road would be considered to be small and its repair would be easy. Easy access of the regulator bodies can be ensured because the access road to the regulator is elevated higher than the extra-ordinary flood water level.

5.1.3 Construction Plan and Schedule

(1) Physical Environment

The physical environment of UTR and LTR is adverse in rainy season for the construction which extends for four months from October to January. The river water level rises extremely in Novemember and December as indicated in Table 5-6. The effective work period is eight months per year, though few work items are available in moderate rainy months. The mobilization and demobilization of equipment and dredger, temporary work and finishing work are allowed to deal with.

According to the meteorological data at Narathiwat and Tak Bai for recent ten years, monthly 25 days of less than 2 mm rainfall are identified as workable days; hence, 200 workable days are led throughout a year. There are eight hours of daily labour being deemed official standard, and additional hours are allowed for over-time.

(2) Traffic Conditions

Physical distance from Bangkok to the site along the national highway is 1,200 km. The Yala quarry is 120 km far away from UTR, and UTR is 35 km from LTR. The laterite mine at Sg. Kolok is 55 km away from the center of the Project area. The traffice condition from Sg. Kolok to the site along the national highway 4084 and 4085 is excellent, while that of Yala quarry along the local highway is also good.

The branch being stem from highway is fairly good but the access to each site is not deemed good, for which an access road and its maintenance have to be kept during the construction work. Temporary laterite pavement is effecitive means to keep the access road and work yard's trafficability good.

(3) Construction Work Mode

The civil work construction of UTR and LTR would be implemented in the form of package contract under the simultaneously proceeding programme from commencement to completion. Design, manufacturing and installation of the UTR and LTR gates would proceed to keep abreast with the progress of civil work. The work starts from the equipment mobilizaition from Bangkok and Hadyai and completes at the accomplishment of gate performance test.

(4) Materials

All quarry products are conveyed from the Yala plant. Sand is taken from the mid-stream of Mae Nam Yakang. Laterite is taken from the source located at Sg. Kolok. Cement is directly conveyed form the production plant in Yala. Steel bar is procured from the rolling mill in Bangkok. Timber and plywood are gathered in the general domestic market in and out of the Southern Region. RC piles are manufactured at the centrifuged plant in Bangkok and conveyed to the site.

Excavated soil from the river bed for new connection channels is fully utilized for land reclaiming in UTR and LTR. The soil taken from hill top in the UTR area is applied for access road embankment and jetty access. Excess soil is applied for general filling. Filling material necessary for the LTR access road is forced to bring from the nearest borrow bit around LTR by all means. Closure dam embankment material for Mae Nam Bang Nara is taken from the river bed after stripping top loose by a dredger.

Only the steel sheet pile is imported from overseas via Port Bangkok.

(5) Labour

Labour force is formed as mixed manpower organization adopting the better part of skilled and unskilled labourers gathered in the Project area and partly very skilled from Bangkok and Hadyai. For the dredging/reclaiming work, the alien expert crews would be required to deal with the dredger, lift boat and tug boat operation for six months in the Project year 4.

(6) Civil Work Construction Procedures

For the UTR and LTR regulator body construction, the caldron is excavated by backhoe and soil is conveyed outside by dump track. A size of the caldron is planned so as to fit to the regulator body size taking into account the workablility of heavy equipment. The caldron is protected from the overflow by a temporarily built coffer dam, and dewatering pumps are arranged to keep its bottom dry during the construction work. In the caldron, the main structures of regulator body, wing wall, apron and riprap are constructed and the gates are also installed. Such work extends for two years over the one rainy season; however, the most of civil work should be properly arranged to complete before the flood season. The coffer dam for caldron work is removed by the dredger's breakthrough during the construction of connection channel.

RC pile and steel sheet pile are driven by the crawler Diesel driver. All embankment being done by on-land equipment is compacted with tire roller and certain percent of laterite sandwitch layer, and the water content is adjusted by sprinkler and proctor density tester. The surface of reclaimed land is levelled by Bulldozer 32 ton all ways. PC bridges, post-tension for UTR and LTR are manufactured near the regulator body and are erected before the rainy season.

Concrete plant is trans-relocated from the existing Sg. Kolok site to a new plant site at hilly tract nearby UTR. The plant of 30 cu.m per hour batching capacity processes more than 200 cu.m per day of concrete to be conveyed by certain numbers of truck mixers to UTR and LTR, and to be casted by concrete pump of 43 cu.m per hour capacity. The total volume of concrete mixing for all structures including PC bridge and architectural work would reach to 14,200 cu.m, while the regulator body nedds 12,980 cu.m of concrete placing.

A set of the dredger fleet consisting of 1,350 Hp dredger with capacity of 5,800 cu.m per day dredging, lift boat, tug boat, pontoon and floated sand pipe plays the role of dredging/reclaiming work for UTR and LTR to process about 600,000 cu.m dredging including stripping top loose within limited time. The work starts from UTR and terminates at LTR after one and half of roundtrip navigation along Mae Name Bang Nara. A complete set of the dredger is due to be mobilized and demobilized from and to Singapore via trans-Malaysia at the beginning of the Project year 4. New connection channels are excavated by the dredger and are broken through after the gate installation. Channels' side slope is shaped up by dragline.

The Bang Nara closure dam is filled by two stage banking method. The lower stage is built by sub-water level filling method using off-shore discharge pipe floated and anchored, and the upper stage is filled by off-shore trestle discharge pipe. Jetty and access road are constructed beforehand. Toe riprap is dumped by barges being towed by tug boat after receiving riprap from dump truck at fetty stage. The jetties are situated in the upstream of UTR, and remain after the completion of job for the convenience of speed boat quay in future. River bed top loose is stripped before the toe riprap dumping and dam material dredging. Surplus embankment and slope, and crest road shape-up are carried out after the dredger's dam embankment and slope is protected by riprap pitching.

Power lines are arranged at the beginning of civil work to make temporary supply of electricity to UTR, LTR and batcher plant for lighting, welding, vibrating, batching, etc. The mode of power supply is converted from the temporary to the permanent before the performance test of gate function for the permanent use. The power supply timing is indicated in the schedule. RID, in this regard, is requested to take necessary procedure to get the timely supply from PEA.

(7) Gate Work

Gate manufacturing starts together with the commencement of civil work from the process of gate designing and approval of every detail. Gates and related system are manufactured within eight months and transported to the UTR and LTR sites just after the rainy season. The installation starts immediately at UTR and LTR respectively having common use of erection cranes. Embedded parts and sections are built in the civil RC structural work in advance in order to accept the gate installation, while the necessary anchor holes and bank holes are arranged according to the detailed designing.

The permanent power supply has to start immediately after the completion of wiring and electric cubicles. The serial performance tests are carried out before the coming rainy season. Operation and maintenance practice and know-how are all due to deliver to RID together with manual, spare parts, loose equipment and tools.

(8) Construction Schedule

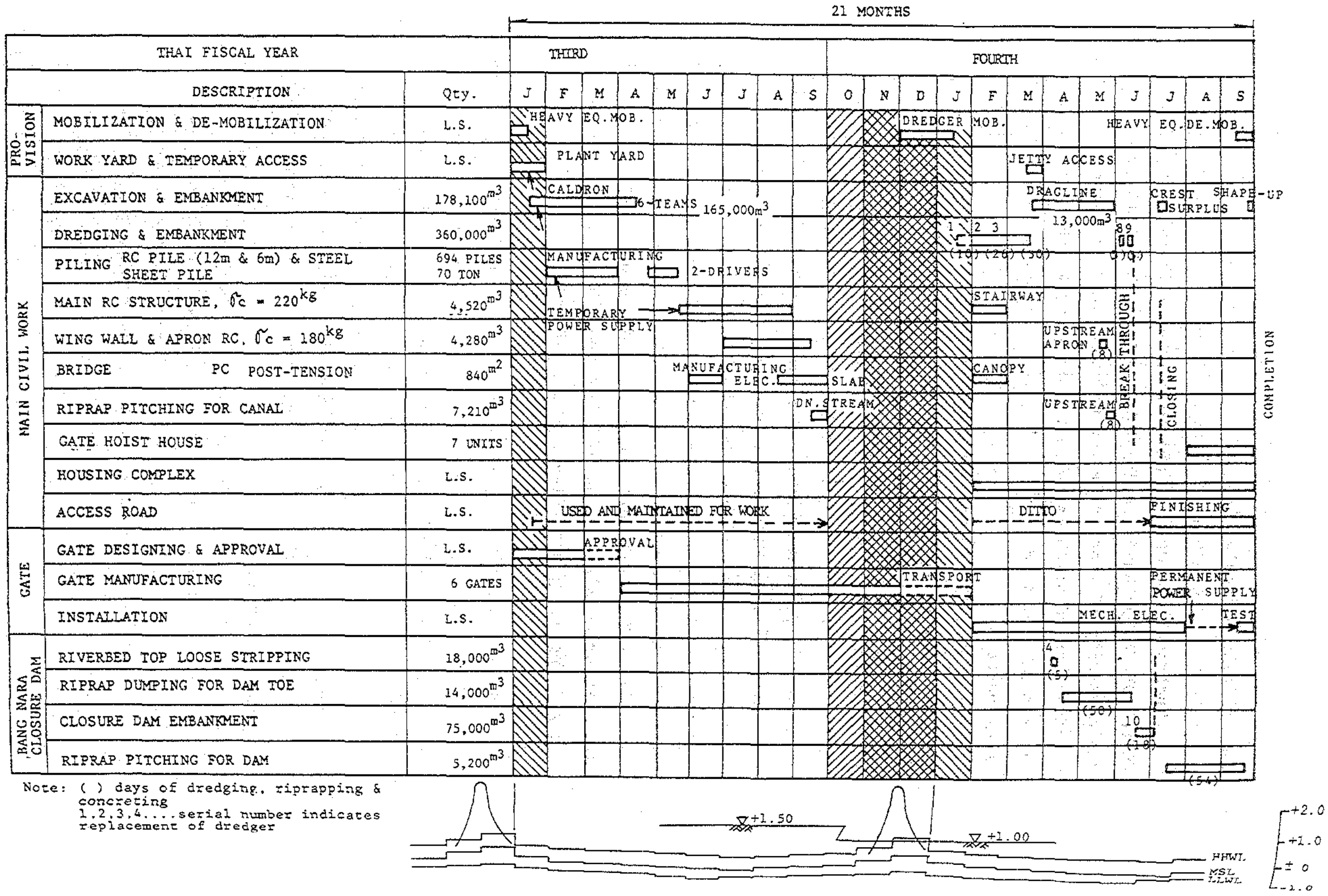
The construction schedule for UTR and LTR is arranged so as to have clear understanding about the tight time limit and the adversity of flood in rainy season. The bar chart schedules as compiled in Table 5-6 are endorsed by the network diagram as explained in Table 5-7 with the work procedures and order numbers.

5.1.4. Mode of Operations

The both UTR and LTR are the gated weirs to be provided for keeping the water fresh in the Bang Nara storage, with the functions of preventing the sea water intrusion from the Gulf of Thailand through the downstream rivers as well as of controlling the water level impounded in the storage. For this purpose, these tidal regulators are operated so that the inflow into the Bang Nara water storage can be quickly discharged to the Gulf of Thailand during the flood stage and also the normal stage in principle in line with the operation to maintain the normal impounding water level at EL + 0.40 m.

The structure of the regulators has a two-leaf roller gate of overflow type at each of UTR and LTR. The upper leaf of such gate can discharge the surplus water in the storage by overflow in case of drop-down of the leaf crest. The lower leaf of the gate can discharge water by submerged flow in case of opening the gate partly, and the regulators have enough cross-sectional area to discharge the flood water with a full opening of the gates.

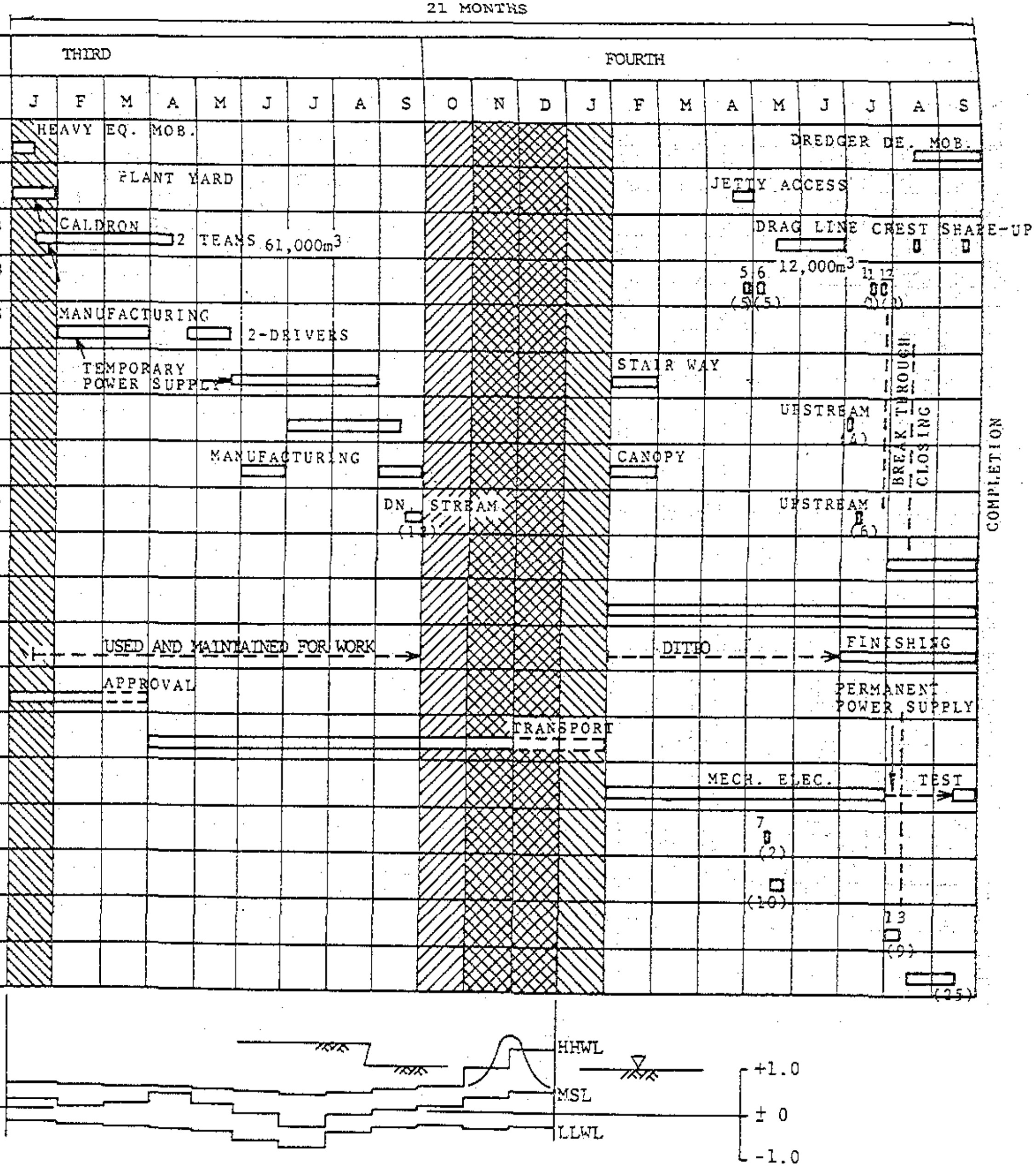
Table 5-6 (1) Construction Schedule for UTR



Note: ( ) days of dredging, riprapping & concreting
1,2,3,4....serial number indicates replacement of dredger

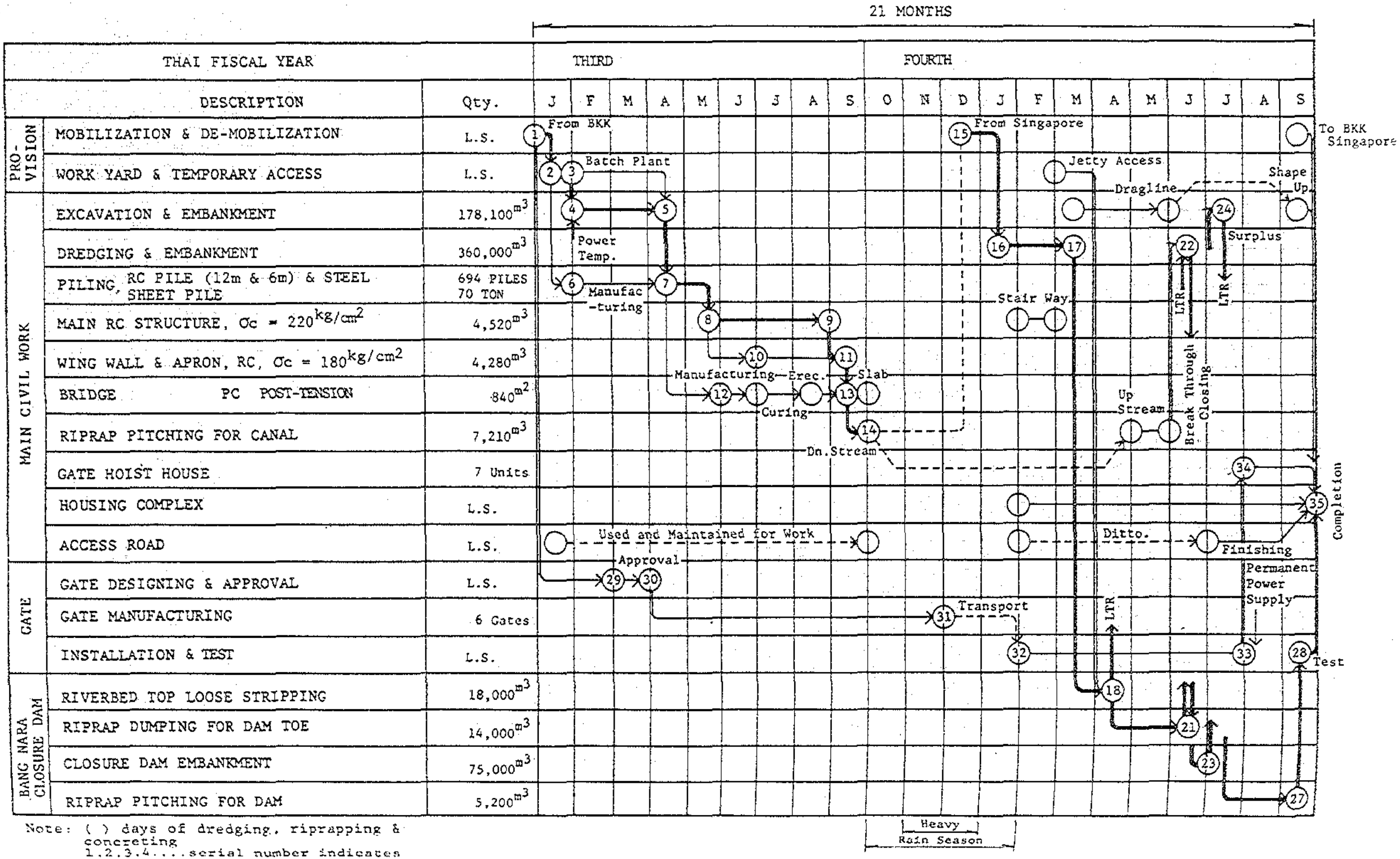
Table 5-6 (2) Construction Schedule for LTR

THAI FISCAL YEAR		
	DESCRIPTION	Qty.
PRO-VISION	MOBILIZATION & DE-MOBILIZATION	L.S.
	WORK YARD & TEMPORARY ACCESS	L.S.
MAIN CIVIL WORK	EXCAVATION & EMBANKMENT	73,000m^3
	DREDGING & EMBANKMENT	88,000m^3
	PILING, RC PILE(18m) & STEEL SHEET PILE	366 PILES 18 TON
	MAIN RC STRUCTURE, $\sigma_c = 220^{kg}$	1,720m^3
	WING WALL & APRON RC, $\sigma_c = 180^{kg}$	1,690m^3
	BRIDGE PC POST-TENSION	170m^2
	RIPRAP PITCHING FOR CANAL	2,560m^3
	GATE HOIST HOUSE	3 UNITS
	HOUSING COMPLEX	L.S.
	ACCESS ROAD	L.S.
GATE	GATE DESIGNING & APPROVAL	L.S.
	GATE MANUFACTURING	2 GATES
	INSTALLATION	L.S.
BANG NARA CLOSURE DAM	RIVERBED TOP LOOSE STRIPPING	5,000m^3
	RIPRAP DUMPING FOR DAM TOE	2,600m^3
	CLOSURE DAM EMBANKMENT	16,000m^3
	RIPRAP PITCHING FOR DAM	1,300m^3



Note: ( ) days of dredging, riprapping & concreting
1,2,3,4....serial number indicates replacement of dredger

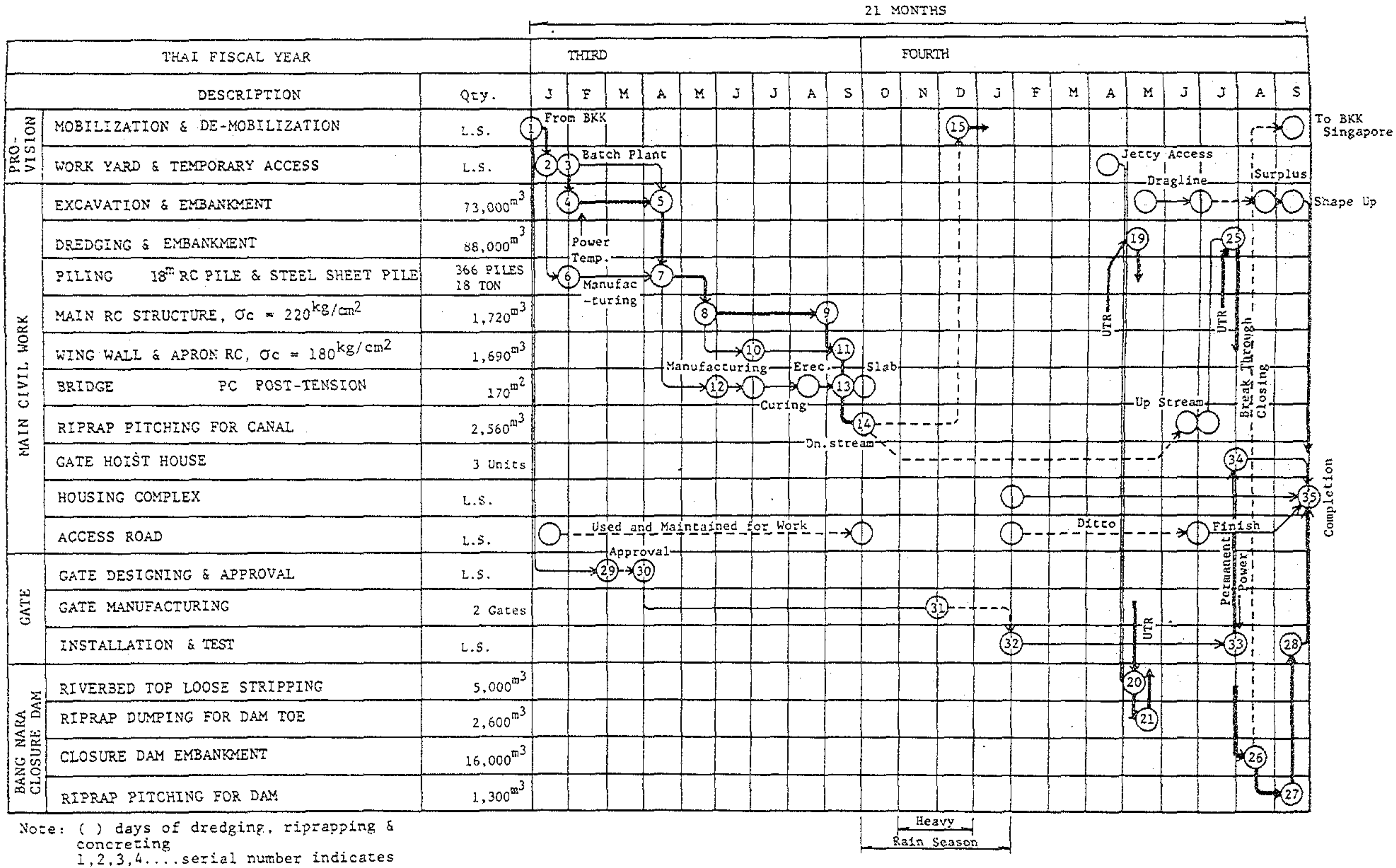
Table 5-7 (1) Construction Network Diagram for UTR



	DESCRIPTION	Qty.
PRO-VISION	MOBILIZATION & DE-MOBILIZATION	L.S.
	WORK YARD & TEMPORARY ACCESS	L.S.
MAIN CIVIL WORK	EXCAVATION & EMBANKMENT	178,100m^3
	DREDGING & EMBANKMENT	360,000m^3
	PILING, RC PILE (12m & 6m) & STEEL SHEET PILE	694 PILES 70 TON
	MAIN RC STRUCTURE, $\sigma c = 220^{kg/cm^2}$	4,520m^3
	WING WALL & APRON, RC, $\sigma c = 180^{kg/cm^2}$	4,280m^3
	BRIDGE PC POST-TENSION	840m^2
	RIPRAP PITCHING FOR CANAL	7,210m^3
	GATE HOIST HOUSE	7 Units
	HOUSING COMPLEX	L.S.
	ACCESS ROAD	L.S.
GATE	GATE DESIGNING & APPROVAL	L.S.
	GATE MANUFACTURING	6 Gates
	INSTALLATION & TEST	L.S.
BANG NARA CLOSURE DAM	RIVERBED TOP LOOSE STRIPPING	18,000m^3
	RIPRAP DUMPING FOR DAM TOE	14,000m^3
	CLOSURE DAM EMBANKMENT	75,000m^3
	RIPRAP PITCHING FOR DAM	5,200m^3

Note: ( ) days of dredging, riprapping & concreting
1.2.3.4....serial number indicates replacement of dredger

Table 5-7 (2) Construction Network Diagram for LTR



THAI FISCAL YEAR		Qty.
	DESCRIPTION	
PRO-VISION	MOBILIZATION & DE-MOBILIZATION	L.S.
	WORK YARD & TEMPORARY ACCESS	L.S.
MAIN CIVIL WORK	EXCAVATION & EMBANKMENT	73,000m^3
	DREDGING & EMBANKMENT	88,000m^3
	PILING 18^m RC PILE & STEEL SHEET PILE	366 PILES 18 TON
	MAIN RC STRUCTURE, σc = 220$^{kg/cm^2}$	1,720m^3
	WING WALL & APRON RC, σc = 180$^{kg/cm^2}$	1,690m^3
	BRIDGE PC POST-TENSION	170m^2
	RIPRAP PITCHING FOR CANAL	2,560m^3
	GATE HOIST HOUSE	3 Units
	HOUSING COMPLEX	L.S.
	ACCESS ROAD	L.S.
GATE	GATE DESIGNING & APPROVAL	L.S.
	GATE MANUFACTURING	2 Gates
	INSTALLATION & TEST	L.S.
BANG NARA CLOSURE DAM	RIVERBED TOP LOOSE STRIPPING	5,000m^3
	RIPRAP DUMPING FOR DAM TOE	2,600m^3
	CLOSURE DAM EMBANKMENT	16,000m^3
	RIPRAP PITCHING FOR DAM	1,300m^3

Note: ( ) days of dredging, riprapping & concreting
1,2,3,4....serial number indicates replacement of dredger

The procedure of operations with reference to Figures 5-1 and 5-2 is outlined as follows:

(1) Closing of the Regulator Gates
When the water level in the storage is lower than the downstream tide level, every gate is closed to prevent the adverse flow.

