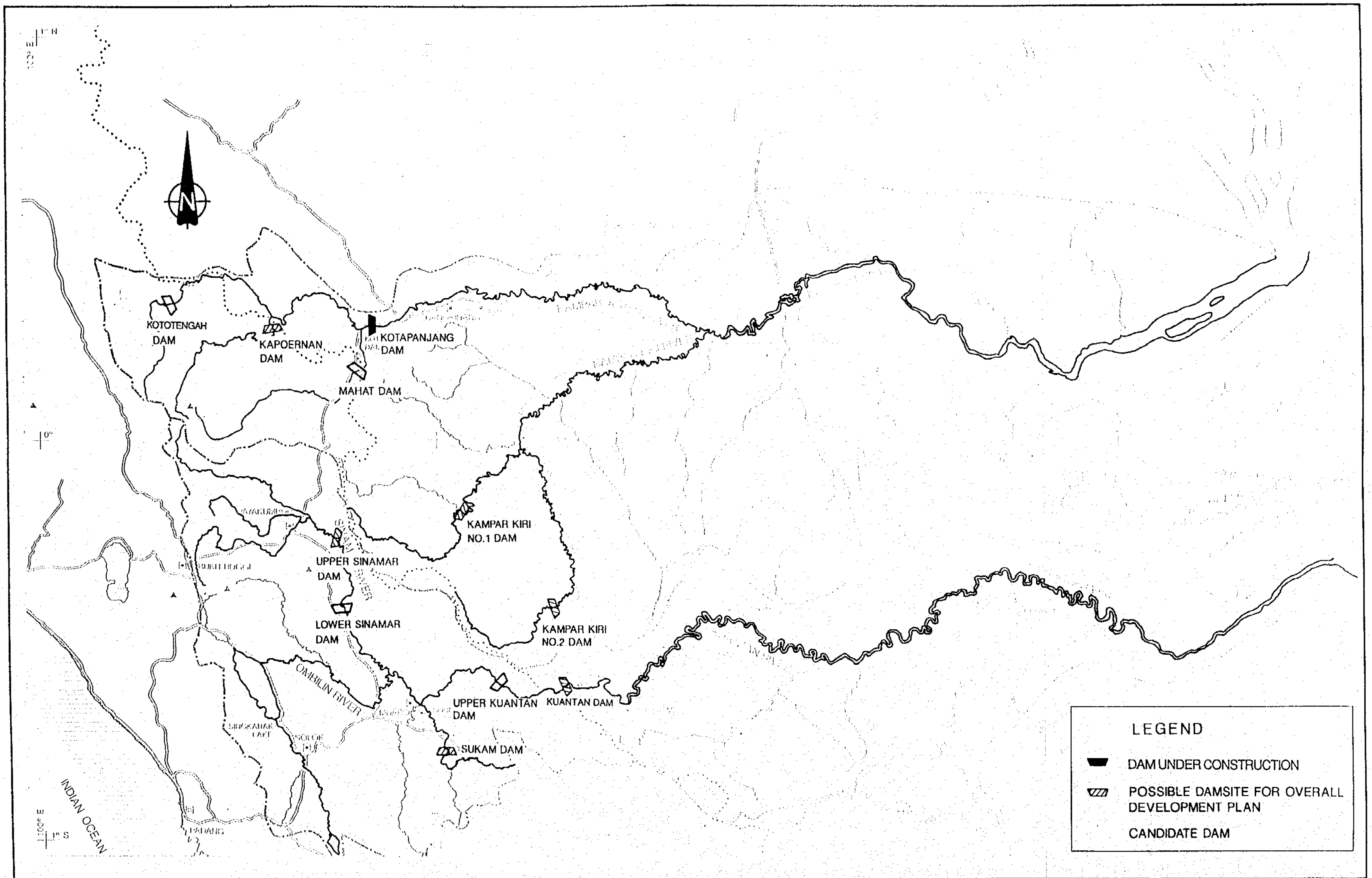
FIGURES

XII DAM ENGINEERING



THE STUDY ON
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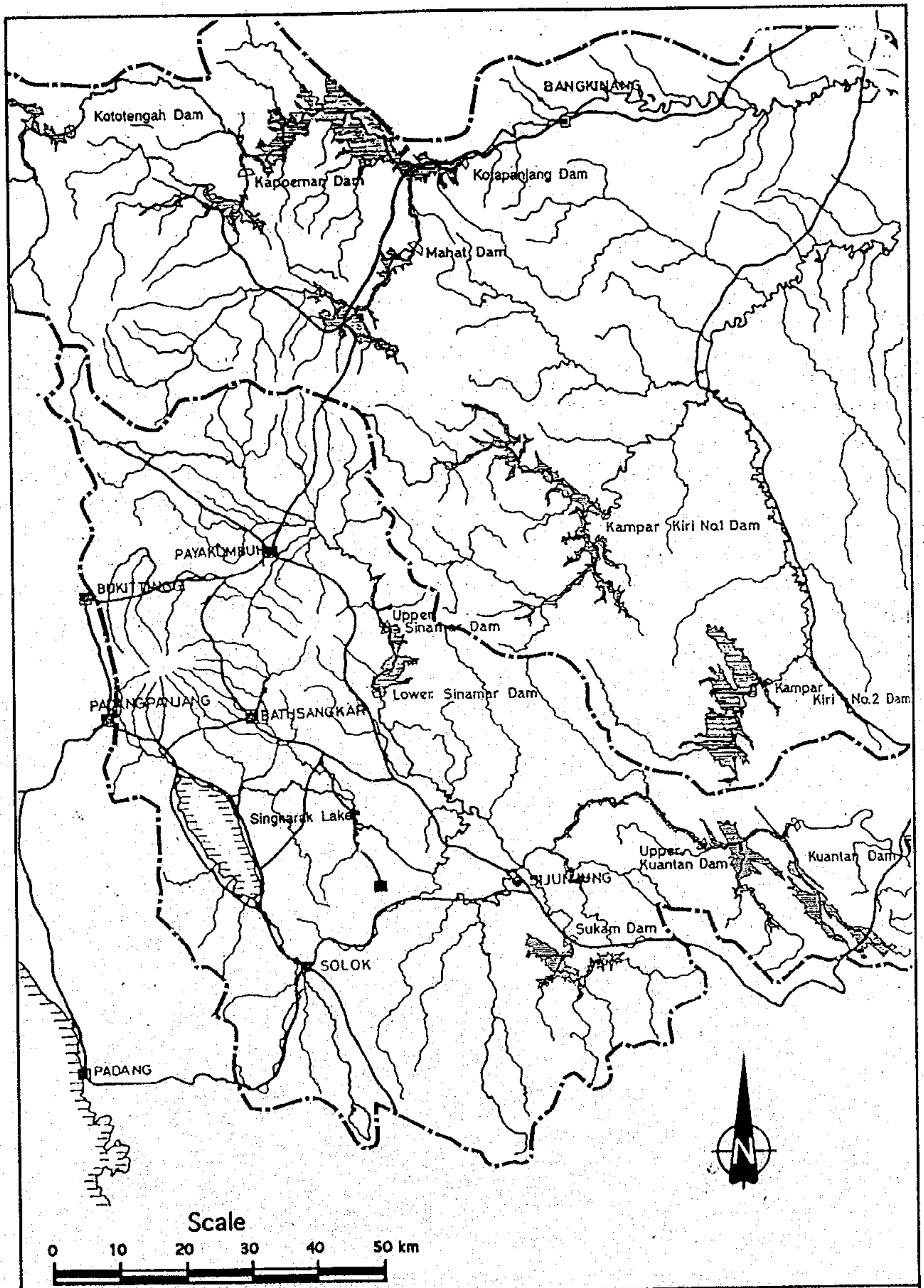
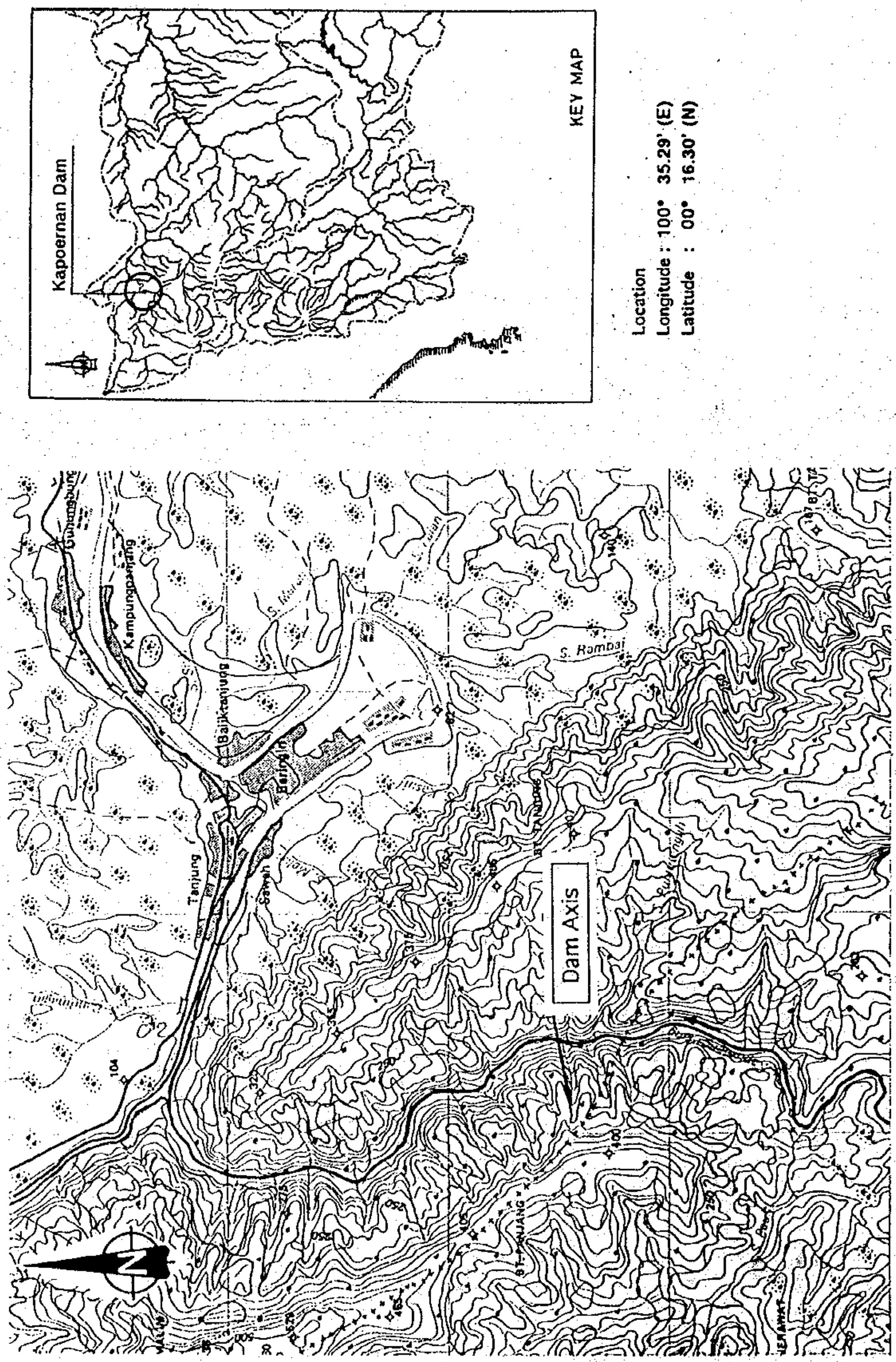
