8	1.0	75.2
	Oct	1	89.1	11.8	1.6	2.2	99.2
		2	79.5	10.5	1.4	1.9	88.8
	Nov	1	63.5	8.8	1.1	1.6	72.3
		2	48.0	6.6	0.9	1.2	53.9
	Dec	1	11.9	1.5	0.2	0.2	10.8
		2	1.2	0.1	0.0	0.0	0.0
1964	Jan	1	2.9	0.0	0.0	0.0	1.3
		2	1.7	0.0	0.0	0.0	0.7
	Feb	1	0.8	0.0	0.0	0.0	0.8
		2	0.3	0.0	0.0	0.0	0.3
	Mar	1	0.2	0.0	0.0	0.0	0.2
		2	0.2	0.0	0.0	0.0	0.2
	Apr	1	0.2	0.0	0.0	0.0	0.0
		2	10.7	0.0	0.0	0.0	8.5
	May	1	45.8	0.0	0.0	0.0	43.2
		2	60.0	0.0	0.0	0.0	58.6
	Jun	1	34.2	1.6	0.0	0.0	34.0
		2	25.0	2.2	0.0	0.0	25.1
	Jul	1	45.5	5.2	0.0	0.0	49.4
		2	59.0	6.3	0.0	0.0	64.2
	Aug	1	87.6	6.0	0.0	0.0	91.7
		2	106.4	8.0	0.0	0.0	112.5
	Sep	1	136.1	14.2	1.4	1.9	148.0
		2	156.0	17.6	2.1	2.8	171.5
	Oct	1	214.5	27.0	3.0	4.1	240.1
		2	179.3	23.4	3.6	5.0	201.9
	Nov	1	90.3	17.2	2.2	3.0	106.1
		2	53.1	12.4	1.6	2.1	63.7
	Dec	1	18.1	3.0	0.4	0.6	18.6
		2	4.5	0.2	0.0	0.0	2.2
1965	Jan	1	4.6	0.0	0.0	0.0	3.1
		2	2.6	0.0	0.0	0.0	1.9
	Feb	1	1.5	0.0	0.0	0.0	1.5
		2	0.9	0.0	0.0	0.0	0.9
	Mar	1	1.3	0.0	0.0	0.0	1.3
		2	2.1	0.0	0.0	0.0	2.1
	Apr	1	4.0	0.0	0.0	0.0	2.9
		2	7.0	0.0	0.0	0.0	4.8
	May	1	11.8	0.0	0.0	0.0	8.9
		2	22.2	0.0	0.0	0.0	19.8
	Jun	1	50.9	0.0	0.0	0.0	48.5
		2	63.4	0.0	0.0	0.0	61.4
	Jul	1	37.1	0.0	0.0	0.0	35.6
		2	32.1	0.0	0.0	0.0	30.8
	Aug	1	10.8	0.2	0.0	0.0	9.4
		2	53.4	0.5	0.0	0.0	52.1
	Sep	1	216.1	11.8	0.0	0.0	225.8
		2	268.9	20.7	1.2	1.7	287.4
	Oct	1	323.9	50.4	5.8	8.0	373.1
		2	267.9	47.0	8.0	11.1	314.4
	Nov	1	97.7	19.4	2.7	3.7	115.6
		2	41.4	11.1	1.5	2.0	50.5
	Dec	1	20.8	8.6	1.1	1.5	27.2
		2	7.6	5.8	0.7	1.0	11.2
1966	Jan	1	5.1	2.0	0.3	0.4	5.5
		2	2.6	0.7	0.1	0.2	2.6
	Feb	1	2.1	0.2	0.0	0.0	2.3
		2	1.6	0.1	0.0	0.0	1.8
	Mar	1	1.1	0.0	0.0	0.0	1.1
		2	1.8	0.0	0.0	0.0	1.8
	Apr	1	3.0	0.0	0.0	0.0	1.9
		2	6.3	0.0	0.0	0.0	4.1
	May	1	14.0	0.0	0.0	0.0	11.2
		2	21.7	0.0	0.0	0.0	19.7
	Jun	1	37.5	2.3	0.0	0.0	38.4
		2	48.9	3.7	0.0	0.0	51.4
	Jul	1	70.9	9.3	0.0	0.0	79.3
		2	78.8	10.9	0.0	0.0	88.6
	Aug	1	79.1	8.9	0.8	1.1	86.4
		2	86.5	8.6	1.0	1.4	92.9
	Sep	1	104.7	8.6	1.0	1.4	110.5
		2	118.9	11.3	1.3	1.8	127.6
	Oct	1	167.2	20.6	2.4	3.3	186.7
		2	140.5	24.6	2.8	3.9	165.1
	Nov	1	74.8	16.6	2.0	2.8	90.0
		2	49.2	13.4	1.7	2.3	60.7
	Dec	1	31.8	8.2	1.0	1.3	38.1
		2	20.5	5.4	0.6	0.8	24.0

Table V-11 Available Discharges to the Study Area (2/2)

(Unit : MCM)

Year	Month		Prek Thnot Basin		Available Discharges to the Study Area		
			dam site	tributaries	Stung Toch	Stung Tonle Bati	Prek Thnot river
1967	Jan	1	8.1	1.6	0.0	0.0	8.3
		2	3.4	0.3	0.0	0.0	3.0
	Feb	1	2.9	0.1	0.0	0.0	3.0
		2	2.1	0.0	0.0	0.0	2.1
	Mar	1	0.9	0.0	0.0	0.0	0.9
		2	2.2	0.0	0.0	0.0	2.2
	Apr	1	5.3	0.0	0.0	0.0	4.2
		2	9.0	0.0	0.0	0.0	6.8
	May	1	16.5	0.0	0.0	0.0	13.5
		2	23.9	0.0	0.0	0.0	21.6
	Jun	1	40.9	0.5	0.0	0.0	40.1
		2	48.0	1.5	0.0	0.0	48.5
	Jul	1	42.6	7.9	0.0	0.0	48.9
		2	69.1	10.0	0.0	0.0	77.4
	Aug	1	159.0	11.1	1.0	1.4	168.1
		2	195.8	12.0	1.4	1.9	205.6
	Sep	1	97.9	12.4	1.6	2.2	107.9
		2	132.8	14.3	1.9	2.6	144.7
	Oct	1	260.4	23.7	3.0	4.2	282.6
		2	195.6	18.3	2.3	3.2	213.1
	Nov	1	24.7	3.5	0.5	0.7	26.1
		2	9.0	0.1	0.0	0.0	6.6
	Dec	1	6.0	0.2	0.0	0.0	3.6
		2	3.0	0.1	0.0	0.0	0.7
1968	Jan	1	2.6	0.0	0.0	0.0	1.3
		2	1.9	0.0	0.0	0.0	1.2
	Feb	1	1.2	0.0	0.0	0.0	1.2
		2	0.8	0.0	0.0	0.0	0.8
	Mar	1	0.3	0.0	0.0	0.0	0.3
		2	0.7	0.0	0.0	0.0	0.7
	Apr	1	1.1	0.0	0.0	0.0	0.0
		2	2.9	0.0	0.0	0.0	0.7
	May	1	7.0	0.0	0.0	0.0	3.9
		2	11.2	0.0	0.0	0.0	8.8
	Jun	1	19.7	0.2	0.0	0.0	19.4
		2	26.4	1.1	0.0	0.0	27.4
	Jul	1	35.3	5.8	0.0	0.0	39.9
		2	50.1	7.5	0.0	0.0	56.1
	Aug	1	88.2	7.5	0.1	0.2	93.1
		2	106.5	8.8	0.4	0.6	112.8
	Sep	1	49.2	10.9	1.3	1.8	57.7
		2	71.9	13.4	1.8	2.4	83.0
	Oct	1	157.6	23.4	2.9	4.0	179.2
		2	116.9	17.9	2.2	3.1	133.5
	Nov	1	13.7	3.5	0.5	0.7	15.1
		2	7.0	0.1	0.0	0.0	4.6
	Dec	1	4.4	0.0	0.0	0.0	1.9
		2	2.8	0.0	0.0	0.0	0.3
1969	Jan	1	2.5	0.0	0.0	0.0	1.1
		2	2.0	0.0	0.0	0.0	1.4
	Feb	1	1.4	0.0	0.0	0.0	1.4
		2	1.2	0.0	0.0	0.0	1.2
	Mar	1	1.0	0.0	0.0	0.0	1.0
		2	0.9	0.0	0.0	0.0	0.9
	Apr	1	0.9	0.0	0.0	0.0	0.0
		2	0.9	0.0	0.0	0.0	0.0
	May	1	8.4	0.0	0.0	0.0	5.5
		2	11.7	0.0	0.0	0.0	9.6
	Jun	1	0.2	0.0	0.0	0.0	0.0
		2	5.2	0.0	0.0	0.0	3.3
	Jul	1	14.8	0.0	0.0	0.0	12.2
		2	25.6	0.0	0.0	0.0	23.4
	Aug	1	37.3	0.0	0.0	0.0	36.3
		2	75.7	1.8	0.0	0.0	76.2
	Sep	1	195.4	15.3	0.6	0.8	208.4
		2	229.7	21.9	1.6	2.2	249.4
	Oct	1	241.5	38.7	5.8	7.9	279.1
		2	214.9	31.6	4.1	5.7	246.1
	Nov	1	133.0	9.3	1.2	1.7	141.0
		2	88.7	2.5	0.3	0.4	89.4
	Dec	1	9.9	1.8	0.3	0.3	9.1
		2	4.8	0.6	0.1	0.1	2.9
1970	Jan	1	3.8	0.3	0.0	0.0	2.5
		2	3.1	0.3	0.0	0.0	2.6
	Feb	1	3.6	0.0	0.0	0.0	3.6
		2	3.4	0.0	0.0	0.0	3.4
	Mar	1	2.1	0.0	0.0	0.0	2.1
		2	2.9	0.0	0.0	0.0	2.9
	Apr	1	4.6	0.0	0.0	0.0	3.5
		2	6.2	0.0	0.0	0.0	4.0
	May	1	7.5	0.0	0.0	0.0	4.7
		2	14.1	0.0	0.0	0.0	12.9
	Jun	1	107.5	3.7	0.0	0.0	109.7
		2	138.4	4.8	0.0	0.0	141.3
	Jul	1	64.1	6.2	0.0	0.0	68.0
		2	96.4	9.3	0.0	0.0	103.4
	Aug	1	179.0	18.1	1.2	1.7	197.0
		2	219.3	22.2	1.5	2.0	239.9
	Sep	1	132.5	15.9	1.4	2.0	145.5
		2	100.4	12.1	1.1	1.5	110.1
	Oct	1	182.2	24.0	3.2	4.4	205.1
		2	206.2	27.2	3.6	5.0	233.4
	Nov	1	142.0	19.6	2.5	3.5	161.5
		2	161.4	22.3	2.9	4.0	182.1
	Dec	1	232.6	28.7	3.5	4.9	261.2
		2	180.3	22.2	2.7	3.8	200.4
Average							
	Jan	1	5.5	0.6	0.1	0.1	4.6
		2	3.8	0.3	0.0	0.0	3.4
	Feb	1	2.9	0.1	0.0	0.0	2.9
		2	2.3	0.0	0.0	0.0	2.4
	Mar	1	2.0	0.0	0.0	0.0	2.0
		2	2.5	0.0	0.0	0.0	2.5
	Apr	1	3.2	0.0	0.0	0.0	2.2
		2	6.4	0.0	0.0	0.0	4.3
	May	1	15.8	0.0	0.0	0.0	12.9
		2	22.2	0.0	0.0	0.0	20.2
	Jun	1	33.8	1.0	0.0	0.0	33.7
		2	45.1	1.7	0.0	0.0	45.3
	Jul	1	56.5	5.9	0.0	0.0	60.8
		2	74.2	7.6	0.0	0.0	80.1
	Aug	1	79.3	6.7	0.4	0.6	84.4
		2	107.9	8.6	0.6	0.8	114.6
	Sep	1	134.6	13.9	1.2	1.6	146.1
		2	157.7	17.1	1.6	2.3	172.5
	Oct	1	207.7	27.8	3.5	4.9	234.1
		2	175.5	24.7	3.4	4.7	199.6
	Nov	1	78.3	11.8	1.5	2.1	88.9
		2	53.0	7.9	1.0	1.4	59.0
	Dec	1	38.4	5.8	0.7	1.0	42.1
		2	25.5	3.8	0.5	0.6	27.1
Annual Total			1,334.0	145.2	14.6	20.1	1,445.6

Table V-12 Result of Water Balance Simulation of Kandal Stung Irrigation Project

(Unit : MCM)

Year	Description	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
1961						No deficit							
1962						No deficit							
1963						No deficit							
1964	Qt	14.7	4.6	1.1	0.4	10.9	105.8	63.0	116.0	208.0	323.9	444.2	173.0
	Qa	10.8	2.2	1.1	0.4	8.5	101.8	59.1	113.6	204.2	319.5	242.0	169.8
	Wd	3.7	2.3	1.8	0.0	0.1	1.9	3.1	4.9	3.6	1.2	2.9	1.4
	Sp	7.1	-0.1	-0.7	0.4	8.4	99.9	56.0	108.7	200.6	318.3	239.1	168.4
1965						No deficit							
1966						No deficit							
1967						No deficit							
1968	Qt	9.3	4.5	2.0	1.0	4.0	18.2	47.4	98.7	211.0	145.4	315.8	24.3
	Qa	4.3	2.3	2.0	1.0	0.7	12.7	46.8	96.0	205.9	140.7	312.7	19.7
	Wd	3.7	2.3	1.8	0.0	0.1	2.1	3.0	4.6	4.0	1.6	1.8	3.6
	Sp	0.6	0.0	0.2	1.0	0.6	10.6	43.8	91.4	201.9	139.1	310.9	16.1
1969	Qt	7.2	4.5	2.6	1.9	1.8	20.1	5.4	40.4	114.8	462.3	526.7	233.5
	Qa	2.2	2.5	2.6	1.9	0.0	15.1	3.3	35.6	112.5	457.8	525.2	230.4
	Wd	3.8	2.1	1.6	0.0	0.1	2.2	3.3	6.1	2.6	0.7	1.7	3.3
	Sp	-1.6	0.4	1.0	1.9	-0.1	12.9	0.0	29.5	109.9	457.1	523.5	227.1
1970						No deficit							

Note :
Qt : Total discharge of the Prek Thnot river ; discharge at dam site + discharges from tributaries
Qa : Available discharge to the Project ; Qt-irrigation demand for the upstream irrigation schemes
Wd : Irrigation water demand of Kandal Stung Project , 1,950 ha
Sp : Surplus discharge ; Qa-Wd

Table V-13 Diversion Water Requirement of Tonle Bati Irrigation Project (Total Area : 4,200 ha)

(Unit : MCM)

	Jan		Feb		Mar		Apr		May		Jun	
Period	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end
1961	4.43	3.36	3.73	2.99	0.00	0.00	0.06	0.16	1.37	3.17	1.99	2.97
1962	4.48	3.47	3.93	3.24	0.00	0.00	0.06	0.16	1.31	3.04	3.59	4.91
1963	4.48	3.50	3.93	3.24	0.00	0.00	0.06	0.17	1.39	2.98	3.72	2.97
1964	4.51	3.50	3.80	3.34	0.00	0.00	0.06	0.17	1.30	2.74	3.47	3.31
1965	4.51	3.50	3.48	3.12	0.00	0.00	0.06	0.17	1.31	2.97	3.14	4.53
1966	4.51	3.41	3.77	3.12	0.00	0.00	0.06	0.17	1.29	3.06	2.77	1.73
1967	4.45	3.41	3.80	3.31	0.00	0.00	0.06	0.16	1.34	3.31	3.24	1.25
1968	4.51	3.50	3.80	3.37	0.00	0.00	0.06	0.16	1.36	3.22	2.64	3.71
1969	4.25	3.16	3.40	3.07	0.00	0.00	0.06	0.17	1.38	3.31	3.10	4.03
1970	4.48	3.47	3.80	3.37	0.00	0.00	0.06	0.17	1.35	2.69	3.02	4.30
Average	4.46	3.43	3.74	3.22	0.00	0.00	0.06	0.17	1.34	3.05	3.07	3.37

(Unit : MCM)

