10. 4 Substations and Electric Houses

The Substations and Electric Houses shall be situated at the Diversion Dam site and the Pumping Station site respectively.

The Substation at the Diversion Dam site is named No. 1 Substation which include Electric House while at the Pumping Station, Substation is located, which also includes an Electric House.

1) No. 1 Substation at the Diversions Dam Site (Ref. Fig 10-1)

a) Scope of Supply Area (Ref. Fig 10-2)

22 KV of electric power shall be received at the No. 1 Substation and reduced to 380/220 V in 3 phases 4 lines and then supplied to the Control House, motor, auxiliary facilities and control buildings for the Tide Protection Gate, air-conditioning and lighting of the training center, road lighting and other Electrical Facilities.

b) Location of Substation

No. 1 Substation and the Electric House shall be constructed near the Control House. The control house shall be located at 70 m downstream from the Diversion Dam, on the left bank of the diversion canal.

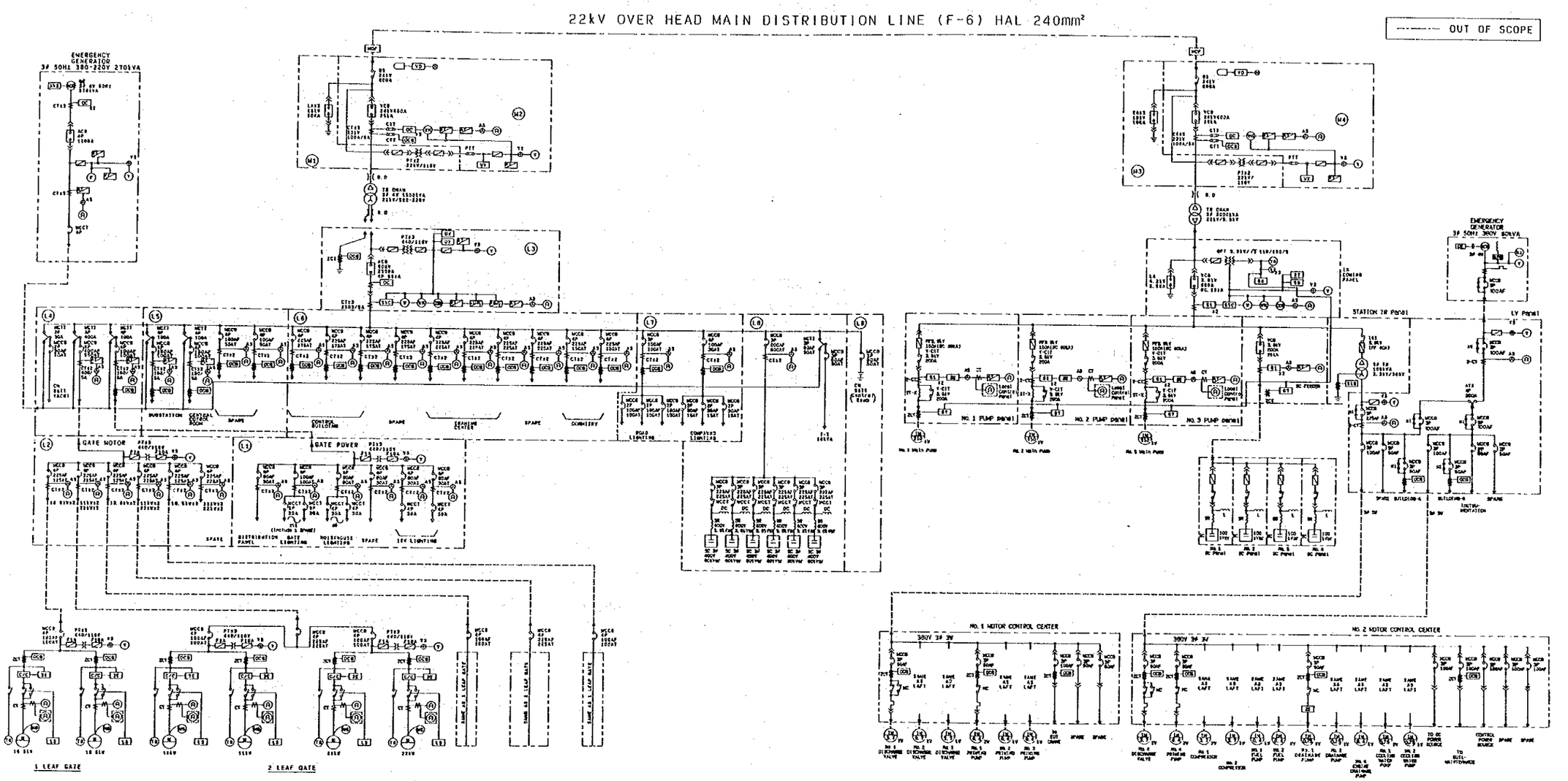
c) Structure of Equipment

All equipment including charging equipment will be enclosed in an iron metal case, so as not to be exposed. Both the high tension and low tension side of the transformer is also the same structure so as not to exposed.

d) Equipment List

Outdoor Facilities

i) 22 KV incoming power board (cubicle type) ..... 2 sets
ii) 3ø - 50 Hz 1500 KVA - 22 KV/ 380 - 220 V 3 phases 4 lines . 1 set
iii) Primary bus duct ..... 1 set



THE KINGDOM OF THAILAND ROYAL IRRIGATION DEPARTMENT	
THE BANG PAKONG DIVERSION DAM PROJECT	
CONTROL SYSTEM & ELECTRICAL FACILITIES	
SINGLE LINE DIAGRAM	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) *SANYU CONSULTANTS INC.*	
DESIGNED	
TRACED	
CHECKED	
APPROVED	
DRAWING NO.	

iv) Secondary bus duct ..... 1 set

Electric House

i) Incoming low voltage cubicle-type switch board ..... 1 set
ii) Low voltage feeder cubicle-type switch board ..... 1 set
iii) Motor power cubicle-type switch board ..... 1 set
iv) Low voltage cubicle-type switch board for gate area ..... 1 set
v) Low voltage switch board for premises Control House ..... 1 set
vi) Low voltage cubicle-type switch board for control building, training center and dormitory ..... 1 set
vii) Low voltage cubicle-type switch board for premises and road lighting ..... 1 set
viii) Low voltage cubicle-type switch board for condenser and Control House ..... 1 set
ix) Battery cubicle-type switch board ..... 1 set
x) Emergency generator operation cubicle-type switch board . 1 set
xi) 270 KVA emergency generator ..... 1 set

e) Electric power for Control House, training center and dormitory

These buildings are currently programmed for construction but the scope of construction is uncertain. The assumed loading power is stated in Table 10-4 and item (vi) and applied in this case but cable works will not be carried out within the Project works.

2) No. 2 Substation at the Pumping Station Site

a) Scope of Power Supply

No. 2 Substation shall provide three motors for the main pump with 350 KW of electric power each, auxiliary Electrical Facilities of diesel engine, interior lighting and outdoor lights, excluding road lighting; that is, electric power is supplied to only the Pumping Station.

b) Location of Substation

The substation shall be installed near the Pump House. The 22 KV incoming power cubicle-type switch board and the transformer shall be located outdoors. The other Electrical Facilities shall be inside the Pump House.

c) Structure of Equipment

As the same case as No. 1 Substation, charging equipment shall be enclosed in an iron metal case so as not to be exposed.

d) Equipment List

Outdoor Facilities

i)	22 KV incoming power cubicle-type switch board	2 sets
ii)	3ø - 50 Hz - 3000 KVA - 22 KV/ 3.3 KV 3 phases 3 lines transformer	1 set
iii)	Primary bus duct	1 set
iv)	Secondary bus duct	1 set

Electricity Room

i)	Incoming low voltage cubicle-type switch board	1 set
ii)	350 KW motor operation cubicle-type switch board	3 sets
iii)	Condenser feeder	1 set
iv)	Condenser in cubicle	4 sets
v)	Station power transformer in cubicle case	1 set
vi)	Premises lighting switch board	1 set
vii)	Auxiliary cubicle type switch board for motor/pump	1 set
viii)	Auxiliary cubicle for engine/pump	1 set
ix)	Battery cubicle-type switchboard	1 set
x)	Auxiliary relay	3 sets
xi)	TM/TC cubicle-type switch board	1 set
xii)	Local control cubicle-type switch board for motor/pump	3 sets
xiii)	Local control cubicle-type switch board for engine/pump	1 set
xiv)	Local control cubicle-type switch board for auxiliary	4 sets
xv)	60 KVA emergency generator	1 set

10. 5 Protective Equipment

No. 1 and No. 2 Substations shall be controlled and monitored by a remote-control system. The group indicators shall be installed in the Control House.

1) A lightning arrester shall be installed to protect major facilities from lightning strikes.

2) Earth relay will be installed at the neutral point of 3 phases 4 lines transformer to detect the earthing of the related circuit systems. The same measures shall also be taken for the major feeders.

3) From the failure of equipment and electric circuit, the Electric Facilities shall be protected by providing over current rely, lack phase, and reverse phase relay. The low voltage motors shall be equipped with a thermal relay.

4) The operation shall be monitored and controlled through the observation panel centralized in the Control House.

10. 6 Condenser for Power Factor Improvement

60 KVA × 6 = 360 KVA condenser for power factor improvement for the Diversion Dam and 400 KVA condenser for power factor improvement for the Pumping Station shall be installed, which will be controlled automatically to the increase/decrease of the loads. Present loading power is light but condenser capacity shall be decided, taking the future extension into account.

10. 7 Emergency Generators

Emergency generators shall be installed, one each for the Diversion Dam and Pumping Station, to act as countermeasures for service interruption.

1) Capacity of Emergency Generator

a) Diversion Dam

3 ø-50 Hz-270 KVA-380/220 V 3 phases 4 lines generator.

The capacity shall be sufficient to operate two 22 KW motors for the lower gate leaf of the regulating gate, including a power supply of 20 KW for the Control House and an additional 20 KW for other facilities at the same time.

b) Pumping Station

3 ø-50 Hz-60 KVA-380/220 V 3 phases 4 lines generator.

The irrigation pumps consist of three sets of pumps driven by 350 KW motor and one set of pump driven by diesel engine. At the time of electric power failure, only a pump driven by diesel engine will operate. Therefore, an emergency diesel generator shall be planned with sufficient capacity to supply the electric power to the emergency engine auxiliaries of 12.5 KVA, lighting and others.

2) Type of Emergency Generator

The cooling method for the generator should be of the air cooling type. The emergency generator for the Diversion Dam facilities shall be soundproofed because the generator capacity of 270 KVA is so large that it may make a lot of noise.

3) Service Interruption Process

- Diversion Dam

Service interruption will be detected by, an under voltage relay and the emergency generator shall start operation automatically to supply electric power to the Diversion Dam facilities.

- Pumping Station

The emergency generator shall be installed in the Pumping Stations for the operation of a pump driven by diesel engine. The starting of the auxiliary equipment for the diesel engine shall be manual at the respective spots, because it is necessary to check the cooling water and fuel supply systems before the operation of generator.

10.8 Maintenance of Facilities

Because of high temperature and humidity in the Project area, proper checks and maintenance should be carried out periodically. Particularly, the facilities in the Diversion Dam site involve several low voltage switchboards for future use. The meters and relays may easily fall into a mechanical failure, if the facilities are left in operation for a long time.

1) Periodical Inspections

Periodical inspections will be carried out twice a year.

Periodical inspection shall be performed by visual check which is mainly conducted to inspect for existence of dust, rust due to humidity and foreign substance and remove those substances.

2) Particular Inspections

Particular inspections will generally be carried out once a year on the following matters.

a) Operations and greasing up of apparatus, overhaul inspection and, check and replacement of contact parts of breakers, if necessary.
b) Pressure test for insulation oil
c) Characteristics test, working test, and measurement of time limiting characteristics of all relays.
d) Error check on all instruments.
e) Check of battery electrolytes and charging circuit.

3) Emergency Generator and Diesel Engine for Pumps

The emergency generator shall be driven by a diesel engine and equipped with many auxiliaries and devices, such as circulating devices of lubricant oil and cooling water and compressor, etc. Particularly a diesel engine for the Pumping Station may have a long nonoperation period.

These devices should be maintained in good condition at all times. In order to check and confirm the condition of the devices, the generator should be operated at least twice a month.

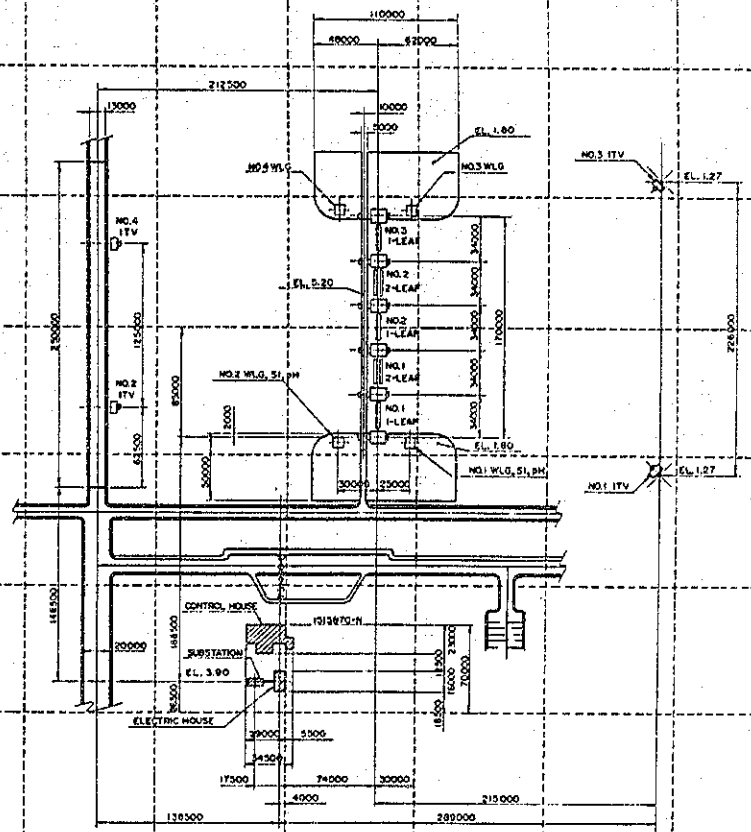
10. 9 Power Distribution

The Diversion Dam and Pumping Station shall be provided with electric power from the No. 1 Substation and No. 2 Substation respectively.

1) Diversion Dam (refer to Figure 10-3)

The locations are presented in the coordinates, as shown in Fig. 10-3.

FIGURE 10 - 3 LOCATION MAP OF DIVERSION DAM SITE



Major loads are motors for the flood gates and regulating gates of the the Diversion Dam and these capacities are shown in Table 10-1. Power supply cable and control cable from the Control House shall be placed by separate routes. The power cable and control cables shall be laid down in the pits located upstream and downstream from the O/M bridge, respectively, connecting each load.

a) Substation (primary side)

Primary side 22 KV power shall be supplied to the south end of the Control House through the overhead line undertaken by PEA.

From this point to the Substation, the power cable shall be wired under the ground up to the incoming power switch board. These cables should be 22 KV-3C-150 mm^2 of LPE-PVC triplex type power cable.

b) Substation (secondary side)

The power will be reduced in voltage to 380 V/220 V with 3 phase 4 wire by the 1,500 KVA transformer and transmitted to incoming low voltage cubicle in the Electric House. And this current capacity is so heavy that the power cable for each phase shall be 5 lines of 1c-250 mm^2 cable and neutral point shall be 3 lines of 600 V CV copper cable.

c) Flood Gate and Regulating Gate

Hoist Houses shall be named in the order of No. 1, No. 2, No. 3, No. 4, No. 5 and No. 6 from left bank to right bank . Local control panel shall be installed in each Hoist House excluding No. 6 Hoist House.

