7. ENVIRONMENTAL IMPACT

Forest area in Thailand has been greatly reduced in the past two decades due to the rapid agronomic expansion and the population growth.

The Thai government has had a policy of managing and maintaining forests for the benefit and welfare of the public, and provided watershed management guidelines or appropriate technical recommendations for land uses.

The land areas in the whole Thailand were divided into five major watershed classes. DWG. 7-1 shows the watershed classification in the project area.

The EGAT has executed environmental studies on natural and socio-economic fields in relation to the Lam Ta Khong pumped storage project.

The investigation or studies have aimed:

- to research the existing conditions of environmental resources from ecological and socio-economic aspects in the project area.

- to identify the probable environmental impacts due to the project implementation.

- to study the possible mitigative measures therefor.

Those study results can provide to the project feasibility study with useful information and various inputs regarding the environment which are referred to in this report.

Further the EGAT, based on the elaboration undertaken by the in-house team, has studied the scope of the works and identified the key issues in order to entrust the detailed environmental impact assessment (referred to as EIA) to a third party institute, the Khon Kaen University, who can be engaged in the EIA under the licence given by

National Environment Board (referred to as NEB) pursuant to the NEB guideline.

The Project impacts on environmental resources/values are of two types:

- Short-term impacts during construction
- Long-term impacts during operation

The impacts of the former type are generally confined in specific areas and can be avoided or minimized by proper mitigation measures which are conducted in conjunction with the Project construction such as measures for minimizing turbid water, dust, noise and vibration, for traffic control and for health and safety.

The impacts of the latter type could be of both positive and negative impacts. The measures needed for enhancing positive impacts and/or alleviating negative impacts are of both non-structure and structure types. The measures needed are:

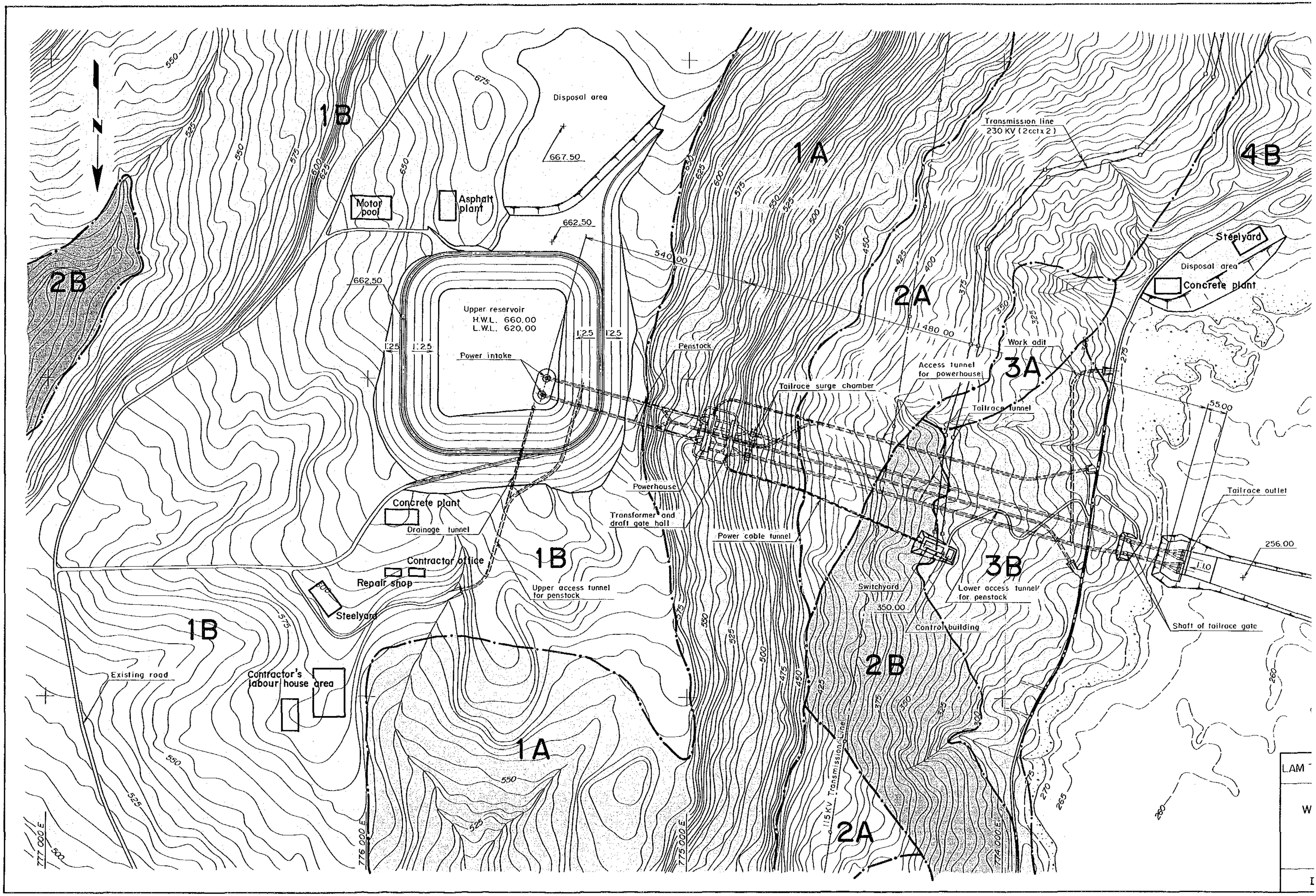
- Compensation and occupation development for the inundated land owners at the upper reservoir site

- Conservation and development of fisheries resource in the existing Lam Ta Khong reservoir

