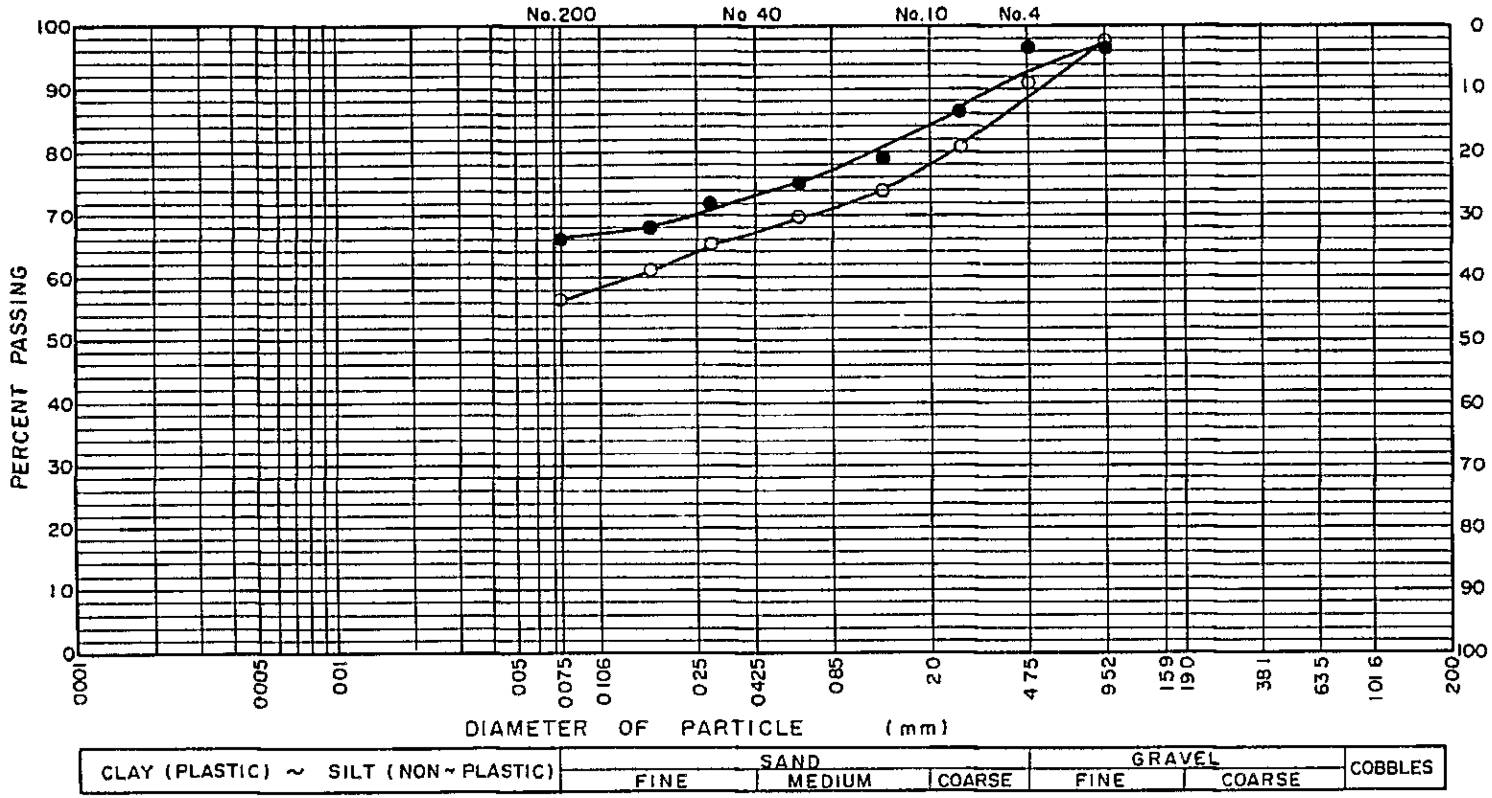


SAMPLE NO.				
MAX. GRAIN SIZE mm (%)				
19.0 mm (%)				
4.75 mm (%)				
0.075 mm (%)				
D_{60} (mm)				
D_{30} (mm)				
D_{10} (mm)				
Cu				
Cc				

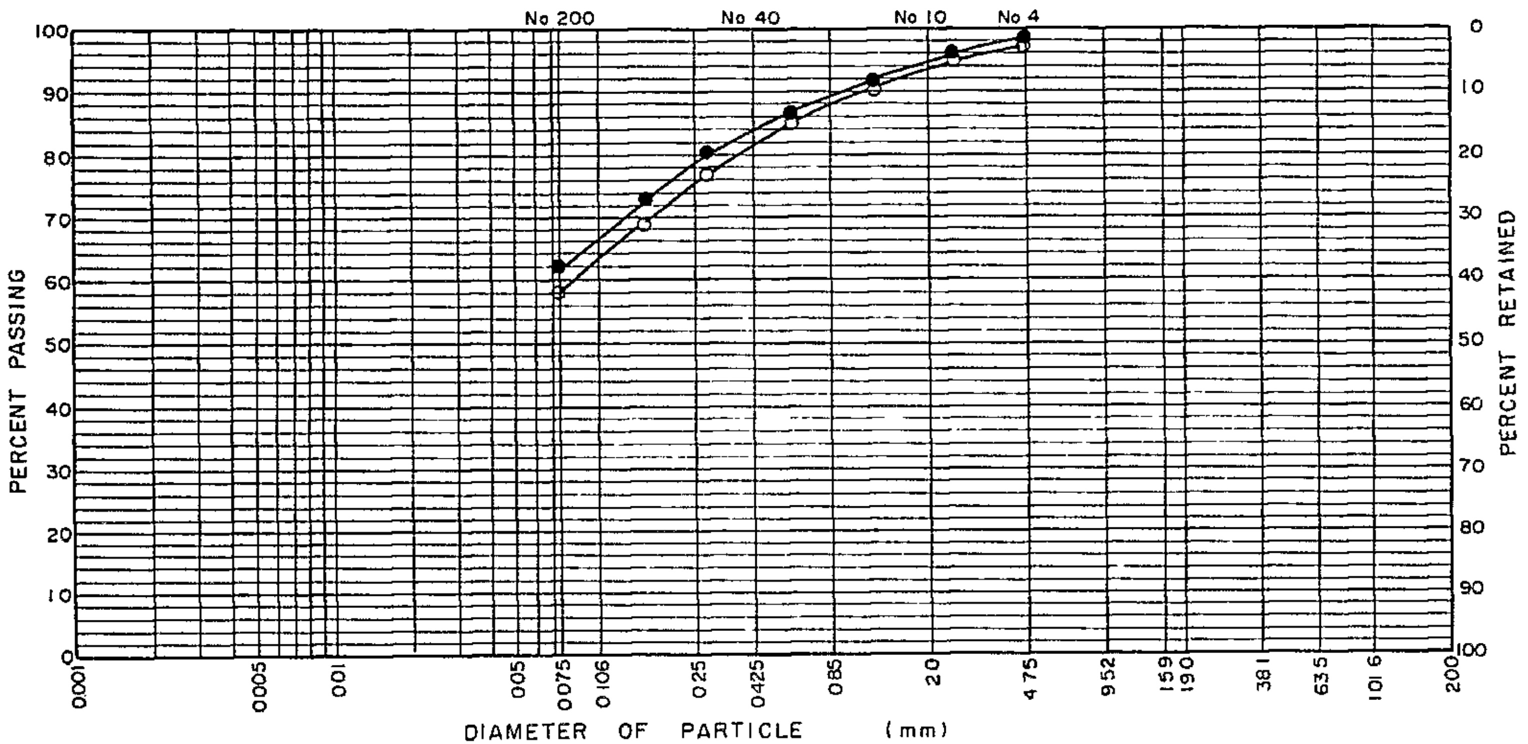
$Cu = \frac{D_{60}}{D_{10}}$ COEFFICIENT OF UNIFORMITY

$Cc = \frac{(D_{30})^2}{(D_{60}) \times (D_{10})}$ COEFFICIENT OF CURVATURE

○ BEFORE COMPACTION
● AFTER COMPACTION

SAMPLE		SOIL CLASSIFICATION		SPECIFIC GRAVITY		ATTERBERG LIMITS			
NUMBER	DEPTH (m)	UNIFIED SYSTEM	REVISED P.R. SYSTEM			LL	PL	PI	SL
P-10	25	SC	A-7-6(2)		2.71	42.2	23.2	19.0	

2-2-7(1) Gradation Analysis after Compaction (Representative Samples of Fine Materials)



CLAY (PLASTIC) ~ SILT (NON ~ PLASTIC)	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE NO				
MAX GRAIN SIZE mm (%)				
mm 19.0 (%)				
mm 4.75 (%)				
mm 0.075 (%)				
D_{60} (mm)				
D_{30} (mm)				
D_{10} (mm)				
Cu				
Cc				

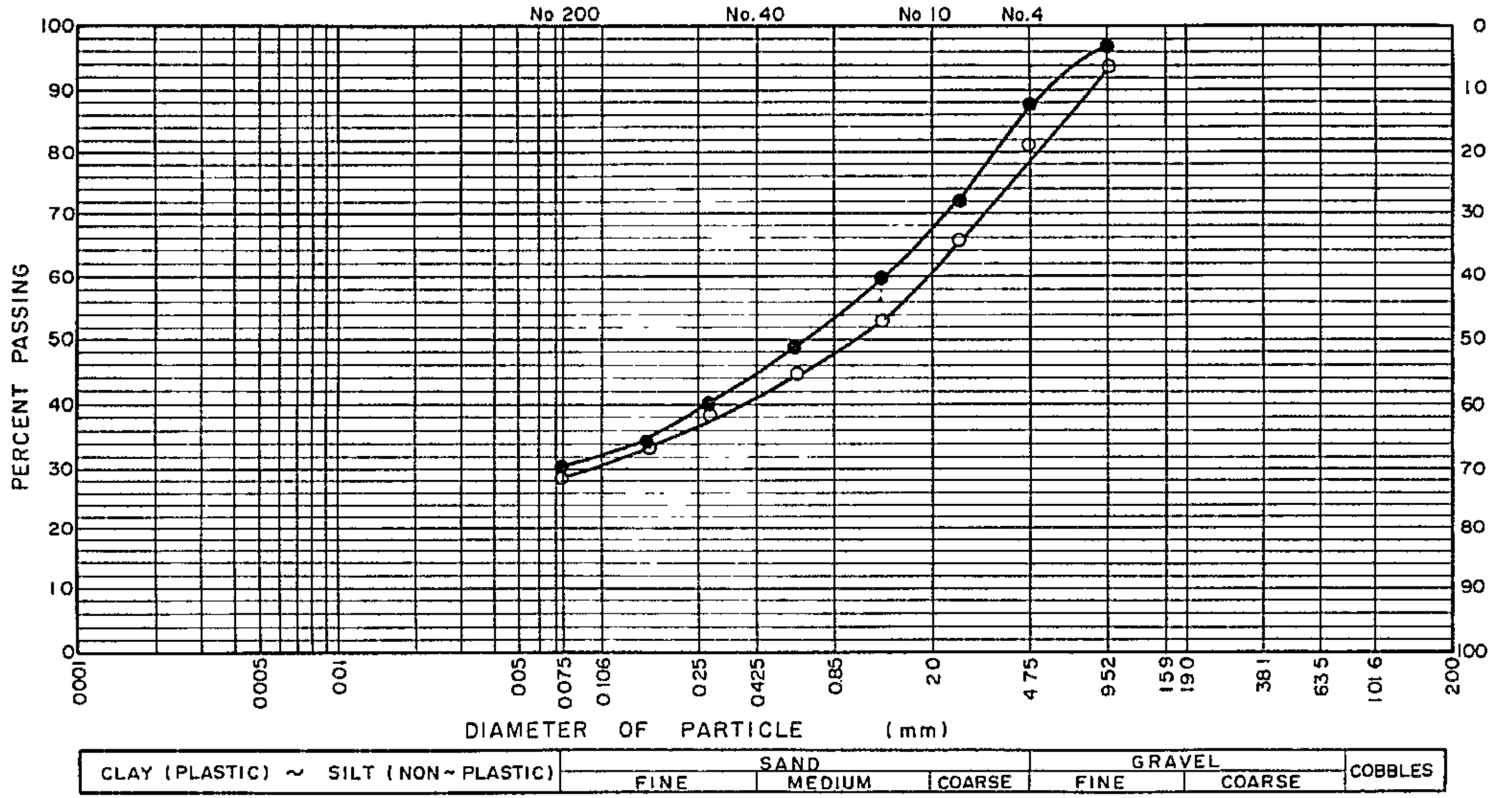
$Cu = \frac{D_{60}}{D_{10}}$ COEFFICIENT OF UNIFORMITY

$Cc = \frac{(D_{30})^2}{(D_{60}) \times (D_{10})}$ COEFFICIENT OF CURVATURE

SAMPLE		SOIL CLASSIFICATION		SPECIFIC GRAVITY		ATTERBERG LIMITS			
NUMBER	DEPTH (m)	UNIFIED SYSTEM	REVISED P.R. SYSTEM			LL	PL	PI	SL
P-25	30	CL	A-6(5)		2.61	30.8	17.2	13.6	

○ BEFORE COMPACTION
● AFTER COMPACTION

2-2-7 (2) Gradation Analysis after Compaction (Representative Samples of Fine Materials)



SAMPLE NO				
MAX GRAIN SIZE mm (%)				
mm 19.0 (%)				
mm 4.75 (%)				
mm 0.075 (%)				
D_{60} (mm)				
D_{30} (mm)				
D_{10} (mm)				
Cu				
Cc				

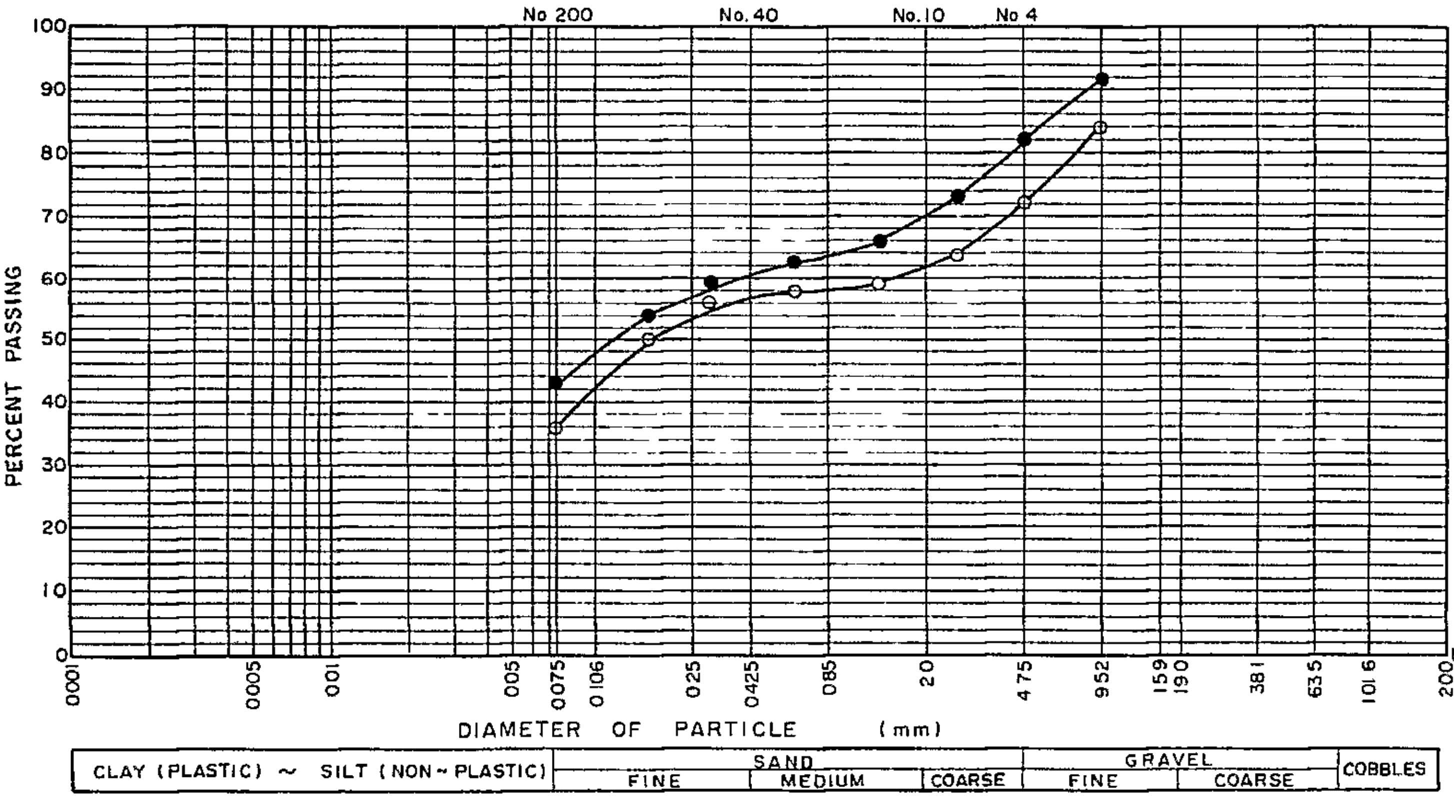
$Cu = \frac{D_{60}}{D_{10}}$ COEFFICIENT OF UNIFORMITY