Cables from the Electric House to each local control panel are presented, below:

FIGURE 10-4 POWER CABLING ROUTE

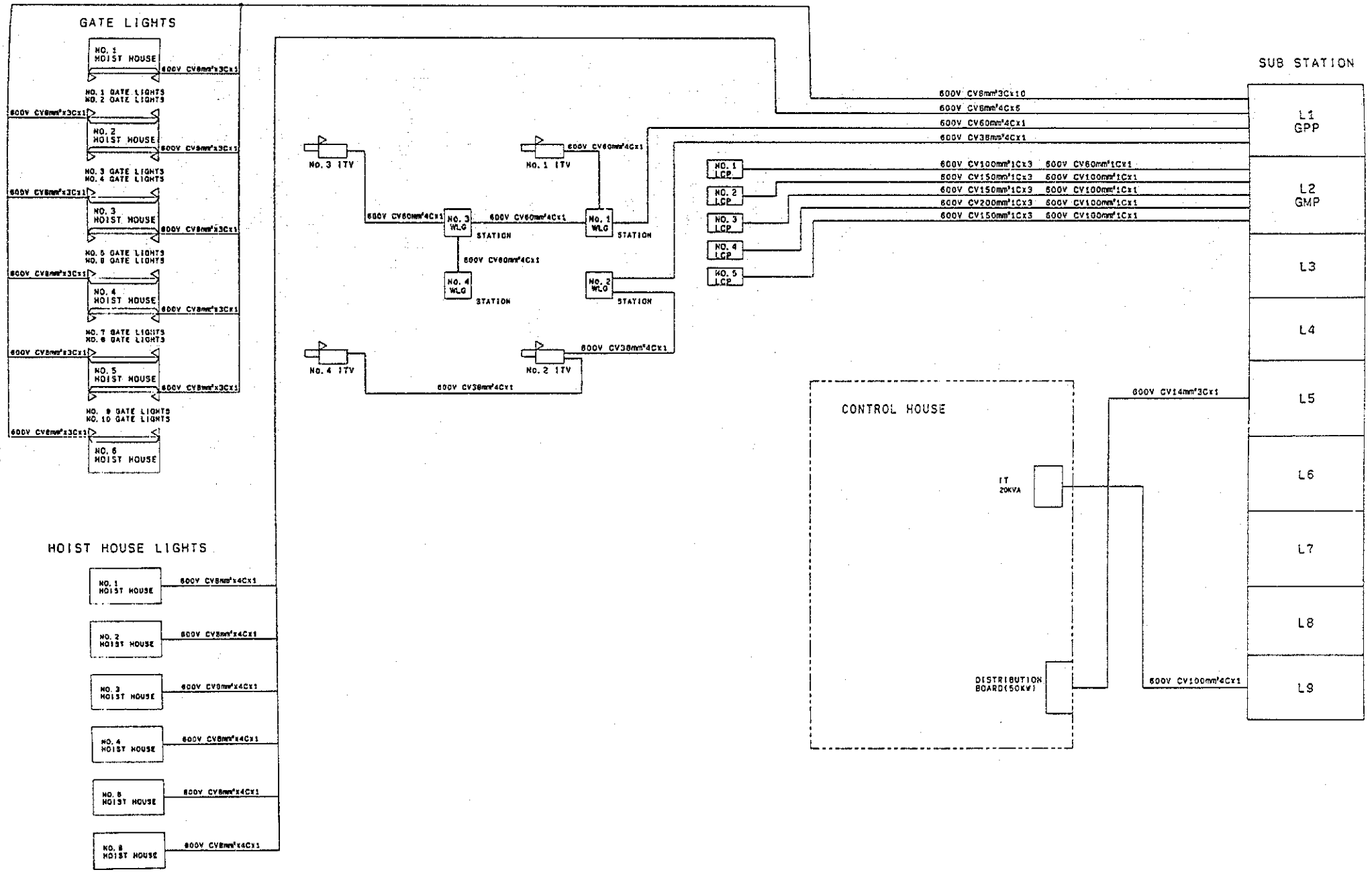


TABLE 10-11 MAIN CABLE LIST

Hoist House No.	Location of Panel	Main Cable from Electric House	Branch Cable To Next Hoist House
No. 1	1 leaf gate	CV, $1_C \times 100\ mm^3 \times 3 + 1_C \times 60\ mm^2$ CVVS, $30_C \times 2mm^2 \times 1$	CV, $4_C \times 14\ mm^2 \times 1$ CVV $30_C \times 2mm^2 \times 1$
No. 2	2 leaf gate	CV, $1_C \times 150\ mm^2 \times 3 + 1_C \times 100\ mm^2$ CVVS, $30_C \times 2mm^2 \times 2$	CV, $4_C \times 22\ mm^2 \times 1 + 4_C \times 8\ mm^2 \times 1$ CVV $30_C \times 2mm^2 \times 2$
No. 3	1 leaf gate	CV, $1_C \times 150\ mm^2 \times 3 + 1_C \times 100\ mm^2$ CVVS, $30_C \times 2mm^2 \times 1$	CV, $4_C \times 14\ mm^2 \times 1$ CVV $30_C \times 2mm^2 \times 1$
No. 4	2 leaf gate	CV, $1_C \times 200\ mm^2 \times 3 + 1_C \times 100\ mm^2$ CVVS, $30_C \times 2mm^2 \times 2$	CV, $4_C \times 22\ mm^2 \times 1 + 4_C \times 8\ mm^2 \times 1$ CVV $30_C \times 2mm^2 \times 2$
No. 5	1 leaf gate	CV, $1_C \times 150\ mm^2 \times 1 + 1_C \times 100\ mm^2$ CVVS, $30_C \times 2mm^2 \times 1$	CV, $4_C \times 14\ mm^2 \times 1$ CVV $30_C \times 2mm^2 \times 1$

Electric power shall be supplied to each local control panel through electric power cable from the motor power cubicles directly.

Local control panel for each 2-leaf gate will be provided with motors of 11 KW (2 sets), 22 KW (2 sets) for upper and lower gates respectively. In this case, load shall be estimated to be a total capacity of, 11 KW (2 sets), and 22 KW (2 sets) of motors. The operation must be carried out in accordance with Article 10-2-a "Basic load and Operation Rule". Necessary data for these cable capacities are shown in Table 10-12.

TABLE 10-12 ELECTRIC SOURCE CAPACITY OF LOCAL CONTROL PANEL

Gate		Motor (KW)	Current (A)		KVA		Break	Control (KVA)
			Normal	Start	Normal	Start		
1-leaf		18.5 KW × 2 sets	36 × 2	180 × 2	23.6 × 2	118.5 × 2	0.3 × 2	2
2-leaf	Upper	11 KW × 2 sets	23 × 2		15.1 × 2		0.3 × 2	3
	Lower	22 KW × 2 sets	44 × 2		29 × 2	149.4 × 2	0.3 × 2	

In the above table, the control electric source is 220 V single phase.

Voltage drop at a switching position in the local control panel is 15 % in 380 V basis.

As the gate opening and closing functions are the most important for water control, the cables will be determined in order to make voltage reduction of less than 15 % for starting operation.

d) Electric Power for Lighting for each Hoist House

The electric power for the lighting for the Hoist House shall be supplied through 380/220 V 3 phases 4 lines electric power, and estimated to be 3 KVA. The lighting for the O/M bridge will benefit by the lighting for the Hoist House. Therefore, lighting shall not be installed for the O/M bridge.

e) Gate Lighting

All gates shall be monitored by ITV camera from a point 200 m downstream and upstream side from the Diversion Dam.

On account of the long distance, it is difficult to maintain adequate illumination for high color rendition and high tension sodium lamps shall be installed in 4 sets for each gate, upstream and downstream of each gate. These lamps shall be placed in the most suitable position to obtain a clear-colored picture by the ITV projector. This will require 4 lamps on the upstream side and 4 lamps on the downstream side; that is, 8 lamps for each gate. Providing the lamps for 5 gates, will total 40 lamps in all. These lamps will be remotely controlled from the Control House, divided into 10 phases.

The cable shall be extended down to the pier from the pit of upstream side of the O/M bridge and connected with the lamps of the upstream and downstream side through conduit tube, and then extended to the pit on the upstream side of the O/M bridge to connect with the lamps for the other gates.

f) Cable to the Hoist House from O/M Bridge

The cable up to the Hoist House shall be wired in the hand hole via the pit on the O/M bridge from the Substation.

g) Observation House and Electrical Power Source for ITV and Paging

The observation house consists of 2 houses for the exclusive use of a water level gauge on the right bank and 2 houses for the exclusive use of a water level gauge and salinity instrument on the left bank which makes 4 houses in total. The necessary electrical power shall be supplied to these facilities.

The ITV cameras shall be installed in 2 places, upstream and downstream of right and left bankside of the diversion dam. Thereby a total of 4 places are required. Two places on the downstream side shall be installed on the pier of the road bridge.

Loudspeakers will be installed on No. 2 and No. 5 Hoist House, which are 4 sets in all, 1 set each for the upstream and downstream sides of the Diversion Dam.

The ITV cameras and observation houses will be installed in total of 4 sets in the upstream and downstream sides of the Diversion Dam. Electrical power will be supplied from the Substation directly.

h) Road Lighting

The road lighting will be provided starting at 300 m far from the road bridge on the right bank side and extended for 3.16 km to the closure dam. Characteristics of basic lamp is as follows:

TABLE 10-13 CHARACTERISTIC OF 380 V HIGH TENSION SODIUM LAMP

Type	Volt. (V)	Hz	Incoming Current (A)			Power (W)	Power Factor (%)	2 ry Vol (V)	2 ry short Current (A)	Lamp Current (A)
			No Load	Start	Normal					
TCP 38 A (R) 40	380	50/60	0.85	0.65	0.55	180	90	200	2.5	2.0

Because of the 3.16 km extension, lighting will be by 380 V-high tension sodium lamps and divided into three sections. The lighting switch board will be installed at three points, A, B, and C. Electrical power will be

supplied to each lamp from these lighting switch boards individually. These 3 circuits shall be remote-controlled from the Control House. No automatic flashing shall be placed. As to lighting for the road bridge, the poles shall be installed on downstream side piers and wired on to poles.

Road for the residential area, which is 20 m wide, and 470 m long, will be lighted from both sides but the other road shall be lighted on the downstream side only.

2) Pumping Station

As for power distribution for the Pumping Station there is no problem, because the supply area is relatively simple and located close to the electrical power source.

a) Substation (primary side)

The primary 22 KV power line of the substation will be connected to the incoming power switchboard by underground cable.

b) Substation (secondary side)

The secondary 3.3 KV power line of the Substations will be connected to the secondary board of the transformer in the Electric House through a cable pit.

c) Pump House

Main loading power in the Pump House requires a for 350 KW motor for the main pump. The cable for this system will be laid through a cable pit and cable rack.

10. 10 Lightning Rods and Earthing Resistance

1) Lightning Rods

As a protective device for indoor Electrical Facilities, a lightning rod will be installed on the top of each house; that is, the Hoist Houses, Pump House and Control House others.

Such lightning rods for the Substation, Electric House and Control House in Diversion Dam area will be provided by RID.

2) Earthing Resistance

Earthing Resistance is as follows.

Neutral point of transformer	less than five ohms
Equipment case earth	less than ten ohms
Earthing rod	less than ten ohms in total each less than fifty ohms

The material of earthing plate or bar should be copper.

CHAPTER 11. CONSTRUCTION PLAN

11.1 Construction Materials and Equipment

1) Construction Materials

Of the construction materials and equipment required for the Bang Pakong Diversion Dam Project, the tide protection gates and the pumps will be supplied by foreign manufactures. The other materials and equipment are procurable domestically. The market conditions for major construction materials are as follows:

a) Cement

Portland blast furnace slag cement is not found on the market so locally produced ordinary Portland cement, which is anti-sulfate cement prescribed as Type V in TIS 15 (Thai Industrial Standard), will be used. In Thailand, this type of cement has been widely used for seashore structures. Therefore, there are no problems with the quality and production capacity.

b) Rock Materials

Aggregate for concrete and rock for riprap will be procured from quarries in Chonburi about 60 km away form the construction site. The rock materials obtained from the quarries are mainly hard sandstone with no problem of quality and quantity.

c) P.C. Pile

A.P.C pile maker in Thailand will be constructed to manufacture piles using type V cement in TIS 15. There being several P.C. pile makers in Thailand, there should be no problem with the manufacturing of the P.C. piles.

d) Reinforcing Bars and Shaped Steel

Round bars and deformed bars of ø 12 ~ 28 mm dia. can be procured from the market easily. Shaped steel is also generally available unless it is of a specialized type.

2) Construction Machinery

The major construction machinery to be required for the Bang Pakong Diversion Dam Project is roughly estimated as shown in Table 11-1.

TABLE 11-1 CONSTRUCTION MACHINERY LIST

Name of Construction Machinery	Specification	Required Number
Dragline	$2m^3$	4 sets
Backhoe	$1m^3$	4 sets
Dump Truck	11t	20 sets
Bulldozer	21t	4 sets
Swamp Bulldozer	15t	5 sets
Pile Driver	Tower-type	2 sets
Concrete Plant	$0.75m^3 \times 2$	1 plant
Concrete Pump	$45\ m^3/hr$	2 sets
Agitator	$3m^3$	5 sets
Crawler Crane	150t	2 sets
Crawler Crane	50t	2 sets
Truck Crane	35t	1 set
Grader	12ft	2 sets
Tire Roller	15t	2 sets
Tamping Roller	2 drams	2 sets
Pump Dredger	1,200 PS	2 ships
Tug Boat	250 PS	2 boats
Bottom Open Type Barge	$200\ m^3$	2 ships

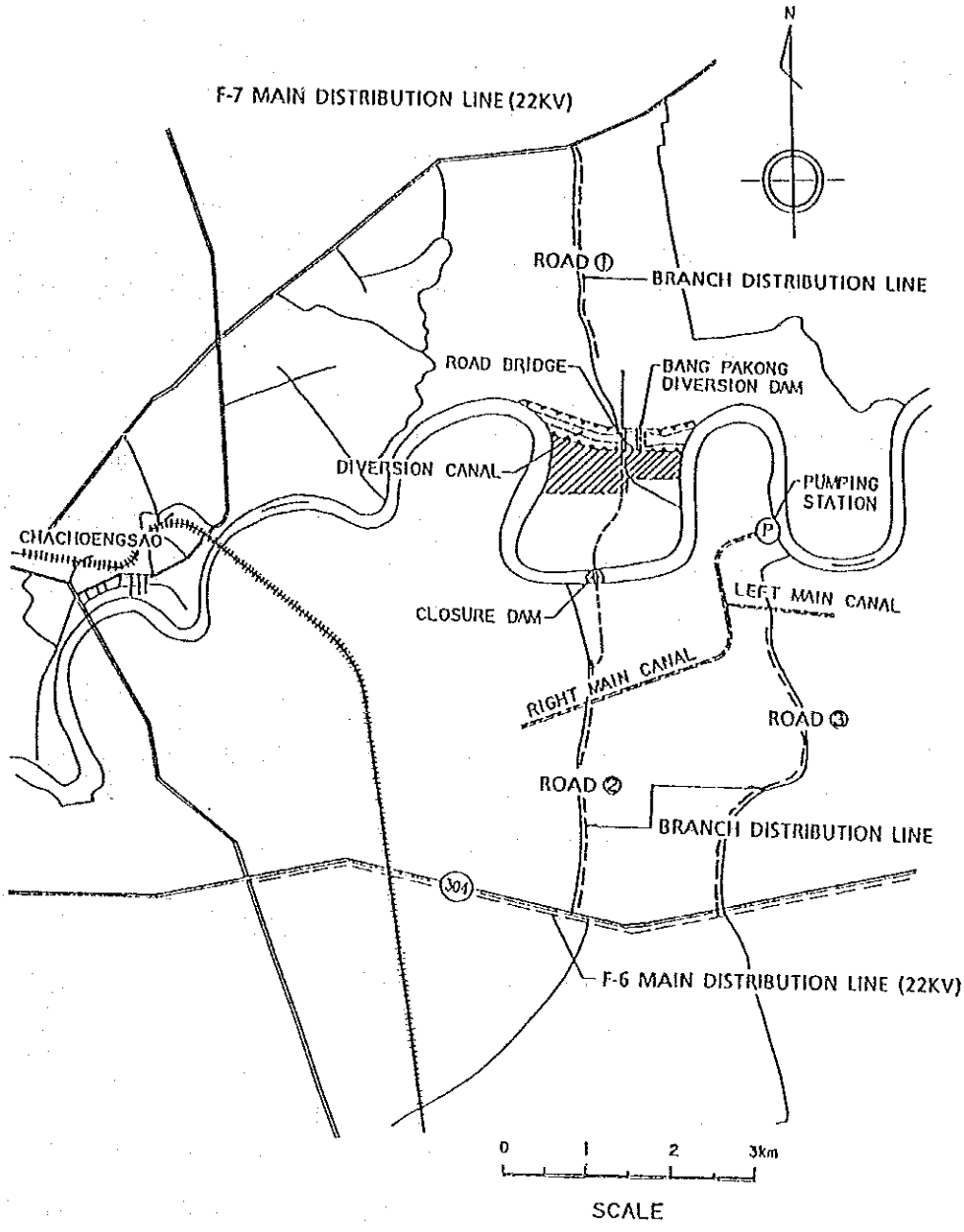
11.2 Temporary Facilities Plan

1) Access Road

As illustrated in Figure 11-1, there is one existing road on the right bank and two existing roads on the left bank, as access to the construction site.

Route No.1 This is the road to the diversion dam and the diversion canal. Since the existing road condition is bad, rehabilitation will be completed by

FIGURE 11-1 LOCATION MAP OF ACCESS ROAD



RID, by the time of the commencement of the Bang Pakong Diversion Dam Project.

Route No.2 This is the road to the closure dam. It is paved with laterite, in good condition and about 9 m in width.

Route No.3 This is the road to the pumping station. It is paved with concrete and is about 4 m in width.

2) Electric Power for Construction Works

Since branch distribution lines with 22 KV have been set up along the roads mentioned above, they will be able to supply electric power for the construction work. The capacity of the main distribution line is estimated to be enough for the construction work, no problem with electric power supply is foreseen.