(2) Operation for Overflow
When the impounding water level in the storage is higher than the downstream water level and the vertical difference between two levels is not large, the surplus water is discharged as overflow by the upper leaf. In this way, the operation of drop-down of the upper leaf is executed timely.

(3) Submerged Flow
When the water level in the storage is higher than the downstream water level and the vertical difference between two levels is large, the surplus water is discharged as submerged flow by the lower leaf. In this way, the lower leaf is opened partly and high salinity remaining in the lower layer of the Bang Nara water storage can be discharged.

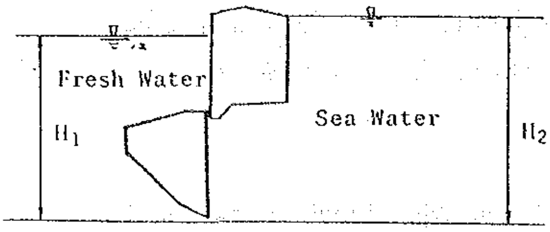
(4) Full Opening
When a large amount of inflow into the storage during the flood discharged through the tidal regulators, every gate is fully opened.

The impounding water level in the Bang Nara storage would be generally operated by adjusting a relation among the three functions: (i) outflow for the irrigation purpose, (ii) groundwater level adjacent to the farmland, and (iii) outflow to flush the sand bar across the river mouths. If water level of the storage is lower than the normal impounding water level for a fairly long time, the gates of the tidal regulators would be closed. But when the water level fluctuates in and around the normal impounding water level, these gates would be controlled pertinently.

The Nam Baeng channel from Mae Nam Bang Nara to the ocean with a tail tidal regulator about 400 m upstream from its channel-end was open sometimes during the high flood season, but was soon blocked from the ocean side by a sand bar right cross the opening to a level of approx. EL +2.0 m. During the 1984 flood, the sand bar was opened by digging a narrow ditch and then adding the flowing water for flushing sand. In order to make any outlet open, much of the sand would have to be artificially moved from the east side of the outlet to its west side. In case of the Nam Baeng regulator, the same operation procedures would be repeated.

FIGURE 5-1 OPERATION MODE OF TIDAL REGULATORS

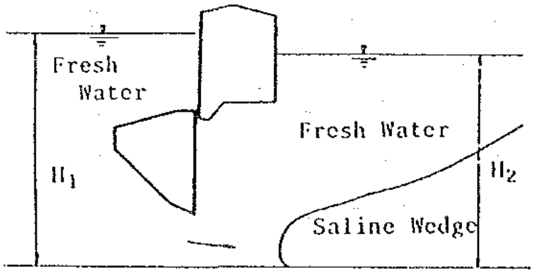
(1) All Close Mode



If $H_1 < 1.03\ H_2$, all gates are closed in order to prevent the adverse flow of sea water.
Even if $H_1 > H_2$, the following condition is required to start the underflow gate operation. When the water level of the reservoir is 0.5 m;

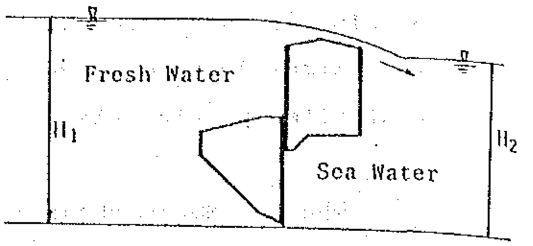
UTR: $H_1 - H_2 > 13$ cm
LTR: $H_1 - H_2 > 16$ cm

(3) Submerged Mode



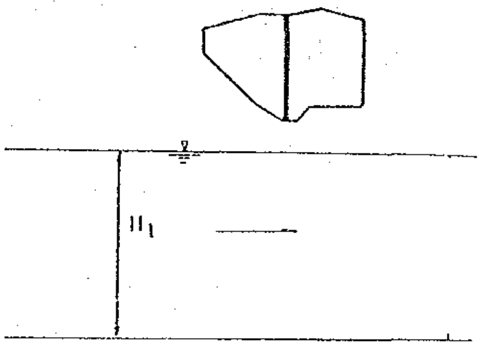
If the vertical distance between inside and outside water levels is considerably large, the underflow gate can be opened. Because water flow through the underflow gate will have the potential energy enough to push back saline wedge shown in FIGURE

(2) Overflow Mode



Even if $H_1 > H_2$, when the underflow gate can not be opened in order to prevent the adverse flow of sea water, surplus water and river maintenance flow are discharged through overflow gate.

(4) Full-open Mode



According to hydraulic simulation, when water level in the reservoir is 1.0 m (MSL) and the outside condition of the gates is in high tide, the discharge in the river through UTR is about 500 m^3/s, and therefore, all gates of UTR must be opened fully. If the gate discharge is Q, in the case of UTR,

$$Q = CBW \times \sqrt{2g \cdot \Delta H} = 0.62 \times 120 \times 4.8 \times \sqrt{19.6} \times 0.1 = 500\ m^3/s.$$

At the preparation of flood stage, when the discharge at the confluence of the Yakang river and the Bang Nara river is more than 500 m^3/s (equal to 250 m^3/s at x 73 in the Yakang river) and a rising of water level in the reservoir continued more than 0.5 m, full-open mode should be started.

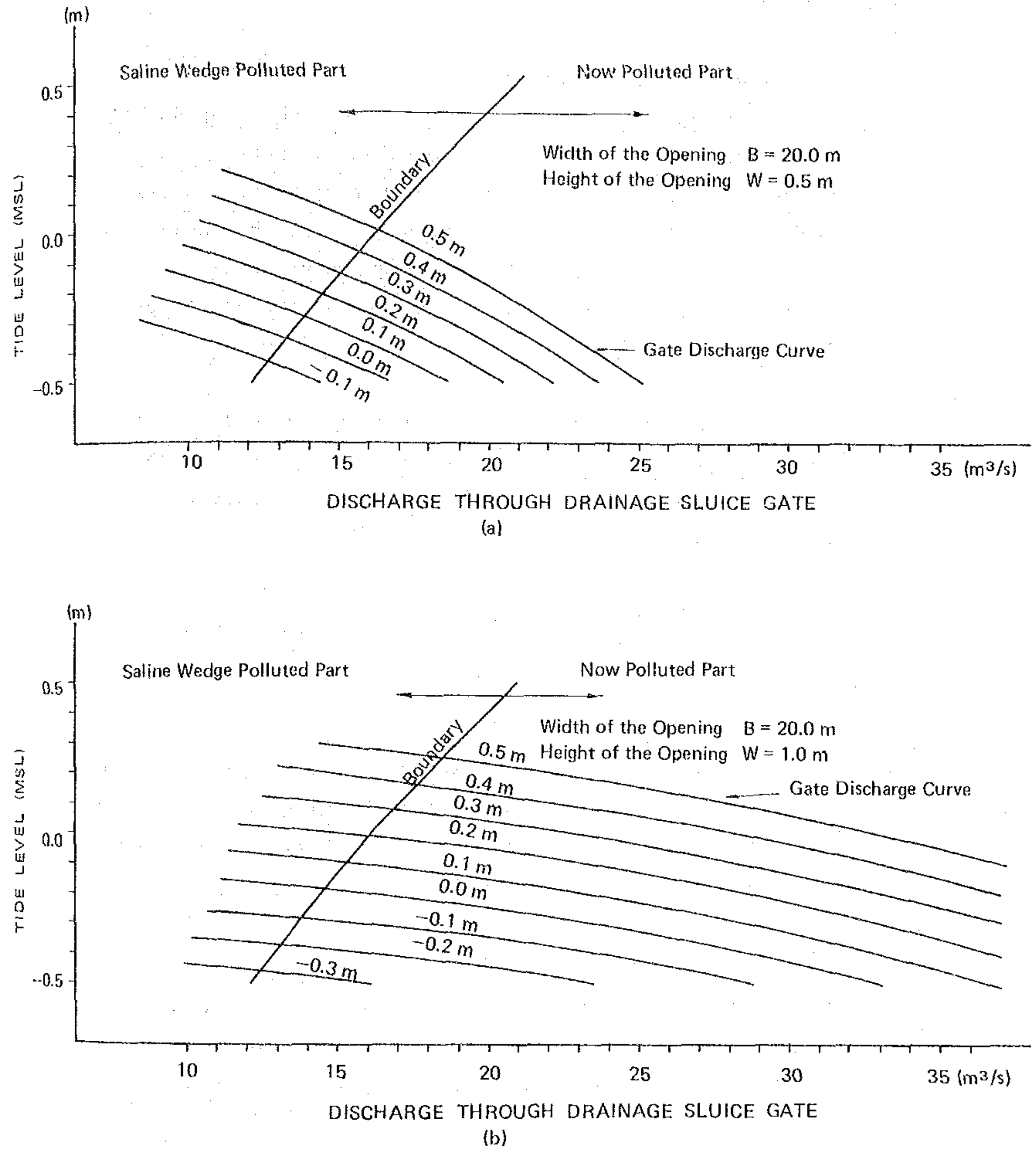


FIGURE 5-2 **UNDER FLOW GATE OPERATION IN ORDER TO CONTROL THE INTRUSION OF SALINE WEDGE**

5.2 Acidic Water Flow Check Facilities

5.2.1 General Concept

The location of the facilities would be chosen in consideration of the profile of the river which needs acidic water flow check facilities as outlined in para.4.2.5 of Chapter 4. With the fact that the potential acid sulfate soil exists 0.5 m under the ground surface, the facilities would be located so that the upstream water level in the river is less than 0.5 m under the ground surface to prevent the potential acid sulfate soil from oxidizing.

In order that the gate for discharging small amount of rainwater in the dry season can be operated easily, the facilities would have a fixed weir on either side of the gate within the range of existing river width.

5.2.2 Location and Types of Facilites

(1) Location

The optimum number and location of acidic water flow check gates are determined considering longitudinal section of the target river (Refer to Figure 5-3). Location of the water level check gate is shown below:

o Khlong Ku Bae Ya Hae (1 place)
KM. 0+000 (At the river mouth)

o Khlong Sg. Padi (2 places)
KM. 0+500 (500 m upstream from the river mouth)
KM. 6+000

o Khlong To Lang (1 place)
KM. 2+200(About 1.5 km upstream from the existing check gate)

o Khlong Bang Toei (4 places)

On the boundary of the Study area between the To Daeng Swamp.

(2) Types of Facilities

Two kinds of facilities, (1) fixed weir type and (2) movable gate type, are designed for the water level control facilities. The facility with a fixed-type weir is of simple construction, and needs little operation, so that O & M cost is lower than the others. However, the fixed-type weir sometimes causes overflowing of flood water, inundating the upstream area in the flood season. On the other hand, the gate type structure is movable so that the structure does not cause any flood influence at its upstream when adequate flow area is given, but this invites complicated operations and higher O & M cost. Considering these merits and demerits, the most suitable type would be selected at each of the proposed sites.

o Khlong Bang Toei

Since the To Daeng swamp is located at the upstream of the sites, it would in no way impede the operation to raise water level at flooding time. Therefore, the fixed-type facility is used on this river.

o Other rivers

Considering the topographic and social conditions, the slide gate type facility would be applied. Especially, the radial gate type facility would be employed for Khlong Sg. Padi due to the considerable flood discharge.

5.2.3 Site Geology and Soil Properties

Major check gates include those of Ku Bae Ya Hae, Sg. Padi No.1, Sg.Padi No.2, and To Lang. The following describe the site geology and soil properties of the points where the gates, other than the To Lang, are to be provided. *For the To Lang gate, refer to para.* IX-3-1 *of* Appendix IX.

Topography and Geology

The proposed location of the Ku Bae Ya Hae gate is at a confluence point between Khlong Ku Bae Ya Hae and Mae Nam Bang Nara, that of the Sg. Padi No.1 gate at a confluence between Khlong Nam Baeng and Mae Nam Bang Nara, and that of the Sg. Padi No.2 gate at a confluence between Khlong Nam Baeng and *Khlong Sg. Padi. The elevation of each site is* +0.4 *to* 1.6m, and the location is in swamp area. These sites are shown in Figure IX-2-2 of Appendix IX.

The geological conditions at each site consist, from upper to lower, of a very soft clayey silt layer, a medium to very stiff clayey silt layer and a sand layer, and partly of a peat layer and a granite layer in other areas (refer to Figure IX-2-3 of Appendix IX).

The foundation of existing bridge (Pi Leng project) is of the 8 to 18 m length pile construction presumably being held in a medium to very stiff clayey silt layer. As is clear from the fact that N-value of this layer is 3 to 21, it implies that the layer would have in part a considerably high bearing capacity and a large friction resistance would be generated against the piles being driven in. However, in the clayey silt layer, settlement would possibly occur. A bearing stratum should, *therefore, be the sand layer or granite layer distrubuted at a* depth of 10.9 to 25.3 m or lower. The pile length for the regulator under the Pi Leng project is designed at 20 m.

The pile length of the gates and the allowable bearing capacities of the sand or granite layer when used as a bearing stratum are as shown below:

Gate	Length of pile (m)	Allowable bearing capacity (ton)
Ku Bae Ya Hae	17 - 22	119 - 246
Sg. Padi No.1	27 - 28	281
Sg. Padi No.2	25	140

Note: (1) Type of pile = precast reinforced concrete pile
(2) Size of pile = 400 mm x 400 mm
(3) Calculation formula = refer to Appendix IX-3-1.

Soil Properties

The soil properties of each layer are as presented in Table 5-8. Bulk density, nature void ratio, cohesion, angle of internal friction, compression index, and coefficient of permeability are estimated by the same methods as applied to UTR in para. 5.1.1.

Table 5-8 Soil Properties (Acidic Flow Check)

Layer	Clay - Silt		Sand
	Very soft to soft	Medium to very stiff	
N-VALUE	0 - 4	5 - 24	8 - 50<
LIQUID LIMIT WL (%)	47.9 - 78.8	40.5 - 56.25	-
SOIL CLASSIFICATION (ASTM)	OH. MH. CL. CH	CL. CH	SW. SP. SM. SC
BULK DENSITY rt (g/cm^3)	1.4	1.7	1.9
NATURE VOID RATIO e_n	1.1 - 1.7	-	-
COHESION C (kg/cm^2)	0.03 - 0.25	0.31 - 1.50	0
ANGLE OF INTERNAL FRICTION ϕ (°)	0	0	29 - 42
COMPRESSION INDEX Cc	0.34 - 0.62	0.27 - 0.42	-

5.2.4 Preliminary Design

(1) Ku Bae Ya Hae Check Gate

(i) Catchment area

As the potential acid sulfate soil in the embankment of the Ku Bae Ya Hae canal is distributed up to approx. 5 km upstream of the junction of Khlong Ku Bae Ya Hae and Mae Nam Bang Nara at the ground elevation of + 1 m, this check gate would be provided near the above junction point. The catchment area at this point is 14.3 sq.km.

(ii) Design flood discharge

The design flood discharge at this catchment area would be 12.58 cu.m per sec when calculated on the basis of the drainage module (8.8 litre per sec per ha) referred to para. 4.3.1.(2) of Chapter 4. On the other hand, the design flood discharge for the Khlong Ku Bae Ya Hae construction project carried out by RID is 12.822 cu.m per sec. With this in mind, the design flood discharge would be set at 13 cu.m per sec.

(iii) Gate width

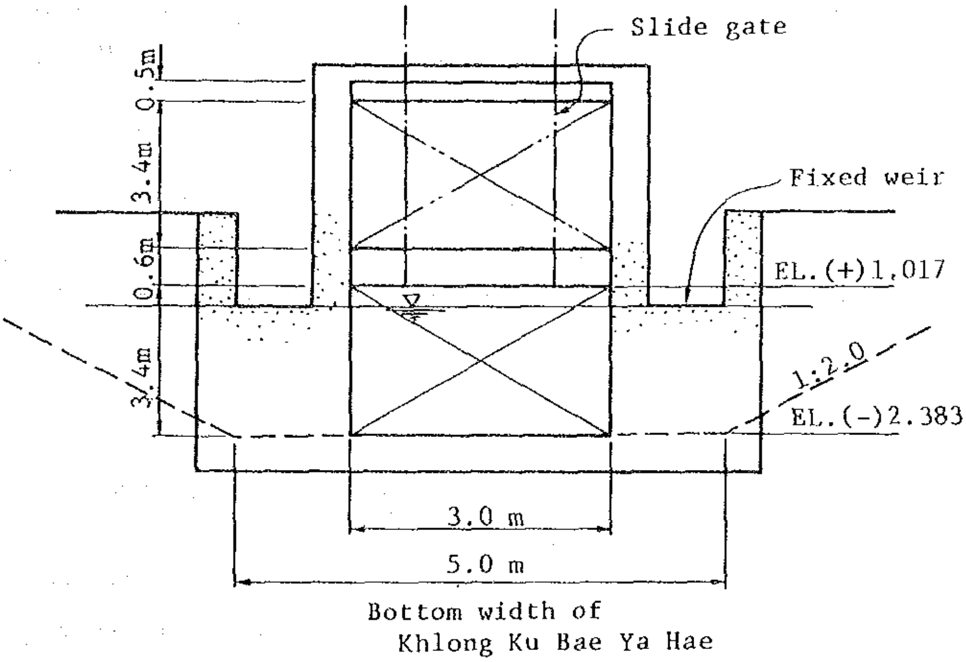
The 2 km section of Khlong Ku Bae Ya Hae from the junction point was constructed at a drainage canal gradient of 1:8,000 with a design velocity of 0.62 m per sec. To prevent silt from building up, a velocity of 1.0 and 1.5 m per sec is often used, therefore, through-gate velocity would be taken at 1.5 m per sec. The elevation of the check gate bottom would be -2.383 m. Assuming the water level is maintained at EL +0.5 m because the potential acid sulfate soil on the upstream side is distributed, at EL +1.0 m, water depth would be 2.883 m (Refer to Figure 5-3). From the above, the width of the check gate would be:

$$B = \frac{13.0}{1.5 \times 2.883} = 3.0\text{m}$$

In this connection, the difference in water level between the upstream and downstream of the gate would be $h\Delta = 0.10$m which is derived from the equation for flood discharge through the gate, $\Delta h = \frac{1}{2g} \frac{Q^2}{(\mu.B.H)}$.

It can be judged that the gate would in no way affect the upstream.

The typical configuration of the check gate would be shown as follows:



(2) Sg. Padi Check Gate

(i) Catchment area

The water quality survey made for Khlong Sg. Padi indicates that the section of about 7.5 km extending from the point where Khlong Sg. Padi joins Mae Nam Bang Nara to the upstream contains the acidic water. And, the soil distribution chart shows that the strong acid soil is distributed within this section. Judging from the topographical conditions based on the relief map (scale: 1/10,000) and assuming the junction point of Khlong Sg. Padi to be KM.0 + 000, it would be considered necessary to provide a check gate near the stations KM. 0 + 500 and 6 + 000. Since both stations are located in close vicinity each other when measured in comparison with the overall basin and the left side of the downstream is blocked by the dike constructed as part of the Pi Leng project, both stations seem to have almost the same catchment area at 78.2 sq km.

(ii) Design flood flow volume

From a drainage module (8.2 litre per sec per ha), the design flood discharge would be 65 cu.m per sec.

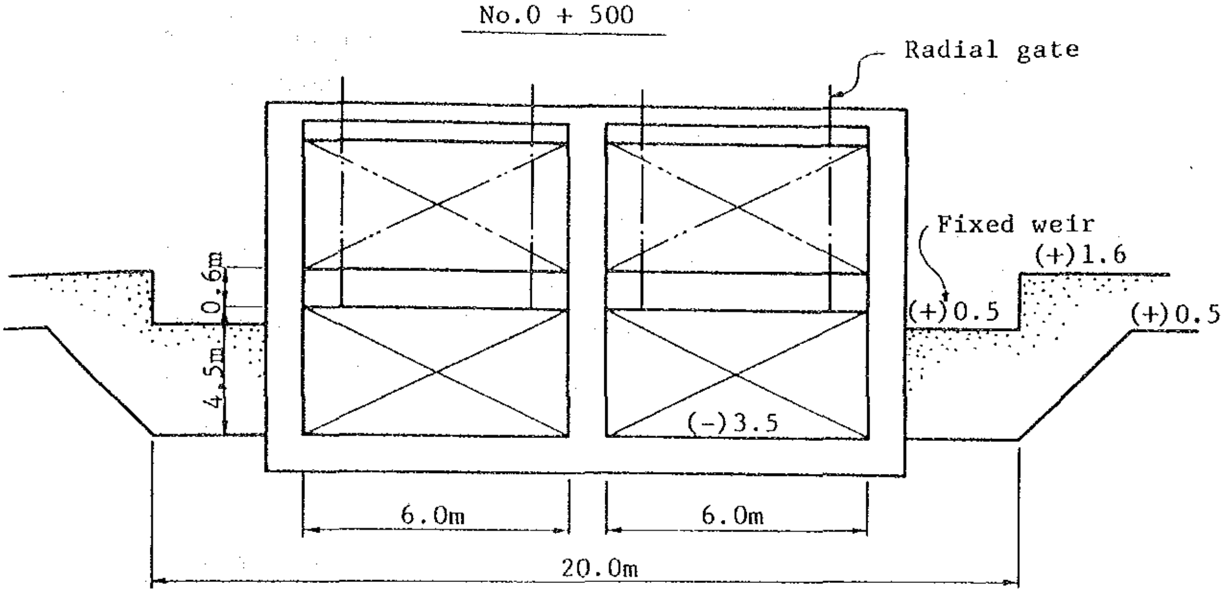
(iii) Gate width

From the site investigation, the conceivable configuration of the river near the station KM. 0 + 500 is 28 m in water surface width and is some 20 m in riverbed width with side slope of 1 : 1. The estimated riverbed elevation near this station is - 3.50 m, and the estimated river gradient at the downstream area of Khlong Sg. Padi is 1 to 10,000. When the flow velocity within the flood flow check gate is set at 1.5 m per sec, the gate width would be:

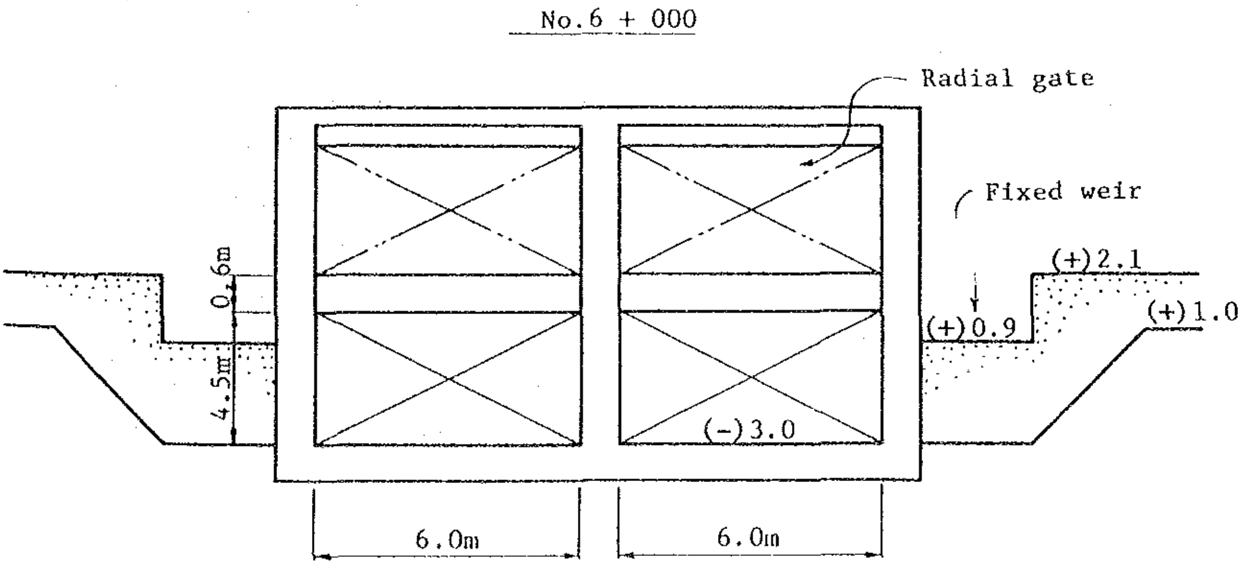
$$B = \frac{65}{1.5 \times 3.9} = 11.2\text{m say } 12\text{m} \quad (\Delta h = 0.10\text{m})$$

From the above, the typical configuration of the check gate would be shown as follows:

o Check gate No. 1



o Check gate No. 2



(3) To Lang Check Gate

(i) Catchment area

Currently there is the check gate 700 m upstream from the point where Khlong To Lang joins Mae Nam Bang Nara. However, judging from the topographical conditions of the Khlong To Lang basin area, this check gate would be insufficient to provide acidic water control. Therefore, another check gate would be provided at a point 2.2 km upstream from the junction point. The catchment area at this point is 6.7 sq.km.

