5.7 Resettlement Plan

Through the implementation of this project, about 4,330 ha (27.1 thousand rai) of land composed of 1,930 ha (12.1 thousand rai) of farm land and housing lots and 2,400 ha (15.0 thousand rai) of forest land will be submerged in case of the water level of EL.140.0 m (compensation water level). Additionally, the number of households affected by the water level is estimated at 324. However, by the provision of low protection dikes, which will function as a detour road along the reservoir, the number of these households could be reduced.

In the project plan, the protection dikes are planned to be built on the ground at an elevation of EL. 138.5 m, resulting in a dike height of two meter, when the crest elevation of protection dikes is planned at El. 140.5 m above mean sea level, which is 50 cm higher than the compensation water level of El 140.0 m

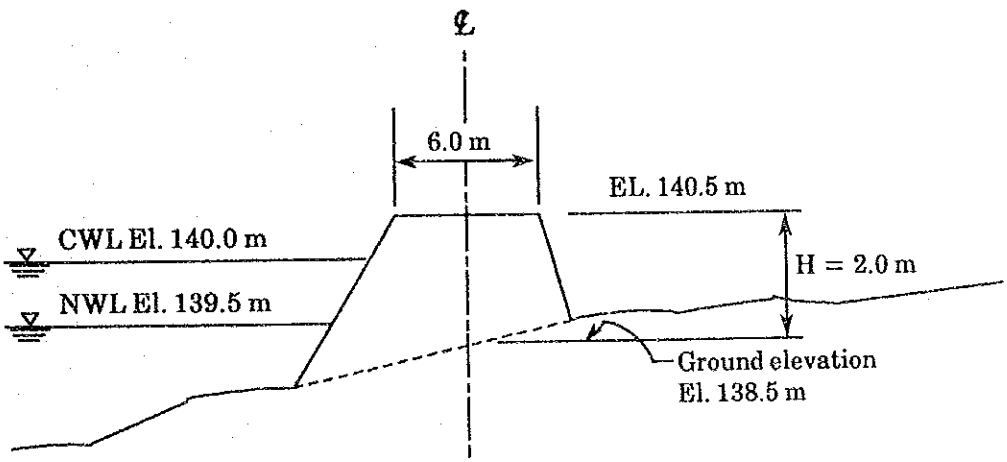


Figure 5-10 indicate the layout of proposed protection dike for the D-28 reservoir.

Description of reservoir areas and planned resettlement households and population are given below;

Description	Ban Bua Thiam	Ban Khok Thiam	Ban Fang Phe, Ban Non Chich
Length of Dike (m)	1,060	1,350	1,650
Height of Dike (m)	2.0	2.0	2.0
Catchment Area (sq.km)	17.0	22.2	24.8
Pump Facilities			
Flood Discharge (cu.m/m)	102.0	133.2	148.8
Pump Unit	2	2	2
Pump Discharge/unit(cu./m)	51.0	66.6	74.4
Diameter (mm)	700	800	800
Output (Hp)	45	60	65
Pump Type	VAFP 1/	VAFP	VAFP

Note : VAFP : Vertical axial flow pump

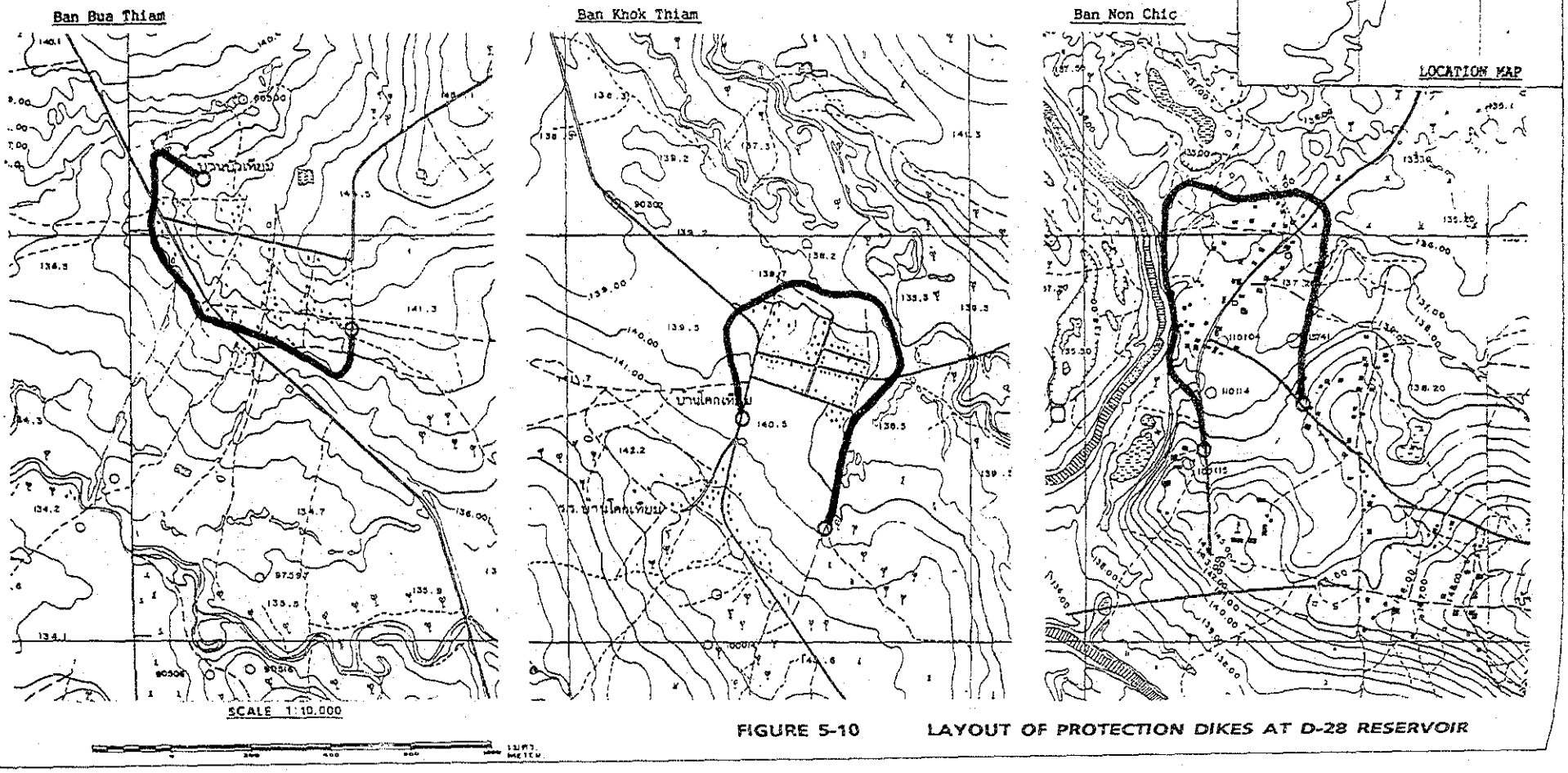


FIGURE 5-10 LAYOUT OF PROTECTION DIKES AT D-28 RESERVOIR

Item	Left Bank Area	Right Bank Area	Total
- Land-use (ha)			
Farm land and residential lots	280	1,650	1,930
Forests and others	990	1,410	2,400
Total	1,270	3,060	4,330
- Land category (ha)			1,320
Reserved forest	1,320	-	3,010
ALRO area	-	3,010	4,330
Total	1,320	3,010	122
- Household (household)	-	-	659
- Population (person)	-	-	(5.4 person/h.h)

In the above figures, the number of households to be resettled is estimated at 122 in cases where protection dikes of two meter in height will be provided. The relation between the number of households and the height of the dike is presented as follows;

Submerged Household and Height of Dike

Case	Location of Dike	Height of Dike	No. of Households	Elevation of Dike
Case - 1	No Dike	-	324	-
Case - 2	EL. 139.0 m	1.50 m	152	EL. 140.5 m
Case - 3	EL. 138.5 m	2.00 m	122	EL. 140.5 m
Case - 4	EL. 138.0 m	2.50 m	91	EL. 140.5 m

In order to provide the new land for these 122 householders, the RID, main executing agency for project implementation, should take necessary countermeasures for resettlement with close cooperation with related government agencies such as ALRO (Agricultural Land Reform Office) and RFD (Royal Forestry Department).

Regarding the location of resettlement areas for the project, the following possible sites are considered; Namely, one will be located on the right bank area covered by the Ubon Ratchathani Land Reform Project Area, while the other is located on the left bank area being categorized by reserved forest under the RFD.

Therefore, two resettlement sites are proposed in the project plan, that is, one will be on the right bank area and the other will be on the left bank area, respectively, considering the farmers' convenience for farm works under such severe circumstances as the extension of the submerged farm land and households.

Figure 5-11 shows the tentatively selected resettlement areas.

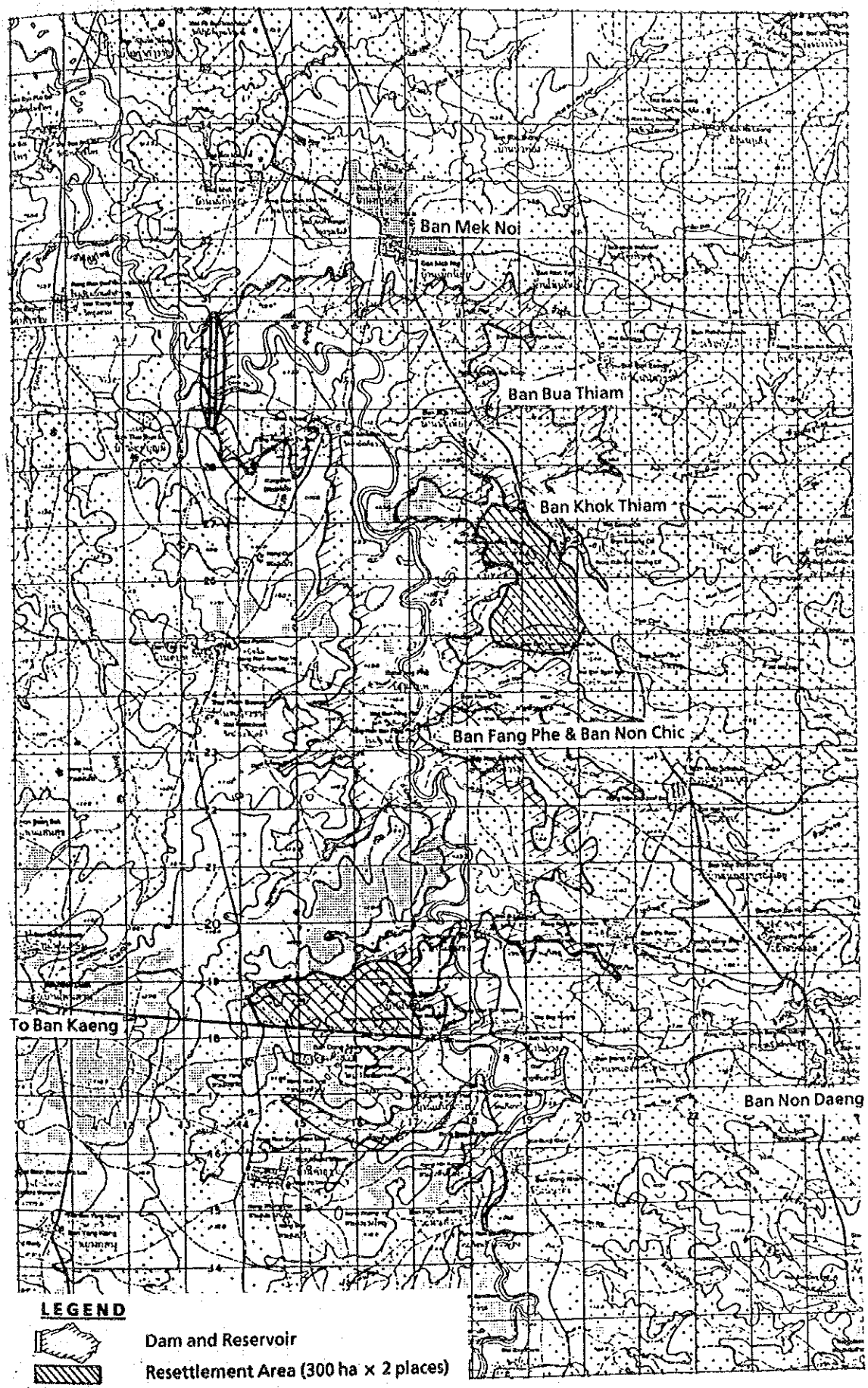


FIGURE 5-11 TENTATIVE LOCATION OF RESETTLEMENT AREA

5. 8 Rural Development Plan

5. 8. 1 Social Infrastructure

The present road conditions in the Project Area are deemed to be insufficient for intercommunication between villages and farm-to-market arrangements. Therefore, operation and maintenance roads appurtenant to the canal systems are to be used for public transport.

The road networks provided in the project are as follows;

Operation And Maintenance Roads

Item	Effective Width (m)	Road Length (km)	Remarks
Feeder Road (main)	6.0	111.4	Laterite pave.
O & M Road (Lateral)	4.0	188.4	Laterite pave.
Total		299.8	
Road Density (m / ha)		8.8	

In addition, farm road networks at the on-farm level will be provided over the Project Area. Although these roads should be basically provided by the Water Users' Association to be established, they can also be utilized for inter communication between the associations. The total length of the on-farm road in the Project Area is estimated at about 360 km, equivalent to 10.6 m/ha.

5. 8. 2 Integrated Community Center

According to the Seventh National Economic and Social Development Plan (1992-1996), distributions of income and development prosperity to the regions are emphasized as major objectives. Especially, in order to improve the income distribution problems, emphases are placed on poorest farmers, employees in agriculture sectors, small self-employed workers, and so forth.

Under these national strategies and policies, Lam Dom Yai Basin Irrigation Project will contribute to regional development with the increase in agricultural production under stable irrigation water supplies. Furthermore,

in accordance with the project implementation, additional consideration is incorporated into rural development, aiming at rural community development on a Muban level, such as;

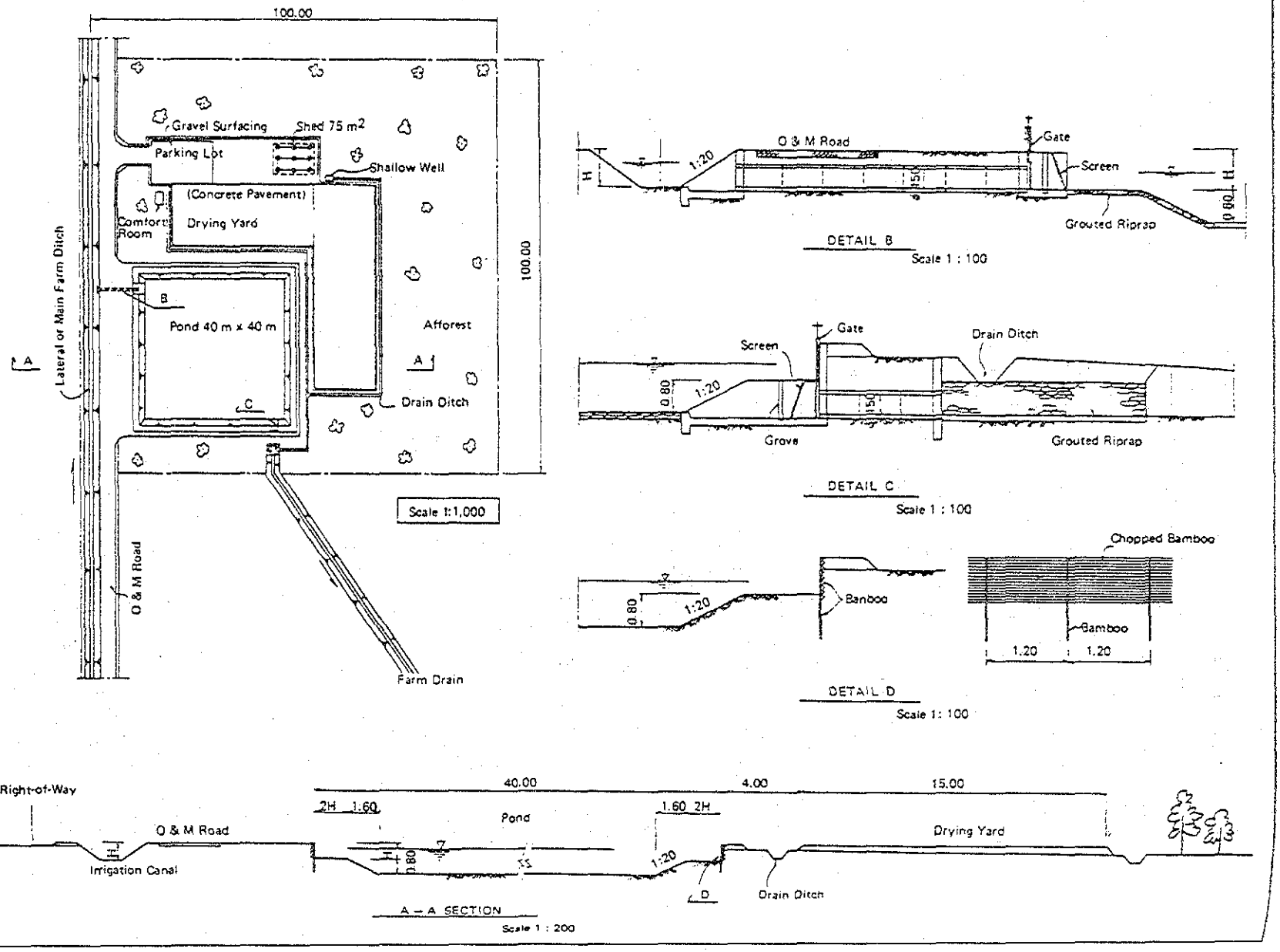
- Village fisheries in which all the villagers would enjoy fishing activities in the village pond to be constructed in order to help increase their protein consumption and to get additional cash income,
- Domestic water supply by means of canal systems, and
- Agricultural cooperative works equipped with processing yard,

In the direction of the above-mentioned rural development strategies, integrated rural community centers at the Muban level were planned at 68 sites in the Project Area.

The village community facilities consist of an open space provided with a shallow well, a comfort room, a processing yard, a sunshade space, afforestation area and a village pond. These sort of public facilities will be the core of communities at the Muban level.

Figure 5-12 indicates the typical layout of the proposed integrated community center.

FIGURE 5-12 GENERAL PLAN OF INTEGRATEED COMMUNITY CENTER



CHAPTER VI. PROJECT ENGINEERING

CHAPTER VI. PROJECT ENGINEERING

6.1 Dam and Reservoir

6.1.1 Geological Conditions

1) Topography

The D-28 dam-site is located halfway along the Lam Dom Yai, which meanders from east to north near the site and flow around a ridge standing out from the right bank at the dam axis. The river has formed a wide flood plane which reaches to about 600 m around the dam axis, and old river courses and natural levees can be recognized from topographic maps and aero-photographs. Dammed lakes exist on the old river courses and back marshes, which are utilized for irrigation. The flood plane is mostly flat, that is, the gradient is 1/600 and the elevation ranges from 130 to 133 m above mean sea level.

Both sides of the Lam Dom Yai have rolling hills with relatively steep banks and mostly flat hilltops. The gradient is 1/15 on the left abutment and 1/28 on the right abutment. The left abutment is a wide hillside of EL150.0 m, but the right abutment is on a narrow ridge which juts out on the Lam Dom Yai and is EL 142 m high at the top.

Talus and river terraces exist on a small scale at the skirts of the rolling hills. A thin bed of terrace deposit is distributed on the hilltops of the right bank, due to excavated gravel from a pond near the spillway.

2) Geology

As shown in Figure 6-1 and 6-2, the geology of the investigated area consists of bed rock, residual soil, terrace deposit, talus deposit and flood plane deposit.