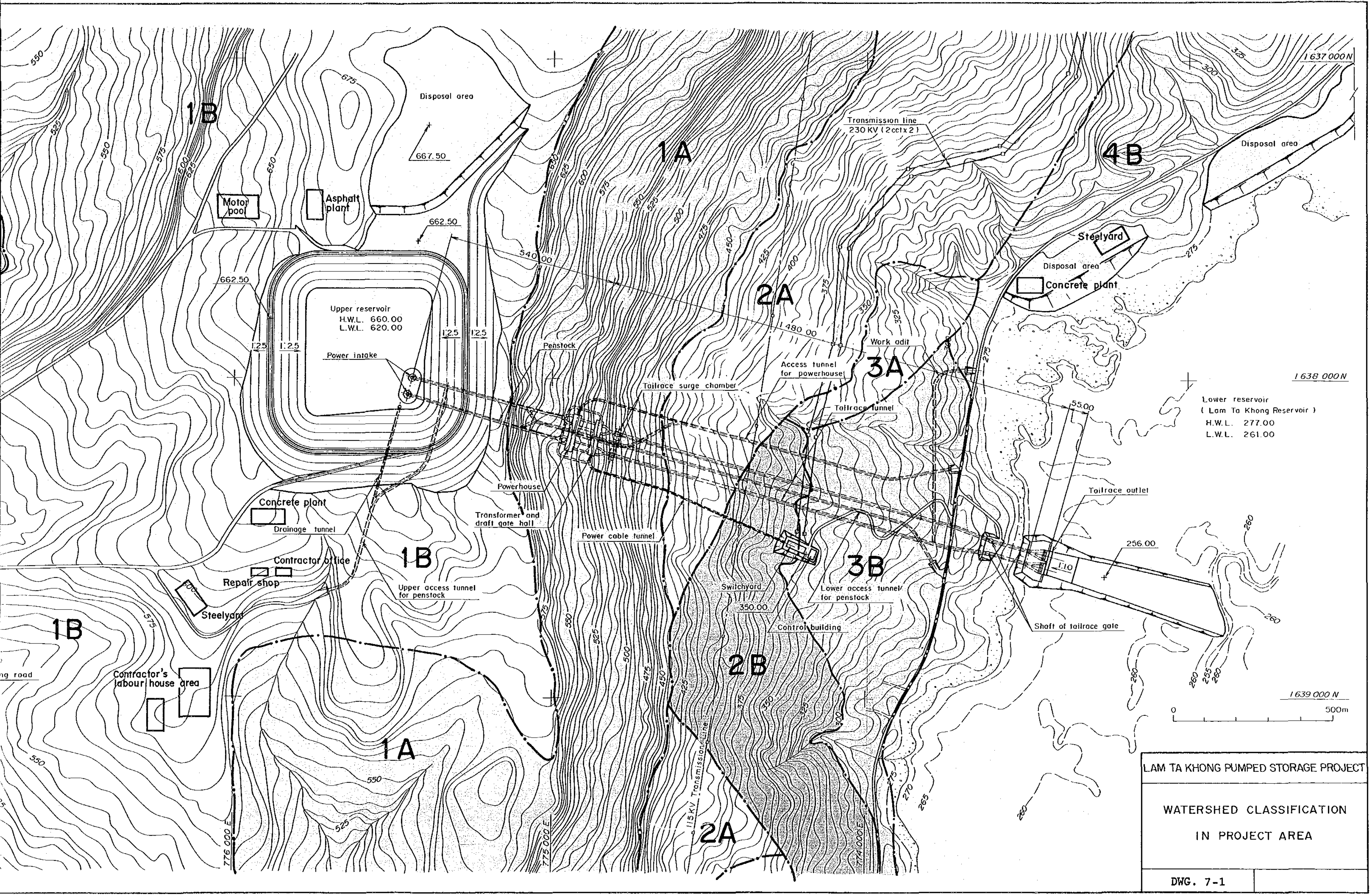
- Land rehabilitation and development for the disposal areas and vicinities

- Tourism and recreation development to promote the use of tourism resource potential being enhanced by the Project

- Water use planning to properly allocate the available water in the Lam Ta Khong reservoir to meet future requirements



1A
1B
2A
2B
3A
3B
4B
Disposal area
667.50
662.50
Motor pool
Asphalt plant
Upper reservoir
H.W.L. 660.00
L.W.L. 620.00
Power intake
1:2.5
540.00
480.00
55.00
256.00
Penstock
Tailrace surge chamber
Access tunnel for powerhouse
Work adit
Tailrace tunnel
Transmission line
230 KV (2cct x 2)
Steelyard
Disposal area
Concrete plant
Powerhouse
Transformer and draft gate hall
Power cable tunnel
Tailrace outlet
Concrete plant
Drainage tunnel
Contractor office
Repair shop
Upper access tunnel for penstock
Lower access tunnel for penstock
Switchyard
350.00
Control building
Shaft of tailrace gate
Steelyard
Existing road
Contractor's labour house area
115 KV Transmission Line
777 000 E
776 000 E
775 000 E
774 000 E
LAM



LAM TA KHONG PUMPED STORAGE PROJECT

WATERSHED CLASSIFICATION

IN PROJECT AREA

DWG. 7-1

8. DEVELOPMENT PLAN

(1) Selection of Layout

In the initial stage of the study, location of the upper reservoir and power house sites were studied from topographical, geological, environmental and economical viewpoints.

As a result of this study and the reconnaissance survey, the most optimum layout was selected.

(2) Available Energy for Pumping

Pumping energy for the Lam Ta Khong power plant was studied and as a result of the study, it was confirmed that enough pumping energy can be supplied from thermal power plant.

(3) Study on Unit Capacity

The unit capacity of Lam Ta Khong project was decided to be 250 MW after examining fluctuations of the power system frequency caused by start and stop of pumping.

Frequency fluctuations caused by the start and stop of pumping of a 250 MW unit is estimated to be 0.22 Hz - 0.47 Hz with 70% probability in 1997 and this fluctuation level is lower than the present level.

Frequency fluctuations become lower, as the system capacity becomes larger. Therefore, there is no problems for using a 250 MW unit in view of frequency fluctuations.

However, the introduction of a 300 MW unit machine to Lam Ta Khong project is not recommendable, because frequency fluctuations caused by this machine would become bigger by 20% than those caused by a 250 MW machine and the system frequency may go up very often to above 50.5 Hz, the level at which the thermal units must be disconnected from the power system.

The introduction of a 250 MW unit to the project has no problem in manufacturing technique and means of transportation as well.

(4) Study on Development Scale (Investigation Stage)

Optimum development scale was studied by varying the installed capacity (500 MW ~ 1,200 MW) and storage capacity (4 ~ 14 hours) of the upper reservoir from a viewpoint of the most effective utilization of the pumped storage resource of Lam Ta Khong site. The study was carried out on the basis of benefit and cost of the project.

As a result of the study, the development scale of 1,000 MW having reservoir capacity of 8 hours was superior to the other alternatives, and the plan was selected.

(5) Study on Development Scale and Scheme (Feasibility Design Stage)

Upper limit of pumping is 500 MW because of the power system stability on the basis of EGAT's transmission expansion plan up to year of 2006. However generating of 1,000 MW is possible without strengthening the main transmission line.

JICA team predicts that EGAT's main transmission system would be strengthened and 1,000 MW pumping be possible in the future. However, this study is carried out on the most reliable condition of 500 MW pumping and 1,000 MW generating.

- Following four cases for 1,000 MW development were studied and the conceptual figures is shown in Fig. 8-1.

Case 1 (DWG. 8-1)

Development Stage:	Two Stages
1st Stage :	Reservoir (500 MW x 8 hours) and Generating Facilities with 250 MW x 2 units (Operation 1997)
2nd Stage :	ditto (Assumed Operation 2007)

Case 2 (DWG. 8-2)

Development Stage:	Two Stages
1st Stage :	Reservoir (1,000 MW x 8 hours) and civil works for 250 MW x 2 units, Generating facilities with 250 MW x 2 units (Operation 1997)
2nd Stage :	Generating Facilities with 250 MW x 2 units (Assumed Operation 2007) including civil works

Case 3 (DWG. 8-3)

Development Stage:	Two stages
1st Stage :	Reservoir (1,000 MW x 8 hours) and Generating Facilities with 250 MW x 2 units (Operation 1997) including civil works of the 2nd stage
2nd Stage :	Generating facilities with 250 MW x 2 units only (Assumed Operation 2007)

Case 4 (DWG. 8-3)

Development Stage:	One stage 250 MW x 4 units (Operation 1997)
Reservoir Capacity:	1,000 MW x 8 hours

- Results of the study is shown in Table 8-1 and the main points are described below.