IN THE REPUBLIC OF INDONESIA
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. XII.1.1 LOCATION OF CANDIDATE DAMSITES



THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.1.2 RESERVOIR AREAS OF CANDIDATE DAMS
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON
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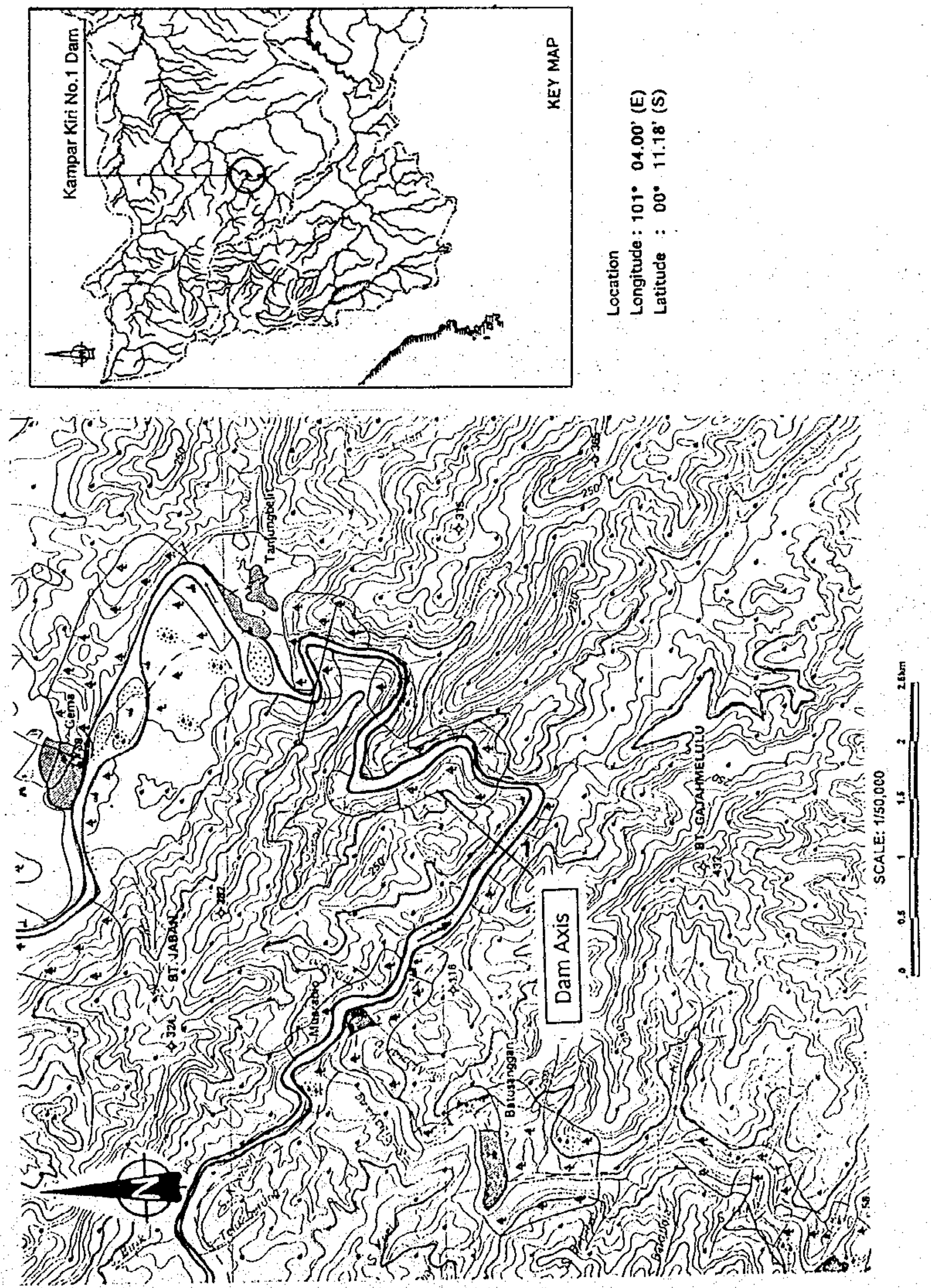
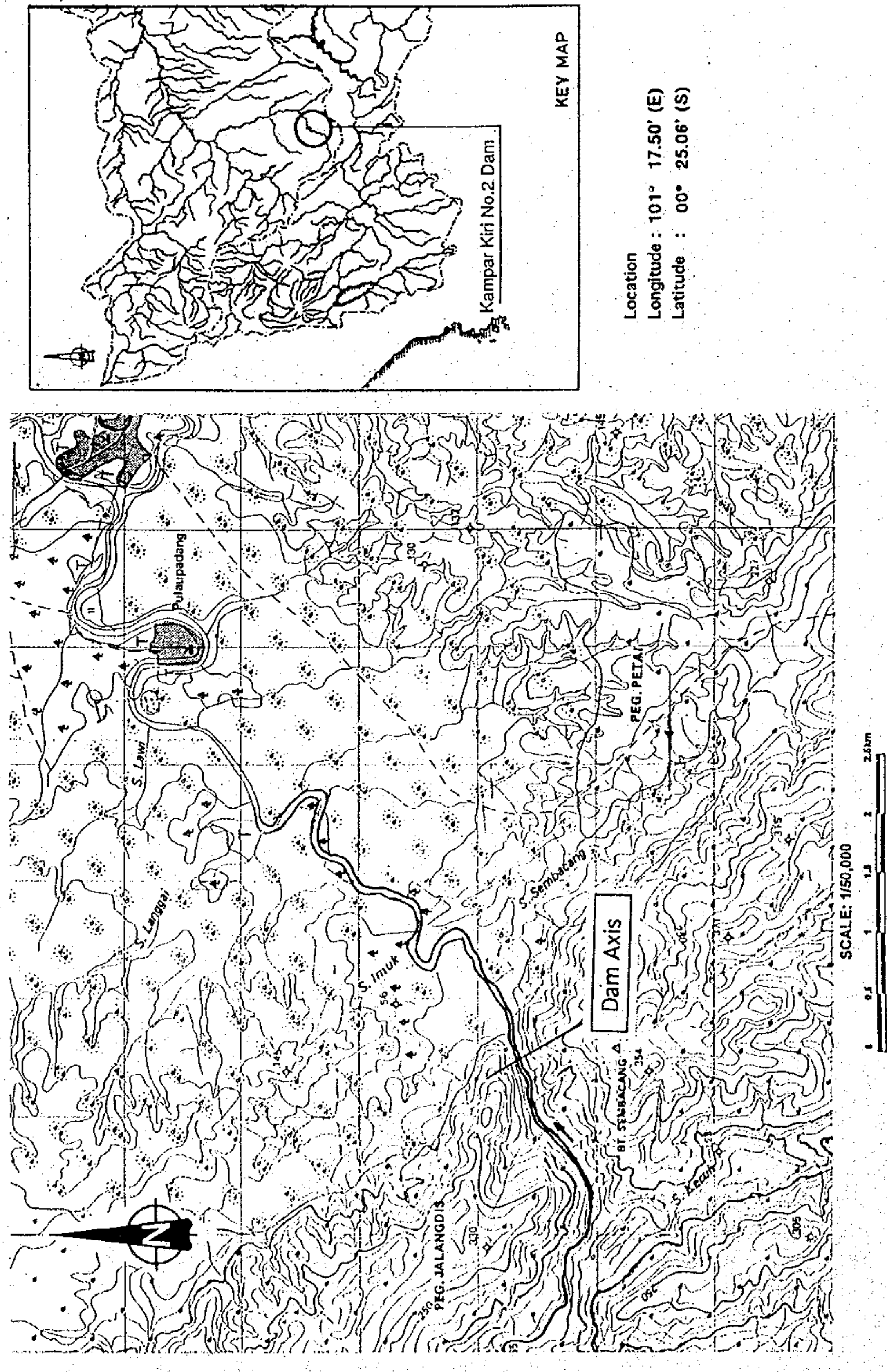
Fig. XII.1.3 (1/6) LOCATION OF DAM AXIS (KAPOERNAN DAM)