3) Water Supply for Construction Works

For stable water supply for concrete mixing and curing, and for other purposes, facilities for storing water with sufficient capacity, such as a water tank or a reservoir, will be required.

Water pumped from the Bang Pakong river in the wet season will be stored in the facilities. Drinking water purchased at Chachoengsao or water taken from appropriate water sources in the dry season will be conveyed by tank lorries and also stored in the facilities.

The capacity of the facilities storing water for construction works should be determined taking into account sedimentation as well as the quantity required to ensure a stable water supply.

4) Plan of Temporary Buildings

The temporary buildings to be built on the site are roughly listed below. An area of about 22,000 m^2 will be needed as the temporary building lot.

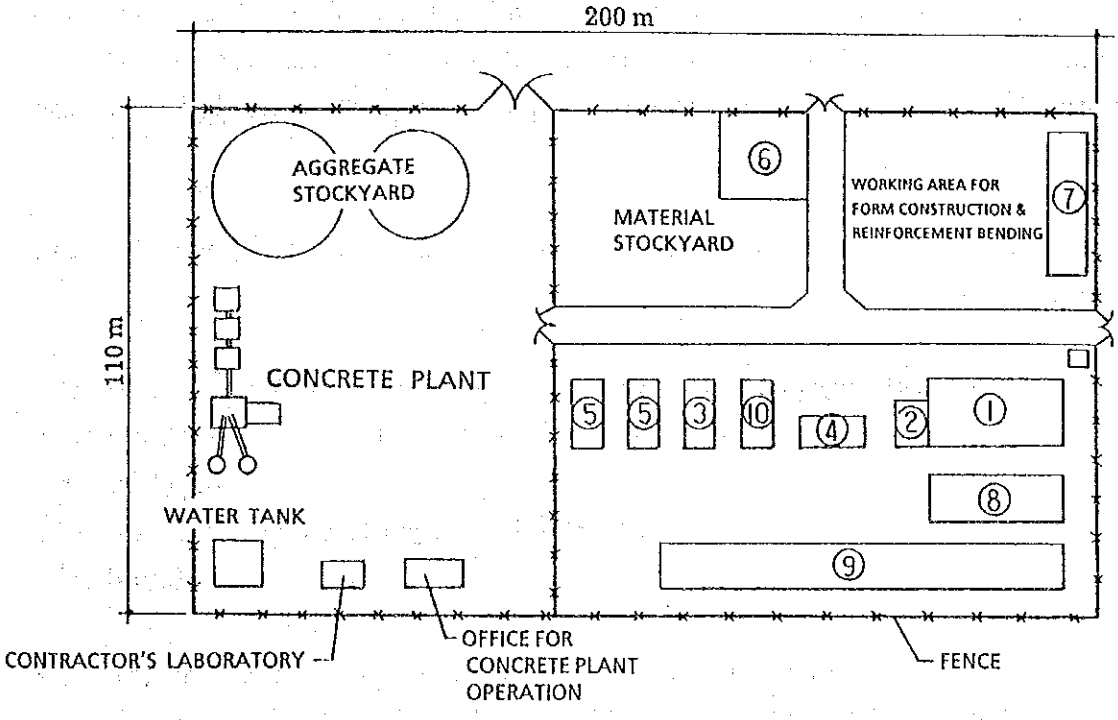
a) Contractor's Facilities

①	Contractor's Office	450 m^2
②	Warehouse	75 m^2
③	Community House	105 m^2
④	Toilet & Shower	105 m^2
⑤	Work Shop	210 m^2
⑥	Motor Pool	400 m^2
	Labourers' Quarter	2,000 m^2
⑦	Staff Quarter	350 m^2

b) RID and Consultants' Facilities

⑧	Employer's and Consultant Office	600 m^2
⑨	Employer's and Consultant Residence	900 m^2
⑩	Filed Laboratory	100 m^2

FIGURE 11-2 LAYOUT PLAN OF TEMPORARY BUILDINGS



11.3 Construction of Diversion Dam

1) Excavation Plan

a) Excavation Method

Concerning the excavation of the diversion dam, the 450 m section from the diversion dam to the road bridge (① in Figure 11-3) will be excavated under dry conditions. The total excavation volume will be 1,110,000 m^3. In the first stage, the diversion dam portion of 610,000 m^3 will be excavated, and successively at the second stage the road bridge & protection work portion of 500,000 m^3 will also be excavated.

The excavation method for the upper layers is different from the lower layer, and is planned as follows:

Upper layer excavation: The ground between the surface and EL(-) 4.0 m in depth will be excavated by dragline 2 m^3 each in capacity and hauled by 11 ton dump trucks.

Lower layer excavation: The ground below (-) 4.0 m will be excavated by backhoes of 1.0 m^3 each in capacity, installed on the access road which was constructed at EL.(-) 8.0 ~ 9.0 m for heavy machinery, and hauled by 11 ton dump trucks.

The excavated soils are classified into good quality soil and soft soil as follows:

Comparatively good soil	:	Surface layer (E.L.0 ~(-) 8.0m)	95,000 m^3
	:	Lower layer (below (-) 8.0 m)	230,000 m^3
Total	:		325,000 m^3
Soft Soil	:	Intermediate layer (EL.0 ~ (-) 8.0 m)	785,000 m^3

The excavated materials will be banked on the site for the O/M building area (Ⓐ 400,000 m^2 + Ⓑ 150,000 m^2 = 550,000 m^2 in Figure 11-3). The good soil of 325,000 m^3 will be used as embankment materials for the O &

FIGURE 11 - 3 EXPLANATION MAP OF EXCAVATION PLAN

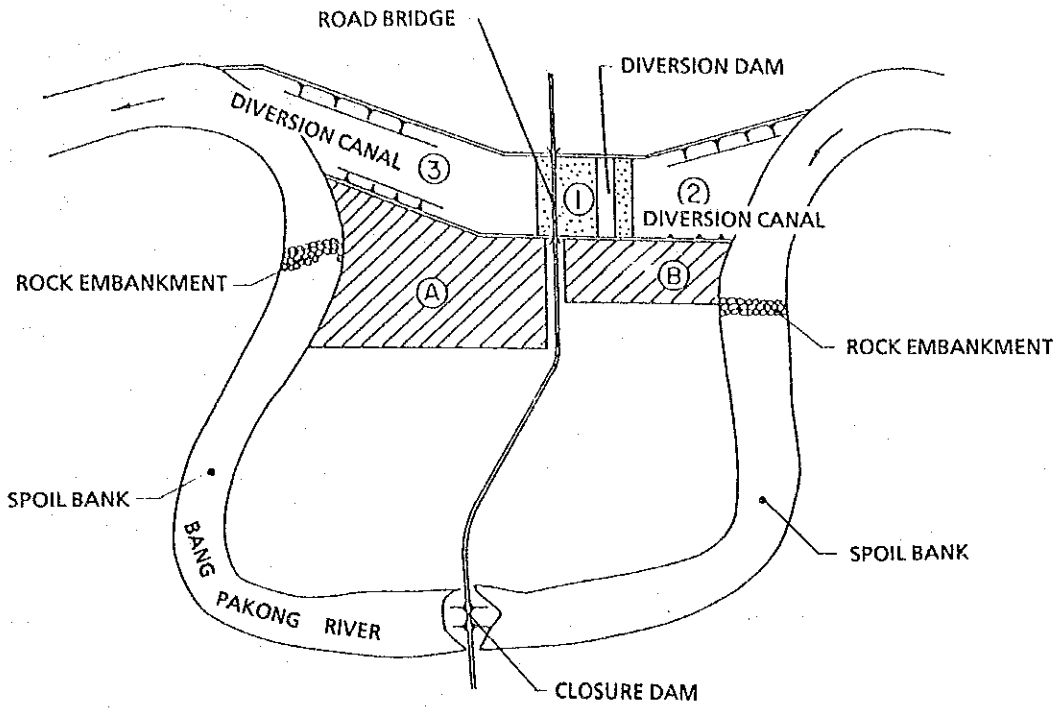
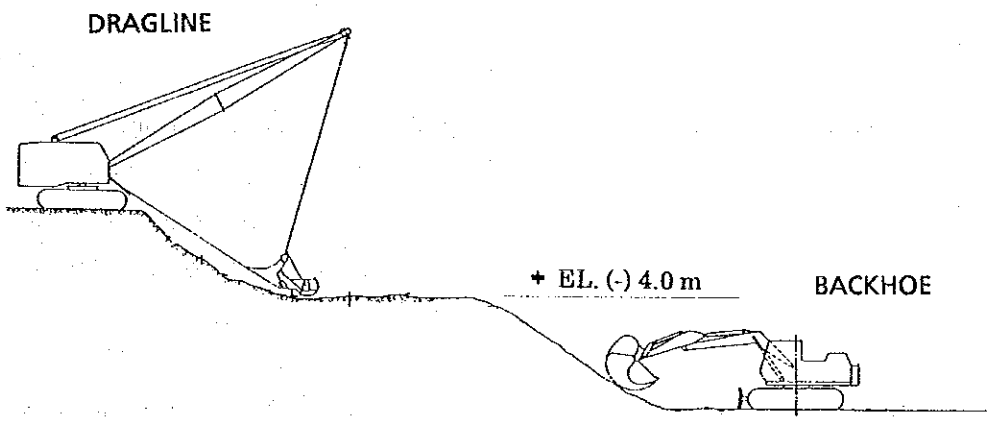


FIGURE 11 - 4 EXCAVATION FOR DIVERSION DAM



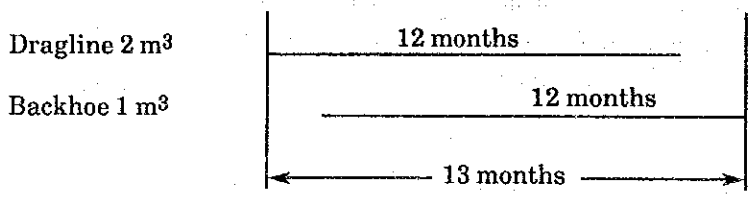
M building lot, and the soft soil of 785,000 m^3 will also be used as embankment materials by drying as much as possible, using a very wide spoil banking area.

Judging from the results of the geological survey and soil mechanical test, since it was found out that well-point method is difficult to discharge groundwater, in case of open excavation damsite; a plan for curbing oozing groundwater by setting up the cut-off wall with lightweight steel sheet piles around the excavation portion, will be made up.

Also for the purpose of discharging rain water speedily, drains are disposed latticedly on the excavating bottom, and rain water is drained from collecting pits at the corner's by pumps.

b) Required Amount of Equipment

Total excavation volume 1,060,000 m^3



Each piece of equipment works for 12 months, and total period is assumed for 13 months.

i) Dragline

- Excavation volume : 1,110,000 × 62% = 680,000 m^3
- Working capacity of 2 m^3 dragline: 80 m^3/Hr
- Workable hours a day : 10 hours/day because of bad ground foundation, soft soil to be excavated and night work with risk.

680,000 m^3 ÷ (800 m^3/day × 24 days/month × 11 months) = 3 sets

ii) Backhoe

- Excavation volume : 1,100,000 m^3 × 38% = 430,000 m^3
- Working capacity of 1 m^3 backhoe: 50 m^3/Hr
  430,000 m^3 ÷ (500 m^3/day × 24 days/month × 11 months) = 3 sets

iii) Dump Truck-11 ton

- Working capacity of 11 ton dump truck (Hauling distance of 1 km): 18 m^3/Hr
  This figure shows the number of sets on average.
  In fact, the number of sets are shown below, in combination of loaders.
  For first 1 month: 80 m^3 × 3 sets ÷ 18 m^3 = 14 sets
  For intermediate 11 months : {(80 m^3 × 3)+(50 m^3 × 3)} ÷ 18 m^3 = 22 sets
  For last 1 month: 50 m^3 × 3 ÷ 18 m^3 = 9 sets

2) Backfill and Embankment

A part behind the retaining wall should be backfilled up to 2.0 m in width and with laterite or good quality materials. The soil backfilled should be compacted enough with Tampers. The remaining portions will be backfilled with purchased soil or dried excavated soil.

3) Foundation Piling Works

Piling works begin from the dam foundation portion. A pile for this portion is ø800 mm S.P. pile, 10 m in length and 1.8 ~ 2.4 ton in weight. Tower-type driving equipment and the drop hammer, popular in Thailand, are applied to this operation. The hammer should be used as heavy as possible and the dropping height be limited to below 2 m.

Working capacity: 5 pcs/day/unit
780 pcs ÷ 5 pcs × 24 days = 6.5 units/month
6.5 units/month ÷ 2 units = 3.3 months

After completion of piling at the dam foundation portion, piling works will be carried out at both upstream and downstream apron portions.

A pile for these portions is ø300 mm P.C. pile, 10 ~ 12 m in length and 1.0 ~ 1.2 ton in weight.

Working capacity: 8 pcs/day/unit
1,400 pcs ÷ 8 pcs × 24 days = 7.3 units/month
7.3 units/month ÷ 2 units = 3.7 months

The period required for piling is 3.3 months at the diversion dam foundation portion, and 3.7 months at the upstream and downstream apron portions, 7 months in total.

4) Concrete Works

a) Concrete Plant

Although several ready-mixed concrete plants can be found around Chachoengsao city, a concrete plant will be set up at the site to ensure a secure supply of concrete. The concrete plant is planned to be equipped with 2 sets of mixers with a capacity of 0.75 m^3.

Capacity of supplied volume,
0.75 m^3 × 2 sets × 15 batches/Hr × 10 Hr × 0.8 = 180 m^3/day

Prior to commencement of mixing, mixing of concrete for each structure shall be determined by field mixing tests based on the specified mix proportion of each structure.

b) Placing

Concrete placing is planned to be carried out by concrete pumps of 45 m^3/hr in capacity. A conveyance from a concrete plant to placing spots will be done by agitator cars 3 m^3 each in capacity.

Since concrete volumes of foundation slabs and piers are 39,000 m^3, the required concrete placing period will be as follows:

39,000 m^3 ÷ (180 m^3 × 0.7) = 310 days
310 day ÷ 20 days/month = 16 months

The climate over the project site being tropical and the temperature being generally high, some ways to reduce concrete temperature in case of mass concrete placing will be needed. That is, using ice mixing water make up for sunshade over the aggregate, or placing at night.

c) Form

Metal forms should be used for finally exposed portions if possible, and wooden forms should be used for the portions to be buried in soil or submerged in water, and for complicated structures.

5) Dike and Riverbed Protection

For dike protection, rocks 30 ~ 50 cm in diameter will be paved on the slope. Although the slope consists of soft soil, it is assumed that the surface will become compacted to some extent, because of being left for about 18 months, as working foundation.

Being expected, however, to have a weight within the range of 50 ~ 150 kg, rock material should be paved using a crane with an orange bucket.

Concrete cross blocks for river bed protection will be manufactured at the founding site. The number of cross blocks to be manufactured daily is calculated using total founding area of 18,000 m^2 and an area of 4 m^2 to be occupied by one block, as follows:

18,000 m^2 ÷ 4 m^2 = 4,500 pcs
4,500 pcs ÷ 10 monts = 450 pcs/month
450 pcs ÷ 24 days = 20 pcs/day

In order to manufacture 20 pcs of cross blocks per day, 60 sets of metal forms should be provided. Since one block requires approximately 1 m^3 in concrete, 20 m^3 of concrete a day will be necessary. This volume will not affect the plant capacity.

6) Dike Work

The embankment materials for the dike works will be obtained from purchased soil or lower layer soil excavated at the diversion damsite.

The bottom width of each dike is at least 8 m. No working roads are therefore prepared. The material will simply be dumped and the dike gradually built up.

The tamping roller, flat roller and grader will be applied for compaction. Finally the bank slope will be protected by sodding.

7) O & M Bridge

The p.c beam cast at a factory or the site will be hauled by trailer, then hung up by two cranes, 100 ~ 150 tons each in capacity.

11.4 Construction of Diversion Canal

1) Excavation Plan

Two methods of excavation will be examined.

Case 1: Excavation mainly by pump dredgers
Case 2: Excavation of conjunctions with the river by pump dredging and excavation of the other portion by open cut.

a) Case 1

There are four bridges from the estuary up to the damsite (of which one is a railway bridge) and a 2,500 ~ 3,000 ps class pump dredger cannot pass below these bridges. Accordingly, two units of 1,200 ps dredgers procurable in Thailand will be selected for this project.

As a result of the survey by RID, it was found that paddy field areas proposed as spoil banks are not located closer than 5 km from the site. In fact, it

will be very hard to secure them as spoil banks. And it will be uneconomical, even if they can be procured at a place closer than 5 km from the site.

Therefore, excavated soil will be dumped into the old river course, keeping the end of the discharge pipe not in the air but in the river water, 2 ~ 3 m above the river bed, so as to accelerate the deposit of dredged soil and prevent river water turbidity as much as possible. Also to prevent outflow of dredged materials dumped into the old river course, a rock embankment with a crest elevation of EL.(-) 3.0 ~ (-) 4.0 m will be constructed at two spots as shown in Figure 11-3.