  Concerning 1,000 MW development, Case-4 is the most feasible from an economic view point because the investment cost is lower than any other cases. The daily generating hours is 4.1 hours for 1,000 MW generating and 500 MW pumping.

(6) Adopted Development Plan

The development plan of installed capacity of 1,000 MW having reservoir capacity of 8 hours was selected on the basis of the study mentioned above and meetings with EGAT and JICA team.

The adopted plan is shown in Table 8-2 and DWG. 8-3.

Position of the Project in the daily load duration curve (year of 2000) is shown in Fig. 8-2.

Table 8-1 Comparison of Development Methods

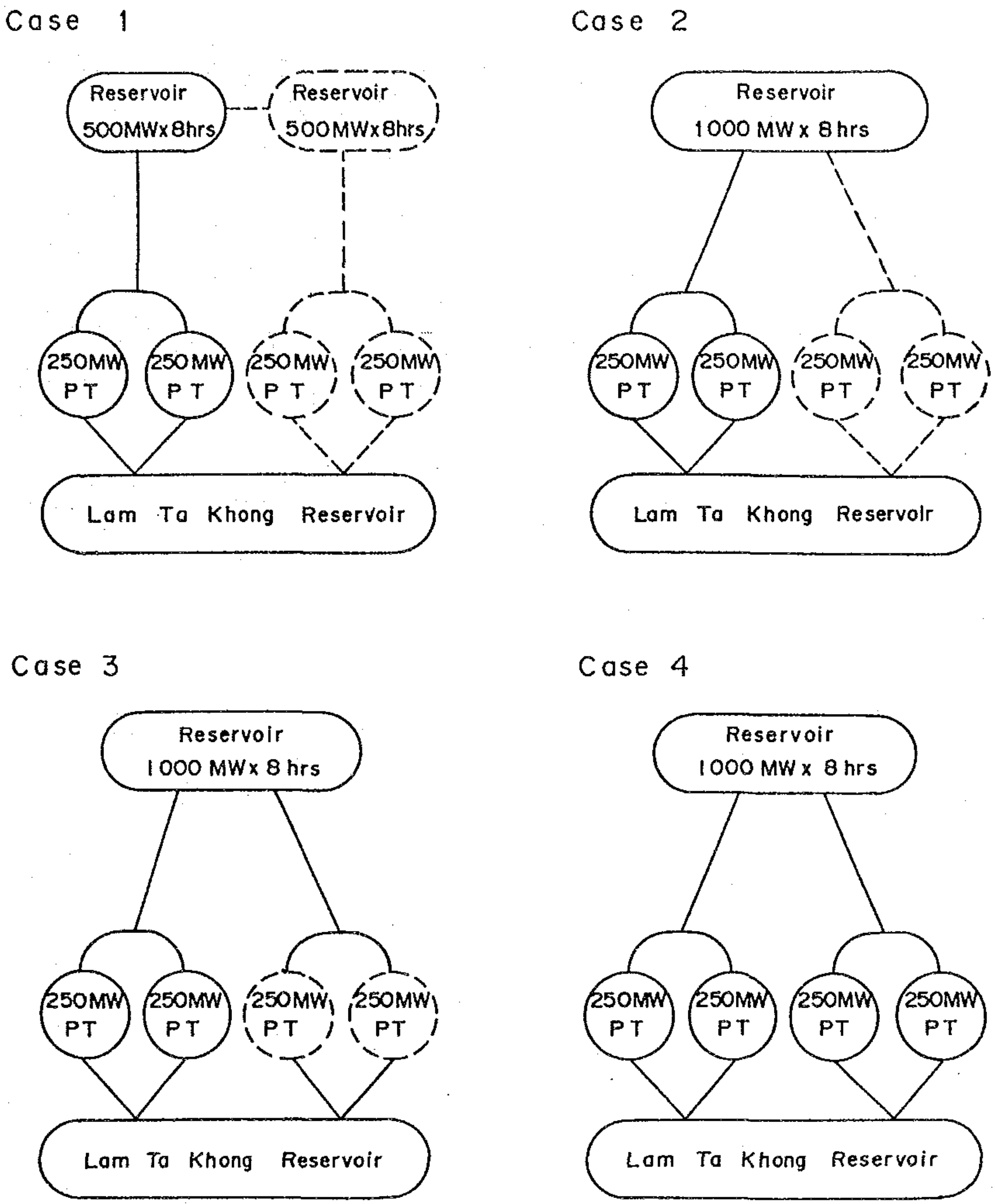
	Case 1		Case 2		Case 3		Case 4
	1st Stage	1st & 2nd Stage	1st Stage	1st & 2nd Stage	1st Stage	1st & 2nd Stage	1st Stage
(500 MW Pumping)							
Installed Capacity (MW)	500	1,000	500	1,00	500	1,000	1,000
Start of Operation	1997	2007	1997	2007	1997	2007	1997
Construction Cost (M฿)	6,466*	12,636	7,261	11,861	8,465	11,432	11,254
NPV (M฿) OF B-C	310	351	-274	140	-1,111	-310	1,504
B/C	1.05	1.05	0.96	1.02	0.84	0.96	1.16

(Note) Condition: 500 MW pumping, 1,000 MW generating
(Note) 1st stage: year of 1997, 2nd stage: year of 2007
(Note) * including cost of a part of connecting conduit between two upper reservoirs and cost of the outlet for the 2nd stage

Table 8-2 Description of Adopted Development Plan

Item	Upper Reservoir	Lower Reservoir*
Normal High Water Level (WL.m)	660	277
Low Water Level (WL.m)	620	261
Available Drawdown (m)	30	16
Effective Storage Capacity (MCM)	5.0	290
Intake Water Level (m.MSL)	653	
Tail Water Level (m.MSL)	276	
Normal Effective Head (m)	357	
Maximum Discharge (m^3/s)	340	
Installed Capacity (MW)	1,000	
B-C (M฿)	1,504	
B/C	1.16	

* : The Lam Ta Khong Reservoir (existing)



(Note) Solid line : 1st Stage
Dotted line : 2nd Stage
PT : Pump Turbine (Including Generator)