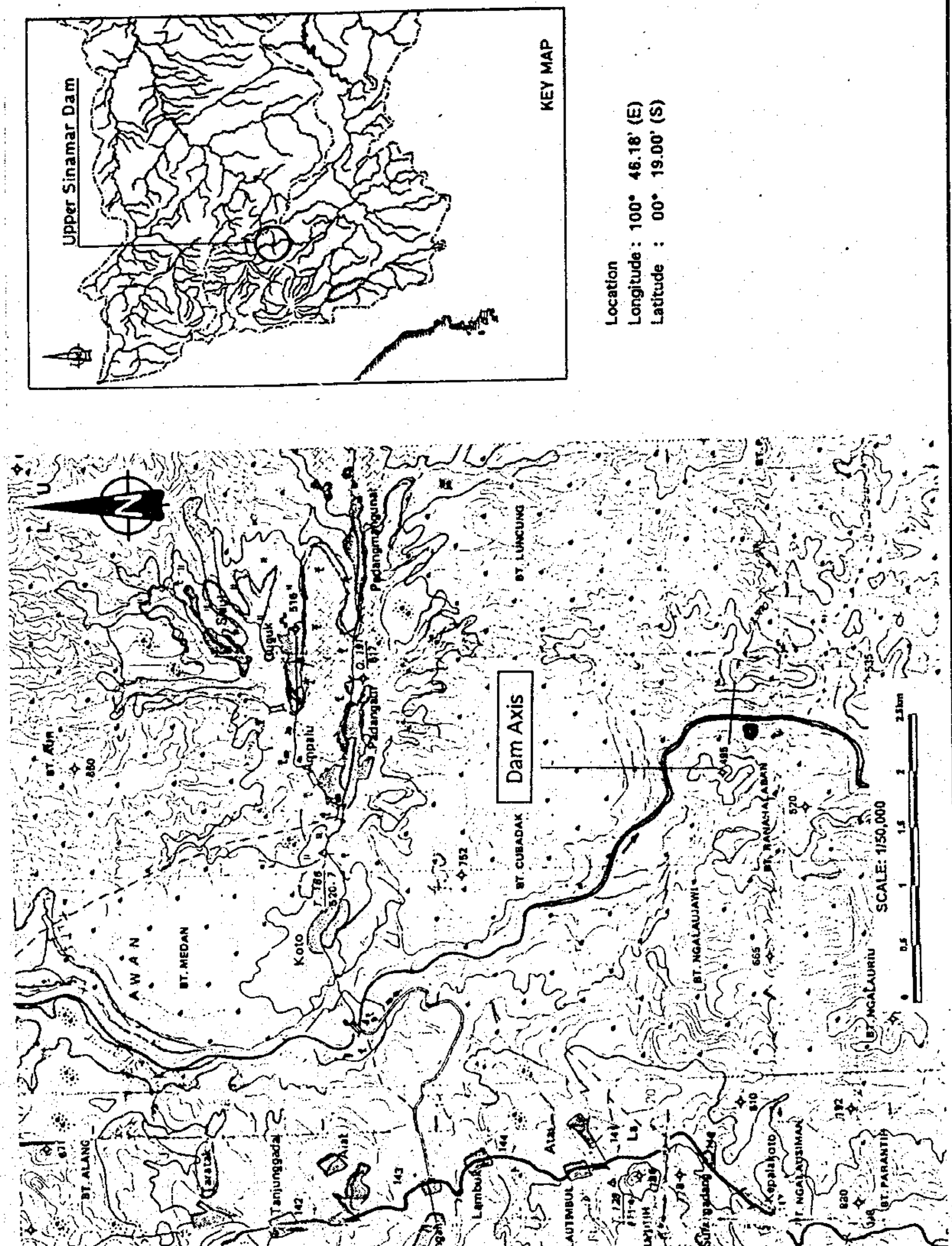
THE STUDY ON
KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT
IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

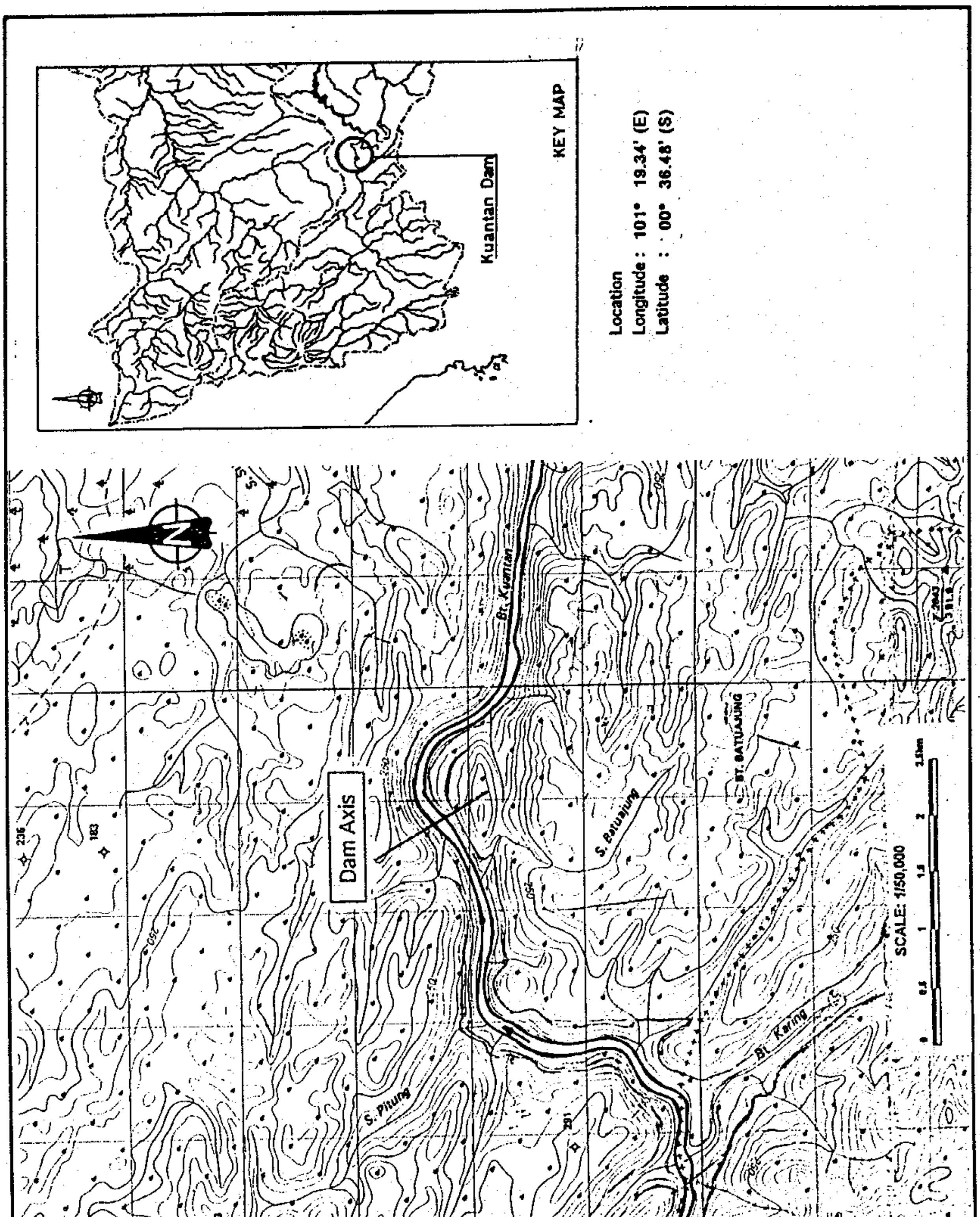