No bedrock crops out in the investigated area, and its lithologic character can be observed only from boring cores. The bedrock belongs to the Khok Kruat formation from Cretaceous age, and the general strike and dip are assumed to be N 30°W to N 40°E to 5° to 15° NW judging from existing data and

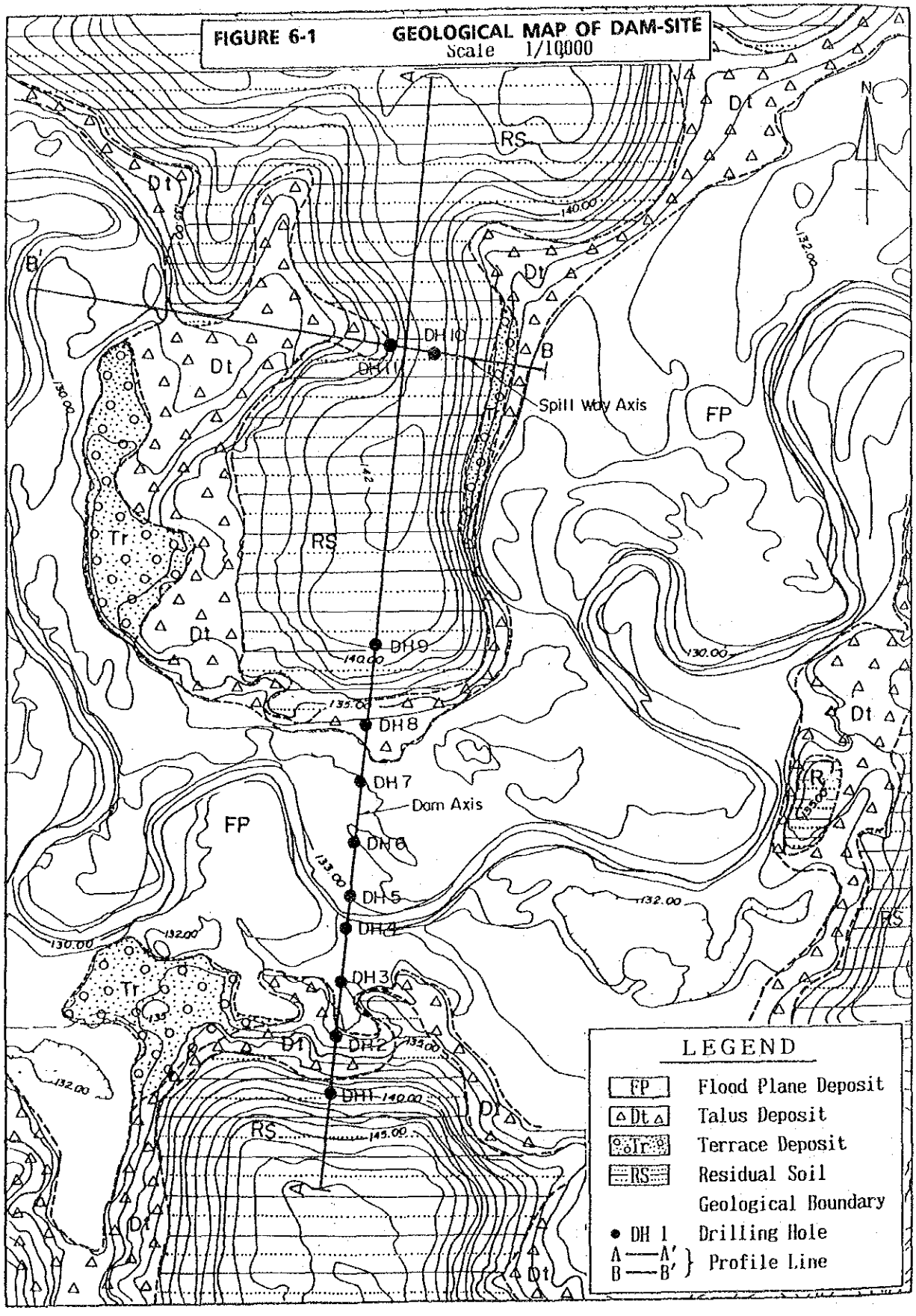


FIGURE 6-1 GEOLOGICAL MAP OF DAM-SITE
Scale 1/10000
N
RS
Dt
B'
B
DH 10
DH 11
Spill Way Axis
FP
Tr
DH 9
DH 8
DH 7
Dam Axis
DH 6
DH 5
DH 4
DH 3
DH 2
DH 1
140.00
135.00
130.00
132.00
145.00
LEGEND
FP Flood Plane Deposit
Dt Talus Deposit
Tr Terrace Deposit
RS Residual Soil
Geological Boundary
DH 1 Drilling Hole
A—A' B—B' Profile Line

FIGURE 6-2 GEOLOGICAL PROFILE (ALONG A-A' LINE)

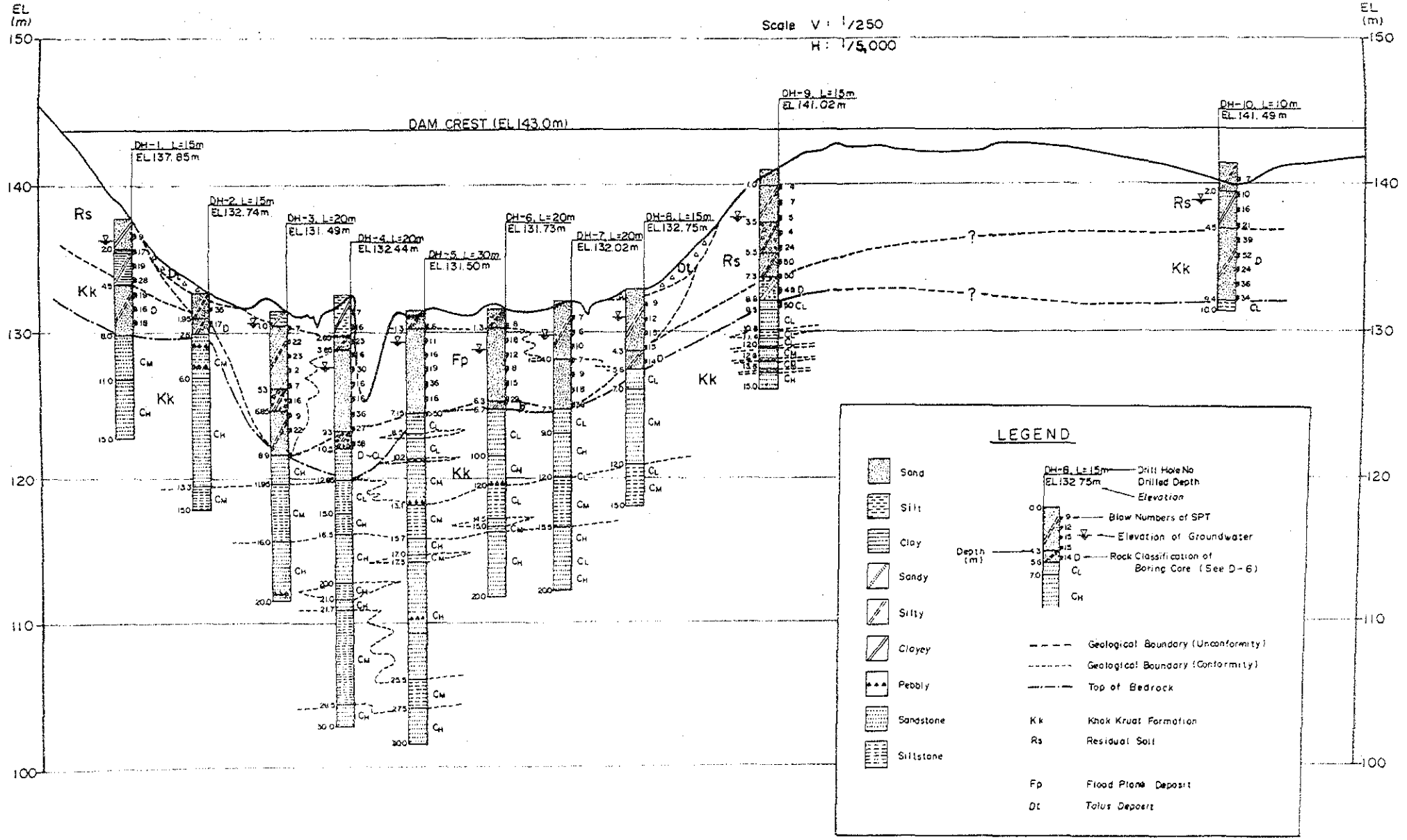
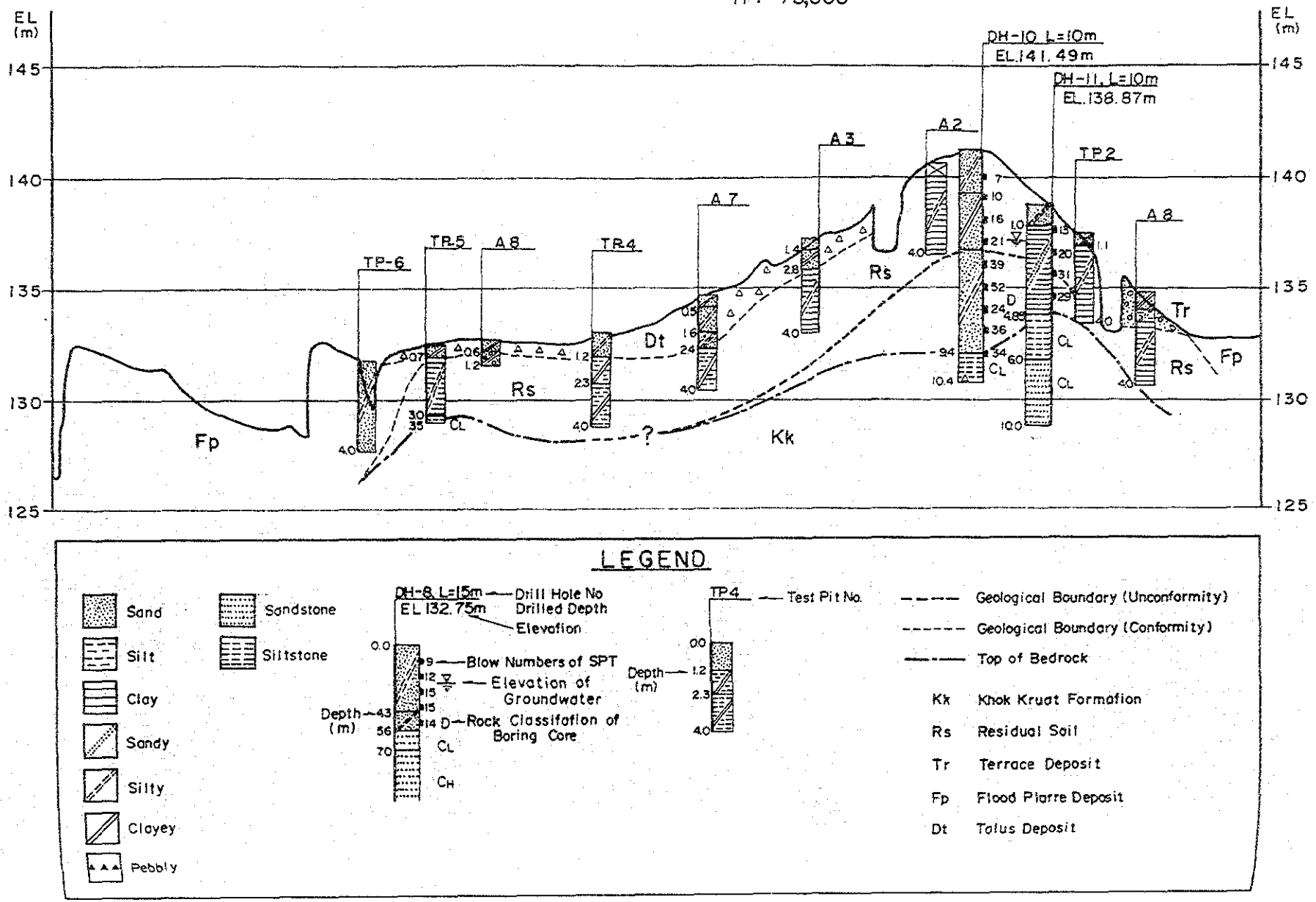


FIGURE 6-3 GEOLOGICAL PROFILE (ALONG B-B' LINE)

Scale V : 1/250
H : 1/5,000



LEGEND

- Sand
- Silt
- Clay
- Sandy
- Silty
- Clayey
- Pebbly
- Sandstone
- Siltstone

DH-8, L=15m — Drill Hole No. / Drilled Depth
EL 132.75m — Elevation
Blow Numbers of SPT
Elevation of Groundwater
D — Rock Classifation of Boring Core
Depth (m)
CL
CH

TP4 — Test Pit No.
Depth (m)

- Geological Boundary (Unconformity)
- Geological Boundary (Conformity)
- Top of Bedrock

Kk Khok Kruat Formation
Rs Residual Soil
Tr Terrace Deposit
Fp Flood Plain Deposit
Dt Talus Deposit

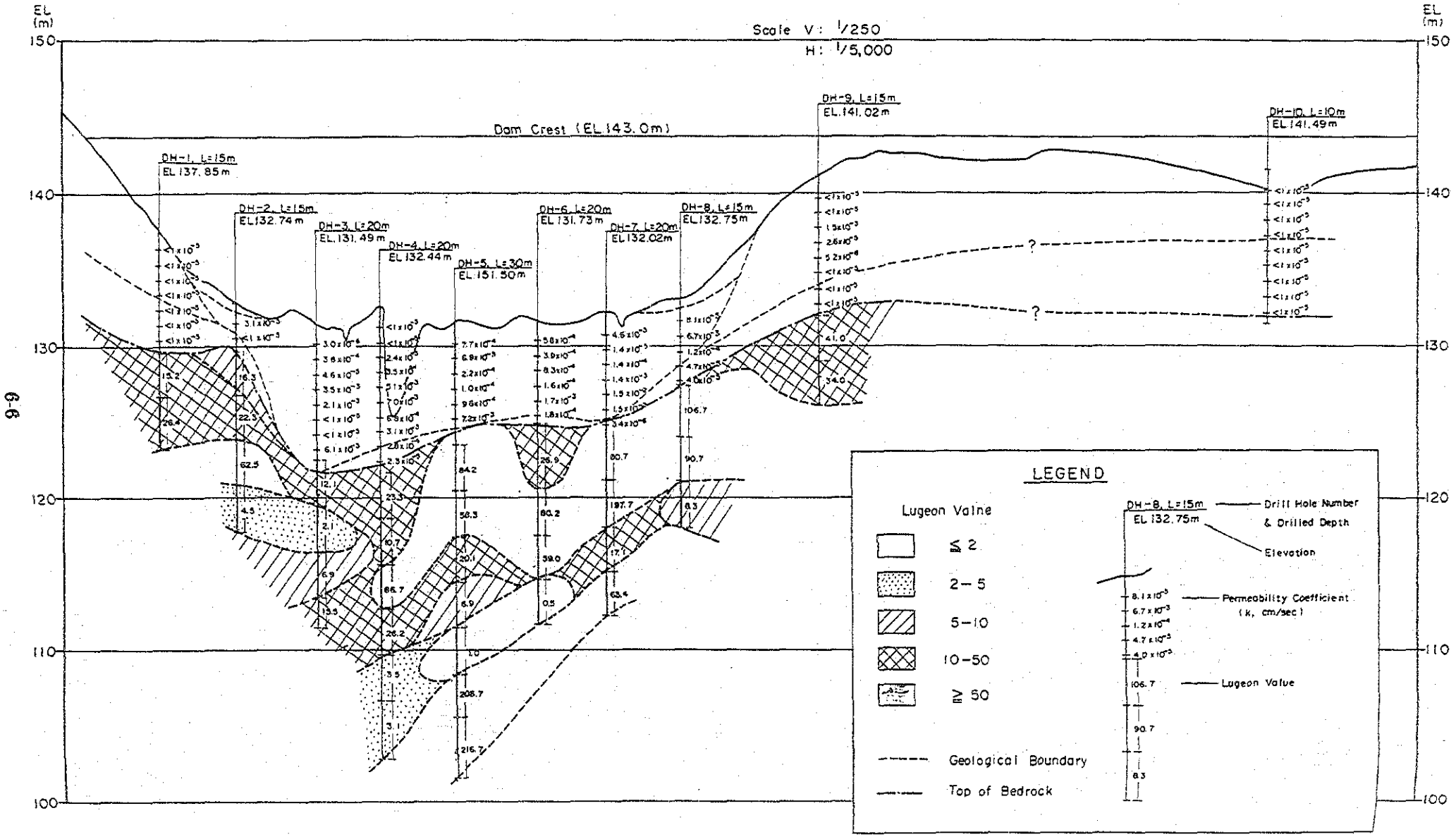
the field reconnaissance so far made. It consists of fine to coarse grained sandstone, siltstone, thin beds of conglomerate and alternations of them. The weathering condition of cores ranges from completely to moderately weathered, and from mostly closed to opened fissures exist with the distance of 5 to 50 cm in intervals. Cores are easily broken by soft hammering along fissures and are partly dissolved by drilling water. As shown in Figure 6-2, the bedrock is generally soft and ranges in rock classification from CH to D class (rock classification by boring core observation, see Annex D). The surface of the bedrock has been changed to soil including angular gravel, and classified into CL to D class that is 3.5 m in maximum thickness in the flood plane and five meter in maximum thickness in the hilly areas. As shown in Figure 6-2, the soft layer overlies hard bedrock, in which grouting is effective against seepage flow.

The permeability ranges in Lugeon value from 0.5 to 216.7 as shown in Figure 6-4. The whole bedrock shows high Lugeon value more than 10 except some areas consisting of less than 10 Lugeon. Especially, the right bank ranges from 10 to 106 Lugeon in six to ten meter deep, and the left bank in three to ten meter deep. Another high Lugeon value zone, ranging form 63.4 to 216.7, is distributed in more than ten meter deep of the right bank. This high Lugeon value is presumably caused by fine cross bedding of sandstone and siltstone and fissures along them. Thin siltstone beds in sandstone are generally very soft and have possibility of slaking. When thin and soft beds distribute with gradient from upper to downstream, piping will occur along the beds. Grouting will be required for the foundation. More investigations on permeability of the bedrock should be conducted and the characteristics of the bedrock on permeability should be confirmed. Additional boring will be required on the dam axis, especially, on the abutment of left bank, between right abutment and the spillway and down and upperstream of the dam axis.

From the viewpoint of N value, the bearing capacity of the bedrock including its highly weathered surface layers will be sufficient for planned load of the fill-type dam.