Fig. 8-1 Development Cases of 1000 MW

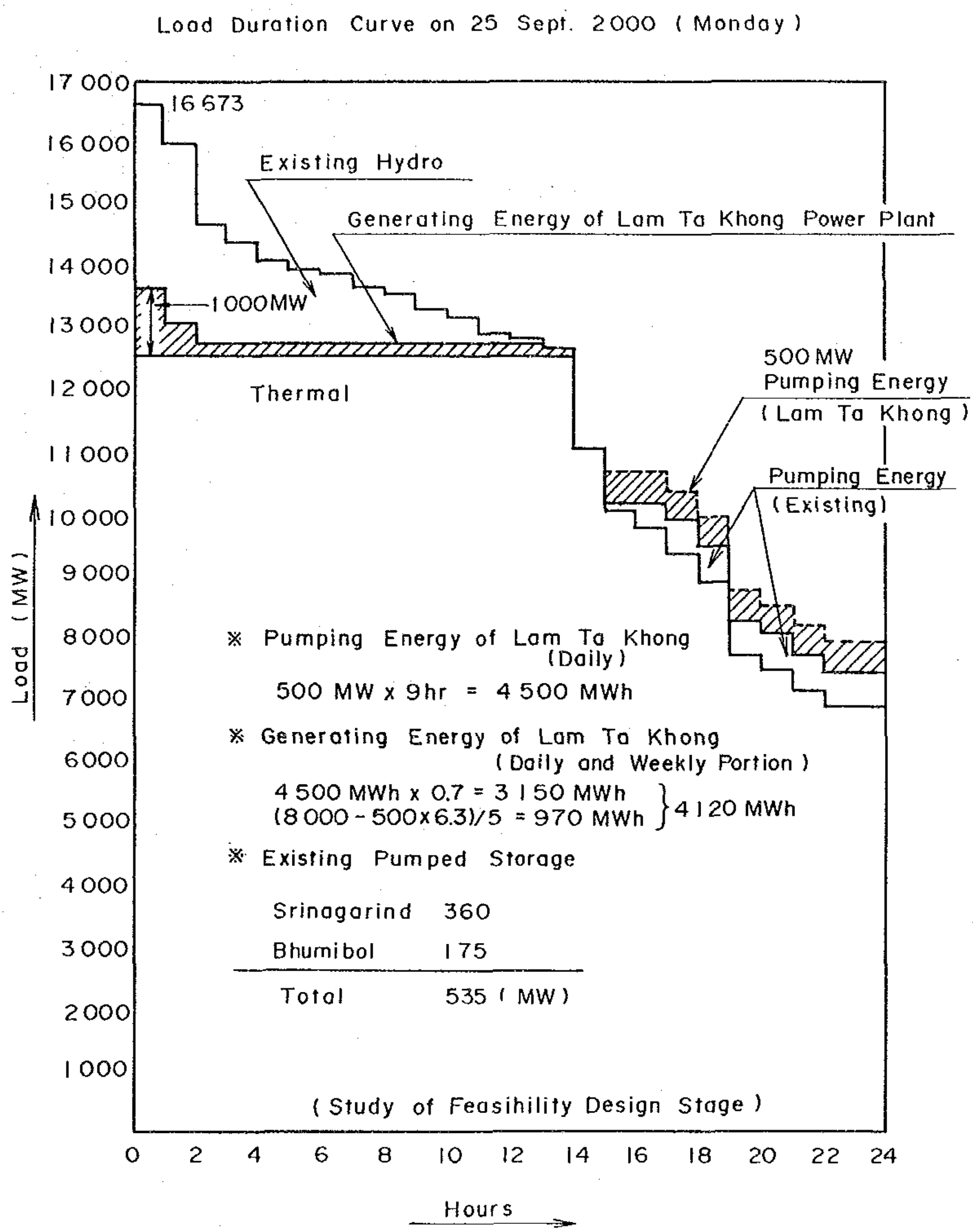