Fig. XII.1.3 (2/6) LOCATION OF DAM AXIS
(KAMPAR KIRI NO.1 DAM)



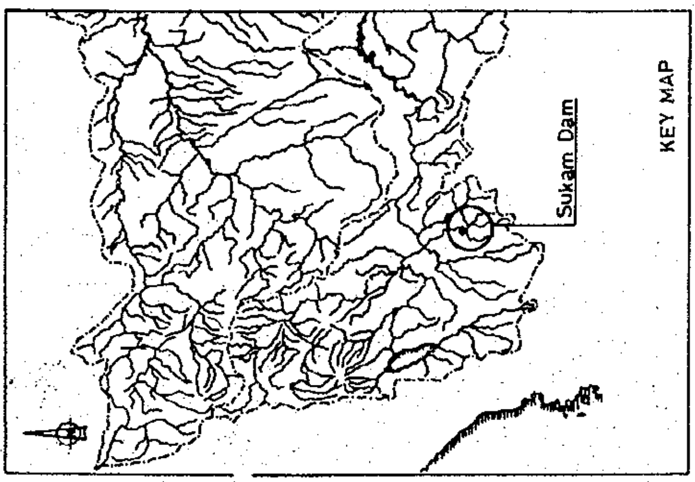
THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.1.3 (3/6) LOCATION OF DAM AXIS (KAMPAR KIRI NO.2 DAM)
JAPAN INTERNATIONAL COOPERATION AGENCY	