Residual soils, which consist of weathering material of bedrock, is distributed widely in the hilly areas and overlie the bedrock. As shown in Figures 6-2, 6-3 and 6-5, the soil is mainly composed of fine sand, silty sand, silt and clay which indicate the lithological characters of the bedrock. The

FIGURE 6-4 LUGEON MAP (ALONG A-A' LINE)



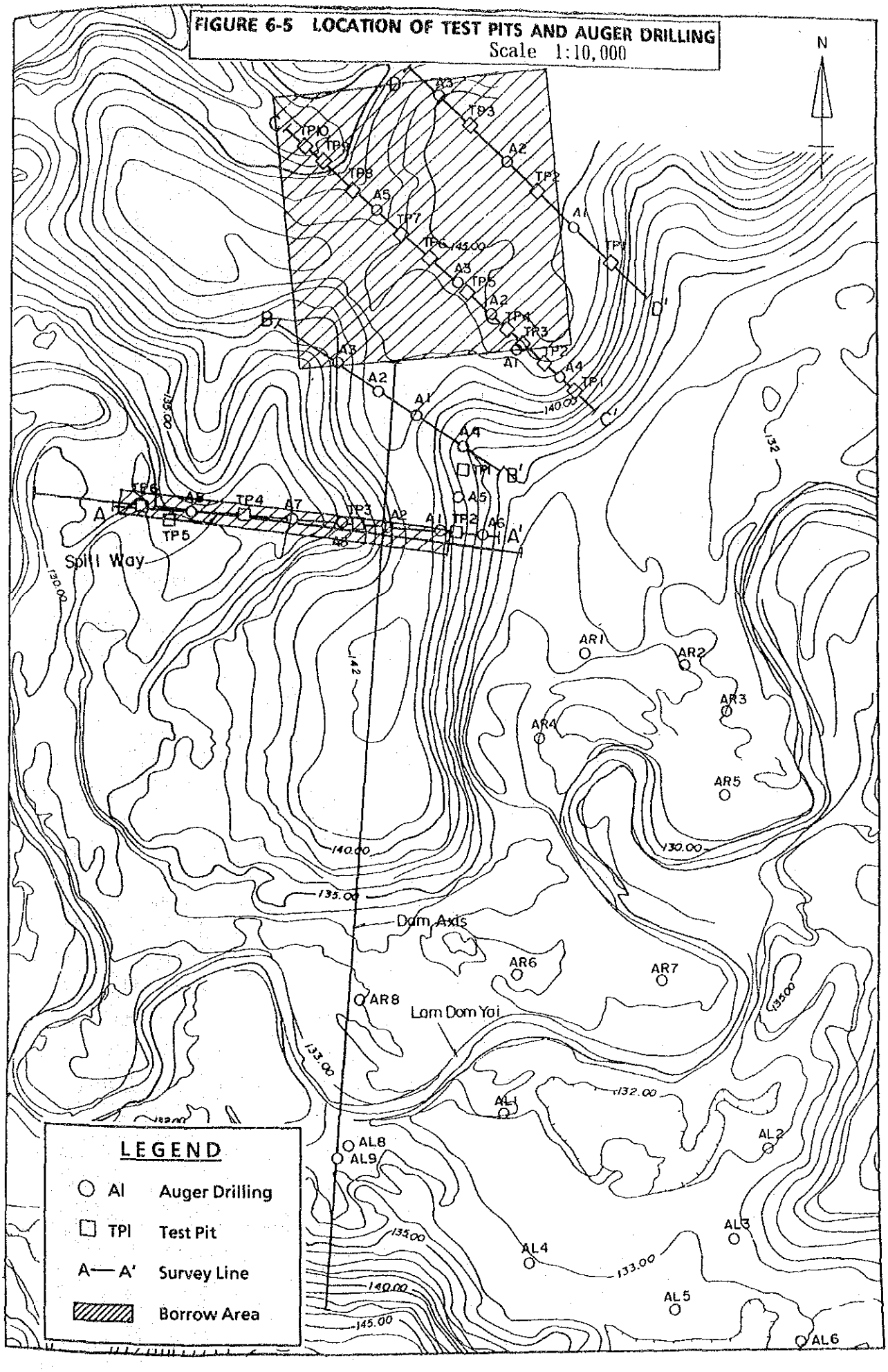


FIGURE 6-5 LOCATION OF TEST PITS AND AUGER DRILLING
Scale 1:10,000
N
TP10
TP9
TP8
TP7
TP6
TP5
TP4
TP3
TP2
TP1
A5
A4
A3
A2
A1
AB
AR1
AR2
AR3
AR4
AR5
AR6
AR7
AR8
AL1
AL2
AL3
AL4
AL5
AL6
AL8
AL9
Spill Way
Dam Axis
Lam Dom Yai
145.00
140.00
135.00
130.00
132.00
133.00
LEGEND
Al Auger Drilling
TPl Test Pit
A— A' Survey Line
Borrow Area

permeability of residual soil is generally low and the coefficient is less than 1×10^{-5} cm/sec. N value ranges from four to more than 50, and less than ten within five meter deep. Particular attention should be paid to the soft ground.

Flood plain deposits, which have been transported by the river, are widely distributed along the most recent river course. The deposit on the dam axis is composed mainly of very loose to dense and silty sand, and is 9.3 m thick in the middle of the flood plane. As shown in Figure 6-2, the deposit is partly dense, but N value is less than 20 within six to eight meter deep. The permeability ranges in coefficient from 7.2×10^{-3} to 4.8×10^{-5} cm/sec. It seems that excavations to eliminate the soft and pervious ground are required for the core zone unless adequate measures are taken instead of elimination. According to the auger drilling, the flood plain of the upper-stream of the dam-axis also consists mainly of sand or silty sand as shown in Figure 6-5, therefore, a natural blanket for the dam foundation is not expected.

Talus deposit overlies residual soil at the base of the hillside and is presumably less than two meter thick. The deposit is formed mainly of loose sand, silt and clay.

Fault and landslide have not been observed in the investigated area.

6. 1. 2 Reservoir Planning

The D-28 dam construction consists of dam, outlet and spillway works. The dam is to be constructed across the Dom Yai river about 30 km upstream from Muang Det Udom which is the central municipality of the basin. The dam is of homogeneous earthfill type requiring about 850,000 cu.m of embankment in total. The dam length is 2,000 m long at the crest elevation of EL.143.0 m, and has a maximum height of 21.5 m above the lowest point of the foundation.

The materials required for the impervious zone of the dam will be obtained from the borrow area located within about one kilometer from the excavated sites for the proposed structures, and the riprap and filter materials will be purchased from the sand and gravel production company in Nam Yun or other neighborhood.

The proposed D-28 dam raises the water surface about 6.5 m and thus forms a reservoir. The reservoir area is about 39.1 sq.km (24.4 thousand rai) at the normal water level of EL.139.5 m, and has a total storage capacity of 117.1 MCM, out of which 104.6 MCM is effective capacity (see Figure 6-6).

The chute type spillway with a designed flood capacity of 641.0 cu.m/sec is planned for the right abutment of the dam. The spillway crest elevation is 139.5 m, and the crest length is 170 m, respectively.

A cut-and-cover conduit type outlet work is planned under the right abutment of the dam. The outlet works, of which maximum designed discharge is 5.5 cu.m/sec serve to release stored water to the downstream.

The alignments of dam, spillway and outlet are illustrated in the Attached Drawing No. 1 and the major features of D-28 dam and reservoir are tabulated in Table 6-1.

FIGURE 6-6 RESERVOIR AREA AND CAPACITY CURVE

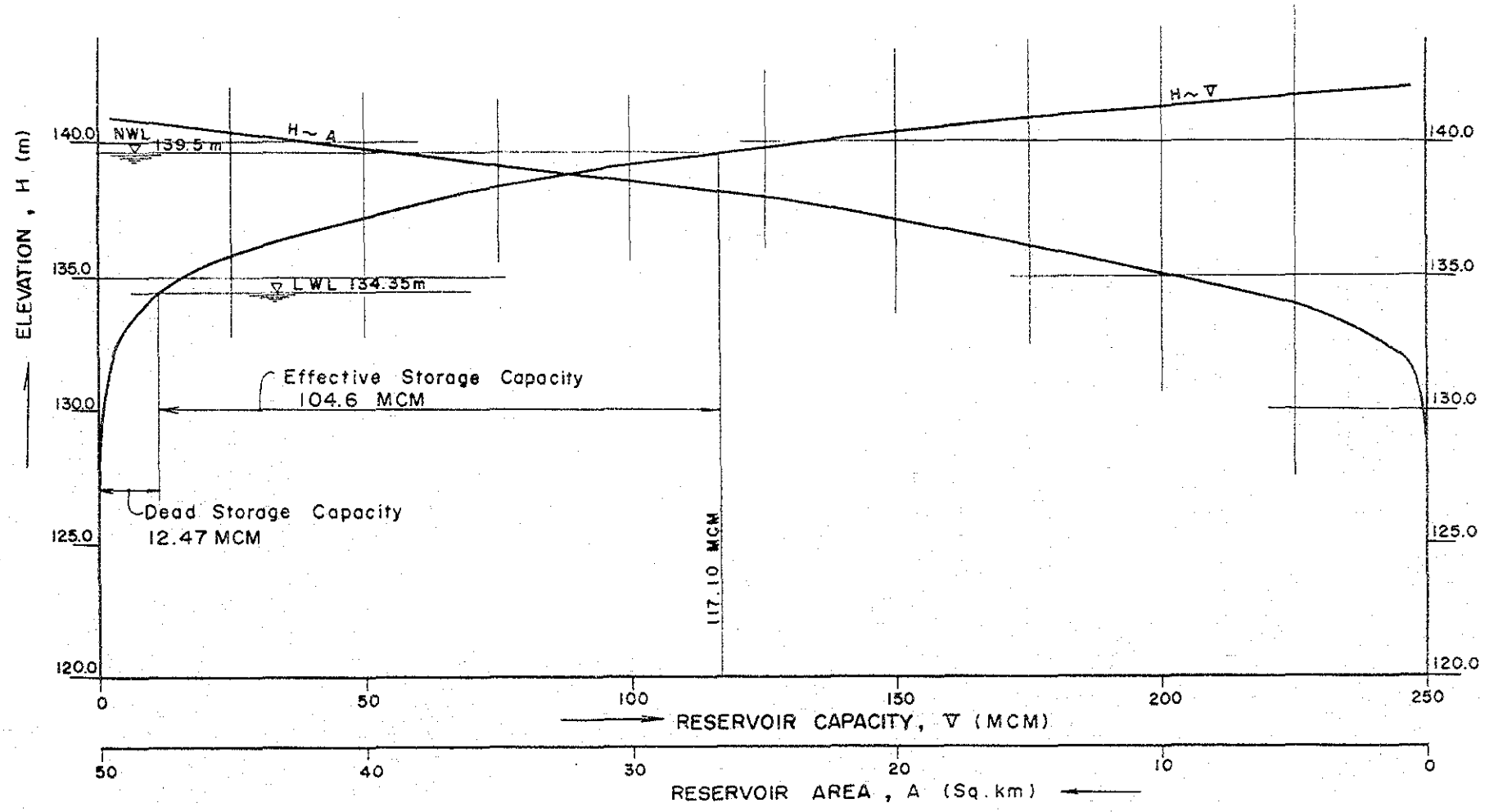


TABLE 6-1 MAJOR FEATURES OF D-28 DAM AND RESERVOIR

Reservoir	
Average annual rainfall	1,416 m
Catchment area	1,245 sq.km
Average annual run-off	591 MCM
1/5-year probable annual run-off	501 MCM
High water level (HWL)	EL.141.0 m
Normal water level (NWL)	EL.139.5 m
Low water level (LWL)	EL.134.4 m
Reservoir area (at NWL)	39.1 sq.km
Total storage capacity	117.1 MCM
Effective storage capacity	104.6 MCM
Dead storage capacity	12.5 MCM
Dam	
Dam Type	Homogeneous earthfill type
Crest length	2,000 m
Maximum height	21.5 m
Crest elevation	EL.143.0 m
Embankment volume	Approx. 850,000 cu.m
Spillway	
Spillway type	Chute type
Crest length	170 m
Crest elevation	EL.139.5 m
Spillway capacity	641 cu.m/sec
Inflow designed flood (1/500-year probable flood)	1,087 cu.m/sec
Outlet Works	
Type	Concrete-encased pressure pipe conduit
Function	

- to flow down the run-off during the dry season for dam construction work (Qmax = 5.5 cu.m/sec)
- to release stored water into the Dom Yai river for supplemental water supply to the downstream areas.

6. 1. 3 Dam Design

1) Construction Materials

The phase-1 investigation reveals that the soils in the hills of the right bank and in the flood plain are suitable for construction materials. Therefore, 19 test pits and 35 auger borings were dug in the hills of the right bank and in the flood plane, as shown in Figure 6-5. The geological logs of each hole are shown in Figure D-16, in Annex D.

The soil in the hilly area consists of silty and clayey sand, silt and clay, and the grain size becomes coarser toward the north, that is, from A-A' line to D-D' line in Figure 6-5.

The soil in the flood plain is mainly composed of fine sand and silty fine sand, and clay. The clay in the skirts of the rolling hills is suitable for core material, but the soil is distributed sporadically in the area and far from the dam embankment. Therefore, it seems that the hill of the right bank is more economical than the flood plain as borrow area. Excavation of the test pits and samplings were made in the hilly area, because of the reasons mentioned above.

Samples taken from the test pits were sent to the RID laboratory, and details of the field survey and laboratory test are discussed in Appendix D. Table 6-2 shows the summary of the test.

The borrow area consists of silty sand, clayey sand, silt and clay, and well graded (UC = 10 ~ 583). The gradation is characterized by high contents of fine materials, that is, the ratio of 200# sieve passings is 20.0 to 82.5 percent, and the contents of gravel are zero to five percent. Natural water contents (Wn) range in percentage from 10.6 to 20.3 percent, and most samples are lower than Plastic Limit (PL) and are in semi-solid state. Therefore, it appears that excavated soils are blocky, and sheep's-foot roller will be needed to eliminate void between soil blocks. During fieldwork of the excavation of test pits, many blocks of soil were actually observed.

As shown in Table 6-2, permeability ranges in coefficient from 1.4×10^{-7} to 1.9×10^{-8} cm/sec which means an effective level of protection from water

seepage. It seems that the compaction effect is high, because optimum water contents are near natural water contents.

As shown in Figure D-16 in Annex D, the groundwater table in the borrow area was high during the field survey period, and excavation was abandoned in some test pits because of water seepage. Drainage ditch will be required before excavation, when the excavation starts immediately after the wet season. Dispersive tests for soil have not been conducted in the stage of the Feasibility Study.

Physical, chemical and clay mineralogical tests are necessary for judgment whether the proposed soil is dispersive or not. When the soil is dispersive, residual soil around the proposed dam cannot be used for impervious materials of the dam embankment. It is difficult to find impervious materials except residual soil around the dam-site. Soil treatment and appropriate considerations for residual soil, therefore, are necessary in the detailed design and construction stages, when the soil is dispersive.

TABLE 6-2 SUMMARY OF SOIL TEST

Soil Classification	:	CL, CL-ML, SM, SC, SM-C
Max. Grain Size (mm)	:	20
Grain Size - 200 # (%)	:	20.0 ~ 82.5
Uniformity Coefficient (UC)	:	10 ~ 583
Max. Dry Density (t/cu.m)	:	1.7 ~ 2.0
Natural Water Contents (%)	:	10.6 ~ 20.3
Plastic Limit (%)	:	12.4 ~ 25.0
Plasticity Index (%)	:	4.6 ~ 22.0
Opt. Water Contents (%)	:	9.3 ~ 17.1
Wn - Wopt (%)	:	+2.9 ~ -5.0
Permeability Coefficient (cm/sec)	:	1.4×10^{-7} ~ 1.9×10^{-8}
Specific Gravity	:	2.61 ~ 2.78

The data from the field survey and tests reveal that the soil in the tested area is composed of sufficiently impervious materials for the dam embankment and also has good compaction works. However, the materials have the factors which must be considered in design and construction, that is, i)

poor construction condition due to sparse contents of gravel less than five percent, ii) need for excavation of drainage ditch in the borrow area because of high water table, iii) need for careful execution control of water contents because of low Plasticity Index (PI) and high contents of fine grain, iv) need for careful design taking into account potential to swell after the impoundment because of a high content of fine grains and v) selection of appropriate rolling compaction machine, and vi) confirmation of dispersive soil and necessary considerations during design and construction stages in the case of dispersive soil.

The residual soil is three to seven meter thick, but an appropriate properties of thickness for the embankment materials will be three meter. Therefore, the quantity of embankment materials is estimated as follows;

Area of B, C and D Line	; 500 m × 500 m × 3.0 m =	750,000 cu.m
Cutting from Spillway (A line)	; 600 m × 40 m × 4.0 m =	96,000 cu.m
Total (the quantity of natural ground);		≒850,000 cu.m

When the volume of material in the surveyed area is insufficient, the residual soil of another hilly area, such as the left bank, will be available. However, surveys are also required for this additional area.

Sand obtained by pumping from the Mun river by private companies is suitable for the drain of dam body and for concrete. The results of laboratory test are shown in Figure D-19, in Annex D. The location is about 10 km south-west of Ubon Ratchathani city area and the borrow is located on the area where the highway No. 24 goes across the Mun rivers. The access raod is pavement between the borrow and Det Udom town area, and is lateritic road between Det Udom and the dam-site. The distance between borrow and the dam-site is about 60 km.

Basalt distributed in the Lam Dom Yai basin is suitable for riprap material and for coarse aggregate of concrete. Two crushing plants are operated by private companies in Amphoe Num Yun, Ubon Ratchathani Province and Amphoe Phu Fhayi, Si Sa Ket Province. The location of quarry site in Num Yum is near than Phu Fhayi, and it is located on along the highway No. 2171 and about 30 km south of the dam-site (see Figure 2-8, the quarry is located in basalt body.) The following table shows the results of

specific gravity and abrasion tests of the basalt performed by the Regional Irrigation Office V.

Rock Test

Location	Specific Gravity (ton/cu.m)	Abrasion Test (%)
Phu Fhayi	2.7	10.9
Num Yun	2.7	20.5

2) Dam Body

a) Dam Type

The selection of a suitable dam type should be made based on such overall views as the scale of dam, site's topography and geology, quality and quantity of available construction materials, etc. In the case of this site, the homogeneous earthfill type dam would be suitable taking into account the following conditions:

- The site is gently sloped (the span-height ratio is about 110).
- Obtaining construction materials, especially impervious materials, for earthfill dam near to the site is possible in quantity and quality.
- Earthfill type dam is most economical.
- Simplicity of construction works

Preliminary dam design was made based on the following criteria:

- Width of dam crest : 8.00 m
- Free-board : HWL (High water level) +
  hw (height of wave by wind) +
  ha (height allowance for fill type dams)
  = HWL + 1.0 + 1.0
- Slope gradient : Following slope gradients are determined based on other dams already constructed.
  Upstream 1 : 3.0
  Downstream 1 : 2.5

- Seismological acceleration : k = 0.05 g

The proposed typical cross section and profile of dam are preliminarily designed as shown in Attached Drawing NO. 2 and NO. 3. More details are shown in Annex I.

b) Stability Analysis

The stability of the dam-body was analyzed under the following conditions;

- Method	:	Slip circle slice method
- Cases	:	Two cases of upper and downstream
- Condition		
Water level	:	Normal water level (NWL)
Seismic force	:	0.05 g (100%)
Seepage	:	Steady flow state at NWL, Kv/Kh = 1/5

The analysis results show the planned cross section reach the minimum requirement for stability. Namely, the safety factors were more than 1.2. Details are shown in Annex I.

c) Foundation Treatment

1) Bearing Capacity

Flood plain deposit, residual soil and talus deposit overlie the bedrock and are composed of soft ground of less than 20 in N value. In the cut-off trench base, elimination of the soft ground by excavation will be conducted as a matter of course, and in the dam-site base except cut-off trench base also, elimination or reinforcement by adequate methods will be required for the soft ground that is less shear strength than the embankment.

2) Seepage Flow

Foundation treatment for the seepage flow will be required for both the unconsolidated and consolidated layers, that is, flood plain deposits,

residual soils and bedrocks. Safety from seepage failure is generally estimated by stability analysis. However, the possibility of seepage failure is estimated roughly by coefficient of permeability, that is, seepage failure will occur when the coefficient of permeability is more than 1×10^{-4} cm/sec. Foundation treatment will be required for this layer.

As shown in Figure 6-4, Lugeon value in the upper part of the bedrock is more than 20. It is considered that the depression of the storage function, appearance of excessive uplift and piping in bedrock will occur by seepage flow. Grouting in core zone will be needed.