	Jul		Aug		Sep		Oct		Nov		Dec		
Period	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	1-15	16-end	Average
1961	6.27	7.59	5.45	3.88	1.83	2.51	2.45	2.15	2.36	2.72	3.95	5.34	2.95
1962	5.96	6.06	5.23	2.89	0.12	1.25	2.31	1.28	2.40	3.19	4.62	5.65	2.88
1963	6.02	4.73	2.40	1.17	1.61	2.11	2.15	4.47	0.13	2.70	4.62	5.65	2.68
1964	3.98	4.42	5.28	2.55	1.35	1.27	5.13	1.45	0.46	2.92	3.84	5.65	2.69
1965	4.33	6.33	5.45	0.14	0.12	1.25	3.42	1.39	2.82	2.26	2.60	3.99	2.54
1966	5.15	2.49	1.88	2.93	0.12	2.24	2.49	2.68	4.19	1.09	3.24	5.08	2.39
1967	5.79	1.85	4.49	2.85	1.22	1.25	2.46	5.50	3.73	3.91	4.62	5.65	2.82
1968	5.62	4.19	4.27	4.38	1.55	1.90	2.47	1.63	4.69	3.75	4.62	5.65	2.96
1969	6.66	6.56	3.75	1.90	0.27	1.27	2.38	1.50	4.00	3.89	4.60	5.65	2.85
1970	6.35	6.86	0.43	1.98	3.14	1.84	2.27	1.18	0.61	2.59	0.44	4.81	2.47
Average	5.61	5.11	3.86	2.47	1.13	1.69	2.75	2.32	2.54	2.90	3.72	5.31	2.72

Table V-14 General Features of the Project Works

(1) Improvement of Kompong Tuol Irrigation Intake

a)	Tuk Thla Regulator	Replacement of gates, (width 6 m x height 3 m x 5 sets)
b)	Kompong Tuol Regulator	Replacement of existing regulator, (gate: width 6m x height 5m x 5 sets, bridge: width 15 m)
c)	Spillway	Overflow type, 400 m in length
d)	Road Dike	Total width 15 m, asphalt pavement & width 9 m
e)	Flood Dike on Upstream Right Banks	Length of 4 km and 1 km for right and left banks dike crest width 4 m
f)	Radio Communication System	Main, branch and two site stations

(2) Kandal Stung Irrigation Project

Description		First Stage Work	Second Stage Work
Main canal			
- Improvement of main canal	(km)	5.3	0
Lateral			
- Improvement of existing lateral	(km)	8.2	0
- Construction of lateral	(km)	4.0	18.3
Tertiary canal			
- Improvement/construction of tertiary canal	(km)	56.8	65.5
Quaternary canal system	(ha)	1,950	1,750
Saba Scheme			
- Saba dam	(nos)	-	1
- Connection canal	(km)	-	4.5
- Lateral canal	(km)	-	8.0
- Tertiary canal	(km)	-	11.0
- Quaternary canal system	(ha)	-	500
Drainage works			
- Major drainage canals	(km)	18.1	20.9
- Tertiary canal	(km)	64.6	74.5

(3) Tonle Bati Irrigation Project

Description		First Stage Work	Second Stage Work
Main canal			
- Improvement of main canal	(km)	8.3	-
- Construction of main canal	(km)	-	-
Lateral			
- Improvement of existing Lateral	(km)	6.9	-
- Construction of Lateral	(km)	3.1	16.3
Tertiary canal			
- Improvement of existing tertiary canal	(km)	15.0	-
- Construction of tertiary canal	(km)	33.1	78.2
Quaternary canal system	(ha)	1,600	2,600
Improvement of Tonle Bati Lake Related Structures			
- Intake	(nos)	1	-
- Pumping Station	(nos)	1	-
- Spillway of Lake	(nos)	1	-
- Lake Dike	(km)	L.S	-
Improvement of Connection Canal			
- Connection canal	(km)	4.6	-
- Stung Toch Regulator	(nos)	1	-
- Kandal Stung Regulator	(nos)	1	-
Drainage works			
- Major drainage canals	(km)	24.1	39.2
- Tertiary canal	(km)	41.8	66.6

Figures

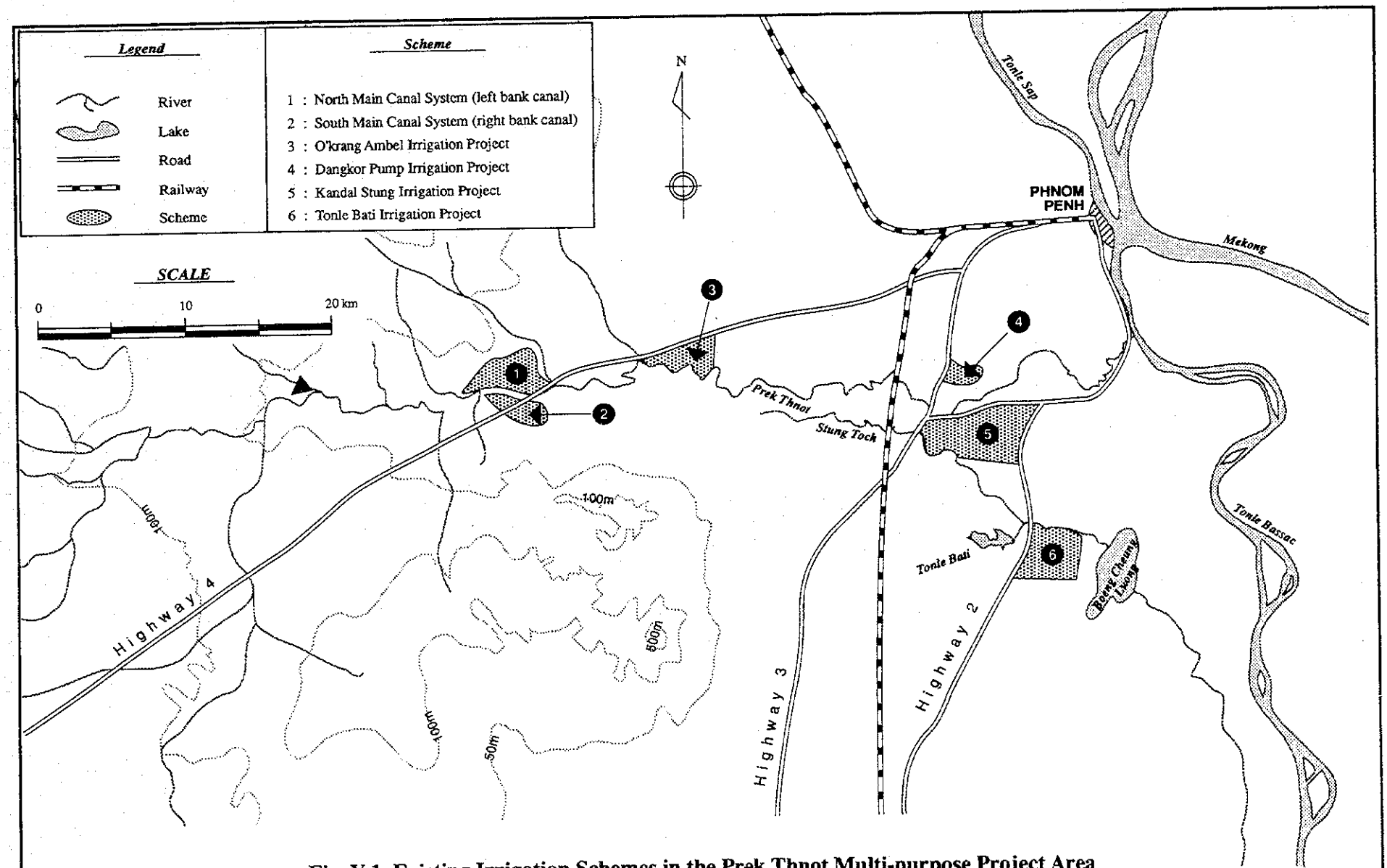


Fig. V-1 Existing Irrigation Schemes in the Prek Thnot Multi-purpose Project Area