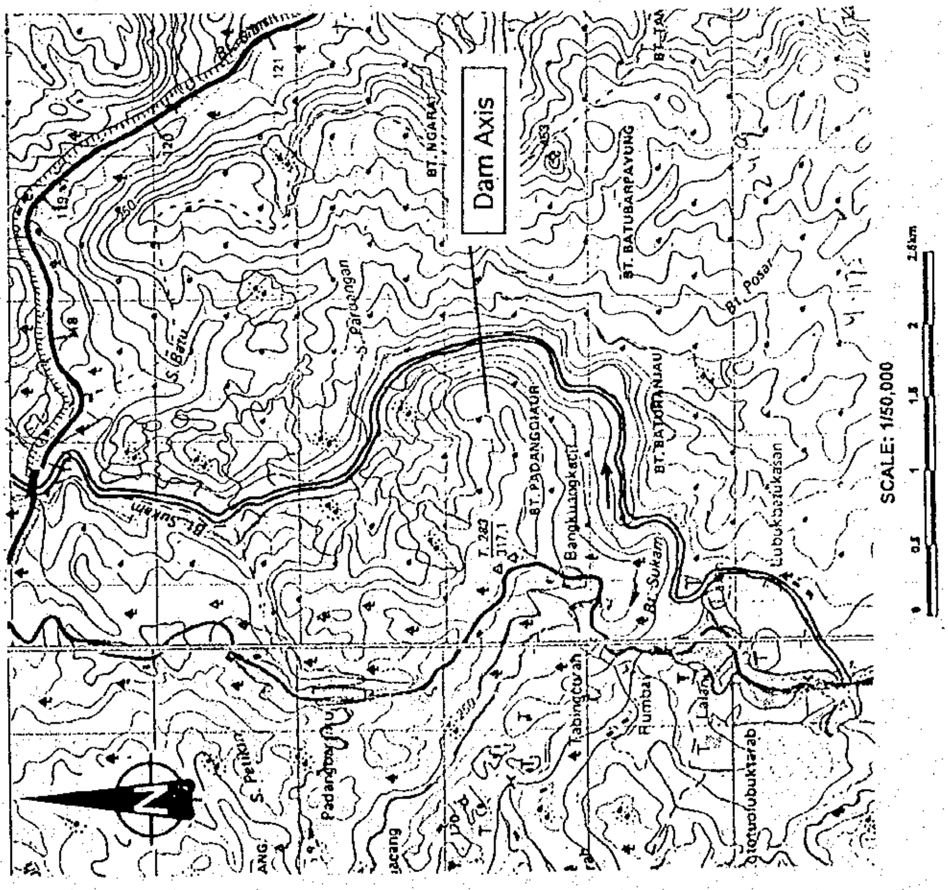
THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.1.3 (4/6) LOCATION OF DAM AXIS (UPPER SINAMAR DAM)
JAPAN INTERNATIONAL COOPERATION AGENCY	