3) Design

As stated above, treatments for bearing capacity and seepage flow are required in the dam foundation. General treatment methods to be considered are as follows:

- Talus deposit; elimination by excavation
- Flood plain deposit in core zone; elimination by excavation
- Flood plane deposit in pervious zone; improvement of bearing capacity by stage loading and counterweight fill or elimination of low shear strength zone
- Residual soil; elimination of top five meters at surface
- Bedrock; elimination of surface D class zone, and curtain grouting of 10 m

Taking into account the above consideration, concrete treatment methods are as follows;

i) Dam Base Excavation Line

The cut-off trench base is determined as follows:

River bed part : The basic sandstone and siltstone are regarded as cut-off trench vase, removing flood plain deposit (sand layer).

Right bank part : The medium part of residual soil layer meeting N $\geqq$ 15 and also sufficiently meeting imperviousness, is regarded as the base.

Left bank part : The residual soil layer is regarded as the base, removing surface layer of two to three meter.

The necessary conditions for dam-site base apart from the cut-off trench base, are that the vase is stable against the slip surface passing through the vase, and has sufficient bearing force for the dam body load. In the vicinity of the maximum cross section, the flood plain deposit meeting N > 20 is regarded as the base.

In the parts on both the abutments, where the scale of dam body becomes smaller, the residual soil layer with N > 15 is regarded as the base.

The above-stated cut-off trench and dam body cutting lines are shown in Attached Drawing NO.3.

ii) Foundation Treatment :

As the water cut-off treatment for the D-28 dam, grouting method is adopted for the following reasons:

- The flood plain deposit consisting mainly of sand, showing partly high permeability of 10^{-2} order, in which soft part intervenes, has an anxiety of piping due to the stored water permeation.

- The flood plain deposit is the sand layer with uneven N-values, that is N = 2 - 50, and must be removed owing to unsuitableness for dam foundation. After the removal, basic sandstone and siltstone will mostly be the dam foundation.

- The basic sandstone and siltstone having a characteristic permeability passing through the cracks, show partly large Lugeon value. Cutting-off of the water with earth blanket has anxieties of wash out of soil material and outbreak of piping.

The feature of grouting is as follows;

- Grouting Extent

  Grouting was planned in the extent with the Lugeon value of more than 50 (Lu $\geqq$ 50), that is, the required length is 760 m from the station 1 + 80 to station 9 + 40, because other parts of area has high groundwater table as shown in Figure 6-2.

  Grouting at the spillway was not planned, because the area has a low permeability of 1×10^{-5} cm/sec, and also high groundwater table.

- Grouting Depth

  The grouting depth is determined to be 10 m, equivalent to about 50 percent of the stored water depth in order to cover the extent of Lu $\geqq$ 50 situated near the surface layer.

- Grouting Hole Disposition

  The hole disposition is planned to be two lines with 1.5 m in space, holes on the line 2.0 m at interval in zigzags.

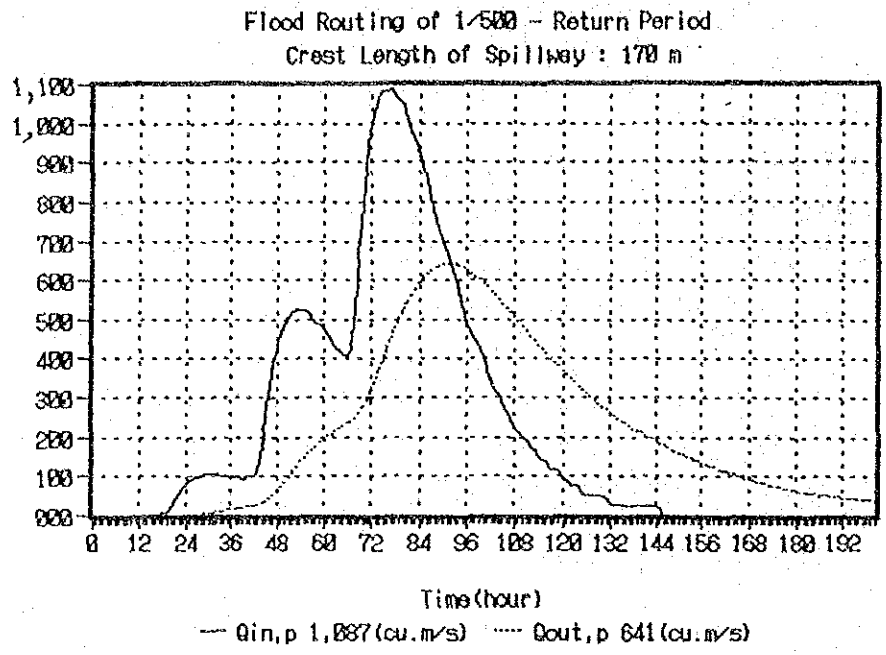
- Target Value to be Improved

  The target value to be improved is planned to be three to five Lugeon (Lu), and will be judged using test holes after an execution of grouting.

d) Spillway

1) Spillway Capacity

The designed spillway capacity is planned to be 1,087 cu.m/sec corresponding to a return period of 1/500-year. As the proposed dam-site has a large reservoir area of 39.1 sq.km at the normal water level of EL.139.5 m, the surcharge storage is relatively large. Accordingly the spillway capacity can be reduced considerably. The spillway capacity is determined at 641 cu.m/sec from flood routing as shown in Figure 6-7. Then, the maximum requirable capacity of spillway is checked by the regulated peak discharge of 1,063 cu.m/sec estimated by flood routing based on probable maximum flood as shown in Figure 6-7.



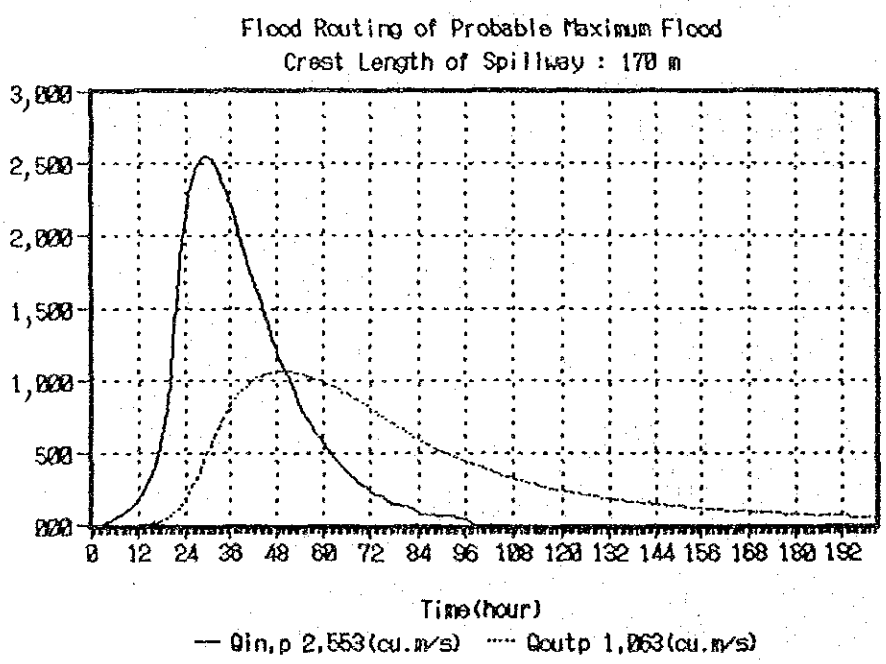


FIGURE 6-7 RESULT OF FLOOD ROUTING ANALYSIS

2) Location and Type

Although the rock foundation can be expected on both the abutments of the proposed dam, the location of spillway is decided on the right bank in consideration of the connection with the lower stream of the Dom Yai river. Taking into account the topography and foundation conditions of the site, a chute type spillway is recommended. Profile and plan of the spillway is shown in Attached Drawing No. 4.

e) Outlet Works

Main functions required for the outlet works are as follows:

i) to allow the river run-off at the dam-site to flow down to the lower-stream during the dry season in the construction period.

ii) To release stored water into the Dom Yai river for supplemental water supply to the downstream areas in the dry season.

The designed discharge of outlet is 5.5 cu.m/sec corresponding to 1/10 probable flood in the dry season. The outlet works will be generally classified structurally into two types, one will be the tunnel type and the other will be cut-and-cover conduit type. The cut-and cover type is more recommended from the viewpoint of construction costs. Profile of the outlet works is shown in Attached Drawing No. 5.

6.2 Pumps And Canals

6.2.1 Pumping Station

1) Motive Power

Generally diesel engines are more expensive than electric motors in both the initial and running costs as motive power for pump operation. The high tension electric power supply facility, to satisfy the power requirement for the pumping facility, however, has not yet been set up at the site as of 1992.

In the case of electric power being used, the facilities such as the transformer sub-station, high tension transmission lines, transformers, etc., are required, of which construction costs will be borne by RID.

From the above viewpoint, a comparative economic study of the motive power at this pumping station between electric power and diesel power was carried out. And, the comparative study results are tabulated below.

Comparative Study on Motive Power for Pumping Station

Item	Electric Power	Diesel Engine
Output (kw/hr)	370	500
Price of pump ('000 Baht)	11,440	11,400
Price of motive power ('000 Baht)	4,180	22,800
Sub-station, Transmission etc. ('000 Baht)	12,930	-
Total	28,550	34,200
Unit operation cost (Baht/hr)	433[1/]	1,135[2/]

Note: Diameter of Pump : 800 mm
Type of pump : vertical mixed flow
Total lift head : 16.4 m
1/ : 370 kw × 1.17 Baht/kw/hr
2/ : 500 ps × 2.27 Baht/ps/hr

Judging from the above comparative study results, electric power is more economical as pump motive power. It was therefore adopted.

2) Total Lift Head

The total lift head of pump is calculated with the following expression;

Total lift head : $H = H_2 - H_1 + H_L$

where;

H_2 : water level at delivery pipe outlet (WL)

H_1 : reservoir low water level (LWL)

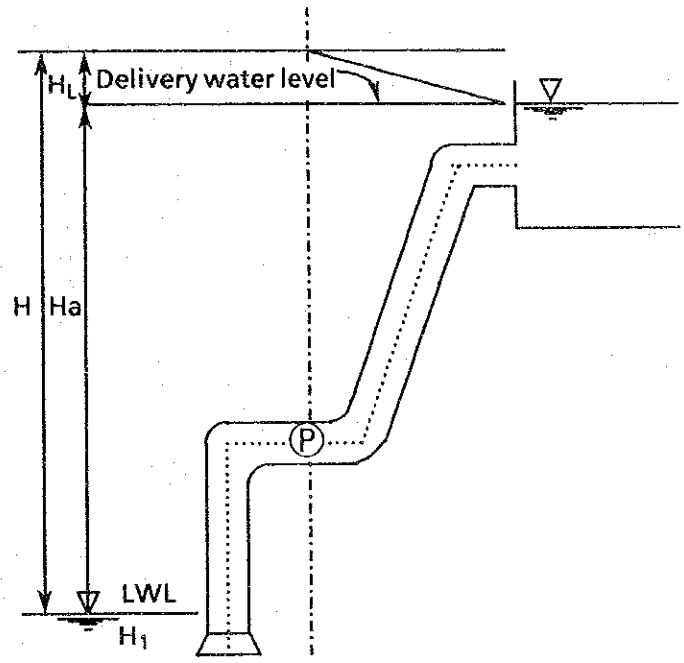
H_L: total loss head

Actual lift head : $Ha = H_2 - H_1$

Total loss head : $H_L = Ha^* (0.20 \sim 0.25)$

The total lift heads by plans are shown below;

Item	Left Bank Area	Right Bank Area
WL at delivery pipe outlet (m)	148.0	158.0
Low water level (m)	134.4	134.4
Actual lift head (m)	13.6	23.6
Total loss heads (m)	2.8	4.8
Total lift head (m)	16.4	28.4



3) Pump Bed Level

The pump bed levels are decided at EL.148.0m on the left bank area and EL.145.0 m on the right bank area, judging from the ground elevation at the proposed site.

4) Type, Diameter and Number of Pump Sets

The type, diameter and number of pump sets are determined on the following conditions and the summaries are shown below.

Pump Type

The main factors for pump type selection are lift head, pumping discharge and extent of variation of suction water level. In this plan, the lift head ranges from low to medium head. The pumping discharge ranges from medium to large discharge. It can be said that the variation of suction water level is large, showing about five meter (HWL 139.5 m - LWL 134.4 m).

Judging from these conditions, the type of pump selected will be the vertical mixed flow pump. It is also installed in the neighbouring project area, and should be adopted for the Project Area.

Diameter and Number of Sets

Fewer pump sets with largest possible diameter of pump will be advantageous from a civil engineering viewpoint. Since very large diameter of pump will be very expensive, the total construction cost will be disadvantageous. Accordingly, in consideration of the marketing circumstances in Thailand, the maximum diameter for pump is determined to be 1,000 mm in this plan.

The number of pump sets should be six units at the minimum, considering seasonal water requirement. It is determined by dividing the total required pumping discharge by the unit pumping discharge of pumps with same diameters.

Outline of Pumps

Item	Left Bank Area	Right Bank Area
Irrigation Area (ha)	8,800	25,200
Pumping Discharge (cu.m/sec)	8.80	25.20
Total Lift Head (m)	16.4	28.4
Diameter (mm)	800	1,000
Number of Sets	6	12
Output (kw/hr)	370	880

5) Water Supply Pipeline

For the benefited area on the right bank, the water supply pipes are necessary from the pumping station up to the benefited area on a higher elevation with a water level of EL.155.0 m at the delivery pipe outlet (the elevation of pumping station site is about EL.145.0 m).

The pipeline is about 4.0 km in length and is of steel pipe with less friction loss. It has resistance against inner and outer pressures, and with less likelihood of leakage from the joints of which, in case of conveying water by pressure.

The pipe diameter is designed for the discharge velocity in the pipe to be V = 2.50 m/sec to the peak discharge, and is determined in combination with the most economical diameters and number of sets. (In the case of a pipeline 2,000 mm in diameter, the designed velocity will be V = 2.00 - 2.50 m/sec).

The dimensions of the water supply pipeline are shown as follows;

Diameter (mm)	:	2,000
No. of Pipelines	:	3
Pipe Thickness (mm)	:	20
Foundation	:	Sandbed at an angle of 180°

6) Incoming Power Facilities

Although the domestic power supply has been conducted around the proposed pumping station site as of 1992, the high tension power supply to be required for the pumping station has not yet been actualized. The new transforming sub-station, high tension transmission lines and transformers are needed and the construction cost will be borne by RID. One sub-station is needed for the whole area and a transformer is needed for each pumping station.

The dimensions of the substation, the transformer and the distance of transmission lines are shown below;

- Transforming substation	115 kv ----> 22 kv
- Transformer	22 kv----> 230 or 400 v
- Distance of transmission lines	5.0 km (in which 4.0 km on right bank and 1.0 km on left bank)

7) Intake Channel

The present topography of the proposed pumping station site is a relatively flat field at an in the elevation of EL.145.0 m. In order to take water from the reservoir of EL.134.4 m corresponding to the lowest intake water level of the pumping station, an intake channel should be excavated towards the center of the reservoir. The intake channel must be trapezoid-shaped and only be excavated with no concrete lining.

The cross section must have a sectional area as large as possible, so as to suppress the inflow velocity to prevent suspended loads from flowing into the suction tank of the pump. In consideration of the current trough topography and geology such as sandy series, the proper dimension of the intake channel will be B = more than 20 m in bed width, and 1 : 2.0 in side slope to be protected with rip-rap.

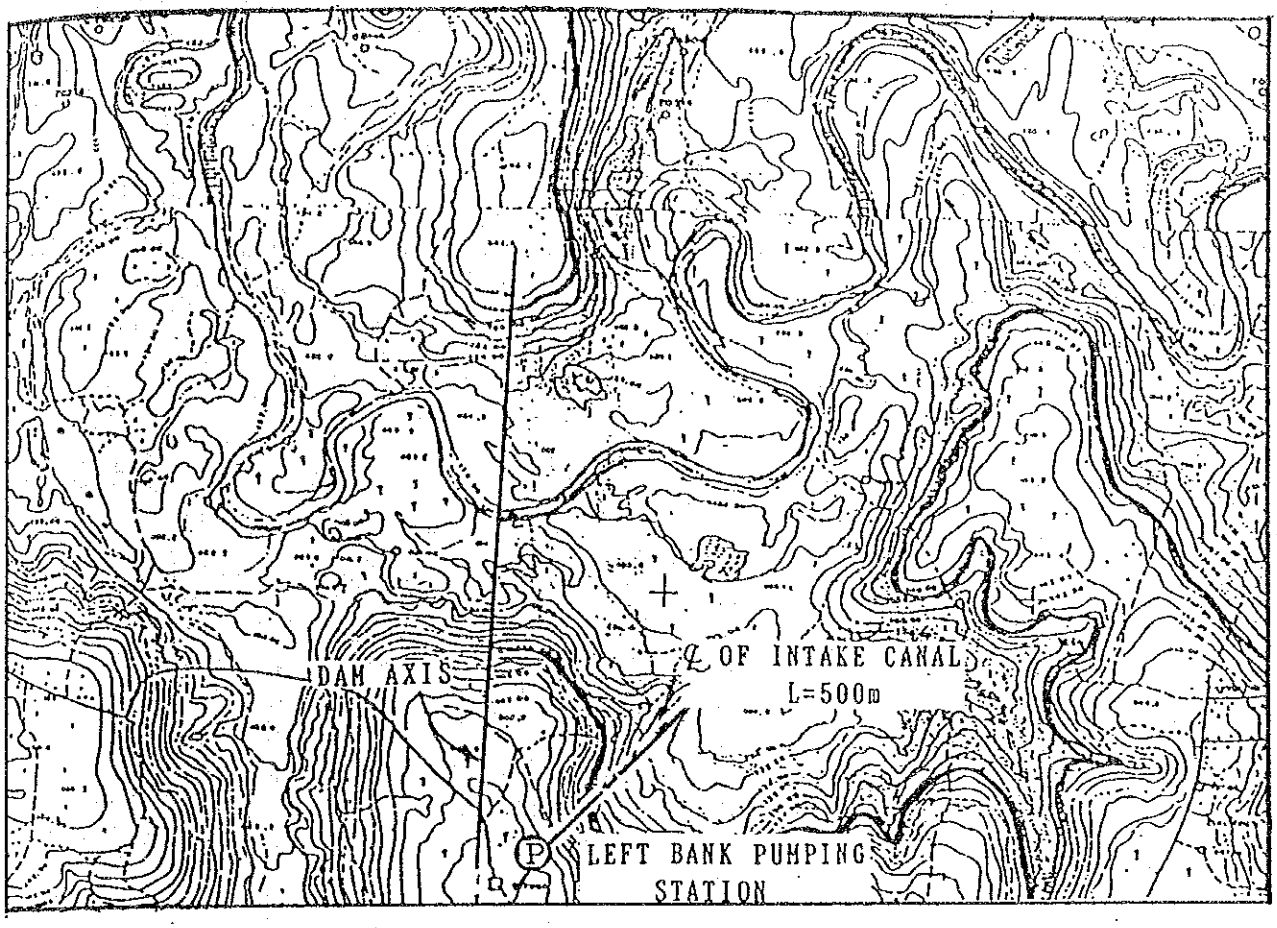
Figure 6-8 indicates the location map of both pumping stations and intake channel to be constructed, and also plan of pumping stations are shown in Attached Drawing No.6 (Left bank) and No.7 (Right bank).