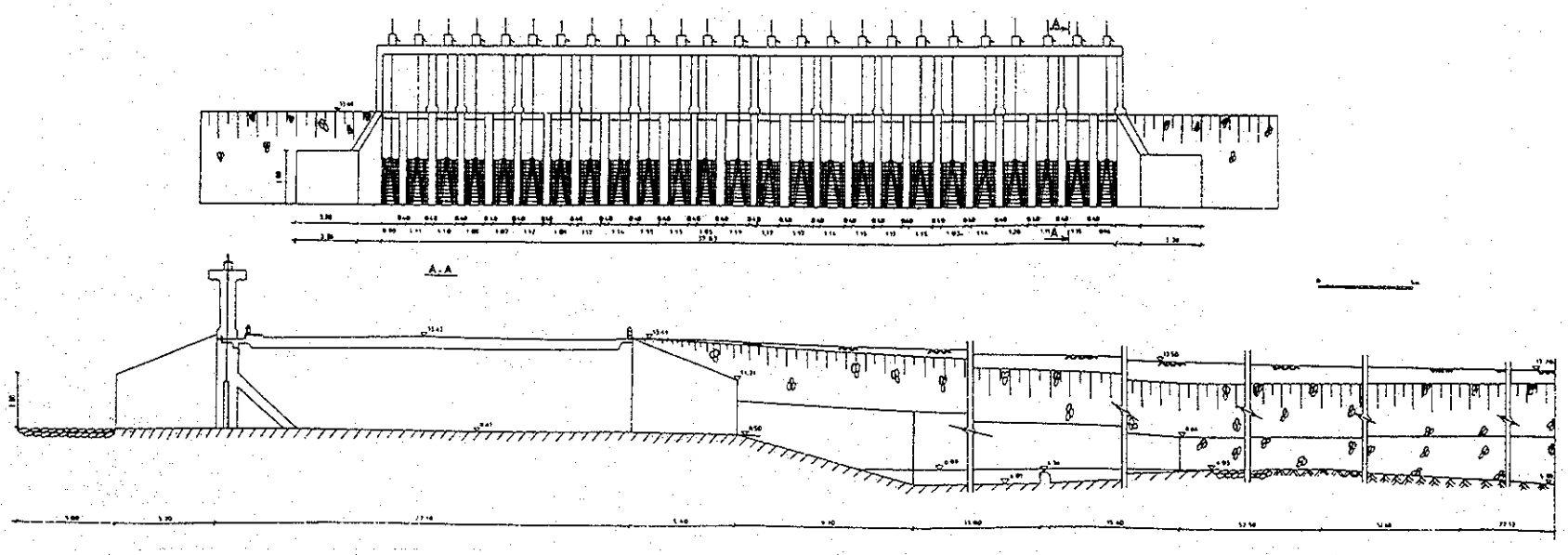


Fig. V-2 General Features of Existing Tuk Thla Regulator

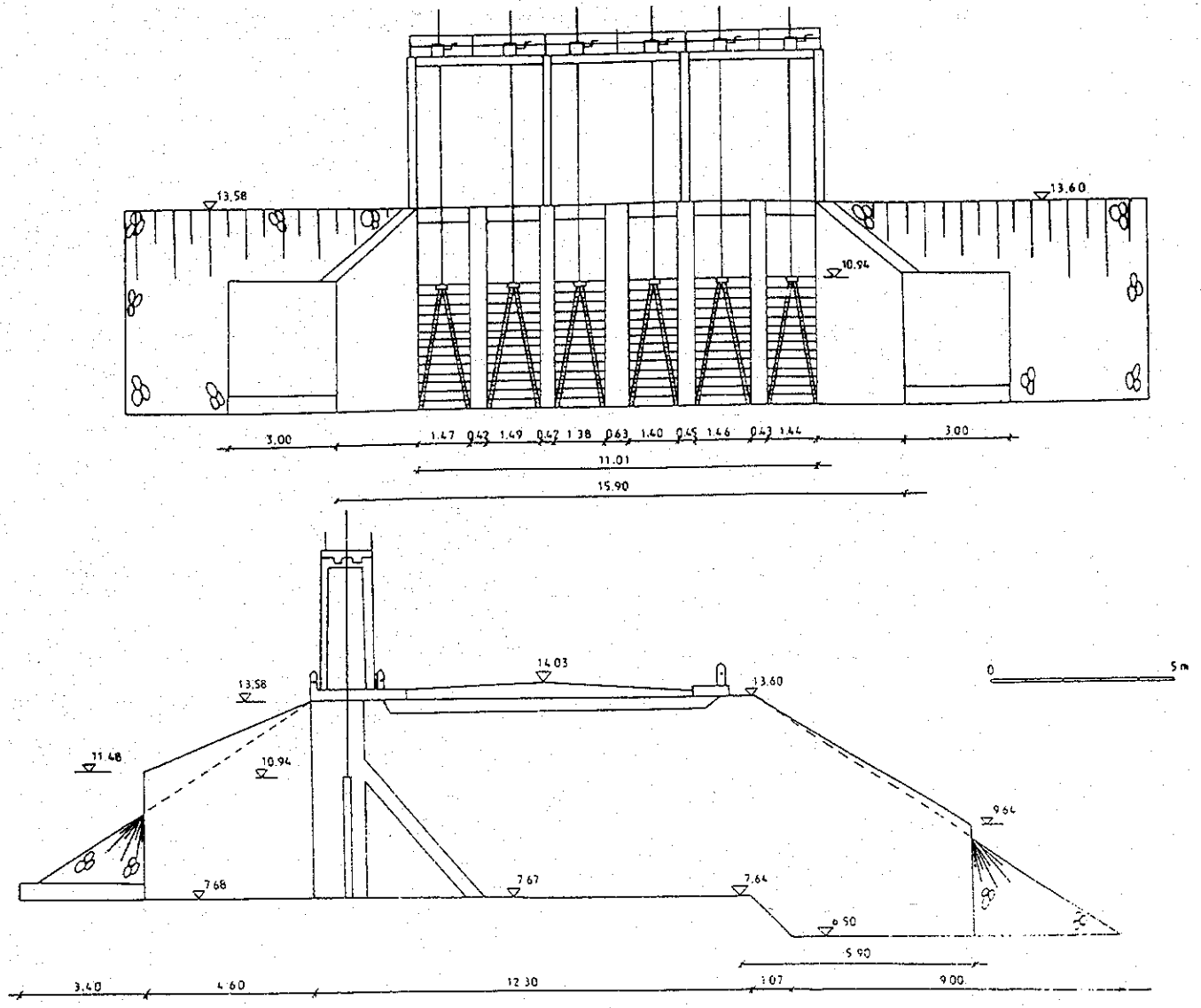


Fig. V-3 General Features of Existing Kompong Tuol Regulator

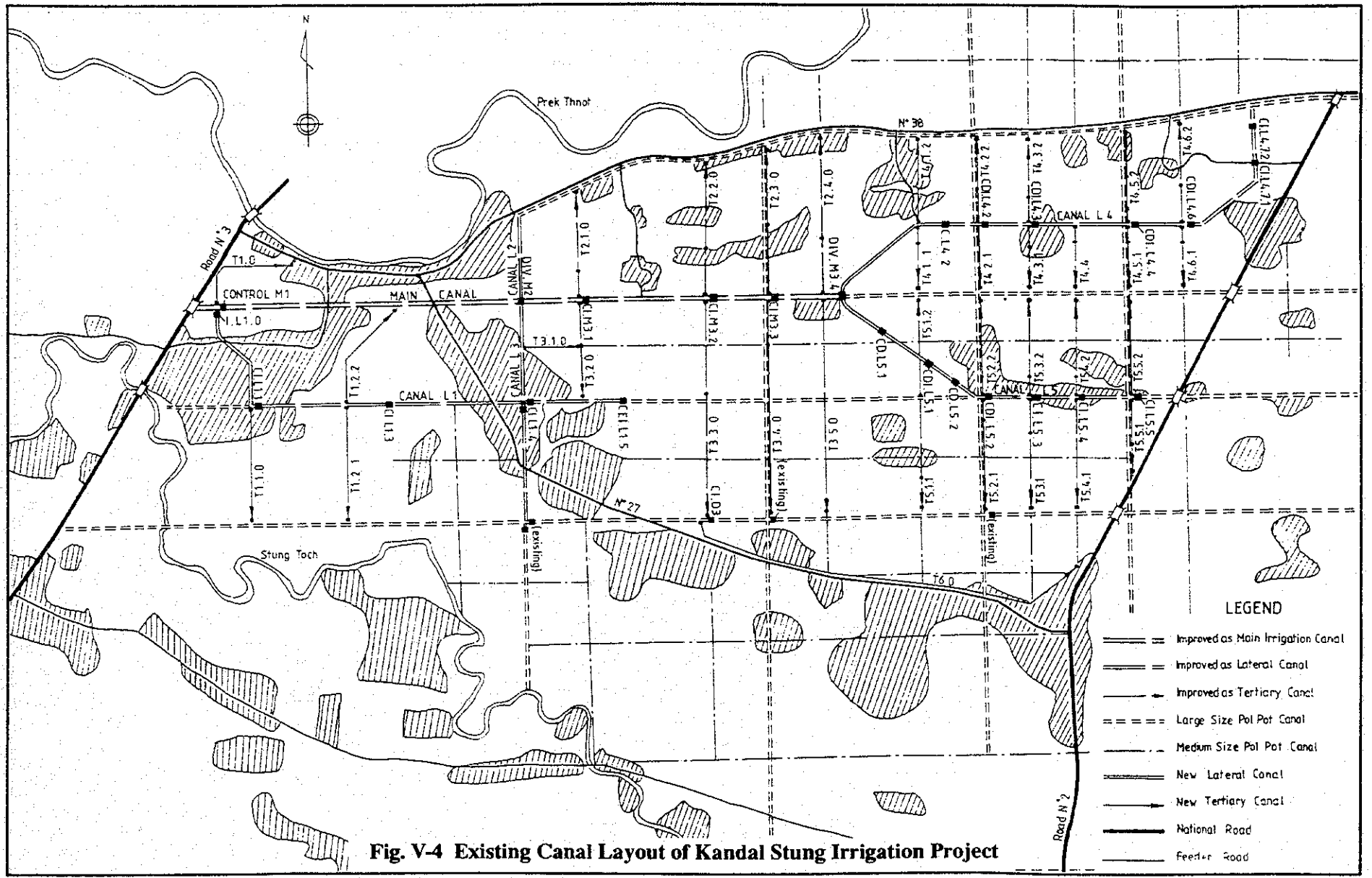


Fig. V-4 Existing Canal Layout of Kandal Stung Irrigation Project

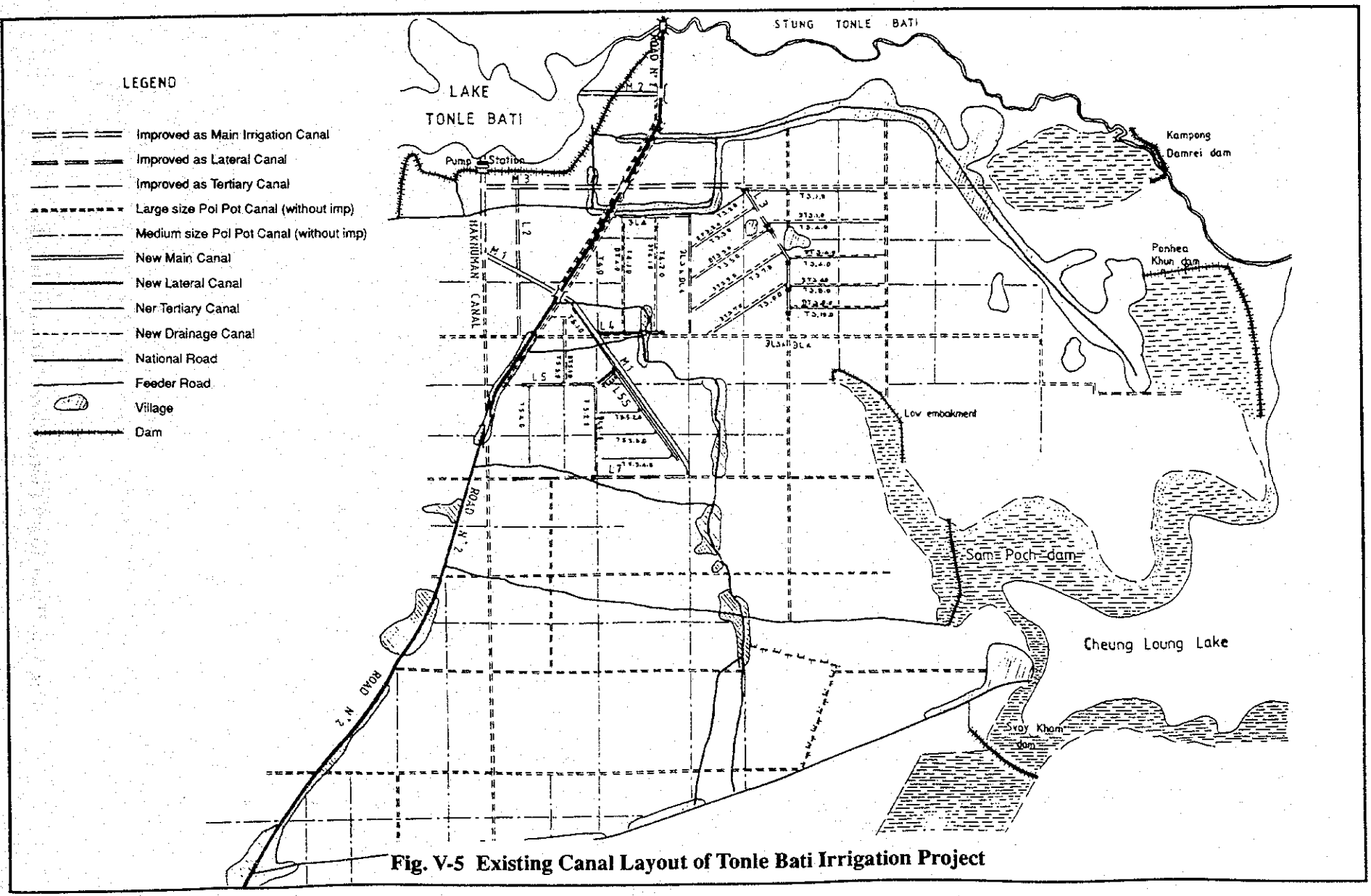


Fig. V-5 Existing Canal Layout of Tonle Bati Irrigation Project

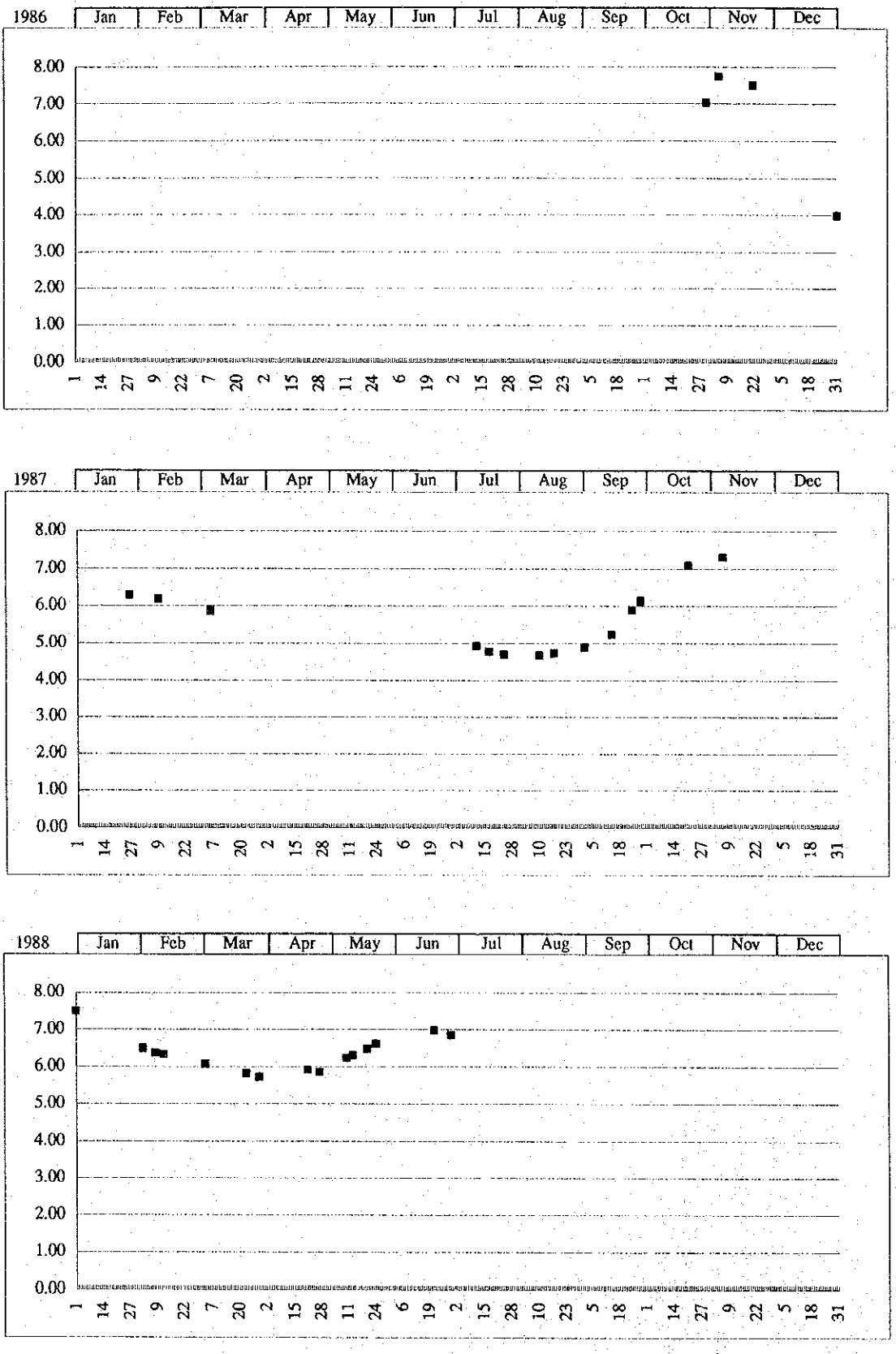


Fig. V-6 Water Level Fluctuation of Tonle Bati Lake

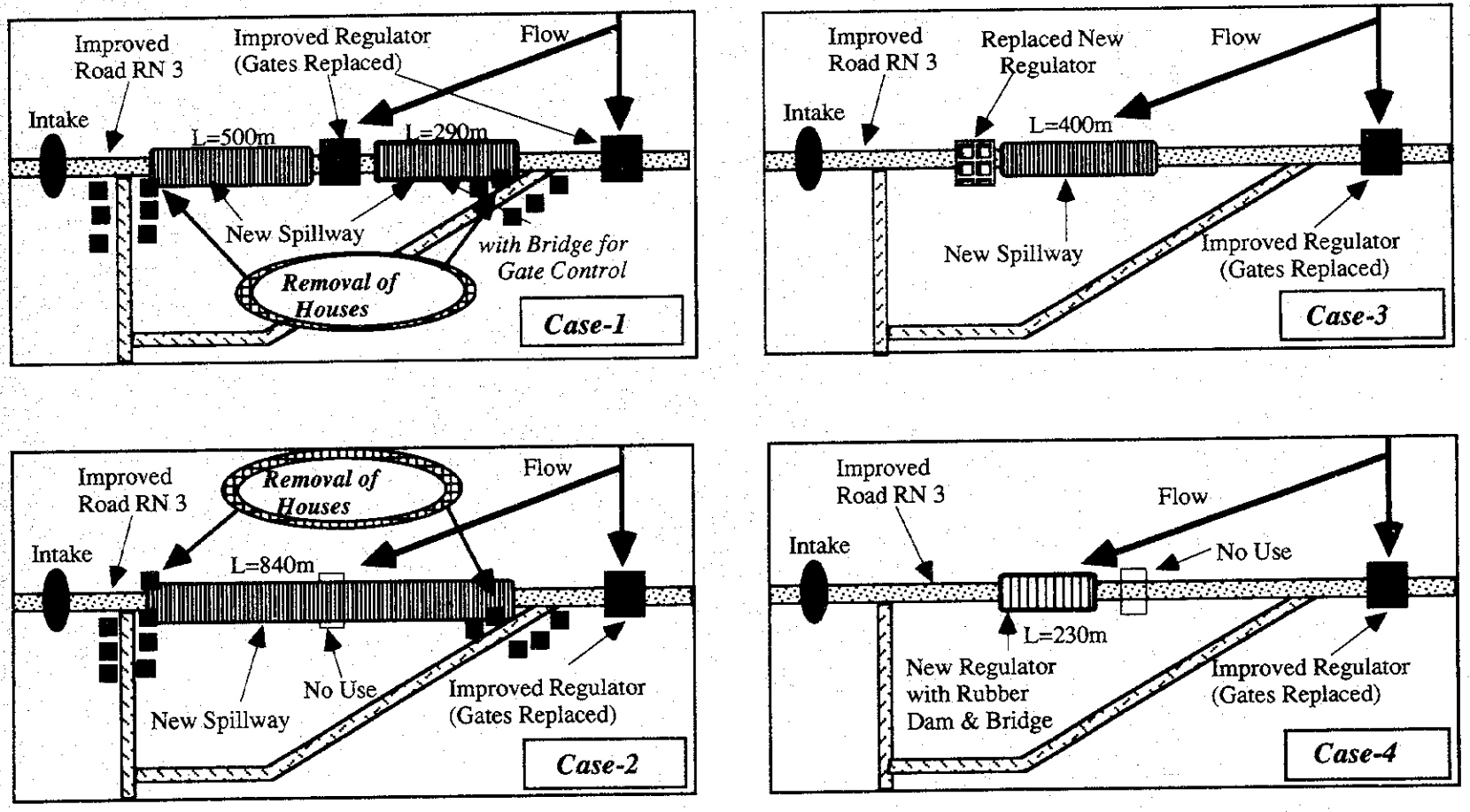


Fig. V-7 Alternative Plans of Improvement of Kompong Tuol Irrigation Intake

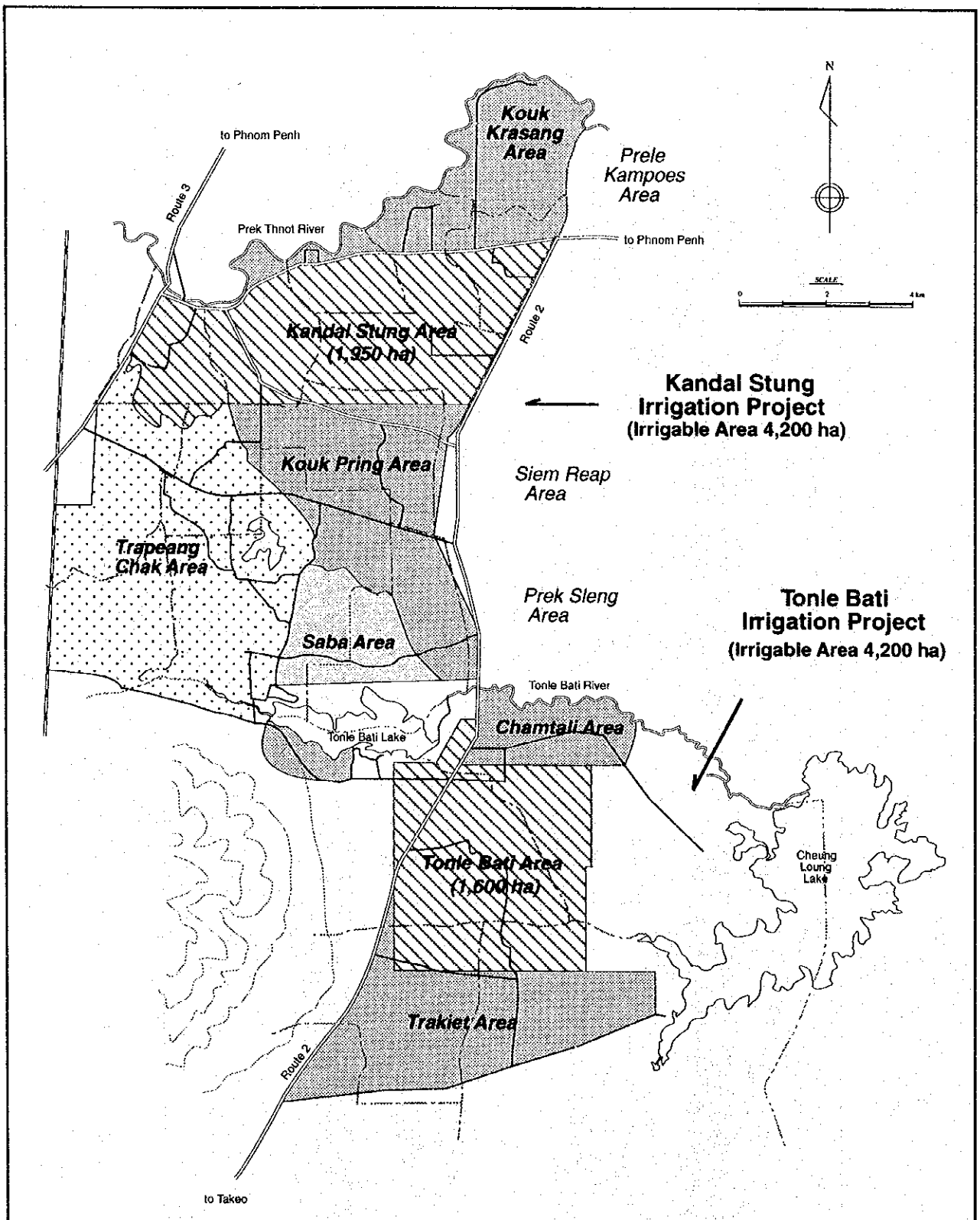


Fig. V-8 Overall Irrigation Development Plan

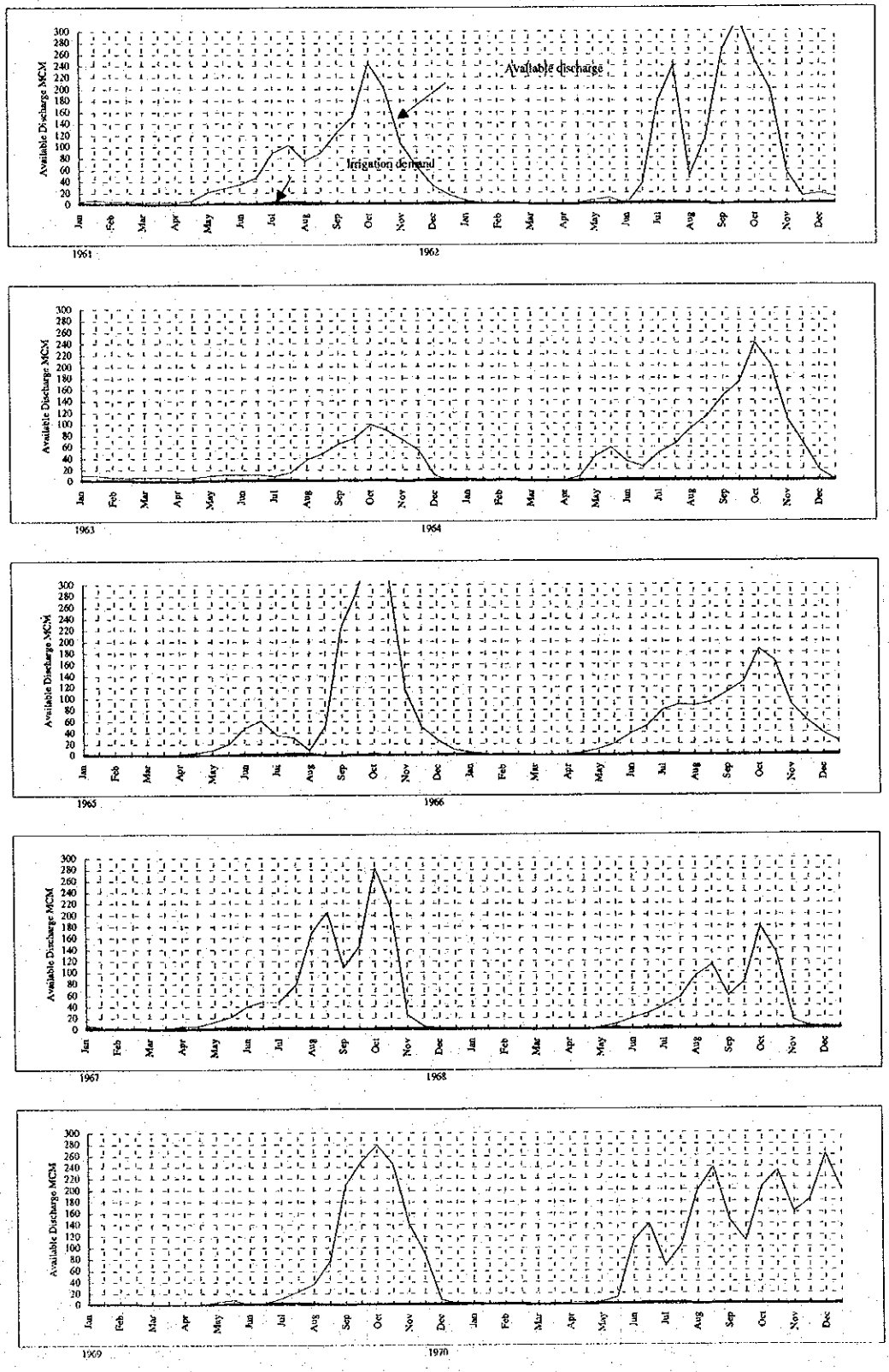


Fig. V-9 Water Balance Simulation of Kandal Stung Irrigation Project (Irrigation Area 1,950 ha)

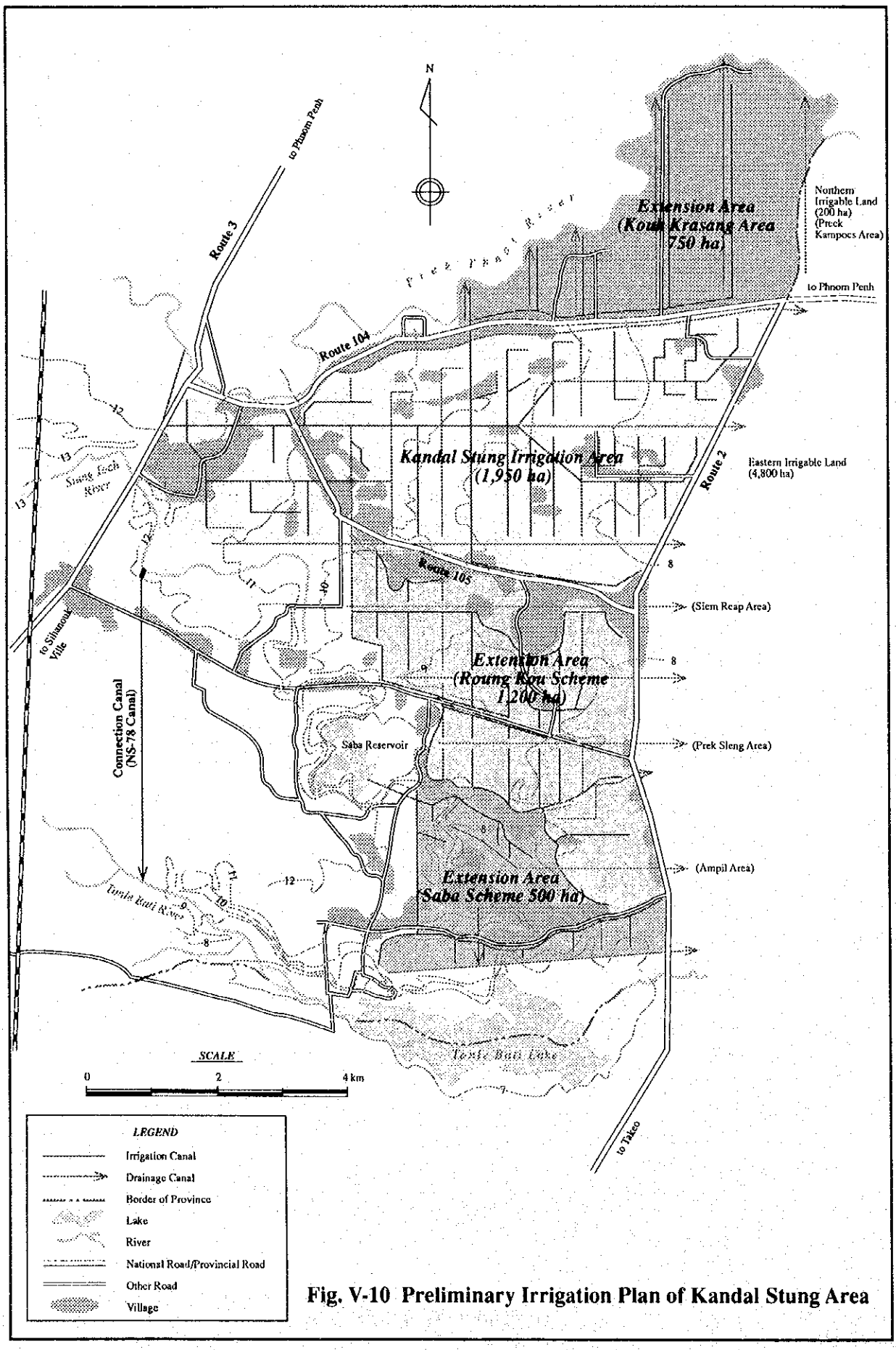
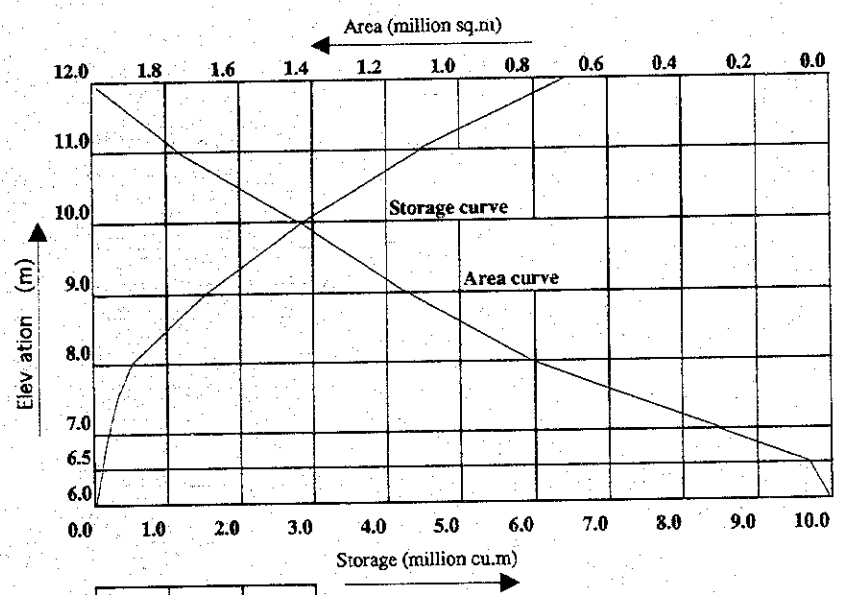


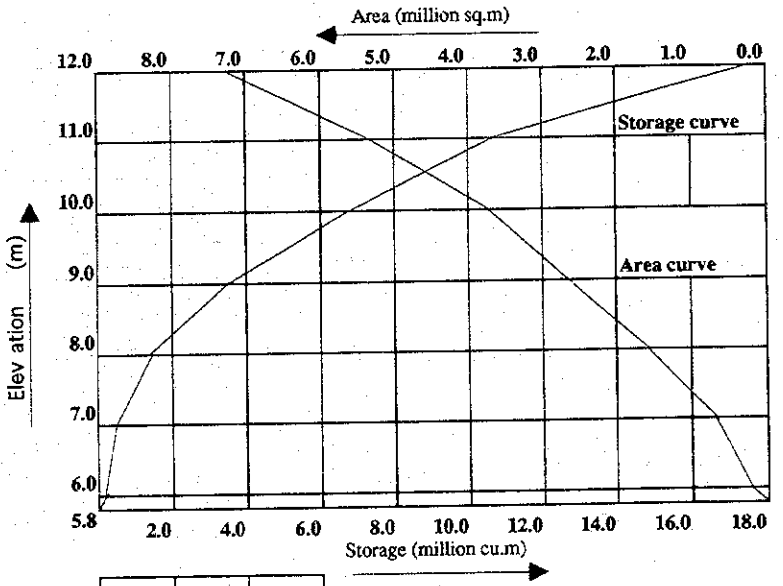