Prior to the commencement of the pump dredging work, the ground will be excavated from the surface to the depth of EL(-) 0.6 m by backhoe with a capacity of 1.0 m^3, and then hauled by 11-ton dump-trucks to the O/M building area.

The amount to be excavated at ② and ③ (Fig. 11-3 refers) at the diversion canal is estimated to be 2,450,000 m^3. The excavation work is classified into two methods, as follows:

Open cutting	-	Top soil	150,000 m^3
	-	Soil down to EL(-) 0.6 m	300,000 m^3
Total		.....	450,000 m^3
Pump dredging		.....	2,000,000 m^3

The required units of equipment for open cut excavation work are as follows:

Backhoe, 450,000 m^3 ÷ (500 m^3/day × 24 days × 12 months) = 3 units
Dump-truck, 450,000 ÷ (180m^3/day × 24 days × 12 months) = 9 units

This work will be executed for one year during the period between the completion of the excavation at the diversion dam and the commencement of the diversion canal dredging work.

The dredging work will be carried out by 1,200 PS-pump dredger. In case average delivery distance is 1,500 m, dredging capacity will be 250 m^3/hr. The required working periods for the work will be as follows:

Production Volume: 250 m^3/Hr × 20Hr × 24D = 120,000 m^3 /month/unit

Required period: 2,000,000 m^3 ÷ 120,000 m^3 × 2 units = 9 month

During this operation, the pump dredgers will be engaged in closure dam excavation work for three months, and it will take 12 months for the whole dredging operations.

As a result of an examination of the construction schedule, it is planned that the excavation of this portion should be intensively carried out over a period of 12 months towards the end of the construction schedule. In order to secure the minimum water volume required for gate testing, the construction of a waterway about 20 m wide should first be carried out, and then be widened gradually to the design cross section.

b) Case 2

The excavation in this case is divided into two categories;

Open cutting : 2,150,000 m^3 (including topsoil of 150,000 m^3)
Pump dredging : 300,000 m^3

The excavated soil, through open cut, will be dumped on the spoil bank which should be procured about 5 km north of the site. The dredged soil by pump dredgers will be dumped into the old river course in the same manner as Case 1. Open cut is applied, divided into upper and lower layers similar to the excavation at the diversion damsite.

i) Open Cut

① Upper layer excavation
1,350,000 m^3 ÷ 80 m^3/Hr × 10 Hr = 1,688 unit day
1,688 unit day ÷ 24 D/M = 70 unit months

② Lower layer excavation
800,000 m^3 ÷ 50 m^3/Hr × 10 Hr = 1,600 unit days
1,600 unit day ÷ 24 D/M = 67 unit months

③ Hauling out by 11t dump truck

Output of dump truck when hauling distance is 5 km: 8 m^3/Hr

$\therefore$ 2,150,000 m^3 ÷ 8 m^3/Hr × 10 Hr = 26,875 unit days

26,865 unit day ÷ 24 D/M = 1,120 unit months

The working schedule for this operation will be restrained due to the limitation of the number of dump trucks workable at the site, because of working space, hauling road distance, etc. Allowable number of dump trucks working at the site in some instant is assumed as follows;

excavating & loading place	15 units
running on the road	20 units (One unit at the interval of 500 m)
as spoil bank	5 units
Total	40 units (may be at a maximum)

Required period: 1,120 unit month ÷ 40 unit = 28.0 months

ii) Pump Dredging

Required period: (Assuming that the working capacity of a pump dredger is 70% of the Case 1)

iii) Construction Period for Case 2

28.0 + 1.8 = 29.8 month

iv) The soil between EL.0 ~ (-) 7.0 m shows very weak characteristics, such as being slurry, and with a very high liquidity index of 3.5 ~ 4.0, from being disturbed by shearing stress due to excavation, etc. Since the field moisture content is 30 ~ 40% over the liquid limit, there will be difficulty in soil disposal. The conclusions of the above study are shown in Table 11-2 and Table 11-3, as a result of the comprehensive study, the pump dredging method is recommended for the Project.

TABLE 11 - 2 COMPARISON OF EXCAVATION METHODS FOR DIVERSION CANAL

	Pump Dredging	Open Cut Excavation
Outline	Carried out by Pump dredger, and excavated materials will be dumped into the old river course, keeping the outlet of the pipe in the river water to prevent outflow of dredged materials. Rock embankments will be constructed at 2 locations. Major Equipment: Pump Dredger: 1,200 PS 2 units Tug Boat : 250 HP 2 units	Dry excavation will be carried out and disposed of in the spoil bank 5 km away from the site. Subsequent disposal subject to negotiations with the land owner. Major Equipment: Dragline : 2 m^3 4 sets Backhoe : 1 m^3 4 sets Dump Truck: 11t 40 sets
Features & Problems	Easy construction after completion of preparatory work. • No on-shore works area needed. • No weather influence. • No problem for night shift • Susceptible to river flow turbidity, work in dry season preferable.	Construction is difficult for very weak soil. • Works area unstable and bad • Operation vulnerable to rain • Night shift dangerous and time-limited. • Disposal of high water content soil difficult, no adverse effect to the environment
Applicability for This Project	There are some concerns of river flow turbidity, but results of analysis show SS does not exceed 500 PPM, and economical because no spoil bank needed. △	No adverse effect on the environment, but very hard to procure a spoil bank area and with limitation of number of dump trucks workable at site because of small space available as works area. △
Construction Period	9 months ○	30 months ×
Construction Cost	(1,000 B) Stripping & Excavation 28,000 Dredging 120,000 Rock Dumping 5,000 Temporary Access Road 7,000 Total 160,000 ○ (Assumed Total Excavation Volume 2,400,000 m^3, includ. Top Soil)	(1,000 B) Excavation 157,042 Dredge for Cutoff Bank 18,000 Dewatering 32,750 Temp. Road 14,500 Spoil Bank 30,000 Total 252,292 × (Assumed Total Excavation Volume 2,400,000 m^3, includ. Top Soil)
Overall Appraisal	○	×

TABLE 11 - 3 COMPARISON OF CONSTRUCTION METHODS (DIVERSION CANAL)

	Dredging	Open Cut
1. Restraints by Climate	○	×
2. Danger for Operation	○	△
3. Difficulty of Work	△	△
4. Limitation of Working Hour	○	×
5. Problems of Soil Disposal	×	△
6. Influence to Villagers	△	○
7. Problem of River Turbidity	×	○
8. Construction Period	○	×
9. Construction Cost	○	△
Overall Appraisal	17 pts	10 pts

○ 3 points
△ 1 point
× 0 point

2) Dike Protection

Since the slope length in the upper portion of the diversion canal is 22.5 ~ 25.0 m, the lower half of the slope will be paved with rocks 30 ~ 50 cm in diameter by cranes set up on barges, and the upper half of the slope by orange buckets attached to the cranes on land, considering the boom length of the crane. The rock materials will be hauled to the working site by bottom-open type barges and dump trucks.

11. 5 Construction of Closure Dam

1) Excavation Plan

The soft surface layer of 5 m in thickness (190,000) m^3 in the river-bed will be dredged by pump dredgers and dumped into the old river course.

2) Sand Compaction Pile Work

A pile driving machine with crane will be set on the barge, then a ø400 m/m steel casing pipe of which toe portion has a close and open-type plate will be driven at construction point to the necessary depth. Then the toe plate is opened, and sand is poured in. After which the sand is compacted by repeating to drive the casing pipe up and down.

3) Embankment Plan

The embankment material volumes are shown as follows:

The materials are all purchased ones.

Earthfill Zone Embankment	250,000 m^3
Rock Zone Embankment	43,000 m^3
Rip-rap	20,000 m^3

The embankment of the rock zone and earthfill zone in the portion lower than the crest elevation of (-) 5.0 m will be made using a 200 m^3 class bottom open type barge, and upper part of the earthfill zone will be carried out by pushing the embankment materials from the river bank towards the river with bulldozers.

a) Embankment by Barge

Rockfill zone	:	43,000 m^3 (whole volume)
Earthfill zone	:	150,000 m^3

The loading pier will be built on the river side, and will have the capacity of two 11 ton dump trucks which can load earth or rock into the barge at one time. Assuming that dumping is done every two minutes, the required time for one cycle will be,

Loading: (200 $m^3 \div 8\ m^3 \times 2$ unit) $\times 2$ minutes	= 32 minutes
Traveling: going 2 km $\div$ 3 knot = 0.36 Hr	= 20 minutes
returning 2 km $\div$ 5 knot = 0.22 Hr	= 13 minutes
Dumping & Turning:	= 10 minutes
Required time for one cycle	= 75 minutes

Since there are some risks in such operations as loading and traveling, and fixing the correct points for dumping is needed, only daytime work (10 Hr) will be adopted.

Dumping times a day :	10 Hr $\times$ 60 min $\div$ 75 min = 8 times/day
Production volume per day:	200 $m^3 \times 8$ times/day = 1,600 m^3/day

Required months : (150,000 m^3 + 43,000 m^3) ÷ (1,600 m^3 × 24D) = 5 unit months

If 2 barges are utilized while the dump trucks await loading, the construction period will be 2.5 months.

b) Embankment from River Banks by Bulldozers

Earthfill zone : 100,000 m^3

Soil material hauled by 11 ton dump tucks will be pushed successively by 21 ton bulldozers for embankment.

Required months : 100,000 m^3 ÷ (100 m^3 × 10 Hr × 24D) = 4 months

c) Riprap Work

The volumes of riprap work are as follows:

i) EL.(-) 5.0 ~ EL.(-)2.0 7,000 m^3
ii) EL.(-) 2.0 ~ EL.(+) 4.0 13,000 m^3

For the portion of i) rock materials 30 ~ 50 cm in diameter will be set in place by crane barges with orange buckets.

Required time: 7,000 m^3 ÷ 100 m^3/day × 24 D = 3 months

For the portion of ii), the same size rock materials will be set in place, from the lower part, by 50 ton crawler cranes with orange buckets on the closure dam embankment.

Because of the limitation of working radius due to the crane boom length, riprap works should be carried out from 2 - 3 places across the embankment.

Required months: 13,000 m^3 ÷ (20 m^3/Hr × 10 Hr × 24D) = 3 months

Summerlizing the above, the work schedule of embankment is as follows:

Description	1	2	3	4	5	6	7
Below (-) 5 Embankment (Earth & Rock)	2.5 month						
Above (-) 5 Embankment					4 month		
Rip-rap below (-) 2				3 month			
Rip-rap above (-) 2					3 month		
Total				7 month			

11. 6 Construction of Road and Road Bridge

1) Road

The purchased material or the excavated soil in good quality will be used for filled up ground portion.

Laterite is used as the subbase, and crushed rock as base coarse layer. They should be compacted by vibration rollers and flat rollers.

2) Road bridge

According to the results of the soil tests, the N-value for EL.(-8.5) at the bridge construction point is 14. The diversion canal invert has an elevation of (-) 9.15 m, more than 15 N-Value for this ground can be expected. After the diversion canal excavation work is finished, this invert ground can be used for working space.

Abutment A1, A2	:	There is no problem because of the works on the ground surface.
Pier P3, P4, P5	:	There is no problem because of the works on the ground surface.
Pier P2, P6	:	After soft soil is removed to EL.(-)9.0 m, construction work can be executed
Pier P1, P7	:	Construction work should be carried out on the soft ground

The temporary access road to Pier 1, and Pier 7 will constructed from the canal bank by cutting. The road is 6 m wide, of which surface 1 m thick should be replaced by sand, then covered with 20 m/m thick steel plate.

The pile driving work will follow the same manner as diversion dam works. The concrete placement will be done by concrete pumps from the ground surface or canal inverts.

The two temporary roads for trailers and cranes for setting up P.C. girder will be built parallel to the bridge.

The middle 4 spans of the 8-span bridge can be set up on this road (-) 9.0 m in elevation. The two spans on either side require one more temporary road each (-) 4.0 m in elevation, with approaches from the upstream and downstream ground surfaces. The roads are 8 m wide, and their construction will be in the same manner as the former temporary roads (-) 9.0 m in elevation to P1 and P7. P.C. girders will be put in place by two cranes.

11.7 Construction of Pumping Station

1) Excavation Plan

In front of the pumping station's intake canal , a temporary coffer dam with a double row of steel sheet piles will be constructed. The excavation required for construction will be carried out mainly by using a dragline of 2 m^3 in capacity.

The designed base ground elevation for building of this structure is around EL.(-) 4.5 ~ (-) 6.5 m, but according to the soil investigation result, there is very soft soil layer with N value of 0 ~ 1 lying down to around (-) 9.0 m in elevation, so that the basic soil 1 m deep just beneath the structures should be replaced with good quality soil or sand, to secure footings for the work and for stabilizing the structures.

2) Foundation Works

After ground improvement has been performed by replacement with good quality soil or sand, the P.C. pile driving is carried out.

The method of pile driving will be performed in the same manner as the pile driving for the diversion dam portion.

3) Concrete Works

Transportation of concrete from the concrete plant near the diversion dam to the pumping station site will be difficult, so a portable concrete plant with mixing capacity of 0.4 m^3 will be set up at the site.

Concrete will be put in place by concrete pump.

11.8 Supply and Installation of Gates and Pumps

1) Supply of Machinery

The main machinery such as gates and pumps, etc. will probably be imported from abroad, except for some minor portions produced in the country.

Unstatic machinery such as pumps, motors, engines, hoists, controlling, etc. will be imported as single complete articles, but some steel structures such as gates, stairs, trash rack, etc. will be fabricated as parts or divided structures in the factory, and processed, assembled and installed at the site.

2) Unloading and Transportation

The main machinery and steel structures imported from abroad will be unloaded at Leam Chabang Commercial Port. This port is located approximately 100 km south of the damsite, and its pier depth is indicated as 12.0 m, so that a 30,000 ton cargo ship can easily berth at a wharf.

The land transportation from the port to the site using trucks or trailers seems to pose no problem due to the excellent road conditions.

3) Installation

a) Manufacturing order for the gates will be made in the fourth month after the construction work has commenced.

It will take 16 months for design, manufacturing and transportation, and another 9 months for installation at the site, and 2 months for the test. Gate sheets, gate bodies, and opening and closing devices are manufactured in divided structures at the factories and transported to the site to be assembled and installed.

For use as footings, concrete placing of the upstream apron should be finished before assembling and installation at the site. The products and parts to be laid inside the concrete (anchor pats, steel rods, etc.) should be set up at the same time as the concrete placing.

The gate frame must be installed inside the blockout which is then filled with concrete. The biggest divided steel structure is the end portion of the flood gate, and its weight is measured at 65 ton. In this case, a truck crane with a capacity of 250 ton will be applied.

The other portions are smaller than the above, and could be assembled by 40 ~ 180 ton cranes corresponding to the measured weights.

Electric equipment of 400 KVA capacity will be required for the above works. Other and major equipment to be required for this work are as follows:

Truck crane	250 T	1 unit
〃	180 T	1 unit
〃	130 T	1 unit
〃	100 T	1 unit
〃	60 T	1 unit
Crawler crane	80 T	1 unit
Trailer	40 T	1 unit
Jack (by oil pressure)	100 T	4 units
Welder (for alternating current)	500 A	12 unit
Welder (for direct current)	500 A	4 unit
Compressor	15 kw	4 unit

b) Pumps and their Appurtenant Structures

The construction of the pumping station follows the civil works for the diversion dam.

The pumps and their appurtenant structures will be ordered corresponding with the schedule in 15th month after the diversion dam works have started. It will then take 15 months for design, manufacturing and transportation, 5 months for installation at the site, and one month for testing.

11.9 Construction of O/M Building and Electric Facilities

1) O/M Building

The O/M building construction will be commenced two years after the diversion dam construction was started, and be expected for a period of 8 months as construction schedule, considering additional time necessary for the schedule for setting up the equipment and instruments. All the construction materials will be procurable in Thailand.

2) Electric Facilities

The main electric power is taken from the F-6 main distribution line. This work should be committed to PEA.

This work should be commenced in the fourth month at the latest after the diversion dam works have been started, so that this power might be supplied for construction works.

11.10 Working Schedule

The working schedule for the Bang Pakong diversion dam construction project are shown on Figure 11-5.

The total working period is indicated as 42 months, i.e., 3.5 years.

FIGURE 11 - 5 CONSTRUCTION SCHEDULE

Description of Works	Unit	Quantity \ Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
1. Preparation Works	LS																																												
2. Diversion Canal																																													
Excavation	m^3	2,450,000																																											
Riprap	m^3	40,000																																											
3. Diversion Dam																																													
Excavation	m^3	1,110,000																																											
Pile Work	LS																																												
Concrete	m^3	39,000																																											
Riverbed Protection	m^2	18,000																																											
Riprap	m^3	15,000																																											
O/M Bridge	LS																																												
4. Gate																																													
Manufacture & Transportation	LS																																												
Installation	LS																																												
Test	LS																																												
5. Closure Dam																																													
Excavation	m^3	190,000																																											
Sand Compaction Pile	m	17,000																																											
Embankment	m^3	300,000																																											
Riprap	m^3	20,000																																											
Road Surfacing	LS																																												
6. Road & Road Bridge																																													
Road	m	2,700																																											
Road Bridge	LS																																												
7. Pumping Station																																													
Excavation	m^3	31,000																																											
Structure	m^3	3,500																																										
Pump	LS																																												
Pump House	LS																																												
8. Control System & Electric Facilities	LS																																												
9. O/M Building	LS																																												

CHAPTER 12. CONSTRUCTION COST ESTIMATION

12. 1 Basic Rate

The basic rate for labour and material is estimated on the basis of the prevailing rate in Chachoengsao Province on July 1993, as follows:

1) Labour Rate

The following labour rates are adopted for the construction cost estimation.