6. 2. 2 Irrigation Canal

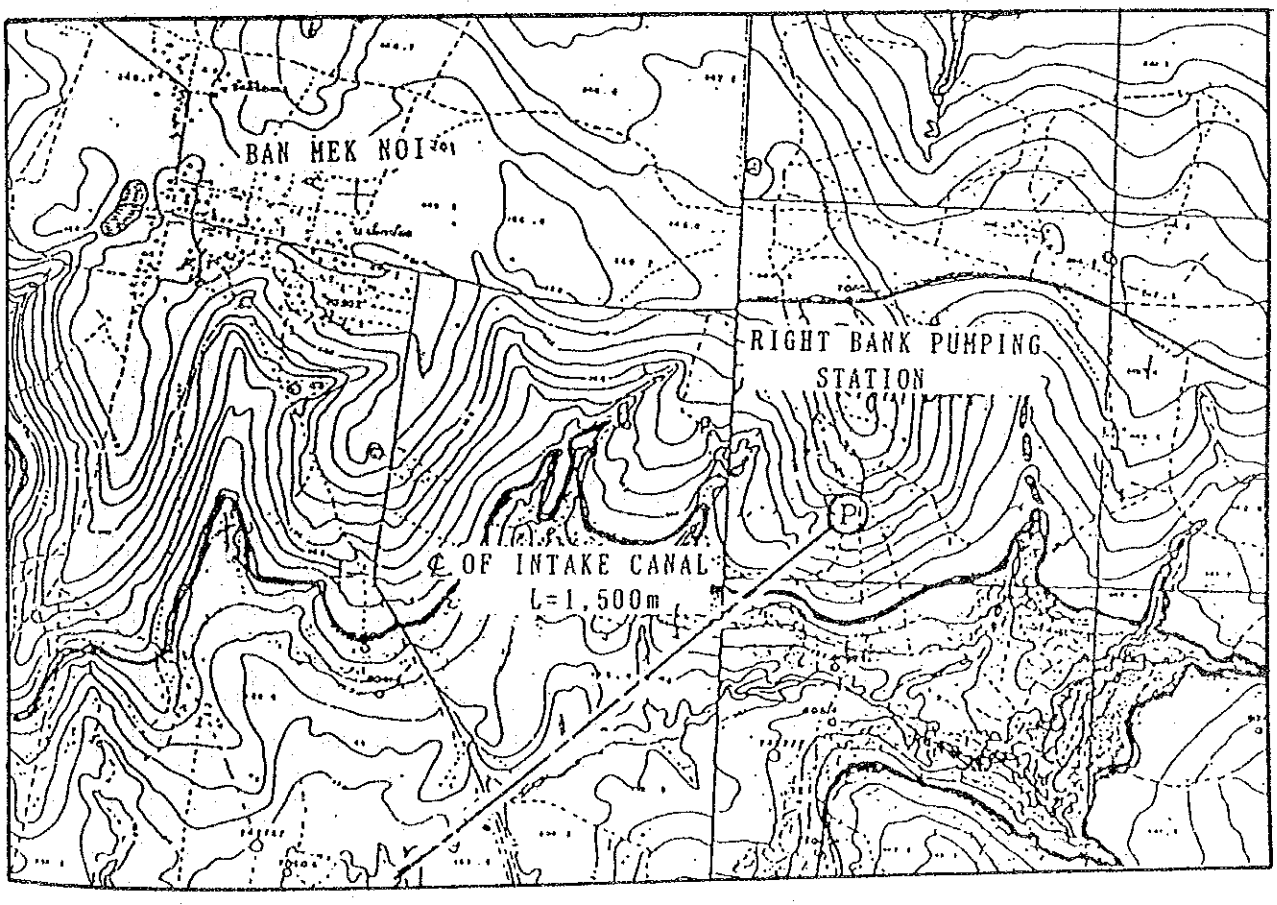
1) Layout of Irrigation Canal System

The layout of the canal system is made based on the topographic maps with scales of 1 to 10,000 and 1 to 50,000.

Since the canal alignment is planned for gravity irrigation, the main canal runs along contour lines and its mean gradient is planned to be 1 to 5,000. The lateral canal runs along higher ground such as a ridge line and its mean gradient is 1 to 4,500. Each canal length is shown as follows;



LEFT BANK



RIGHT BANK

FIGURE 6-8 LOCATION MAP OF PUMPING STATIONS AND INTAKE CHANNEL

Main canal length : 111.4 km
Left bank area : 67.4 km
Right bank area : 44.0 km
Lateral canal length : 188.4 km
Left bank area : 32.2 km
Right bank area : 156.2 km

2) Design of Canal

The canal cross section is designed as a trapezoid which is most economical and advantageous for its construction, and as hydraulically advantageous cross section in which the ratio of bottom width to water depth is 1.0 to 2.0.

The designed unit water requirements (duty of water) for determination of canal capacity are shown below;

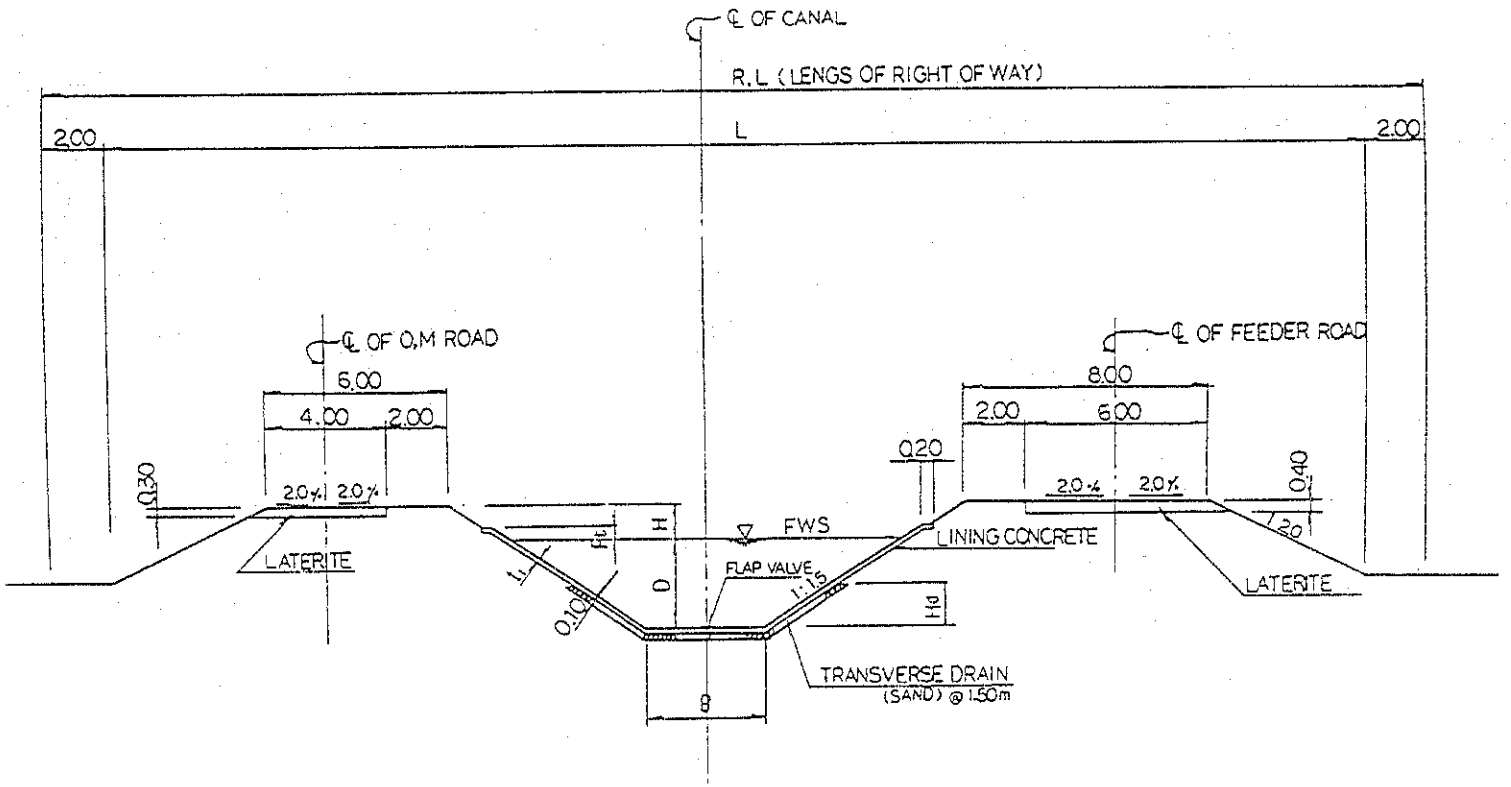
Main Canal : q = 1.00 lit./sec/ha (0.16 lit/sec/rai)
Lateral Canal : q = 1.50 lit./sec/ha (more than 1,000 ha)
q = 2.10 lit./sec/ha (1,000 - 200 ha)
q = 2.90 lit./sec/ha (200 - 40 ha)

The roughness coefficient of the canals is determined to be n = 0.018 in consideration of concrete lining.

3) Canal Structure

The canal structures are designed to be lined with concrete as a result of sandy soils in geological condition, and equipped with a drain filter in the direction across the canal to prevent canal slope failure caused by high ground water table and groundwater pressure in the Project Area. The pitch of the drain filter was determined to be 1.50 m as a result of computation.

Standard section of main canal is shown in Figure 6-9. Location map of canal systems is shown in attached Drawing No.8, and canal profile is shown in attached Drawing No.9.



	Q (m³/sec)	B (m)	D (m)	Fb (m)	H (m)	Hd (m)	L (m)	R.L (m)	t (cm)
M	0.00 ~ 5.00	2.00	1.60	0.25	0.60	0.85	27.00	31.00	5.00
	5.00 ~ 10.00	2.50	2.15	0.30	0.70	1.20	30.75	34.75	7.00
A	10.00 ~ 15.00	3.00	2.40	0.35	0.80	1.30	33.00	37.00	8.00
	15.00 ~ 20.00	3.00	2.80	0.35	0.90	1.50	35.50	39.50	8.00
I	20.00 ~ 25.00	3.50	2.95	0.40	1.00	1.60	37.25	41.25	8.00
	25.00 ~ 30.00	4.00	3.10	0.40	1.10	1.65	39.00	43.00	8.00
N	30.00 ~ 35.00	4.50	3.25	0.40	1.20	1.75	40.75	44.75	8.00
L	0.00 ~ 5.00	2.00	1.50	0.25	0.60	0.80	26.50	30.75	5.00
A	5.00 ~ 10.00	2.50	2.05	0.30	0.70	1.10	30.25	34.25	7.00
T	10.00 ~ 15.00	3.00	2.30	0.35	0.80	1.25	32.50	36.50	8.00

LAT : LATERAL CANAL

FIGURE 6-9 STANDARD CANAL CROSS SECTION

4) Related Structures

The following related structures to each canal are planned;

- River crossing works
- Road crossing works
- Head regulators
- Check culverts

a) River Crossing Works

The river crossing works are classified into the following three types according to canal discharge capacity.

i)	Overshute type	:	Q = 10.0 to 35.0 cu.m/sec
ii)	Siphon type (with box culvert)	:	Q = 5.0 to 10.0 cu.m/sec
iii)	Siphon type (with R.C pipe)	:	Q < 5.0 to cu.m/sec

Overchute Type

The width of the small tributaries / creaks to be crossed by main or lateral canals are within 10.0 m on an average because the canals pass through comparatively high ground. The canal section in which large discharge capacity flows down will be larger than those tributaries / creaks cross sections. In this case, the crossing structures, such as aqueduct, inverted siphon, etc. will become larger on a scale, which will be economically disadvantage.

In the case of the river crossing works with such large canal cross sections as Q = 10.0 to 35.0 cu.m/sec, the river itself should, therefore, pass under the canal.

Structurally speaking, R.C. pipes of 800 to 1,500 mm are laid in parallel on the river-bed to make the river water pass through them.

The canal slope facing the river should be protected with rip-rap to prevent slope failure from river water and the riverbed should be protected from being scoured with gabion baskets .

Siphon Type with Box Culvert

In the case of the canal discharge capacity of Q = 5.0 to 10.0 cu.m/sec, a siphon type is used, because structurally, the scale is not so large.

The R.C pipe structure and the box culvert structure, of which concrete is to be placed at the site can be considered adaptable for this case. the latter will be better in Thailand, as it seems difficult to obtain R.C pipes large enough in diameter. (In case Q = 10.0 cu.m/sec and V = 1.50 m/sec, the required pipe diameter will be D = 3.00 m). The box culvert should be designed so as to make the velocity 1.5 to 2.0 times that of an open channel to prevent soil deposits, etc.

The minimum soil covering depth from the river-bed down to the top of siphon is determined as 60 cm, out of which 30 cm will be covered with gabion baskets in order for riverbed not to be scoured.

Siphon Type with R.C Pipe

In the case the canal discharge capacity is less than 5.0 cu.m/sec, the R.C pipe structure will be used in Thailand, because small size of pipes are easily obtainable. The designing method of pipe size is the same as that of the box culvert.

The diameters of pipes according to their discharges are shown below;

Discharge (cu.m/sec)	Diameter (mm)
0.0 - 1.0	800
1.0 - 2.0	1,000
2.0 - 4.0	1,500
4.0 - 5.0	1,800

River crossing structure is shown in Attached Drawing No. 10.

b) Road Crossing Works

The road crossing works are classified into the following three types according to the canal discharge capacity.

i) Box culvert type under free flow : Q = 10.0 to 35.0 cu.m/sec
ii) Siphon type with box culvert : Q = 5.0 to 10.0 cu.m/sec
iii) Siphon type with R.C pipe : Q < 5.0 cu.m/sec

Box Culvert Type

In the case of large canal discharge capacities such as Q = 10.0 to 35.0 cu.m/sec, the road crossing works will require large scale size and large loss head, if siphon type is taken, resulting in it being disadvantageous for the canal with a little water head surplus.

For the above mentioned reason, the sectional structure is determined as two linked box culverts (also as culvert bridge) with open transitions upstream and downstream of box culvert to shift smoothly from trapezoidal section to rectangular section. The materials of box culverts are designed on the condition that passing vehicles directly load the culverts.

The sizes of one culvert by discharge are shown below;

Discharge (cu.m/sec)	B × H (m)
10.0 - 15.0	2.00 × 3.20
15.0 - 20.0	2.70 × 3.70
20.0 - 25.0	3.50 × 3.95
25.0 - 30.0	4.00 × 4.20
30.0 - 35.0	4.70 × 5.70

Siphon Type with Box Culvert

In the case of such canal discharge capacities as Q = 5.0 to 10.0 cu.m/sec, the siphon type is chosen for economic reason, because both the scale of structure size and loss head do not become large.

The structure should be the box culvert type, of which concrete is to be placed at the site for the above stated reason in the case of the river crossing works. The minimum soil covering will be 1.2m for the culvert body.

Siphon Type With R.C. Pipe

In the case of canal discharge capacity less than Q = 5.0 cu.m/sec, the siphon with R. C type which is cheaper than the box culvert, is chosen.

The designing method is the same as that in the river crossing works, and the pipe diameters by discharges are shown below;

Discharge (cu.m/sec)	Diameter (mm)
0.0 - 20.0	800
1.0 - 25.0	1,000
2.0 - 30.0	1,500
4.0 - 35.0	1,800

The road-crossing structure is shown in Attached Drawing No. 11.

c) Head Regulators

The head regulators are the facilities to divert irrigation water from main canals to lateral canals, and from a lateral canals to lower-grade canals.

In this design, the head regulators are classified into the following three types by diverting discharges.

i) Box culvert type under free flow : Q = 10.0 to 35.0 cu.m/sec
ii) Siphon type with box culvert : Q = 5.0 to 10.0 cu.m/sec
iii) Siphon type with R.C pipe : Q < 5.0 cu.m/sec

Box Culvert Type

In the case of comparatively large lateral canal discharge capacity, a structure in which the diversion loss head becomes larger, should be avoided, since a large difference in water levels of lateral canal and the water level of main canal cannot be allowed. Accordingly, the structure of the diversion facilities with free water surface are hydraulically more advantageous than the siphon. In the case of such diversion discharge as Q = 10.0 to 15.0 cu.m/sec in this plan, the diversion facilities with free water surface are taken and the water level and discharge are adjusted by gate operation, since there is a case in

which the surplus water head between the main canal and the lateral canal becomes small.

In the structure, two lined box culverts are taken with sluice gates on the side of the main canal. The culvert sizes according to main canal discharges are shown below.

Discharge (cu.m/sec)	B × H (m)
15.0 - 20.0	3.25 × 2.90
20.0 - 25.0	3.25 × 3.15
25.0 - 30.0	3.25 × 3.40
30.0 - 35.0	3.25 × 3.65

Siphon Type with Box Culvert

In the case of such diversion discharge as Q = 5.0 to 10.0 cu.m/sec, the siphon type is chosen for economical reasons. In the structure, for the reason stated in the river crossing works, the box culvert of which concrete is to be placed at the site is used and the minimum soil covering is determined to be 1.20 m for protection of the culvert body.The adjustments of the diversion water level and discharge are conducted with sluice gates set up on the main canal side.

Siphon Type with R.C. Pipe

In the case the canal discharging capacity being less than Q = 5.0 cu.m/sec, the siphon type which use R.C pipe is chosen, since the R.C pipe structure is cheaper than the box culvert structure. The minimum soil covering for protecting the pipe body is determined to be 1.20 m, and the diversion water level and discharge are adjusted by sluice gate operation.The pipe diameters according to diversion discharges are shown below;

Discharge (cu.m/sec)	B × H (m)
0.0 - 1.0	800
1.0 - 2.0	1,000
2.0 - 4.0	1,500
4.0 - 5.0	1,800

Head regulator structure is shown in Attached Drawing No. 12.

d) Check Culvert

The check culvert is the structure which adjusts canal water level and aims at stable diversion. The installation site is just downstream of the head regulator and the interval is about 5.0 km judging from the canal mean gradient (which is i = 1 to 4,500 - 5,000). The adjustment is usually carried out by such gates as sluice gate, roller gate and radial gate. In this design, the sluice gate is chosen for the following reasons.

- The radial gate and the roller gate are advantageous in cases where there is a large span, but disadvantageous where there is a small span.
- The three types are same regarding their water level adjusting function.
- The sluice gate is most advantageous in terms of operation and maintenance.

As to the structure, in terms of canal scale, the box culvert attaching regulating gates and concurrently functioning as canal crossing bridge for controlling, seems to be more economical than ordinary concrete frame works with sluice gate. The former is, therefore, adopted. (The former was built in a similar project area adjacent to this project area).

The culvert whose width is equal to the canal bed width, and whose upper frame level is equal to the elevation of O/M road surface, is rectangle shaped and of which concrete is to be placed at the site. The gates are to be set up on the upstream side of the culvert.

The gates are assumed to be hand operated for winding and the number of spans is as follows, according to the canal bed width. If the gate span becomes longer, the hand operation of winding will be impossible due to overweight. Therefore, one gate weight should be not more than 2.0 ton (= 8.0 sq.m).

Canal Bed Width (m)	No. of Span
B > = 3.0	2
B < 3.0	1

On both sides of the culvert, an overflow type fixed weir should be established to keep a check on water level and to secure water supply for downstream water requirement.

The height of the overflow type fixed weir should be designed on condition that the designed discharge can flow down in case the gate is completely opened, and the overflow depth satisfying appointed checking water level is kept in case the gate is operated.

The dimensions of the gate and overflow type weir heights by discharges are shown below;

Discharge (cu.m/sec)	Gate Dimension B (m) × H (m) (m)	Over Flow Type Weir Height (m)
0.0 - 5.0	2.20 × 1.70	1.25
5.0 - 10.0	2.70 × 2.20	1.65
10.0 - 15.0	1.50 × 2.50	1.70
15.0 - 20.0	1.50 × 2.90	2.20
20.0 - 25.0	1.75 × 3.05	2.45
25.0 - 30.0	2.00 × 3.20	2.70
30.0 - 35.0	2.25 × 3.25	2.95

Check culvert structure is shown in Attached Drawing No. 13.

6.3 On-Farm Facilities

6.3.1 Typical Design of On-Farm Facilities

It is considered that the on-farm development at the area of about 40 ha (250 rai) will be prerequisite, i) to attain the well water management in the field, ii) to save limited water resources by increasing irrigation efficiency, and also iii) to drain excess water caused by heavy rainfall so as to meet the requirement for crop diversification during the wet season.