Fig. V-10 Preliminary Irrigation Plan of Kandal Stung Area

1) Saba Storage-Area Curve



El. (m)	Storage (Mil.M3)	Area (Mil.M2)
6.0	0	0
6.5	0.01	0.02
7.0	0.08	0.29
8.0	0.63	0.81
9.0	1.61	1.14
10.0	2.89	1.43
11.0	4.48	1.75
12.0	6.40	2.09

2) Kok Tel Storage-Area Curve

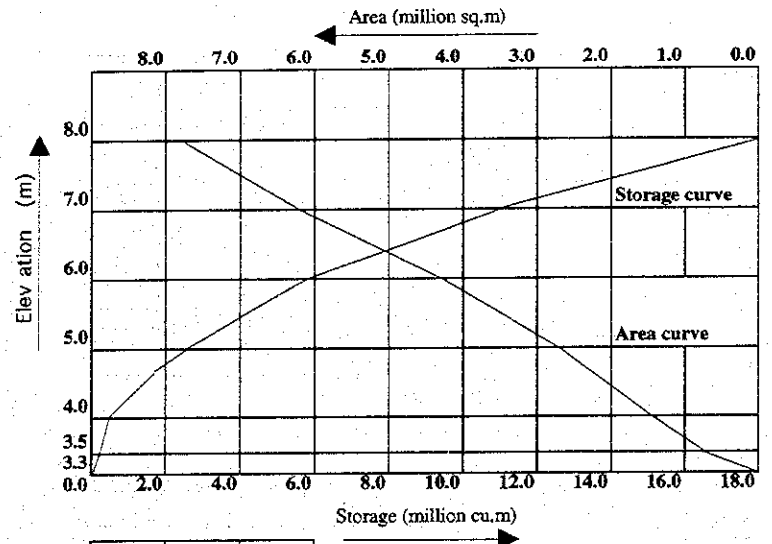


El. (m)	Storage (Mil.M3)	Area (Mil.M2)
5.8	0	0
6.0	0.01	0.07
7.0	0.39	0.69
8.0	1.54	1.61
9.0	3.64	2.60
10.0	6.87	3.85
11.0	11.40	5.22
12.0	17.70	7.37

(prepared on the bais of topographic map 1:10,000)

Fig. V-11 Storage -Area Curve of Saba and Kok Tel Reservoirs

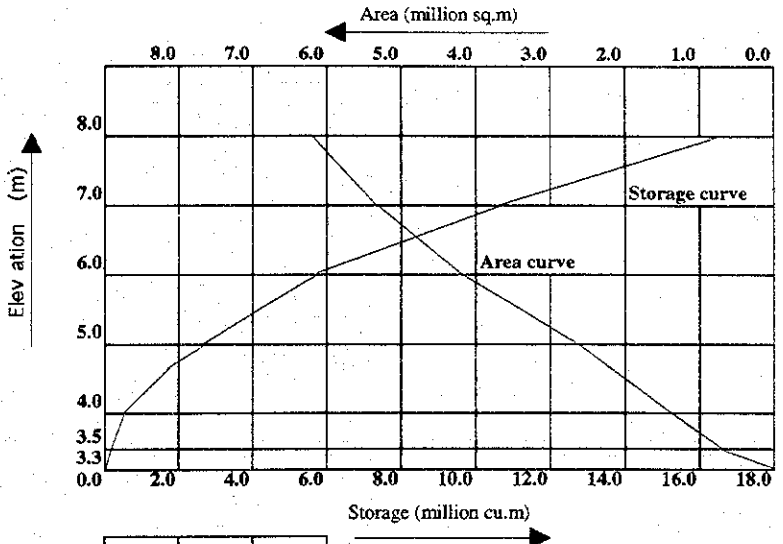
1) Tonle Bati Storage-Area Curve



El. (m)	Storage (Mil.M3)	Area (Mil.M2)
3.3	0	0
3.5	0.08	0.76
4.0	0.63	1.44
5.0	2.55	2.40
6.0	5.87	4.25
7.0	11.07	6.14
8.0	18.06	7.85

(including Kok Tel area)

2) Tonle Bati Storage-Area Curve



El. (m)	Storage (Mil.M3)	Area (Mil.M2)
3.3	0	0
3.5	0.08	0.76
4.0	0.63	1.44
5.0	2.55	2.40
6.0	5.84	4.18
7.0	10.65	5.45
8.0	16.50	6.24

(excluding Kok Tel area)