(ii) Design flood discharge

From a drainage module (9.1 litre per sec per ha), the design flood discharge would be 6.1 cu.m per sec.

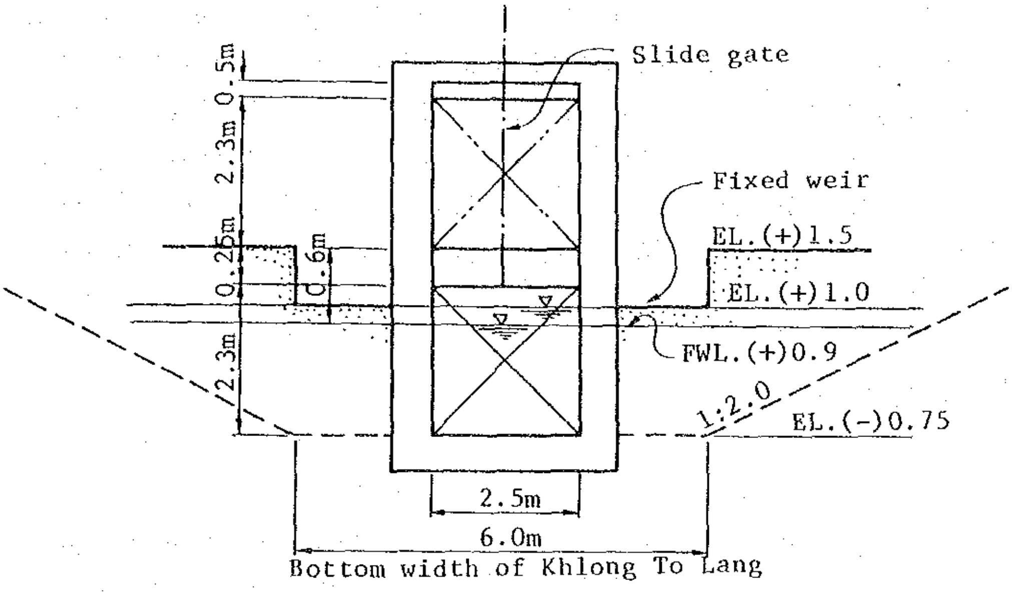
(iii) Gate width

As in the case of the Ku Bae Ya Hae check gate, the flow velocity through this check gate would be 1.5 m per sec. As the elevation of existing check gate bottom is EL - 1.0 m and the riverbed gradient of approximately 1 to 8,000, the elevation of the riverbed at this point would be EL - 0.75 m. Also, assuming that the width of riverbed is 6 m and the side slope is 1:2, the water depth required to allow the above flood discharge would be 1.65 m. Therefore, when the water depth where the check gate stands is taken at 1.65 m, the gate width would be 2.5 m with _h = 0.10 m.

(iv) Control water level

From the relief map and other data, the ground level around the drainage channel upstream from this gate is around EL + 1.5 m, therefore, the control water level would be set at EL + 1.0 m.

From the above, the To Lang check gate would be designed below:



(4) Bang Toei Check Structures

(i) Location

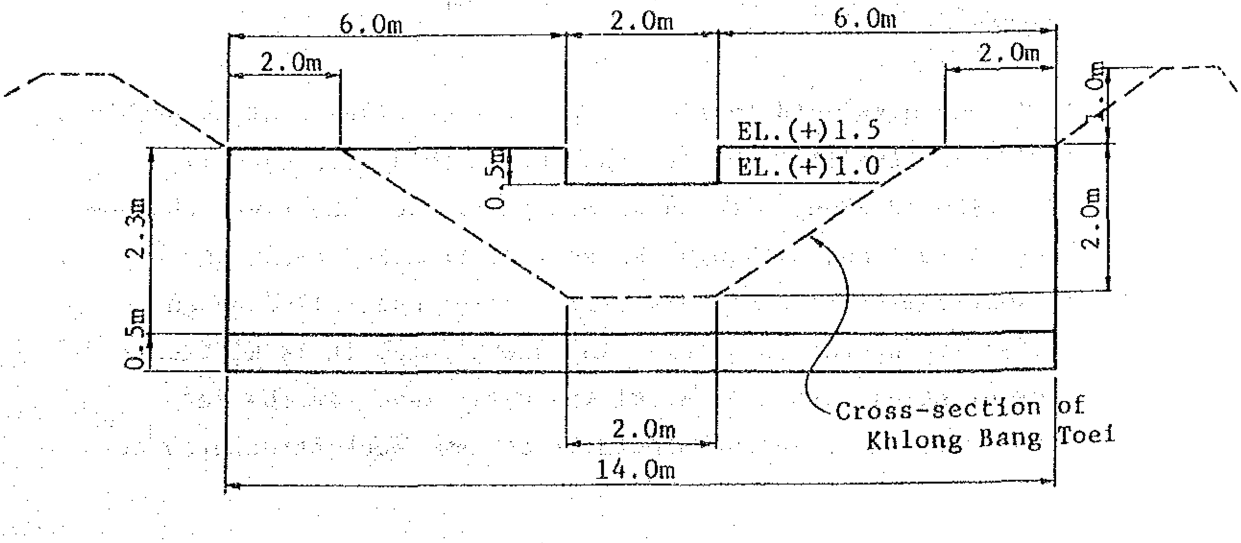
The high acidity registered in this river could possibly be due to the fact that the potential acid sulfate soil distributed along both banks or upstream of the river changes into actual one although the soil distributed along the downstream section of this river can be controlled by an effective operation of existing check gate, it is difficult for existing gate to control the water level in the far upstream, and then the provision of new check structures at four places at the upstream end of the main stream and tributaries of existing river would be necessary.

(ii) Type of structures

The upstream side of the proposed check structures faces expansive grassland/swamp area without human settlement. No problems are envisaged when the water level on the upstream side is to be raised in the rainy season by the provision of a fixed weir. In the dry season, as the water level in the controlled river course is kept 0.5 m below the ground level, there would be no effect on the environment of this region. With this in mind, a fixed weir type check structure with lower construction cost and easier maintenance and control would be designed.

(iii) Typical configuration

The typical configuration of a weir would be accomplished taking into account the cross-sectional shape of the tributary. As the ground level of the upstream side is approx. + 1.5 m, the top of a weir subject to the normal overflow would be set at EL + 1.0 m.



5.2.5 Mode of Operations

(1) General

Since the subject facilities are to prevent the potential acid sulfate soil from changing to actual one, the effective operation of the facilities during the dry season takes a high priority. During the rainy season, because the ground surface is thoroughly wet by frequent rainfalls, it would not always be necessary to keep this river water level 50 cm below the ground surface of the problem soil, and if the gate is closed, it would be rather dangerous for the upstream region to be damaged by ponding. For this reason, the gate should be kept open in the heavy rainy days.

During the dry season, the gate is closed to store outflow water in the river course so as to hold the surrounding groundwater level. For the purpose of facilitating the adjustment of water level, it is suggested that a plate bearing the ground elevation and control water level for use in water level adjustment is displayed in a visible manner so as to render a rise in the water level vs. the rainfall in the upstream region instantly recognizable.

(2) Operation of Existing Check Gates

Since existing check gate has no fixed weir, the water level gauge on the check gate would be promptly checked to confirm the current water level whenever the region is subject to rainfall, and, if necessary, the gate would be opened to release the stored water. In this case, caution should be exercised in ensuring that the water level in the upstream region does not become too low. However, in the case of low-flow discharge, a marginal excess release of the stored water is allowable being subject preferably to a thorough investigation of the outflow mechanics in the upstream region to establish a suitable method in advance.

(3) Operation of the Proposed Check Gates

As the new check gate has a fixed weir, operation of the gate can be simplified. However, when the water in the upstream region is above the tolerable level, the gate would be opened to release the water stored. In this connection, the check gate would be provided with the maximum water level capable of tolerating an overflow from the fixed weir only so as to ease the gate operation in relation to the water level in the upstream region.

The foregoing has outlined the check gate operation. In carrying out the actual operations, the flood characteristics in the upstream region should always be thoroughly investigated in advance to establish the most suitable gate operational criteria for each site.

Figure 5-3 (1)   Longitudinal Section of Target Rivers for Acidic Flow Checks

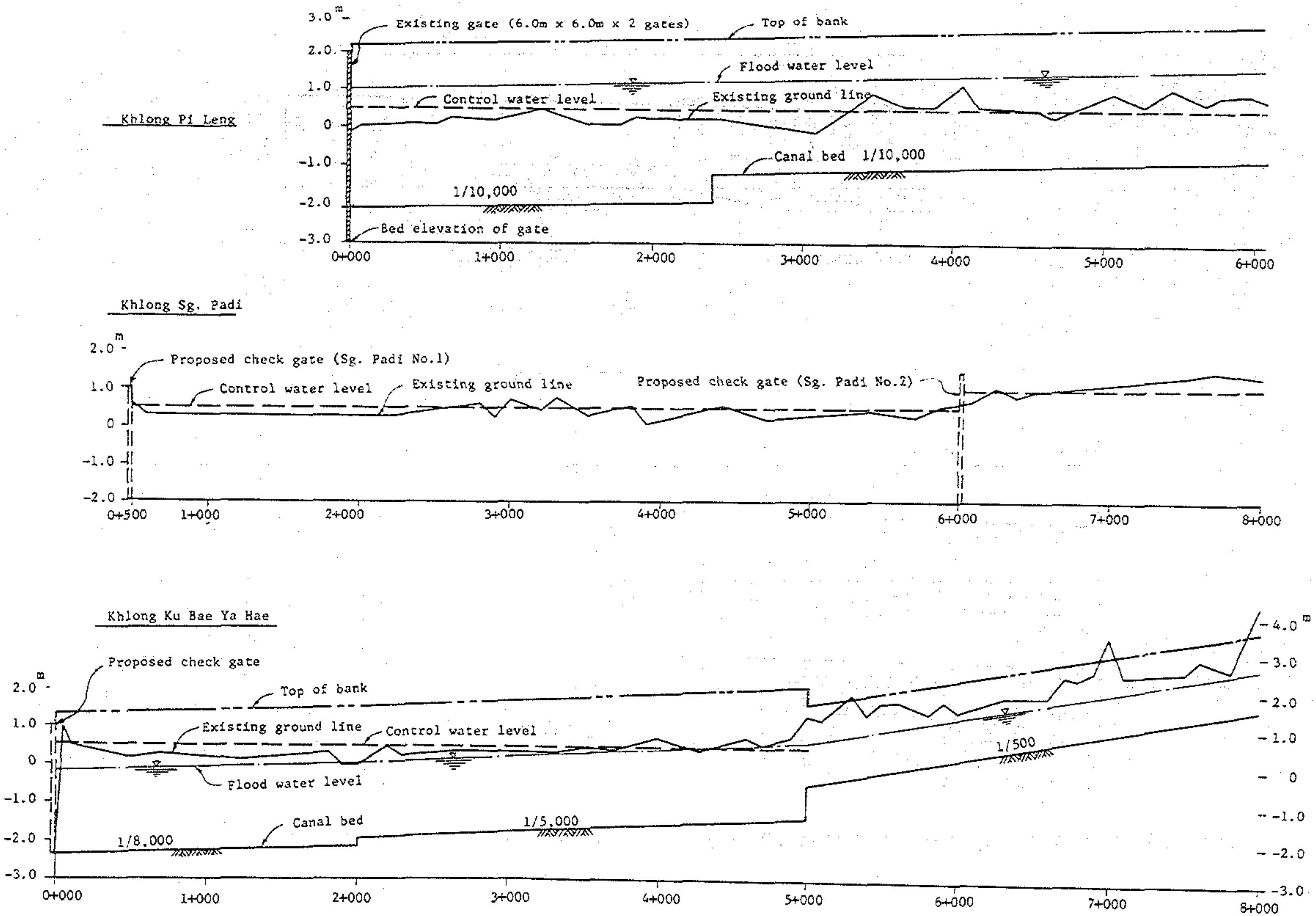
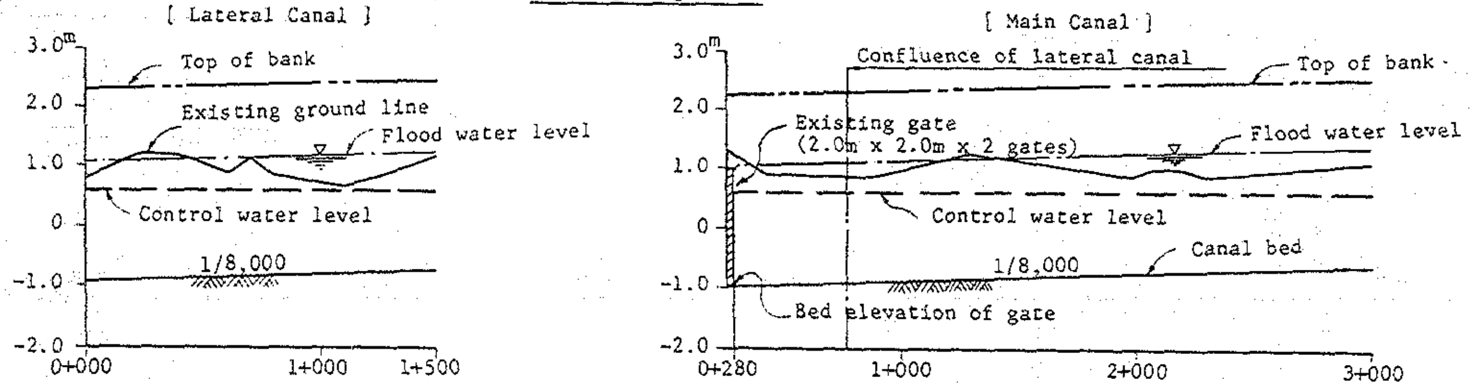
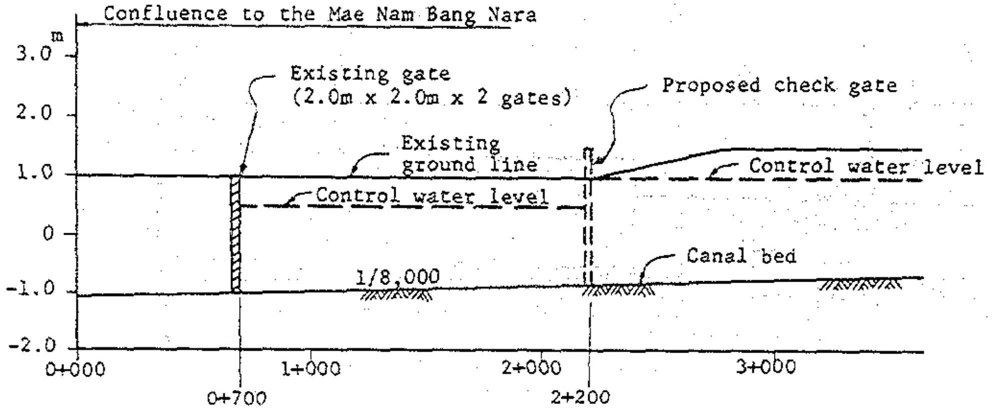


Figure 5-3 (2) Longitudinal Section of Target Rivers for Acidic Flow Checks

Khlong Bang Toei



Khlong To Lang



5.3 Drainage Improvement Facilities

5.3.1 General Concept

Improvement work of the drainage canal would be carried out by adopting the earth canal method. The longitudinal gradient would be determined in such manner that the velocity at the time of flooding would not cause scouring, and the drops would be provided wherever required. The embankment of drainage canal would be used as a maintenance service road with sufficient width to enable it to function as a village road too. Wherever the drainage canal intersects existing roads, the bridges would be rebuilt as occasion demands. Also, in high-lying paddy field where the drainage conditions are poor according to the site survey, new drainage canals would be provided.

5.3.2 Preliminary Design

(1) Expansion of existing canal cross-sections

(a) Design flood discharge

The design flood discharge from each of the canals for improvement would be obtained by using a 1:50,000 scale relief map for the catchment area and then by using the drainage module in para 4.3.1 of Chapter 4 for the design flood discharge for each point. The design discharge for improvement is presented in Figure 5-4.

(b) Dimensions of canal

(i) Cross-section would have a ratio of 1 for water depth to 2 for bottom width, so that excavation depth would not be too great in relation to the required discharge.

(ii) Considering the stability of slope surface in terms of consolidated cohesive soil, side slope gradient would be taken at 1:1.5.

(iii) Because the riverbed material consists of cohesive soil and the flood lasts for only a short period, flow velocity would be set at 1.1 m per sec which is 50 percent greater than 0.7 m per sec of the normal design flow velocity.

(iv) Freeboard (Fb) would be given will be calculated by applying the following equation:

$$Fb = 0.05D + hv + 0.15$$

D : Water depth (m)

hv : Velocity head (m).

From the above conditions, the canal dimensions would be given as presented in Table 5-9.

(c) Design cross-section canal and length to be improved.

From the above design flood discharge and the canal dimensions, the improvement section of problem drainage canals is shown in Figure 5-4, and the typical design cross-sections are shown in Figure 5-5.

(2) Construction of new canals

(a) Design flood discharge

Sub-project	Drainage area (km2)	Design flood discharge (Q) (m3/sec)
1. Ban Lo Mo	1.2	1.27
3. Khlong Ku Ra Po	2.3	2.44
6. Khlong To Che (1)	2.2	2.33
" (2)	2.7	2.48
8. Khlong Chang	4.0	3.68
15. Ban Sala Pradu	1.8	1.91
16. Khlong Sala Mai	3.2	3.40
"	(1.1)	(1.17)
"	(2.1)	(2.23)

(b) Dimensions of canal

The conditions to determine the demension of new canals are as follows:

(i) The ratio of water depth to bottom width at 1:2.

(ii) Side slope gradient at 1:1.5.

(iii) Bearing in mind the riverbed material, the flow velocity is the same as the case of improvement of existing canals.

(iv) Fb = 0.05D + hv + 0.15.

(v) From the topographical conditions at each location, the longitudinal gradient of the canal would be generally be 1:1,000.

From these conditions, the dimensions of the canal would be established as follows. Typical cross-section of the new canals is shown in Figure 5-6, and the canal dimensions are given below:

Sub-project		Q(m3/sec)	b(m)	d(m)	Fb(m)
1.	Ban Lo Mo	1.27	1.40	0.70	0.25
3.	Khlong Ku Ra Po	2.44	1.80	0.90	0.25
6.	Khlong To Che (1)	2.33	1.80	0.90	0.25
	(2)	2.48	1.80	0.90	0.25
8.	Khlong Chang	3.68	2.10	1.05	0.25
15.	Ban Sala Pradu	1.91	1.80	0.90	0.25
16.	Khlong Sala Mai	3.40	2.10	1.05	0.25
	"	(1.17)	1.40	0.70	0.25
	"	(2.23)	1.80	0.90	0.25

(3) Major appurtenant structures

(a) Drops

(i) Type

In order to adjust excessive heads of the canal course as well as to allow a safe and unhindered functioning of the canal, drops would be provided along the canal. Drops would be of a vertical type and of an inclined drop, as presented in Drawing No.ID 11 at the end of this Report.

Because of the topographical conditions, most of the drops would be of vertical type. The inclined type would be employed at the drop site where the Bang Nara storages normal impounding water level is maintained in its immediate downstream side and its water depth is sufficient for energy dissipation.

In total, 31 drops (26 vertical and 5 inclined) would be installed for each canal according to the design canal profile, as listed below:

Khlong	Type of Canal (refer to Table 5-9)	Drops	
		Vertical	Inclined
Khlong Ku Ra Po	IV	2	-
Khlong Na Ko	II	1	1
Khlong To Che	VII	1	-
Khlong Lu Bo Manang	II	1	-
"	IV	1	-
Khlong Khok Niang	II	1	-
"	III	2	-
Khlong Chang	III	3	-
"	IV	2	1
Khlong Ba Ngo Du Dung	IV	4	-
"	VI	3	-
"	VIII	-	1
Khlong Ku Rong Ya Ma	III	4	1
Khlong Sala Mai	II	1	1
Total		26	5

(ii) Structure

The vertical drop would have the maximum head of 1.5 m, and after heading, water would be thoroughly energy dissipated in a stilling basin, and subsequently led to the downstream canal. The vertical drop would be of reinforced concrete structure. (Refer to para 3.1 "Design of Vertical Drop" in Appendix IX).

For inclined drop, it would be of wet masonry structure because of low stress dynamically applied to the structure. (Refer to 3.2 "Design of Inclined Drop" in Appendix IX)

(b) Inlet structures

(i) Number of installations

An inlet structure would be provided at the junction of the improved canal and its tributary so as to protect the embankment of the canal near the junction and sustain the continuity of the service road. Moreover, in order to prevent the groundwater level in the area around the canal from being lowered as a result of the canal widening and deepening, a stop-log would be installed upstream of the inlet to maintain the water level of the tributaries.

The number of inlets provided would be determined from the topographical survey made for Khlong To Che including Khlong Lu Bo Manang section where total number of tributaries entering the 15.6 km section would be nine on both the left and right embankments i.e. one inlet at every 3.5 km-interval. Applying this interval to others, the number of inlets would be as follows:

Khlong	Length	No. of Inlets
Khlong Ku Ra Po	9.0	6
Khlong Na Ko	4.9	4
Khlong To Che	15.6	9
(Khlong Lu Bo Manang)		
Khlong Khok Niang	5.5	4
Khlong Chang	9.8	6
Khlong Ba Ngo Du Dung	10.5	6
Khlong Ku Rong Ya Ma	4.7	4
Khlong Sala Mai	5.0	4
Total	65.0	43

(ii) Cross-sections

When it is assumed that the catchment areas of all inlets are approximately equal, an average figure of approx. 2.5 sq. km for each inlet would be obtained based on the Khlong To Che model. Using the drainage module to establish the design flood discharge for this catchment area, a figure of 2.65 cu.m per sec would be obtained. Assuming the flow velocity is 1.1 m per sec being equal to that of the upstream side canal, the cross-sectional area of the canal would be 2.4 sq.m (1.25 m by 1.25 m).

(c) Bridges

Whenever the improved canal intersects with existing roads, bridges are currently provided. Since the cross-section and depth along the improved canal would be greater than those of existing canals, such bridges would be replaced with the concrete structure as occasion demands. Table 5-10 shows the location and size of these bridges.

5.4 Irrigation Facilities

5.4.1 General Concept

The irrigation facilities envisaged for the project can be classified into three categories of (1) WUG pumps, (2) RID pumps and (3) Gravity irrigation facility. Each of the facilities varies in the methods of water intake and conveyance because the respective location of their water sources and irrigation area is all different. With these differences fully in mind, a proper preliminary design has been made to fully demonstrate the function.