On-farm facilities consist of main farm ditches, supplementary farm ditches, farm drains, farm roads and appurtenant structures. The operation and maintenance of these facilities should be under the responsibility of the farmers' group to be newly established in each irrigation unit of about 20 ha (125 rai), to be called the Irrigation Unit.

The typical design of on-farm facilities was made on the two selected sample areas in the Project Area by using topographic maps of 1/4,000 in scale, which were prepared by the Topographic Survey Division, RID.

The summary of on-farm facilities in the two sample areas is shown in the following table;

Summary of On-Farm Facilities in Two Sample Areas

Item	Area-1 Ban Nong Yang	Area-2 Ban Khitun	Total	Density
1. Location				
2. Area (ha)				
Gross Area	41.4	54.8	96.2	-
Irrigated Area	39.8	54.4	94.2	-
3. Major On-Farm Facilities (m)				
Main Farm Ditch	500.0	500.0	1,000	10.6m/ha
Supplementary Farm Ditch	1,400	2,320	3,760	39.9m/ha
Farm Drain	480	1,020	1,500	15.9m/ha
Farm Road	500	500	1,000	10.6m/ha
Appurtenant Structure (place)	3	5	8	
· Farm Turn-out	11	15	26	
· Farm Inlet	2	1	3	
· Road Crossing				
4. Number of Rotation Unit	5	8	13	
Average Area per Unit	8.26	6.80	-	

6. 3. 2 On-Farm Facilities

On-farm facilities and the functions are outlined as follows;

Main farm ditch	:	A water supply system which conveys water from the turn-out to supplementary farm ditch
Supplementary farm ditch	:	The terminal water distribution system to supply water to farm lots
Farm drain	:	Drainage system to remove excess water from paddy fields
Farm road	:	Terminal road provided along the main farm ditch for the convenience of farm management and operation and maintenance of farm facilities
Farm turn-out	:	Intake facilities at a rotation unit provided with water control and measurement functions
Farm inlet	:	Check structure provided at the head of the supplementary farm ditch to divert water into farm lots
Road crossing	:	Road crossing pipe for ditches

Drawing No. 14 shows the typical design of on-farm facilities.

6.4 Resettlement Facilities

6.4.1 Scale of Resettlement Area

According to the regulations for resettlement projects in Thailand, the minimum requirement of allocated plots to be equipped with suitable irrigation facilities is 1.6 ha (10 rai) per household in the case of the RID project and 2.4 ha (15 rai) in the ALRO project, respectively. In the project, the allocated plots per household are planned to be 2.4 ha (15 rai) from a conservative viewpoint and also based on the actual land holdings in Ban Fang Phe to be submerged by the reservoir (total farm land of 227.2 ha/total household of 112 farmers = 2.03 ha/household), although more detailed study on an adequate plot size should be made and adjusted among the related government agencies concerned. Under the plan, the required land for resettlement is estimated to be about 300 ha (2.4 ha × 122 households).

Minimum requirement of land for each household;

Residential area	:	0.16 ha	(1 rai)
Farm land	:	2.24 ha	(14 rai)
Total	:	2.40 ha	(15 rai)

In addition to the above individual plots, an appropriate size of land for agricultural and social infrastructure such as irrigation canals, roads, school, temple and other public facilities including the areas for reforestation will be needed. About 300 ha (1.9 thousand rai) of land is estimated for this purpose.

Under these estimates, the total resettlement area at one site will be about 300 ha (1.9 thousand rai).

6.4.2 Resettlement Facilities and Compensation Plan

1) Resettlement Facilities

The following facilities will be provided for resettlement areas in each site;

- Construction of water distribution canals

- Construction of service roads
- Provision of power supply
- Construction of school, temple and public health facilities

2) Compensation Plan

The compensation cost to be provided for property submerged by the project could be categorized into two groups according to the property nature, namely, costs for structural properties and costs for land and tree crops. The compensation costs in the project were made based on the following figures;

- Structural properties
  - Privately-owned structural properties : 122 households
  - Public owned structural properties
    - Roads and bridges : 6 km
    - Power transmission line : 6 km

- Land and tree crops
  - Farm land (paddy field) : 1,930 ha (12.1 thousand rai)
  - Forest land and others : 2,400 ha (15.0 thousand rai)

CHAPTER VII. PROJECT IMPLEMENTATION AND OPERATION

CHAPTER VII. PROJECT IMPLEMENTATION AND OPERATION

7.1 Project Implementation

7.1.1 Executing Agency of the Project

The executing agency of the project will be RID, which has sufficient capability and long experience in carrying out detailed design, construction of civil works and operation and maintenance of the completed facilities of the project.

RID will execute the detailed design for major project facilities recruiting a consulting firm, the construction contracting with a competing contractor and the operation and maintenance guiding the water users' association.

The organization of RID is shown in Figure 7-1. In this organization, the detailed design works are carried out by the Design Division, construction by the Large-Scale Projects Construction Division, and operation and maintenance by the Operation and Maintenance Division.

7.1.2 Financing

The foreign currency portion of the project cost will be financed by an international financial agency, while the local currency portion will be provided by the Thai Government.

7.1.3 Construction Mode

A qualified contractor to construct the civil works of the project will be selected by international competitive bidding. Although the construction of on-farm facilities such as farm ditches, farm drain and farm road are basically under the responsibility of farmers' group to be newly established in the service area with technical guidance by RID and other government agencies concerned, the RID will also provide those facilities.

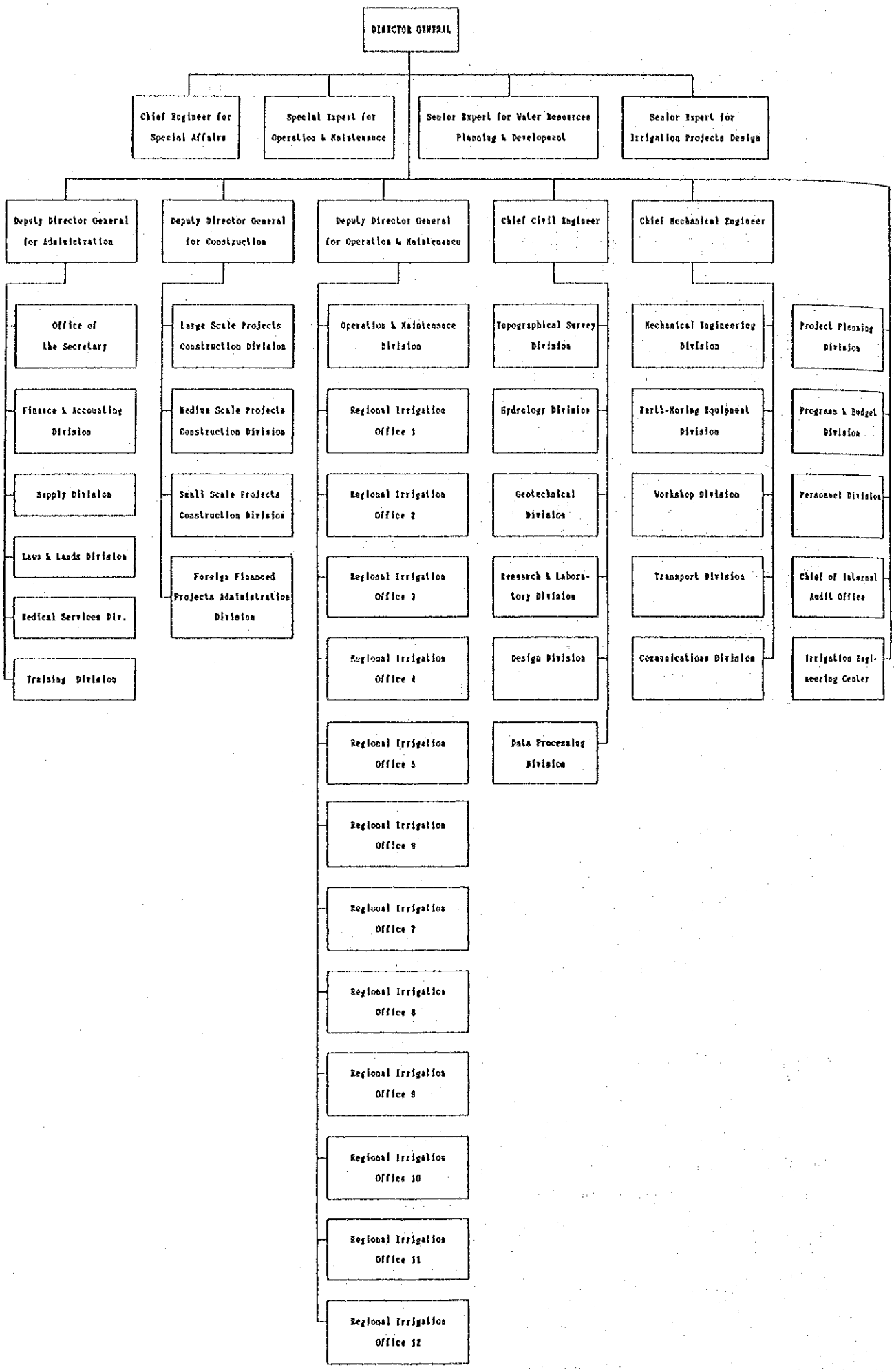


FIGURE 7-1 ORGANIZATION OF ROYAL IRRIGATION DEPARTMENT

7.1.4 Preparatory Work

The preparatory work for the project is composed of additional survey and investigation works for the detailed design stage and site facilities for administration of project implementation.

Since the topographic map (scale: 1/10,000) covering the whole Project Area and geological investigations at the proposed dam-site which had been provided during the Feasibility Study are very useful, additional surveys and investigation work necessary for the detailed design will be limited.

The site facilities for the project administration will be completed by RID, before commencement of project construction.

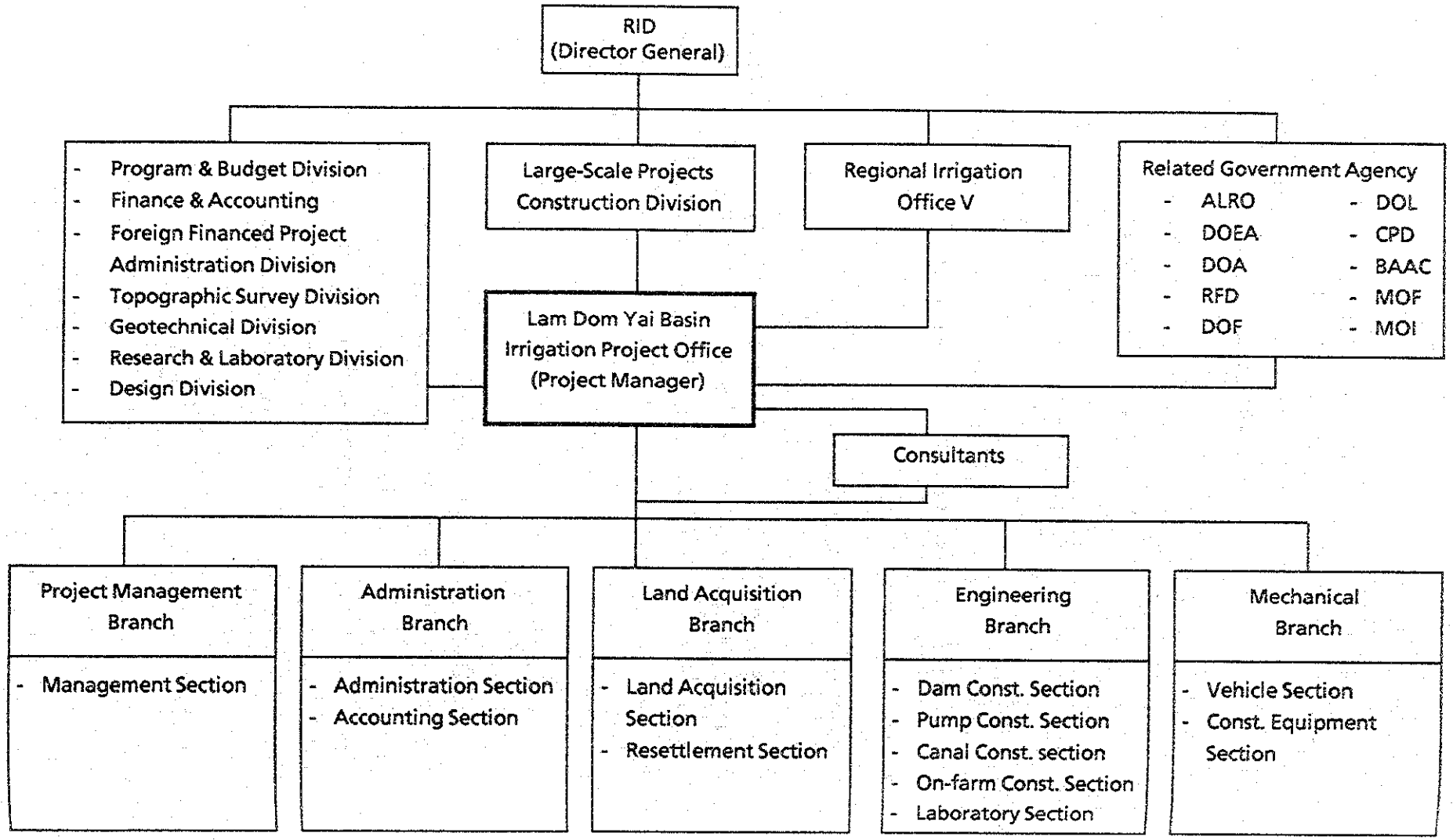
7.1.5 Administration Office

The organization of the RID project implementation office (Lam Dom Yai Basin Irrigation Project Office) is proposed as shown in Figure 7-2, taking into consideration administrative and engineering works at the project site during the construction period.

7.1.6 Consulting Services

RID will employ consulting services in the fields of hydrology, geology, soil mechanics, irrigation, agronomy, dam, pump, canal, civil work, construction planning and bidding. The consultants will assist RID to review the project planning, detail design of dam and canal, cost estimate, preparation of bid documents, tendering and contracting, quality control of construction works and general supervision of the project implementation.

FIGURE 7-2 PROPOSED ORGANIZATION CHART FOR PROJECT IMPLEMENTATION



7.1.7 Land Acquisition

Land acquisition in the reservoir area, dam construction site and along the canal alignment will be undertaken by RID before the construction work is begun. The following gives the estimated land acquisition areas.

Place		Area (ha)
Dam Construction	:	16.0
Pump Construction	:	0.2
Canal Construction	:	928.3
Total		944.5

7.2 Construction Plan

7.2.1 Dam

1) Work Volume

The work volume for construction of the Lam Dom Yai dam (D-28 dam) is as follows;

Work Volumes of Dam

Item of Works	Work Volume
1. Dam	
Excavation	790,000 cu.m
Grouting/Test-hole	8,300 m
Embankment	850,000 cu.m
2. Outlet	
Excavation	24,000 cu.m
Pipe Installation	100 m
Concrete	600 cu.m
3. Spillway	
Excavation	219,000 cu.m
Concrete	24,000 cu.m

2) Basic Plan

Since the Lam Dom Yai dam has a long dam length of about 2,000 m, the dam construction will be planned using river diversion of the open channel.

Namely, the existing river is used for the first river diversion and the open channel at station 6 will be the second diversion.

The dam construction is begun first on the right bank by using the river as the first stage diversion, and then continued on both banks by using the open channel as a second diversion. Construction period will be about three years.

3) Construction Method and Schedule

a) River Diversion Works

River diversion works are planned as follows;

First stage diversion is provided expanding the existing river width in order to release the designed flood of about 380 cu.m/sec. The second diversion is constructed with an open channel crossing the dam axis at station 6 and the diversion is used during dam embankment on the left and right bank, and closed at the final stage in dry the season after completion of embankments on both banks. In the case of the final stage of the embankment being finished in the dry season, the outlet located on the right bank will be used for diversion to release low discharge.

b) Dam Excavation Works

Dam excavation at the first stage is carried out at the sites between station 5 and station 9 in order to provide second stage river diversion at station 6. After completion of second stage diversion, the left and right bank excavation will be carried out.

Excavation works are made with a 21 ton bulldozer, backhoe shovel 2.0 cu.m and 11 ton dump tuck with the following schedule;

- Right bank excavation at the first stage (station 5 ~ 9)
  256,000 cu.m / (15,000 cu.m/month × 4 units) ≒ 4.5 months

- Left bank excavation at the second stage (station 0 ~ 9)
  274,000 cu.m / (15,000 cu.m/month × 4 units) ≒ 4.5 month

- Right bank excavation at the second stage (station 9 ~ 20)
  247,000 cu.m / (15,000 cu.m/month × 4 units) ≒ 4.5 month

c) Grouting Works

Grouting works are carried out at the sites of station 2 to 8 with two rows and a depth of 10 m along the dam axis. Grouting works are carried out firstly at station 5 to 9 and then secondly at station 2 to 5.

The work schedule is as follows;

- First grout works (station 5 ~ 9)
  4,800 m / (150 m/month × 4 units) = 8 months

- Second grout works (station 2 ~5)
  3,500 m / (150 m/month × 4 units) = 6 months

d) Dam Embankment

Dam embankment is carried out with a 20-ton tamping roller for the impervious zone, vibrating roller of 10 to 15 ton for the filter zone as compaction machinery and a 21-ton spreading bulldozer at the dam-site. Embankment materials are collected and transported from borrow area to dam-site by using a 21-ton bulldozer, a 2.5-cu.m wheel loader and a 11 ton dump truck.

At first, trench backfill up to EL.125 m at the sites of station 5 to 8 will be carried out after completion of grouting works, in order to prepare the site for second stage diversion. And then, embankment works are continued at station 5 to 9 and station 9 to 20 on the right bank, and station 0 to 5 on the left bank.

The embankment of the final stage to close the second diversion at station 6 will be carried out after completion of embankment on both banks up to EL.143 m releasing the dry season low flow to the outlet at station 8.

Respective embankment schedule is as follows;

- Trench backfill (station 5 to 8)
  19,000 cu.m / (12,000 cu.m/month × 1 units) ≒ 1.5 months

- Embankment at first stage (station 5 ~ 9)
  323,000 cu.m / (12,000 cu.m/month × 4 units) ≒ 7 months

- Embankment at second stage (station 0 ~ 5)
  352,000 cu.m / (12,000 cu.m/month × 3 units) ≒ 10 months

- Embankment at second stage (station 9 ~20)
  122,000 cu.m / (12,000 cu.m/month × 1 units) ≒ 10 months

- Embankment at final stage (station 6)
  84,000 cu.m / (12,000 cu.m/month × 3 units) ≒ 3 months

e) Outlet Structure

Outlet structure works consist of excavation, pipe installation, concrete placing and gate installation. The works will be carried out after dam excavation at station 5 to 9. The approach canal from the river to the outlet conduit, however, will be carried out immediately before the final stage dam embankment in order to lead the river water to the outlet as the river diversion.

f) Spillway Works

Spillway works can be carried out at any time. However the work will be done during the third year to avoid concentration of construction machines, because dam excavation and embankment works will reach their peak during the second year.

g) Construction Schedule

Construction schedule taking into consideration the above construction methods is shown in Figure 7-3.

7. 2. 2 Pump Facilities

1) Work Volumes

The qualities of pump works can be summarized as follows;

Work Volumes of Pump Facilities

Work Items		Left Bank	Right Bank	Total
Earth Works	(cu.m)			
Excavation		61,400	119,500	180,900
Backfill		6,200	5,000	11,200
Concrete Works	(cu.m)	2,300	6,600	8,900
Pump House	(sq.m)	250	520	770
Sub-station, Transformer		L.S	-	-

2) Basic Plan of Pump Facility Construction

Two pump stations on both banks of the Dom Yai river are planned in the project, and the construction of these pump facilities will be begun firstly from the left bank station. And, after completion of the station, the construction of the right bank station will be started.