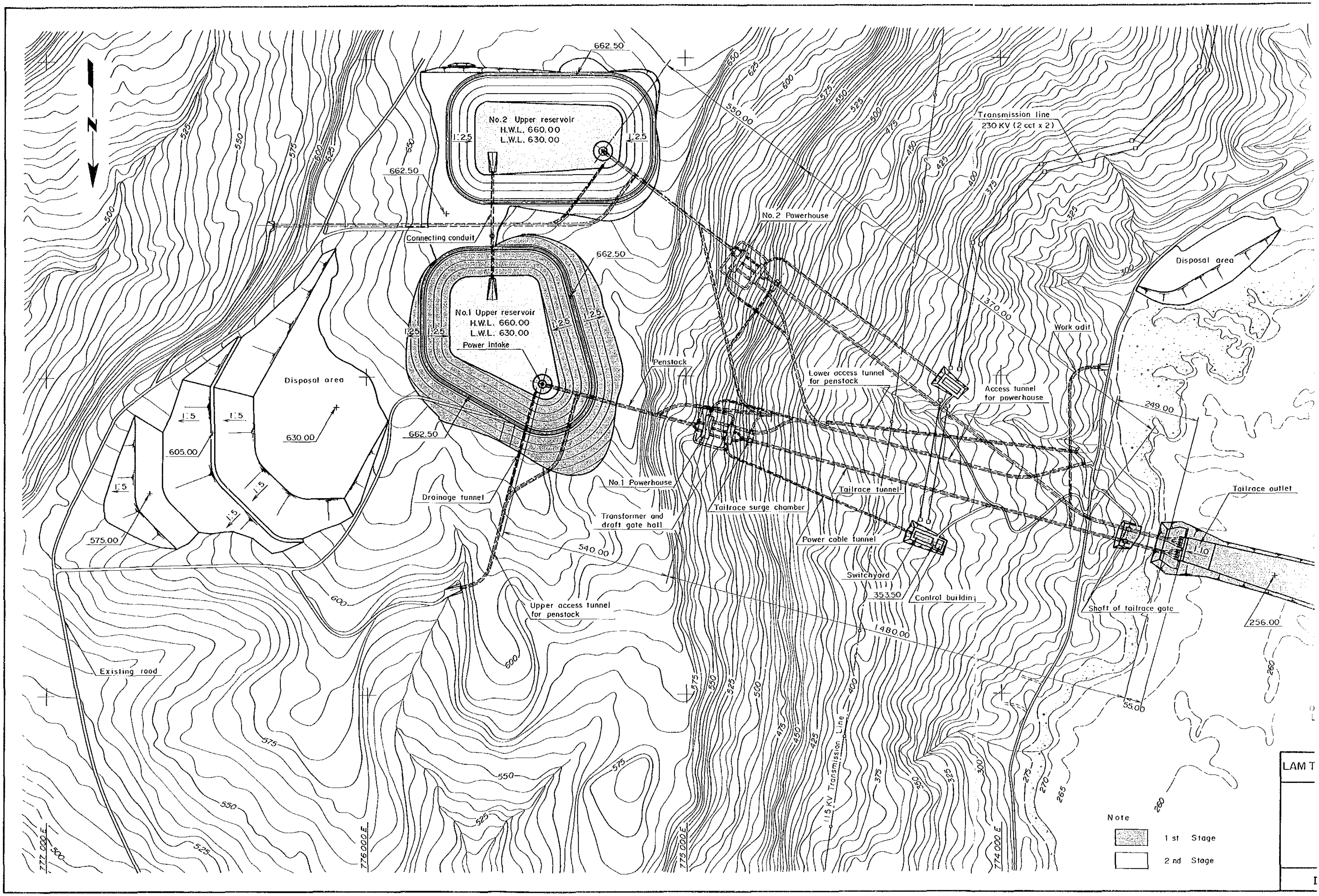
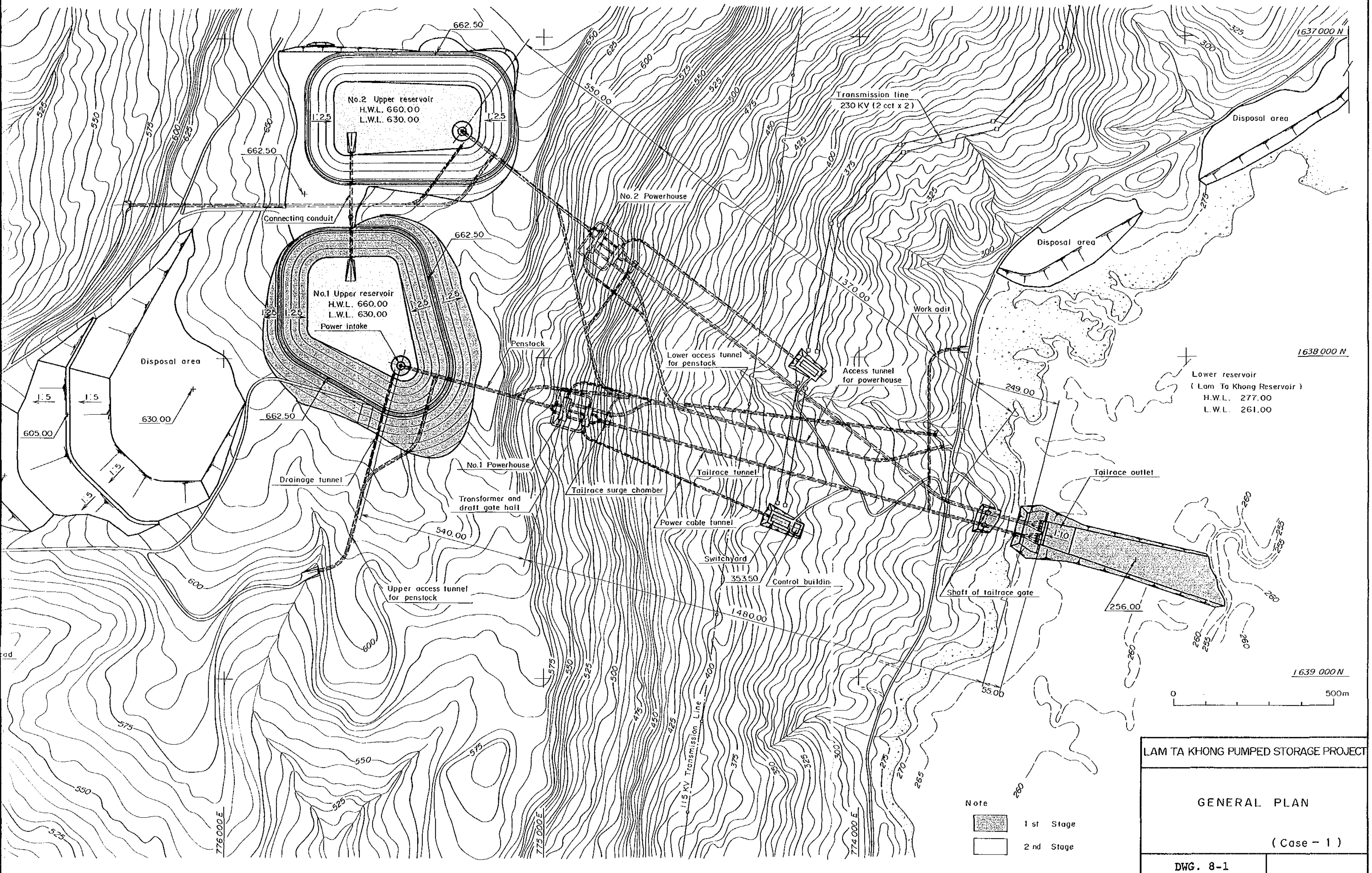