	฿/day
- Foreman Class I	600
- Foreman Class II	400
- Operator of Equipment	400
- Assistant of Operator	180
- Driver	350
- Steel Worker	180
- Welder	300
- Carpenter	220
- Mechanics	300
- Electrician	300
- Mason	220
- Skilled Labour	160
- Common Labour	150

2) Material Rate

The following material rates are adopted for the construction cost estimation.

Item Description	Unit	Unit Price (฿)
Portland Cement Type I	Ton	1,400
Portland Cement Type V	〃	1,900
Sand for Aggregate	m^3	250
Crushed Stone for Aggregate	〃	270
Reinforcing Bar	Ton	13,000
Wood for Form	cu.ft	200
P.C. Pile ø 600 × 10 m	No.	10,300
P.C. Pile ø 500 × 10 m	〃	7,500
P.C. Pile ø 300 × 10 m	〃	3,200
S.P. Pile ø 800 × 10 m (t = 9 mm)	No.	35,000
S.P. Pile ø 450 × 10 m (t = 9 mm)	〃	20,000
Sheet Pile Type II	Ton	15,000
Gasoline	ℓ	9
Diesel Fuel	〃	8
Industrial Oil	〃	4
Electric Charge	KWH	2.6
Plywood 10 m/m × 4'× 8'	No.	420

12. 2 Construction Cost

The estimated construction cost for Bang Pakong Diversion Dam Project based on the detailed design and collected data for labour rates, material rates, etc. is summarized in the following Table.

TABLE 12 - 1 CONSTRUCTION COST TABULATION

Description of Works	Unit	Quantity	Unit Price (Baht)	Amount (1,000 Baht)	Remarks
1. Diversion Dam & Its Appurtenant Facilities					
a) Temporary Work	L.S.			150,000	
b) Diversion Dam & Canal					
Stripping	m^3	200,000	60	12,000	
Excavation - Dam & Bridge	m^3	1,060,000	94	99,640	
Excavation - Canal	m^3	2,300,000	80	184,000	
Fill & Backfill - Excavated Materials	m^3	30,000	70	2,100	
Fill & Backfill - Selected Materials	m^3	180,000	150	27,000	
Riprap	m^3	55,000	820	45,100	
Riverbed Protection	m^2	18,000	1,700	30,600	
Concrete, Class C	m^3	36,000	2,600	93,600	
Concrete, Other Classes	m^3	2,540	2,300	5,842	
Reinforcing Bar	ton	2,200	28,900	63,580	
Steel Sheet Pile, Type II	ton	190	29,200	5,548	
P.C. Pile ø 300, ø 600	m	17,200	720	12,384	
Steel Pipe Pile ø 800 t; 9, 12 mm	m	7,800	6,640	51,792	
O/M Bridge	L.S.			12,750	
Building (Control House, Electric House, etc.)	L.S.			23,500	
Flood Gate (3 units) &Regulating Gate (2 units)	L.S.			1,083,000	
Stop Log	L.S.			52,000	
Miscellaneous Works	L.S.			28,799	
Sub-Total				1,833,235	
c) Closure Dam					
Excavation	m^3	190,000	80	15,200	
Embankment - Earth	m^3	230,000	165	37,950	
Embankment - Rock	m^3	43,000	700	30,100	
Riprap	m^3	20,000	820	16,400	
Sand & Gravel Bedding & Sand Mat	m^3	20,000	530	10,600	
Sand Compaction Pile	m^3	14,000	1,400	19,600	
Jetty	No.	2	500,000	1,000	
Sub-Total				130,850	
d) Road & Road Bridge					
Road & Road Bridge	L.S.			88,490	
Sub-Total				88,490	
Total				2,202,575	
2. Pumping Station					
a) Temporary Work	L.S.			24,000	
b) Pumping Station					
Excavation	m^3	28,000	76	2,128	
Fill & Backfill - Selected Materials	m^3	25,000	150	3,750	
Riprap	m^3	1,900	820	1,558	
Concrete, Class C	m^3	3,200	2,600	8,320	
Reinforcing Bar	ton	220	28,900	6,358	
P.C. Pile ø 300	m	2,300	565	1,300	
P.C. Pile ø 500, ø 600	m	1,600	1,440	2,304	
Pump House	L.S.			9,000	
Miscellaneous Works	L.S.			12,651	
Pump	L.S.			200,000	
Sub-Total				247,369	
Total				271,369	
3. Control System & Electrical Facilities	L.S.			260,000	
4. O/M Building	L.S.			300,000	
Grand Total				3,033,944	

PART - IV. ENVIRONMENTAL CONSIDERATION

PART IV. ENVIRONMENTAL CONSIDERATION

(PREFACE)

Basic Direction of Environmental Consideration

In Thailand, the development project over the standards stipulated in 1981 by the Ministry of Science, Technology and Energy, concerning the specification of type and size of the project or activity must have the Environmental Impact Assessment (EIA) and mitigation measures, following the passing of the improvement and Conservation of National Environtal Quality Act of 1975.

Since the Bang Pakong Diversion Dam Project will have a storage capacity, a surface area and an irrigable area lower than the standards, that is, a storage capacity of 100MCM, a surface area of 15 sq.km and an irrigable area of 12,800 ha, it is not within the requirement for the EIA study. Moreover, the Cabinet has already approved this diversion dam construction on December 4, 1990.

RID, However, has realized it duty toward the general public, and from a viewpoint of the overall river basin development in the future deemed it appropriate to contract Kasetsart University to undertake the EIA of the proposed project. And then as a result of the EIA study, it deems that there is no major obstruction or negative influence on the implementation of the project. In addition to the above-mentioned judgment of the conditions, the Bang Pakong river is only the large river capable of large-scale water resources development near the Bangkok Metropolitan Circle and the Eastern Seaboard Development Area regarded as the industrial and economic center of Thailand. The river, however, being a tidal river and at present few dams having been built, there is no cultivation in a dry season, only cultivation in a wet season, and shortage of domestic and industrial water is under very serious condition.

Consequently, this project having the top priority on the importance and urgency, very early project implementation has been expected.

SUMMARY OF THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF BANG PAKONG DIVERSION DAM PROJECT MADE OUT BY KASETSART UNIVERSITY

CHAPTER 1. CONSIDERATION ON ENVIRONMENTAL IMPACT AND ITS MITIGATIVE MEASURES

The EIA draft report of Bang Pakong Diversion Dam Project was reviewed in order to draw consideration and conclusion on the impact and mitigative measures together with monitoring program. Such information is useful for the JICA study team in carrying out detailed design of the diversion dam. This review was made during the first field work and home office work periods from October 1992 to January 1993. At this time final EIA report has not yet been completed. Summary of existing environment and probable impacts during construction and operation phases was made under four environmental resources.

Each item of the review will cover brief conclusion on significant findings during the EIA study as well as impacts and mitigative measures as well as its comments on each study-item.

1. Physical Resources

1.1 Surface Water Hydrology

The EIA has pointed out the great advantage of the Bang Pakong Diversion Dam having an impoundment capacity for freshwater of 30 MCM. This amount of freshwater can be supplied to both existing irrigable area on the left bank and future expanded agricultural land in the total area of 14,300 ha (about 92,000 rai) during rainy and dry seasons, 18.9 MCM as domestic water and 69.7 MCM as industrial water.

A study was also made on the effects of back water. As a result, a dike on the left bank mat be required. When considering safety height of 0.50 m, the embankment of the dike should be constructed at the level of +2.64 m MSL for 10-year-return period or +2.80 m MSL for 20-year-return period. The dike should be located from the diversion dam up to Khlong The Luang in Amphoe Bang Khla which is about 13 km.

The present average range of maximum water level at the damsite in dry season is 1.10-1.20 m MSL. Therefore, when tide gates are closed up after future impoundment, water level in the lower stream may increase to 1.45-1.65 m MSL. Sea water protection dike should be provided along Bang Pakong left bank to protect future expanded irrigable area from high sea water level. The dike should start from damsite along the river bank down to Highway No. 304 for a total length of 15 km. This dike will also serve as flood protection dike during inundation period. Therefore, a suitable height of this dike should be considered to serve both purposes.

1.2 Surface Water Quality

Sampling of surface water in the Bang Pakong river was made monthly during August 1991 to January 1992 for a total of six times at 5 different locations (See Figure 4-1-1) including:-

Station 1 - Upstream of diversion dam, at Bang Khlong Lat to the south of Amphoe Bang Khla.

Station 2 - About 3 km upstream of the diversion dam at Wat Nai Bang Khla.

Station 3 - Downstream of diversion dam and upstream of Amphoe Muang Chachoengsao, at railroad bridge across the river.

Station 4 - Khlong Bang Phai in Amphoe Muang, which is a tributary acting as drainage canal carrying runoff from the left bank irrigable area into the downstream Bang Pakong river.

Station 5 - Khlong Don Si-Non in Amphoe Ban Pho which is a tributary serving as drainage canal carrying runoff from the left bank irrigable area into downstream of Bang Pakong river.

The analysis covers 43 parameters including the first group of temperature, pH, turbidity, salinity, conductivity, suspended solids (SS), total solids (TS), total dissolved solids (TDS) alkalinity, dissolved oxygen (DO), BOD, hardness, nitrate, phosphate, ammonia, fecal and total coliforms, and another group of trace elements including potassium, sodium, calcium, magnesium, bicarbonate, carbonate, sulphate, chloride, fluoride, arsenic, cyanide, iron, manganese, nickel, copper, zinc, lead, cadmium, chromium, mercury and pesticides (e.g. DDT, a-BHC, dieldrin, aldrin, heptachlor and endrin).

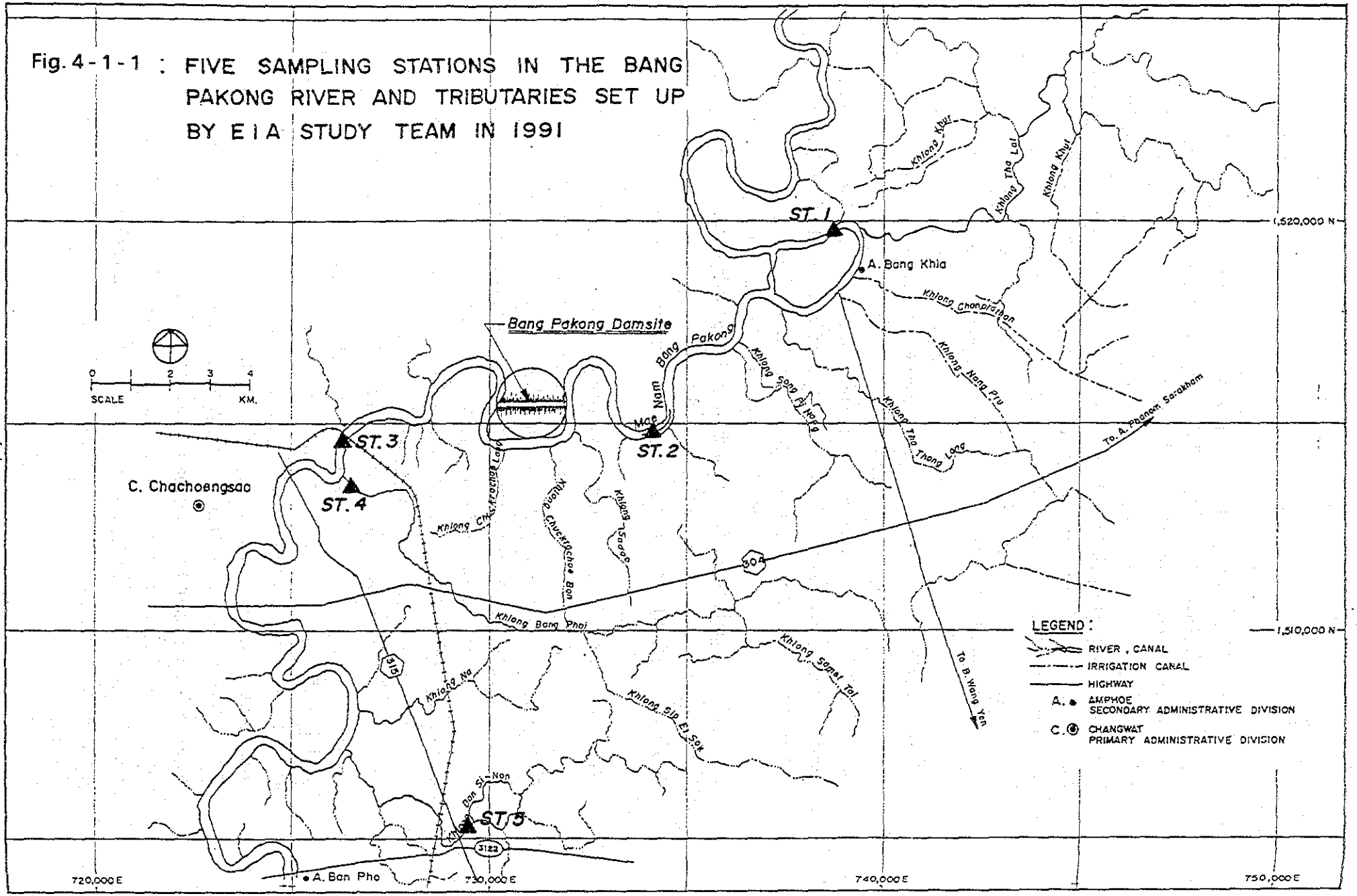


Fig. 4-1-1 : FIVE SAMPLING STATIONS IN THE BANG PAKONG RIVER AND TRIBUTARIES SET UP BY E I A STUDY TEAM IN 1991

Sampling in the Bang Pakong river was made at 2 depths, i.e. mid-depth and surface level, while in its tributaries, sampling was made only at mid-depth level. First group parameters were analysed monthly while the second group parameters were analysed only twice, i.e. in the low and high flow seasons. Samples are integrated for analysis. Sampling was made during ebb tide by using Rigosha Sampler.

The results of survey showed no difference in most water quality at different depths of each sampling location excluding BOD and coliforms.

Bang Pakong River Water Quality

The pH of the Bang Pakong river water ranged from 6.9 - 7.6. The upstream pH value reduced slightly in the end of rainy season, and in January pH value increased slightly. Salinity was not detectable throughout the survey period, i.e. during August to January river water flowing from upper reaches down to Amphoe Muang Chachoengsao was all freshwater.

The river water was found to be soft with moderate turbidity, conductivity, total dissolved solids (TDS), alkalinity and hardness. All above parameters decreased to minimum in September 1991 and reached maximum in January 1992 (dry period).

Turbidity at all stations was almost equal. In October and November, turbidity was lower than the other months because it was the end of rainy season, therefore, river flow was decelerating and resulted in more sedimentation to the riverbed. Turbidity and suspended solids are found the highest in January.

Do was almost equal at all sampling stations, ranging from 4.3 to 5.4 mg/l at the beginning and in mid-rainy season (August to September). The minimum DO of 3.1 mg/l was found at station 1 in November and station 3 in December 1991.

BOD fluctuated with sampling times and sampling locations ranging between 0.1 - 2.5 mg/l. Surface BOD was found higher than the mid-depths.

During heavy runoff (in September), upstream BOD was high with the maximum value of 2.05 mg/l at Station 1.

Ammonia (NG_3), NITRATE (NO_3) and phosphate (PO_4) in Bang Pakong river were about moderate. Most nitrogen presented in form of NO_3. NH_3 content was influenced by biological degradation of organic matter ranging from non-detectable level up to 0.06 mg/l with the higher content at stations 1, 3 than at station 2. NO_3 and PO_4 were ranging between 0.042 - 0.456 mg/l and non-detectable to 0.084 mg/l, respectively. Both increased with distance from upstream to downstream and became maximum in January.

Fecal and total coliforms were very high with the range between 460 - 54,000 MPN/100 ml and 700 - 92,000 MPN/100 ml, respectively. More coliforms were observed at surface rather than the mid-depth, and also at stations 1 and 3 close to large communities than station 2 (damsite). The highest content of total coliforms (92,000 MPN/100ml) was found as often as three sampling times, i.e. in September, November and December.

Toxic substances and heavy metals, cationic and anionic elements presented at low level in August, i.e. inundation period. Sulphate (SO_4) and chloride (Cl) were also very low. However, in the low flow month of December, sodium (14-20 mg/l) and chloride (27 - 40 mg/l) became doubled when compared to the detectable level in the flooding season. The SAR value in the dry season was still low and the river water from Bang Khla down to Amphoe Muang had SAR lower than 10 and conductivity less than 250 microsiemens/cm in August till December. This means Bang Pakong river in that section has suitable quality for irrigation.