$Cc = \frac{(D_{30})^2}{(D_{60}) \times (D_{10})}$ COEFFICIENT OF CURVATURE

○ BEFORE COMPACTION
● AFTER COMPACTION

SAMPLE		SOIL CLASSIFICATION		SPECIFIC GRAVITY		ATTERBERG LIMITS			
NUMBER	DEPTH (m)	UNIFIED SYSTEM	REVISED P.R. SYSTEM			LL	PL	PI	SL
P-19	1.5	SC	A-2-6(1)		2.67	36.2	22.1	14.1	

2-2-7 (3) Gradation Analysis after Compaction (Representative Samples of Medium Materials)



SAMPLE NO				
MAX. GRAIN SIZE mm (%)				
mm 19.0 (%)				
mm 4.75 (%)				
mm 0.075 (%)				
D_{60} (mm)				
D_{30} (mm)				
D_{10} (mm)				
Cu				
Cc				

$Cu = \frac{D_{60}}{D_{10}}$

COEFFICIENT OF UNIFORMITY

$Cc = \frac{(D_{30})^2}{(D_{60}) \times (D_{10})}$

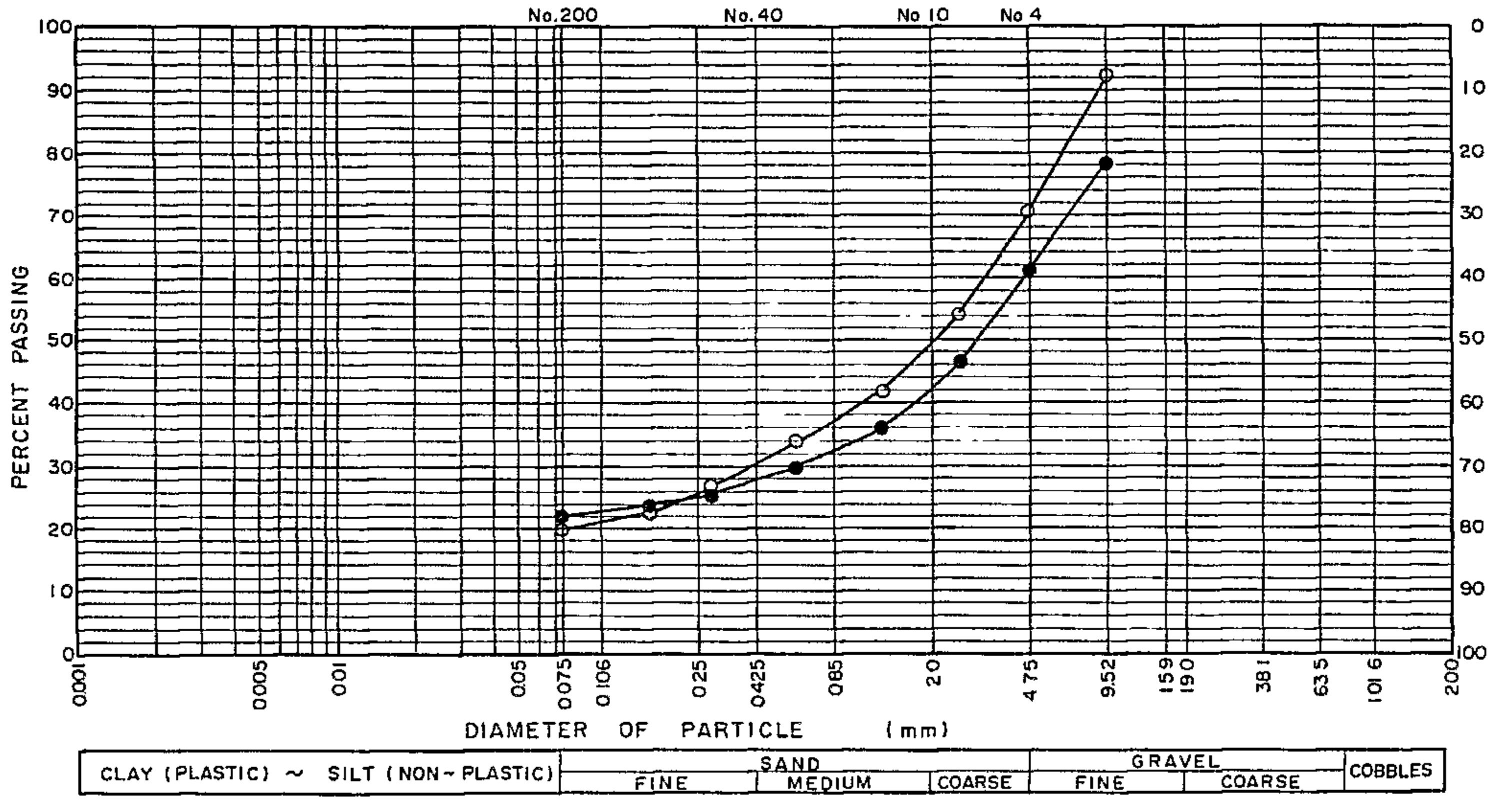
COEFFICIENT OF CURVATURE

SAMPLE		SOIL CLASSIFICATION		SPECIFIC GRAVITY		ATTERBERG LIMITS			
NUMBER	DEPTH (m)	UNIFIED SYSTEM	REVISED P.R. SYSTEM			LL	PL	PI	SL
P-29	4.5	SC	A-2-6(0)		2.71	37.0	19.6	17.4	

○ BEFORE COMPACTION

● AFTER COMPACTION

2-2-7(4) Gradation Analysis after Compaction (Representative Samples of Mediun Materials)



SAMPLE NO.				
MAX GRAIN SIZE mm (%)				
9.0 mm (%)				
4.75 mm (%)				
0.075 mm (%)				
D_{60} (mm)				
D_{30} (mm)				
D_{10} (mm)				
Cu				
Cc				

$$Cu = \frac{D_{60}}{D_{10}}$$

COEFFICIENT OF UNIFORMITY

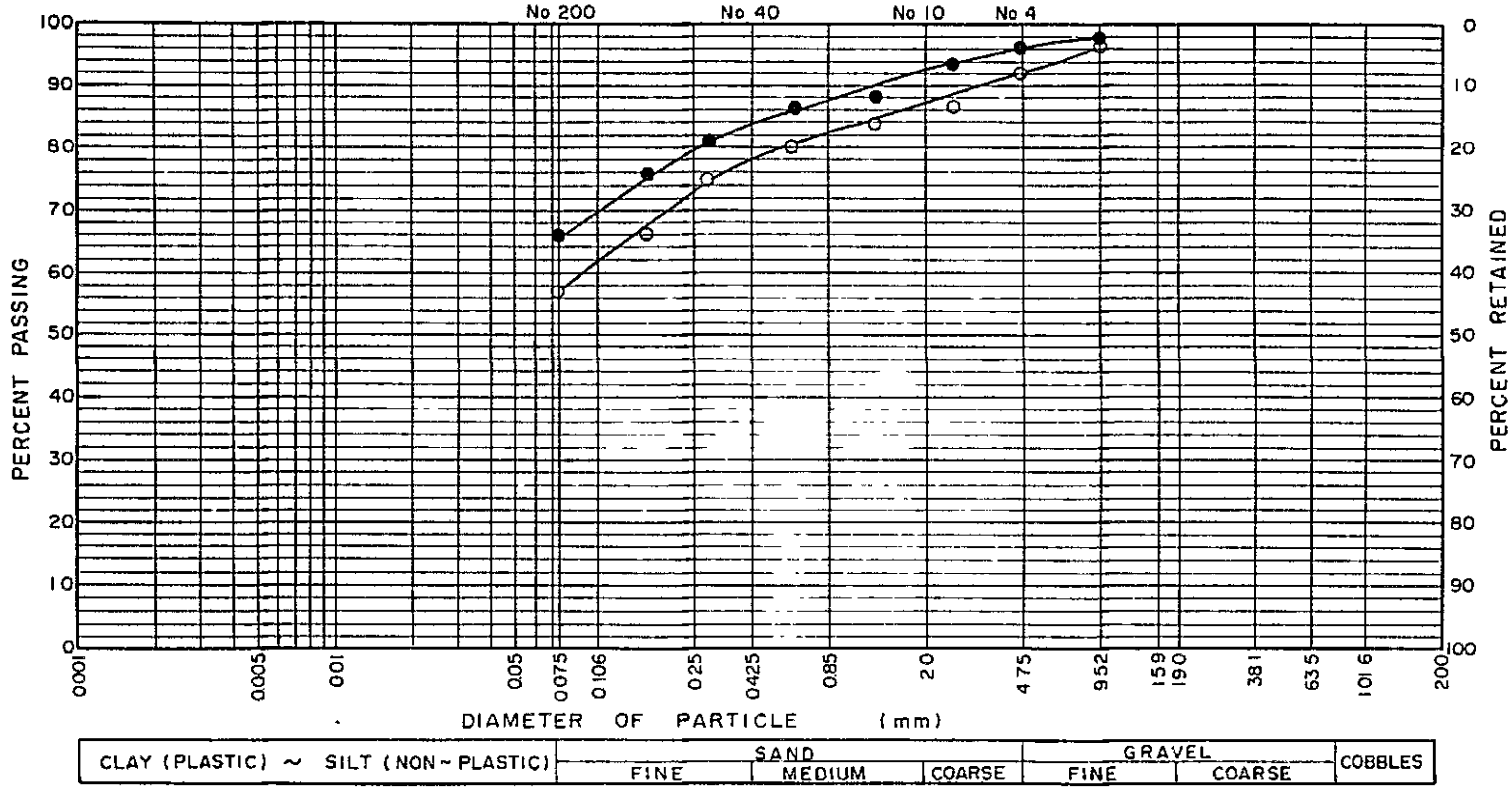
$$Cc = \frac{(D_{30})^2}{(D_{60}) \times (D_{10})}$$

COEFFICIENT OF CURVATURE

○ BEFORE COMPACTION
● AFTER COMPACTION

SAMPLE		SOIL CLASSIFICATION		SPECIFIC GRAVITY		ATTERBERG LIMITS			
NUMBER	DEPTH (m)	UNIFIED SYSTEM	REVISED P.R. SYSTEM			LL	PL	PI	SL
P-20	4.5	GW-GC	A-2-6(0)		2.77	36.4	21.5	14.9	

2-2-7 (5) Gradation Analysis after Compaction (Representative Samples of Coarse Materials)



SAMPLE NO				
MAX GRAIN SIZE mm (%)				
mm 19.0 (%)				
mm 4.75 (%)				
mm 0.075 (%)				
D_{60} (mm)				
D_{30} (mm)				
D_{10} (mm)				
Cu				
Cc				

$Cu = \frac{D_{60}}{D_{10}}$ COEFFICIENT OF UNIFORMITY

$Cc = \frac{(D_{30})^2}{(D_{60}) \times (D_{10})}$ COEFFICIENT OF CURVATURE

○ BEFORE COMPACTION
● AFTER COMPACTION

SAMPLE		SOIL CLASSIFICATION		SPECIFIC GRAVITY		ATTERBERG LIMITS			
NUMBER	DEPTH (m)	UNIFIED SYSTEM	REVISED P.R. SYSTEM			LL	PL	PI	SL
P-25	4.7	GC	A-2-6(0)		265	281	157	124	

2-2-7 (6) Gradation Analysis after Compaction (Representative Samples of Coarse Materials)

2-3-1 Results of Tests for Coarse Aggregate

1. Quarry Site A-1

Test for Soundness of Coarse Aggregate by Use of Sodium Salfate

Kind of Specimen	Prepared Sample	Weight of Test Fractions before Test g	Weight of Test Fractions after Test g	Weight Passing Designated Sieve after Test g	Percentage Passing Designated Sieve after Test	Remarks
Ledge Rock	Broken Fragments of 100 g (each) are used	5,000	4996.20	3 80	0.076	–

Constituent	No. of Particles before Test	No. of Particles after Test					
		Split	Crumbled	Cracked	Flaked	Sound	Total
	41	–	–	9	–	32	41

Test for Resistance to Abrasion of Coarse Aggregate by Use of the Los Angeles Machine (Gradation A)

Kind of Specimen	Sieve Size		Before Test		After Test		Percentage of Wear
	Passing	Retained on	Weight of Sample g	Total Weight g	Weight of Materials coarser than No. 12 Sieve (after washing and drying in an oven at 105°C to 110°C) g	Weight of Materials Loss g	
Ledge Rock	1 1/2" 1" 3/4" 1/2"	1" 3/4" 1/2" 3/8"	1,250 1,250 1,250 1,250	5,000	3,290	1,710	34.2

2. Quarry Site B

Test for Soundness of Coarse Aggregate by Use of Sodium Salfate

Kind of Specimen	Sieve Size			Grading of Original Sample percent	Weight of Test Fractions before Test g	Percentage Passing Designated Sieve after Test	Weighted Percentage Loss
A Mixture of Quartzite and Silt stone	1 1/2" to 3/4"	1 1/2" to 1" 1" to 3/4"	1,010 g 518 g	72.20	1,528	0.97	0.70
	3/4" to 3/8"	3/4" to 1/2" 1/2" to 3/8"	672 g 334 g	26.10	1,006	3.07	0.80
		3/8" to No.4	300 g	1.70	300	3.07	0.05
	Total			100.00	2,834		1.55

Test for Resistance to Abrasion of Coarse Aggregate by Use of the Los Angeles Machine (Gradation A)

Kind of Specimen	Sieve Size		Before Test		After Test		Percentage of wear
	Passing	Retained on	Weight of Sample g	Total Weight g	Weight of Materials coarser than No. 12 Sieve (after washing and drying in an oven at 105°C to 110°C) g	Weight of Materials Loss g	
A Mixture of Quartzite and Silt stone	1 1/2" 1" 3/4" 1/2"	1" 3/4" 1/2" 3/8"	1,256 1,251 1,253 1,252	5,012	4,254	758	15.1

APPENDIX 3

DESIGN OF STRUCTURES

APPENDIX 3 DESIGN OF STRUCTURES

CONTENTS

LIST OF FIGURES

APPENDIX 3 DESIGN OF STRUCTURES

Introduction

Upper Quae Yai Project consists of the main power station of Nam Chon Power Station of output of 580,000 kW and Thi Khong Power Station of output of 51,000 kW utilizing the head between Nam Chon Power Station and Srinagarind Reservoir.

Nam Chon Project site is to be located 141 km upstream from the Srinagarind and Thi Khong Project site be located about 8 km downstream from the proposed Nam Chon Project site.

The general features of the Upper Quae Yai Project are given below:

Nam Chon Power Station

Catchment area	4,908 km^2
Annual mean inflow	2,975 x 10^6 m^3
Reservoir normal high water level	EL. 370 m
Reservoir min. water level	EL. 331 m
Total storage capacity	5,975 x 10^6 m^3
Effective storage capacity	4,100 x 10^6 m^3
Reservoir surface area	137 x 10^6 m^3 (at EL. 370 m)
Power generation	
Max. output	580,000 kW
Annual energy production	1,095 x 10^6 kWh
Dam	
Type	Rockfill dam with center core
Height	185 m
Volume	12.7 x 10^6 m^3
Main electrical equipment	
Turbine and generator capacities	145,000 kW
Number of units	4

Thi Khong Power Station

Catchment area	5,145 km^2

Annual mean inflow	$3,090 \times 10^6$ m^3
Regulating pond normal high water level	EL. 197 m
Regulating pond normal min. water level	EL. 196.8 m (EL. 193.5 m during 1 unit drop)
Total storage capacity	16×10^6 m^3
Effective storage capacity	0.3×10^6 m^3
Pond surface area	1.45×10^6 m^3
Power generation	
Max. output	51,000 kW
Annual energy production	93×10^3 kWh
Dam	
Type	Concrete gravity
Height	32 m
Volume	46×10^3 m^3
Main electrical equipment	
Turbine and generator capacities	25,500 kW
Number of units	2

In this Appendix, major points concerning the design of structures mainly Nam Chon Project, are described below.

1. Selection of Dam Thpe

The area in from about 600 m to about 800 m upstream of the Huai Tong Thai for the setting of dam axis of the Nam Chon Project can be said suitable taking also the layout of appurtenant structures into account.

The types which can be objects of comparison are concrete gravity dam, concrete arch dam and rockfill dam, but considering the geological conditions of the right bank at the site, a thin arch dam would be difficult.

The next to be considered would be concrete gravity dam, but on designing with a downstream slope of 1 : 0.75, the dam volume came out as 3,340,000 m^3, and this was not economically acceptable.

The layout is shown in Fig. 4 for the thin arch dam for reference.