Fig. 8-2 Position of Lam Ta Khong Power Plant in Load Duration Curve


N
No.2 Upper reservoir
H.W.L. 660.00
L.W.L. 630.00
No.1 Upper reservoir
H.W.L. 660.00
L.W.L. 630.00
Power intake
662.50
Connecting conduit
Disposal area
630.00
605.00
575.00
1:5
1:2.5
No.2 Powerhouse
No.1 Powerhouse
Penstock
Drainage tunnel
Transformer and draft gate hall
Tailrace surge chamber
Tailrace tunnel
Power cable tunnel
Lower access tunnel for penstock
Upper access tunnel for penstock
Access tunnel for powerhouse
Switchyard
Control building
353.50
Work adit
Shaft of tailrace gate
Tailrace outlet
1:10
256.00
249.00
1370.00
1480.00
540.00
550.00
55.00
Transmission line
230 KV (2 cct x 2)
115 KV Transmission Line
Existing road
777 000 E
776 000 E
775 000 E
774 000 E
LAM T
Note
1 st Stage
2 nd Stage

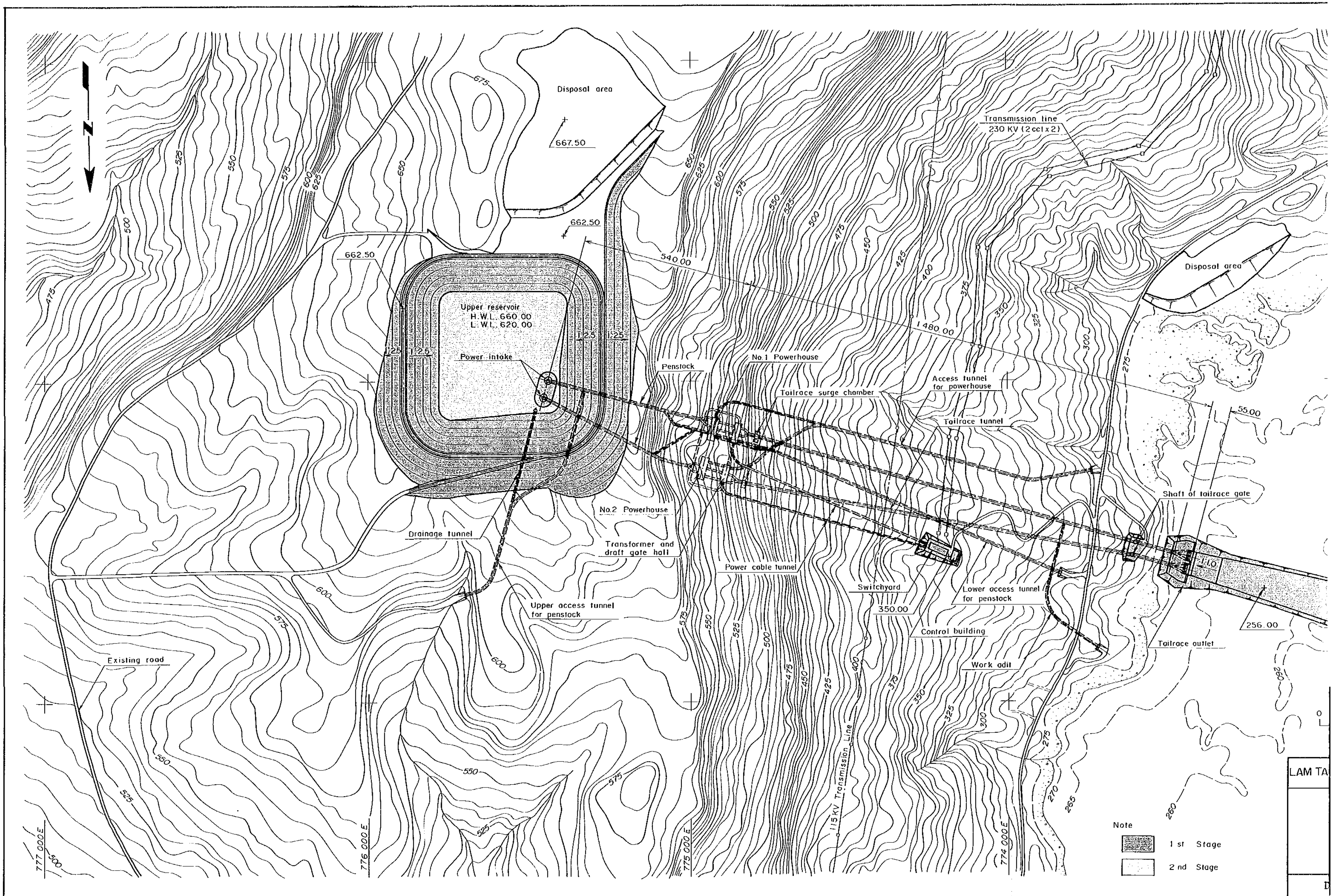


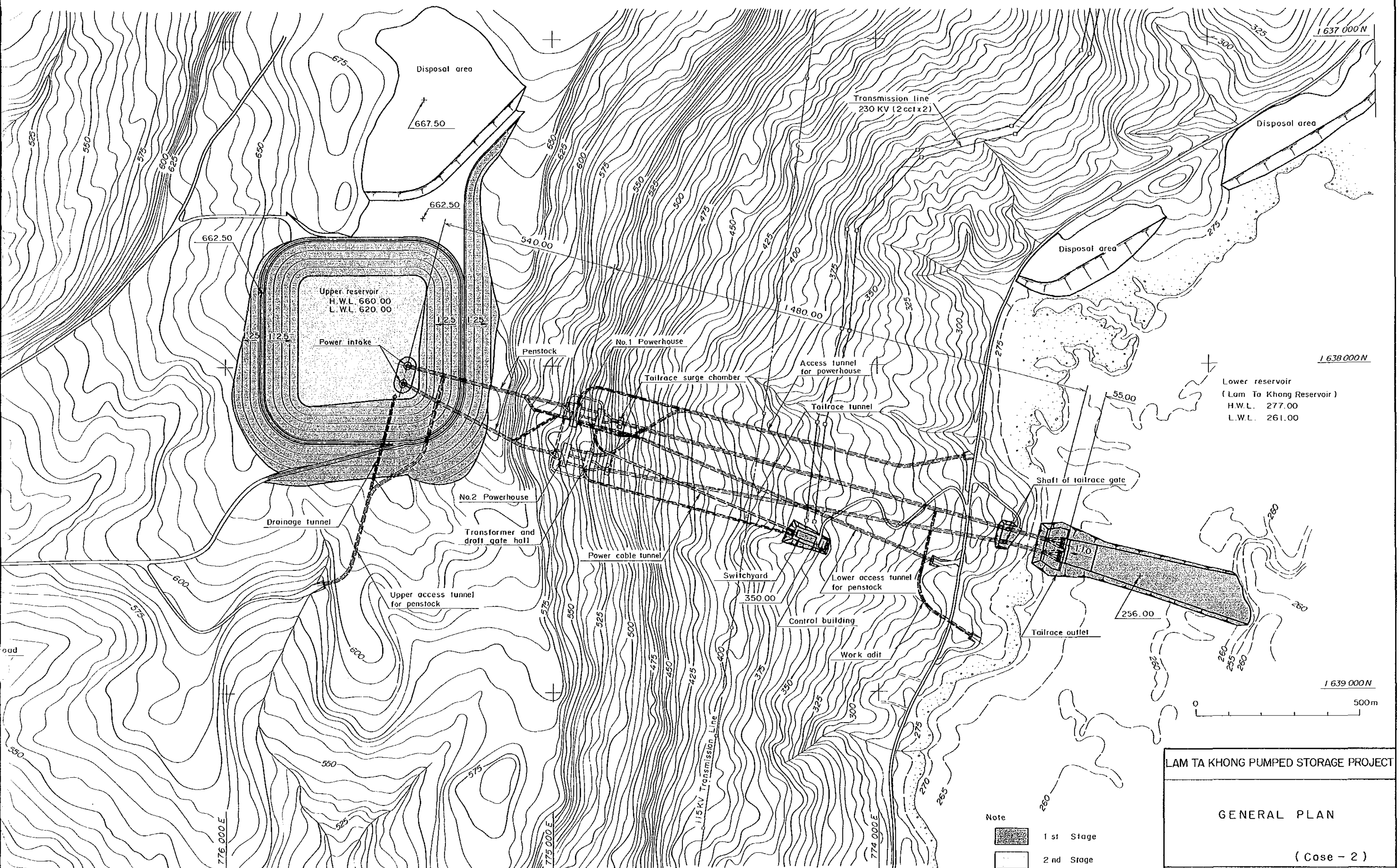
LAM TA KHONG PUMPED STORAGE PROJECT

GENERAL PLAN

(Case - 1)

DWG. 8-1


N
Disposal area
667.50
662.50
662.50
540.00
Upper reservoir
H.W.L. 660.00
L.W.L. 620.00
Power intake
1:2.5
1:2.5
1:2.5
Penstock
No.1 Powerhouse
Tailrace surge chamber
Access tunnel
for powerhouse
Tailrace tunnel
Transmission line
230 KV (2cct x 2)
Disposal area
1480.00
55.00
Shaft of tailrace gate
No.2 Powerhouse
Transformer and
draft gate hall
Drainage tunnel
Power cable tunnel
Switchyard
350.00
Control building
Lower access tunnel
for penstock
Upper access tunnel
for penstock
256.00
Tailrace outlet
Work adit
Existing road
115 KV Transmission Line
777,000 E
776,000 E
775,000 E
774,000 E
LAM TA
Note
1 st Stage
2 nd Stage