The total construction period is one and half years beginning mid-1998.

3) Construction Method and Schedule

a) Excavation

The excavation works of the pump station will be started initially at the site of the suction sump and at the upper portion of the intake canal connected to the pump station.

b) Concrete Works

The concrete works will be started after the completion of the excavation works of the suction sump. Concrete works will be done in the order from suction sump to delivery sump.

c) Backfill

After completion of the concrete works in the suction sump, the backfill work will be carried out, in which sufficient compaction works should be included.

d) Pump House

Construction of the pump house will be carried out after completion of the backfill work mentioned above. The pump facilities will be installed after setting up an overhead traveling crane.

e) Sub-Station and Transformer

The provision of sub-station and transformer will be provided near the left bank pump station, after necessary preparation work of the project. Power cables will be installed together with the pump house works.

f) Construction Schedule

Construction schedule of pump facility works is shown in Figure 7-3, after due consideration of the above construction methods.

7. 2. 3 Irrigation Canals

The quantities of canal works are summarized as follows;

Work Volumes of Irrigation Canal Works

Work Items		Main Canal	Lateral Canal	Total
Stripping	(cu.m)	914,000	1,633,000	2,547,000
Excavation	(cu.m)	1,241,000	731,000	1,972,000
Embankment	(cu.m)	1,523,000	2,967,000	4,490,000
Concrete Lining	(cu.m)	40,000	56,000	96,000
Pipe Line	(km)	4.0	-	4.0

2) Basic Plan of Canal Construction

The construction period of canal works is planned to be the three years from 1997 to 1999. Main canals will be constructed in the first year, followed by the lateral canals and pipeline in 1998 and 1999.

3) Construction Method and Schedule

a) Stripping Works

Stripping works for the proposed canal alignment will be done before the excavation work of the canals. The thickness of the stripping work is to be around 30 cm.

b) Excavation Work

Excavation work for the designated canal cross section will be done by back hoe shovel, and the side slopes of the canals will be reshaped by man power.

c) Embankment Works

In the embankment works, sufficient compaction should be done paying attention to the wetness of embankment materials.

d) Concrete Lining Works

The maximum width of concrete lining panel is planned to be three meter, the work will be carried out by manpower. The work order of concrete lining placement will be firstly on the side slopes of canals and secondly on the bottom of the canals.

e) Pipe Line

The minimum soil covering of a pipe line is planned to be two meter. In constructing the pipe line, due attention should be given to the welding of pipe joints and compaction works for sanded and backfill portions.

f) Construction Schedule

The construction schedule for canal works is shown in Figure 7-3, based on the above mentioned considerations.

7. 2. 4 On-Farm Development

a) On-Farm Facilities

For the model designing of on-farm facilities, two sample areas were selected, and their work volumes are summarized as follows:

Work Volumes of On-Farm Facilities

Items		Sample-1 Ban Nong Yang	Sample-2 Ban Khitum
Main Farm Ditch	(m)	500	500
Supplemental Farm Ditch	(m)	1,400	2,320
Farm Drain	(m)	480	1,020
Farm Road	(m)	500	500
On-Farm Turnout	(place)	3	5
On-Farm Outlet	(place)	11	15
Road Crossing	(place)	2	1

b) Community Center

68 community centers in total will be provided in the Project Area.

2) Basic Plan of On-Farm Development

On-farm facilities with extensive methods will be basically constructed by farmers' groups to be newly established at the on-farm level having an area of about 20 ha (125 rai).

3) Construction Method and Schedule

a) Main and Supplementary Farm Ditches

Main and supplementary farm ditches will be constructed by the "Ditch and Dike Method" used in RID projects.

b) On-Farm Drains

On-farm drains will be excavated from original ground surface, and ridges will be provided at both sides of the drain.

c) Construction Schedule

Construction schedule for on-farm development is shown in Figure 7-3, considering the above mentioned construction methods.

7.3 Implementation Schedule of the Project

The project will be implemented over seven years from 1993 to 1999, consisting of such work as the evaluation of the project by Thai Government including environmental aspect, economic viability, loan procedures, detailed design and construction of civil works.

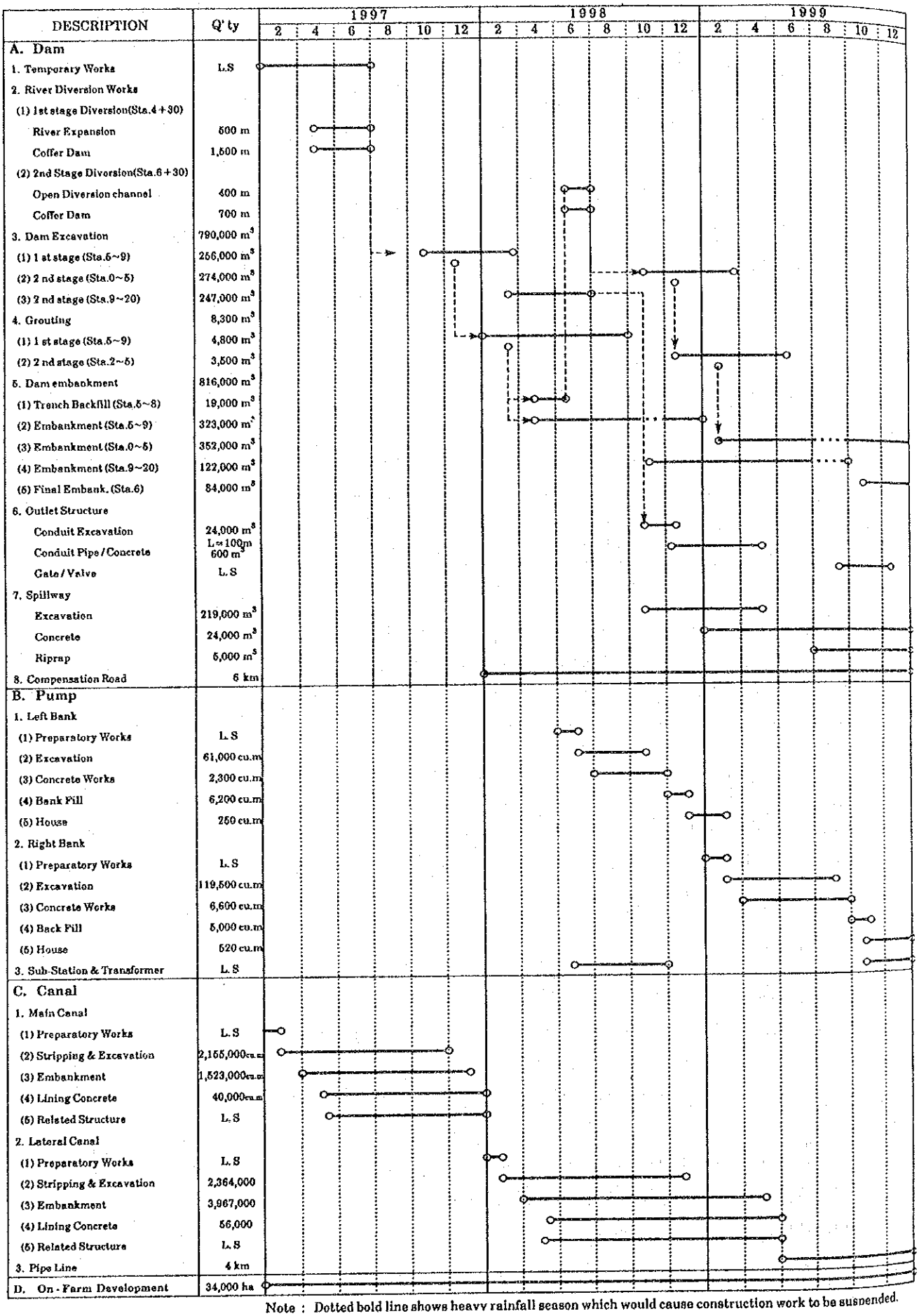
RID will commence the detailed topographic surveys of dam-site, pumping station and canal works during 1994, after the evaluation and approval of Thai Government in 1993. The detailed design will be completed during 1995 by employing consultants.

The construction of civil works such as dam, pumping station, canal systems and on-farm facilities is scheduled to start at the beginning of 1997 with a construction period of three years. The construction of the pumping station will commence one-and-half years before the completion of other major civil works.

In accordance with the above mentioned schedule, construction works will be completed by the end of 1999, and the first irrigation water supply will begin from the wet season paddy cultivation in 2000. Figure 7-4 shows the implementation schedule of the project in the case of loan basis.

In addition to the above implementation schedule, alternative schedule in the case of using local budget was studied, and attached in Annex O as reference.

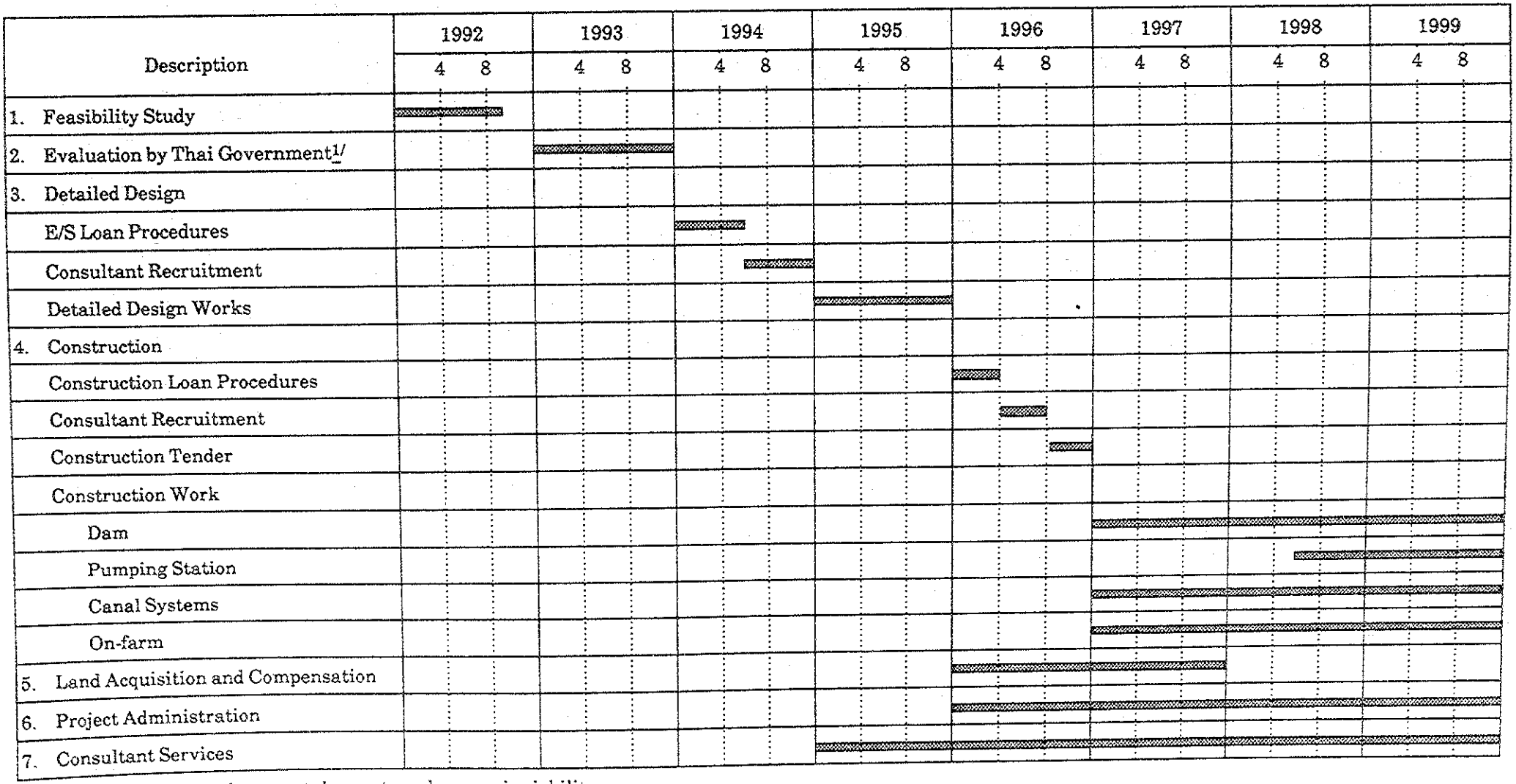
FIGURE 7-3 CONSTRUCTION SCHEDULE



DESCRIPTION	Q'ty
A. Dam	
1. Temporary Works	L.S
2. River Diversion Works	
(1) 1st stage Diversion(Sta.4+30)	
River Expansion	500 m
Coffer Dam	1,500 m
(2) 2nd Stage Diversion(Sta.6+30)	
Open Diversion channel	400 m
Coffer Dam	700 m
3. Dam Excavation	790,000 m^3
(1) 1 st stage (Sta.5~9)	256,000 m^3
(2) 2 nd stage (Sta.0~5)	274,000 m^3
(3) 2 nd stage (Sta.9~20)	247,000 m^3
4. Grouting	8,300 m^3
(1) 1 st stage (Sta.5~9)	4,800 m^3
(2) 2 nd stage (Sta.2~5)	3,500 m^3
5. Dam embankment	816,000 m^3
(1) Trench Backfill (Sta.5~8)	19,000 m^3
(2) Embankment (Sta.5~9)	323,000 m^3
(3) Embankment (Sta.0~5)	352,000 m^3
(4) Embankment (Sta.9~20)	122,000 m^3
(5) Final Embank. (Sta.6)	84,000 m^3
6. Outlet Structure	
Conduit Excavation	24,000 m^3
Conduit Pipe / Concrete	L=100m 600 m^3
Gate / Valve	L.S
7. Spillway	
Excavation	219,000 m^3
Concrete	24,000 m^3
Riprap	5,000 m^3
8. Compensation Road	6 km
B. Pump	
1. Left Bank	
(1) Preparatory Works	L.S
(2) Excavation	61,000 cu.m
(3) Concrete Works	2,300 cu.m
(4) Bank Fill	6,200 cu.m
(5) House	250 cu.m
2. Right Bank	
(1) Preparatory Works	L.S
(2) Excavation	119,500 cu.m
(3) Concrete Works	6,600 cu.m
(4) Back Fill	5,000 cu.m
(5) House	520 cu.m
3. Sub-Station & Transformer	L.S
C. Canal	
1. Main Canal	
(1) Preparatory Works	L.S
(2) Stripping & Excavation	2,155,000cu.m
(3) Embankment	1,523,000cu.m
(4) Lining Concrete	40,000cu.m
(5) Related Structure	L.S
2. Lateral Canal	
(1) Preparatory Works	L.S
(2) Stripping & Excavation	2,364,000
(3) Embankment	3,967,000
(4) Lining Concrete	56,000
(5) Related Structure	L.S
3. Pipe Line	4 km
D. On-Farm Development	34,000 ha

Note : Dotted bold line shows heavy rainfall season which would cause construction work to be suspended.

FIGURE 7-4 IMPLEMENTATION PROGRAM FOR THE PROJECT



1/ : including environmental aspects and economic viability

7.4 Operation and Maintenance Plan

7.4.1 Operation and Maintenance (O/M) Organization

1) Organization of Government O/M Office

RID is responsible for the operation and maintenance of major project facilities, which consist of dam, reservoir, and irrigation and drainage systems. The operation and maintenance works of the project facilities will be carried out by the Lam Dom Yai O/M Project Office to be newly established in the Project Area under the jurisdiction of Operation and Maintenance Division, RID.

The proposed organization chart for O/M Project Office is shown in Figure 7-5. The O/M Project Office headed by a project manager consists of four Branches; Administration, Engineering, Water Management and Mechanical Branches. Under the O/M Project Office, five Section Offices headed by a Section Chief (Water Master), who has actual responsibility of operation and maintenance work, will be set up in each area averaging 5,000 to 6,000 ha (31.3 to 37.5 thousand rai).

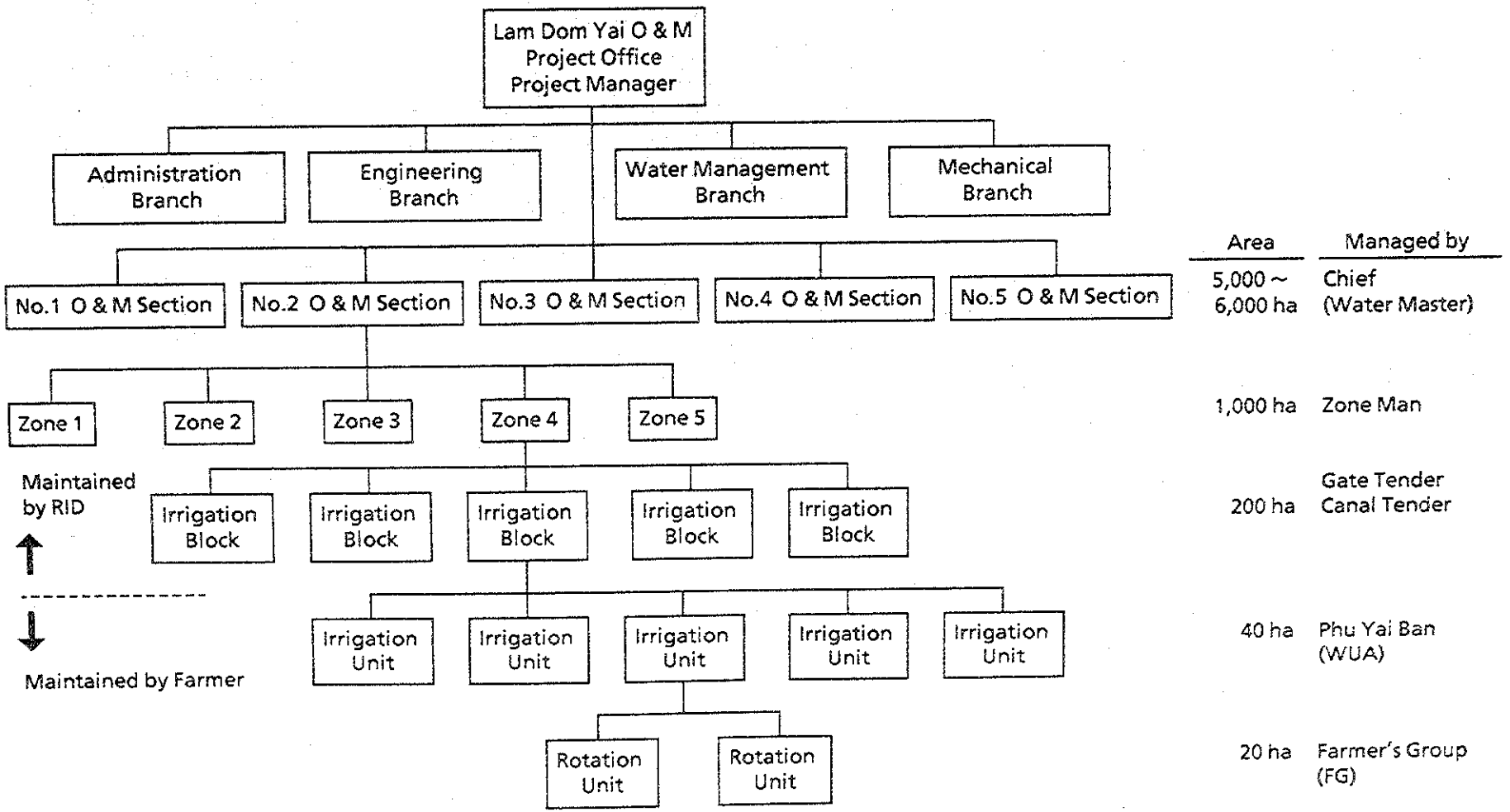
Each Section Area will be sub-divided into about five Zone Areas each having an area of about 1,000 ha (6.3 thousand rai), and a Zone Man will be assigned for operation and maintenance purposes. Each Zone Area, furthermore, will be sub-divided into about five Irrigation Blocks with an area of about 200 ha (1.3 thousand rai) as indicated in Figure 7-5. Gate and Canal Tenders are to be assigned to every 500 ha (3.1 thousand rai).