Therefore, the objects of comparison that remained were the following alternatives as shown in Fig. 5:

Rockfill Dam

- Central Sloping Core Type
- Concrete Facing Type

Concrete Dam

- Concrete Arch Dam

(a) Central Core Type Rockfill Dam

An open chute type spillway was selected to be generally considered as a preliminary stage for design, in this case the dam axis would be located approximately 600 m upstream of the Huai Tong Thai as shown in Figs. 6, 7 and 8.

Calculating the dam volume and construction cost according to the above Figs., the results were the following:

Dam Volume = 12,200,000 (m^3)

Construction Cost = 4.3 x 10^9(₿)

Provided that this construction cost consists of costs of civil works and hydraulic equipment, with miscellaneous and contingency costs not included in civil works. It is also noted that the costs concerned was estimated by 1980 price level.

(b) Concrete Facing Type Rockfill Dam

Dam volume was calculated as 9,130,000 m^3 basing on Fig. 9.

Compared with the above-said central core type one, the construction cost is only about 0.2% lower. Furthermore, the following can be said taking the Nam Chon Dam site into consideration:

- Considering that rate of decrease in dam volume is low in such a V-shaped gorge and a separate cofferdam at the upstream of the main dam shall be provided, the construction cost is not so cheap as stated above.
- Provision of a grouting gallery at the left abutment will not be so easy to fit the configuration of the topography.
- Water barrier system at the right abutment will be much complicate and its expectance of grouting efficiency will be in fear.
- There is no precedent in construction of such a high dam having such a large storage of this type.

(c) Concrete Arch Dam

A study of layout having the crest spillway in the center part was made, but this layout was rejected because of difficulty of the arrangement for the powerhouse.

Consequently, the layout having an open chute type spillway at the right bank was selected for comparison as shown in Fig. 10.

Concrete Volume = 1,850,000 m^3

The construction cost was about 15% higher compared with the central core type rockfill dam stated in (a).

In this case, it is necessary to scrutinize the conditions of procurement and transportation of cement, special specified cement, and quantity and quality of cooling and curing water.

2. Rockfill Dam

Regarding the type of the dam, it can be found that a rockfill dam having an impervious core is most appropriate for this site from the comprehensive standpoints including the stated in previous clause.

In this clause, a comparison study of layouts having a spillway at right/left bank is given.

2-1 Layout having Spillway at Right Bank

The geological conditions show that the left bank consists of hard and massive calcareous sandstone with low permeability, and of no problem for the foundation of structure.

In the riverbed portion, it could be judged no special problem through the conventional foundation treatment even though a fault is running.

On the other hand, the geological conditions of the right bank consist of dolomite, conglomerate, calcareous sandstone and limestone. Besides, the rocks at the right bank are prominently weathered and cracked as a whole.

The topographical conditions show that the site is generally very steeply sloped, and the gullies of streams cut into the left bank at upstream and downstream of the dam axis planned while a big gully of stream called Huai Tong Thai cuts into the right bank at downstream of the dam axis planned.

The location of the dam axis seemed appropriate to be situated in approximately 600 m upstream of the Huai Tong Thai in case that the provision of a water-way system and a powerhouse be at the left bank and the provision of diversion tunnels and an open chute type spillway be at the right bank taking the above-mentioned geological and topographical conditions into consideration.

The layout having a spillway at the right bank is given in Figs. 6, 7 and 8 as stated in previous clause.

It can be said that an elimination of poor rock by excavation of spillway foundation and an improvement of it through careful foundation treatment would have no special trouble concerning the karstic limestone, continuing on to downstream the Huai Tong Thai, distributed above approximately EL. 320 m at the right abutment.

2-2 Layout having Spillway at Left Bank

The tunnel spillway and the diversion tunnels were also provided at the left bank from the standpoint of that geological condition.

The location of the powerhouse should have to be shifted approximately 150 m upstream from the downstream-side gully located at the left bank taking the arrangement of the outlet of the spillway (conversion from the diversion tunnels). It goes without saying that material excavated in the downstream of the above-mentioned outlet at the left bank should be one of the dam embankment.

In this case, the location of the dam axis at the right bank should be in approximately 800 m upstream from the standpoint of reservoir watertightness against the the karstic limestone to be avoided as much as possible. It can be found that more noneconomic, getting more the dam axis located upstream in the case of open chute spillway type.

The layout having a tunnel spillway at the left bank is given in Figs. 1, 2 and 3.

2-3 Study on Scale of Spillway (Fig. 1 and Fig. 2)

As explained in the Main Report and the Appendix 1, the relation between reservoir water level and spill discharge was given in Fig. 11.

In adopting the relation mentioned above, an economic comparison regarding the dam height and gate size was made.

At first, the relations between gate size and rising of the reservoir water level were given as shown in Fig. 12.

In order to select the optimum combination concerning the dam height and the gate size from the viewpoint of economy, Figs. 13 and 14 were prepared. In these Figs., description "Spillway Gate Width" means total clear span of spillway gates and description "Civil Works Cost" means total amount of civil works cost including hydraulic equipment.

As can be seen from these Figs., the construction cost of the layout having one spillway tunnel with a crest of EL. 355.0 m came to the nearly same amount as the adopted layout having two spillway tunnels as shown in Figs. 1 and 2.

But, the layout having one spillway tunnel can not be recommended from the standpoints of manufacturing and accidental operation error of a spillway gate.

2-4 Summary

Comparison studies on the selection of dam type for the Nam Chon Project were made from the technical and economical points. As can be found from the result of studies, a rockfill dam having an impervious core is most appropriate for the Project site.

Consequently, the layout having tunnel spillway at the left bank is recommended for the Nam Chon Project basing on the available data from the viewpoint of reservoir watertightness against the karstic limestone (Figs. 1, 2 and 3).

Further investigations in progress should be required to fix the location of the dam axis.

3. Other Principal Structures (Figs. 1, 2 and 3)

3-1 Power Intake and Headrace Tunnel

Considerations as for the reduction of the length of the waterway system from the power intakes to the powerhouse and of the amount of the open-cut excavation were given in the study.

The intakes are the reinforced concrete structure with 2 pieces of the roller gate each of 8 m in width and 10 m in height.

The headrace tunnels each of 7.9 m inner diameter, which are composed of two lines of 370 m and 450 m length, have maximum discharge capacity of 460 m^3/s and is connected to the chamber type surge tanks of each 11 m inner diameter.

The penstocks are to be embedded steel pipes bifurcated at upper parts so that 2-lines will become four (inner diameter 5.00 m to 4.20 m, length 260 m) to connect to each turbine.

3-2 Study on the Ground Surface-type Penstock

Considering the topographical and geological conditions, the water-way system should be arranged at the left bank.

The layout having the ground surface-type penstocks at the left bank as shown in Fig. 15 was studied.

The construction cost of this type is larger than one of the embedded type by 10 percent at least.

In addition to the above, if the layout having 4-lines ground surface-type penstocks was adopted, its construction cost would be jumped up.

Therefore, it was made clear that the layout having the ground surface-type penstocks was not suitable for the Nam Chon Project.

3-3 Powerhouse and Switchyard

As stated in previous clause, the location of the powerhouse should be arranged at the left bank.

At first, the project layout having an open chute type spillway at the right bank was considered.

In such a case, the powerhouse should be situated in the gully of the downstream side stream from the dam axis at the left bank in order to decrease the quantity of the excavation works.

The space behind the dam should be for the switchyard.

A comparative layout for the powerhouse having 2 and 4 units was made as shown in Figs. 6 & 8 and Figs. 16 & 17.

As the result of the study, the powerhouse with 2 units seemed better for the Nam Chon Project.

But, later, a comprehensive study was given from the view points of operation and maintenance of the units, the layout having 4 units was most suitable for this Project.

On the other hand, the layout having tunnel spillways at the left bank was also studied as indicated in Fig. 1.

In such a case, the location of the powerhouse should be shifted upstream side for siting the outlets of the spillway tunnels, and the tailrace bay was considered for the switchyard.

4. Thi Khong Project

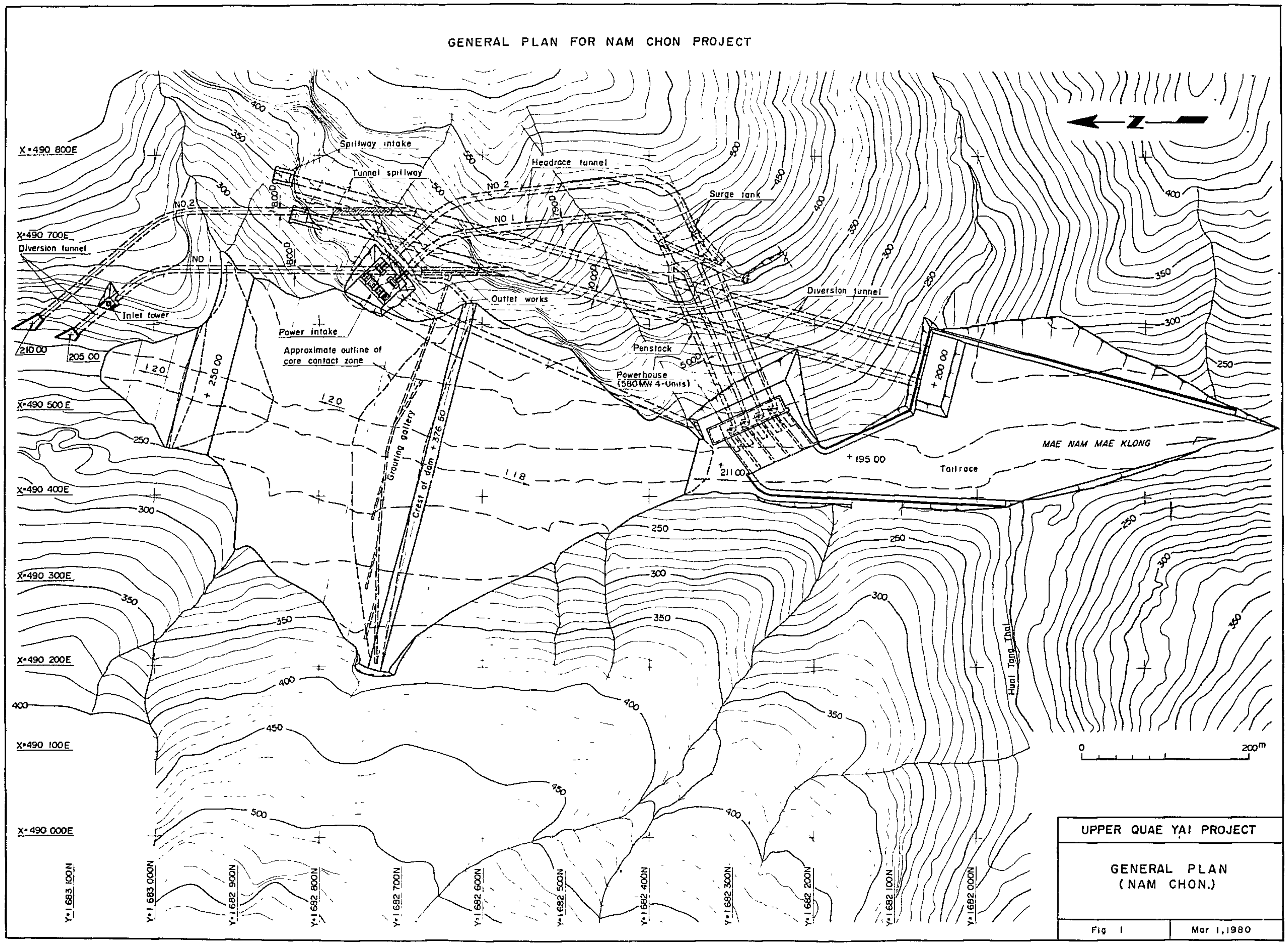
As stated in Main Report, this Project site is located approximately 8 km downstream from the Nam Chon damsite and has slopes of approximately 25° at the right bank and approximately 30° at the left bank, but conversely, good foundation rock is reached under approximately 4 m of talus deposit at the right bank and approximately 8 m at the left bank.

Regarding the arrangement of structures, as shown in Fig. 18, the spillway is to be located at the present thalweg to quickly discharge the runoff of approximately 2,800 m^3/s during floods, while it was judged best location of the powerhouse at the right bank side where the talus deposit is thinner.

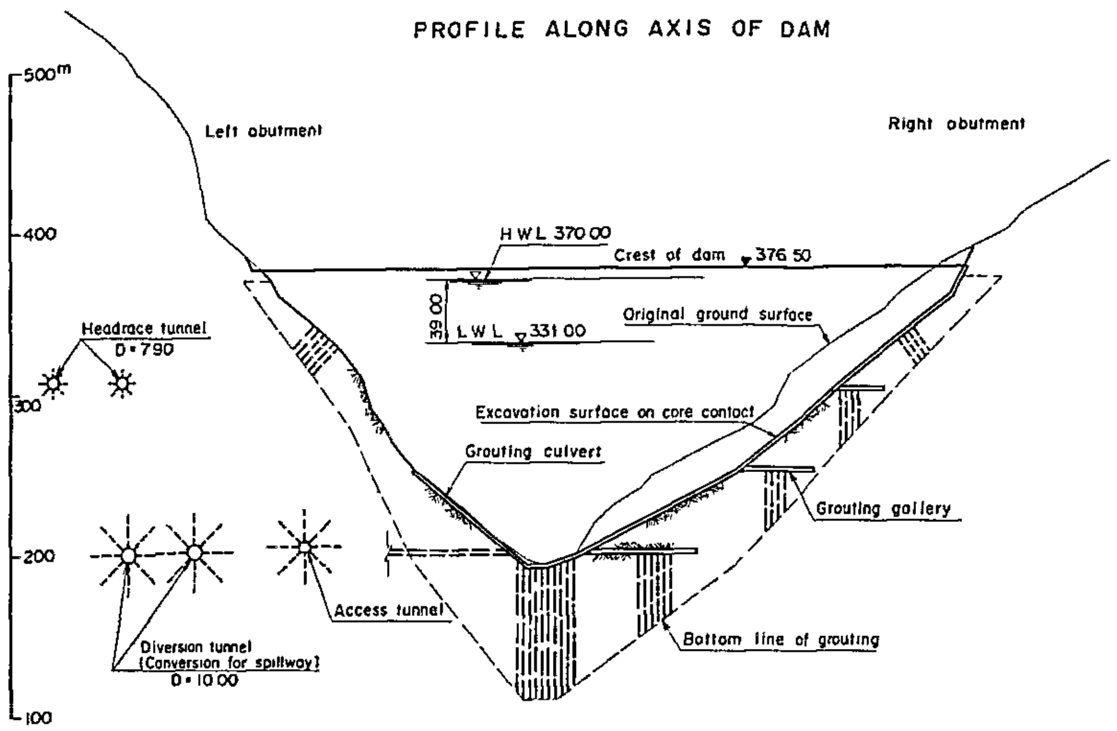
On the other hand, the restudy concerning the power-up of the power station in order to make most use of the remaining head between the Nam Chon Power Station and the Srinagarind Reservoir was made based on river bed profile obtained.

Accordingly, a large increase in head can not be looked forward to even if the damsite were to be moved downstream.

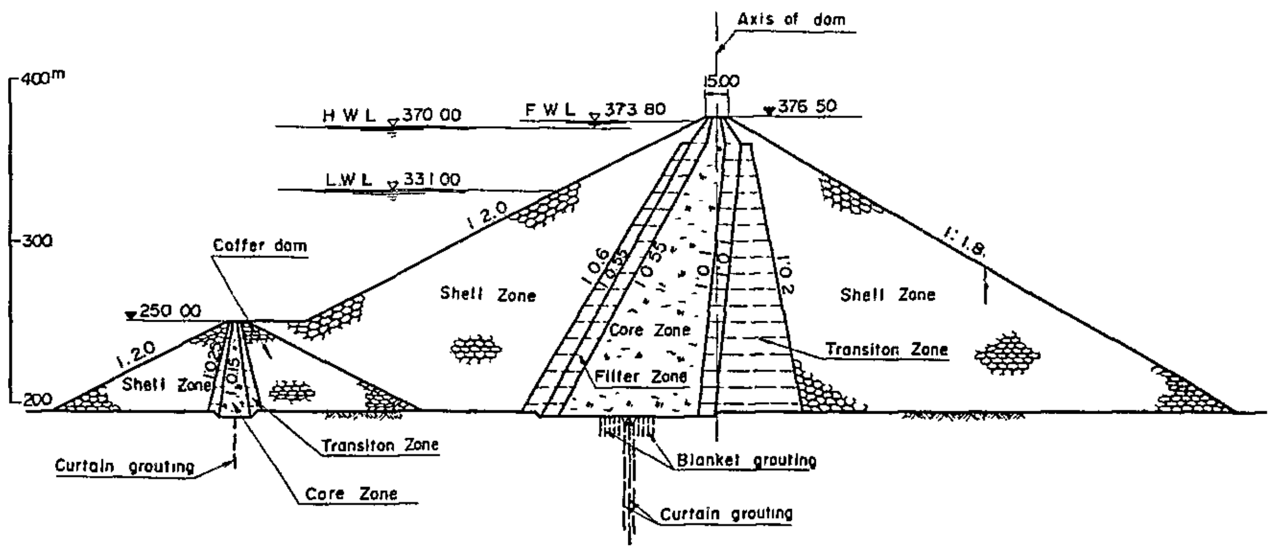
It would be possible to increase the head if lowering of the river bed at this part could be readily done both economically and technically.