Figure 5-4 Schematic Diagram of Drainage Improvement Systems

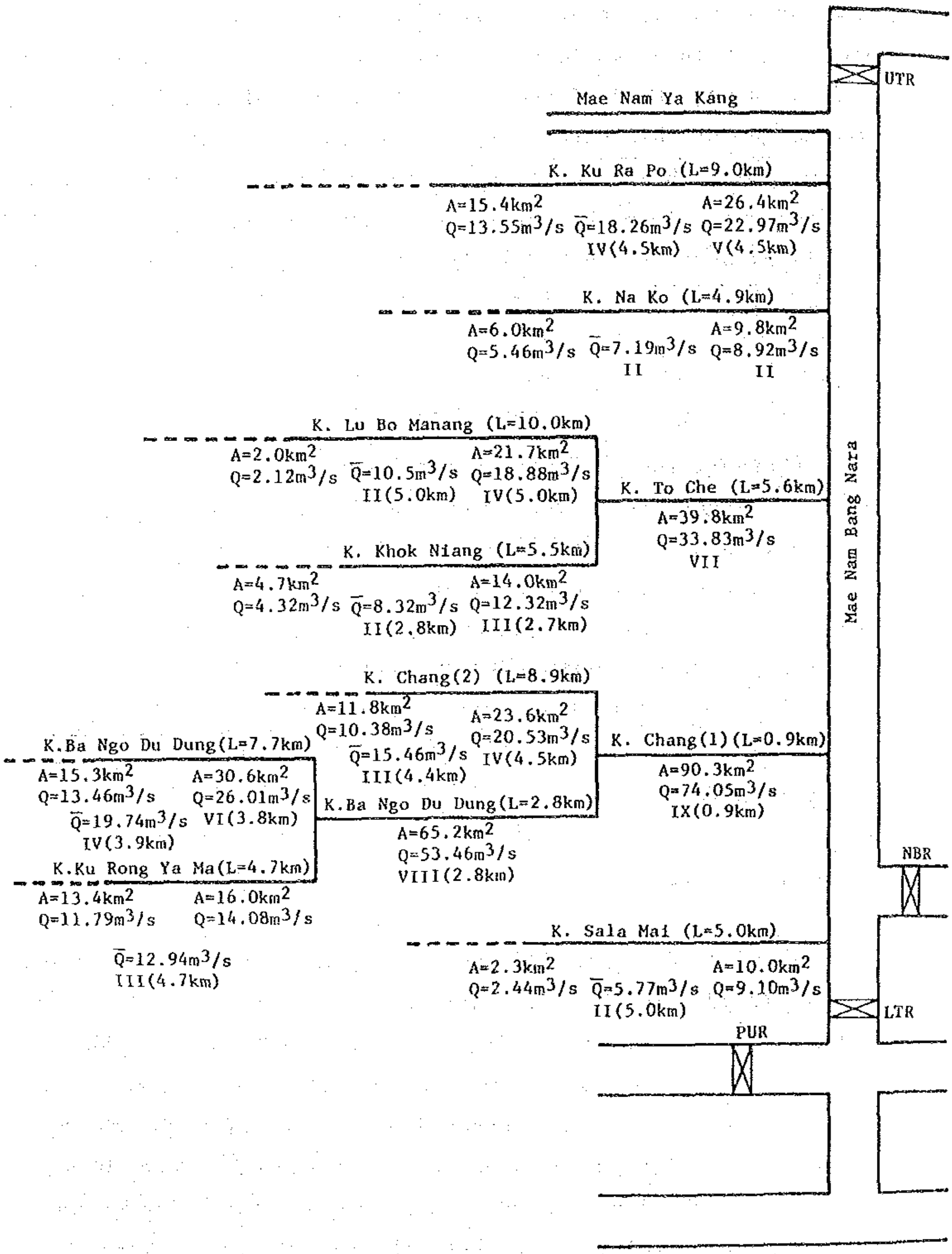


Figure 5-5 Typical Cross-Section for Improvement of Drainage Canal

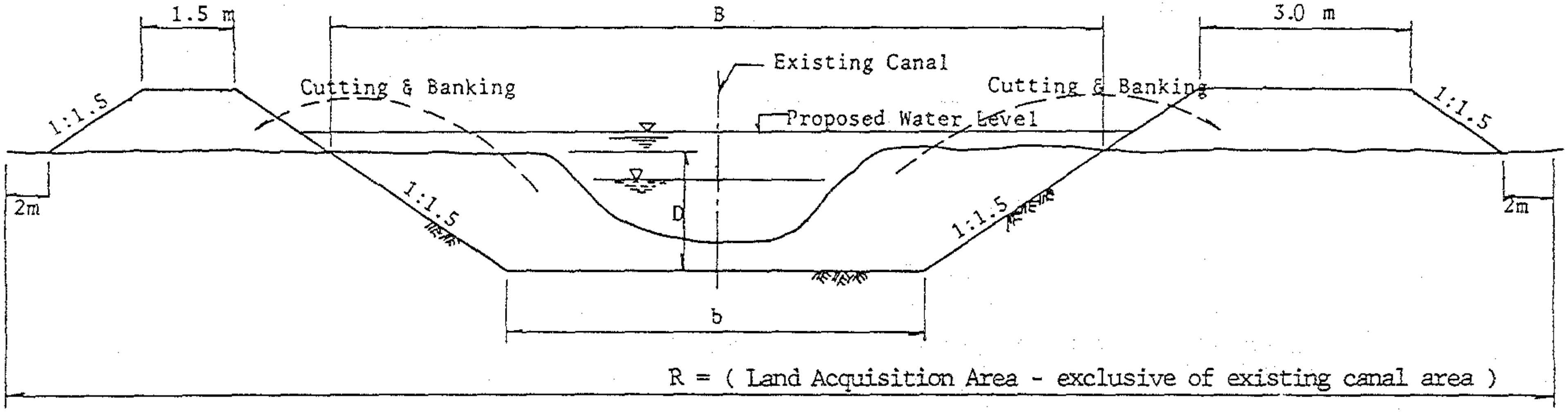


Figure 5-6 Typical Cross-Section for New Construction of Drainage Canal

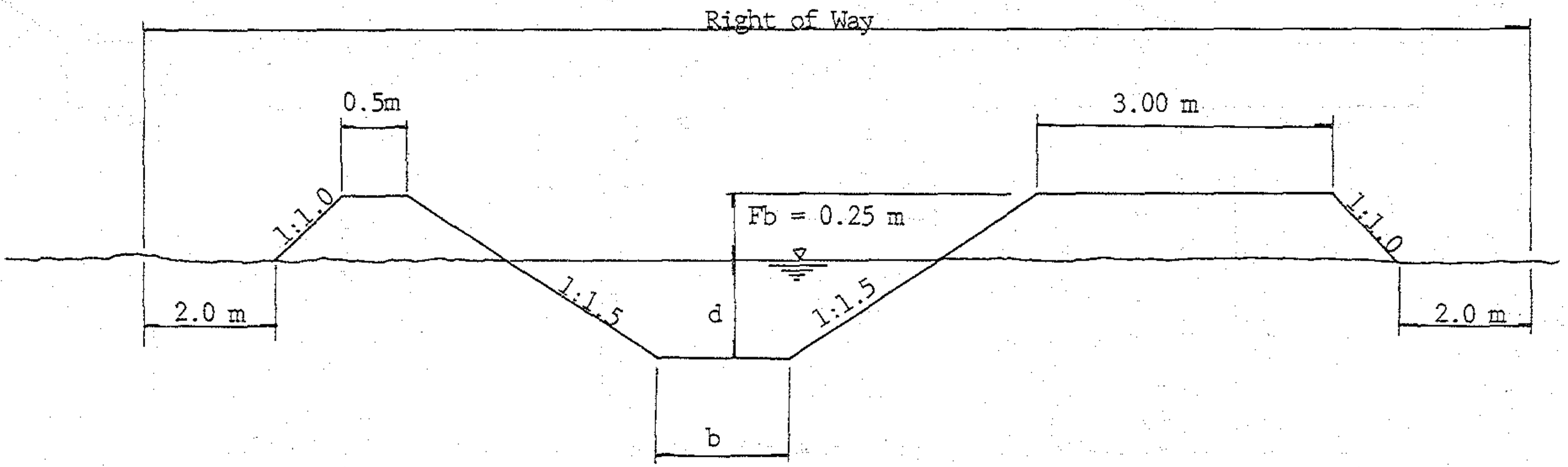


Table 5-9 Dimension of Proposed Drainage Canal (Typical Type)

Type	Q (m^3/sec.)	A (m^2)	D (m)	D' (m)	b (m)	Fb (m)	B (m)	B' (m)	I
I	5	4.9	1.3	0.9	2.0	0.3	5.9	4.7	1/700
II	10	9.5	1.8	1.4	3.0	0.3	8.4	7.2	1/1,100
III	15	14.3	2.1	1.7	4.0	0.3	10.3	9.1	1/1,400
IV	20	19.0	2.5	2.1	4.0	0.4	11.5	10.3	1/1,700
V	25	23.8	2.7	2.3	5.0	0.4	13.1	11.9	1/2,000
VI	30	28.6	3.0	2.6	5.0	0.4	14.0	12.8	1/2,200
VII	35	33.3	3.2	2.8	6.0	0.4	15.6	14.4	1/2,400
VIII	60	57.1	4.0	3.6	8.5	0.4	20.5	19.3	1/3,500
IX	80	76.2	4.0	3.6	13.5	0.4	25.5	24.3	1/4,000

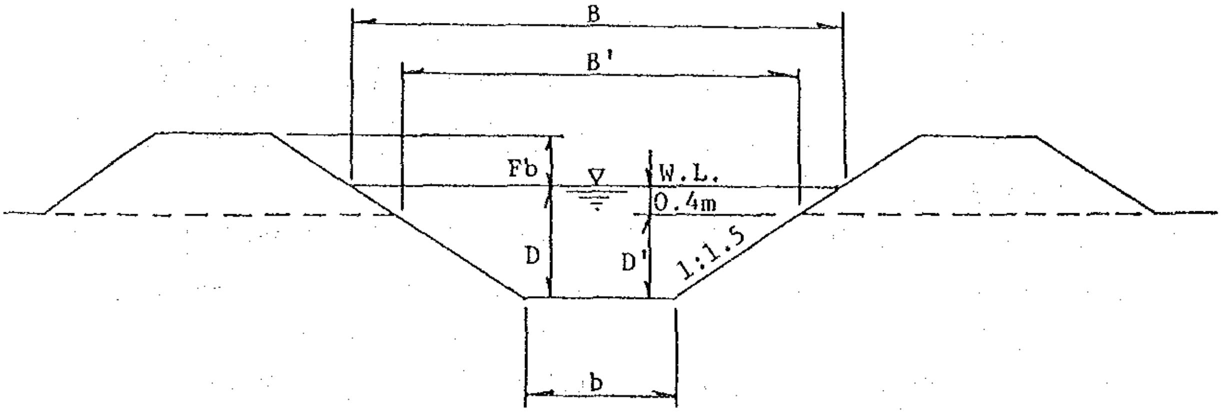


Table 5-10 List of Bridges to be Improved in Drainage Improvement Scheme

No.	Station No.	Type of Road	Type of Canal	Bridge			Note
				Span	Width	Height	
Khlong Ku Ra Po							
1	No.1+800	Amphoe Road	V	14.0^{m}	4.0^{m}	3.0^{m}	Type - III
2	No.3+600	National Rd.	- do -	- do -	5.5	- do -	- do -
3	No.7+200	Amphoe Rd.	IV	14.5	4.0	3.5	Type - II
Khlong Na Ko							
1	No.2+200	Amphoe Rd.	II	10.5	4.0	2.5	Type - IV
2	No.3+300	- do -	- do -	- do -	- do -	- do -	- do -
3	No.4+200	- do -	- do -	- do -	- do -	- do -	- do -
Khlong To Che - Khlong Lu Bo Manang							
1	No.2+000	Amphoe Rd.	VII	18.0	4.0	4.0	Type - I
2	No.2+600	- do -	- do -	- do -	- do -	- do -	- do -
3	No.7+700	National Rd.	IV	13.0	5.5	3.0	Type - III
4	No.11+700	Amphoe Rd.	II	10.5	4.0	2.5	Type - IV
5	No.13+900	- do -	- do -	- do -	- do -	- do -	- do -
Khlong Khok Niang 1/							
1	No.6+500	Amphoe Rd.	III	11.5	4.0	2.5	Type - IV
2	No.9+800	National Rd.	II	10.5	5.5	- do -	- do -
Khlong Chang							
1	No.4+100	Amphoe Rd.	IV	13.0	4.0	3.0	Type - III
2	No.7+350	National Rd.	III	- do -	5.5	- do -	- do -
Khlong Ba Ngo Du Dung 1/							
1	No.4+750	Amphoe Rd.	VI	15.5	4.0	3.5	Type - II
2	No.7+000	National Rd.	- do -	- do -	5.5	- do -	- do -
Khlong Sala Mai							
1	No.0+250	ARD Rd.	II	10.5	5.0	2.5	Type - IV
2	No.1+750	- do -	- do -	- do -	- do -	- do -	- do -

1/ Station No. shows the distance from the Bang Nara Water Storage.

5.4.2 WUG Pumping Scheme

Elevation of irrigation area with WUG Pumps

As previously described, 90 percent of the total paddy area (3,870 ha) to be irrigated by the use of WUG pumps is located below EL + 2 m, and the remaining 10 percent at a range of EL + 2 to 4 m. Based on these figures, the elevation of the area irrigated by the WUG pumps can be considered as high as + 2 m.

Total pump head

The operation water level of the Bang Nara water storage is normally EL + 0.4 m and rarely EL -0.2 m. Pumps would be installed along the Bang Nara tributaries and farm drain and water be pumped up directly to on-farm facilities. It is, therefore, unnecessary to make allowance for any pipeline loss. Based on this, the required total pump head would be 2.45 m for the low-lying paddy field and 4.45 m for the high-lying paddy field taking into account the loss in the short length of the water conveyance pipe.

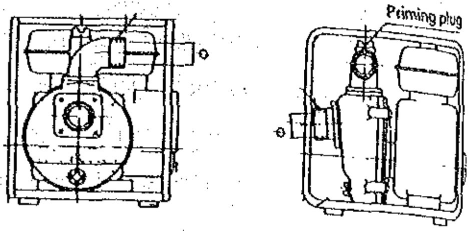
Irrigable area per pump

The examination conducted at the sample area design indicates that the irrigable area per pump would be 20 ha being managed by one WUG. Since it is desirable from the viewpoints of pump operation and maintenance under one group to use one pump unit, the irrigable area for one pump unit would be taken at 20 ha. With additional consideration given to the unit water requirement, the required pump capacity would be 1.65 cu.m per min.

Type of pump

Based on the above-mentioned conditions, the pump with the following specifications would be selected:

Type of pump: Self priming centrifugal pump
Nozzle dia : ∅100 mm x ∅100 mm
Total head : 5 m
Capacity : $1.65\ m^3/min$
Revolutions : 1,800 rpm
Engine power: 7 HP



In addition, the pump and its gasoline engine would be secured on a common base and be driven together through a direct flexible coupling, in order to facilitate transportation. The gross weight of pump and engine would be approximately 100 kg and they can be easily transported by a simple carrier.

Number of pumps

The irrigable area by WUG pumps would be 3,870 ha for the whole of the Bang Nara water storage basin, and the required number of WUG pumps would be 193.

5.4.3 RID Pumping Scheme

(1) Site of pumping stations

Based on the conditions where the RID pumping station is to be located, the irrigation water would be conveyed by utilizing the drainage canal as headrace from the Bang Nara water storage:

No.	Pumping station	Drainage canal to be used
3	Du Song	Khlong Na Ko
5	Khok Ti Te	Khlong Chang
6	Maru Bo	Khlong Ku Rong Ya Ma
7	Sala Mai	Khlong Sala Mai

The location which can be considered for the pumping station would be (i) downstream area, (ii) midstream area and (iii) upstream area of each Khlong. With respect to these alternatives, advantages and disadvantages can be examined as follows:

Item	Downstream area	Midstream area	Upstream area
Excavation of headrace	Small	Medium	Large
Right-of-way of headrace	Small	Medium	Large
Length of conveyance channel	Large	Medium	Small
Right-of-way of conveyance channel	Large	Medium	Small
Protection against flood level	High embankment required	Only small scale of embankment required	Only small scale of embankment required

Based on the above in consideration of the civil work, the unit cost of embankment is greater than that of excavation, and the upstream area is more advantageous. In this case, however, the depth required for a headrace would be great and consequently this plan would not be of the realistic configuration. In addition, in consideration of the difficulty of acquiring any land as well as a high flood level during the rainy season, it can be judged that provision of the pumping stations at the midstream of the respective Khlong would be the most practical.

(2) Examination of elevation at headrace bed

First, the basic factor involved is to establish the bed elevation of the headrace vs. the lowest impounding water level of EL - 0.2 m at the Bang Nara storage, to select the location of the pumping station within a range less than 5 m in the excavation depth of a headrace, and then to calculate the distance of headrace. Based on the concept that the bottom width of a headrace is the same as that of the drainage canal, the conveyance loss in the headrace section is calculated by applying the non-uniform flow equation (refer to para. 4.1. of Appendix IX.). Based on the calculation, the bed elevation, water level at the pumping station and its location from the river mouth of the respective Khlong would be shown below:

No.	Pumping station	Bed level of drainage canal (EL - m)	Water level (EL - m)	Station No.
3	Du Song	- 1.6	- 0.36	KM.3 + 300
5	Khok Ti Te	- 1.5	- 0.42	KM.3 + 500
6	Maru Bo	- 1.1	- 0.29	KM.5 + 400
7	Sala Mai	- 1.1	- 0.29	KM.1 + 300

It is anticipated that deep excavation of the drainage canal as headrace could result in new acidic water generation. Soil investigation indicates that the potential acid sulfate soil is distributed over Khlong Ku Ra Po from its mouth to approximately 3.5 km upstream point such as an intersection with a national highway and over Khlong Chang to a point approximately 1 km from its mouth. The possible measures for preventing such problem soil from changing the potential into the actual would be to install a stop-log at the upstream side of the box culvert (confluence point with the tributary) to be provided under the drainage improvement scheme, and the river flow would be stored in the upstream course of this tributary during the dry season so as to prevent the groundwater level from lowering. This stop-log would be constructed so that whenever the river flow exceeds the established water level during the rainy weather, the excess water would overflow its crest to protect the upstream area from ponding.

(3) Pump and delivery channel

Type of pump

The fixed pumps to be introduced can be divided into three types of (i) volute pump, (ii) axial-flow pump and (iii) mixed flow pump. Since the actual pump head is within the range of 5 to 11 m in consideration of the water supply network for irrigable area and the average discharge of pumps is 22 cu.m per min, the use of vertical mixed-flow pump is the most suitable, taking into account the probable cavitation with the suction head of 4 to 6 m. In addition, the vertical type pump takes a motor above the pump body, therefore, it is advantageous with regard to pump equipment protection particularly in view of the flood level. Details of the pump type selection is discussed in para. IX-4-2 of Appendix IX.

Type of pumping station

The following three types of configuration would be contemplated for a pumping station with a vertical mixed-flow pump:

(i) Provide a reinforced concrete well and mount pumps thereon.

(ii) Drive in piles within the headrace, construct a concrete slab on the driven pile heads, and mount pumps thereon.

(iii) Install inclined pumps at right angles to the surface of the embankment slope on one side of the headrace.

As a result of comparing these configurations, the pumping station of the type (iii) would be considered the most beneficial with regard to the construction cost and maintenance (refer to para. IX-4-2 of Appendix IX.).

Delivery channel

Two types of (i) open channel and (ii) pipe channel would be contemplated for lifting water to the head of irrigation channel from the pumping station. Its selection would depend on the difference in elevation between the pumping station point and its starting point of the irrigation channel. The comparison study for the both cases as shown in para. IX-4-3 of Appendix IX explains that an open channel type takes less construction cost when the height of embankment is less than 3 to 3.5 m and the pipe channel type is favorable when this height is more than the above. Therefore, the type of delivery channel would be determined in consideration of the topographical conditions of each pumping station and the water level at the starting point of the open channel. The following table shows the proposed pumping stations for which the pipe channel is to be adopted:

	Pumping station	GL. of pump	WL. of canal	El. of bund	h	Delivery channel
1	Pu Ta	+5.8	+7.7	+8.2	2.4	Open
2	Khao Kong	+7.5	+9.1	+9.6	2.1	Open
3	Du Song	+3.4	+9.6	+10.1	6.7	Pipe
4	Tan Yong Mat	+16.8	+15.7	+16.2	0	Open
5	Khok Ti Te (1)	+3.5	+10.8	+11.3	7.6	Pipe
	(2)	+3.5	+7.4	+7.9	4.4	Pipe
6	Maru Bo	+3.9	+8.4	+8.9	5.0	Pipe
7	Sala Mai	+3.0	+6.5	+7.0	4.0	Pipe
8	Ko Sawat	+4.3	+6.4	+6.9	2.3	Open
9	Phru Kap Daeng	+4.3	+6.9	+7.4	3.1	Open
10	Ku Cham	+3.0	+6.9	+7.4	4.4	Pipe

The typical in-pipe design flow velocities used for selecting the pipe diameter are given below:

Diameter (mm)	Design velocity (m/sec)
200 - 400	0.9 - 1.6
450 - 800	1.2 - 1.8
900 - 1,500	1.3 - 2.0

The pipe diameters for the proposed pumping stations are shown below:

Pumping station	Q (m^3/sec)	Diameter of pipe line (mm)
3. Du Song	1.22	ø900
5. Khok Ti Te (1)	0.84	ø800
(2)	0.70	ø800
6. Maru Bo	0.65	ø700
7. Sala Mai	0.68	ø700
10. Ku Cham	0.26	ø600

The prestress concrete pipes would be used in consideration of the total head of each pump in the range of 5 to 22 m and the pipe diameter between ø600 to 900 mm.

In addition, water hammering may occur in the case of pipe channel laid over a long distance, or depending on the undulating conditions. The topography in the subject area is inclined in one direction, however, the possibility of water hammer occurrence would still exist particularly when the extension of pipe channel is great. As a result of examining the longitudinal distance of each pipe channel, it is apparent that the pipe channel of the pumping stations at Du Song and Khok Ti Te (upper and lower) would be susceptible to water hammering, therefore, the fly-wheels would be attached to the pump of each pipe channel in this case. Table 5.11 shows the contents of pumping station equipment resulting from the above examinations.

Geological conditions

The Project area is largely divided into beach-sand area, swamp and old swamp area, and flood plain area (refer to Figure IX-3-1(1), Appendix IX. 3.1), where the beach-sand and flood plain areas would be the foundation for pumping stations. The clayey silt with N-value of 5 or the sand with N-value between

5 and 10 lies near the ground surface, and no poor foundation exists. As illustrated in Figure IX.4.2 of Appendix IV, the proposed pumping stations would be of light-weight and load-decentralizing structure. Bearing this fact in mind, the proposed pumping stations would be built without any foundation treatment.

(4) Main and lateral channels

Selection of channel types

Based on the layout of irrigation canal networks in the respective pumping irrigation scheme, the typical rate of water discharge in each channel is shown in Figure 5-7. Bearing this design discharge in mind, the gradient with which the embankment of each channel can be minimized has been selected from the topographical conditions, and then the cross sections have been given as is in Table 5-12.

Appurtenant facilities

o Division works or Farm turnouts

A division work or farm turnout would be provided at a diversion point from the main channel to the lateral or to a service unit. The diversion work would have a slide gate at the intake and transverse in a pipe culvert under the embankment of a channel. A partial-flume capable of measuring the discharge rate would be provided at a diversion point of main channel so that the discharge rate after diverted could be ascertained. The typical design of these facilities are presented in Drawing No.ID5.

o Check gate

In order to ensure that the required water is diverted through the division work, the water level at the division point should be maintained as designed. For this purpose, a check gate would be provided at a location determined in consideration of the longitudinal configuration of the channel. The check gate would consist of an overflow part as a fixed weir and a gate section as a movable part.

o Drops

In order that the flow velocity along the channel is maintained within the tolerable limit, channel gradients would be adjusted. To this end, a drop as shown in Drawing No.ID7 would be provided wherever required.

o Crossing structures

At a point where a channel intersects another facility, a crossing structure would be provided to hinder the function of the other facility. The pipe culvert, syphon and aqueduct are explained in Drawings No.ID6 and ID8.

o Combination spillway and outlet

In order that the channel be prevented from collapse when the channel water overflows its embankment as a result of an unusual water level, a spillway would be provided upstream of the diversion point of the main channel near existing river or canal. In addition, the spillway would be needed with an outlet function to empty the channel for maintaining and repairing of the channel.

(5) Summary of systems

List of structures

All of the various structures so far described have been designed on preliminary basis in line with the location maps and profiles of the irrigation channels and are collectively listed in Table 5-13.

O & M roads

National highways, ARD roads and Amphoe roads are currently available in the Project area. As is obvious from Table 5-13, when the banks of the main and lateral canals are used for the purpose of road communication, the rural road would be newly extended by 150km, and it is expected that such O & M road would also be served for the farm to maketing purpose and be useful in improving the life of the villages as a means of better communications.

5.4.4 Gravity Irrigation Scheme

Intake facilities

The intake would have a slide gate at its entrance and a pipe culvert with the diameter of ϕ600 mm in consideration of the diversion rate of 0.25 cu.m per sec to serve 180 ha.

Cross-section of canal

In consideration of the topographical conditions and the total channel length of 1.6 km, the channel gradient would be taken at 1:600. The channel cross-section required would be b = 0.7 m, d = 0.35 m, side slopes of 1:1.5 and V = 0.6 m per sec, providing that this channel is of the same type as that of the RID pump scheme.

Crossing structures

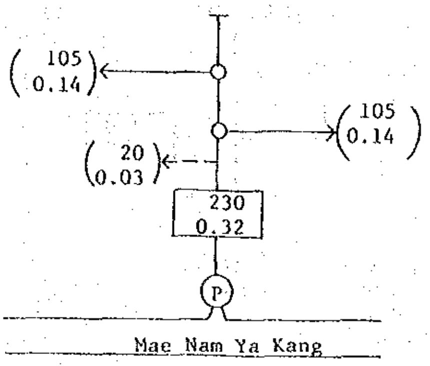
For the purpose of eliminating the effluent from the mountain behind the area, three drain culvert would be provided with each of three ϕ1,000 mm reinforced concrete pipes arranged in parallel.

Rehabilitation of existing canal

As the discharging capacities of existing channels have deteriorated as a result of accumulated sediment, these channels would be rehabilitated and then connected to the new channel so that irrigation can be carried out even in the dry season. The total length of existing channels rehabilitated would be 6.5 km.