Cyanide was the only toxic element found in the river at the concentration between 0.002 - 0.003 mg/l which is still lower than standard limit of surface water. Iron in the river water has its origin of the natural mineral resources. Simple coagulation is expected to remove iron to the safe level of domestic consumption. For heavy metals, only nickel and mercury exceeded the surface water standard at all stations in inundation period for nickel and only at stations 1 and 2 in dry season for mercury.

Residual herbicides e.g. o, p-DDT, a-BHC, dieldrin and heptachlor epoxide were detectable during high flow season but at very low

concentrations. Only dieldrin could be detected in the dry period at all stations (0.10 ppb.).

Compared to records of Bang Pakong water quality surveyed by the National Environment Board (NEB) during 1986 - 1987, the river water between Amphoe Bang Khla and Amphoe Muang Chachoengsao showed much increasing trend of deterioration especially in terms of organic matter. As a result, BOD and coliforms bacteria thus sharply increased. This is also the same for mercury, lead and cadmium. Especially mercury has increased many times more, which is expected to be due to the generation of waste water from metal and electronic factories, which also results in increasing of nickel and cadmium in the river. On the other hand, copper, chromium and organochlorine and herbicides reduced. The reduction of such herbicide is related to the prohibition of using these substances in agriculture since 1984.

NEB (1988) summarized that main pollution sources of the Bang Pakong river are livestock farming, communities and factories. In 1987 pig farms generated as much as 12,560 kg BOD/d while community wastewater contributed about 5,760 kg BOD/d. In 1989 industrial wastewater discharged about 140 kg BOD/d into this river (Industrial Works Department, 1989). In this study BOD loading from pig farms was estimated at 15,504 kg/d.

Water Quality in Tributaries of Bang Pakong River

As previously mentioned, water quality in Khlong Bang Phai and Khlong Don Si Non which are tributaries of the Bang Pakong river was also surveyed. Both are drainage canal receiving discharge from left bank irrigable area. Water in both canals were even more deteriorated as compared with that in the Bang Pakong river. No salinity could be detected at both places. BOD was between 0.5 - 6.8 mg/l (average, 3.5 mg/l) in Khlong Bang Phai and between 0.7 - 2.9 mg/l (average, 1.8 mg/l) in Khlong don Si Non. Consequently, DO in both canals were very low (average, 0.8 and 1.4 mg/l, respectively). Much higher NH_3 (1.82 mg/l) was observed in Khlong Bang Phai in January than that in the Bang Pakong river. However, fecal and total coliforms were less in the tributaries than in the river water. Concerning concentration of herbicides, organochlorine at very low level could still be detected but much less than the previous survey result (1984 -

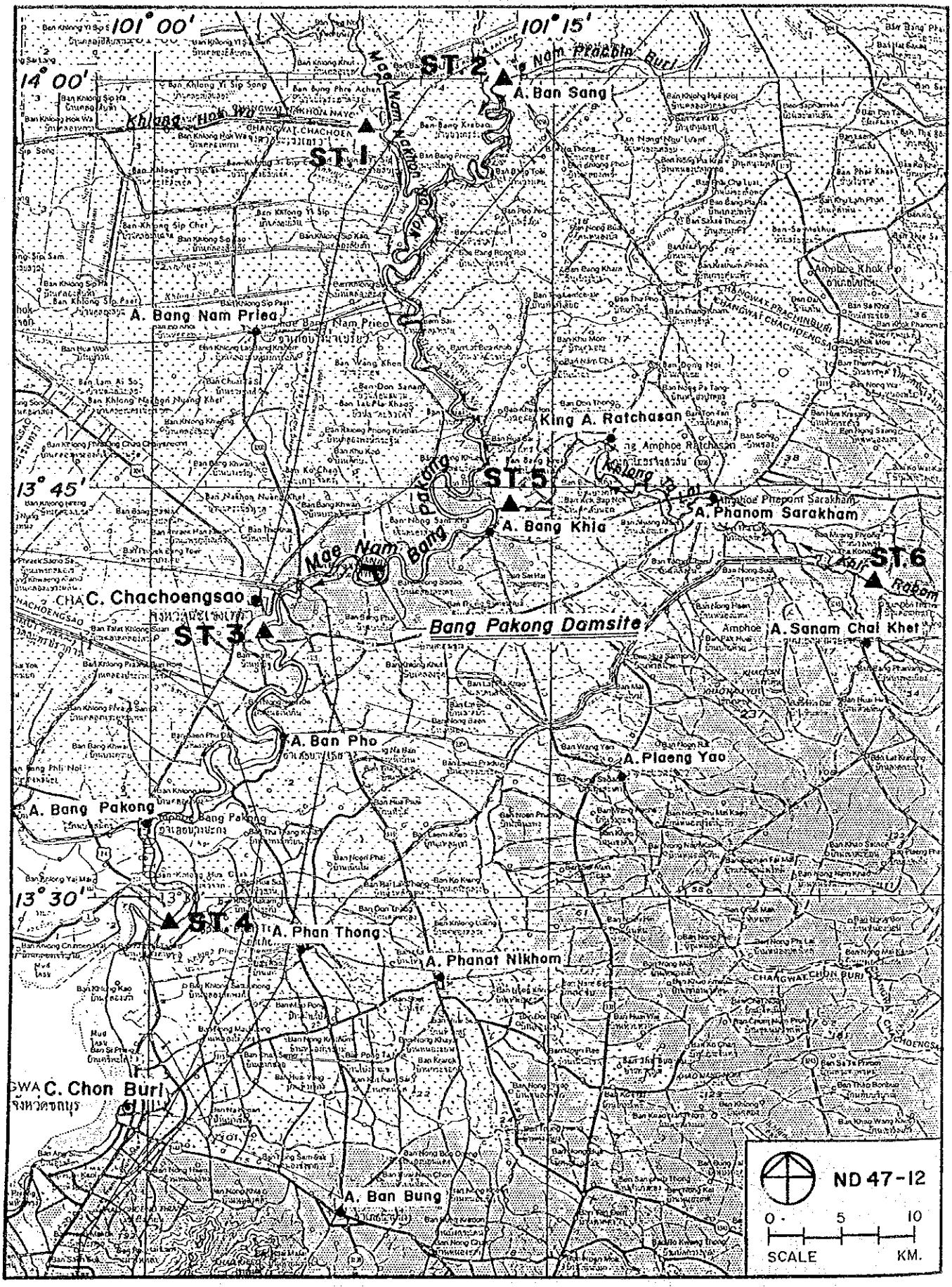


Fig. 4-1-2 : SIX SAMPLING STATIONS IN THE NAKHON NAYOK RIVER, PRACHINBURI RIVER, BANG PAKONG RIVER AND TRIBUTARIES SURVEYED BY RID. IN 1991-1992

1985). High organic contamination in both tributaries is expected to come from factories and pig farms.

Water quality in the Nakhon Nayok river, Prachinburi river, Bang Pakong River and Tributaries Surveyed by RID

Since water quality survey in the EIA was conducted during August 1991 to January 1992 due to the very limited study period, some additional surveyed data obtained from RID were taken into consideration to cover all three weather seasons in a year. The data included the survey results only in May 1991 and March 1992 at 6 different locations as follows (See Figure 4-1-2).

Station 1 - Nakhon Nayok river at Hog Wa canal
Station 2 - Prachinburi river at Amphoe Bang Sang
Station 3 - Bang Pakong river in front of Wat So Thorn in Amphoe Muang Chachoengsao
Station 4 - Bang Pakong river at Bang Pakong bridge
Station 5 - The Lat canal before joining Bang Pakong river
Station 6 - Radom canal before joining Tha Lat canal

The results showed that in dry season of 1992 and 1992, water in Nakhon Nayok river (station 1), lower Bang Pakong river (stations 3 and 4) and at the mouth of Tha Lat canal (station 5) was turbid and much affected by salt water intrusion resulting in high electrical conductivity beyond 5,000 micromhos/cm. Less effect of saline water was observed in Prachinburi river (less than 500 micromhos/cm). Radom canal in dry season still had soft water with only 81-110 micromhos/cm of electrical conductivity.

DO level in the lower Bang Pakong in May 1991 was lower (3.4 - 3.6 mg/l) than at other locations. In March 1992 BOD in the lower Bang Pakong river was high (1.4 - 1.6 mg/l) and much higher (4.1 mg/l) at the mouth of Tha Lat canal that received wastewater from communities in Amphoe Tha Lat and Phanomsarakham. However, DO at all stations was still high (5.2 - 8.3 mg/l).

As regards plant nutrients, all stations showed high concentration of nitrate and phosphate in the dry period of 1991 and 1992 especially in the lower Bang Pakong and at the mouth of Tha Lat canal. Nitrate (0.9 - 9.3

mg/l) and phosphate (0.1 - 0.4 mg/l) were many times higher than those observed in the flooding season. Very high content of total iron (3.7 - 11.6 mg/l) was detectable in Nakhon Nayok river, Bang Pakong river and at the mouth of Tha Lat canal especially in 1992. Dissolved iron at all locations in May 1991 was low except in Rabom canal where dissolved iron (1.27 mg/l) was higher than the drinking water standard.

Heavy metals and all toxic substances in dry period of the years 1991 and 1992 at all locations were still within the surface water standard.

Salt intrusion in dry season has caused very high concentrations of cations and anions in Nakhon Nayok river, Bang Pakong river and Tha Lat canal. Particularly when considering sodium iron content, electrical conductivity, Soluble Sodium Percentage (SSP) and Sodium Adsorption Ratio (SAR) as well as high content of chloride and sulphate, all the results pointed out that water quality at three above-mentioned sources were not suitable for irrigation in the dry season. This intensifies the necessity of prohibition of salt water intrusion in the Bang Pakong river basin. However, after in Prachinburi river and Rabom canal was still usable for irrigation purpose even for the dry period.

Regarding impacts on water quality, the EIA pointed out that increase of turbidity during construction period will cause deterioration of river water quality both up-and downstream and subsequently reduces beneficial uses of the river water. However, the impact will be moderate in mid-and end of rainy season during when turbidity is generally low. In dry season Bang Pakong river is normally highly turbid, and the degree of impact is less due to construction.

When the diversion dam is completed, accumulation of organic matter is likely to occur in the upstream water. The biodegradation of this accumulated organic matter will result in reduction of dissolved oxygen (DO) especially for dry period when river flow diminishes and absorption of oxygen gas from atmosphere is less. In a severe case, anaerobic condition may occur and generates hydrogen sulphide gas. Degradation of organic matter will also result in increase of plant nutrients and subsequently causes eutrophication or phytoplakton bloom. In such event, the upstream river water will no longer be suitable for any beneficial uses. Therefore, it is strongly recommended that wastewater discharged from all pollution

sources upstream of the diversion dam including livestock farming, local communities and factories be strictly controlled.

The Lower Bang Pakong River was also expected to have higher accumulation of pollutants after the diversion dam and closure dam are constructed. This is because of less river flow flushing from the upper reaches and extensive expansion of industrial activity in Chachoengsao province. Deterioration of downstream river water will adversely affect aquatic lives and aquiculture. Therefore, pollution control should not be implemented only to upstream sources but also along the lower reaches of the Bang Pakong river down to the river mouth.

Increased availability of freshwater due to the upstream impoundment of the Bang Pakong Diversion Dam will result in increase of fresh water distribution into the left bank irrigable area. It is thus likely that flushing of pollutants out of the drainage canals of that irrigable area, including Bang Phai and Don Si-Non canals as surveyed in this study, would become more efficient. This will greatly improve water quality in drainage canals that receive discharge from irrigable area. However, if agricultural pattern on the left bank is changing from paddy fields to livestock farming or aquiculture, these drainage canals can become even more polluted. Therefore, monitoring of water quality in the canals when the dam is completed is recommended.

The EIA Report pointed out that impact on water quality during impoundment due to accumulation of pollutants both upstream and downstream of the dam will become serious, if no control at sources is implemented. Therefore, effluent standard for livestock wastewater especially pig farm waste should be set up by the responsible environmental agency, such as the Ministry of Science, Technology and Environment (MOSTE).

This mitigative measure is expected to be able to effectively reduce BOD loading into the receiving water.

Another measure of providing drainage canal to divert pig farm wastewater to lower reaches has been extensively discussed about its direction, sizing and requirement of downstream treatment plant. Since pig

farms are located in many places, the direction of this canal and their branches for efficient collection of all discharged wastewater has to be carefully determined. Survey on locations of all the pig farms in the vicinity has to be primarily carried out. At this stage it seems that the proposed measure of setting up standard for livestock wastewater by responsible implementing agency would be the key solution for effective control of discharged wastewater from pig farms.

Wastewater from RID office at damsite, where not more than 500 staff and their families will be staying, should also be properly treated to avoid discharging of polluted wastewater into the Bang Pakong river.

Instead of drainage canal construction, simple drainage treatment facilities (oxidization ponds) are sought to be built by farmers themselves, keeping more than 1000 pigs under the guidance of the Livestock Department the Ministry of Agriculture and Cooperations (MOAC). If a prevention of pollutant from pig farms from flowing into the river is possible by strengthing and developing this idea, it will be extremely realistic means of solution for the pig farms lying scattered.

1.3 Soil Property

Soil property in most part of the whole study area is suitable for sustainable agriculture. The only problem found at some locations on the right and left bank irrigable areas is related to saline soil condition and high acidity. Soil property at the project site also shows high potential for sustainable agriculture, i.e. suitable for rice and fruit tree cultivation.

Development of Bang Pakong Diversion Dam will need to clear certain part of fertile orchards covering about 126.4 ha (793 rai) for dam structure, diversion canal, office building, staff housing, etc. However, great benefit will be offered to agricultural land area on both right and left banks of the Bang Pakong river. Systematic water regulation will be able to reduce saline and acid soil problems.

1.4 Groundwater Hydrology and Quality

There are 79 deep wells in total in the study area. Most of them were dug by Department of Mineral Resources and Public Works Department and located far from the proposed damsite. Most wells have diameters between 4-6 inches with depth ranging from 27 - 146 m or 50 - 80 m on an average. Water yield is generally low between 2 - 4 cu.m/hr with the maximum yield of 18 cu.m/hr. Almost all of deep wells are operated with hand pumps and many of them are no longer in use due to poor water quality regarding too high chloride content.

It is not expected that Bang Pakong Diversion Dam will cause any impact on groundwater hydrology and quality in the study area.

1.5 Erosion and Sedimentation

Erosion and sedimentation along the Bang Pakong river banks are caused by:-

(1) river currents
(2) land use pattern
(3) waves induced by water transport and wind

Erosion and sedimentation caused by river currents

The Bang Pakong river has long been eroded until now reaching the equilibrium condition, i.e. no more erosion on the river banks (with erodibility index of 0.44 - 0.49) and at the river bed (with erodibility index of 0.35 - 0.38) at the straight river portion.

Some sedimentation is evident along the river banks. This is because some plants growing on both the banks caused deceleration of river flow during high tide resulting in higher sedimentation rather than erosion. These sediments will be traveling along with the current during low tide to the Gulf of Thailand. Therefore, silty clay is found remaining along the river banks and became good bases for water plants resulting in formation of natural river bank protection strip.

The meandering of the river was noted to have deeper erosion at the river bed, about 1 m deeper than the straight portion. The outer meandering shows very steep bank while inner meandering has about 8 - 15% sloping.

Erosion and sedimentation caused by land use pattern

Land use pattern along the left bank irrigable area mostly consists of orchards, shrimp and fish ponds and paddy fields. Nypa palm, avicennia and sonneratia that are found along the river banks can protect the banks from the river flow. Discharge from orchards containing some sediment generally flows into the river and the sediments settle along the river bank.

Erosion and sedimentation caused by water transport and wind

Driving boats along the Bank Pakong river has caused erosion at all the meandering portions of the river. On the other parts with thick vegetation or with stone barrier, the river banks do not get eroded by such water transport. Waves induced by driving boats have amplitudes ranging between 30 - 40 cm for large passenger boat (about for 30 passengers) and between 20 - 30 cm for small long-tailed boat. Amplitude of waves by wind action is much lower with the maximum range of only 15 - 20 cm.

During the construction period some sediments mainly of soft clay will be generated. It is expected that these sediments will flocculate well for a period of about 15 - 30 days and results in insignificant impact on water quality.