GENERAL PLAN FOR NAM CHON PROJECT
Spillway intake
Tunnel spillway
Headrace tunnel
Surge tank
NO 2
NO 1
Diversion tunnel
Inlet tower
Power intake
Outlet works
Approximate outline of core contact zone
Grouting gallery
Crest of dam
Penstock
Powerhouse (580MW 4-Units)
Diversion tunnel
MAE NAM MAE KLONG
Tailrace
Huai Tang Thai
X=490 800E
X=490 700E
X=490 500E
X=490 400E
X=490 300E
X=490 200E
X=490 100E
X=490 000E
Y=1 683 100N
Y=1 683 000N
Y=1 682 900N
Y=1 682 800N
Y=1 682 700N
Y=1 682 600N
Y=1 682 500N
Y=1 682 400N
Y=1 682 300N
Y=1 682 200N
Y=1 682 100N
Y=1 682 000N
UPPER QUAE YAI PROJECT
GENERAL PLAN
(NAM CHON.)
Fig 1
Mar 1,1980

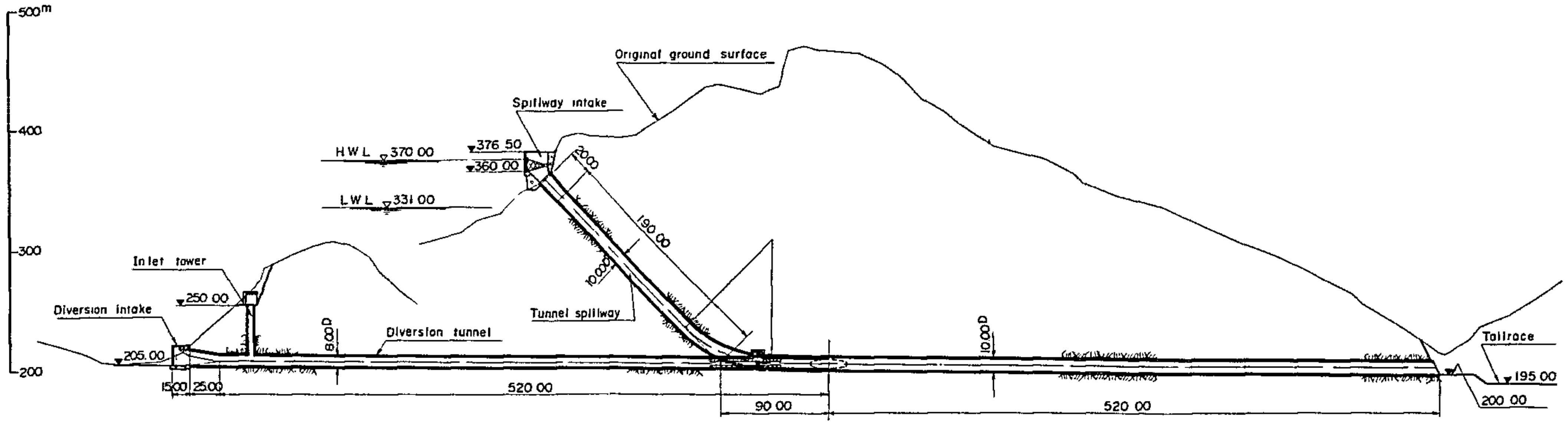
PROFILE ALONG AXIS OF DAM



TYPICAL SECTION OF DAM

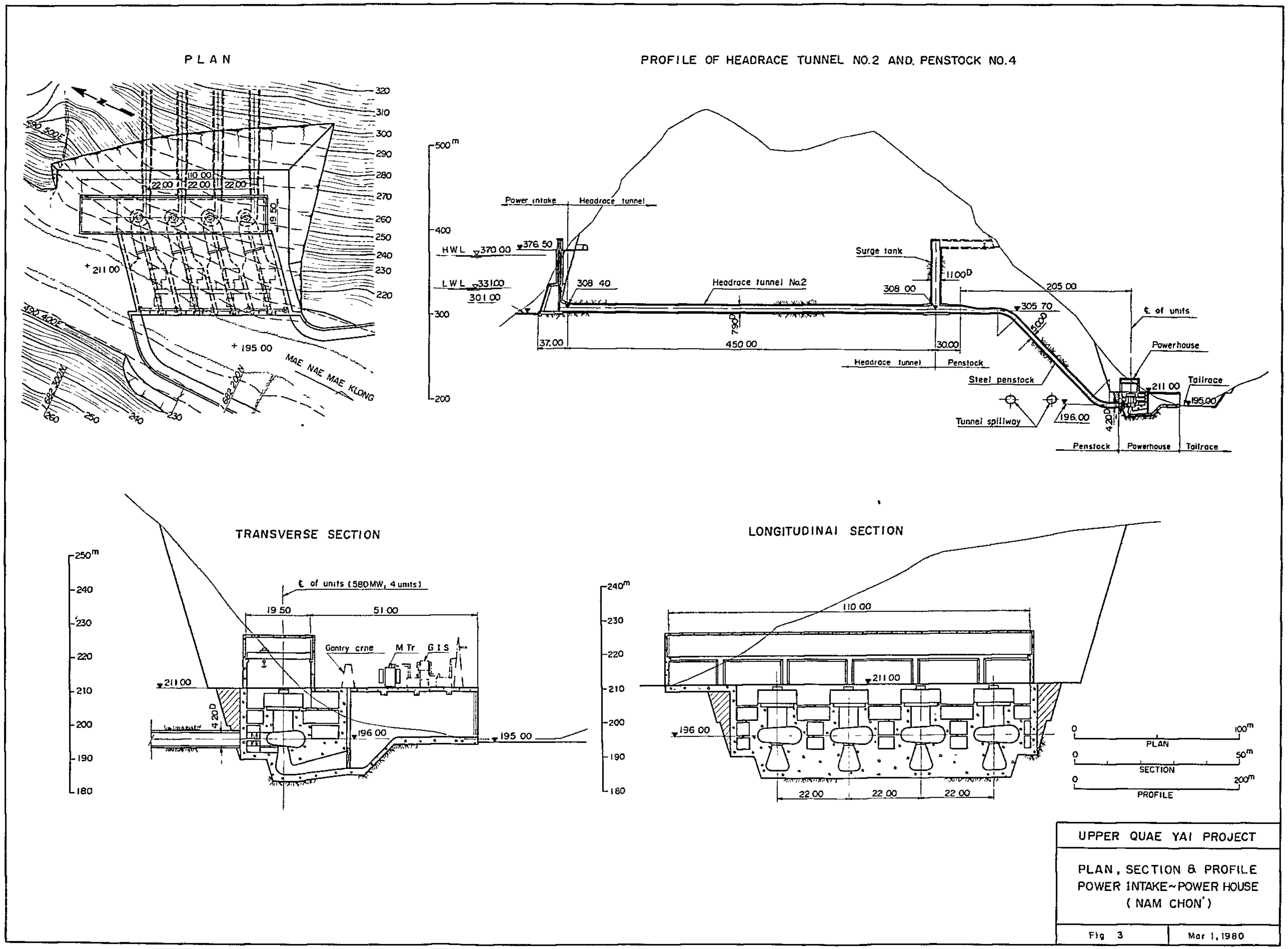


PROFILE OF DIVERSION TUNNEL NO.1 AND TUNNEL SPILLWAY NO.1



0 200m

UPPER QUAE YAI PROJECT	
TYPICAL SECTION & PROFILE PRINCIPAL STRUCTORE (NAM CHON)	
Fig 2	Mar 1,1980


PLAN
PROFILE OF HEADRACE TUNNEL NO.2 AND PENSTOCK NO.4
MAE NAE MAE KLONG
+ 195 00
+ 211 00
Power intake
Headrace tunnel
HWL 370 00
376 50
LWL 331 00
301 00
308 40
Headrace tunnel No.2
Surge tank
308 00
11 00D
205 00
305 70
℄ of units
Powerhouse
37 00
450 00
30 00
Headrace tunnel
Penstock
Steel penstock
211 00
Tailrace
195 00
Tunnel spillway
196 00
Penstock
Powerhouse
Tailrace
TRANSVERSE SECTION
℄ of units (580MW, 4 units)
19 50
51 00
Gantry crne
M Tr
G I S
196 00
195 00
LONGITUDINAL SECTION
110 00
211 00
196 00
22 00
22 00
22 00
PLAN
SECTION
PROFILE
UPPER QUAE YAI PROJECT
PLAN, SECTION & PROFILE
POWER INTAKE~POWER HOUSE
(NAM CHON')
Fig 3
Mar 1, 1980

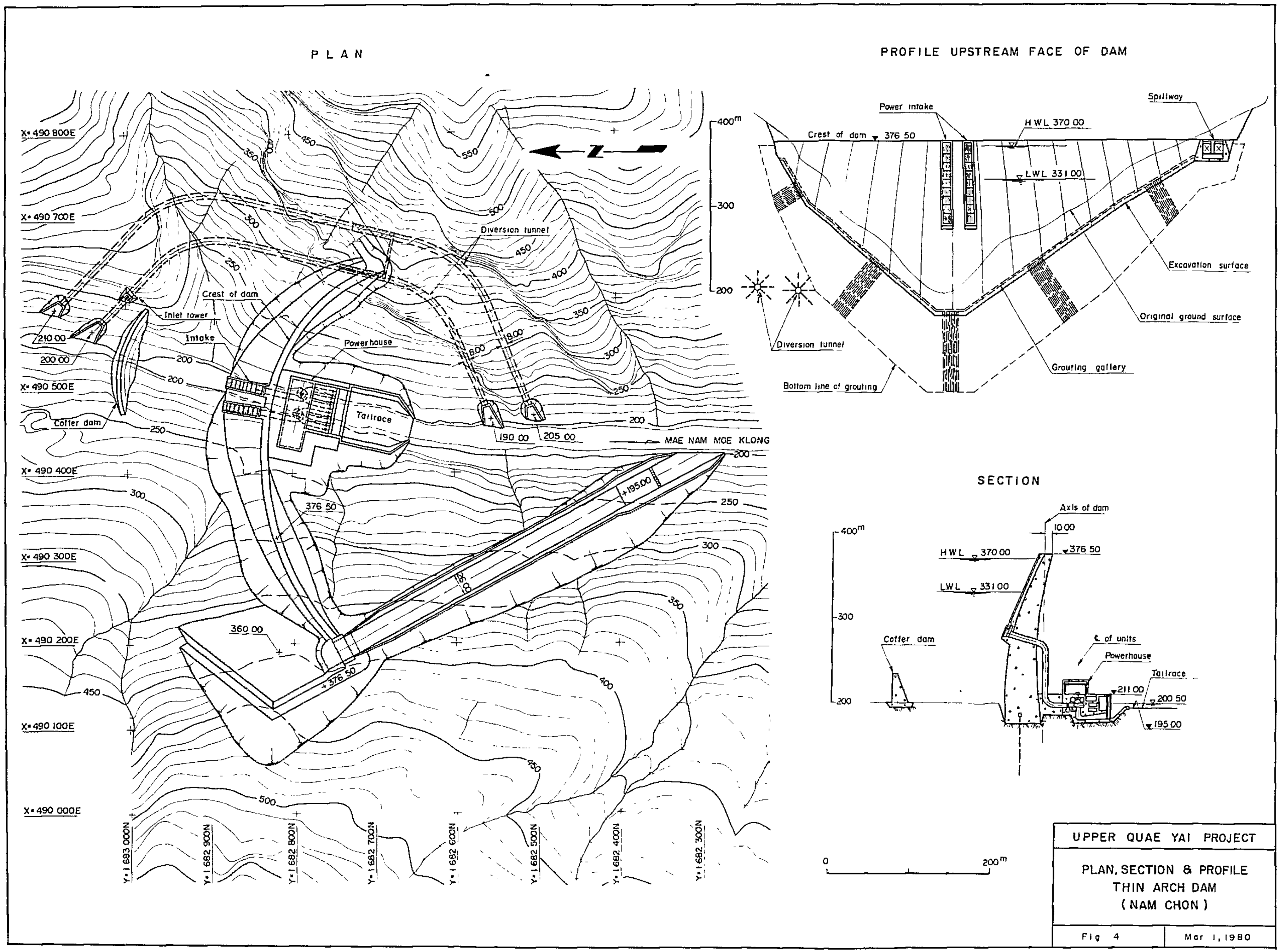
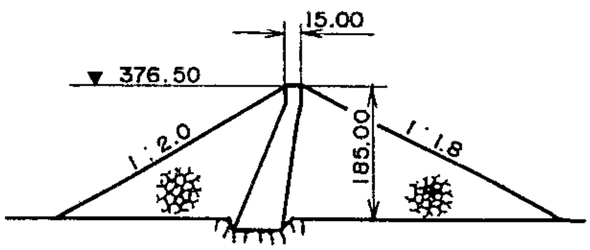
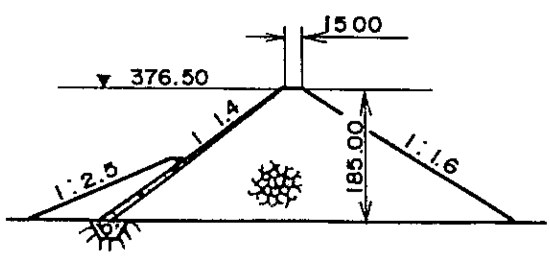

PLAN
PROFILE UPSTREAM FACE OF DAM
SECTION
X= 490 800E
X= 490 700E
X= 490 500E
X= 490 400E
X= 490 300E
X= 490 200E
X= 490 100E
X= 490 000E
Y= 1 683 000N
Y= 1 682 900N
Y= 1 682 800N
Y= 1 682 700N
Y= 1 682 600N
Y= 1 682 500N
Y= 1 682 400N
Y= 1 682 300N
Diversion tunnel
Crest of dam
Inlet tower
Intake
Powerhouse
Tailrace
Coffer dam
MAE NAM MOE KLONG
210.00
200.00
190.00
205.00
376.50
360.00
+195.00
Power intake
Crest of dam 376.50
HWL 370.00
LWL 331.00
Spillway
Excavation surface
Original ground surface
Grouting gallery
Bottom line of grouting
Axis of dam
10.00
HWL 370.00
LWL 331.00
Coffer dam
℄ of units
Powerhouse
Tailrace
211.00
200.50
195.00
0
200m
UPPER QUAE YAI PROJECT
PLAN, SECTION & PROFILE
THIN ARCH DAM
(NAM CHON)
Fig 4
Mar 1, 1980