(prepared on the basis of topographic map 1:10.000)

Fig. V-12 Storage -Area Curve of Tonle Bati Lake

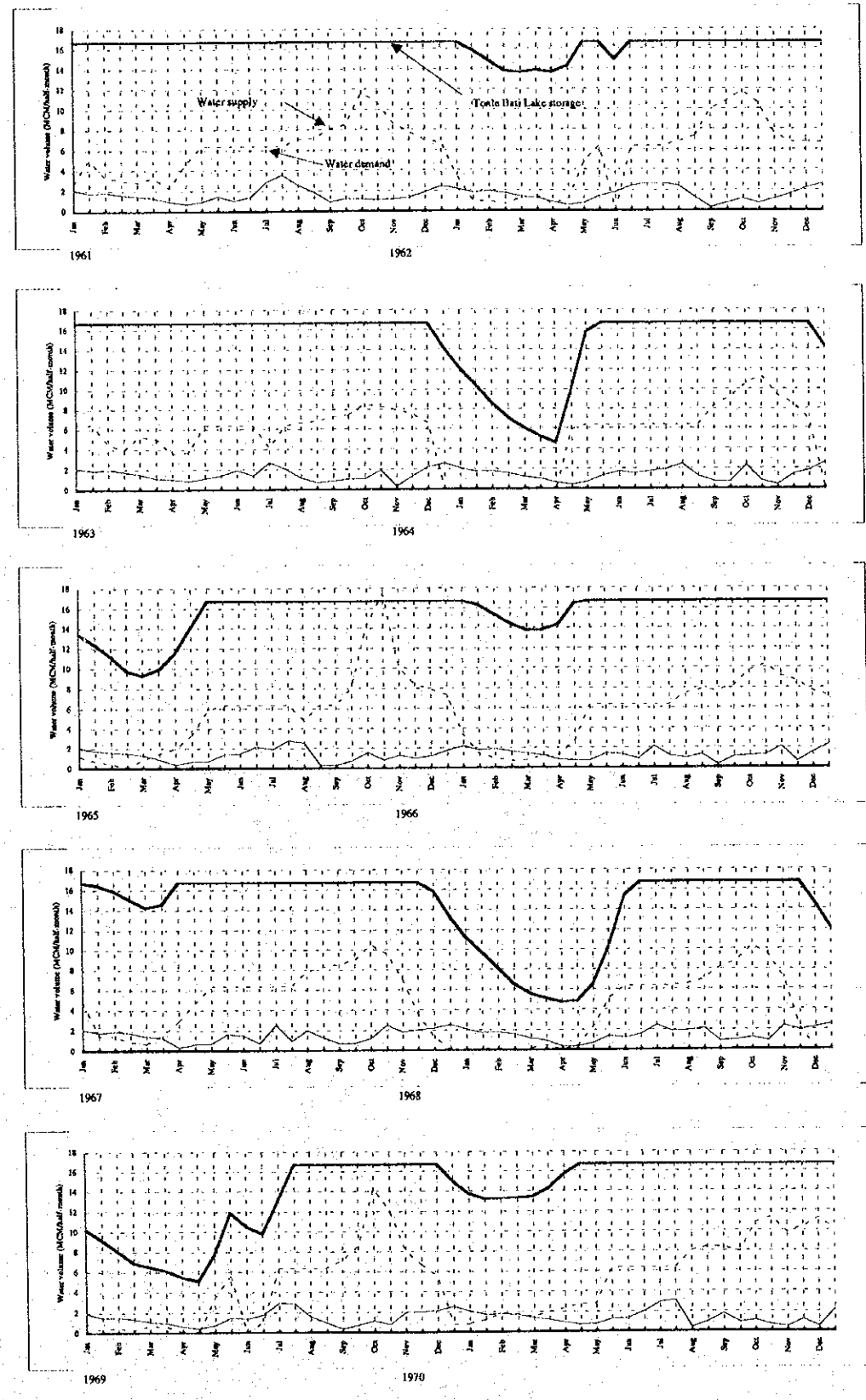
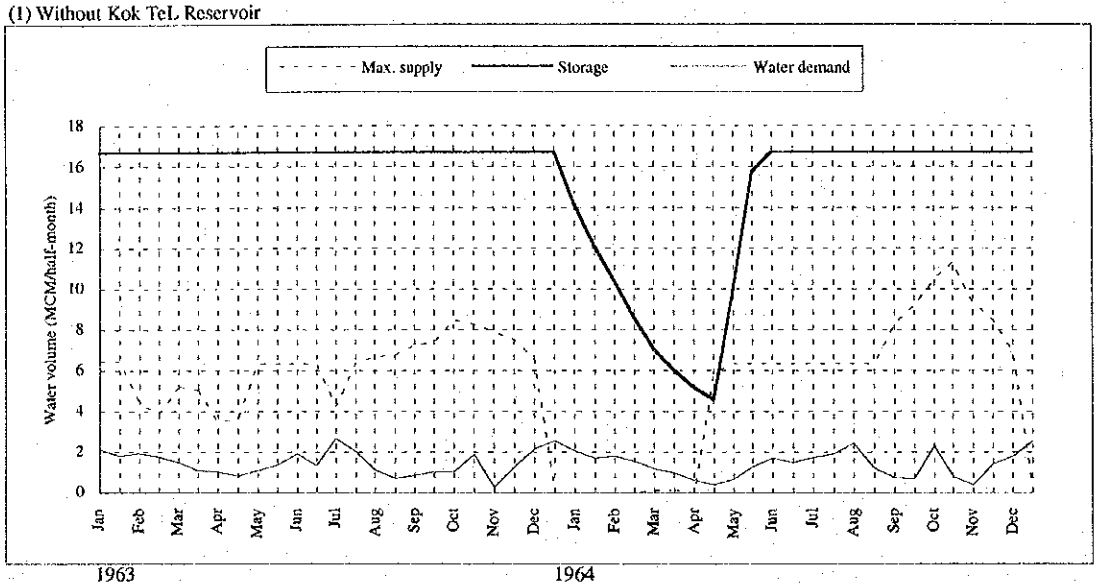


Table V-13 Water Balance Simulation of Tonle Bati Irrigation Project (without Kok Tel Reservoir, irrigation area 1,600 ha)

(1) Without Kok Tel Reservoir

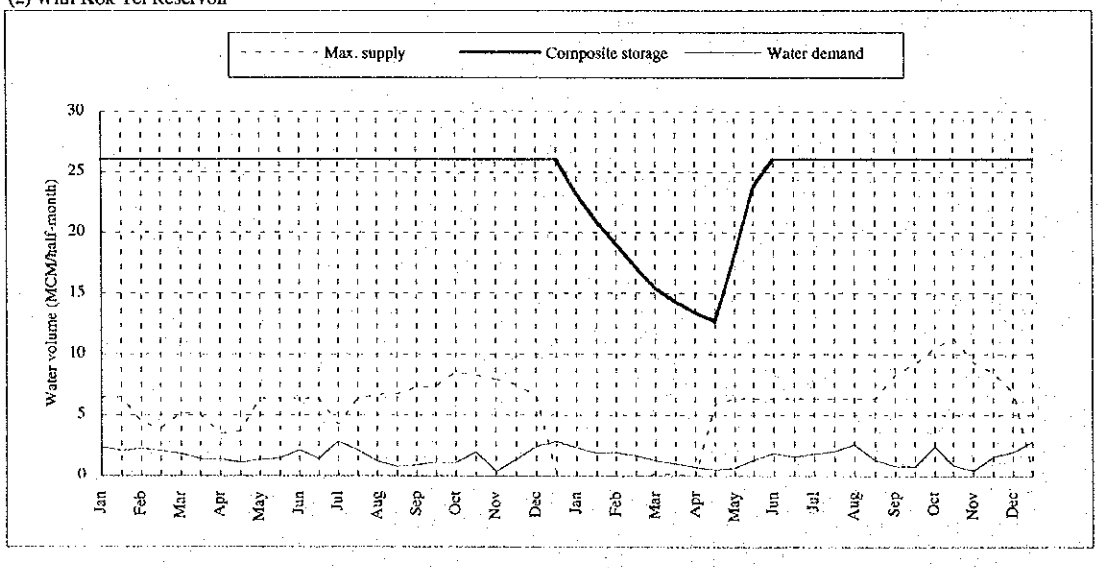


Tonle Bati Pump Station Capacity

Description	Unit	1963 Dec 1	Dec 2	Jan 1	Jan 2	Feb 1	Feb 2	1964 Mar 1	Mar 2	Apr 1	Apr 2	May 1	May 2	Jun 1	Jun 2
Tonle Bati Lake Storage	MCM	16.70	16.70	14.20	12.10	10.40	8.60	7.00	6.00	5.20	4.50	10.00	15.70	16.70	16.70
Irrigation demand	MCM	1.53	1.77	1.24	0.80	0.86	0.74	0.00	0.00	0.02	0.06	0.50	1.04	1.32	1.26
Pump-up water	MCM	0.00	0.88	1.20	0.80	0.90	0.70	0.00	0.00	0.02	0.05	0.50	0.52	0.00	0.00

Note : pump is required to be operated on lower water lever than EL.7.8 m (storage 16.7 MCM)
operation hour/day ; 24 hour at a peak requirement period
Total pump-up water 5.57 MCM for 4.5 months
Maximum pump-up /half-month 1.2 MCM

(2) With Kok Tel Reservoir



Minimun storage : 12.6 MCM corresponding water level of Lake Tonle Bati 7.2 m

Fig. V-14 Tonle Bati Lake Storage Simulation
(Irrigation area 1,600 ha 180 % cropping intensity)

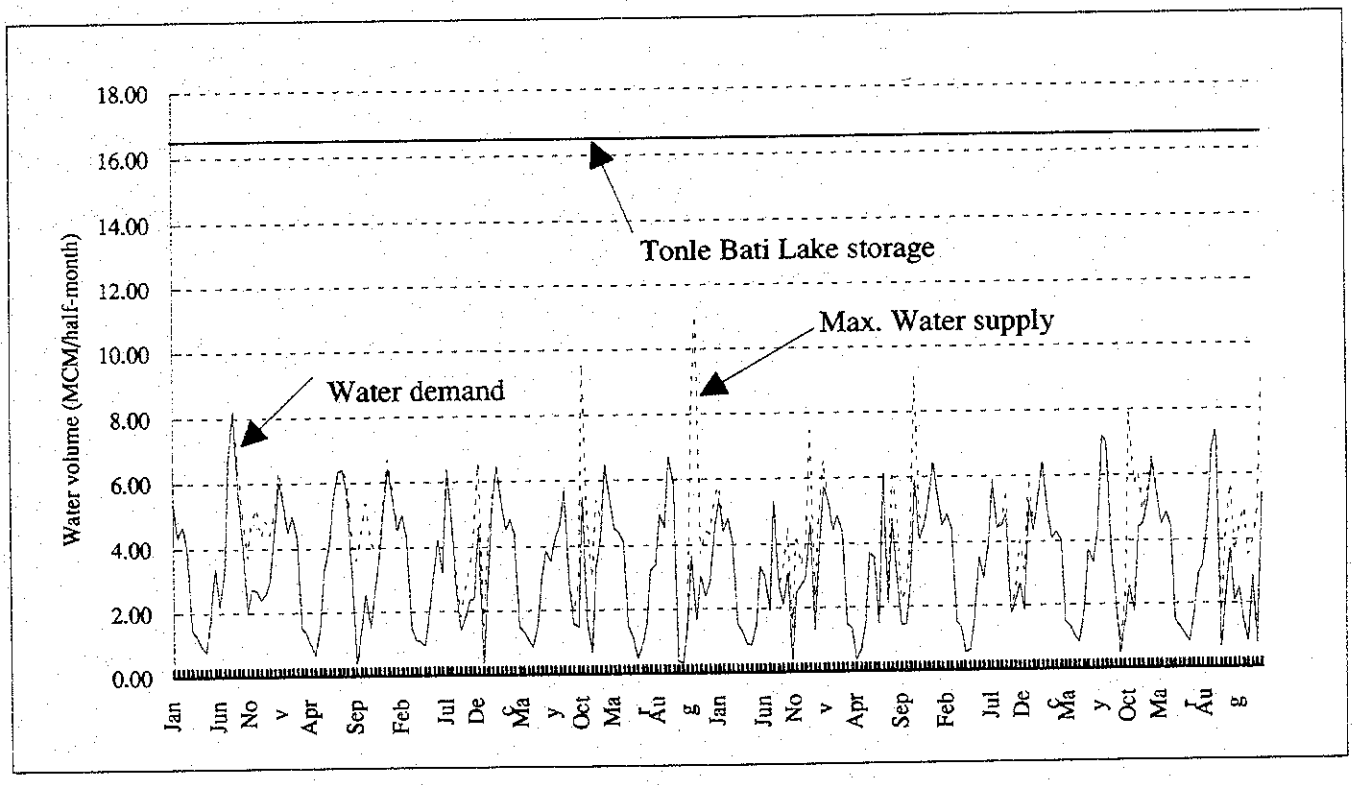


Fig. V-15 Tonle Bati Lake Storage Simulation (Irrigation area 4,200 ha)