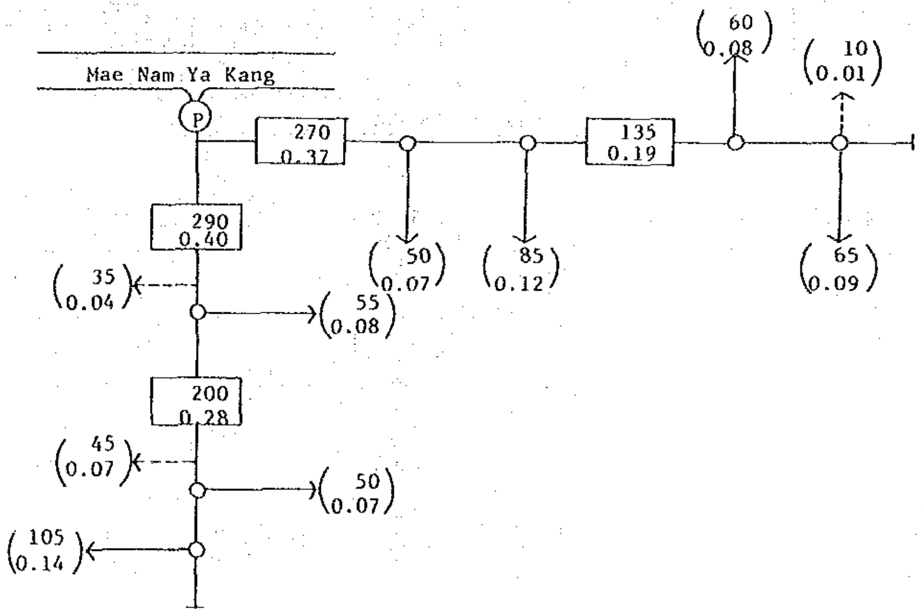
Figure 5-7 Schematic Diagram of RID Pumping Irrigation Systems

No.1 Pu Ta Pump

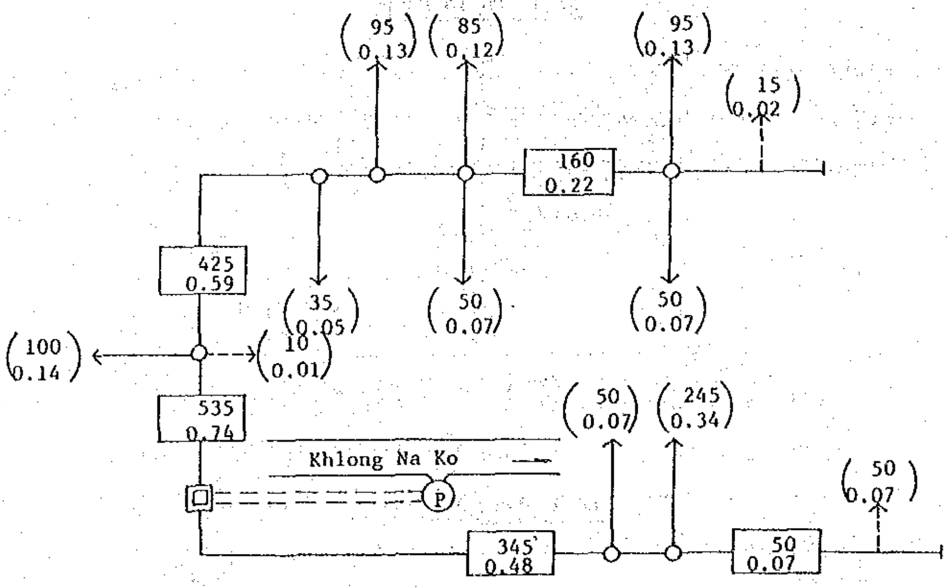


Unit : ha
cu.m/sec

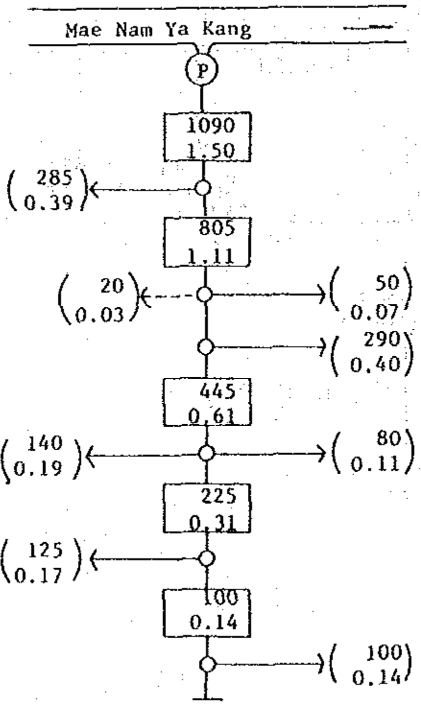
No.2 Khao Kong Pump

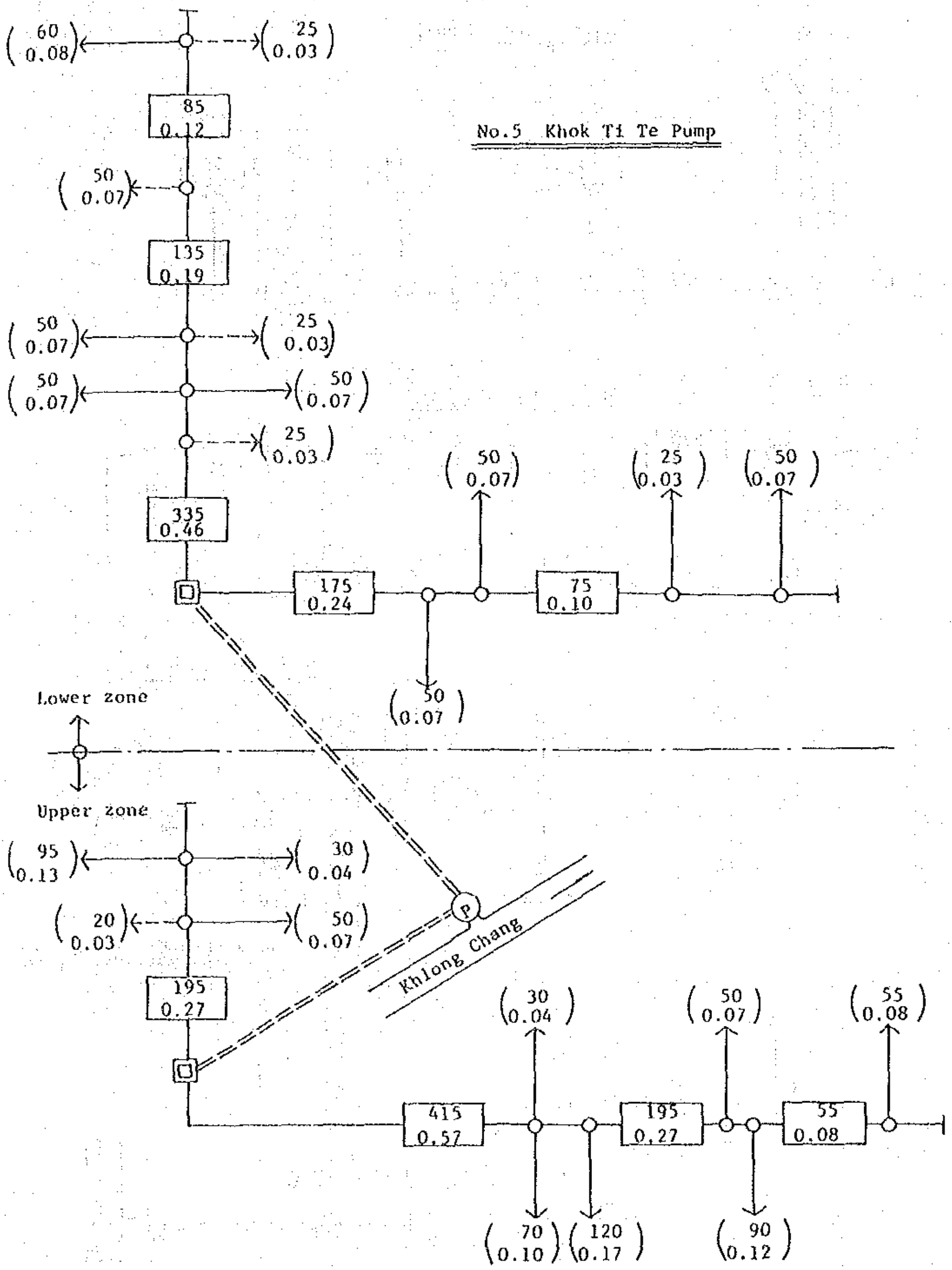


No.3 Du Song Pump

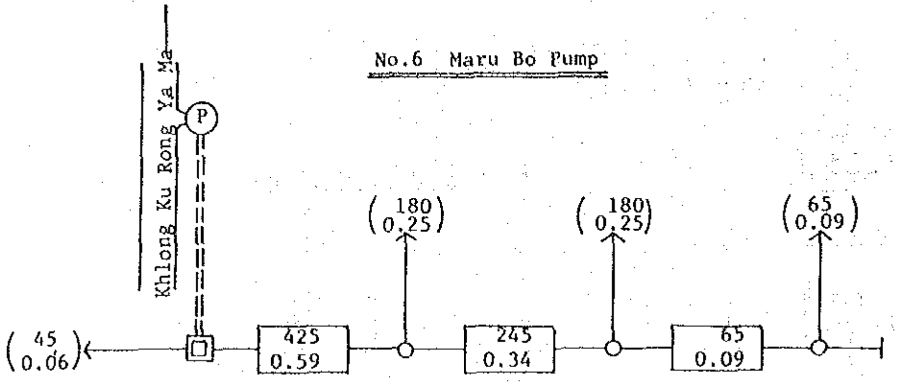


No.4 Tan Yong Mat Pump

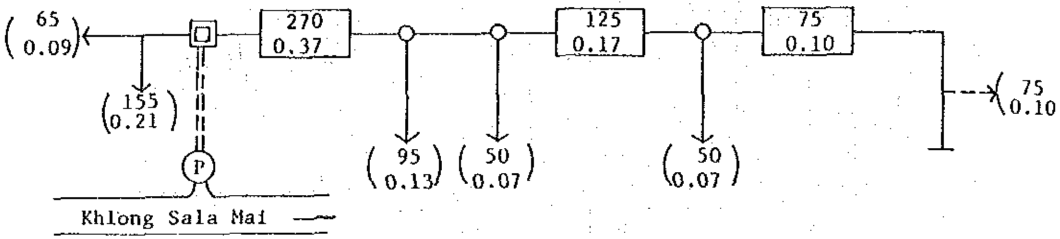



No.5 Khok Ti Te Pump
60 0.08
25 0.03
85 0.12
50 0.07
135 0.19
50 0.07
25 0.03
50 0.07
50 0.07
25 0.03
335 0.46
175 0.24
50 0.07
75 0.10
25 0.03
50 0.07
50 0.07
Lower zone
Upper zone
95 0.13
30 0.04
20 0.03
50 0.07
195 0.27
P
Khlong Chang
30 0.04
50 0.07
55 0.08
415 0.57
195 0.27
55 0.08
70 0.10
120 0.17
90 0.12

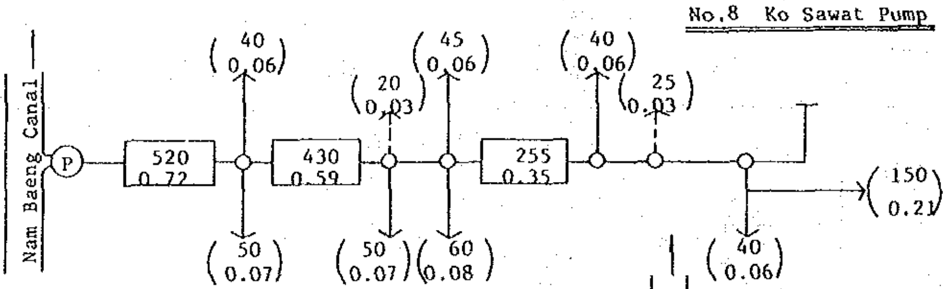
No.6 Maru Bo Pump



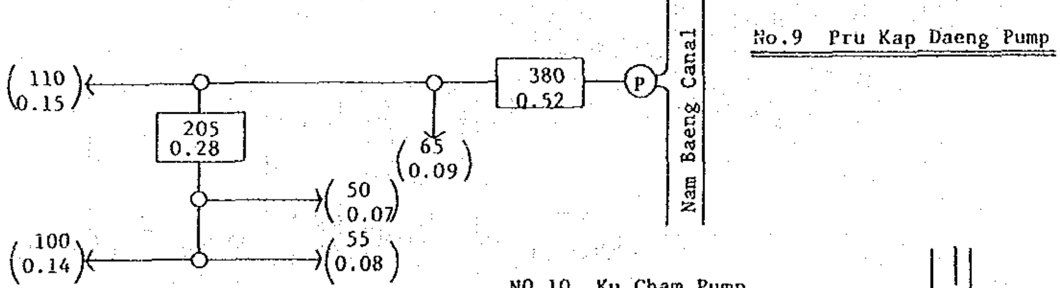
No.7 Sala Mai Pump



No.8 Ko Sawat Pump



No.9 Pru Kap Daeng Pump



NO.10 Ku Cham Pump

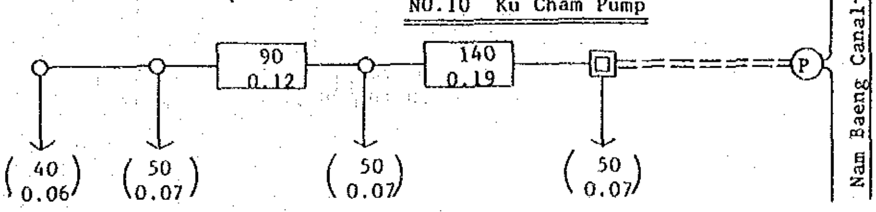


Table 5-11 List of RID Pump Equipment

No.	Pumping Station	Dia. of Pump (mm)	Type of Pump	Capacity (m^3/min.)	Head (m)	Speed (rpm)	Out put (KW)	Remarks
1	Pu Ta	300 x $2^{\text{Nos.}}$	Mixed Flow	9.6	7.0	1450	18.5	
2	Khao Kong	450 x 2	- do -	23.1	7.9	980	45	
3	Du Song	500 x 2	- do -	36.6	17.9	- do -	160	Fly-wheel
4	Tan Yong Mat	600 x 2	Axial Flow	45	5	740	55	
5	Khok Ti Te	450 x 2	Mixed Flow	25.2	21.5	980	132	Fly-wheel
		400 x 2	- do -	21	11.7	1475	75	- do -
6	Maru Bo	- do -	- do -	19.5	12.9	- do -	- do -	
7	Sala Mai	- do -	- do -	20.4	9.3	- do -	55	
8	Ko Sawat	- do -	- do -	21.6	6.7	980	37	
9	Phru Kap Daeng	- do -	- do -	15.6	7.2	- do -	30	
10	Ku Cham	300 x 2	- do -	7.8	8.4	1475	18.5	

Table 5-12 Type of RID Irrigation Canals

(Unit: Q=m^3/sec.)

No. of Area	Location of Canal	Type of Canal I	II	III	IV	V	VI
No.1			Q=0.32- 0.15 I=1/1,000				
No.2	Right	Q=0.14 I=1/2,500	Q=0.28- 0.14 I=1/2,500	Q=0.40- 0.35 I=1/2,500			
	Left	Q=0.10 I=1/1,500	Q=0.19- 0.10 I=1/1,500	Q=0.37- 0.30 I=1/1,500			
No.3	Right	Q=0.07 I=1/1,500		Q=0.48- 0.41 I=1/1,500			
	Left	Q=0.02 I=1/1,200	Q=0.22 I=1/1,200	Q=0.59- 0.41 I=1/1,200	Q=0.74 I=1/1,200		
No.4			Q=0.14 I=1/2,500	Q=0.31 I=1/2,500	Q=0.61 I=1/2,500	Q=1.11- 1.01 I=1/2,500	Q=1.5 I=1/2,500
No.5	Upp.Right	Q=0.08 I=1/1,200	Q=0.27- 0.20 I=1/1,200	Q=0.57- 0.43 I=1/1,200			
	Left		Q=0.27- 0.17 I=1/1,500				
	Low.Right	Q=0.10- 0.06 I=1/2,000	Q=0.24- 0.17 I=1/800				
	Left	Q=0.12 I=1/600	Q=0.19 I=1/1,600	Q=0.46- 0.29 I=1/1,600			
No.6	Right	Q=0.09 I=1/2,000		Q=0.34 I=1/2,000	Q=0.59 I=1/2,000		
	Left	Q=0.06- 0.01 I=1/700					
No.7		Q=0.10- 0.03 I=1/2,500	Q=0.17 I=1/2,500	Q=0.37- 0.24 I=1/2,500			
No.8				Q=0.35- 0.26 I=1/2,000	Q=0.59- 0.50 I=1/3,300	Q=0.72 I=1/3,300	
No.9			Q=0.28- 0.21 I=1/1,400		Q=0.52- 0.43 I=1/3,300		
No.10		Q=0.12- 0.06 I=1/1,700	Q=0.19 I=1/2,500				
Bottom-width of Canal (m)		0.50	0.70	0.90	1.10	1.30	1.50
Depth of Water (m)		0.25	0.35	0.45	0.55	0.65	0.75

Table 5-13 List of RID Irrigation Facilities

Item	Unit	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	Total
Canal Length (Main)	Km	1.7	8.8	7.2	4.8	15.6	4.1	4.4	5.3	3.0	5.1	60.0
-do- (Lateral)	-do-	3.4	8.1	12.8	14.1	17.1	5.3	7.4	9.7	11.3	2.7	91.9
Division Works(Main)	No.	2	7	8	7	16	3	4	8	5	4	64
Farm Turnout (Main)	No.	1	7	7	8	14	3	4	3	-	-	47
-do- (Lateral)	-do-	12	24	41	49	48	22	23	26	21	11	277
Check (Main)	No.	2	9	9	6	15	6	4	4	4	2	61
Drop (Main)	No.	1	5	3	3	4	3	1	1	-	-	21
-do- (Lateral)	-do-	1	3	4	2	7	4	3	-	-	-	24
Road Cross (Main)	No.	1	5	2	1	7	-	-	2	1	1	20
-do- (Lateral)	-do-	1	3	9	3	8	-	2	3	1	-	30
Syphon (Main)	No.	-	-	-	1	1	-	-	-	-	-	2
-do- (Lateral)	-do-	-	-	-	1	-	-	-	-	-	-	1
Aguiduct (Main)	No.	-	-	-	-	-	1	-	-	1	-	2
Spillway	No.	1	2	2	1	4	1	1	1	1	1	15
Drain Culvert(Main)	No.	-	2	-	-	2	3	-	2	-	-	9
-do- (Lateral)	-do-	-	3	3	5	1	-	1	-	-	-	13

5.5 On-Farm Work and Demonstration Farm

5.5.1 On-Farm Work

(1) Design Criteria

The on-farm facilities consist of a farm turnout, farm ditches, division boxes, checks, farm inlet (or farm turn-out), road crossing and farm drain. A farm road is not recommended in this area in order to avoid farm land reducing. After farm mechanization would progress in future, however, the farm road would be necessary and be constructed by farmers themselves.

- Farm turnout with measuring device

  When the water users' group want to get water from the main or lateral irrigation canal, a farm turnout with measuring device should be operated to achieve good management in the irrigation services.

- Farm ditch

  A farm ditch which has to convey irrigation water to a field smoothly would be aligned along the existing paddy dike and be touched to every land owners' field in principle. Depending upon the topographical conditions, the supplemental farm ditch would be needed. The ditch has a trapezoidal cross-section with a side slope of 1:1 and the minimum bottom width and water depth of 30 cm. The ditch would not be lined by concrete or other materials except for a portion with high embankment, sandy soil area and a curve point. The bottom slope of 1:400 to 1:5,000 would be applied based on the topographical condition.

  The farm ditch density of about 25 to 70 m per ha or 4 to 10 m per rai would be designed. It would be rather difficult to reduce its density because of the topographic condition with diminutive variation of a ground surface and the adverse slope against water flow. (refer to Figure VIII-2-12 and Tables VIII-2-20 to -25 in Appendix VIII)

- Farm inlet
  When the farmer wants to take irrigation water to his field, he opens a farm inlet on a farm ditch. In principle, the farm inlet would be provided for each of few land owners' plots. When the commanded acreage exceeds more than 15 rai, another farm inlet would be provided. The farm inlet consists of concrete pipe with diameter of 200 mm and a wooden stop log. (refer to Table VIII-2-19 in Appendix VIII)

- Appurtenant structures
  Various appurtenant structures like check, road crossing, drainage crossing and etc. would be provided at necessary points. Where the farm ditch is crossing a depression area, existing drainage canal and proposed farm drain, the drainage crossing would be provided to protect the destruction of farm ditch by concentrating the excess surface water to be drained. (refer to Drawing No. 0-4)

  The check which needs to keep the field ditch water level for easy diversion would be located at the lower side of a farm inlet. The structure consists of a wooden wall and stop logs. (refer to Figure VIII-2-13 in Appendix VIII)

  A foot bridge would be provided for farmers to cross a farm ditch with an average interval of 500 m on a farm ditch length. (refer to Drawing No. 0-4)

  A farm drain could drain excess water on a field quickly. The farm drain would be constructed when necessary.

  A farm road would be necessary to transport farm inputs to a field and farm output from the field and to make agricultural mechanization. The farm road with 2 m width, 0.5 m height and without pavement will be required along the farm ditch in future if farmer wants.

(2) Preliminary design of On-Farm Facilities

The sample layout of on-farm facilities has been carried out on the topographical maps at a scale of 1 to 4,000 prepared by RID in 1986. The three sample areas in the Study area have been selected considering the topographic conditions such as slope, the size of a paddy plot and so forth. A farm inlet would be provided for few land owners' field which has several paddy dikes. Therefore, irrigation water flows from a paddy plot to the neighbouring field. On the other hand, a farm drain would be provided at the lowest portion in a service unit in order to drain excess water and to convey irrigation water from the Bang Nara water storage to a WUG's pumping if no existing creek is available. (refer to Drawings No. 0-1 to 0-3 and Tables VIII-2-22 to -27 in Appendix VIII)

(3) Construction Plan

Prior to the implementation, the topographic maps on a scale of 1 to 4,000 which have a contour interval of 25 cm in the flat area in principle and indicate the boundaries of paddy plots and existing road and creeks or streams will be prepared in order to align the facilities. The construction of these on-farm facilities including appurtenant structures would be carried out by the members of water users' group under the technical assistance of the RID staff. The right-of-way for the facilities would be offered by the members.

5.5.2. Demonstration Farms

(1) Proposed Location and area

In consultation with the Changwat Planning Unit and DOAE Narathiwat with an agreed target that a demonstration farm is provided in each of Amphoe Muang Narathiwat, Rangae and Tak Bai, the selection of such sites have been made at (1) Ban Ku Ra So, Amphoe Muang, (2) Ban To Lang, Amphoe Rangae and (3) Ban Cha Ro, Amphoe Tak Bai, as presented in Figures 5-8 to -10. Since these sites are located in the center of a series of existing paddy fields, it is expected to demonstrate the intended objectives to the Project farmers on effective basis; however, the final location will be determined by the Changwat Committee which is responsible for implementation of the proposed Project.

The name and acreage of the farms are as follows;

- Ku Ra So Demonstration Farm	:	in Ban Ku Ra So, Amphoe Muang Narathiwat 13.81 ha (86.3 Rai)
- To Lang Demonstration Farm	:	in Ban To Lang, Amphoe Rangae 23.49 ha (146.8 Rai)
- Cha Ro Demonstration Farm	:	in Ban Cha Ro, Amphoe Tak Bai 26.10 ha (163.4 Rai)

(2) Preliminary Design

The Figures 5-8 to 5-10 show the preliminary layout of the facilities in each demonstration farm. The design criteria for on-farm facilities as is discussed in para. 5.5 of this chapter has been employed. Table 5-14 shows the list and quantities of the on-farm facilities.

(3) Temporary Water Sources

It is proposed that the three demonstration farms would be provided and operated during the initial period of the Project implementation when the Bang Nara water storage is not completed. It is, therefore, required to take the irrigation water from temporary sources.

After construction of two tidal regulators, each farm is in a position to take water stored in the Bang Nara water storage. The Ku Ra So and Cha Ro farms belong to the WUG pumping scheme, while the To Lang farm would get the irrigation water from the RID pumping station.

a) Ku Ra So Demonstration Farm

According to the estimate of groundwater availability near the site, the yield of about 180 litre per min (255 cu.m per day) would be expected from a deep well. Since this yield is not enough for the maximum amount of irrigation water requirement as envisaged, the cropping intensity of the upland crops would not reach the proposed 25 percent.

b) To Lang Demonstration Farm

This farm is geographically located at the flood plain. The yield of about 120 litre per min (166 cu.m per day) from a deep well would take less crop intensity of the upland crops during the off-season.

c) Cha Ro Demonstration Farm

It would not be so easy to take the irrigation water from a deep well in this area because of probable salinity concentration of water at existing wells around the area. The careful study and detailed analysis of water source for this farm are, therefore, requested in future.