Accordingly, the Project Area will be divided into about 34 Zone Areas and 170 Irrigation Blocks in total under the responsibility of RID. The subsequent section indicates the major activities conducted by assigned staff for operation and maintenance works.

Water Master

The Water Master will take responsibility for the review and approval of the water allocation program for each cropping season and inspection and supervision of maintenance works. The water Master

FIGURE 7-5 PROPOSED ORGANIZATION CHART FOR OPERATION AND MAINTENANCE OF PROJECT FACILITIES



is responsible for 5,000 to 6,000 ha (31.3 to 37.5 thousand rai). Therefore, five Water Masters will be assigned to the Project Area.

Zone Man

The Zone Man will take responsibility for the compilation of information necessary for water allocation, such as cropping pattern, crop water requirement, rainfall, water allocation schedule and regulation of water by giving instruction to the Gate Tender. A Zone Man is proposed to superintend the benefited area of about 1,000 ha (6.3 thousand rai).

Gate Tender

The Gate Tender will take responsibility for regulating discharge released from the reservoir to the canal and from canal to the ditch, keeping records on water level in the reservoir and in the canal, and reporting the water level to the Zone Man on a daily basis. Each Gate Tender is charged with covering an area of about 500 ha (3.1 thousand rai).

Canal Tender and Maintenance Crew

The Canal Tender and Canal Maintenance Crew will take charge of all kinds of maintenance work such as cutting weeds, cleaning silt in the canal, repairing damaged concrete works, etc. Each Canal Tender is supposed to cover an area of about 500 ha (3.1 thousand rai).

2) Organization of Farmers

At the early stage of project implementation, beneficial farmers at the on-farm level (farm ditch level) having an area of about 20 ha (125 rai), which will be called a rotation unit as indicated in Figure 7-5. It should be organized into Farmers' Group with the initiative and assistance by RID and other government agencies. Two Farmers' Groups will be integrated into a Water Users' Association headed by the village chief (Phu Yai Ban) at the turn-out level with an area of about 40 ha (250 rai).

The Common Irrigator elected from among the Farmers' Groups will be responsible for operation and maintenance of on-farm facilities, which will be finally taken over by the Farmers' Group. Possibly close cooperation between Farmers' Groups and O/M Project Office is essential for successful day-to-day water management.

7.4.2 Operation and Maintenance Plan

1) Planning of Seasonal Water Supply

The O/M Project Office will prepare a water supply plan for each cropping season along with the proposed reservoir operation rules. When sufficient water is available in the reservoir at the beginning of cropping season, the water supply is planned to meet the full irrigation requirement for the proposed cropping pattern.

However, when water resources are insufficient for the proposed cropping pattern at the beginning of cropping season, a water supply plan is arranged to supply water evenly by the discounted rate for all the rotation areas by magnitude of proposed deficiency of water.

2) Water Management of Irrigation System

Water distribution schedule in major irrigation systems will be drawn up by the Zone Man, while the instruction of the water distribution schedule will be distributed by the Water Master. The Zone Man will direct to the Gate Tender order to discharge the required amount of water from the reservoir to canals and from canals to farm ditches.

On the other hand, the water management at the on-farm level having an area of about 40 ha will be under the responsibility of the Common Irrigator in Farmers' Group with the assistance of the Section Office. Irrigation water will be conveyed to individual farmers lots through farm ditches in rotation systems with about 40 ha (250 rai) covered by turn-out depending on the irrigation area.

In the case of rainfall during the water distribution period, the water distribution schedule for the following week will be adjusted by the Zone Man and an instruction of adjustment will be given to the Gate Tender to regulate the flow. The Common Irrigator will be informed of the adjustment as well in order to revise the distribution schedule to the farmers. In the case of water shortages, a rotation schedule will be established and informed to the Common Irrigator.

3) Maintenance

Periodical minor maintenance works will be carried out twice a year before the wet and dry seasons, in which those works of the main systems will be carried out under the responsibility of O/M Project Office and on-farm level will be done by the Water Users' Association under the supervision of the Zone Man. The minor maintenance work in the main systems will consist mainly of removing silt deposit and weed cutting along the banks of the canals.

7. 4. 3 Operation and Maintenance Costs

The office and facilities provided during the construction stage will be utilized for operation and maintenance purposes. The equipment for operation and maintenance will be newly provided, because the construction works will be done on a contract basis, and repair and maintenance costs will be needed. Operation and Maintenance costs were estimated at about 3,260 million Baht per annum, and are summarized as follows;

Operation and Maintenance Costs

Depreciation	Cost ('000 Baht)
Salary and wages	10,404
Administration and general expenditure	1,561
Pump operation costs	14,963
Equipment repair and maintenance costs	4,421
Fuel costs	875
Office maintenance costs	380
Total	32,604

7. 5 Additional Survey and Investigation

The following additional survey and investigations are proposed to be undertaken during the detailed design stage;

1) Reservoir and Dam

Topographic Survey

(1)	Dam axis and cross section	:	4.9 km
(2)	Temporary diversion channel alignment and cross section	:	3.1 km
(3)	Access road profile and cross section	:	3.0 km
(4)	Bench mark survey	:	5.0 km

Geological Investigation

(1) Seismic survey for dam-site

- along service spillway	:	900 m
- along dam-axis	:	2,000 m
- on flood plane	:	400 m
Total		3,300 m

(2) Core drilling works

- on service spillway,	15 m × 2	:	30 m
-	30 m × 6	:	180 m
- on dam-axis,	15 m × 4	:	60 m
	30 m × 6	:	180 m
Total			450 m

- Permeability test		
Gravity test	:	270 nos
Packer test	:	60 nos
- Standard penetration test	:	60 nos

(3) Embankment materials

- Test pit excavation :	:	30 nos.
- Soil laboratory tests		
Physical test	:	30 nos.
Mechanical test	:	30 nos.
- Rock test for riprap (Specific gravity, water absorption, abrasion tests)	;	5 nos.

2) Pump Station

Topographic Survey

(1)	Topographic survey of pumping site	:	0.2 ha
(2)	Intake canal alignment and cross section	:	3.6 km
(3)	Pipeline alignment and cross section	:	8.0 km

Geological Investigation

(1)	Core drilling	:	60 m
(2)	Standard penetration test	:	30 time

3) Canal Systems

Topographic Survey

Topographic survey of the proposed alignment of main, lateral and sub-lateral irrigation canals should be carried out, and their total length is as follows;

(1) Strip topographic survey

-	Main canal	:	111.4 km
-	Lateral/Sub-lateral canal	:	188.4 km

Geological Investigation

(1)	Cone penetration test	:	300 pla.
(2)	Laboratory test	:	60 pla.

4) Reservoir Area Survey

The D-28 reservoir area survey on the following items should be conducted to meet the requirement of compensation subjects by the construction of the dam, of which compensation water level is EL.140.0 m above mean sea level.

(1)	Present land use	: 4,330 ha (27.1 thousand rai)
(2)	Population and household	: 4,330 ha (27.1 thousand rai)
(3)	Land holding and ownership	: 4,330 ha (27.1 thousand rai)
(3)	Public facilities such as roads, electricity line	: 330 ha (27.1 thousand rai)

CHAPTER VIII. PROJECT COSTS

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8. 1 Conditions of Cost Estimation

The project costs are estimated under the following conditions;

i) The civil works are constructed on a contract basis. The construction machinery and equipment required for construction works will be provided by the contractors. Therefore, only depreciation costs of machinery and equipment are included in the construction costs.

ii) The project costs consist of construction and associated costs. Components of the project costs are shown in Table 8-1.

iii) The exchange rate between Thai Baht and U.S. Dollar is fixed as follows.

U.S Dollar = 25.0 Thailand Baht

ix) The physical contingency related to the construction and associated costs is set at 10 percent of the direct costs. The price escalation is predicted applying the international infraction index, established by World Bank.

v) The following overhead costs were taken into account the project cost;

- Management and operation : 3.5% of material and wage costs
- Profit : 6.5% of material and wage costs
- Taxes : 4.1% of above two items

8. 2 Construction Costs

1) Basic Rate

The basic rates for labor, material and construction equipment is estimated considering the prevailing rate in Thailand, as of October 1991.

2) Unit Cost

The unit cost of construction work is calculated, according to the proposed items, which are classified by construction methods since the construction of the project will be executed on a contract basis with the costs of overhead, profit and taxes used in current RID projects.

3) Construction Costs

The construction costs are estimated based on the unit cost for individual working items. The construction costs will be divided into foreign and local currency portions. The local currency portion is to be estimated on basis of current prices in Bangkok in 1991, while the foreign currency portion is estimated according to CIF prices in Bangkok.

8. 3 Associated Costs

Associated costs are composed of four items, such as on-farm development cost, land acquisition cost, engineering and administration cost, and O/M equipment cost.

8. 4 Project Costs

The project costs are estimated to be about 4,846 million Baht. The summary of the project costs is shown in Table 8-1.

Annual disbursement schedule of the total project costs is given as follows;

Annual Disbursement Schedule

(unit : Million Baht)

Year	Foreign Currency	Local Currency	Total
1995	26.0	9.0	35.0
1996	31.4	85.3	116.7
1997	505.9	598.1	1,104.0
1998	909.6	765.0	1,674.6
1999	1,289.2	626.9	1,916.1
Total	2,762.1	2,084.3	4,846.4

TABLE 8-1 PROJECT COSTS

(unit : Million Baht)

Item	F/C	L/C	Total
1. Civil Works			
1.1 Preparatory Works	2	19	21
1.2 Dam Works	150	135	285
1.3 Pump Facilities	595	24	619
1.4 Canal Works	612	536	1,148
1.5 Resettlement Works	29	350	379
Sub-Total	1,388	1,064	2,452
2. On-Farm Development			
2.1 On-Farm Facilities	307	218	525
2.2 Community Center	6	6	12
Sub-Total	313	224	537
3. Land Acquisition	-	66	66
4. Engineering and Administration			
4.1 Consulting Services	97	34	131
4.2 Administration	7	14	21
Sub-Total	104	48	152
5. O/M Equipment	38	6	44
6. Total (1 - 5)	1,843	1,407	3,250
7. Physical Contingencies (10%)	184	141	325
8. Total (6 - 7)	2,027	1,548	3,575
9. Price Escalation	734	537	1,271
10. Grand Total			
With On-Farm and Rural Development	2,761	2,085	4,846
Without On-Farm andRural Development	2,297	1,751	4,048

CHAPTER IX. PROJECT EVALUATION

CHAPTER IX. PROJECT EVALUATION

9.1 Introduction

The project is one of the irrigation projects in the Lam Dom Yai basin. The Project Area has high a poverty distribution owing to the unfavorable conditions of farming, even for the Northeast region. The irrigation projects in the basin aims to improve declining regional socio-economic conditions by generating job opportunities, increasing cash-income, and improving the living standards of the farmers, and thus establishing stabilized agricultural production through the development of resource potentials. The Project Area has been set up as a high priority area, which obtains benefit from D-28 reservoir, selected by the Overall Basin Study.

Agriculture in the area depends on rainfall and is carried out mainly as wet season paddy cultivation. Cassava and kenaf as traditional crops are used to follow. With project implementation, the D-28 reservoir will be constructed as a water resource for agriculture and the irrigation facilities are to be provided in the area. The irrigation water will be mainly supplied to wet season paddy as supplementary water and an increase of wet paddy yield will be expected. On the other hand, through the change of cropping from paddy to perennial crops (tree crops) on a part of the paddy field and supply of the irrigation water in the dry season for a part of the area, cash crops will be introduced. Moreover, the irrigation water would bring about the development of inland fishery in the area. As a result, poverty eradication by improvement of farm income and contribution to the regional economy can be expected.

9. 2 Economic Justification

9. 2. 1 Method of Economic Evaluation

The method of economic evaluation is as follows;

1) Economic benefits and costs of the project are expressed in monetary terms.
2) On the assumption that the project life is 50 years after completion of the project, and that both benefits and costs in annual form over the project life are converted to the respective present worth value.
3) The benefits and costs are evaluated with incremental value based on the difference between without and with the implementation of the project.
4) The economic prices valued at border price are applied.
5) Economic internal rate of return (EIRR) is used as the main indicator for economic evaluation.

9. 2. 2 Economic Price of Commodities

The economic price used in the evaluation will be adopted on the basis of the following criteria.

1) The value of traded/tradable goods is measured by border prices in Thai Baht.
2) The value of non-traded/non-tradable goods measured by domestic price is converted into border prices using a conversion factor evaluated by the World Bank.
3) As for a forecast of commodity prices, the World Bank Commodity Price Forecasts for the year 2000 (1990 actual prices) are used.
4) The official exchange rate used for the evaluation is US$1.00 = 25 Baht.
5) Economic farmgate prices for farm products are as follows;:

- Rice
  According to World Bank Commodity Price Forecasts evaluated by 1990 actual prices, the Thai white rice, broken five percent, CIF Bangkok is projected at US$406/ton in the year 2000. Therefore, the

farmgate price of paddy is estimated at 4,209 Baht/ton using the above projection price.

- Soybeans

Since, CIF Rotterdam soybeans are projected at US$310/ton in the year 2000, the farmgate price for this crop is estimated at 7,873Baht/ton.

- Groundnuts

Owing to shelled groundnuts, CIF Europe are projected at US$784/ton in the year 2000, the farmgate price for this crop is estimated at 11,708 Baht/ton.

- Other crops

Watermelon, chilli, vegetables (represented by stringbeans) and fruit (mango) to be introduced are tradable crops. The economic price of these crops is estimated based on the results of the field survey. The economic prices of these crops are shown as below.

Watermelon	0.9 Baht/kg
Chilli	7.0 Baht/kg
Vegetable	7.1 Baht/kg
Fruit (Tree Crop)	4.0 Baht/kg

6) Economic Prices of Fertilizers

Fertilizers are currently imported and economic prices are estimated as follows, using the projected price by World Bank Commodity Price Forecasts in the year 2000.

Urea	4,695 Baht/ton
DAP	6,300 Baht/ton
TSP	5,424 Baht/ton
Potassium Chlide	4,032Baht/ton

7) Economic Prices of Chemicals

The market prices of pesticide, insecticide and herbicide are obtained from OAE and the field survey. The economic prices for these chemicals are converted by a factor of 0.92 (Standard Conversion Factor).

8) Economic Price of Farm Labor

Pricing of farm labor is the assessment of opportunity costs. The opportunity costs are estimated by the general criteria of the opportunity for off-farm employment in the off-season of farming and farm wage in the farming season and outside labor market. The marginal opportunity costs of labor supplied for farms in the area are evaluated using the minimum wage of 30 Baht, average wage of 40 Baht and maximum wage of 60 Baht, also outside labor wage of 50 Baht.

9. 2. 3 Project Benefits

Economic benefits of the project generated from project implementation are made up of three categories of benefits; farm production, inland fishery, and others (road, domestic water, etc.).

In crop benefits, the goal of full development will be set up at five year after completion of the project implementation, applying the other project as Sebai-Sebok. Fishery benefits will be set up at three year after completion of the project implementation. Benefits from saving cost of transport will be corresponded to crop production. Benefits from domestic water use will be applied from 1st year after completion of the project implementation.

1) Farm Production Benefits (Crop Benefits)

Crop benefits are constituted by incremental net agricultural production values brought about by the provision of irrigation water and supporting services to the farmers. After completion of the project, two types of production plan, described in the agricultural production plan will be carried out and the benefits are estimated in the same way as before.

Type-I : for 5 years after the project implementation
Wet season = Paddy + Tree crop (perennial crop)
Dry season = Upland crop + Tree crop

Type-II: after the Type-I
Wet season = Paddy + Upland crop + Tree crop
Dry season = Upland crops + Tree crop

Farm production benefits, for economic evaluation, based on the agricultural production plan have been calculated as shown below;

Cropping Pattern Type-I:

(unit : 1,000 Baht)

Item	With Project	Without Project	Increased Value
Gross Production Value	581,198	200,367	380,831
Production Cost	243,016	140,117	102,899
Net Production Value	338,183	60,250	277,932

Cropping Pattern Type-II :

(unit : 1,000 Baht)

Item	With Project	Without Project	Increased Value
Gross Production Value	678,080	200,367	477,713
Production Cost	273,816	140,117	133,699
Net Production Value	404,264	60,250	344,014

2) Inland Fishery Benefits

Inland fishery benefits can be expected through aquiculture in the reservoir, paddy fields and village ponds. Incremental annual benefit can be expected as follows:

Considering the Northeast Rainfed Agriculture Improvement Project as mentioned in Annex H and previous paragraph on Agricultural Development Plan, Freshwater Fisheries, fish production in paddy will be adopted. Fish production in paddy is planned at a part of limited paddy field. Therefore, effects of insecticide on farm practice will be not considered.

Paddy fields:
Annual benefit (per ha) ..... 6,020 Baht
5,380 ha × 6,020 Baht/ha ..... 32,387,600 Baht
Reservoir:
Annual benefit ..... 1,015,434 Baht

Village ponds in the community center:
Annual benefit (total: 68 ponds, 8 ha).... 574,630 Baht

3) Other Benefits

Other benefits can be defined as the anticipated effects of the feeder roads for maintenance of reservoir and main canals and by a secure supply of domestic water.

Domestic water use benefits consist of water consumption of household and drinking water for animal. The project is proposed to use machines. In the case of other projects in the Northeast, as Nam Oon, most the farmers are raising domestic animals (buffaloes) which are not use for farming despite the farm machinery is introduced. In seems that they are raising as their properties. Hence, estimated head as 2.8 per farm household is computed considering some head reduced from the present situation.

- Anticipated effect of feeder roads (annually) ···· 3,737,000 Baht
- Anticipated effect of domestic water (annually) ···· 2,488,000 Baht

4) Minus Benefits of Submerged Area

After completion of the project, for the cultivated area to be submerged, the opportunity cost as minus benefits is estimated considering the potential productivity.

Annual minus benefit ..... 918,310 Baht

5) Effects by Resettlement Program

By the implementation of resettlement program in the project, the following resettlement effects could be anticipated for the rural people in the areas;

- Stabilized agricultural production in the areas will be secured by the provision of agricultural infrastructures such as water resource facilities, irrigation and drainage canals and on-farm facilities.

- Improvement of rural environment and raising of living standard of the rural people can be expected by the provision of rural infrastructures such as service/communication roads, electric

power supply, and public facilities of schools, temples and health facilities.

- Resettlement areas equipped with above-mentioned facilities will function as demonstration farm/villages, and especially effects on irrigated agriculture will be propagated to the neighboring rural people, prior to the project implementation.

These anticipated effects mentioned-above, however, are not counted in the analysis of economic evaluation, because the required costs for the resettlement program are excluded from the evaluation.

9. 2. 4 Project Costs

Economic costs of the project are comprised of construction works, land acquisition and compensation, project administration, consulting services, and physical and price contingencies, but price contingency is excluded from the economic costs.

On-farm works will basically constructed by farmers themselves. Accordingly, the cost are not included in the project costs. However, alternative project evaluation inclusive of on-farm costs was made in Annex O, as a reference.

1) Project Costs

Project construction costs were estimated on the basis of 1990 price levels. Since the main construction works are scheduled to be completed within some five years, changes in future price relationships were not considered. For the evaluation, all construction costs were broken down into two components; foreign costs (foreign currency) and local costs (local currency). The conversion factor of the non-traded component and services produced by the project is 0.92 (standard conversion factor).

Local financial costs are converted to economic costs using construction conversion factor of 0.88. Economic costs of the project is estimated as follows;