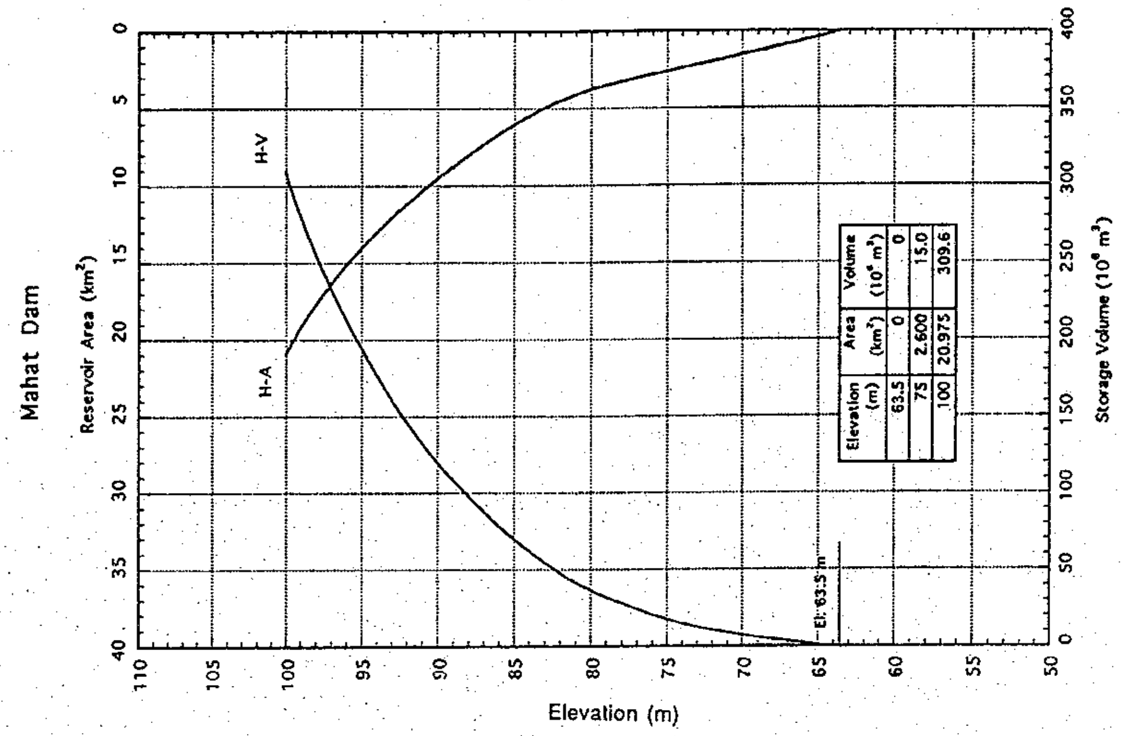
THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.1.3 (5/6) LOCATION OF DAM AXIS (KUANTAN DAM)
JAPAN INTERNATIONAL COOPERATION AGENCY	

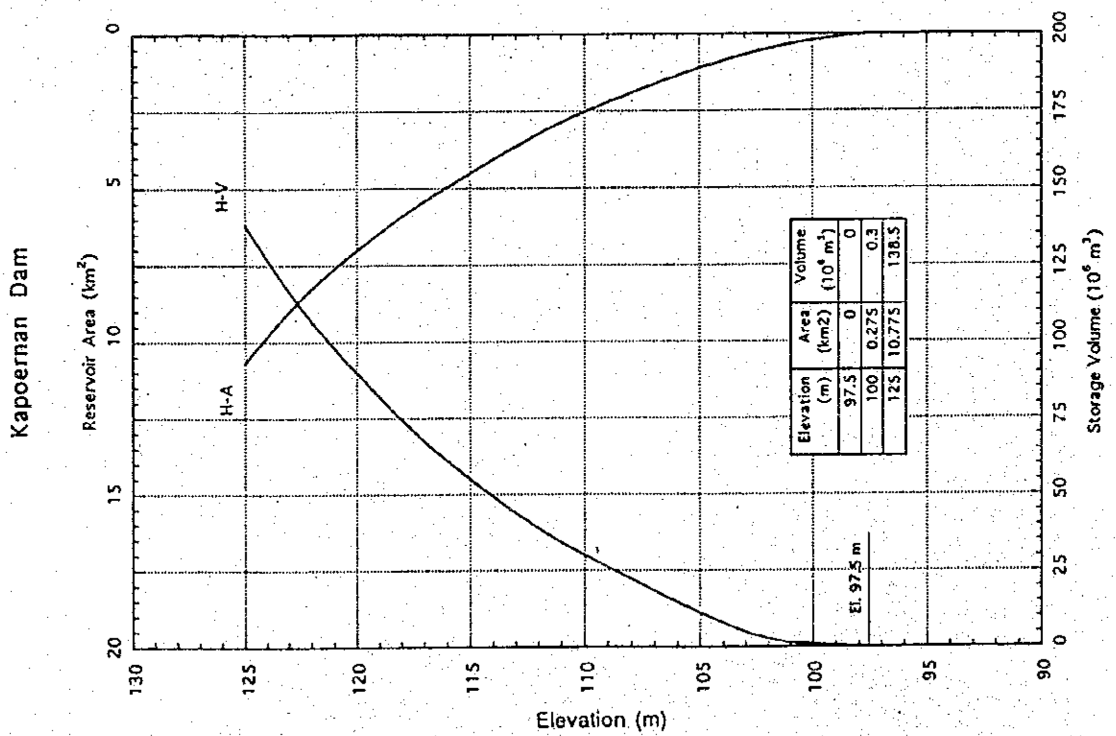


Location