To predict effects of erosion and sedimentation during impoundment of the Bang Pakong Diversion Dam, quantity of sediment was estimated in the EIA using mathematical modeling. Monthly runoff and sedimentation at the damsite are as follows:-

	Runoff (MCM)	Sedimentation (Ton)
April	31.9	2,705.7
May	124.1	12,800.4
June	472.3	59,054.8
July	843.6	114,670.1
August	1,406.7	205,822.2
September	1,954.6	299,861.0
October	1,547	229,470.4
November	298.9	34,996.6
December	103.4	10,388.7
Manuary	30.1	2,531.8
February	12.5	926.4
March	13.5	1,011.7
Total	6,838.6	974,233.8

The sum of above monthly sedimentation can be compared for different period of opening/closing tide gates for further determination on tide gates operation as follows:-

Tide Gates Operation	Sum of Sediments	
	Ton	%
a) Tide Gates Opening Period		
May - November	956,670	98
June - November	897,615	94
May - December	967,058	99
b) Tide Gates Closing Period		
December - April	17,564	2
December - May	52,555	6
January - April	7,176	0.7

Based on the above figures, the EIA concluded that impacts due to sedimentation when tide gates are closing in dry season will be insignificant,

compared with the effects of accumulated pollutants which seem to be much more serious.

Closing of tide gates in dry season is expected to cause stagnation from Ban Laem Sai up to the confluence of Nakhon Nayok and Prachin rivers at Ban Pan, Amphoe Ban Sang in Prachinburi Province. This would result in sedimentation along the Bang Pakong river up to Ban Pan. Highest degree of sedimentation will occur at the location where the stagnant water joining with the flowing river water. However, all the sediments will be flushed out during in undation period when tide gates are open.

Erosion by wave action during impoundment is expected to be more serious especially at all the meandering portions of the river. The upstream vegetation will change from brackish type to fresh water ecosystem. No erosion will occur on the straight portion of the river because of existing thick vegetation.

2. BIOLOGICAL RESOURCES

2.1 Aquatic Ecology, Fisheries and Aquiculture

The EIA Report indicated that fish found in the Bang Pakong river during the study are of general types. No rare species were observed. Marine fish usually migrate from the Bang Pakong river mouth far up to Amphoe Bang Khla during dry season. Only 5 species of brackish water fish and freshwater fish that can live in brackish water are reported migrating up to Amphoe Muang Nakhon Nayok and Amphoe Ban Sang in Prachinburi. Freshwater fish will travel down to Amphoe Bang Pakong only for short period during rainy season along with the high river flow and travel back quickly. Usually freshwater fish does not travel down beyond Amphoe Bang Khla.

Bang Pakong river mouth is abundant with nutrients for aquatic lives. Therefore, aquiculture is extensively practiced in Amphoe Bang Pakong close to the river mouth. In 1989 Amphoe Bang Pakong was reported to have fish ponds covering about 5,500 ha (34,269 rai) and shrimp farm about 2,650 ha (16,565 rai). Later shrimp farming for Penaeus monodon has become popular especially in Amphoe Bang Pakong where there are over 1,000 P. monodon farms. Stronger effect of salt-water intrusion and must drop of rice price are main reasons why farmers in Chacheongsao tend to change their paddy fields into shrimp farming.

In 1991, aquiculture was performed in 5 Amphoes, i.e. Bang Nam Priew, Bang Khla, Muang Chachoengsao, Ban Pho and Bang Pakong. P. monodon culture covered area of 3,344 ha (20,900 rai) with production yield of about 44 million kg/year or economic value of 3,156 million Baht. Cuture of fresh water and brackish water fish covered total area of 5,870 ha (36,685 rai) resulting in production yield of about 27 million kg/year which cost about 23 million Baht.

Shrimp farms usually obtain saline water from Bang Pakong river and branch canals. Extensive culture will be performed during 8-month period (November - June) when salt water is available. Most hatchery farms purchase concentrated brine water with salinity 60 - 110 ppt. from salt farm to save cost on transportation and storage. Freshwater is obtained from

underground water, tap water or river water/tributaries located in the northern area.

Aquiculture of freshwater fish obtains freshwater from upstream of the Bang Pakong river. Dikes are erected in some canals for holding of freshwater. The EIA estimated that aquaculture requires about 0.86 MCM/year of freshwater and about one MCM/year of brine water for the whole Chachoengsao province. Supply of fresh water from other sources for aquiculture is extensively required from October to June which covers the dry months of February to May. During July to September rain water is sufficiently available, therefore, requirement of freshwater from other sources is minimum.

Concerning impact during construction phase, it is not expected that turbidity in the river will increase tremendously, therefore, impact on aquatic lives and aquiaulture will not be significant. However, technical approach to minimize sediment dispersion must be applied such as bundling of the sediment disposal site, etc.

After the dam is completed, fish productivity is expected to increase in the upstream impoundment area, as it generally occurs in other impoundment dams. The dam will clearly separate freshwater and salt water, therefore causing separation of freshwater fish in the upstream and brackish water or marine fish in the lower reaches. Being completely different in their nature of living, fish ladder is then not recommended to transfer fresh water fish to downstream area and brackish water/marine fish to upstream fresh water because fish will die when changing to unfavorable habitat abruptly.

Freshwater aquaculture will no longer be possible in the downstream area except there is fresh water distribution system to low income agriculturist who cannot afford P. monodon farming.

With less river runoff to the lower reaches when the dam is constructed, water quality downstream may become worse due to more accumulation of pollutants discharged from various downstream activities. Such poor water quality will adversely affect the aquaculture in the river lower reaches.

2.2 Forestry

Mangrove forest along shoreline has higher density than at the Bang Pakong river mouth due to less degree of development of aquaculture and other activities and being far away from large communities. However, the remaining mangrove forest both along shoreline and river mouth is not so productive.

The proposed project site of about 127 ha (793 rai) is at present occupied by orchards, e.g. areca palm (Areca catch), coconut (Cocos nucifera), and mang (Mangifera indica). Mangrove forest can also be observed on a narrow strip along the river banks and along the canals in the orchards. Main species in the mangrove forest are nypa palm (Nypa fruticans) and Bruguiera sp.

To construct diversion dam and canal, a total of 60,017 trees will have to be cut off, most of which are planted orchards rather than mangrove forest.

After starting impoundment, the upstream water will be fresh water all year-round. Thus, the remaining of a little mangrove forest along upstream river bank may disappear.

2.3 Wildlife

Four groups of animals are found in the study area including amphibians, reptiles, birds and mammals. There are a total of 167 species reported, the details of which are as follows:-

Type	Damsite	Mangrove Forest (at the river mouth)	Total No. of Species Found
Amphibians	9	2	10
Reptiles	32	9	36
Birds	53	95	112
Mammals	6	8	9
Total	100	114	167

A great number of amphibian and reptile species are found at damsite, while a lage number of birds are also observed at mangrove forest around the river mouth. Number of mammal species are not much different in both the areas.

During construction of the diversion dam and canal there will be only little effects to wildlife species in the project site, because they can migrate to the nearby vicinity of the same ecological system. No impact on wildlife will occur during operation period.

3. Human Use Value

3.1 Water Supply

During the recent years, Bang Pakong River is no longer considered as good source of water supply mainly due to too high salinity, low DO value and presence of trace elements, e.g. heavy metals and pesticides. "Degradation of the river water quality also causes reduction of productivity of brackish water shrimp farms in Amphoe Muang Chachoengsao, Amphoe Bang Pakong and Amphoe Ban Pho close to the river mouth. In addition, rapid expansion of industrial sector has also resulted in freshwater shortage and wastewater pollution.

At present, in spite of poor water quality, river water not only from Bang Pakong river but also from tributaries mostly downstream of the proposed damsite is taken up as water supply source. The water is treated and supplied for domestic uses.

The EIA Report presented the demand of water supply for different activities in 1990 and also forecast of the future demand as shown in Table 1.

TABLE 1

ANNUAL DEMAND OF WATER SUPPLY FOR DIFFERENT ACTIVITIES IN 1990 AND FORECAST OF INCREASING DEMAND FOR FUTURE YEARS

Activities	Year 1990		Year 1995		Year 2000		Year 2005	
	MCM	%	MCM	%	MCM	%	MCM	%
1. Domestic water supply	4.913	27	6.266	22	7.896	21	9.757	19
2. Industrial use								
- For industrial estates	0.365	2	6.023	20	9.692	25	18.050	35
- For factories outside industrial estate	5.842	33	8.531	30	12.374	32	14.260	30
Sub-total	6.207	35	14.554	50	22.066	57	32.310	63
3. Livestock farming	6.014	33	7.177	25	7.625	20	8.102	16
4. Aquaculture	0.822	5	0.822	3	0.822	2	0.822	2
Grand total	17.956	100	28.819	100	38.409	100	50.991	100

Ref.: Draft Final EIA of Bang Pakong Diversion Dam Prepared by Kasetsart University, April 1992.

Regarding impact during construction of the proposed Bang Pakong Diversion Dam project, turbidity of river water might increase but it is not expected to cause adverse impact on water supply because locations of raw water intake locations are much far away from the project site. Positive impact on water supply can be predicted due to the increase of availability of freshwater for nearby Provincial Waterworks Authority (PWA). Therefore, the EIA Report strongly recommended that mitigative measures to preserve good water quality at the upstream of the damsite be strictly undertaken.

3.2 Land and Water Transportation

The EIA Report has summarized that no problems is expected on both land and water transportation in Chachoengsao province after the dam is constructed. Road transport between both the banks would become even more convenient due to new connecting road, connecting bridge and extension road across the closure dam. Small passenger boats which are at present the only water transport means along Bang Pakong river will not be able to go through the diversion dam in the future.

3.3 Livestock Farming and Industry

3.3.1 Livestock Farming

The EIA Report concluded the data on livestock farming in the study area in the year 1991, as follows:-

Province	Location	No of Individuals		
		Pig	Chicken	Duck
1. Chachoengsao				
- Amphoe Bang Khla	Upstream		84,574	45,009
- Amphoe Muang	Downstream		286,702	275,324
- Amphoe Ban Pho	Downstream		30,009	71,000
- Amphoe Bang Pakong	Downstream		10,718	160,000
Sub-total	Upstream	84,574	1,097,609	45,009
	Downstream		11,368,754	506,324
Total (1)		412,003	12,466,363	551,333
2. Chonburi				
- Amphoe Phan Thong	Downstream		1,572,789	278,000
Total (2)	Upstream	84,574	1,097,609	45,009
	Downstream		12,941,543	784,324
Grand Total in study area		443,427	14,039,152	829,333

Ref: Provincial Livestock Development Office (1991)

Water supply sources for livestock farming are from Bang Pakong river and its branch canals, tap water and also underground water. Livestock water demand in the study area in 1992 is concluded in the EIA Report as follows:-

Pig farming	6.06	MCM/year
Chicken farming	0.56	MCM/year
Duck farming	0.02	MCM/year
Total	6.64	MCM/year

Most livestock farming is considered to be on large scale. Since wet and dry pig manure are salable, remaining waste generated from all pig farms are farm wash water mixing with pig urines and left-over pig feed. This mixed waste stream is generally retained in a small holding sump before seeping into the soil or flowing over into nearby swamp. However, most small-scaled pig farms generally do not have such holding sumps. For chicken and duck farms, their manure can also be sold and the farms do not require washing. Thus, wastewater generation from chicken and duck farms is very limited. It can, therefore, be concluded that pig farming is the prime wastewater source among livestock development in the study area. Size of pig farms and estimation of BOD loading into the Bang Pakong river in the study area covering 2 provinces, i.e. Chachoengsao and Chonburi can be summarized as follows:-

Size of Pig Farm	Upstream		Downstream		Total	
	No. of farm	BOD loading (kg/d)	No. of farm	BOD loading (kg/d)	No. of farm	BOD loading (kg/d)
Less than 100 pigs	336	299	1,428	1,272	1,764	1,571
More than 100 pigs	375	6,759	398	7,174	773	13,933
Total	711	7,058	1,826	8,446	2,537	15,504

The above BOD loading estimation is based on the survey data of Department of Livestock Development that each pig farm of less than 100 pigs generates the average waste flow of 1.8 cu.m/day with BOD concentration of 495 mg/l. In addition, large pig farm of more than 100 pigs

generally discharges 10.8 cu.m/day of waste with BOD concentration of 1,669 mg/l.

It can be noted that livestock farming in the study area is expanding at the decreasing rate of expansion due to increasing land price caused by the development of Eastern Seaboard Project. With approximately 3 percent expansion of livestock farming according to Chachoengsao Provincial Development Plan, the number of livestock farming in the years 1992 and 1996 which is the year end of the this development plan can be concluded below:-

Livestock	Livestock	
	Year 1992	Year 1996
Pig	424,363	477,623
Chicken	12,840,354	14,451,932
Duck	567,873	621,146

Note: The above mentioned figures are for Chachoengsao province only not including Amphoe Phan Thong of Chonburi province.

As a result, BOD loading into the upstream and downstream of diversion dam will increase to 8,188 kg/day and 8,973 kg/day, respectively.

It can be noted that survey on locations of existing farms has not been conducted in the EIA study and such location map is not available at the Provincial Livestock Development Office.

The EIA Report already mentioned that pig farms located upstream of the Bang Pakong Diversion Dam discharge not less than 7,058 kg GOD/day into branch canals e.g. Chuckrachoe Bon canal, Sadao canal, Song Phi-Nong canal and Thong Lang canal. All of these canals will transfer pig farm wastewater into the Bang Pakong river. When the diversion dam is constructed, accumulation of organic matter in the upstream of the dam may be resulted and consequently causes extensive deterioration of river water quality.

3.3.2 Industry

Most factories in Chachoengsao province are related to agro-industrial type such as rice mill, noodle mill, tapioca mill, animal feed plant, etc. Industrial sector has expanded sharply during the past years. Industrial types and number of factories are summarized in Table 2.

Most factories are located along main roads, i.e. highway nos. 3, 34 and 304. Exact number and location of factories require to be surveyed because such information is not available at both Provincial Industrial Office and Industrial Works Department in Bangkok.

It was mentioned in section "3.1 Water Supply" that the industrial water demand in the year 1990 was about 6.2 MCM/year, and by the years 1995 and 2005 it will increase to 14.6 and 32.3 MCM/year, respectively. The source is mainly from the Bang Pakong river, of which the quality is deteriorated especially during dry period.

The Industrial Environment Division, Industrial Works Department, Ministry of Industry surveyed some industries in Chachoengsao province during 1978-1979 and the following conclusions can be made:-

(1) Most agro-industrial factories are rice mills having waste flow rate of 30-200 cu.m/day with BOD content in the raw waste between 20-3,200 mg/l. All rice mills have waste treatment system, most of which are collection sump or ponding system. Most mills do not discharge the waste stream to the surrounding canals. Only some mills discharged BOD of about 4-60 mg/l into nearby canals. The effluent standard is set up as the limiting value for BOD of 20 mg/l with the maximum allowable limit of 60 mg/l.

(2) For food mills such as noodle plant, beam thread mill, chinese cake plant, etc., the waste discharge was about 3-300 cu.m/day with BOD in the raw wastewater between 100-1,000 mg/l. Collection sump and ponding system are applied for wastewater treatment. All the generated wastewater is recycled without discharge to the nearby canals.

(3) BOD loading from various factories into the Bang Pakong river can be summarized as follows:-

TABLE 2

INDUSTRIAL TYPES AND NUMBER OF FACTORIES IN CHACHOENGSAO PROVINCE

Industrial Type	Amphoe				Total
	Muang	Ban Pho	Bang Pakong	Bang Khla	
1. Agro-industrial related or food preservation	21	20	25	20	86
2. Food production	10	1	2	11	24
3. Textile and spinning mill	-	-	1	-	1
4. Construction material and equipment production	9	1	6	3	19
5. Animal feed production	1	-	4	1	6
6. Leather/Shoes manufacturing	-	-	4	-	4
7. Furniture manufacturing	2	1	4	3	10
8. Machine/tool production or repair shop	45	-	1	6	52
9. Printing shop	4	-	-	1	5
10. Plastic pellet production	1	-	5	-	6
11. Electronic plant	-	-	5	-	5
12. Sport utility production	1	-	2	-	3
13. Medical equipment production	1	-	-	-	1
14. Decorative articles production	2	-	1	-	3
15. Cooking gas filling plant	1	-	-	1	2
16. Container manufacturing	-	1	-	-	1
17. Chemical plant	-	-	1	-	1
Total	98	24	61	46	229

Source: Industrial Works Department (1989).

Source	BOD loading (kg/d)
Amphoe Bang Khla	17
Amphoe Muang	112
Amphoe Ban Pho	7
Amphoe Bang Pakong	3
Total	139

Main source of BOD loading is from agro-industry and food production plants, most of which are provided only with primary treatment system.

It is expected that in the near future industrial sector will still be expanding in Chachoengsao province. However, the limiting factors for industrial expansion are related to insufficient availability of freshwater and tap water, insufficient power supply, insufficient telephone connection system as well as environmental problems.

The BOD loading from industry in the upstream area of only 17 kg/day is considered to be minor when compared to that discharged from pig farms (7,058 kg/day). Therefore, pig farm will be considered as the main source of BOD contamination in the upstream of the Bang Pakong Diversion Dam.

3.4 Land Use and Agriculture

Total project area for construction of diversion dam, diversion canal, office building, housing, etc. will cover about 126.4 ha. (793 rai). The existing land use pattern of this area is potential agricultural land, most of which are for mango and coconut plantation. All areas will be expropriated.