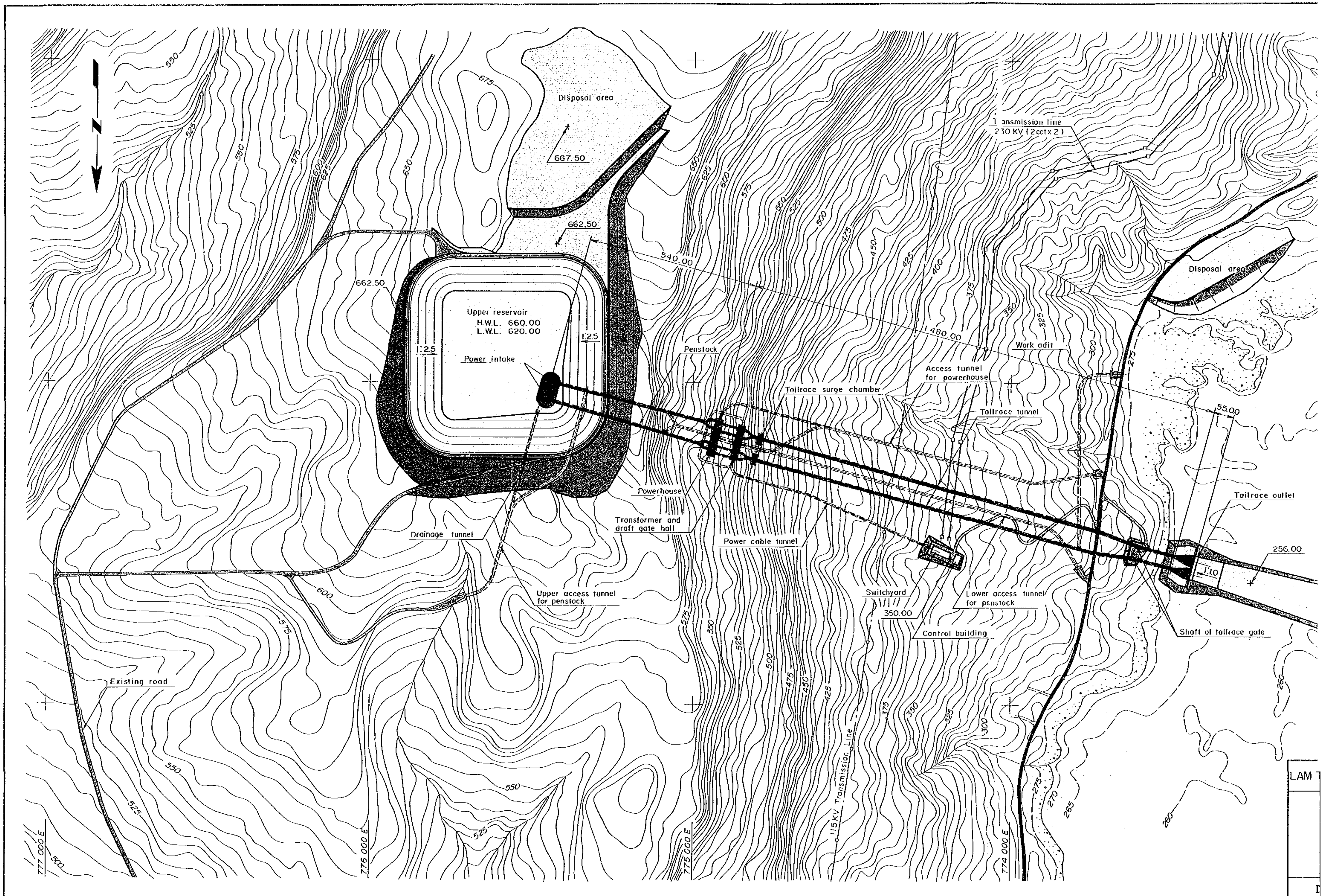


LAM TA KHONG PUMPED STORAGE PROJECT

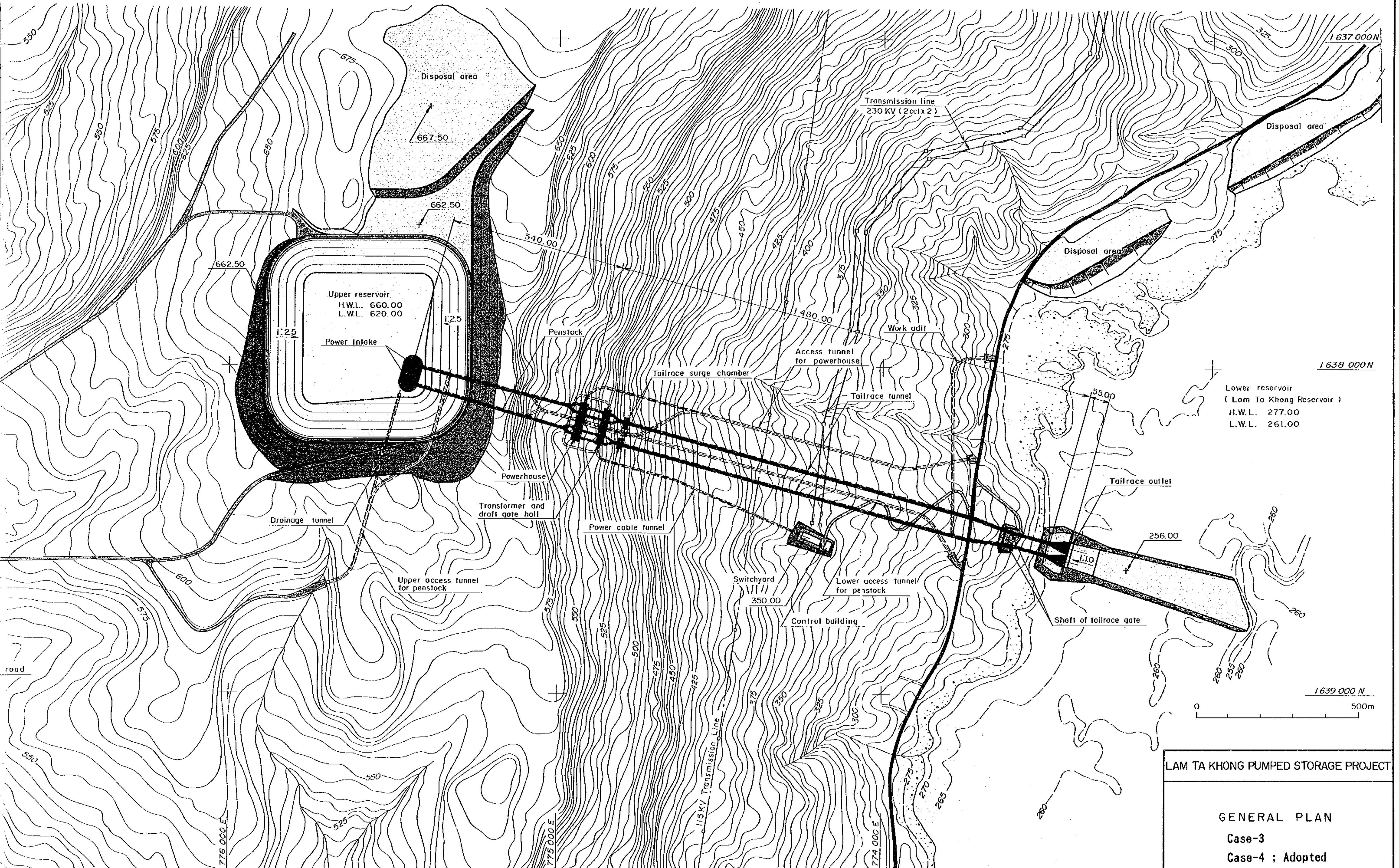
GENERAL PLAN

(Case - 2)

DWG. 8-2



Disposal area
667.50
662.50
540.00
Upper reservoir
H.W.L. 660.00
L.W.L. 620.00
1:2.5
Power intake
Penstock
Tailrace surge chamber
Access tunnel
for powerhouse
Tailrace tunnel
480.00
Work adit
Transmission line
230 KV (2cctx2)
55.00
Tailrace outlet
256.00
1:1.0
Shaft of tailrace gate
Powerhouse
Transformer and
draft gate hall
Power cable tunnel
Drainage tunnel
Upper access tunnel
for penstock
Switchyard
350.00
Control building
Lower access tunnel
for penstock
Existing road
115 KV Transmission Line
777,000 E
776,000 E
775,000 E
774,000 E
LAM T



LAM TA KHONG PUMPED STORAGE PROJECT

GENERAL PLAN

Case-3

Case-4 ; Adopted

DWG. 8-3

9. POWER TRANSMISSION PLAN AND POWER SYSTEM ANALYSIS

9.1 Capacity of Lam Ta Khong Project from Power System Analysis

Capacity of Lam Ta Khong project was studied by the power system stability analysis on the power system in 1997-2000.