Fig. 5 Typical Cross Section of Dam

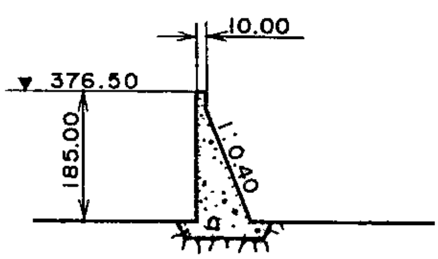
Central Sloping Core Type Rockfill Dam

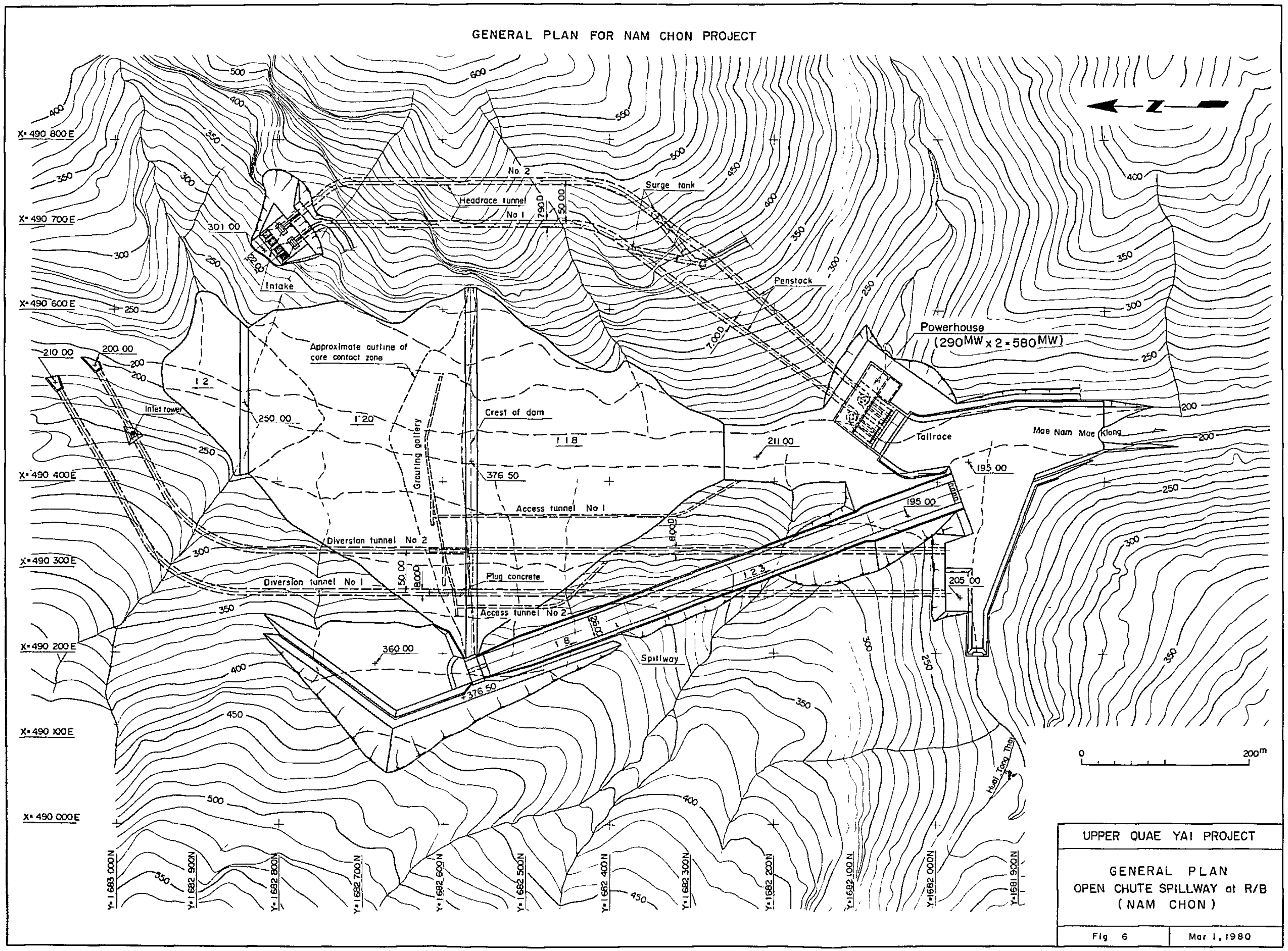


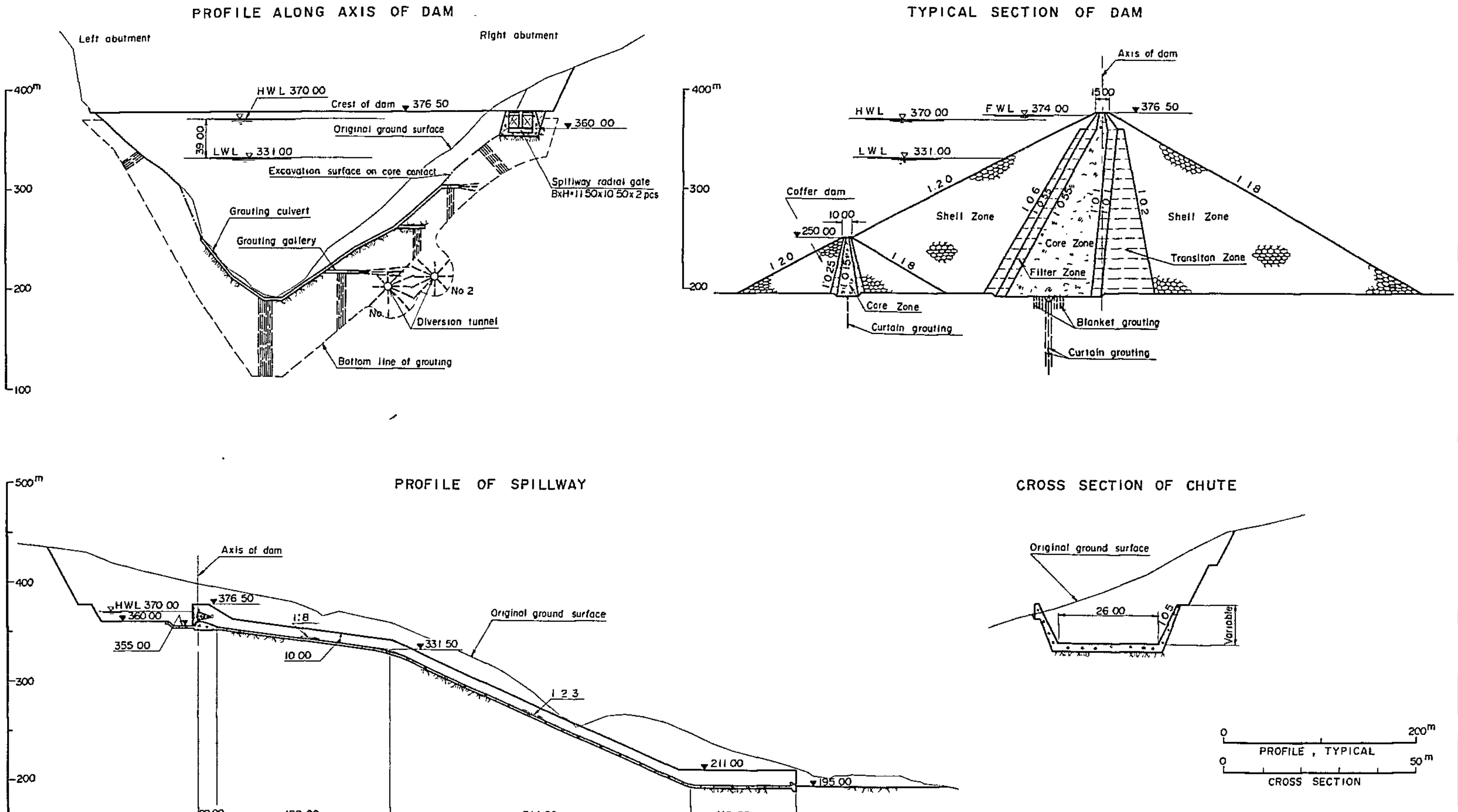
Concrete Facing Type Rockfill Dam



Concrete Arch Dam



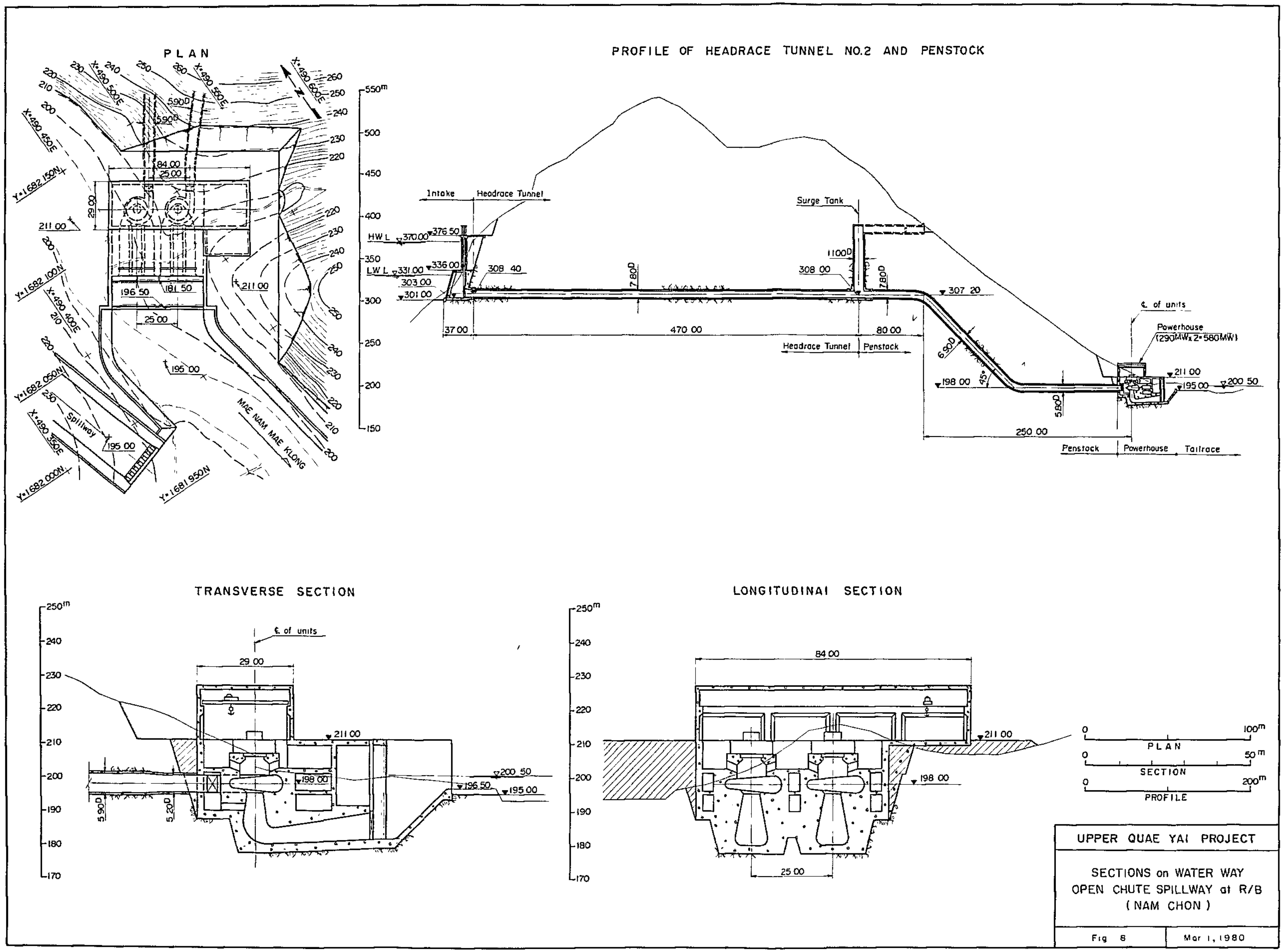

GENERAL PLAN FOR NAM CHON PROJECT
Headrace tunnel
No 2
No 1
Surge tank
Penstock
Intake
Powerhouse
(290MW x 2 = 580MW)
Tailrace
Mae Nam Mae Klong
Inlet tower
Approximate outline of core contact zone
Crest of dam
Grouting gallery
Access tunnel No 1
Access tunnel No 2
Diversion tunnel No 2
Diversion tunnel No 1
Plug concrete
Spillway
Huai Tong Thai
UPPER QUAE YAI PROJECT
GENERAL PLAN
OPEN CHUTE SPILLWAY at R/B
(NAM CHON)
Fig 6
Mar 1, 1980

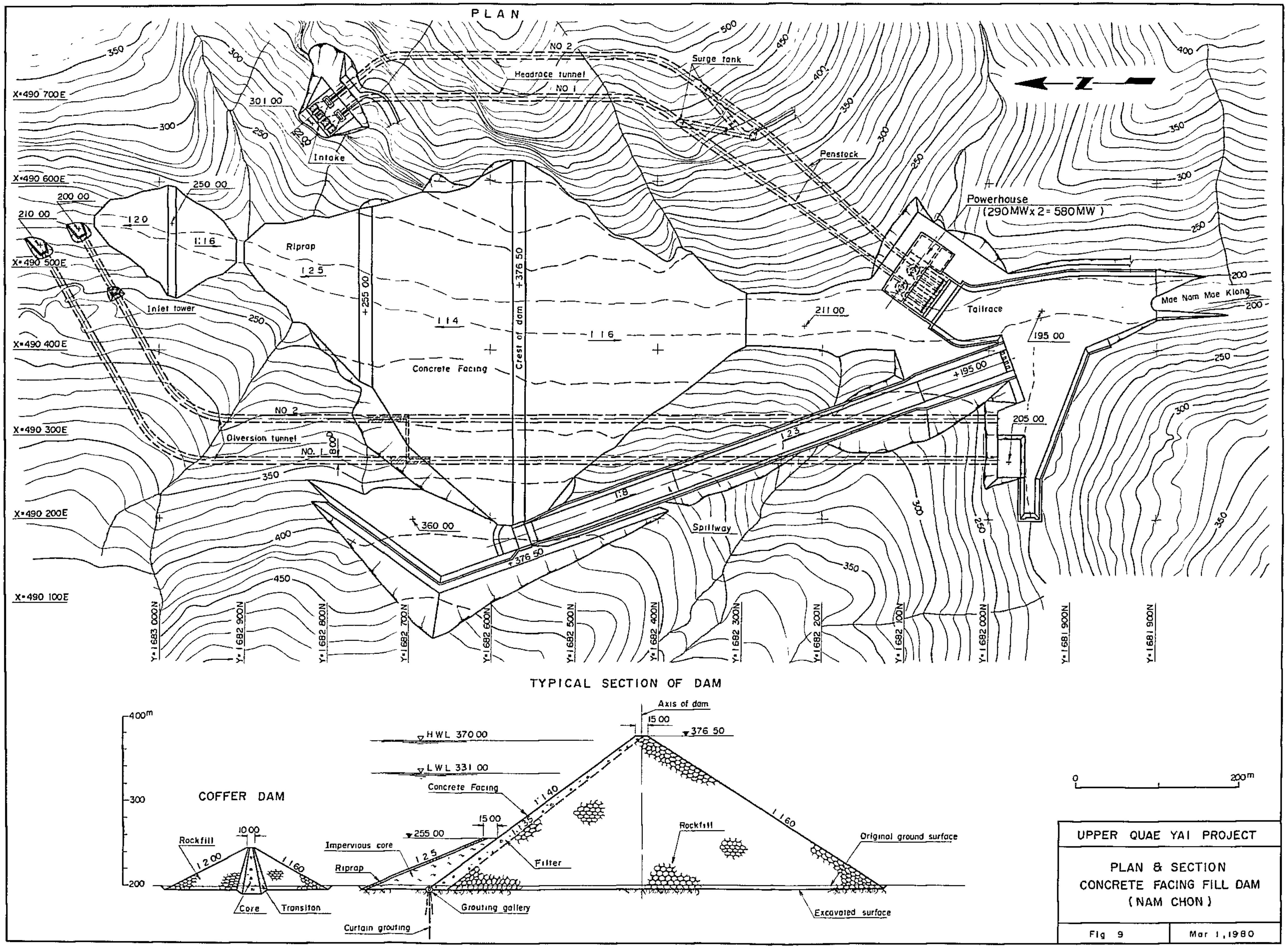


UPPER QUAE YAI PROJECT

TYPICAL SECTION & PROFILE
OPEN CHUTE SPILLWAY at R/B
(NAM CHON)

Fig 7	Mar 1, 1980


PLAN
PROFILE OF HEADRACE TUNNEL NO.2 AND PENSTOCK
Intake
Headrace Tunnel
Surge Tank
HWL 370.00
LWL 331.00
Headrace Tunnel
Penstock
Powerhouse (290MW x 2 = 580MW)
℄ of units
Penstock
Powerhouse
Tailrace
MAE NAM MAE KLONG
Spillway
TRANSVERSE SECTION
LONGITUDINAL SECTION
PLAN
SECTION
PROFILE
UPPER QUAE YAI PROJECT
SECTIONS on WATER WAY
OPEN CHUTE SPILLWAY at R/B
(NAM CHON)
Fig 8
Mar 1, 1980


PLAN
Headrace tunnel
NO 2
NO 1
Surge tank
Intake
Penstock
Powerhouse
(290MW x 2 = 580MW)
Tailrace
Mae Nam Mae Klong
Riprap
Concrete Facing
Crest of dam
Inlet tower
Diversion tunnel
Spillway
X=490 700E
X=490 600E
X=490 500E
X=490 400E
X=490 300E
X=490 200E
X=490 100E
Y=1683 000N
Y=1682 900N
Y=1682 800N
Y=1682 700N
Y=1682 600N
Y=1682 500N
Y=1682 400N
Y=1682 300N
Y=1682 200N
Y=1682 100N
Y=1682 000N
Y=1681 900N
TYPICAL SECTION OF DAM
COFFER DAM
Axis of dam
HWL 370 00
LWL 331 00
376 50
255 00
Concrete Facing
Impervious core
Riprap
Filter
Rockfill
Original ground surface
Excavated surface
Grouting gallery
Curtain grouting
Core
Transition
UPPER QUAE YAI PROJECT
PLAN & SECTION
CONCRETE FACING FILL DAM
(NAM CHON)
Fig 9
Mar 1, 1980