Table 5-14 List of Quantities of On-Farm Work for Demonstration Farms

I T E M	Demonstration Farm Ku Ra So	 To Lang	 Cha Ro
1. Acreage (ha) (rai)	13.81 (86.3)	23.49 (146.8)	26.10 (163.4)
2. Temporary deep well (set)	1	1	1
3. WUG's pumping facility (set)	1	1	1
4. Farm ditch (m)	729	1,050	1,968
5. Farm Inlet (pls)	7	9	12
6. Road crossing L=4.0m (pls)	1	3	-
7. Division box (pls)	1	1	3
8. Curve Protection Works (pls)	8	8	13
9. Check (pls)	4	10	8
10. Concrete lining (m)	-	-	340
11. Drainage crossing	1	-	2
12. Foot Bridge	2	3	4

FIGURE 5-8

KU RA SO DEMONSTRATION FARM, A. MUANG NARATHIWAT

A = 13.81 ha (86.3 rai)

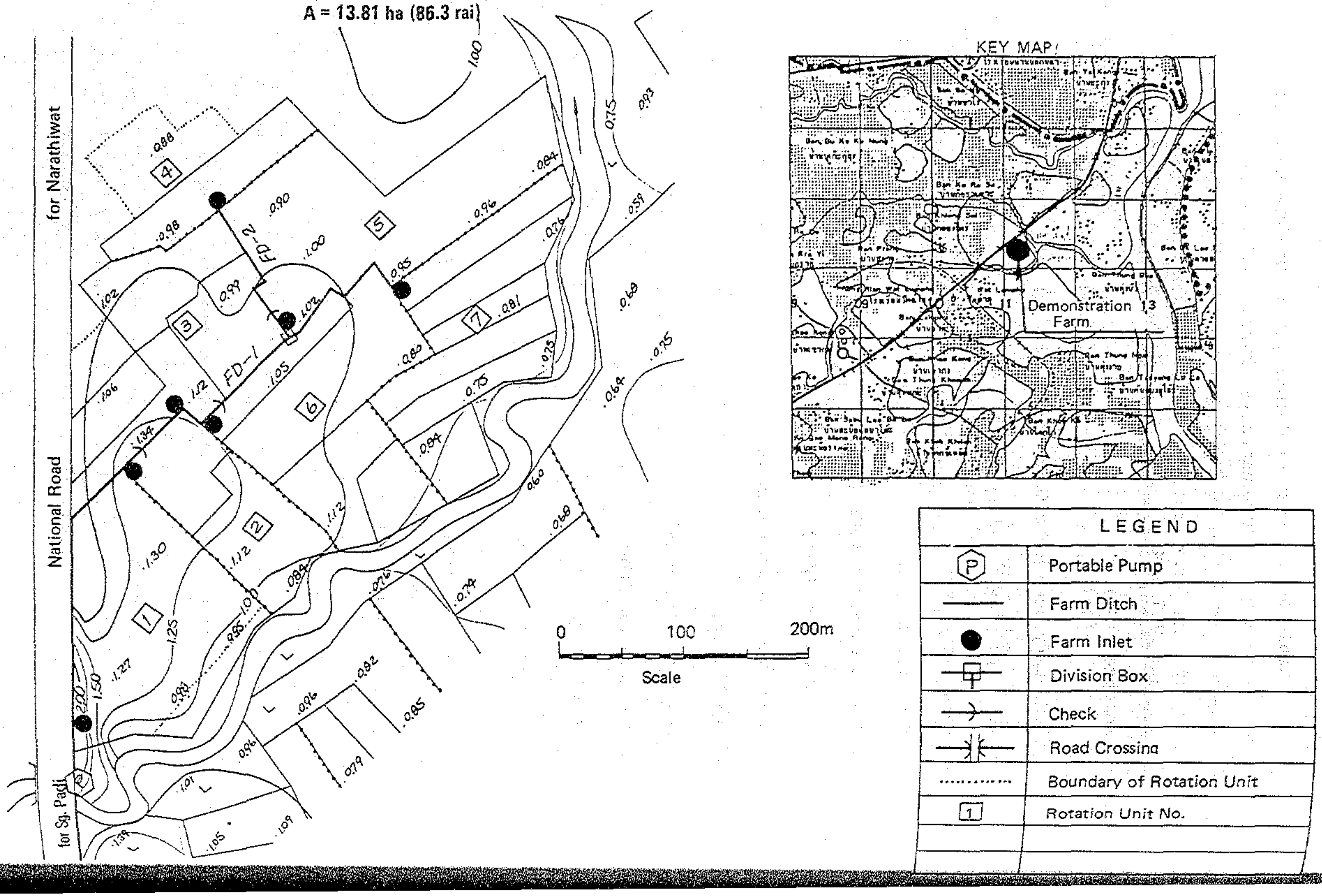
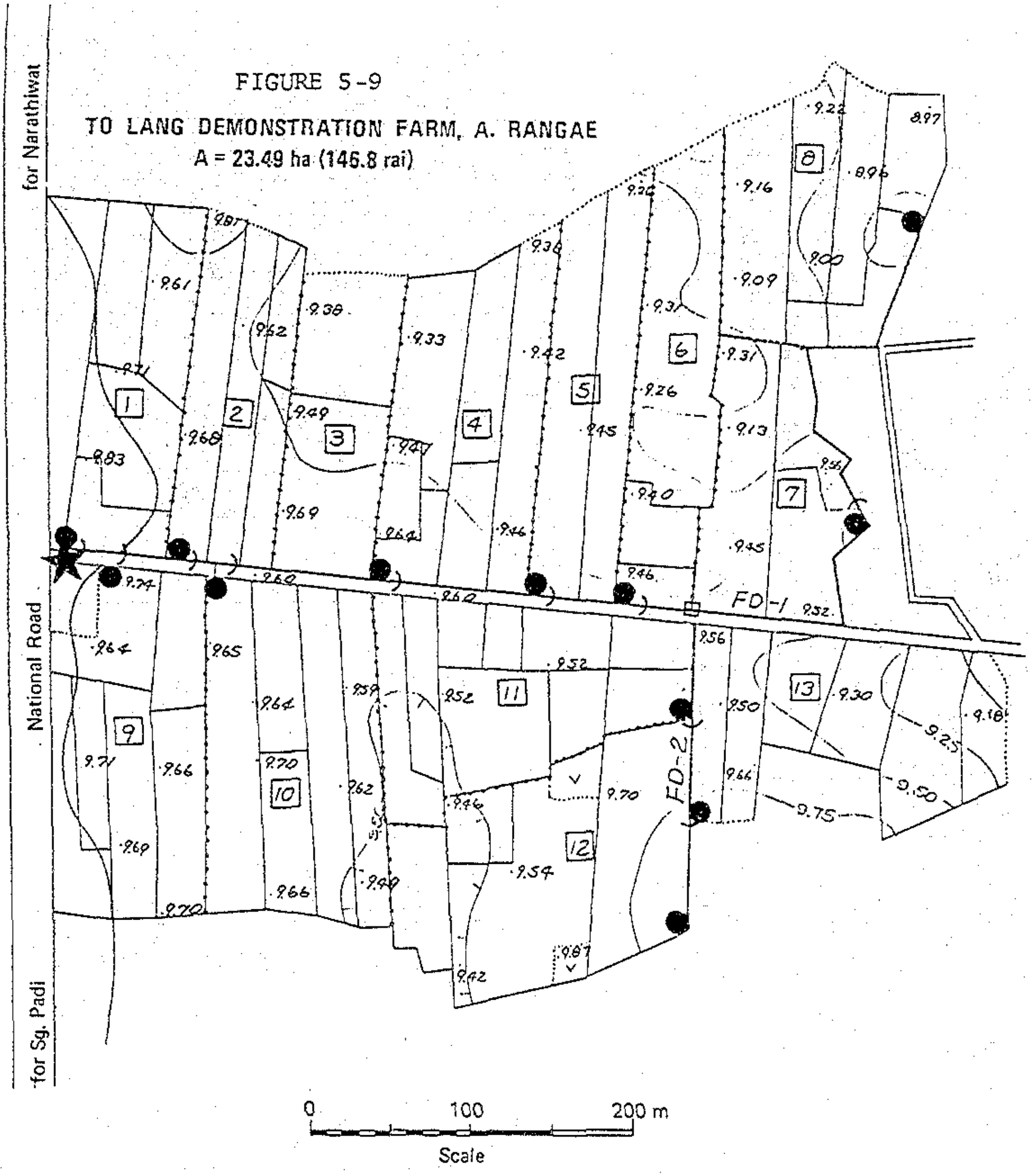


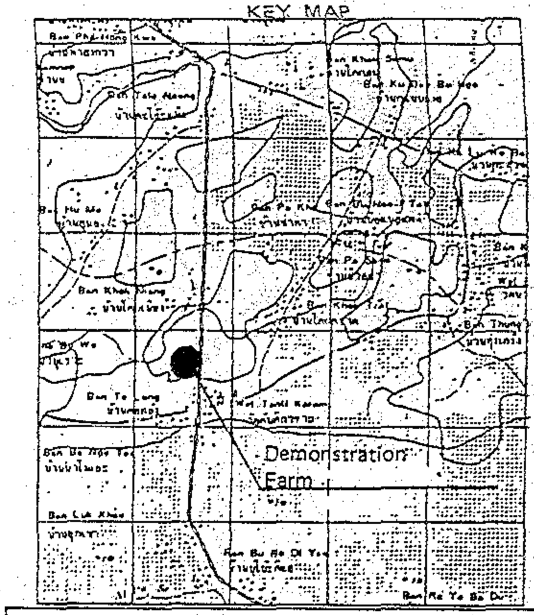
FIGURE 5-9

TO LANG DEMONSTRATION FARM, A. RANGAE

A = 23.49 ha (146.8 rai)



KEY MAP



LEGEND	
★	Deep Well
—	Farm Ditch
●	Farm Inlet
⊞	Division Box
⟩	Check
⫲	Road Crossing
⋯⋯	Boundary of Rotation Unit
1	Rotation Unit No.

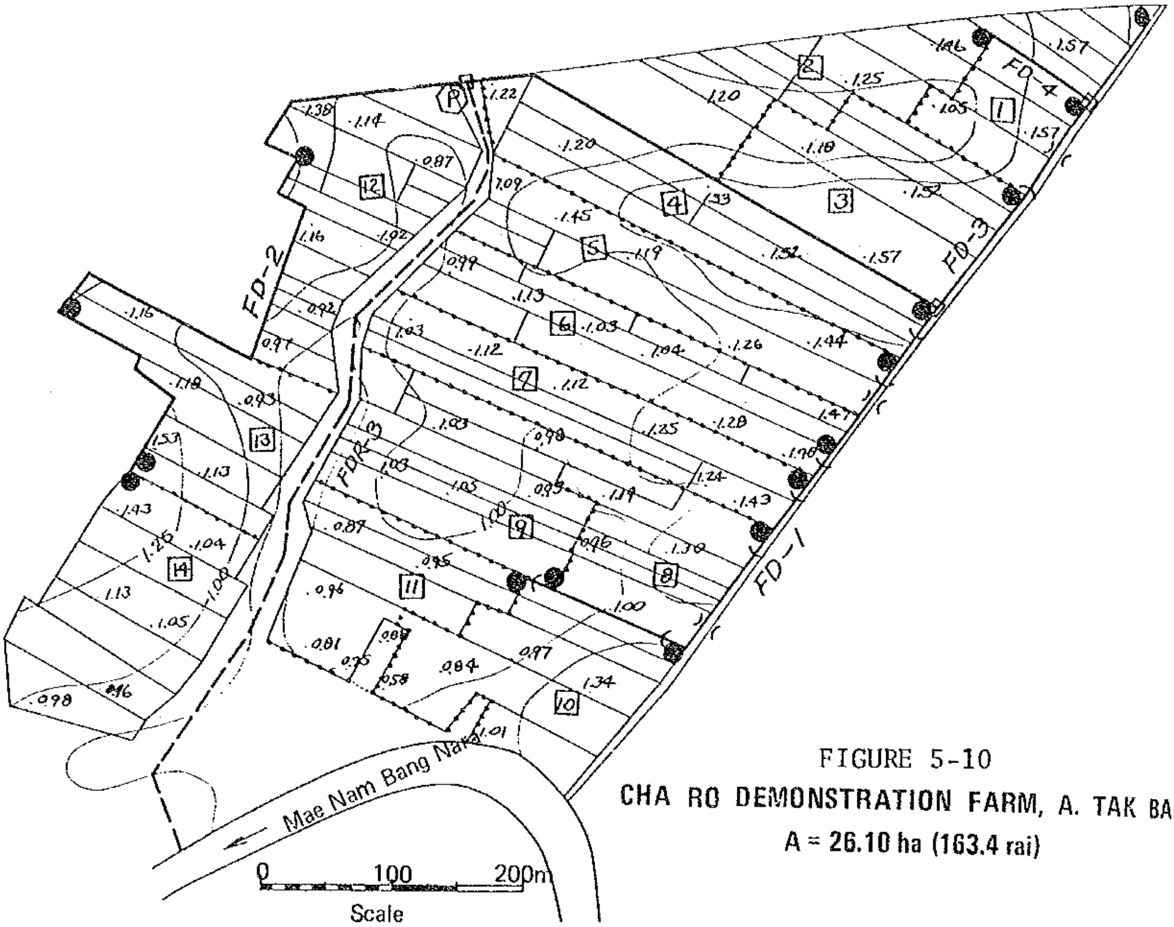


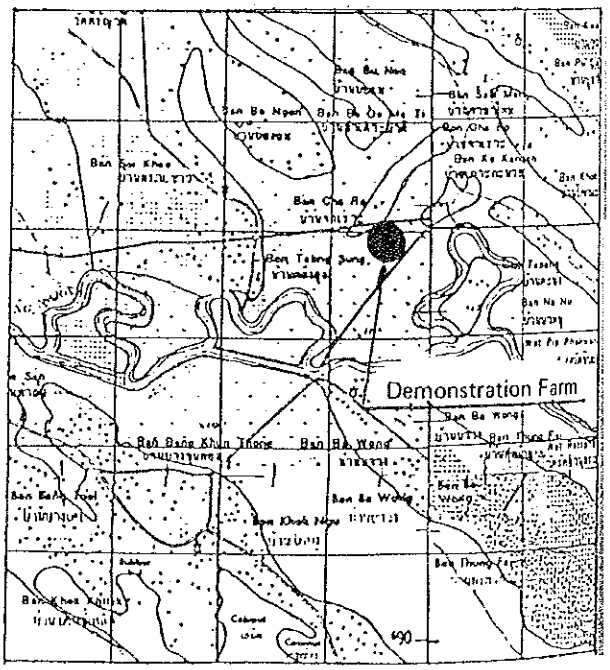
FIGURE 5-10

CHA RO DEMONSTRATION FARM, A. TAK BAI

A = 26.10 ha (163.4 rai)

LEGEND	
Ⓟ	Portable Pump
———	Farm Ditch
●	Farm Inlet
—⊡—	Division Box
—)—	Check
—)(—	Road Crossing
....	Boundary of Rotation
1	Rotation Unit No.
— — —	Farm Drain

KEY MAP



CHAPTER 6 ORGANIZATION AND MANAGEMENT

6.1 Project Implementing Agencies

There are a wide range of the Government agencies providing the services for water resources and related agricultural development in the Bang Nara Irrigation and Drainage Project. Most of the agencies are within the Ministry of Agriculture and Cooperatives (MOAC) or the Ministry of Interior (MOI). The functions of key agencies are outlined below:

6.1.1 Royal Irrigation Department (RID)

RID would be responsible for design, construction and O & M of the tidal regulators, fixed irrigation pumps and related canal networks up to the outlets into the terminal service units, and drainage channels. RID also provides technical assistance, in strong cooperation with CDD, DOAE. CPD and others, in organizing the water users' group (WUG) in each irrigation terminal service unit and extends technical assistance to each WUG in planning, design, construction, O & M and water management for its service unit.

The programme would be directed and supervised by the head office located in Bangkok where major tasks would be handled by the Design Division for detailed design, the Large Project Construction Division for construction work and the O & M Division for the subsequent O & M activities together with the cooperation of other Divisions concerned. It has been informed that the proposed Project would have a project manager at the UTR site who has the responsibility for directing the Project construction to its completion under the supervision of the Large Project Construction Division, and the Project office is staffed with the required construction, engineering, mechanical and administrative staff to perform all aspects of the construction activities.

O & M activities of the Project would be the joint responsibility of the O & M Division in Bangkok and the Regional Office in Hadyai. The latter office supervises the operations in Region 12 including the Changwat Irrigation Service, Narathiwat which executes the actual O & M of the Project during the initial period, but later on when approved by the Budget Bureau, it is anticipated that the O & M Project Branch of the Regional 12 Office would be responsible for the O & M of the subject Project with a project office headed by a project engineer as are seen in the cases of Pattani and Muno. It is noted that RID was originally responsible for the formation and supervision of water users association, but this function has been transferred to CPD.

6.1.2 Department of Agriculture (DOA)

DOA would be responsible for research on all aspects of crop production including paddy, all field crops, horticultural crops and rubber. The DOA's headquarters is in Bangkok which services the Project area through a regional rice station at Pattalung and a substation at Pattani as well as a regional rubber research center at Hadyai. DOA is currently being strengthened through the World Bank-supported National Agricultural Research Project, and it is expected that the specific initiatives would reach the Project for sometime when additional resources are made available.

6.1.3 Department of Agricultural Extension (DOAE)

DOAE with the head office in Bangkok, its regional office in Songkhla and its Changwat office in Narathiwat, would be responsible for extension services on all agricultural commodities except livestock, marine fishing and forestry. The field services are staffed with a supervisor (Kaset Amphoe) in an extension office of each Amphoe and with a number of field extension workers (Kaset Tambol) in the facilities of Muban Headmen. The extension activities are being strengthened through the World Bank-assisted National Agricultural Extension II Project which provides for a maximum ratio of one Kaset Tambol to 1,000 farm families with the TV system operation. The subject matter specialists at Changwat level are required to train Kaset Tambol.

DOAE is constrained in the provision of extension services in the Project area. The first is that about a half of the field extension workers cannot speak Jawi with difficult communication with the Thai Muslim farmers. The second is that Kaset Tambol are not trained to take a whole farm approach to extension; hence, their services are often inappropriate to local needs or not coordinated with the development effort of other agencies. It is proposed in the Project that these factors would be overcome and a ratio of one Kaset Tambol to 500 farm families would be realized during the development period of the Project.

6.1.4 Department of Land Development (DLD)

DLD has the headquarters in Bangkok and a regional land development unit in the Pikulthong educational and development center near Narathiwat. Its current programmes are more detailed soil and water survey and land classification in Changwat Narathiwat and research on development and management of organic soils including the reclamation of acid sulfate soils. DLD would have a crucial role under the Project in the specification of land capability at micro level and in collaborative efforts towards developing proper management practices for the poor soils in the irrigation service area.

6.1.5 Livestock Development Department (LDD)

LDD headquartered in Bangkok would be responsible for all aspects of the livestock promotion inclusive of breeding, forage production, animal health, animal production, artificial insemination, diagnostic services, quarantine and vaccine production. LDD has a Changwat office and a center in each Amphoe staffed with one technical officer and an assistant. A 200 rai forage research center near the Nam Baeng tidal regulator carries out the research of forage species, and a 700 rai seed production center at Sg. Padi is being developed for pasture seed production.

It has been explained that the LDD's major problem would be the inability to provide appropriate extension services to the livestock producers due to under-staffing and under-funding at Amphoe level. In some areas, the Kaset Tambol from DOAE attempts to cover animal production extension needs but he suffers from lack of the technical backup.

6.1.6 Department of Fisheries (DOF)

DOF would be responsible for servicing both the marine and freshwater fisheries in all aspects of production and marketing with the exception of the extension service for small pond culture that is the responsibility of DOAE. Its head office is in Bangkok, and it has the Changwat office, Narathiwat and the Amphoe fisheries office, Tak Bai. DOF also has a brackish water fisheries station under construction at Tak Bai and the National Institute for Coastal Aquaculture (NICA) at Songkhla. DOF would be responsible for promoting the Bang Nara freshwater storage fisheries under the Project, for which fish fry are available from the fisheries station at Pikulthong and the DOF hatchery at Pattani.

6.1.7 Cooperative Promotion Department (CPD)

CPD would be responsible for promoting the establishment of cooperatives including the water user's group for each irrigation service unit as well as a cooperative for the Bang Nara water storage fisheries under the Project. In addition to the Changwat office, CPD has two officers located at each Amphoe. More particularly, CPD would play an important role to promote adequate types of cooperative organizations for economic activities in crop agriculture, fisheries, livestock production, credit supply, purchase of production inputs and marketing of agricultural produce as well as non-agricultural commodities and manufactured goods, making use of the opportunities of dealing with farmers of the water user's groups.

The Land Settlement Division of CPD has been active in Changwat Narathiwat in attempting to establish land settlement cooperatives. A unit at Pileng, Amphoe Rangae which is located in the Study area has a plan to settle 334 landless farmers in total upon development of the area of the Royal Assent on the margins of the To Daeng swamp. To date, the land settlement cooperative includes 116 farmers with partial failure of the project due to over-drainage of organic and acid sulphate soils and lack of a viable farming system.

6.1.8 Department of Local Administration (DOLA)

DOLA in the Ministry of Interior would be responsible for the Changwat Administration consisting of Changwat office, Amphoe offices, Tambol and Muban councils as well as the local administration comprising Changwat Administration, Municipality and Sanitary District.

The Changwat Government is the primary unit of territorial administration and is a Local State Government because it is a hierarchical unit administered and staffed under the deconcentration system by the Central Government. The Changwat Administration, Narathiwat is under the authority and responsibility of the Governor who is appointed by MOI and assisted by the Changwat Board consisting of their respective ministries such as education, agriculture, health and so on.

Amphoe is headed by the Amphoe Officer (Nai Amphoe) who supports the administrative work of the Governor at district level in the field of administration and technical services. He is appointed by MOI and is also responsible to his Governor. Amphoe Officer also supervises the Tambol and Muban, and he is regarded as the most important link between the Government and the local people.

Tambol is a group of Muban, and its delimitation is decided by the Central Government. It is headed by Kamnan elected by Muban headmen who is charged with several duties involving both civil and criminal matters, keeping law and order and looking after public welfare. Muban is the smallest unit and the keystone of Changwat Administration. It is headed by the elected Puyaiban (Muban Headman) who keeps law and order, maintains records and is the leader in public emergencies. He is not an official of the Government, but, like Kamnan, under supervision and control of the Amphoe Officer and the Governor.

The Changwat Governor is responsible for overall coordination of the various agencies at local level with particular responsibility for full mobilization of the Changwat Administration and local self-administration system, and also specifically responsible through the Changwat Planning Office for overall coordination of development for the Project.

6.1.9 Community Development Department (CDD)

CDD under the Ministry of Interior has the responsibility to assist Muban people in identifying and planning the rural development schemes, help supervise the construction, and organize Muban people for O & M in line with a policy to maximize the participation of Muban people. Each Tambol has a Community Development Worker who acts as secretary to the Tambol Council, and each Muban has a committee for CDD projects. The CD worker relays requests to the Government agencies and helps the people operate projects built by other agencies.

CDD, Narathiwat would be responsible for strong assistance to the farmers organizing themselves for self-help, self-reliance and active participation in planning, construction and O & M for the WUG's irrigation service units under the Project, as a liaison between the

Project farmers and the Government agencies. As a matter of fact, the community organizers in the Special Task Force Unit proposed in the Project would play a crucial role to ensure the rapid and sound execution of the Project. (see para. 6.3.3 of this chapter)

6.1.10 Office of Rubber Replanting Aid Fund (ORRAF)

ORRAF is a statutory body with the Minister of Agriculture and Cooperatives as the Chairman of the Board, established in 1960. Its responsibilities are to encourage and assist smallholders to replant their senile rubber areas to high yielding clones and to operate the accelerated rubber replanting programme. Its programme is financed by 90 percent of the proceeds of the cess levied on rubber exports with the target of 50,000 ha replanting per annum. By law, ORRAF should strive to allocate about 90 percent of its available funds to smallholders up to 8 ha. The replanting grant to individual replanters is currently ฿ 30,000 per ha spread over five or six years.

The headquarters of ORRAF is in Bangkok, and its Changwat office at Narathiwat is responsible for implementing the programmes in the Project Amphoes. The rubber replanting programme would be dependent on budget allocations set by the ORRAF Board. The programme for the Project area is inadequate to remove the backlog of over-aged or low-yielding rubber. At present, ORRAF does not have the adequate financial resources or manpower to accelerate rubber replanting in Changwat Narathiwat.

It has been incorporated in the Project that the rubber planted area where the proposed drainage improvement scheme is contemplated would be improved. In line with this improvement and further good incentive for the Project farmers to promote the proposed irrigated agriculture, the rubber smallholders would be duly stimulated and accelerated to replant their old-aged or poor yielding rubber in the area, for which additional effort of ORRAF to provide such farmers with the grant assistance and relevant technical extension services is being sought.

6.1.11 Marketing Organization for Farmers (MOF)

MOF is a unit within MOAC which administers programmes to improve the input supply and product marketing. Fund for these is financed by the Farmers Welfare Fund which comes from taxes on rice exports and the deposit of local currency under the Japanese Grant Aid for Increasing Food Production (so-called "KR II Aid"). The programme includes the purchase of paddy when the price falls below acceptable levels, and distribution of the fertilizers to paddy growing areas at a standard rate.

At present, Thailand is importing the fertilizers and pesticides from Japan through KR II Aid. MOF is in charge of the distribution of fertilizers throughout the country, while DOAE for the pesticides. It has been proposed that the distribution of such commodities at least to the Project demonstration farms would be directed taking advantage of lower prices for the Project in Changwat Narathiwat. Although the MOF operations in Changwat Narathiwat appear limited, there are large number of small private traders carrying a wide range of the agricultural inputs. These traders generally offer a competitive service although it is common to find that some items may not be available to farmers.

6.1.12 Bank for Agriculture and Agricultural Cooperatives (BAAC)

BAAC is a statutory body with the Minister of Finance as the Chairman of the Board. Its main function is limited to lending to individual small farmers, agricultural cooperatives and farmers' associations for agricultural purposes, excluding agri-business. Farmers who are members of cooperatives are not entitled to borrow directly from BAAC. Most of the BAAC loans to cooperatives are made available under credit line agreements including the on-lending to member farmers.

Short-term loan of one year is offered for crop production. Medium-term loan for up to 3 years is for purchase of equipment, draught animals, and constructing or renovating infrastructure. Long-term loan for up to 20 years is available to individual farmers for the investments in agriculture including on-farm investment. Interest rates for farmers are 14 percent per annum, while those to cooperatives for on-lending are 11 percent. It can be mentioned that the Japanese Government's Overseas Economic Cooperation Fund (OECF) maintains its position as the BAAC's leading overseas creditor, while the World Bank has become prominent over more recent years. By the agreement with OECF, the prodeeds of the OECF loans have been disbursed mainly to the BAAC's individual farmers as long-term loans for investment in on-farm development and agricultural machinery and equipment in specially selected areas.

BAAC has a branch office at Narathiwat and its field offices in each Amphoe with 13 credit officers to serve about 20,000 farmers. BAAC is currently adjusting the staff numbers to achieve a ratio of one credit officer per 500 borrowers. About 25 percent of lending is through the cooperatives and the balance directly to farmers. Currently over 7,000 farmers or 27 percent in the Project Amphoes are BAAC clients. The greatest volume of credit is provided for livestock (50 percent), rubber (20 percent) and fishing (10 percent), while very little for paddy production except in the lower risk area of Tak Bai. Despite the normal problems associated with the provision of small amount of credit to large members of the small farmers, there is no reason to believe that BAAC would not be able to supply the adequate credit for future development needs of the Project farm households.

6.1.13 Southern Regional Agricultural Office (SRAO)

SRAO established at Songkhla in 1978 under the Permanent Secretary in MOAC has a main function to coordinate development planning, research, extension, training and conservation of resources in

14 Southern Changwats including Narathiwat. It has an executive committee comprised of members of the departments concerned and 10 commodity subcommittees covering key commodities in the region. To date, SRAO has found it difficult to exercise its mandate for coordination, and it is clear that the eventual role which SRAO would play in agricultural development in the Southern region has still to be decided. It can be mentioned that lack of the coordination would remain a major constraint to the efforts to achieve a successful implementation of the proposed Project.

6.2 Project Management and Implementation

6.2.1 Project Lead Agency

Aside from the construction and subsequent O & M of major civil work which would be under the sole responsibility of RID, the key issue for successful implementation of the subject Project should focus upon realization of the proposed irrigated agricultural development programme through the operation of demonstration farms, the organization of active water user's groups with subsequent development of on-farm facilities and the implementation of various extension services to the Project farmers. This is a serious and challenging task that cannot be carried out without a concerted effort of the various Government agencies being coupled with increasing participation of the Changwat administrative pipeline at Changwat, Amphoe, Tambol and Muban levels under the Ministry of Interior.

Although the responsibility for implementation of the various Project components providing the agricultural extension and support and the engineering infrastructure rests with different agencies as explained in para. 6.1 of this Chapter, all of these agencies concerned are within the Ministry of Agriculture and Cooperatives (MOAC). There is no single line department within MOAC whose mandate is sufficiently broad to coordinate the range of activities proposed under the Project, and there is a need for a lead agency or coordinating agency to ensure that the various individual agencies comply with the overall development programme and assist other agencies as required.

It is suggested that an appropriate agency to serve as lead agency would be the Office of the Permanent Secretary in MOAC which has both the mandate and authority needed to take a broad overview of the rural area development. Therefore, the organization structure proposed for development of the Project consists of the Office of the Permanent Secretary in MOAC as the coordinating lead agency with individual departments and agencies as implementing agencies. It is also proposed that a senior management position in the headquarters of the Office of the Permanent Secretary in Bangkok would be concurrently appointed as the Project Director who would be supported by a financial officer, administration officer and support staff.