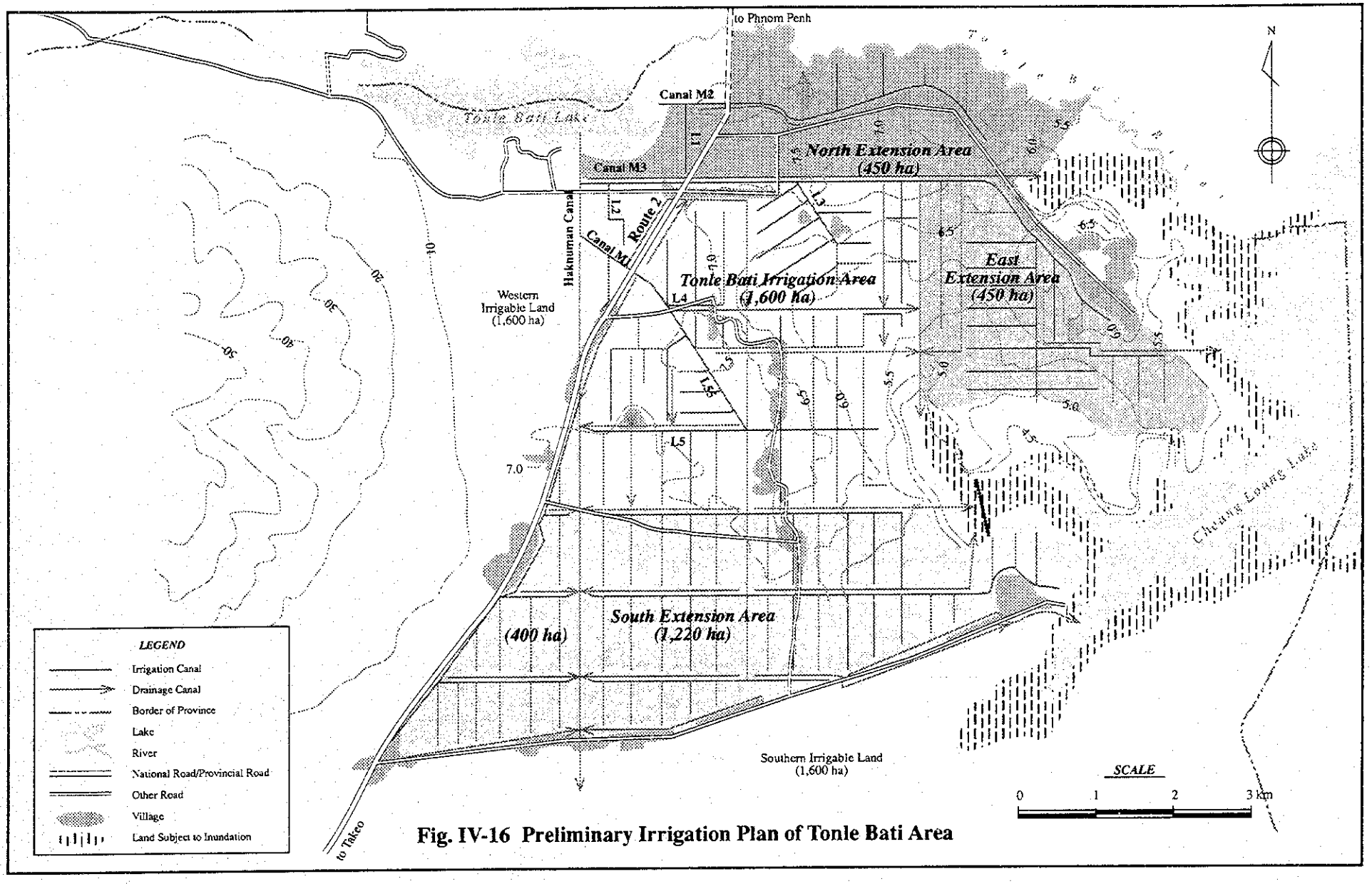


Fig. IV-16 Preliminary Irrigation Plan of Tonle Bati Area

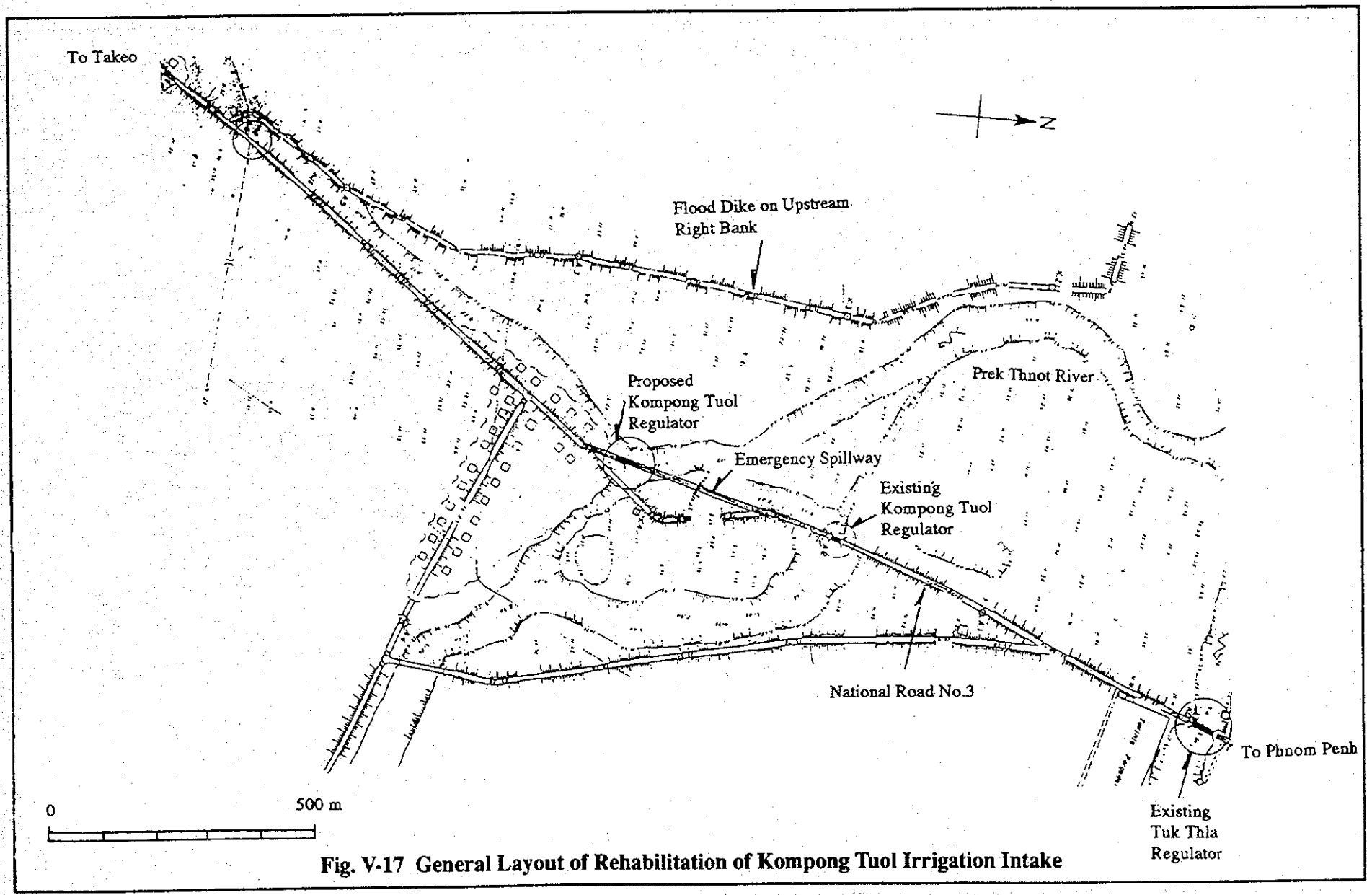


Fig. V-17 General Layout of Rehabilitation of Kompong Tuol Irrigation Intake

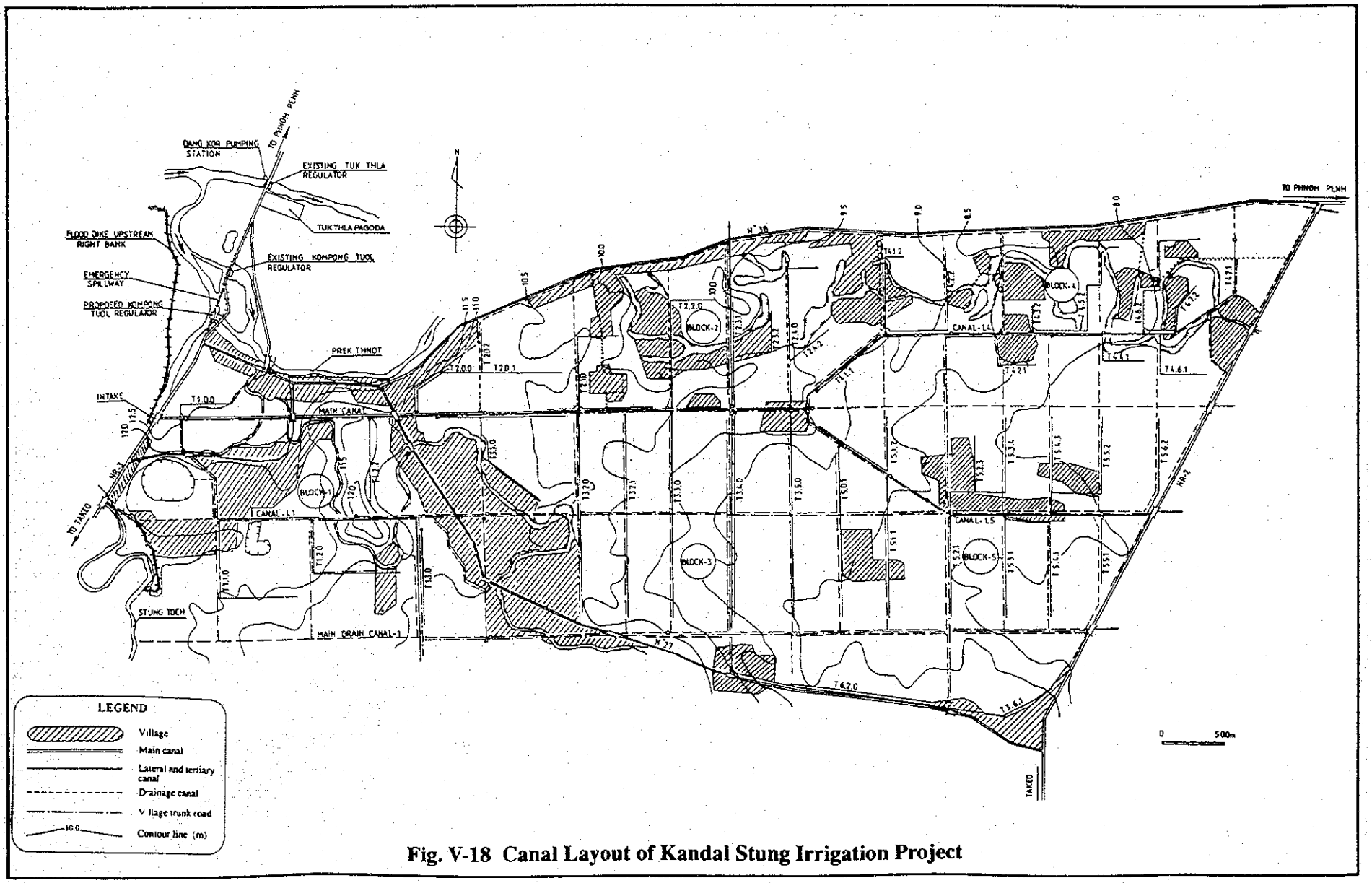


Fig. V-18 Canal Layout of Kandal Stung Irrigation Project

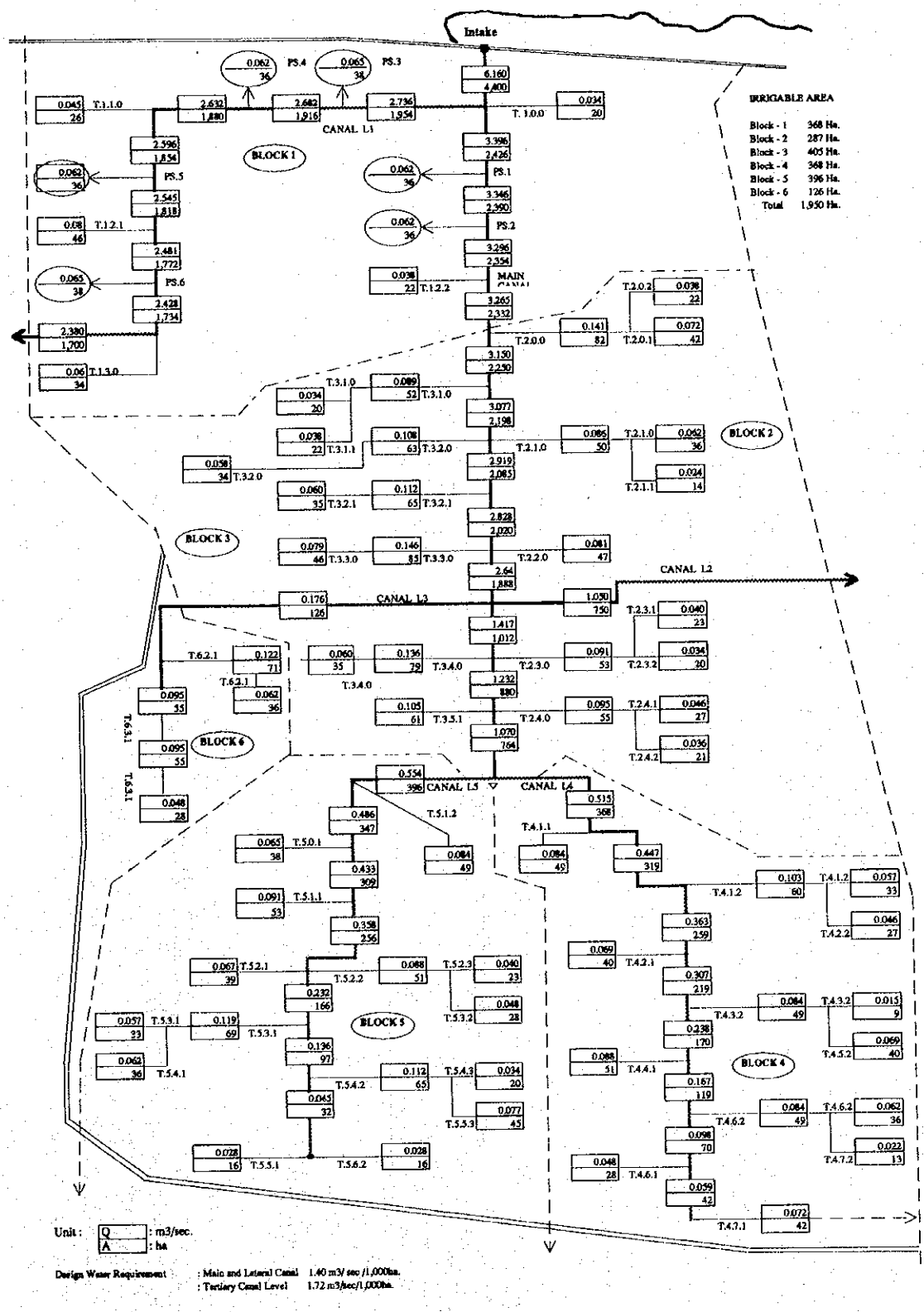
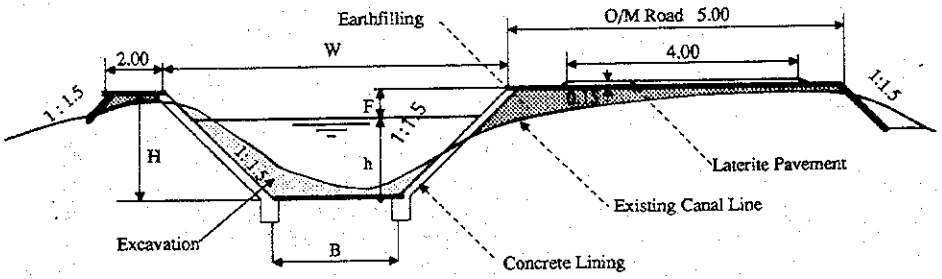
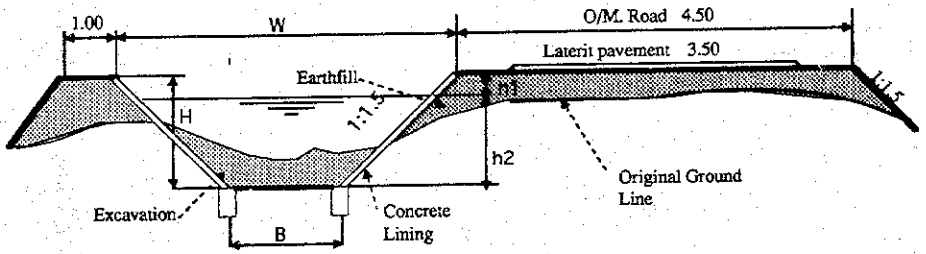


Fig.V-19 Irrigation Diagram of Kandal Stung Irrigation Project

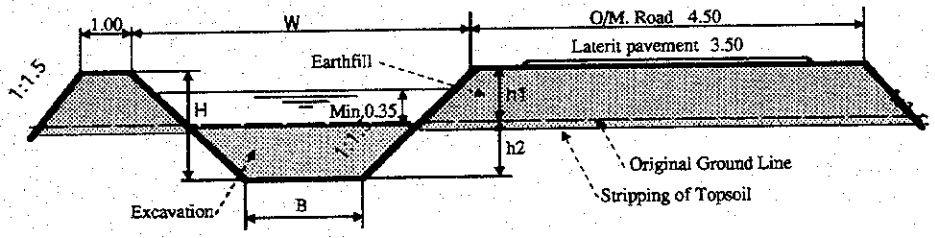
1. MAIN IRRIGATION CANAL (Existing canal)



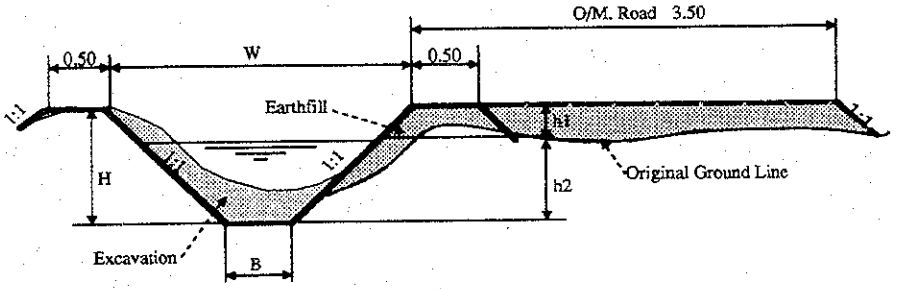
2. LATERAL IRRIGATION CANAL (Existing Canal)



3. LATERAL IRRIGATION CANAL (New Construction)



4.TERTIARY IRRIGATION CANAL (Existing Canal)