Construction of diversion dam will give great benefit to irrigation area along both banks of the Bang Pakong river especially the left bank irrigable area of about 20,000 ha consisting mainly of paddy fields (about

13,500 ha) and orchards (about 6,000 ha). Sufficient availability of freshwater as a result of the construction of Bang Pakong Diversion Dam is expected to increase the agricultural productivity of the irrigation area. Additionally, regulation of water level by the diversion dam is also believed to reduce problems of acid/salty solid in some areas which, in turn, will give more favorable condition for agricultural production. No other suggestion is added on this aspect.

4. Quality of Life Values

4.1 Socio-economics

Bang Pakong Diversion Dam is one component of the Bang Pakong River Basin Development Project. The dam is expected to provide freshwater to the existing 12,300 ha (76,900 rai) irrigable area on the left bank and future expanded zone of 2,000 ha (12,500 rai) located in Amphoe Bang Khla, Amphoe Muang, Amphoe Ban Pho and Amphoe Bang Pakong of Chachoengsao province and also Amphoe Phan Thong of Chonburi province.

In 1991, Chachoengsao province had 124,020 households, each with average number of 4.8 persons. Amphoe Phan Thong in Chonburi had 7,227 households with average number of 6.2 persons per household. Number and characters of households in the study area can be summarized as follows:-

Description	Damsite	Upstream irrigable area		Upstream irrigable area		Total
		Exist-ing	Future expand-ed	Exist-ing	Future expand-ed	
No. of household	52	106	33	175	29	395
Av. members	4.6	4.7	5.5	4.9	5.2	4.9
Family member,	1-9	1-11	1-11	1-11	2-9	1-11
person	2.8	2.9	3.5	2.9	3.0	49.1
Av. workforce, person	45.4	49.1	48.0	50.4	48.3	50.9
% of male	54.6	50.9	52.0	49.6	51.7	
% of female						

Office of Agricultural Economics (1991) predicted that agricultural workforce in Chachoengsao province would have tendency to reduce. It was predicted that out of total workforce of 310,125 in 1992, the agricultural workforce would be only 137,617 or about 44 percent. And in 1996, the agricultural workforce would become only 126,879 or about 38 percent of total workforce of 331,175. The survey in this EIA study revealed the distribution of workforce as detailed in Table 3.

Thus, about 40 percent of population in the study area are agricultural workforce and about 23 percent are non-agriculturist while unemployed is as low as 1.8 percent. It can be noted that the upstream and downstream irrigable areas to be expanded in the future exhibited quite high percentage of non-agricultural workforce of about 18 and 41 percent, respectively.

Agricultural areas in Chachoengsao and Chonburi occupy about 62 and 67 percent of total area of the provinces as shown in detailed below:-

Land Use	Chachoengsao		Chonburi	
	ha	%	ha	%
Forest	126,400	24	25,600	6
Agricultural land	331,200	62	292,800	67
Unclassified	76,800	14	118,400	27
Total	534,400	100	436,800	100

In Chachoengsao, about half of the agricultural area is paddy field with about 27 percent of the remaining agricultural area as orchard. Agricultural products in Chachoengsao in 1991 can be listed as follows:-

	M ton	M Baht
Rice	0.8	2,652
Tapioca	1.3	884
Mango	0.06	1,468

TABLE 3

DISTRIBUTION OF WORKFORCE IN STUDY AREA

Description	Damsite		Upstream Irrigable Area				Downstream Irrigable Area				Total	
			Existing		Future Expanded		Existing		Future Expanded			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Agricultural workforce	132	55	185	38	90	49	330	39	38	25	775	40
Non-agri. workforce	18	8	130	26	33	18	197	23	62	41	440	23
Unemployed	3	1	4	1	3	2	19	2	5	4	34	2
Younger than 15 yrs. old	62	26	101	20	35	19	189	22	23	15	410	21
Others (houseworker, handicapped and old aged)	25	10	73	15	21	12	121	14	23	15	263	14
Total	240	100	493	100	182	100	856	100	151	100	1,922	100

Considering only the districts related to the Bang Pakong Diversion Dam, i.e. Amphoes Bang Khla, Muang, Ban Pho and Bang Pakong, rice and mango are two main products from these districts resulting in income of total 1,357 and 907 million Baht, respectively.

Regarding the construction of Bang Pakong Diversion Dam, the study revealed that about 73 percent of surveyed population is aware of this project. About 43 percent do not know the real purposes of the dam, while about 14 percent perceived that it is aimed at irrigation, and about 12 percent thought that the dam will serve the water consumption demand. Details of surveyed on this regard is summarized in Table 4.

Most of people in the study area are aware of this project from local officers such as district or village heads. Only few percentages learned about this project from mass media.

About 60 percent of surveyed population perceived that this project will bring good benefit to them while the negative perception is that the dam will cause flooding, water pollution and retardation of water drainage. The details on this aspect are summarized in Table 5.

About 41 percent of surveyed population agreed with this project, 30 percent have no idea while 29 percent disagreed. Most people who disagreed have their households at the damsite where they have to be relocated. And those who live at the upstream area disagreed with this project because they are afraid of inundation, wastewater caused by stagnant impoundment and loss of living households and vegetative land. The reason for disagreement expressed by downstream people is because the dam will result in salt water intrusion for a longer period.

Regarding land expropriation and compensation, about 36 percent of surveyed population are willing to cooperate, 22 percent are not willing and 42 percent of people have no idea. The reasons for their willingness to cooperate are mainly because of the perception that the dam will bring great benefit to public and that opposition against the government requirement is considered not possible. Those who are not willing to cooperate gave the reason that they have to lose their agricultural land and believed that the dam is rather disadvantageous. It is worth noted that there seems to be

TABLE 4

SURVEYED RESULT ON ATTITUDE TOWARDS BANG PAKONG DIVERSION DAM

Description of Dam Purpose	Damsite		In the Vicinity of Damsite		Upstream Irrigable Area				Downstream Irrigable Area				Total	
					Existing		Future Expanded		Existing		Future Expanded			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Perception of this project														
Never heard about this project before	0	0	2	11	42	40	2	6	63	36	3	10	112	27
Already knew	52	100	17	89	64	60	31	94	112	64	26	90	302	73
Total	52	100	19	100	106	100	33	100	175	100	29	100	414	100
Perception of purpose of project														
No idea	2	4	6	35	27	42	16	52	68	61	10	39	129	43
Irrigation	10	19	3	17	8	12	3	10	13	12	5	19	42	14
Consumption	13	25	2	12	5	8	4	13	11	10	1	4	36	12
Prevention of brine intrusion	5	10	1	6	10	16	1	3	6	5	3	11	26	9
Flood protection	4	8	1	6	5	8	1	3	2	2	1	4	14	4
Distribution of water to eastern region	8	15	1	6	4	6	1	3	6	5	4	15	24	8
Irrigation and prevention of brine intrusion	2	4	2	12	3	5	1	3	4	3	2	8	14	4
Irrigation and consumption	8	15	1	6	2	3	4	13	2	2	0	0	17	6
Total	52	100	17	100	64	100	31	100	112	100	26	100	302	100

TABLE 5

SURVEYED ATTITUDE TOWARDS WILLINGNESS TO COOPERATE IN LAND EXPROPRIATION/COMPENSATION

Attitude	Damsite		In the Vicinity of Damsite		Upstream Irrigable Area				Downstream Irrigable Area				Total	
					Existing		Future Expanded		Existing		Future Expanded			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
- Willing to cooperate	25	48	6	32	31	29	8	24	67	38	12	41	149	36
- Not willing to cooperate	22	42	4	21	17	16	9	27	33	19	7	24	92	22
- Not decided yet	5	10	9	47	58	55	16	49	75	43	10	35	173	42
Total	52	100	19	100	106	100	33	100	175	100	29	100	414	100
Reasons to cooperate														
- Public benefit	8	32	1	16.7	10	32	3	38	24	36	4	33	50	34
- Reasonable expropriation/ compensation	4	16	1	16.7	1	3	1	12	4	6	1	8	12	8
- More availability of water	0	0	1	16.7	5	16	1	12	6	9	1	8	14	9
- Cannot be opposable against government	13	52	1	16.7	8	26	3	38	18	27	4	33	47	32
- No reason	0	0	2	33.2	7	23	0	0	15	22	2	17	26	17
Total	25	100	6	100	31	100	8	100	67	100	12	99	149	100
Reasons not to cooperate														
- Loss of agricultural land property	13	59	1	25	4	23	4	45	22	67	3	43	47	51
- The dam would bring more disadvantages	4	18	2	50	2	12	2	22	5	15	2	29	17	19
- More serious flooding	0	0	1	25	1	6	1	11	2	6	1	14	6	6
- Severe water pollution due to stagnant impoundment	0	0	0	0	1	6	1	11	1	3	0	0	3	3
- Existing agricultural land is already fertile	5	23	0	0	2	12	0	0	1	3	0	0	8	9
- No reason	0	0	0	0	7	41	1	11	2	6	1	14	11	12
Total	22	100	4	100	17	100	9	100	33	100	7	100	92	100

fewer well-cooperated people in the upstream area as presented in detail in Table 6.

The EIA Report emphasized that 65 households at the damsite have to be relocated. Almost all of them (96 percent) are satisfied with existing environment, e.g. neighbourhood, vegetative land, etc. Strong feeling of loving and clinging to present living places makes most of people at the damsite area disagree with this project. About 75 percent of these people still have no plan to relocate. This implies that it would be quite difficult for the government to find new relocation site as suitable as the present living places. Therefore, definite advice and planning for relocation is needed to avoid escalating the unsatisfaction to strong opposition among inhabitants to be relocated. In addition, expropriation and compensation must be completed quickly at one time with reasonable price.

TABLE 6

ATTITUDE TOWARDS IMPACT DUE TO CONSTRUCTION OF BANG PAKONG DIVERSION DAM

Nature of Impact	Damsite		In the Vicinity of Damsite		Upstream Irrigable Area				Downstream Irrigable Area				Total	
					Existing		Future Expanded		Existing		Future Expanded			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Positive impacts:-														
a) Irrigation improvement	5	27	4	25	27	44	5	29	71	66	4	24	116	49
b) Water consumption	1	6	2	13	2	3	2	12	5	4	3	17	15	6
c) Flood protection	0	0	1	6	2	3	1	6	4	4	1	6	9	4
d) Prevention of brine intrusion	4	22	1	6	10	16	3	18	9	8	2	12	29	12
e) Flushing of wastewater	1	6	1	6	4	7	1	6	3	3	1	6	11	5
f) Provision of new professions	1	6	2	13	3	5	0	0	4	4	2	12	12	5
g) Provision of benefits to other development	2	11	1	6	4	7	4	23	2	2	3	17	16	7
h) a)/c)/d) above	2	11	3	19	8	13	0	0	7	6	0	0	20	8
i) No supporting reasons	2	11	1	6	1	2	1	6	3	3	1	6	9	4
Total	18	100	16	100	61	100	17	100	108	100	17	100	237	100
Negative impacts:-														
a) Reduction of irrigation water	1	2	1	10	2	4	2	7	4	7	1	11	11	6
b) Flooding	20	50	2	20	28	55	7	26	28	53	3	34	88	46
c) More wastewater	5	13	2	20	4	8	2	7	5	9	1	11	19	10
d) Longer period of salt intrusion	3	8	1	10	1	2	2	7	2	4	1	11	10	5
e) Poorer drainage	7	18	1	10	5	10	1	5	3	6	2	22	19	10
f) Inconvenient water transport	1	2	0	0	3	6	2	7	1	2	0	0	7	4
g) b)/c)/e) above	2	5	2	20	7	13	8	30	10	19	1	11	30	16
h) No supporting reasons	1	2	1	10	1	2	3	11	0	0	0	0	6	3
Total	40	100	10	100	51	100	27	100	53	100	9	100	190	100

Although it was reported in the EIA study carried out in August to November 1991 that most inhabitants disagreed with relocation, agreement of all the inhabitants to be relocated by monetary land purchasing and compensation were made as a result of the governments efforts, getting the last two households' agreement in December 1991. As of October 1992 when JICA Study Team were executing the first field works, the pressing matters of land expropriation and compensation where the existing difference of land purchasing price and compensation cost between the government side and the related inhabitants should be lessened and ceased to exist for the final agreement of both the sides, and the necessary amount of money should be provided for early payment at once by the Provincial Government. The governor of the Province stressed to JICA Study Team to solve this problem in order that project implementation will not be delayed.

4.2 Land Expropriation and Compensation

The land requirement for the project is 126.4 ha (793 rai) as stated above.

Three alternative approaches were applied to estimate land price:-

Alt. 1 Estimation by provincial sub-committee (Provincial Land Office)

Alt. 2 Estimation by provincial working group on Bang Pakong Project

Alt. 3 Estimation by EIA study team

Land value recently evaluated since Jan 1, 1992 by provincial subcommittee (Provincial Land Office) is as follows:-(Alt. 1)

		Baht/rai
1.	Land strip within 80 m along Bang Pakong river bank	600,000
2.	Land strip within 40 m along irrigation canal	400,000
3.	Land area below irrigation canal up to Bang Pakong river	
	(a)Close to road or passage within 40 m	300,000
	(b)Other than 3(a) above	200,000
4.	Land area below irrigation canal up to boundary of Amphoe Bang Nam Priew	
	(a)Close to road or passage of canal within 40 m	200,000
	(b)Other than 4(a) above	120,000

Provincial working group on Bank Pakong Diversion Dam project has estimated land price as follows (Alt. 2):-

		Baht/rai
1.	Land strip within 80 m along Bang Pakong river bank	1,000,000
2.	Other areas	500,000

Land price estimated by EIA study team is based on Alt. 1 above and also sale price expected by landlord which is as follows:- (Alt. 3)

		Baht/rai
1.	Land strip within 80 m along Bang Pakong river bank	900,000
2.	Land close to street, road, public passage within 40 m	650,000
3.	Other areas	500,000

Comparison of land price at market value and expected price by landlord at the location of damsite is as follows:-

Damsite		Market value (Baht/rai)	Expected price by Landlord (Baht/rai)
Village no.1 - Ban Phai Saweg		557,241	766,667
Village no.11 -	Ban Laem Praya Chak	692,857	820,000
			793,334
	Average price	625,049	

The average investment cost for land development is estimated at 1,620 Baht/rai consisting of following items:-

		Baht/rai
1.	Land preparation for crop cultivation	340
2.	Dredging of fish/shrimp pond	145
3.	Annual dredging of 2x2 m ponding for fighting fish	600
4.	Annual construction of flood protection earth dike	535
	Total	1,620

Compensation cost consisting of land value and investment cost to develop land property can be summarized for each alternative approach as follows:-

Alternatives	Land Value (Million Baht)	Investment Cost (Million Baht)	Total (Million Baht)
1) By provincial sub-committee	197.6	1.3	198.9
2) By provincial working group	439.9	1.3	441.2
3) By EIA study team	437.6	1.3	438.9

Vegetative orchards of mangoes, areca palms and coconuts at damsite will be expropriated and compensated. compensation cost is about 53.7 million Baht.

Government properties and privately-owned buildings will be with total value of 20.3 million Baht. Total compensation cost for each alternative approach can be summarized as follows:-

	Alternative 1 (Baht)	Alternative 2 (Baht)	Alternative 3 (Baht)
1. Land value and investment for development	198,865,480	441,150,880	438,840,230
2. Orchard			
3. Privately-owned building	53,666,881	53,666,881	53,666,881
4. Government property	20,334,140	20,334,140	20,334,140
5. Expense of survey and management	1,090,112	1,090,112	1,090,112
6. Contingency (10%)	1,500,000	1,500,000	1,500,000
	27,395,660	51,624,200	51,393,130
Total	302,852,273	569,366,213	566,824,493

The third alternative estimated by the EIA study teamwas based on present market value and seems to be the most reasonable estimation.

4.3 Evacuation and Relocation

Two alternative evacuation plans were proposed in the EIA. The first plan involves zone-by-zone evacuation depending on development phasing, while the second plan is complete evacuation out of the project site at one time. Advantages and disadvantages for each alternative can be summarized as follows:-

First alternative Advantage

(1) With less number of evacuees each year, less annual budget will be generated. Market price of construction material and requirement of land area will not much increase.

(2) Those evacuees who are relocated to new places in the former year can assist their relatives to be relocated thereafter.

(3) The remaining groups of evacuees will have longer time for better preparedness, thus having less troubles.

Disadvantages

(1) Longer evacuation period may affect the project schedule.

(2) The remaining villagers may be psychologically affected when their neighbouring friends are gradually relocated.

(3) The same neighbourhood may not be possible to get reunited due to evacuation at different period of time.

Second alternativeAdvantages

(1) Complete evacuation out of the whole project site will not affect the project schedule.

(2) No psychological effect because evacuation is made continuously and shortly finished.

(3) Formation of the same neighbourhood at the new resettlement site is more possible.

Disadvantages

(1) Higher cost for compensation will have to be paid at once for relocation of the whole group of people. This may result in great increase of demand and market price of construction materials and new resettlement sites.

(2) The evacuees may not be able to assist their relative because all of them will have to be relocated together.