6.2.2 MOAC Administration

Some of the MOAC central departments have the operating units located outside Bangkok which report directly to their chiefs in Bangkok without formal links or contacts with the Changwat Governor. The staff in their operation areas are either paid directly from Bangkok or fund is transferred from Bangkok to the Changwat treasuries to pay salaries. In the former case, such agencies are able to act independently of the Changwat authorities.

The Changwat administration of MOAC operates under the general supervision of the Changwat Governor. All fund for such agencies are drawn from the allocation made in their names to the Changwat budget, and the Governor has the power to approve all procurement and staff promotion. The Narathiwat Changwat administration system operates at least with DOAE, DOF, LDD and CPD concerned with the Project. These dual administrative systems as mentioned above are that there are two independent lines of command, and is potential for making coordination of the Project development difficult, especially when the development effort requires the participation of the central administration agencies.

6.2.3 Project Policy and Steering Structure

It has been mentioned by RID that a special board to be chaired by the Minister of Agriculture and Cooperatives would be organized as a Central Steering Committee for the proposed Bang Nara Irrigation and Drainage Project, both for overall planning and decision-making functions at the national level. The Committee would have its members comprising the Permanent Secretary of MOAC and the heads of all line departments concerned including RID, DOA, DOAE, DLD, DOF, LDD and CPD; the Changwat Narathiwat Governor; Directors of ORRAF and MOF; General Manager of BAAC; and the representatives of DOLA and CDD, Ministry of Interior as well as the Budget Bureau and the National Economic and Social Development Board. The Project Director as proposed in para. 6.2.1. would serve as a chief of the Board Secretariat and an executive officer to the Board.

This Central Board would meet quarterly with its function to determine policy, approve the Project component plans and budgets, ensure the coordination of various activities and to resolve the implementation problems. To do this, the Board would be required to evaluate and monitor progress through the formal reports from the Project Director's Office and through the routine monitoring carried out as part of the normal functions of the various participating departments and agencies.

An existing Changwat Development Committee which advises the Governor and serves as a coordinating body at Changwat level would be fully mobilized with the Project policy structure and function at area development level. The Committee under the chairmanship of the Narathiwat Governor would have the members including the Director of SRAO; the Chief of Changwat Planning Office: Changwat heads of all involved departments or the highest ranking officers in the Changwat for those agencies without the Changwat representation inclusive of RID, DOAE, DLD, DOF, LDD, CPD, CDD, ORRAF, MOF and BAAC; and Amphoe heads of Muang Narathiwat, Tak Bai, Rangae and Yingo. The officers in charge of each Project component including RID Project Manager would be eligible to attend as observers. The SRAO Director would serve as a secretary and executive officer to the Changwat Development Committee for the Bang Nara Project and be supported by the Project Director stationed in Bangkok. The Committee would meet quarterly in the month proceeding the Central Board at national level and would deal with its functions which would be generally parallel with those of the Central Board and submit its recommendations to that Board.

The necessary coordination among the line agencies on the basis of a multi-agency approach would not be suggested on a voluntary basis. Given that each agency has established a structural pattern of well-entrenched competition rather than of functional consultation and cooperation, one would not expect that the confrontation could easily be overcome and reversed into the collaboration. It is, therefore, expected that the above-mentioned Central Board for the Project outlines directions as to which agency be responsible for what field, phase, stage, step or spatial unit of planning, implementation and O & M. In particular, these indispensable directions should stipulate purpose, objective, approach, technique, method, input, link, control and information, in order to facilitate or strengthen functional effectiveness. Consolidating and reviewing the budgets for the subject Project of various agencies could assist the Board in guiding policy. Finally, decisions on strategy are necessarily dynamic in nature; therefore by learning from past experience, strategy would be improved over time.

6.2.4 Project Coordination and Management Structure

The overall responsibility for coordination and management of the subject Project would rest with the Office of the Permanent Secretary in MOAC. As a chief of the Central Board's Secretariat and an executive officer to the Committee, the Project Director would be responsible for ensuring the effective and timely implementation of the Project and of all the Board's decisions with the following:

- To prepare a consolidated Project annual plan and budget on the basis of submissions from the SRAO Director and the Project component heads, and to coordinate the component programmes and budgets where required;

- To ensure the timely provision of staff, procurement and fund release by the departments concerned and the Budget Bureau as required by the Project;

- To maintain the separate Project accounts for the agencies financing the Project; and

- To check the progress of specific programmes in the field and to supervize the monitoring and evaluation of the Project in cooperation with the SRAO Director.

The Project coordination in the field would be the prime responsibility of SRAO headed by a director at Songkhla, although both the Central Board and Changwat Committee would assist as required. The SRAO Director who would serve as a secretary to the Changwat Committee would have the key functions, through his assistants, to work with and through the officers in charge of individual Project components, as outlined below:

- To prepare a detailed programme and budget for the Project with appropriate phasing of activities for submission through the Changwat Committee and the Project Director to the Central Board;

- To ensure in the field the coordination between the Project components as required and the timely implementation of the Project particularly for activities of the Special Task Force Unit as explained later; and

- To prepare the quarterly progress reports for both the Changwat Committee and Central Board including monitoring and evaluation of the Project performance, and to bring the implementing problems that cannot be resolved at field level to the Changwat Committee or Central Board as necessary.

6.3 Water User's Groups/Associations

6.3.1 General View

Farmers in the irrigation service area are the ultimate users of the Bang Nara Irrigation and Drainage Project. These farmers would have to be relied upon to produce the maximum benefits from the Project; hence, they would be considered as key factors in the successful operation of the Project. To realize this, a strong sense of ownership would be generated to ensure proper operation and maintenance of the Project. The final links in the system for delivery of the irrigation water to the crops are (1) the farm ditches including their portable pumps directly from the Bang Nara water storage and (2) the tertiary canals extending from the RID's irrigation canal outlets for the RID pumping and gravity irrigation schemes, to the farm and the field itself. While there are many forms of the farmer's participation, it appears to be realistic at this point to form a water user's group for each of the portable pumping irrigation schemes and of the tertiary service units in the RID pumping and gravity irrigation schemes as the appropriate minimum spatial unit or important working unit for the Project water use.

6.3.2 Farmers' Participation

It is strongly stressed that the efforts to organize the local farmers into a water users' group after a tertiary on-farm system is completed generally meet with serious indifference. This means that the farmers completely ignored during the planning stage assume that since

RID is constructing the on-farm work, RID would also manage and maintain it. Since no shared sense of commitment to managing the on-farm system is developed during its creation, an "Each Man for Himself" mentality is likely to reign.

In examining this process, it may be concluded that the on-farm development would be left entirely to the local initiative. With this participatory programme, community organizers where the construction of on-farm work is planned are fielded to the area prior to the design and layout of the system in order to organize a water users' group which would work with the RID engineers in determining the layout of irrigation ditches and constructing such works. Throughout these activities which are designed to contribute to the development of responsible leadership and a well-structured group capable of moving spontaneously into constructing, operating and maintaining the on-farm work, the community organizers would work to ensure that there is participation from the farmers*/ whose fields lie throughout the entire service area. While this approach is conceptually simple, the building of the Government capacity to operate in this manner is surely a major task for successful implementation of the Bank Nara Irrigation and Drainage Project in orderly and quick-yielding manner.

*/ ..... The farmers' participation would strengthen their sense of ownership and concern with the O & M with a greater contribution to construction and development of the physical system.

6.3.2 Needs of the Special Task Force Unit

It is needless to say that the development of irrigated agriculture under the Project including the establishment and operation of demonstration farms require a multi-disciplinary approach utilizing the knowledge of community organizers in CDD, irrigation engineers in RID, agricultural extension specialists in DOAE, cooperative promotion specialists in CPD and administrative personnel in Changwat Narathiwat. This would be all part of the accepted truth, but remain an ideal under most circumstances. To make this ideal more practical, the Central Board and Changwat Committee as proposed in para. 6.2 of this Chapter would need to provide proper incentives for cooperation among such Government agencies. This may take the form of special meetings to examine possible forms of cooperation, streamlining specific forms of cooperation between the departments which are currently feasible but too complicated to carry out, and providing budgetary incentives for cooperation by increasing the budgets for joint operations.

Taking into account the information of communities and target groups as well as the current problems from a combination of agronomic, economic and social causes which are introduced in Chapter 3, it would be imperative, among others, to organize Special Task Force Unit in the Project to commence the favorable operation of three demonstration farms during the initial period of detailed design work for two tidal regulators and to facilitate the formation of viable water users' groups during the pre-construction stage of RID major irrigation work. The Project Director would be responsible for ensuring the timely organization and active operation of this Unit and effective formation of water users' groups under the direction of both the Central Board and Changwat Committee. The field coordination and routine management of the Special Task Force Unit would be the responsibility of the SRAO Director under the supervision of the Changwat Committee.

The Special Task Force Unit would be composed of the community development workers or organizers in CDD, agricultural extension specialists in DOAE, irrigation engineers in RID, cooperative promotion specialists in CPD and administrative personnel in Changwat Narathiwat and, when necessary, anthropologists or rural sociologists from the Center for the Southern Thailand Studies at Pattani campus of the Prince of Songkhla University. The community organizers who play an essential role in forming the water users' groups would live in Muban and devote themselves full-time to developing the water users' groups on weekends when the farmers often prefer to hold their meetings. It is assumed that one community organizer is needed per approximately 500 ha during the first 12 months, while later after construction, a lower ratio is possible if the strong groups have developed. Building of the staff of community organizers who can speak Jawi and are trained and oriented to the needs of irrigated agriculture with the recommendations to suit local circumstances would be a major challenging task for the Government, for which the lessons to be obtained through the operation of demonstration farms at three sites to experiment with involving the farmers from the beginning could be fully mobilized.

6.3.4 Operational Requirements for the Group Formation

There would be several major needs during the stage of planning the tertiary irrigation system and of developing a water users' group:

- to make a full use of both the engineers' technical knowledge and the farmers' local knowledge in laying out the tertiary and on-farm system;

- to generate the participation by a broad segment of farmers to ensure that the irrigation system layout is not biased to favor a few individuals and to create the sense of shared commitment to the system that is important to the subsequent O & M;

- to develop the group leadership gradually through the activities that would reveal who is committed to the hard work required to make the group function; and

- to develop clear understandings between the Government and the water users' group on the Project particularly regarding what is to be constructed, when, by whom and at what cost to the farmers.

A variety of the mechanisms would be developed to ensure broad based farmers' participation in the layout of on-farm irrigation system. First is to have the farmers, assisted by the community organizers and RID staff, look into the maps indicating all of the bunded paddy fields in the area. When each farmer identifies his own paddies, it ensures early broad awareness and involvement in the Project from all the potential members of a water users' group. It also identifies exactly which farmers are eligible for membership and how much land they cultivate. The map can be used for discussions of alternative ditch locations and can provide a better basis for determining which paddies can be reached by each ditch. It also provides a basic tool to use during O & M stage in determining water allocation, collecting irrigation fees and mobilizing for maintenance.

Secondly, to ensure an agreement between the farmers and the RID engineers on system layout, a series of the meetings are held. The RID technical staff plan the ditch locations and present at the meeting, and this explanation is supplemented by a walk-through of the proposed ditch locations since the farmers generally relate to the on-the-ground descriptions better than to the map. As the preliminary ditch locations are given, the farmers obtain the right of way waivers from the land owners involved, and this is an iterative process since if certain landowners refuse, then the ditch locations may have to be shifted. Finally, farmers identify who will be served by the system and encourage them to join the water users' group, and they also develop rules for the treatment of individuals who choose not to joint the group.

The water users' group is provided a set of standard by-laws; however, these may not be well-suited to the particular needs of the individual local area and are actually ignored by the farmers resulting in the water users' group not having a well-defined framework. To avoid these problems, the Special Task Force Unit encourages farmers to develop by-laws to fit their own group's needs which are discussed to ensure that there is wide involvement in the process and agreement on the rules all members would be expected to follow.

All of the activities proposed so far would reveal the need for constant coordination between the members in the Special Task Force Unit. While in most cases close coordination among the engineering staff and organizing/extension staff develop as a natural part of the field level activities, there would also be cases where tensions exist between the two. This may be the results of introducing a new approach which requires substantial changes in a manner in which the engineering stage approach their jobs. It is particularly likely to occur when there are distinct differences between ideas of the development of the farmers and engineers. The community organizers and cooperative promotion specialists who work and live with the farmers often develop a strong identification with the farmers' point of view, while the engineers' point of view may be shaped by the RID technical considerations or constraints. The Special Task Force Unit under the responsibility of the SRAO Director for field coordination and routine management would develop a variety of mechanisms for encouraging best communications and problem resolution between the two groups. In addition to frequent review meetings, the specific mechanisms would include (1) flow chart of pre-construction activities depicting the parallel activities of the community organizers, engineers and farmers, (2) planning and monitoring forms reporting the stage of accomplishment and planned activities on different dimensions, (3) joint training courses and workshops to build a common perspective on irrigation development and help each type of specialists understand the viewpoints and constraints of the other.

As is previously emphasized, formation of the water users' groups at the pre-construction stage is the key recommendation to ensure proper development of the tertiary irrigation facilities with the subsequent efficient O & M. In addition, an ultimate goal to be expected is to entrust to an association of several water users' groups all of the O & M activities in each of the RID pumping systems. It is currently common that the pumping system constructed by RID is operated and managed by RID. To achieve a higher efficiency in its operation, it would be desirable that rural youths carefully selected from the relevant water users' groups or association in the service area would be in charge of such operation and management after their training for some years in response to the timely and reliable supply of pumped water for downstream irrigation needs. Such youths under the RID technical assistance would devote themselves to develop their better understanding of the practices and performance to be made in the O & M of such pump system. After transferring the O & M to the water users' association, RID would be responsible for monitoring of such system and also major repair works.

CHAPTER 7 PROJECT IMPLEMENTATION PROGRAMME

7.1 Construction and O & M of Major Work

7.1.1 Mode and Procurement of Construction Work

RID would be solely responsible for initial construction and subsequent O & M of such major work as (1) two tidal regulators (UTR and LTR), (2) eight acidic water flow check facilities, (3) seven drainage improvement schemes and ten RID pumping irrigation systems down to tertiary outlets. It is suggested that all the above mentioned major work construction would be awarded on the basis of international competitive bidding in accordance with the premise that the proposed Project would be financed by the international lending agency.

Aside from the large contract for a simultaneous construction work of the two tidal regulators, the size and phasing of contracts for other major work would be dictated by the rate at which detailed design and contract documents could be prepared; therefore, the contracts for such work would probably be too small to be of little interest to international contractors and such work would be packaged for execution by the contractors local to the Project area. The manufacture and installation of tidal gates at UTR and LTR and RID pumping equipment at 10 stations would be procured from overseas manufacturers.

7.1.2 Design and Construction Schedule

Planning and design of the major civil work would be the responsibility of the RID Design Division. A proposed schedule of the detailed design work which would be assisted by the consultants is compiled in Figure 7-3. Detailed design of two tidal regulators would be carried out in the first half of the Project year 2 without any particular item for the pre-engineering work. In parallel with this, the planning and detailed design of eight acidic water flow check facilities as discussed in para. 5.2 of chapter 5 would be done. With the tendering procedures in the second half of the Project year 2, the construction work of two tidal regulators would be carried out during the Project years 3 and 4 and completed at the end of September in the

Project year 4 after the running test for tidal gates and ancillary equipment. The acidic water flow check facilities proposed at eight sites would be constructed by local contractor in the Project year 3, and the acidic water flow control into the Bang Nara water storage would be ready to operate immediately after the storage establishment taking one year for operational procedures and operators training including for those existing nine check facilities.

The Project office would be built at UTR site in the Project year 1 to accommodate staff of the Special Task Force Unit and RID construction staff. In addition, the residences, dormitory, garage and workshop would be attached during the Project years 1 and 2.

Prior to the detailed design for RID irrigation and drainage systems, the pre-engineering work would be executed. The topographical mapping work which is aerial-photo based with a scale of 1 : 4,000 and a contour interval of 0.25 m would be done in the Project years 1 and 2 covering the area of 130 sq.km for irrigation development, so that the subsequent detailed planning and design of irrigation systems could be carried out. It is proposed that the detailed design of such facilities would be supported by the consultants and take 4.5 years including the pre-engineering work such as the survey of profiles and cross-sections and hand auger tests for irrigation canals and drainage channels.

It is suggested that construction of part of the RID irrigation and drainage systems which are located in the relatively low-lying areas would be commenced in the Project year 4 taking into account more quick accrual of the anticipated benefits to be derived from the two tidal regulators' construction, the Government's financial load on the Project as well as the assumed rate of WUG's formation and subsequent on-farm development as is compiled in Figure 7-3. Construction of those RID facilities would take 6 years with four packages, each of which would need 2 years for completion including the procurement of incline pumps to be imported. This construction schedule has been conceived on the basis of (1) sound yearly distribution of the construction cost and (2) combination of the drainage and irrigation subprojects on the premise that the drainage improvement proceeds prior to irrigation development. Composition of four packages as envisaged is orderly explained in Tables 7-1 to 7-3.

Table 7-1 Relation of the Drainage Schemes with the Irrigation Schemes in the RID Irrigation and Drainage Systems

Drainage Improvement			Drainage and Irrigation			RID Pumping Irrigation	
	Paddy (ha)	Rubber (ha)	Gravity	WUG Pump	RID Pump		Paddy (ha)
1. Ban Lo Mo	70	50	-	-	70	1. Pu Ta	230
2. Khlong Ku Ra Po	590	240	-	160	430	2. Khao Kong	560
3. Khlong Na Ko	520	280	-	140	380	3. Du Song	880
4. Khlong To Che	2,290	1,740	- -	- -	150 510	4. Tan Yong Mat	1,090
4.1 To Che	660	160					
4.2 Lu Bo Manang	1,230	840	- -	- -	100 1,000	5. Khok Ti Te	1,120
						5.1 Lower	510
4.3 Khok Niang	400	740	-	-	180		
						5.2 Upper	610
5. Khlong Chang	750	3,880				6. Maru Bo	470
5.1 Chang (1)	50	60	-	50	-		
5.2 Chang (2)	430	1,470	-	-	430	7. Sala Mai	490
5.3 Ba Ngo Du Dung (1)	140	130	-	-	-		
5.4 Ba Ngo Du Dung (2)	20	2,180	-	-	-	8. Ko Sawat	520
5.5 Ku Rong Ya Ma	110	40	40	-	60	9. Phru Kap Daeng	380
6. Ban Sala Pradu	130	0	-	-	130	10. Ku Cham	190
7. Khlong Sala Mai	500	0	- -	- -	360 140		
Total	4,850	6,190	40	350	3,940	Total	5,930

Table 7-2 Grouping of the RID Irrigation and Drainage Schemes

Group No.	Grouping of the Irrigation and Drainage Schemes		Construction Cost	Service Area (ha)							
	Drainage	Irrigation	(฿ x 10^6)	Rubber	Paddy						Total
				D.	D.	D.+ R-I.	D.+ W-I.	D.+ G-I.	R-I.	G-I.	
A.	Ban Lo Mo	Pu Ta	8.48	50	-	70	-	-	160	-	280
B.	K. Ku Ra Po	Khao Kong	32.43	240	-	430	160	-	130	-	960
									250		
C.1.	K. Nako	Du song	52.46	440	(510)	530	140	-	(100)	-	1,970
	K. To Che										
	(To Che)										
C.2.	K. To Che				→(100)	→100					
	(Lu Bo Manang)	Tan Yong Mat	32.34	840	130	1,000	-	-	90	-	2,160
D.1.	K. Chang										
	(Chang (1))		6.00	60	-	-	50	-	-	-	110
D.2.	K. To Che					→510					
	(Khok Niang)	Khok Ti Te	74.76	2,210	220	610	-	-	-	-	3,550
	K. Chang										
	(Chang (2))										
D.2.	K. Chang										
	(Ba Ngo Du Dung (1) & (2))	-	20.16	2,310	160	-	-	-	-	-	2,470
D.3.	K. Chang	Gravity Irrigation									
	(Ku Rong Ya Ma)	Maru Bo	25.46	40	10	60	-	40	410	140	700
E.	Ban Sala Pradu	Sala Mai	39.03	-	-	630	-	-	380	-	1,010
	K. Sala Mai	Ko Sawat									
F.	-	Phru Kap Daeng	31.35	-	-	-	-	-	570	-	570
		Ku Cham									
Total			322.47	6,190	520	3,940	350	40	1,990	140	~~13,780~~ 13,170

D : Drainage
R-I: RID Pumping Irrigation
W-I: WUG Pumping Irrigation
G-I: Gravity Irrigation

Table 7-3. Construction Sequence of the RID Irrigation and Drainage Schemes

Construction Period	Group No.	Grouping of the Irrigation and Drainage Schemes		Construction Cost	Service Area (ha)							
		Drainage	Irrigation	(฿ x 10^6)	Rubber	Paddy Field						Total
					D.	D.	D.+ R-I.	D.+ W-I.	D.+ G-I.	R-I.	G-I.	
Stage I												
Fiscal Years	A.	Ban Lo Mo	Pu Ta	8.48	50	-	70	-	-	160	-	280
4 & 5 (First	E.	Ban Sala Pradu	Sala Mai	39.03	-	-	630	-	-	380	-	1,010
Package)		K. Sala Mai	Ko Sawat									
Total				47.51	50	-	700	-	-	540	-	1,290
Stage II												
Fiscal Years	B.	K. Ku Pa Po	Khao Kong	32.43	240	-	430	160	-	130	-	960
5 & 6 (First	F.	-	Phru Kap Daeng	31.35	-	-	-	-	-	570	-	570
Package)			Ku Cham									
Sub-total				63.78	240	-	430	160	-	700	-	1,530
Fiscal Years 7 & 8 (Second Package)	C.1.	K. Nako K. To Che (To Che)	Du Song	52.46	440	-	530	140	-	(100) 250	-	1,460
	D.1.	K. Chang (Chang (1))		6.00	60	-	-	50	-	-	-	110
	D.2.	K. To Che (Khok Niang) K. Chang (Chang (2))	Khok Ti Te	74.76	2,210	220	1,120	-	-	-	-	3,550
Sub-total				133.22	2,710	220	1,650	190	-	350	-	5,120
Fiscal Years 8 & 9 (Third Package)	C.2.	K. To Che (Lu Bo Manang)	Tan Yong Mat	32.34	840	→ (100) 130	→ 100 1,000	-	-	90	-	2,160
	D.2.	K. Chang (Ban Ngo Du Dung (1) & (2))	-	20.16	2,310	160	-	-	-	-	-	2,470
	D.3.	K. Chang (Ku Rong Ya Ma)	Gravity Irrigation Maru Bo	25.46	40	10	60	-	40	410	140	700
Sub-total				77.96	3,190	300	1,060	-	40	500	140	5,330 5,230
Total				274.96	6,140	520	3,240	350	40	1,450	140	11,980 11,880

D : Drainage
R-I: RID Pumping Irrigation
W-I: WUG Pumping Irrigation
G-I: Gravity Irrigation

7.1.3 Operation and Maintenance

At the Regional Office level, the O & M Project Branch is the organizational unit directly responsible for the O & M of individual projects as are seen in the cases of Pattani and Muno. The Branch is divided into the project offices each headed by a project engineer, and each with a complement of water masters, zonemen, common irrigators, maintenance crew, and some administrative and engineering support staff.

At the bottom of the O & M chain-of-command is the common irrigator who is responsible for opening and closing turnouts at the direction of his superior, the zoneman for keeping an assigned length of main or lateral canal free of unwanted debris and for reporting any damages needed for repair. A common irrigator would be responsible for the equivalent of about 160 ha of the irrigated area including eight turnouts. The zoneman supervises the work of six common irrigators and also is the first supervisor to be confronted with the problem of farmers who take more than his share of water. The water master is primarily an administrator in charge of five zonemen and is responsible for the repair and maintenance crew attending to the canals. The project engineer would supervise about three water masters.

O & M of the tidal regulators would be carried out by one water master and eight gate operators. In the case of WUG pumping irrigation scheme which is directly operated by each of the water users' groups, RID would be responsible for supervision and direction of their activities with the staffing of one water master and four zonemen. The acidic water flow check facilities at 17 sites would be operated by one gate operator, each under the supervision of one water master and four zonemen for the WUG pumping irrigation scheme. The RID irrigation and drainage system would be operated under one water master, six zonemen, 38 common irrigators and 33 pump operators (three per each). At the workshop to be provided at UTR site, two mechanics and two electricians would be staffed.