5. TERTIARY IRRIGATION CANAL (New Construction)

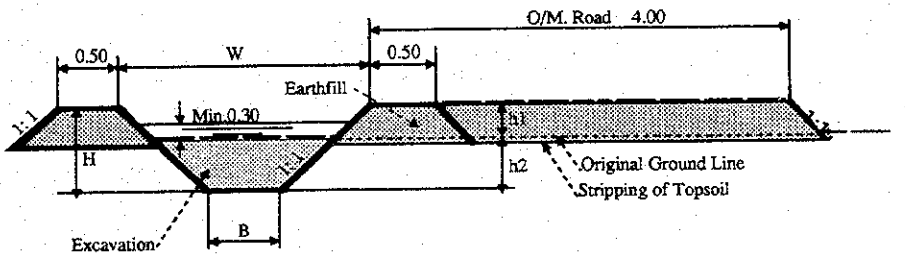


Fig.V-20 Typical Sections of Canals

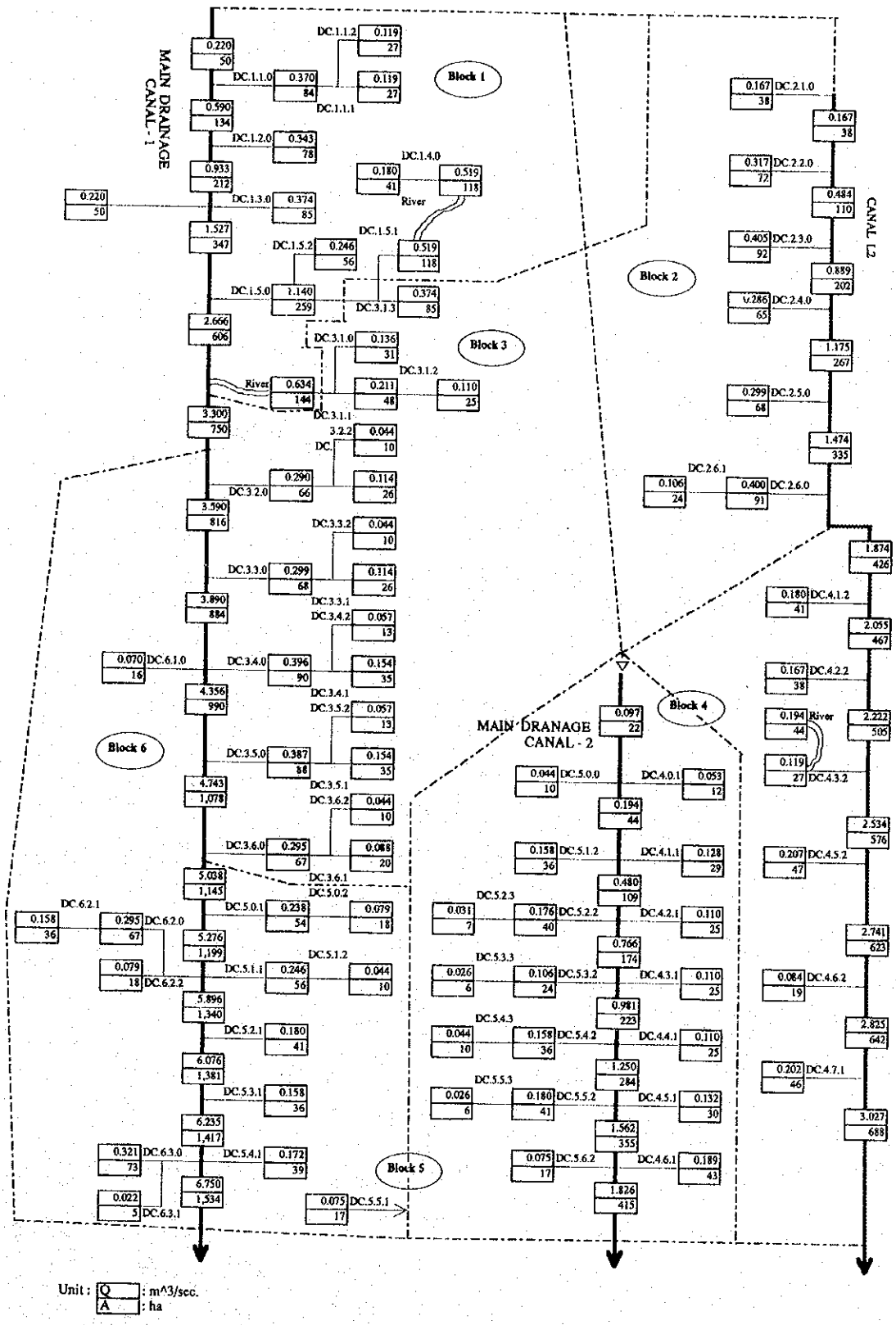


Fig.V-21 Drainage Diagram of Kandal Stung Irrigation Project

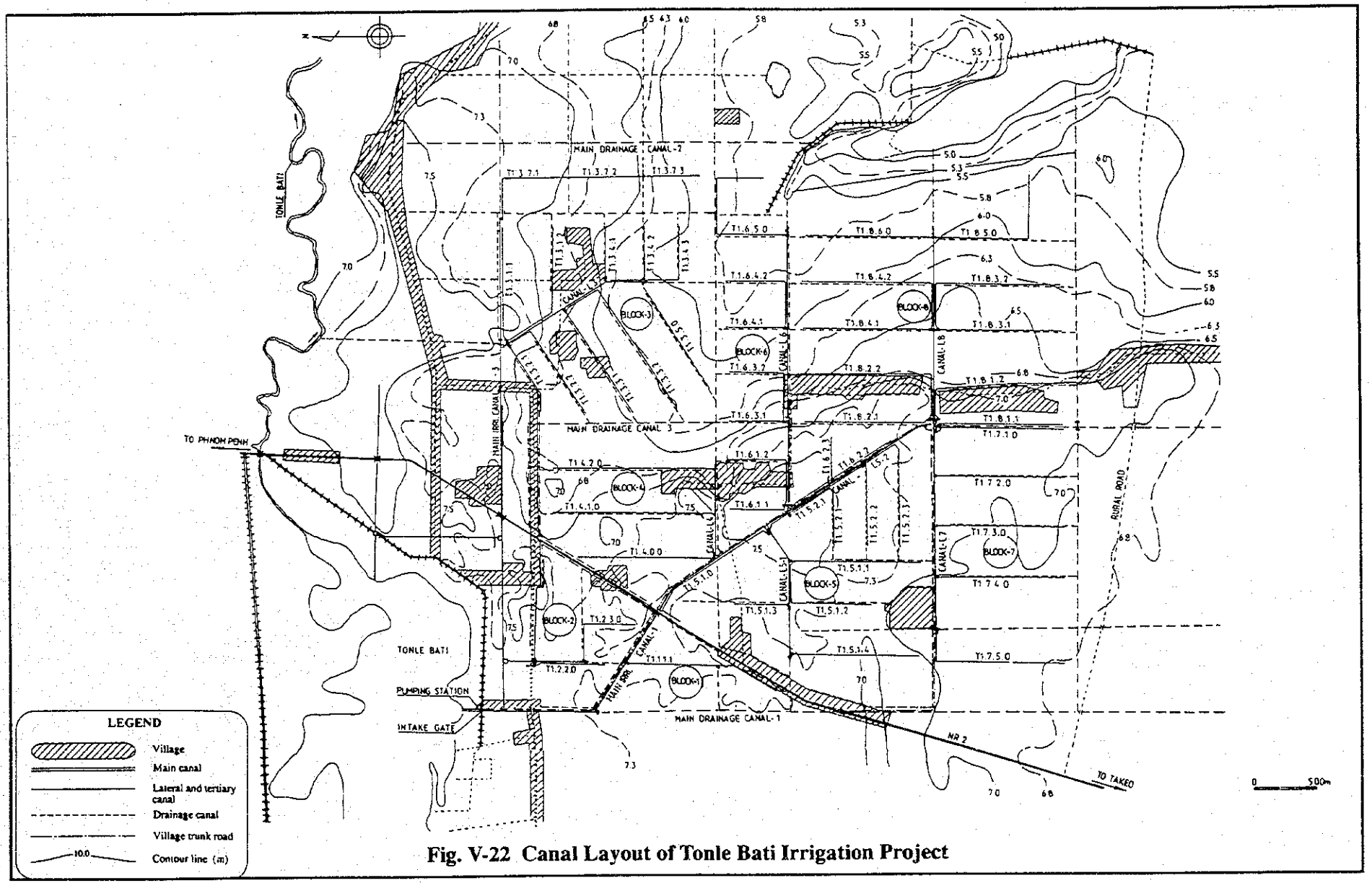


Fig. V-22 Canal Layout of Tonle Bati Irrigation Project

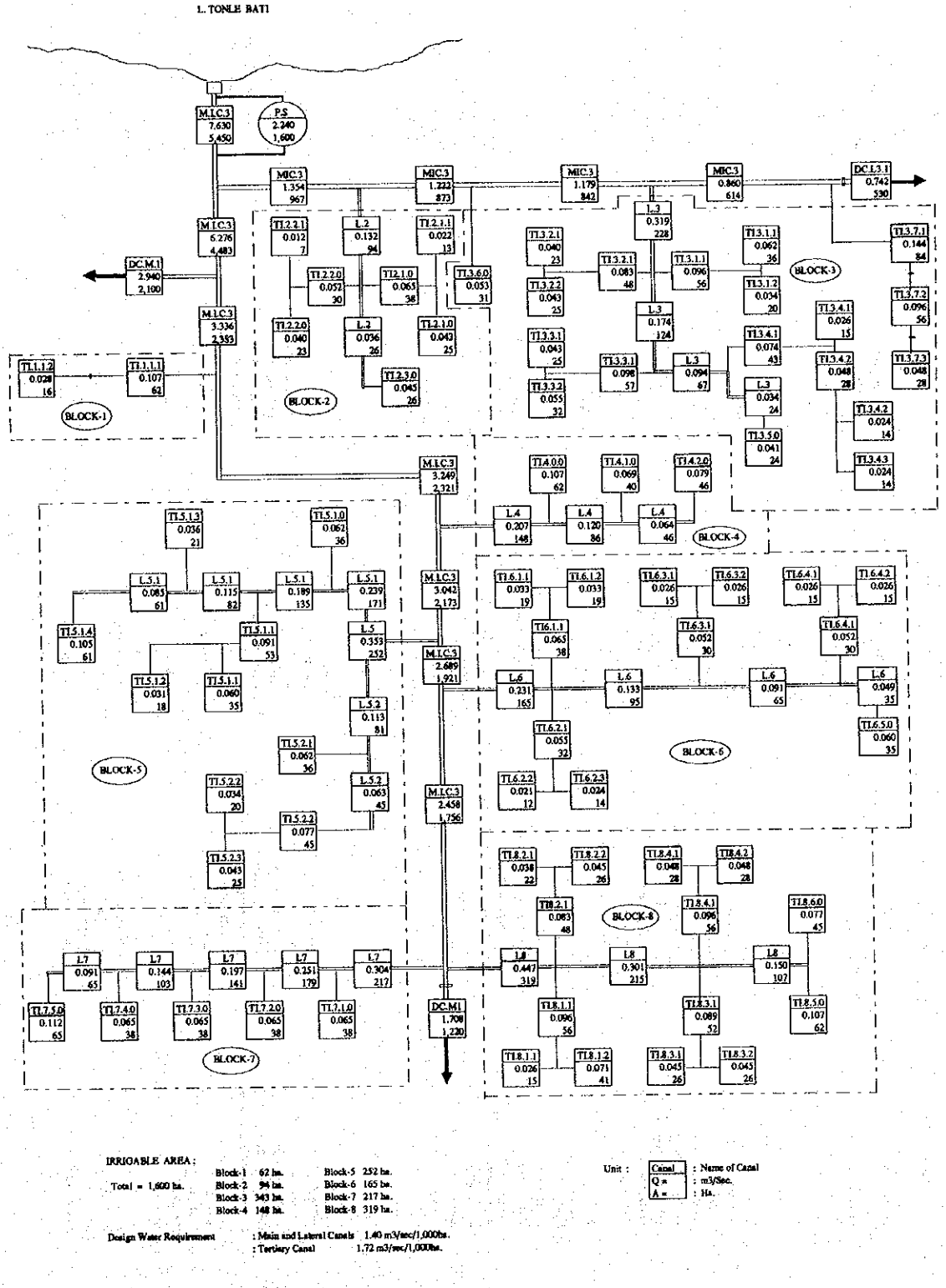


Fig. V-23 Irrigation Diagram of Tonle Bati Irrigation Project

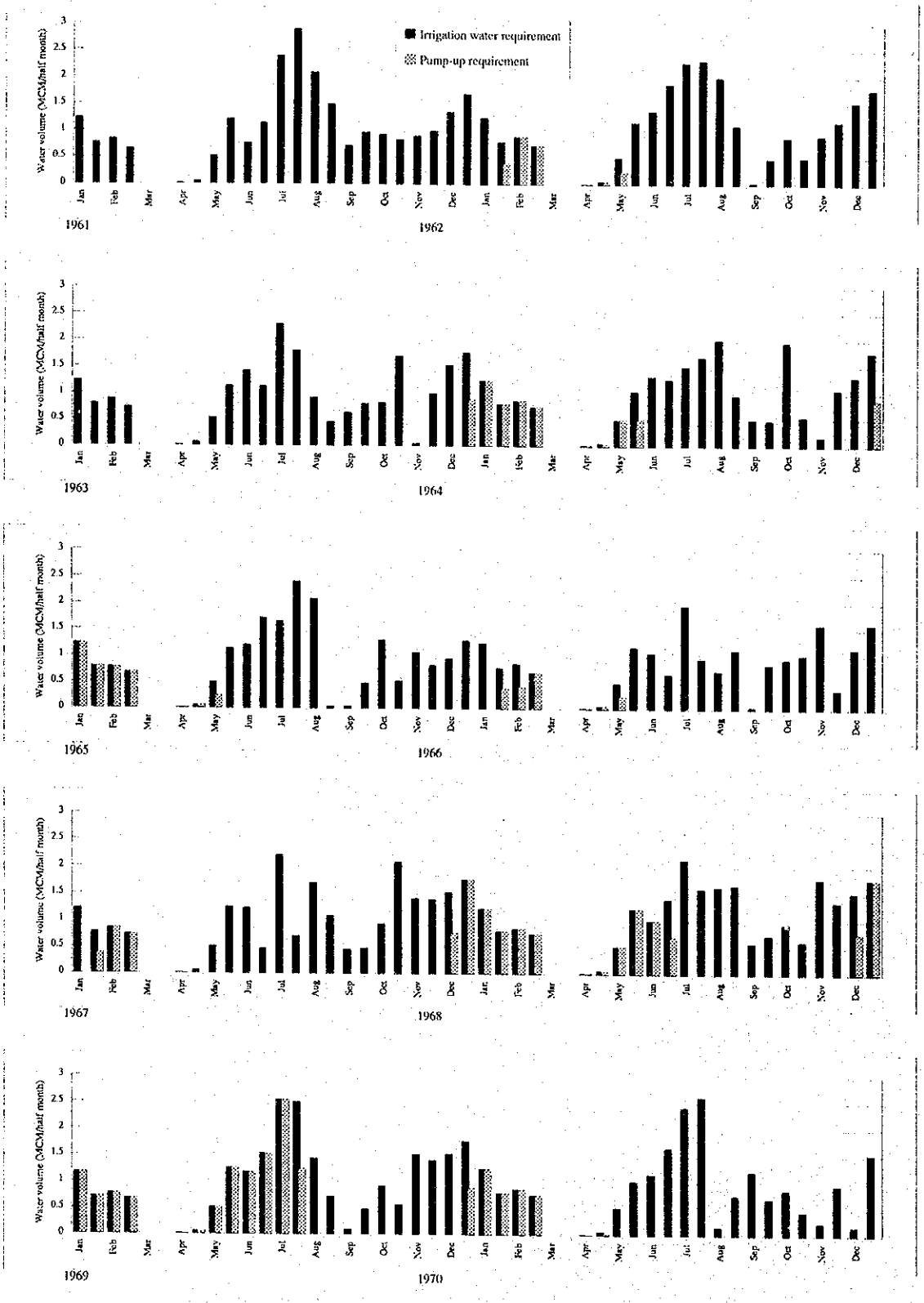


Fig. V-24 Irrigation Requirement and Required Pump-up of Tonle Bati Irrigation Project