Several alternatives were studied with regard to capacity ranging from 450 MW to 1,000 MW, but 500 MW and 600 MW were studied especially in detail.

The results of the analyses are as follows:

(1) In case the project is developed in 1997, the power for pumping at off-peak time is limited to 500 MW by the power system stability.

(2) Pumping power larger than 600 MW would require quite a lot of investment to the power system to solve the power system instability.

(3) There is, however, no problems of the stability for generating 1,000 MW at peak time.

The plant can have a capacity of 1,000 MW by installing four units with a capacity of 250 MW each from the beginning of service, which enables to generate 1,000 MW at peak time, but only two units at most can be operated for pumping at off-peak time because of the stability problem.

Fig. 9-1 and Fig. 9-2 show power flows on the power system at peak time and at night time in 1997 respectively according as this pattern of plant operation.

The results of power flow calculation show that there are no problems such as overloading on Mae Moh - Tha Tako - Thalan 3 - Saraburi 2 transmission system which has close connection to power transmission for Lam Ta Khong pumped storage, but the Thalan 3 - Ang Thong 2 transmission line may be overloaded when the plant generates 1,000 MW. Some measures should be taken to avoid this problem.

Reactive power facilities are required to be installed at many substations to hold voltages at the appropriate level.

The voltages at Saraburi 2 substation and Nakhon Ratchasima 2 substation need to be maintained with great care, since they are close to the pumped storage.

It is necessary to study installing reactive power facilities at each substation, along with the detail study of the project development.

To maintain the voltage of each substation invariably at about 100% or slightly over 100% of the nominal value is necessary from a viewpoint of making the power system more stable and stronger.

Power system stability at pumping hours will be very severe after the end of nineteen-nineties. Therefore, it is necessary to study reinforcement of the power system, in order to develop the power sources in the northern area and enable the Lam Ta Khong power plant to pump up by three or four units for the purpose of making effective use of the equipment.

9.2 Power Transmission Plan

The way to send power generated by Lam Ta Khong project depends on the developing scale of the project.

As a result of power system analyses, it has been cleared that the Lam Ta Khong power plant can generate 1,000 MW at peak time in 1997. Therefore, we have made up a plan of power transmission to meet that power.

The recommended power transmission plan is as follows:

(1) Lam Ta Khong power Plant is connected by π connection to the existing 230 kV transmission line which runs in the vicinity of the project site between Saraburi 2 and Nakhon Ratchasima 2 substations.

(2) In addition, the plant is connected to the newly constructed Thalan 3 substation by means of a 230 kV double-circuit transmission line.

(3) That is, two double-circuit 230 kV transmission lines must be constructed to connect the Lam Ta Khong power plant to the power system.

(4) The conductor to be used for these transmission lines is ACSR 1272 MCM which is used for the above existing line.

Fig. 9-1 POWER FLOW DIAGRAM
1997 PEAK

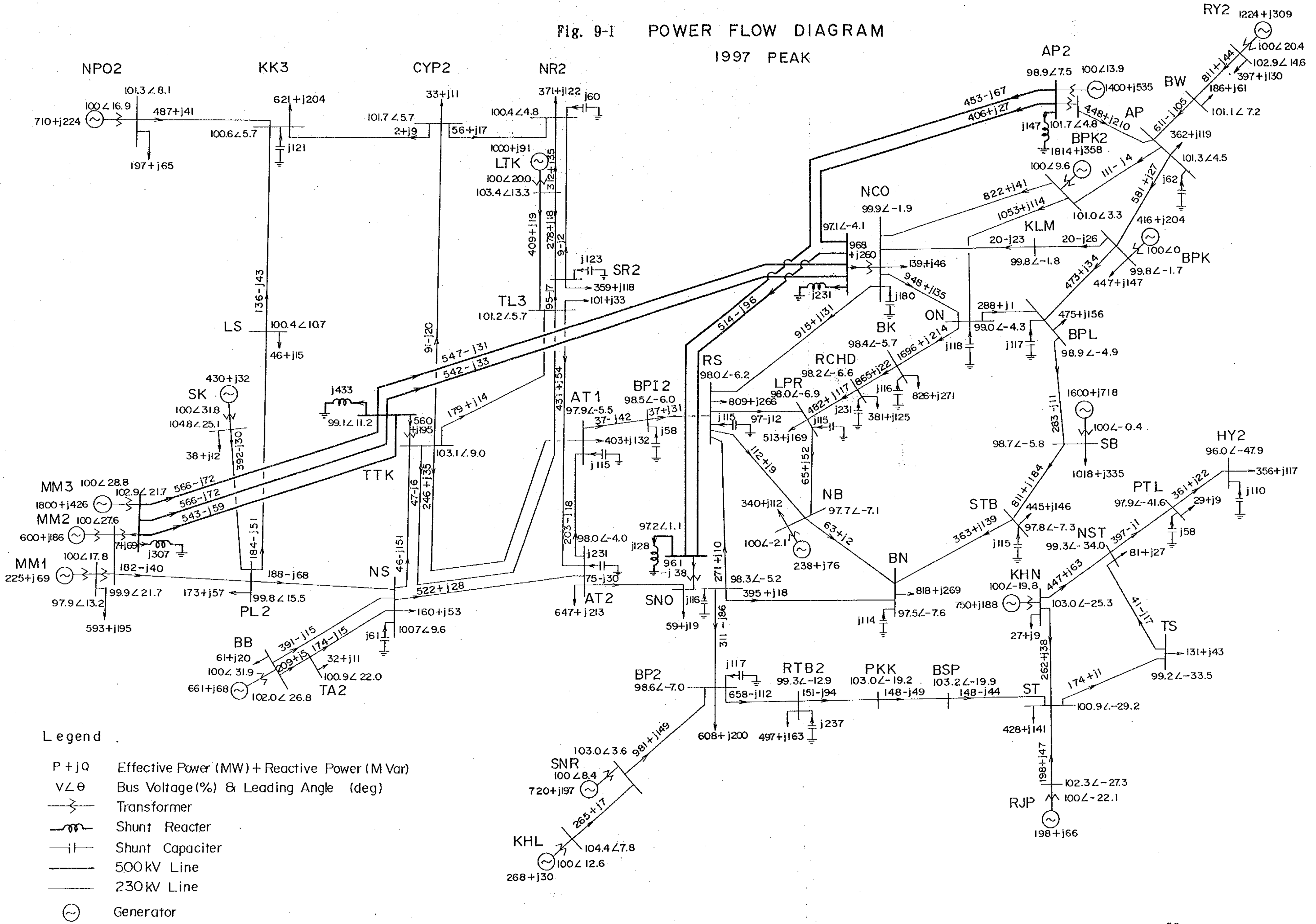


Fig. 9-2 POWER FLOW DIAGRAM

1997 NIGHT