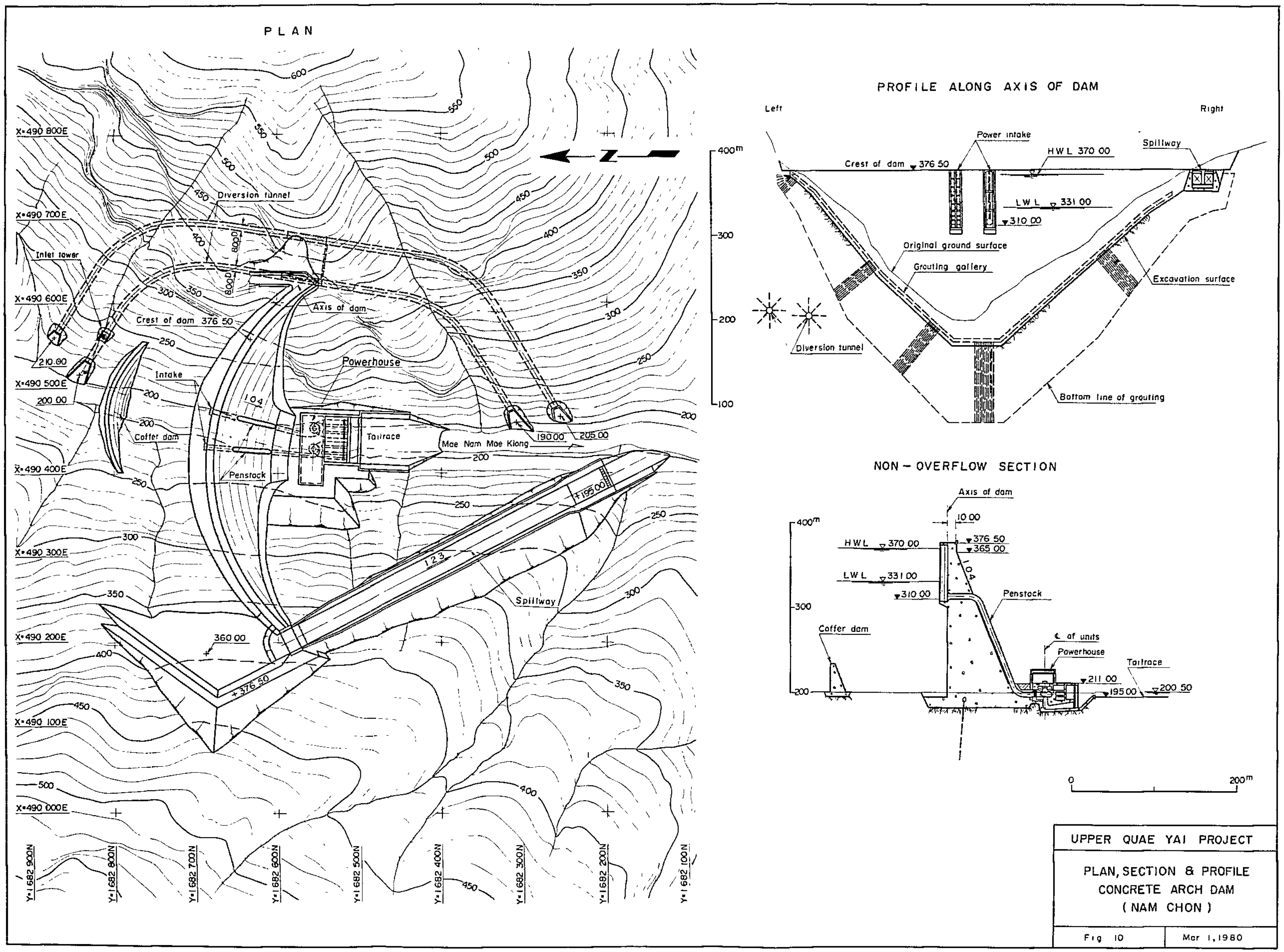

PLAN
X=490 800E
X=490 700E
X=490 600E
X=490 500E
X=490 400E
X=490 300E
X=490 200E
X=490 100E
X=490 000E
Y=1682 900N
Y=1682 800N
Y=1682 700N
Y=1682 600N
Y=1682 500N
Y=1682 400N
Y=1682 300N
Y=1682 200N
Y=1682 100N
Diversion tunnel
Inlet tower
Crest of dam 376 50
Axis of dam
Powerhouse
Intake
Coffer dam
Penstock
Tailrace
Mae Nam Mae Klong
Spillway
210.00
200 00
190 00
205 00
195 00
360 00
376 50
400m
300
200
100
PROFILE ALONG AXIS OF DAM
Left
Right
Power intake
HWL 370 00
Spillway
Crest of dam 376 50
LWL 331 00
310 00
Original ground surface
Grouting gallery
Excavation surface
Diversion tunnel
Bottom line of grouting
NON – OVERFLOW SECTION
Axis of dam
10 00
376 50
365 00
HWL 370 00
LWL 331 00
310 00
Penstock
Coffer dam
℄ of units
Powerhouse
Tailrace
211 00
195 00
200 50
0
200m
UPPER QUAE YAI PROJECT
PLAN, SECTION & PROFILE
CONCRETE ARCH DAM
(NAM CHON)
Fig 10
Mar 1, 1980

Fig. 11 Nam Chon Reservoir — Flood Routing —

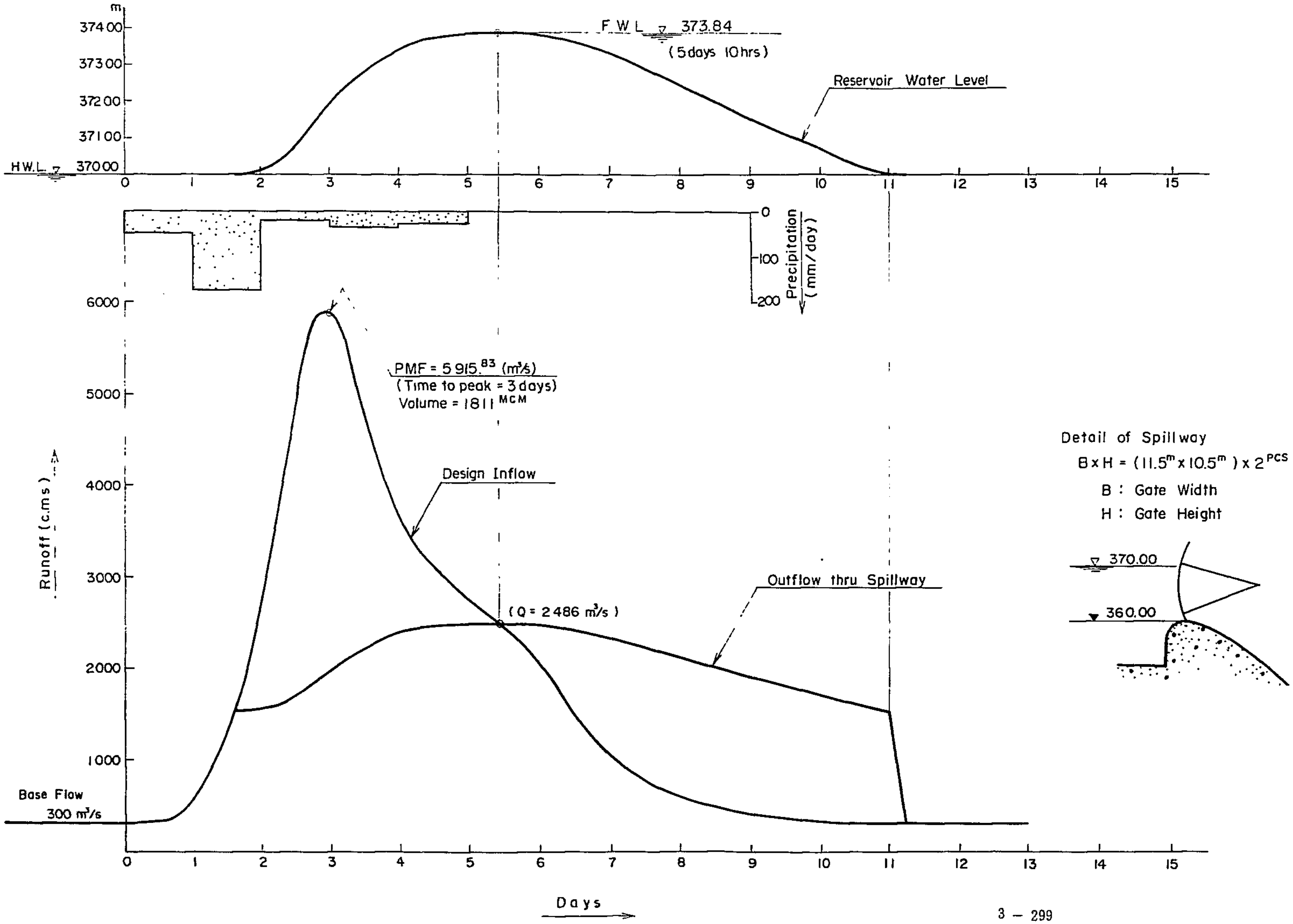


Fig. 12 Relation between Spillway Scale and Flood Water Level

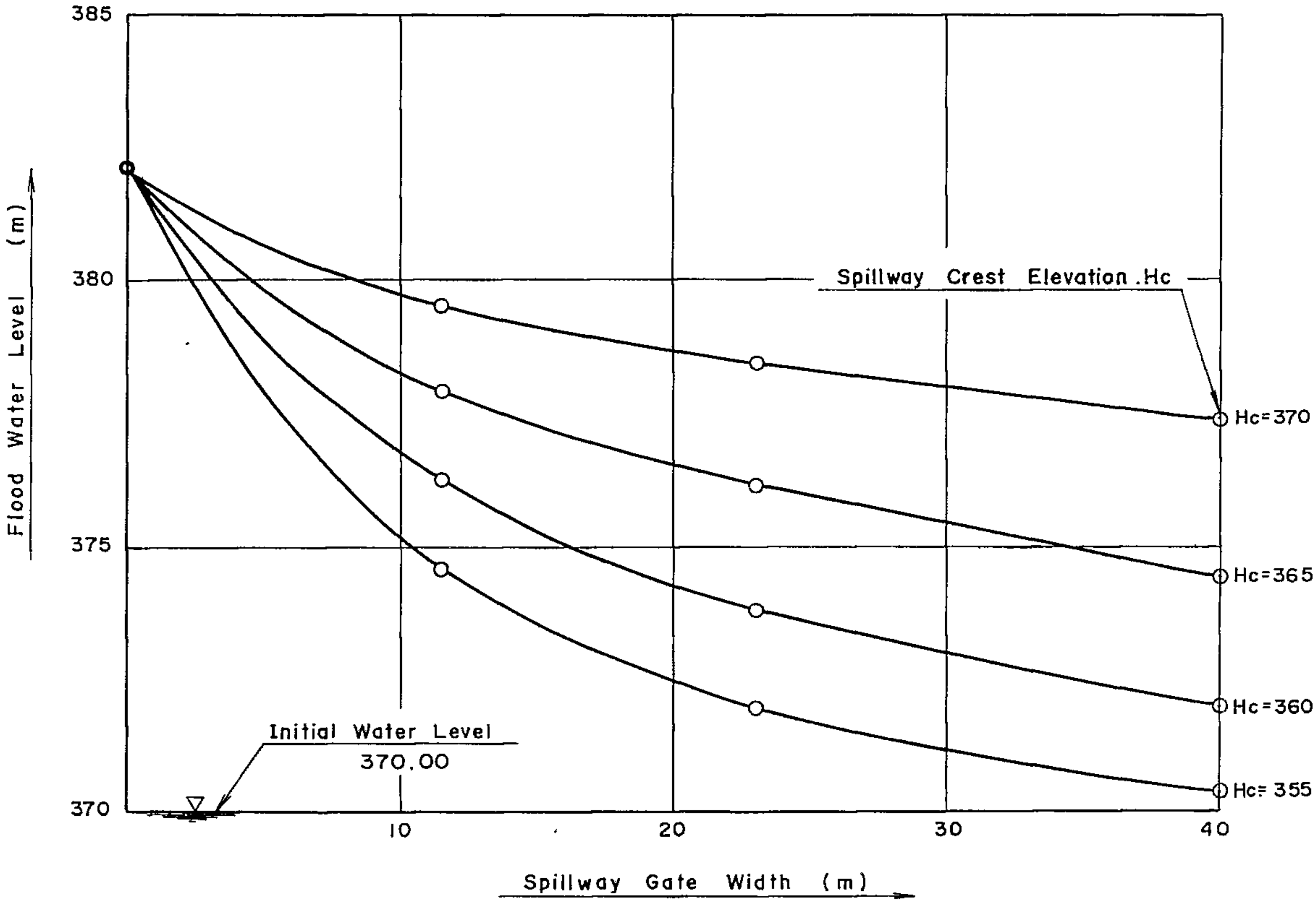


Fig.13 Economic Comparison for Spillway(I)