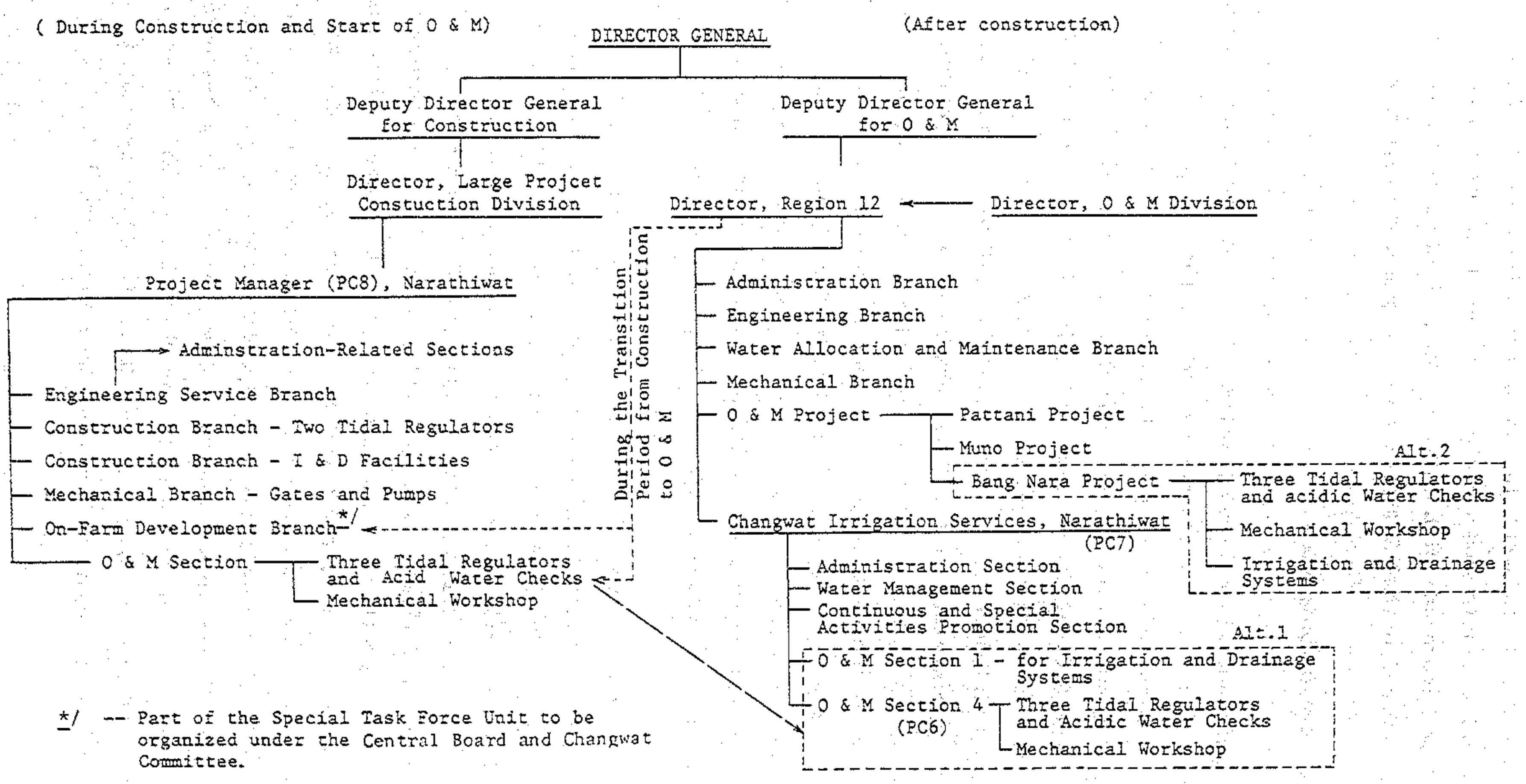
The O & M equipment including the vehicles for RID staff and those for routine repair works would be procured in the Project years 5, 7, 8 and 9 in accordance with the expansion of RID O & M work in the Project. A list of the O & M equipment to be procured is explained in chapter 8.

7.1.4 RID Organization

Reference is made to para. 6.1.1 of chapter 6. The proposed Project would have a project manager at the UTR site who has the responsibility for directing the Project construction to its completion during seven years (Project years 3 to 9) under the supervision of the RID Large Project Construction Division. The Project office would be equipped with (1) the Engineering Service Branch (including the administration-related sections), (2) the Construction Branch for two tidal regulators, (3) the Construction Branch for irrigation and drainage facilities, (4) Mechanical Branch for gates and pumps and (5) On-Farm Development Branch. The On-Farm Development Branch would be part of the Special Task Force Unit to be organized under the proposed Central Board and Changwat Committee and concurrently be surpervised by the RID Regional office in Hadyai. The organization of RID proposed for the Project is shown in Figure 7-1.

As soon as two tidal regulators are completed, the O & M Section for tidal regulators and acidic water flow check structures would be provided within the Project office and concurrently supervised by the RID Regional office. With the progress of construction work for the RID irrigation and drainage facilities, O & M for such completed systems would be handled by existing O & M Section 1 of the Changwat Irrigation Services, Narathiwat. After closing of the Project office at the end of the Project year 9, the O & M for tidal regulators and acidic water checks would be transferred to the O & M Section 4 to be newly established in the Changwat Irrigation Services, Narathiwat. When approved by the Budget Bureau, a new project office headed by a project engineer would be responsible for the O & M of the subject Project under the O & M Project Branch of the Regional office in Hadyai. The above mentioned arrangements are explained in Figure 7-1.

Figure 7-1 Organization Chart of RID, MOAC



*/ -- Part of the Special Task Force Unit to be organized under the Central Board and Changwat Committee.

7.2 On-Farm Work Development

(1) Size of the Tertiary Irrigation Service Units

Many experiences in other areas indicate that the local farmers generally prefer to do most of the preconstruction, construction and subsequent O & M activities in small groups with a traditional mutual aid system among closer kinsmen, when they believe their participation would benefit them. Taking into additional account the Project farm size and piecemeal distribution of the irrigation service areas as are specifically featured in the Project, it has been suggested in para. 4.3 of Chapter 4 that an appropriate size of a tertiary unit would range from 20 to 30 ha in comparison with the present RID standard size of 50 ha. As is designed on three sample areas in para. 5.5 of Chapter 5, an appropriate average size of the tertiary unit in the Project would be about 20 ha. With this figure, the proposed Project would have 193 tertiary units for WUG pumping irrigation scheme, 299 for RID pumping irrigation scheme and 9 for RID gravity irrigation scheme, with a total number of 501.

With the reduction of this size, the section of tertiary canals from the RID turnouts would be smaller resulting in considerable decrease of the current troubles such as right-of way and canal maintenance as are seen in the nearby RID projects, and there would be the increasing possibility to construct by the water users' groups.

As is stressed in Chapter 6, the formation of water users' groups at the preconstruction stage is the key recommendation to ensure the rapid and sound implementation of the proposed Project with timely development of the tertiary irrigation service units. To realize this, it has been imperatively suggested to organize the Special Task Force Unit on a multidisciplinary approach in the Project to achieve the favorable operation of three demonstration farms at each of three Amphoe concerned and to facilitate the formation of viable water users' groups on the basis of tertiary unit.

It is proposed that a special effort would be made to build up the Special Task Force Unit in the Project years 1 to 3 which would be composed of one Chief, four Community Organizers, one Agricultural Extension Officer, one Irrigation Engineer, one Cooperative Promotion Officer and several technical assistants under the field coordination and routine management of the SRAO Director. This Special Unit which would be accommodated in the RID Project office at UTR site would be supported by the consultant's advisory services including those of one WUG Specialist, one Rural Sociologist and On-Farm Work Specialist in an intensive manner particularly during the initial period.

(2) Demonstration Farms

The first task to be carried out by the Special Task Force Unit would be the final location and planning of three demonstration farms, the formation of three water users' groups concerned, and the construction of water source work and on-farm facilities. It has been tentatively proposed to locate three demonstration farms as given below:

(1) Ban Ku Ra So (13.8 ha) in WUG pumping scheme (Stage I)
Tambol Lamphu, Amphoe Muang Narathiwat

(2) Ban To Lang (23.5 ha) in RID Khok Ti Te pumping scheme (Stage II)
Tambol Tanyongmilo, Amphoe Rangae

(3) Ban Cha Ro (26.1 ha) in WUG pumping scheme (Stage I)
Tambol Phraiwan, Amphoe Tak Bai

As is scheduled in Figure 7-3, the Special Task Force Unit would complete three demonstration farms after the formation of respective water users' group at the end of the Project year 2 and would commence the actual operation of irrigated agriculture by using deep wells as temporary water source until the switch over to the Project irrigation water sources. It is anticipated that the demonstration activities at three sites would be terminated in the

Project year 9 in connection with the field training of agricultural extension workers, and then all the activities at these demonstration areas would be transformed to the normal operations by respective water users' groups.

It is commonly understood that the selection and location of demonstration farms are decisive for quick yielding of the proposed Project to demonstrate to the Project farmers an advanced agricultural technology coupled with an efficient irrigation water management and to be used for the field training of staff of the Special Task Force Unit as well as the agricultural extension workers and the on-farm development design engineers. The choice in locating the demonstration farms would be kept free of undesired influences, which otherwise could easily be a reason for criticizing the Project at a later stage.

It is suggested that the final selection and location of demonstration farms be made under the Changwat Development Committee in the Project year 1. Criteria for judging the demonstration areas could be based upon such factors (1) past agricultural performance, (2) relationship between farmers clients and Government staff, (3) interrelationship between inhabitants of the demonstration farms, role of the leadership and the farmers' willingness to cooperate in water management matters, and (4) accessibility for inputs and cars. Once the demonstration areas have been selected, proper arrangements would be made with the farmers who cultivate the demonstration area under the guidance of the Special Task Force Unit. Probably more important is the necessary contact with farmers in surrounding area, and it would be a major task to explain to those farmers why it is impossible to improve more than one tertiary unit at this stage.

To make the demonstration scheme successful, the relevant farmers in each area would form a water users' group and organize any required construction work within their service unit. It is expected that the farmers would contribute, free of charge, all the unskilled labor for construction and all the land required, while such water structures as made of concrete and other materials as well as the deep well facilities could be constructed on local contractor or force account basis under the RID financial assistance. In addition, the farmers would organize the rotational water distribution between the users of a field ditch with a particular reference to guaranteeing the constant water supply to certain marginal areas. The last difficulty to be overcome is the actual field irrigation practices, for which intensive guidance and assistance by the irrigation extension staff in the Special Task Force Unit would be indispensable.

(3) Construction of On-Farm Work

After the formation of water users' group for each tertiary unit, the relevant on-farm work would be in construction stage and it is suggested that the executing agency for this would be the water users' group. Relevant lessons inherent in development experience in Thailand indicate that since the evidence strongly supports that the free development assistance generates little sense of gratitude or responsibility for maintenance or production follow-through, it would not be considered necessary for development assistance to be a donation to be effective and helpful even in Changwat Narathiwat. It is stressed, with this concept, that the farmers in each tertiary unit would be organized to contribute, free of charge, all the unskilled labor and land for construction, while such water facilities as made of concrete and other materials would be constructed on local contractor basis or force account basis under the guidance of RID.

The financial resources for construction of such facilities which could not be technically made by farmers themselves would be mainly of two kinds: (1) Government subsidies which need not be recovered, and (2) loans which need to be recovered over time. It can be considered that the provision for loans would be extremely useful because, when the loan is repaid, the farmers would own such structures and maintain them properly. Recovery may take some of the forms such as paying water charge and land tax. Funds which are recovered can be used again, while funds which cannot be recovered are a direct transfer to the farmers concerned. The poverty of farmers in the Project area would be alleviated to a considerable extent, however, the poverty alleviation effect would not necessarily be limited by (1) financial constraints and (2) the critical need to make farmers self-reliant in future, capable of taking care of their own need without further assistance. It would be important to design the appropriate construction and financing plan for on-farm work so that it does not undermine long-term growth prospects introducing gradually a sense of ownership and responsibility, which would ultimately uplift the poor Bang Nara river basin.

There is a way of the BAAC's financing for the on-farm work construction where the borrower is not the water users' group but individual farmers participating in on-farm operations. For investment in agriculture, viz. purchase or develop agricultural resources or invest in agricultural assets which require a lengthy period before the borrower starts to receive a return on his investment, repayment is by installment within its period of up to 20 years at interest rate of 14 percent, and the borrowers are requested to submit their applications (for loan amount in excess of ฿160,000) in the form of detailed long-term agricultural investment programme for BAAC's consideration. Borrowers are also required to furnish an equity contribution of at least 20 percent of the total investment costs and to secure the loan either by the use of two personal guarantors or by mortgaging their fixed assets with BAAC.

(4) Development Pace of the On-Farm Work

In view of the slow achievement of irrigation development in existing projects at Pattani and Muno, a drastical change would be introduced to overcome the current problems involved and associated obstacles in order to ensure a successful implementation of the proposed Project with a gestation period for the anticipated benefit accrual as short as possible. Major concern to achieve this would be to promote the on-farm work development on more orderly and systematic basis in the Project with a view to recognizing that the farmers in the irrigation service area are the ultimate users of the Project and are to be relied upon to produce the maximum benefits from the Project. Several key recommendations to facilitate the on-farm work development in the Project have been examined previously.

With the anticipated maximum effort and positive services to be made by the Special Task Force Unit under proper coordination of the Central Board and Changwat Development Committee, the pace of development for on-farm work for 501 water users' groups in total has been worked out as is shown in Figure 7-3. This has been based upon the premise that the formation of water users' group and the engineering design of on-farm work are completed one year before the actual construction of on-farm work is done. In connection with the initial activities of three demonstration farms, the Special Task Force Unit would devote himself to accelerate the organization of water users' groups for the WUG pumping irrigation scheme which lifts water from the Bang Nara water storage to be completed at the end of the Project year 4. As is shown in Figure 7-3, the construction of on-farm work for 191 water user's groups would be assumed to be carried out at 38 units in the Project year 4, 77 units in the Project year 5, 57 units in the Project year 6 and 19 units in the Project year 7, with a total development period of 4 years.

For the RID pumping and gravity irrigation scheme, for which 307 water users' groups are formed, the on-farm work construction would take place in accordance with four packaging construction schedules of the RID subprojects. With the matured performance of demonstration farms and the refined activities to be taken by the Special Task Force Unit, it is anticipated that an accelerated pace in the formation of water users' groups and subsequent on-farm work construction would be achieved with an assumed rate of 40 percent in the first year, 40 percent in the second year and 20 percent in the third year for each construction package. In line with the construction schedule of RID facilities in the form of four package scheme, it is assumed that the construction of on-farm work for 307 water users' groups would be made at 25 units in the Project year 5, 48 units in the Project year 6, 36 units in the Project year 7, 51 units in the Project year 8, 75 units in the Project year 9, 54 units in the Project year 10 and 18 units in the Project year 11, with a total development period of 7 years.

Taking into combination the above mentioned factors in each of the irrigation development schemes, a total of 501 tertiary units to be involved in the proposed Project would be developed for respective on-farm work after the formation of water users' groups with a total period of 8 years excluding three units for demonstration purpose. This schedule is explained in Figure 7-3.

7.3 Special Issues on Pumping Irrigation Schemes

Recent research works of the comparison on the use of three different scales */ for pumping irrigation water from surface sources have identified the following:

*/ ... "Large" belonging to the Government agcency for ownership and O & M.
"Medium" to the water users' group.
"Small" to the individual farmers.

- Farmers in the small pump systems would take less time to prepare their lands, use less pumped water and maintain lower water levels in their fields than farmers in larger systems.

- Farmers in the larger systems would keep paddy spill-way levels an average of 20 mm higher than the farmers in the small systems. This implies that farmers in the larger systems tend to keep water at a higher level in the paddies as a reflection of the perceived lag-time for resupply by the system.

° Even though the seasonal effectiveness of rainfall would be about the same being irrespective of the system sizes, water pumped by farmers in the small systems would be consistently lower than by those in larger systems. This could be attributed to losses in water conveyance which are greater in larger systems because of a larger distribution network.

In view of the above, it is anticipated that a number of the WUG pumps to be included in the Project, Stage I which would be owned, operated and managed by the water users' groups would be eager to attain maximum efficiency to avoid any substantial losses in operation since the pumped water is costly to waste. On the other hand, the RID pumping station to be introduced in the Project which would serve about 25 tertiary units on the basis of about 500 ha on average size and be operated and managed by RID would have a tendency of being less responsive to irrigation needs and to effectiveness of rainfall utilization.

There would be two particular aspects to be examined for the RID irrigation pumping irrigation system with the above mentioned scale which is equivalent to "Small Medium Scale" tentatively classified by RID just on the extension line of the Small Scale Irrigation Project (SSIP):

- It is currently common that the pumping irrigation system constructed by RID is operated and managed by RID. To achieve a higher efficiency in its operation, it would be desirable that rural youths carefully selected from the relevant water users' groups in the service area would be in charge of such operation and management after their training for some years in response to the timely and reliable supply of pumped water for downstream irrigation needs. Such youths under the RID technical assistance would devote themselves to develop their better understanding of the practices and performance to be made in the O & M of such pump system. After transferring the O & M to the water users' association, RID would be responsible for monitoring of such system and also major repair works.

- While the O & M expenditures on the portable pumps to be introduced in the Project are borne by respective water users' group, it is the present practices that those on the RID pumps to be installed in the Project be by RID. Between the two, there would be a great discrepancy which would be solved prior to the Project implementation. To consider this item, ready reference is made to existing NEA pumping irrigation projects which are being operated with the water charges (฿0.60 per KWH) from the service farmers to cover part of the pump operating electricity and O & M costs. It may be noted that collection of the water charge to a reasonable extent would surely contribute towards the saving of pumped water and the quick development of irrigated agriculture.

- Chapter 8 examines the pumping motive power costs of the WUG pumps (type of self priming centrifugal pump coupled with gasoline engine on common base) and the RID pumps (type of inclined mixed flow pump directly coupled with motor). An average gasoline cost per ha per annum for the WUG pumps would be estimated at ฿139 at full development, although the engine outputs vary according to lift head or location. On the other hand, the RID pumps would take an average electricity cost of ฿387 per ha per annum ranging from ฿166 for Tan Yong Mat system to ฿709 for Khok Ti Te, upper part system. When a half of the annual electricity cost for the RID pumps that is equivalent to ฿194 per ha is collected from the service farmers in line with the NEA current procedures, there would be well-balanced consideration between the cost of WUG pumps to be borne by the service farmers taking into additional account the amortization cost of such pumps.

(Special note) NEA Pumping Irrigation Projects

° Background

Since the year 1965, NEA has implemented a number of the pumping irrigation projects to promote the electrical utilization for agricultural activities in rural areas. The Fifth Plan indicates that NEA should expand the pumping irrigation projects for an area of 200,000 rai of 80 stations each year throughout the Kingdom.

In the Southern Border Provinces, the following NEA pumping irrigation Projects with the standard type of 3,000 rai (480 ha) service are under construction:

- Changwat Narathiwat

  Baloa, Amphoe Muang Narathiwat
  Laraea, Amphoe Sq. Kolok
  Tan yong Mas, Amphoe Rangae

- Changwat Pattani

  Ban Pavo, Amphoe Sai Buri

- Chagwat Yala

  Two projects

° Standardized Project: 3,000 rai

- Farm areas less than 2 km from the water resources with perennial flow, and less than 5 km from the NEA transmission line.

- Farmers should agree to donate the land where irrigation canals run through, to organize the water users' groups*/ for the project participation and to pay part of the electricity charge for pumping.

  */ ... Effort is currently made by CPD to form "Farmers' cooperatives" as cooperative administration body to look after the project.

- Project Initiation:

  Organizing the farmers' group → Requesting NEA for the project → Constructing by NEA

- NEA Construction:

  ° Pumps (inclined axial flow type, two units) to head tank with a control switch board and 22 KV power line.

  ° Main, lateral and sub-lateral irrigation canals, all concrete lined down to tertiary turnouts.

  ° Construction period: three years

- Farmers Group's Responsibility:

  ° Right of way for all the canals.

  ° On-farm works within each tertiary unit, size of which is less than 100 rai (16 ha).

- NEA's O & M Responsibility:

  Pump to head tank.

- NEA Pumping Irrigation Service:

  To set up Pumping Irrigation Service Centers in Changwat to provide O & M of pumping stations, give advice, procure facilities and set rules and regulations in water use to farmers.

- NEA Electricity Charge Collection:

  ° NEA is currently paying for ฿1.12 per KWH to PEA.

  ° Farmers groups are collected at ฿0.60 per KWH[*/] by NEA.

  This would be equivalent to ฿100 per rai of paddy in one case and ฿120 in another case according to the group.

[*/] ... By Cabinet Order dated June 1982 when the PEA rate was ฿1.19 per KWH.

7.4 Consulting Services and Staff Training

7.4.1 Consulting Services

To ensure the rapid and sound execution of the Project, the services of a consultant team which would be composed of the foreign and Thai local firms in a joint-venture manner would be provided under the Project during the five-year service period to assist RID in detailed design and construction for two tidal regulators and for irrigation and drainage work, as well as to carry out the advisory services for the Project-related agricultural development inclusive of strengthening the Special Task Force Unit responsible for the operation of three demonstration farms, the formation of water users' groups and the implementation of on-farm facilities and assisting DLD in programming and monitoring a soil improvement scheme. It is estimated that about 300 man-months of consultant effort would be required as shown in Figure 7-2.

RID and the Special Task Force Unit under coordination of the Office of the Permanent Secretary in MOAC would provide appropriate full-time professional and technical personnel who work with the consultants and are trained and guided in their performance by the consultants. General terms of reference for the consultants are given below:

(1) Engineering Services

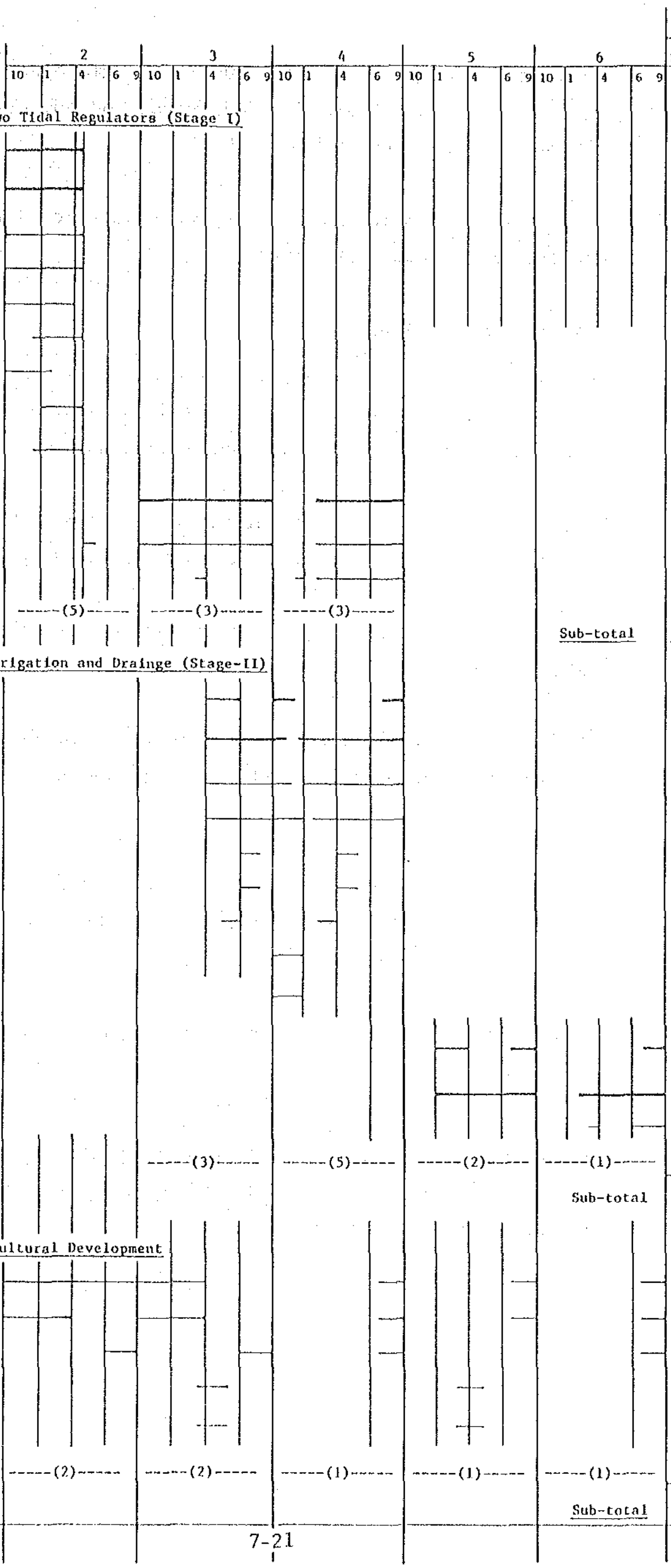
(a) Two Tidal Regulators

- Review all previous engineering studies, data and reports including those of the acidic water flow check facilities, with modification when necessary;

- Prepare detailed design, construction drawings, detailed specifications, cost estimate and tender documents including electrical and mechanical works;

- Assist in invitation of tenders and evaluation of tender documents;

Figure 7-2. Consulting Services: Manning Schedule



	Man-Month Foreign	Man-Month Local
1. Engineering Services for Two Tidal Regulators (Stage I)		
Civil Engineer/Team Leader	7	
Civil Engineer/Asst. Team Leader		7
Design Engineer, Civil (1)	7	
Design Engineer, Civl (2)		7
Design Engineer, Gate	6	
Design Engineer, Electrical		5
Soil Mechanics Engineer		4
Specialist, Tender Document	4	
Specialist, Construction Planning and Cost	5	
Construction Engineer/Team Leader	20	
Construction Engineer,Civil		21
Gate Engineer	10	
Not allocated	5	6
Sub-total	64	50
2. Engineering Services for Irrigation and Drainge (Stage-II)		
Civil Engineer/Team Leader	7	
Civil Engineer/Asst. Team Leader		17
Design Engineer,Civil (1)		17
Design Engineer,Civil (2)		17
Design Engineer, Pump	4	
Design Engineer, Electrical		4
Soil Mechanics Engineer		4
Specialist, Tender Document		3
Specialist, Construction Planning and Cost		3
Construction Engineer/Team Leader	7	
Construction Engineer,Civil		17
Pump Engineer	4	
Not Allocated	3	8
Sub-total	25	90
3. Advisory Services for Agricultural Development		
Specialist, WUG	24	
Rural Sociologist		18
Specialist, On-Farm Work		10
Agronomist		5
Specialist, Soil Improvement	5	
Not Allocated	2	5
Sub-total	31	38
Total	120	178

- Assist the Project office in construction management, quality control, testing of gates and equipment and any other works relevant to the construction; and

- prepare the O & M manual of relevant structures including existing Nam Baeng regulator.

(b) Irrigation and Drainage Work

- Review all previous engineering studies, data and reports, propose modification if necessary and supplement information as required by additional survey and investigation;

- Prepare detailed design, construction drawings, detailed specifications, cost estimate and tender documents;

- Assist in invitation of tenders and evaluation of tender documents;

- Assist the Project office in construction management, quality control, testing of pumps and other equipment and any other works relevant to the construction;

- Evaluate O & M of tidal regulators and acidic water flow check facilities and assist in development and water management of the WUGs' pumping irrigation scheme; and

- Prepare the O & M manual of relevant structures.

(2) Advisory Services for Agricultural Development

- Advise and assist in the establishment of demonstration farms and in demonstrating improved agricultural technology to extension workers and farmers;