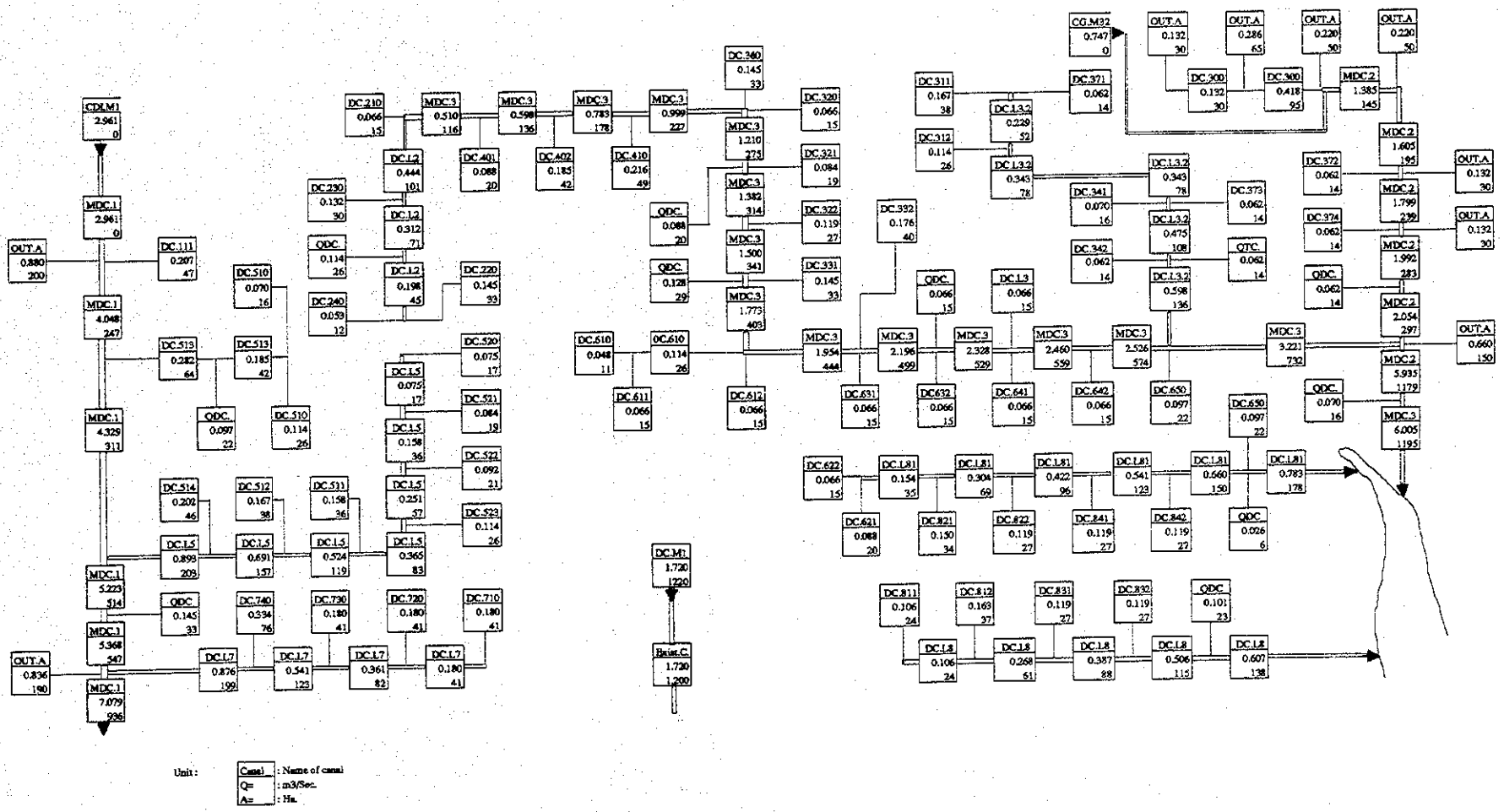


Fig.V-25 Drainage Diagram of Tonle Bati Irrigation Project

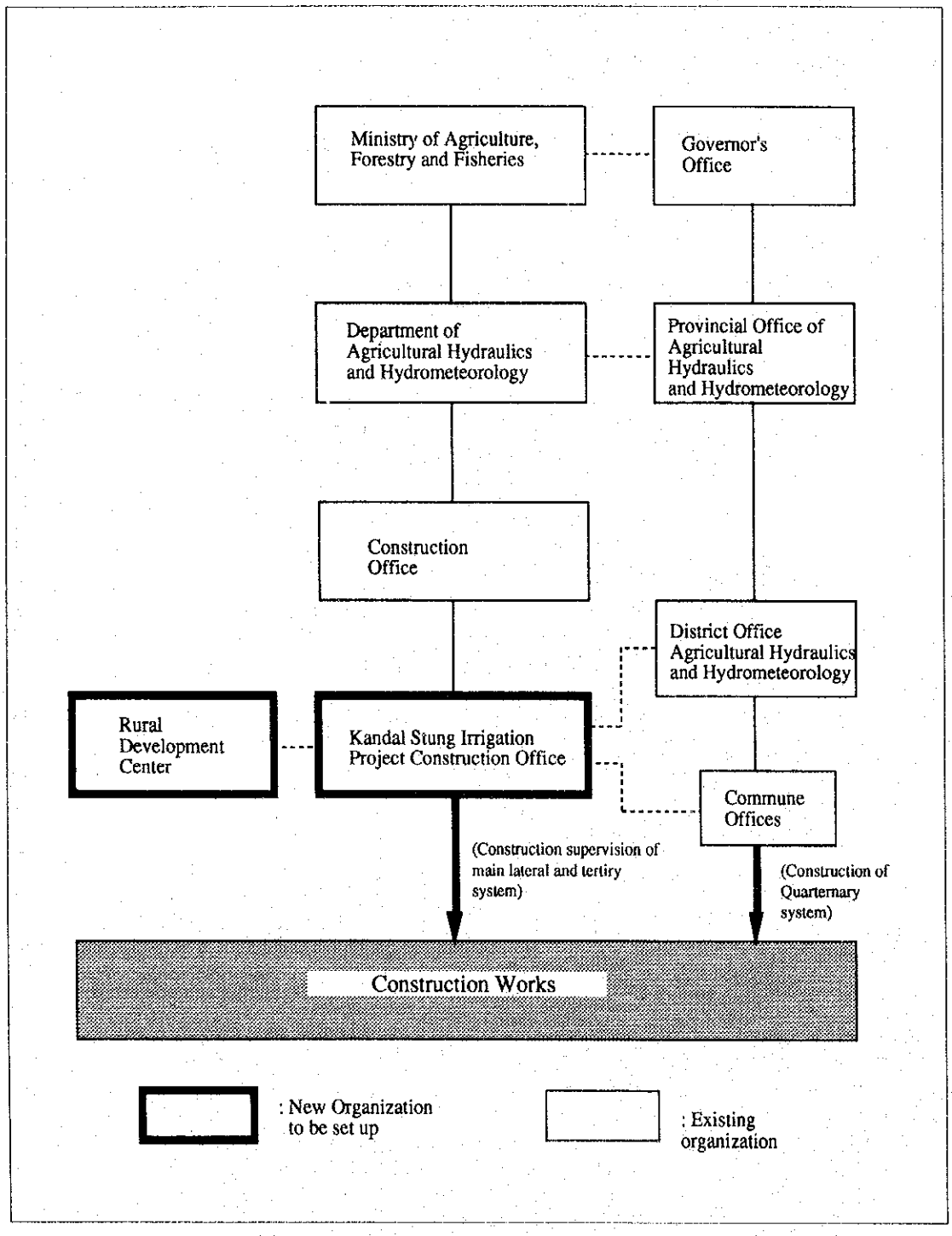
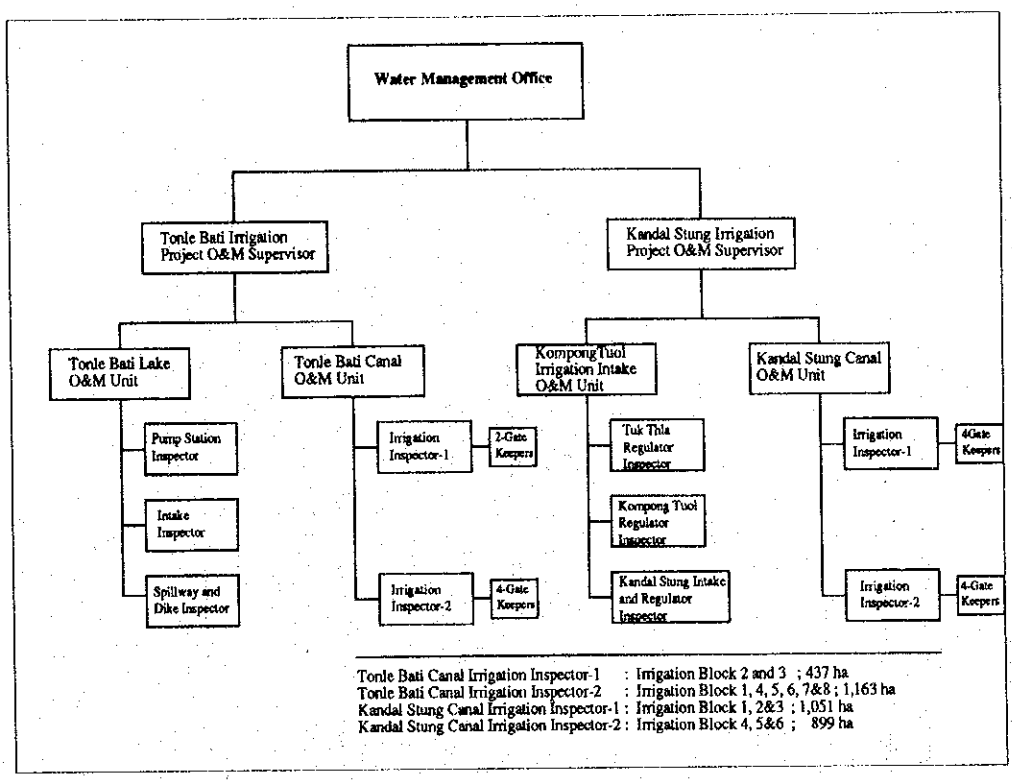


Fig. V-26 Proposed Organization of Project Implementation



Organization of Water Users Association

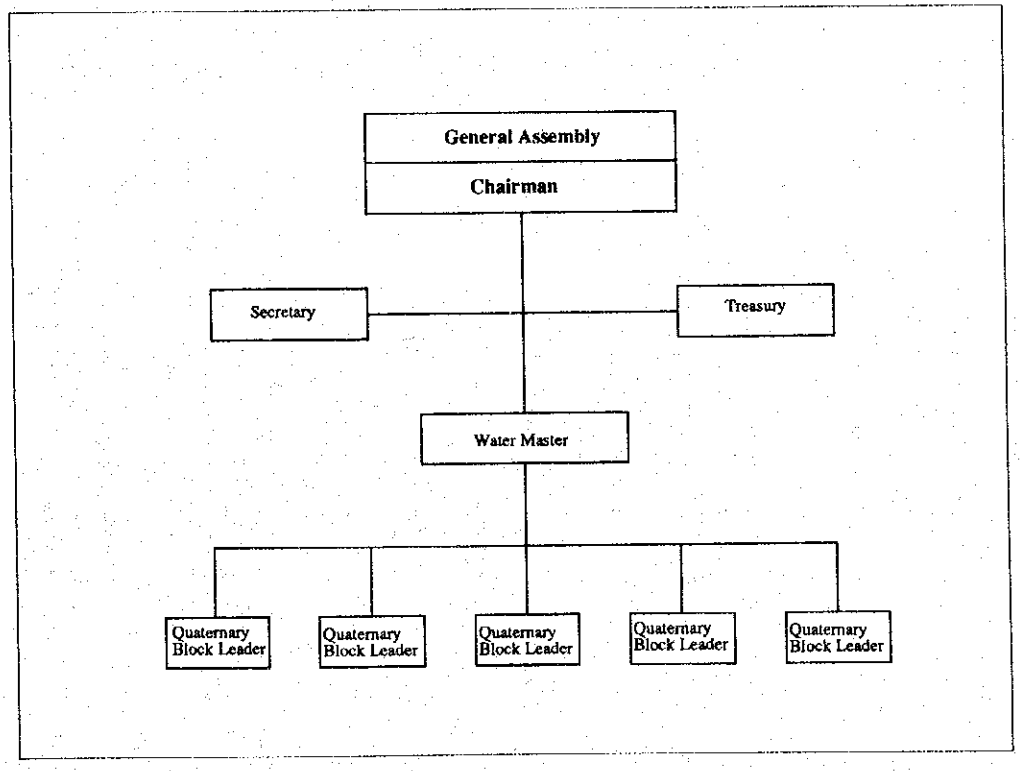


Fig.V-27 Proposed Organization of O&M

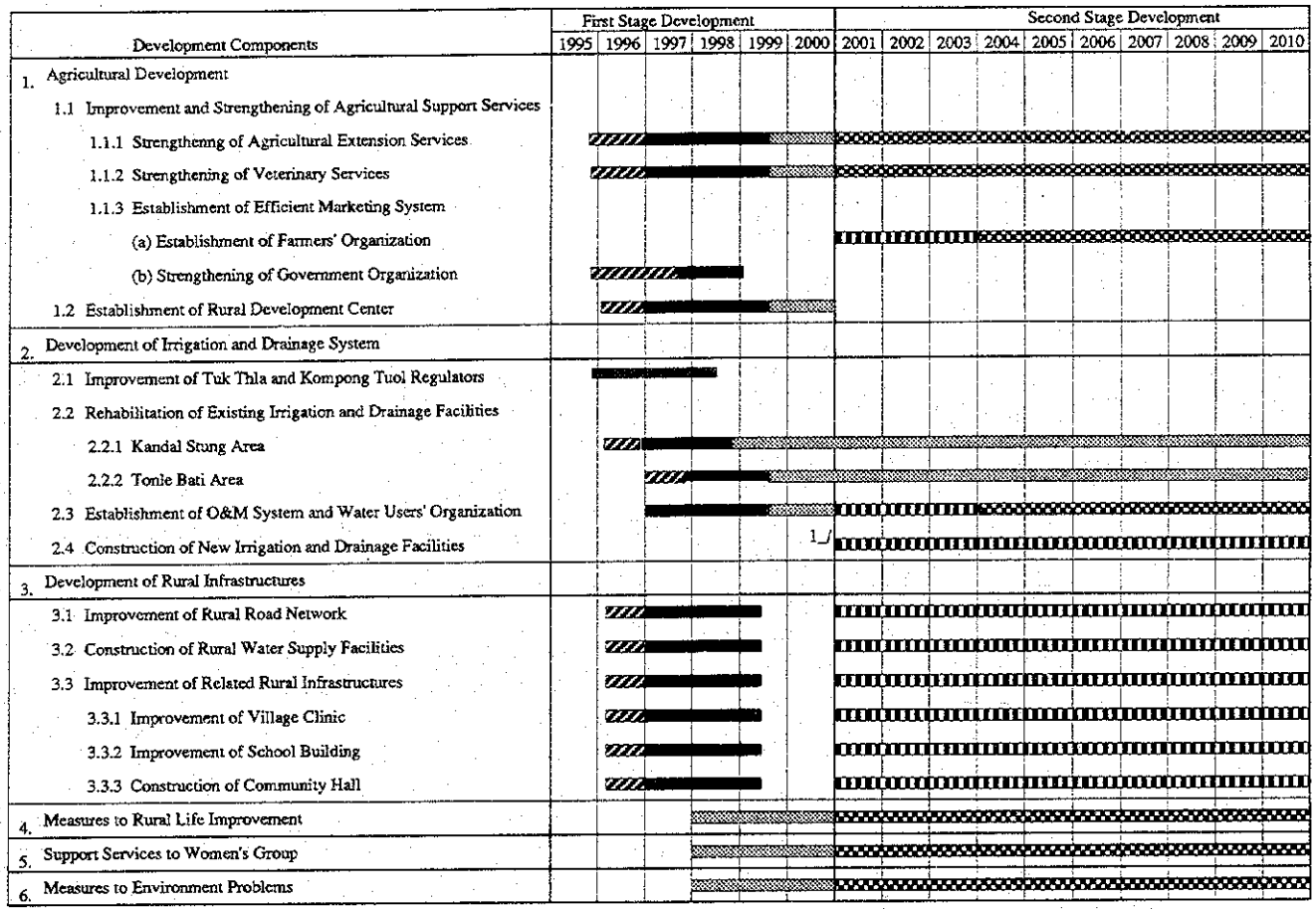


Fig.V-28 Overall Project Implementation Schedule