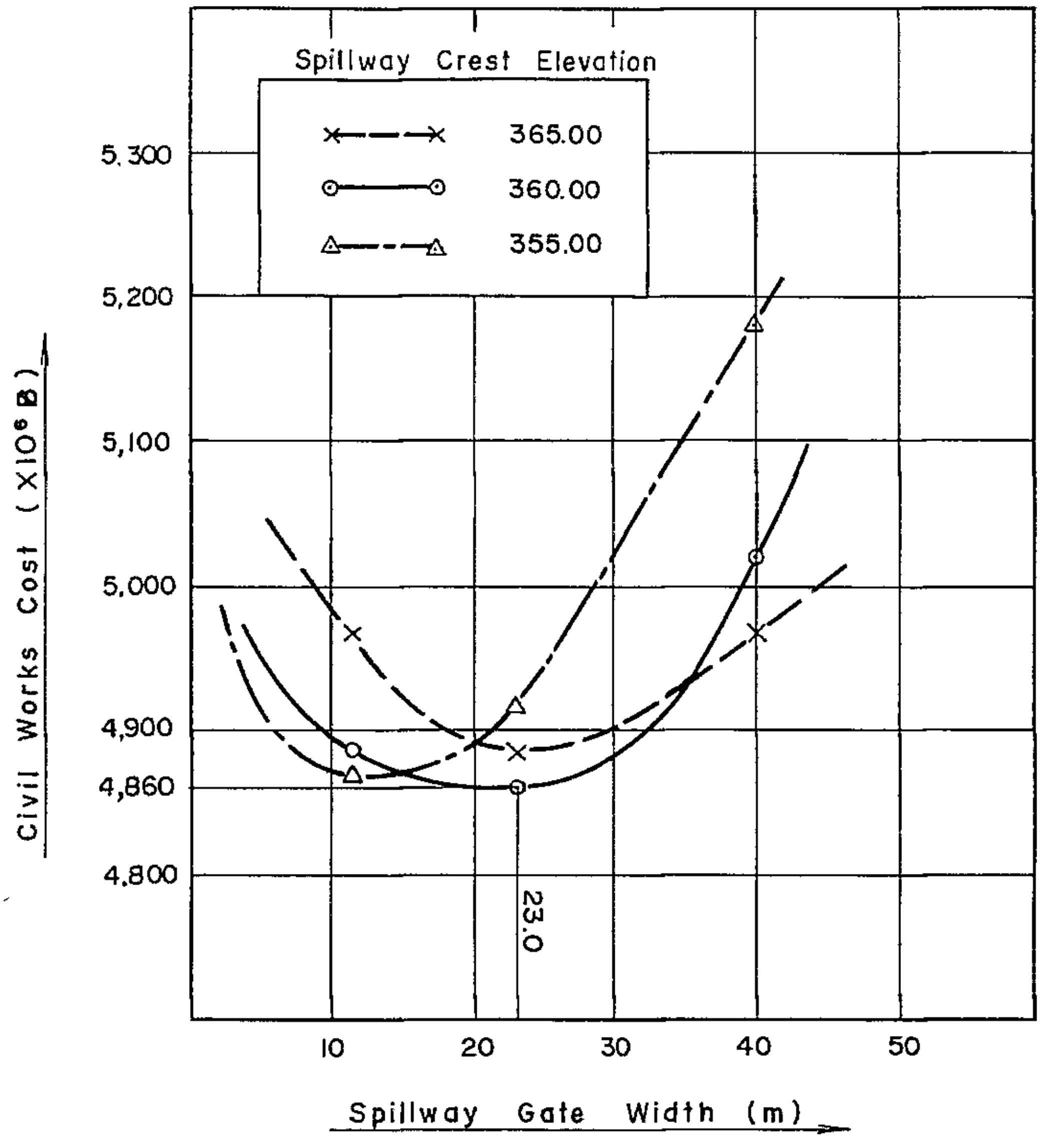
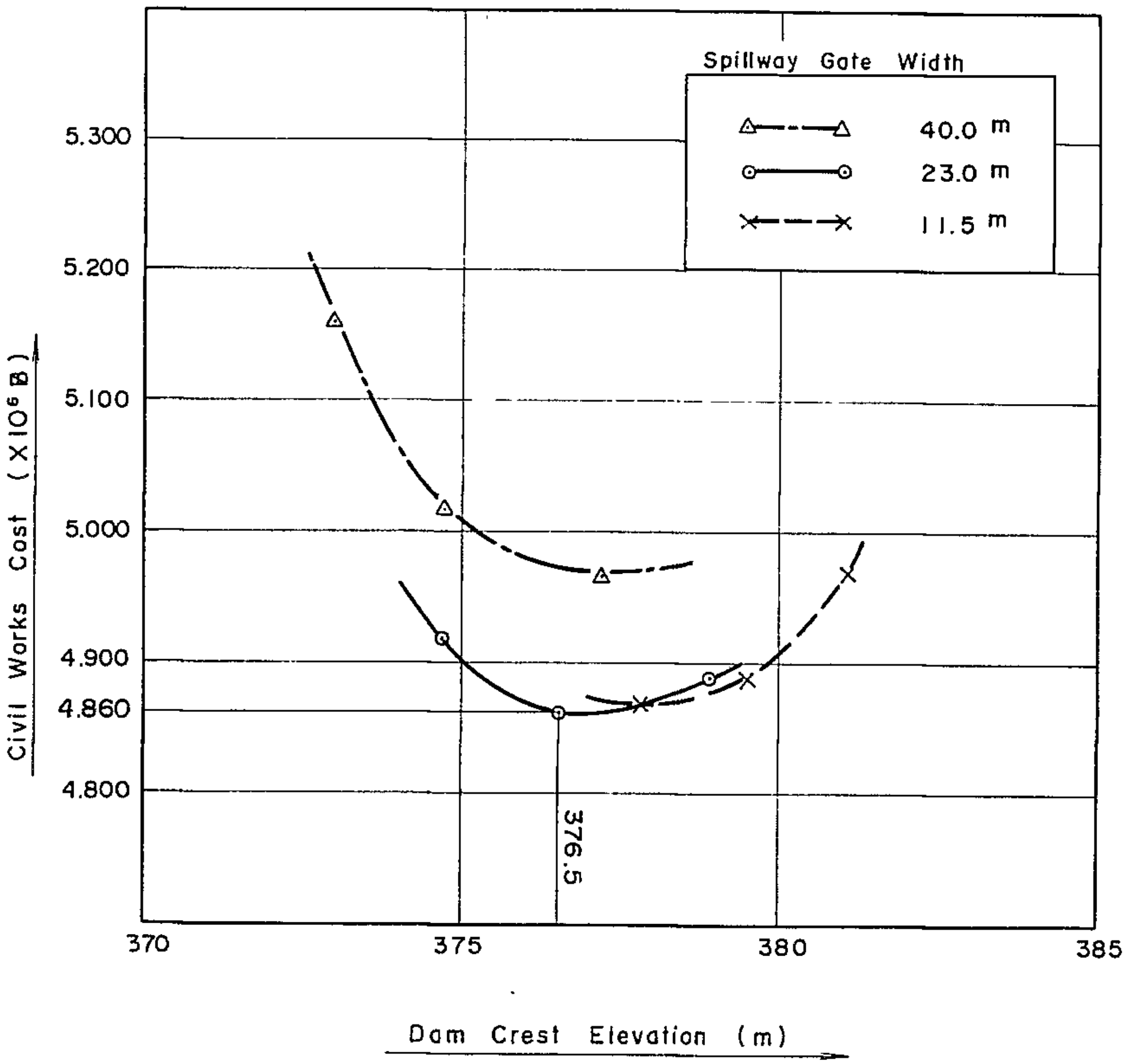
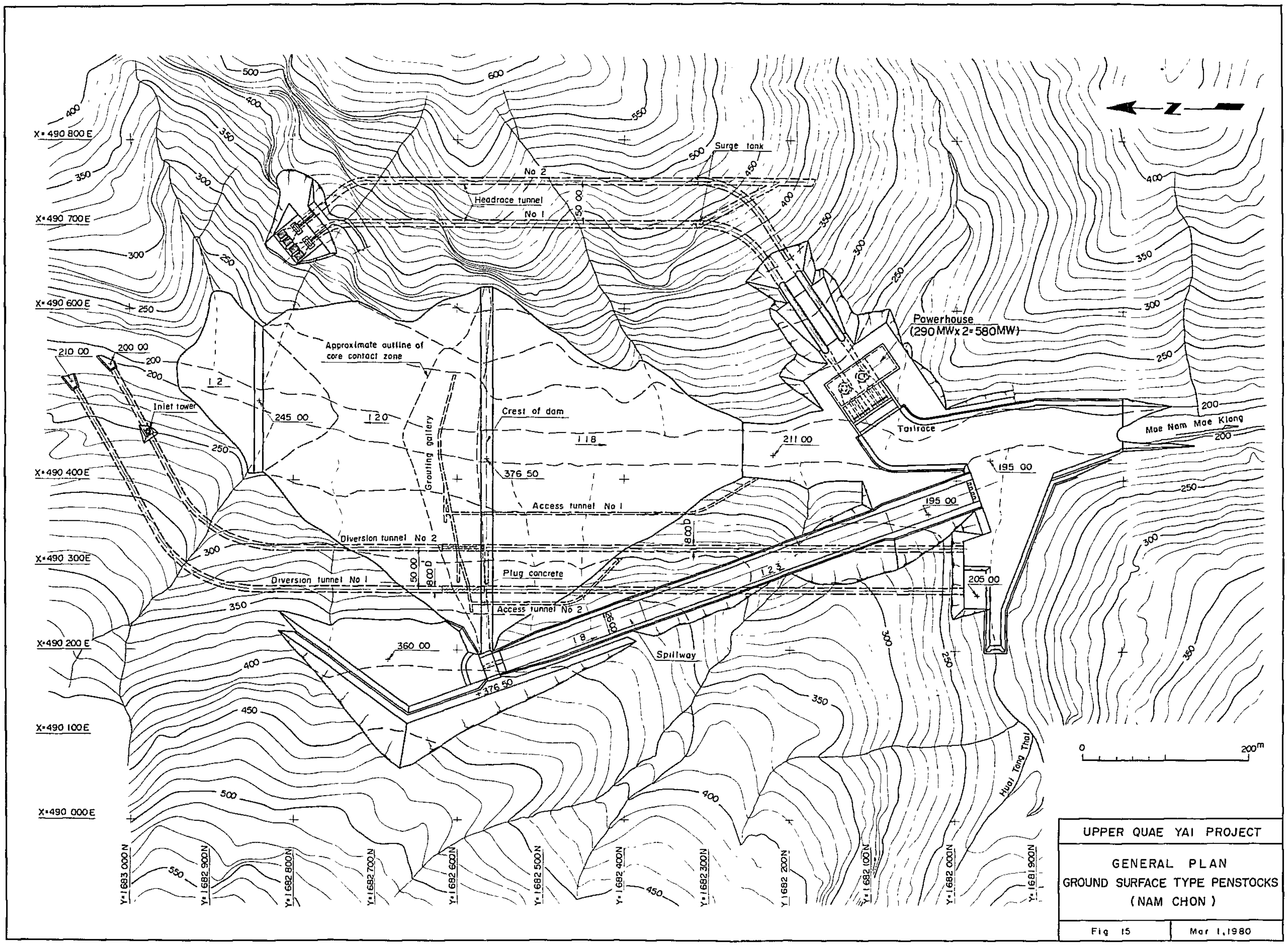


Fig. 14 Economic Comparison for Spillway (2)




Surge tank
No 2
Headrace tunnel
No 1
Powerhouse
(290 MW x 2 = 580MW)
Tailrace
Mae Nam Mae Klong
Approximate outline of core contact zone
Inlet tower
Crest of dam
Grouting gallery
Access tunnel No 1
Access tunnel No 2
Diversion tunnel No 2
Diversion tunnel No 1
Plug concrete
Spillway
Huai Tong Thai
X=490 800 E
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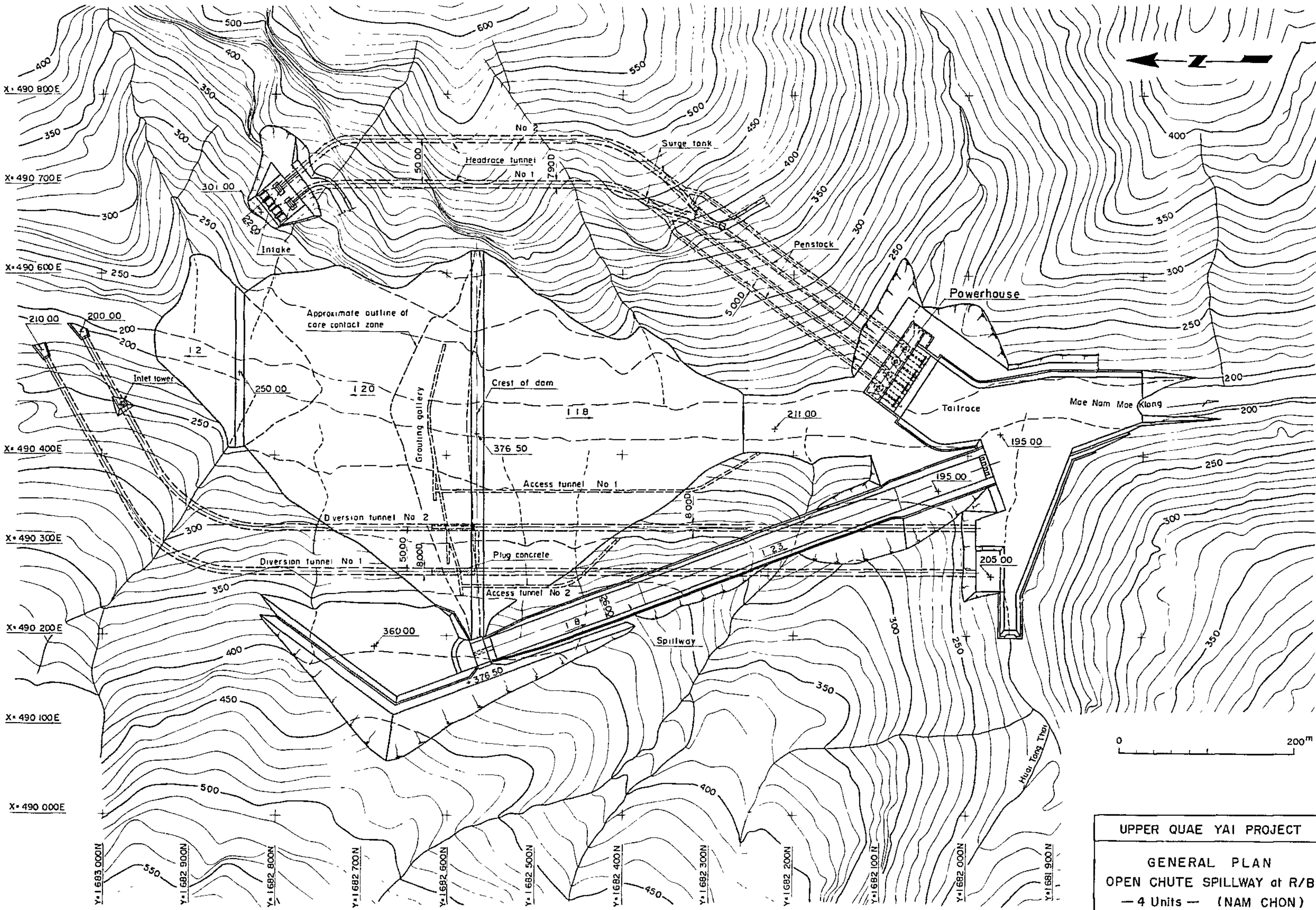
X=490 200 E
X=490 100 E
X=490 000 E
Y=1 683 000 N
Y=1 682 900 N
Y=1 682 800 N
Y=1 682 700 N
Y=1 682 600 N
Y=1 682 500 N
Y=1 682 400 N
Y=1 682 300 N
Y 1 682 200 N
Y=1 682 100 N
Y=1 682 000 N
Y=1 681 900 N
0
200m
UPPER QUAE YAI PROJECT
GENERAL PLAN
GROUND SURFACE TYPE PENSTOCKS
(NAM CHON)
Fig 15
Mar 1, 1980

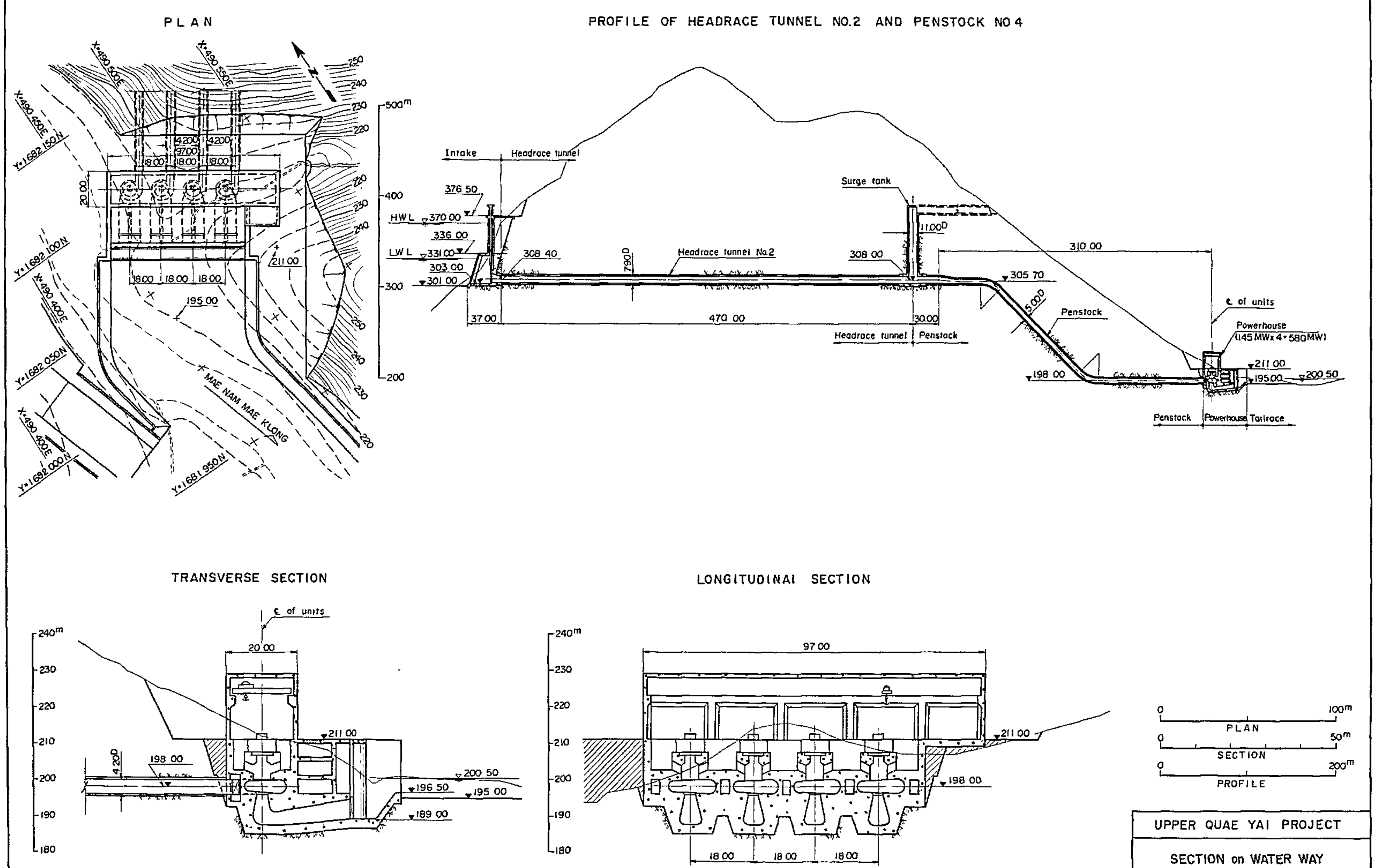
GENERAL PLAN FOR NAM CHON PROJECT



UPPER QUAE YAI PROJECT

GENERAL PLAN
OPEN CHUTE SPILLWAY at R/B
— 4 Units — (NAM CHON)

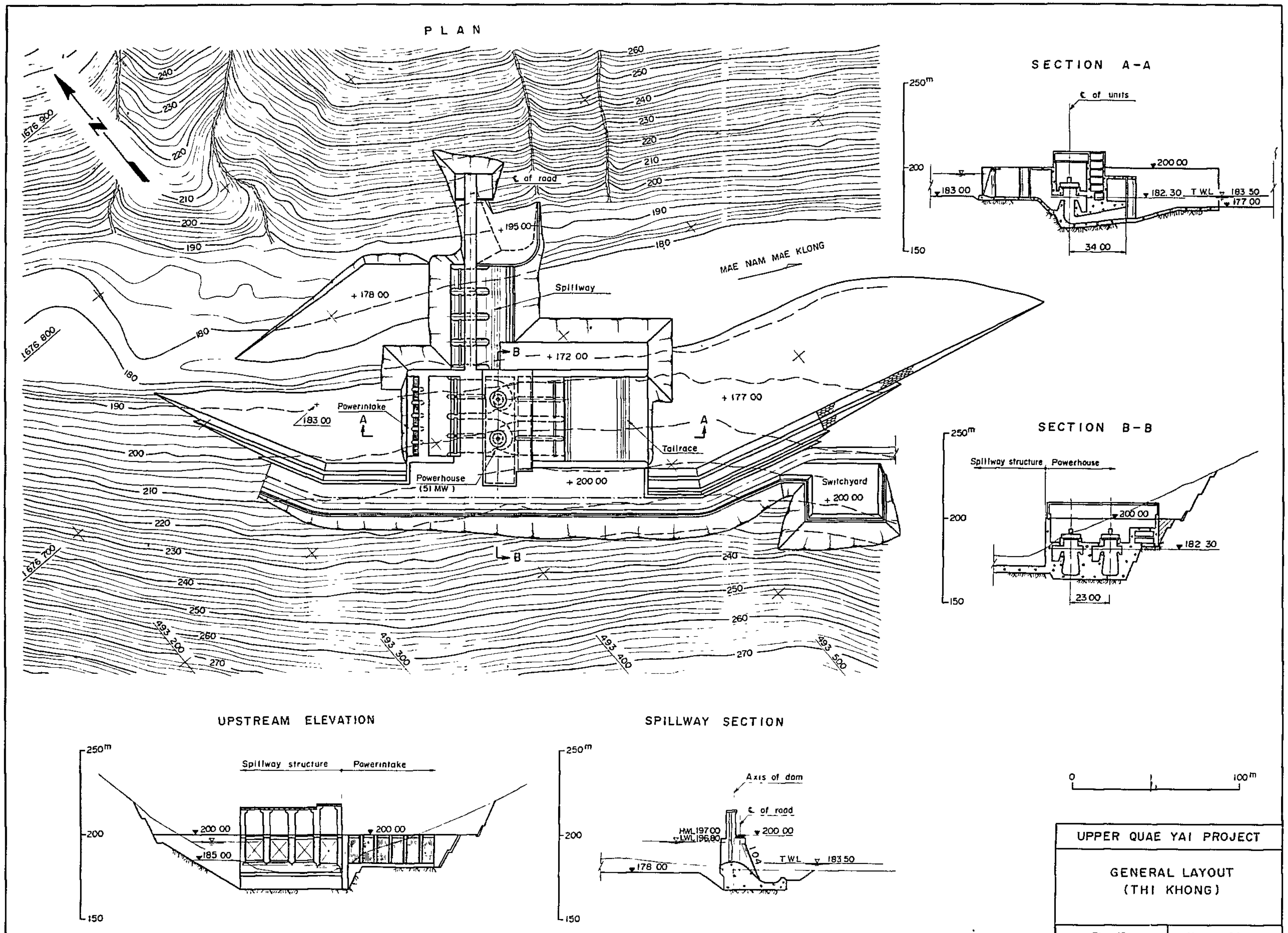
Fig 16	Mar 1, 1980



UPPER QUAE YAI PROJECT

SECTION on WATER WAY
OPEN CHUTE SPILLWAY at R/B
— 4 Units — (NAM CHON)

Fig 17 | Mar 1, 1980



UPPER QUAE YAI PROJECT

GENERAL LAYOUT
(THI KHONG)

Fig 18	Mar 1, 1980

5. Data Obtained

Data concerning the cement in Thailand is also attached for reference.

CAPACITY OF CEMENT FACTORY AND TYPE OF PRODUCTION

(For the 3 Biggest Factories in Thailand)

Name of Company	Place of Factory	Capacity of Cement Production			Type of Production
		Present Capacity Ton/Day	Expansion Project		
			Ton/Day	Operation Year	
1) The Siam Cement Co., Ltd.	1) Bang Sue Bangkok	1,196	-	-	1) Tiger Brand 2) Elephant Brand 3) Erawan Brand
	2) Tha Luang Saraburi	4,117	5,312	1981	
	3) Kaeng Khoi Saraburi	5,620	-	-	
	4) Thung Song Nakhon Sri Thammarat	1,441	2,751	1980	
2) Siam City Cement Co., Ltd.	1) Kaeng Khoi, Saraburi	2,000	7,000	1981	1) Eagle Brand 2) Diamond Brand 3) /1 Three Diamond Brand
3) Jalaprathan Cement Co., Ltd.	1) Takli Nakhon Sawan	1,200	1,700	mid-year 1980	1) Green Naga Brand 2) Red Naga Brand 3) Cobra Brand
	2) Cha-am Petchaburi	1,400	5,000	1983	4) /2 Seven Head Naga Brand 5) Shark Brand

Remark /1 To be produced in 1981 /2 Option

CEMENT TEST RESULTS FOR MIXED CEMENTS

CLASSIFIED BY TYPE OF BRAND

According to the Thai Industrial Standard Specification for Mixed Cements, TIS 80-2517			TIGER BRAND	EAGLE BRAND	COBRA BRAND
FINESS Specific surface					
Air permeability test :	cm^2 per g	min. 2,800	3,200	3,200	4,200
SOUNDNESS					
Autoclave explansion	percent	max. 0.60	0.10	0.10	0.039
TIME OF SETTING Vicat test :					
Initial	minutes	min. 45	120	150	152
Final	minutes		-	-	242
AIR CONTENT OF MORTAR :					
Max. percent by volume	percent	12	-	6	-
COMPRESSIVE STRENGTH Mortar cubes :					
1 day in moist air, 2 days in water	kg/cm^2	min. 65	120	120/1	114
1 day in moist air, 6 days in water	kg/cm^2	max. 115	160	180/2	150
1 day in moist air, 27 days in water	kg/cm^2		-	-	223
TENSILE STRENGTH Mortar briquets :					
1 day in moist air, 2 days in water	kg/cm^2		-		20
1 day in moist air, 6 days in water	kg/cm^2		-		27
1 day in moist air, 27 days in water	kg/cm^2		-		34
FALSE SET					
Final penetration	percent	min. 50	-	85	-

Remark: /1 3 days, /2 7 days.

CEMENT TEST RESULTS FOR PORTLAND CEMENT

CLASSIFIED BY TYPE OF BRAND (ordinary)

According to the Thai Industrial Standard Specification for Portland Cements, TIS 15-2514, TYPE 1			ELEPHANT BRAND	DIAMOND BRAND	GREEN NAGA BRAND
CHEMICAL REQUIREMENTS					
Silicon Dioxide (SiO_2),	percent	-	21.63	21.25	21.82
Aluminium Oxide (Al_2O_3),	percent	-	5.09	5.77	4.90
Ferric Oxide (Fe_2O_3),	percent	-	2.92	3.13	3.00
Magnesium Oxide (MgO),	percent	max. 5.0	0.91	1.08	3.24
Sulphur Trioxide (SO_3) :					
When 3CaO. Al_2O_3 is 8 percent or less,	percent	max. 2.5	-	-	2.00
When 3CaO. Al_2O_3 is more than 8 percent,	percent	max. 3.0	1.68	2.36	
Loss on Ignition	percent	max. 3.0	0.82	0.71	0.68
Insoluble residue	percent	max. 0.75	0.11	0.40	0.20
Tricalcium Silicate (3CaO. SiI_2),	percent	-	58.00	58.00	50.70
Tricalcium Aluminate (3CaO. Al_2O_3),	percent	-	8.6	10.00	7.90
PHYSICAL REQUIREMENTS					
FINESS Specific surface :					
Air permeability test : Average value, min, cm^2 per g		2,800	3,000	3,000	3,200
Air permeability test : Minimum value anyone sample, cm^2 per g		2,600	2,800	2,800	
SOUNDNESS Autoclave expansion,	percent	max. 0.80	0.10	0.01	0.021
TIME OF SETTING Vicat test :					
Set,	minutes	min. 45	125	170/1	150/1 325/2

CEMENT TEST RESULTS FOR PORTLAND CEMENT (cont.)

CLASSIFIED BY TYPE OF BRAND (ordinary)

	According to the Thai Industrial Standard Specification for Portland Cements, TIS 15-2514, TYPE 1		ELEPHANT BRAND	DIAMOND BRAND	GREEN NAGA BRAND
AIR CONTENT OF MORTAR					
Max, percent by volume,					
less than		12.0	6.9	7.3	-
COMPRESSIVE STRENGTH					
Mortar cubes :					
1 day in moist air,	kg/cm^2 (psi)		-	-	
1 day in moist air, 2 days in water,	kg/cm^2 (psi)	min. 85	150 (2140)	170 (2417)	194
1 day in moist air, 6 days in water,	kg/cm^2 (psi)	min. 150	220 (3140)	250 (3555)	260
1 day in moist air, 27 days in water,	kg/cm^2 (psi)	min. 245	300 (4290)	360 (5120)	354
TENSILE STRENGTH					
Mortar briquets, in accordance with method C190					
1 day in moist air	kg/cm^2	-	-	-	-
1 day in moist air, 2 days in water,	kg/cm^2	min. 10.6	-	-	29.0
1 day in moist air, 6 days in water,	kg/cm^2	min. 19.3	-	-	35.5
1 day in moist air, 27 days in water,	kg/cm^2	min. 24.6	-	-	41.5
FALSE SET					
Final penetration	percent	min. 50	-	-	85

Remark /1 initial time /2 final time

CEMENT TEST RESULTS FOR PORTLAND CEMENT

CLASSIFIED BY TYPE OF BRAND (High early strength)

According to the Thai Industrial Standard Specification for Portland Cements, TIS 15-2514, TYPE III			ERAWAN BRAND	THREE DIAMOND BRAND	RED NAGA BRAND
CHEMICAL REQUIREMENT					
Silicon Dioxide (SiO_2),	percent	-	20.48	-	21.56
Aluminium Oxide (Al_2O_3),	percent	-	5.55	-	4.94
Ferric Oxide (Fe_2O_3),	percent	-	2.88	-	3.06
Magnesium Oxide (MgO),	percent	max. 5.0	1.11	1.10	3.03
Sulphur Trioxide (SO_3) :					
When 3CaO. Al_2O_3 is 8 percent or less,	percent	max. 3.0	-	-	2.00
When 3CaO. Al_2O_3 is more than 8 percent,	percent	max. 4.0	2.37	3.60	-
Loss on Ignition	percent	max. 3.0	1.29	1.20	0.62
Insoluble Residue	percent	max. 0.75	0.17	0.30	0.20
Tricalcium Silicate (3CaO. SiO_2),	percent	-	54.00	-	53.30
Tricalcium Aluminate (3CaO. Al_2O_3),	percent	max. 15.0	9.80	9.70	8.00
PHYSICAL REQUIREMENTS					
FINESS Specific surface :					
Air permiability test : Average value, min, cm^2 per g		-	4,400	-	4,250
Air permiability test : Minimum value anyone sample, cm^2 per g		-	4,000		
SOUNDNESS Autoclave expansion,	percent	max. 0.80	0.10	0.03	0.029
TIME OF SETTING Vicat test :					
Set,	minutes	min. 45	100	100/1	160/1 280/2

CEMENT TEST RESULTS FOR PORTLAND CEMENT (cont.)

CLASSIFIED BY TYPE OF BRAND (High early strength)

According to the Thai Industrial Standard Specification for Portland Cements, TIS 15-2514, TYPE III			ERAWAN BRAND	THREE DIAMOND BRAND	RED NAGA BRAND
AIR CONTENT OF MORTAR					
Max, percent by volume,					
less than		12.0	6.9	5.8	
COMPRESSIVE STRENGTH					
Mortar cubes :					
1 day in moist air,	kg/cm^2 (psi)	min. 120	140 (2000)	162 (2300)	153
1 day in moist air, 2 days in water,	kg/cm^2 (psi)	min. 210	270 (3850)	319 (4540)	245
TENSILE STRENGTH					
Mortar Briquets, in accordance with Method C190					
1 day in moist air,	kg/cm^2	min. 19.3	-	-	22
1 day in moist air, 2 days in water,	kg/cm^2	min. 26.5	-	-	31
FALSE SET					
Final penetration	percent	min. 50	-	-	75

Remark /1 initial time /2 final time

CEMENT PRICE CLASSIFIED BY TYPE

(Price at Factory in Aug. 1979)

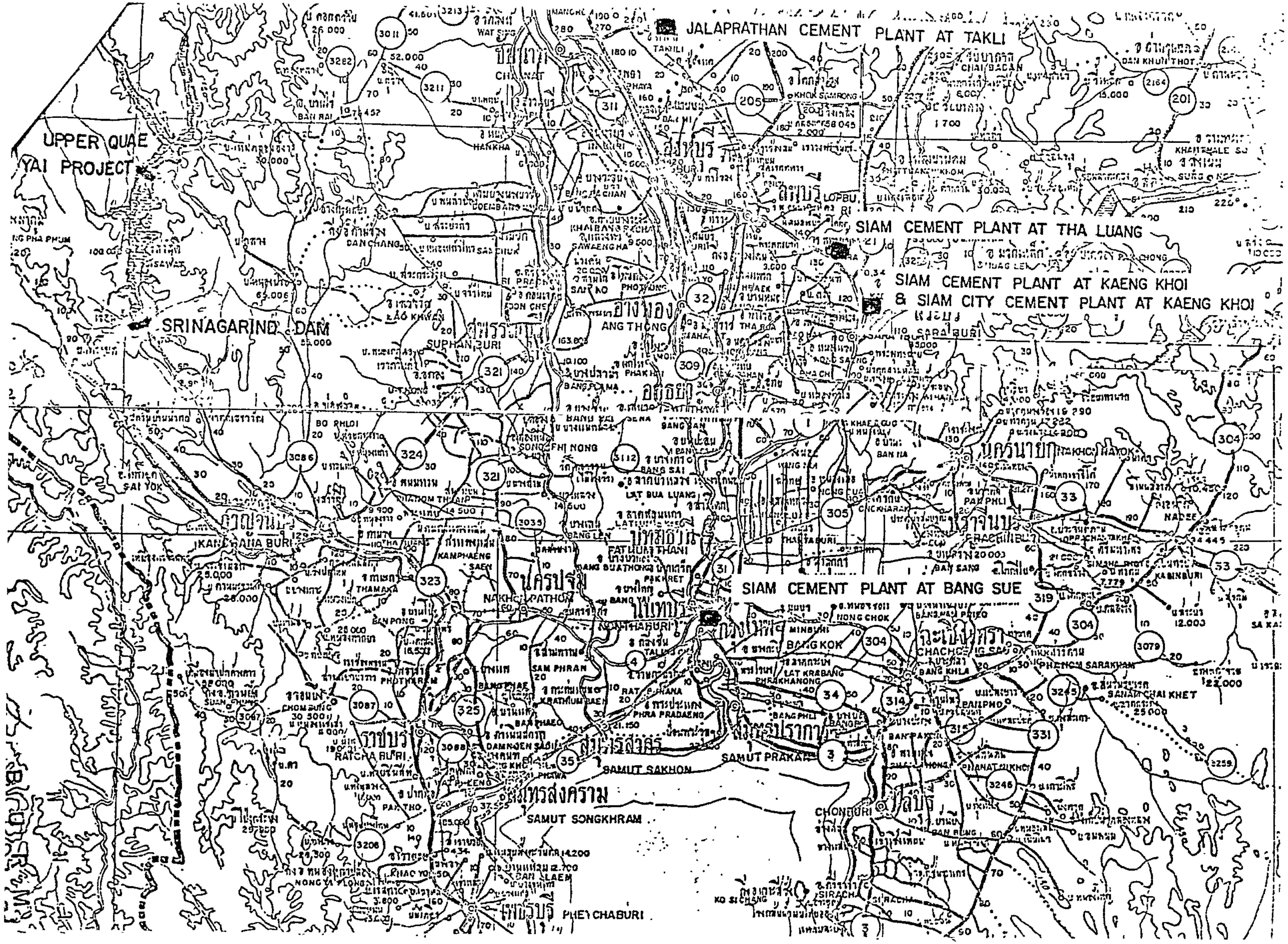
Brand	Price (Baht/Ton)	
	Sack	Bulk
1) The Siam Cement Co., Ltd.		
Tiger Brand	892	842
Elephant Brand	1,040	990
Erawan Brand	1,280	1,180
2) Siam City Cement Co., Ltd.		
Eagle Brand	1,024	858
Diamond Brand	1,176	1,008
3) Jalaprathan Cement Co., Ltd.		
Green Naga Brand	1,095	1,045
Red Naga Brand	1,335	1,235
Cobra Brand	947	897
Shark Brand	1,575	1,485

APPROXIMATE DISTANCES FROM FACTORY TO KANCHANABURI

Name of Company	Place of Factory	Distances (km)
1) The Siam Cement Co., Ltd.	1) Bang Sue Bangkok	126
	2) Tha Luang Saraburi	259
	3) Kaeng Khoi Saraburi	249
	4) Thung Song Nakhon Sri Thammarat	1,176
2) Siam City Cement Co., Ltd.	1) Kaeng Khoi Saraburi	249
3) Jalaprathan Cement Co., Ltd.	1) Takli Nakhon Sawan	390
	2) Cha-Am Petchaburi	199

Note : 1) Distances from Kanchanaburi to Srinagarind Dam 75 km

2) Distances from Srinagarind Dam to Upper Quae Yai 141 km


JALAPRATHAN CEMENT PLANT AT TAKLI
UPPER QUAE YAI PROJECT
SIAM CEMENT PLANT AT THA LUANG
SIAM CEMENT PLANT AT KAENG KHOI
& SIAM CITY CEMENT PLANT AT KAENG KHOI
SRINAGARIND DAM
SIAM CEMENT PLANT AT BANG SUE
CHAINAT
SUPHAN BURI
ANG THONG
SARABURI
LOPBURI
KANCHANA BURI
NAKHON PATHOM
PATHUM THANI
NONTHABURI
BANGKOK
SAMUT SAKHON
SAMUT PRAKAN
SAMUT SONGKHRAM
RATCHA BURI
PHETCHABURI
CHONBURI
CHACHOENGSAO
PHANOM SARAKHAM
NAKHON NAYOK
PRACHINBURI
SRIRACHA

JICA