Longitude : 101° 01.08' (E)
Latitude : 00° 46.47' (S)



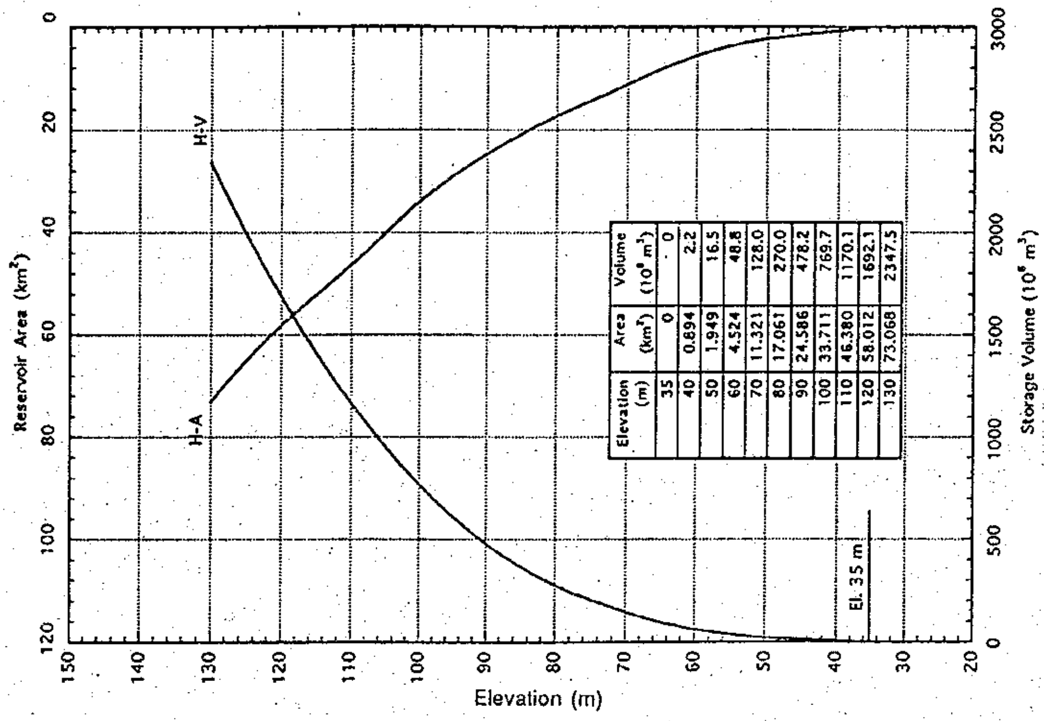
THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.1.3 (6/6) LOCATION OF DAM AXIS (SUKAM DAM)
JAPAN INTERNATIONAL COOPERATION AGENCY	





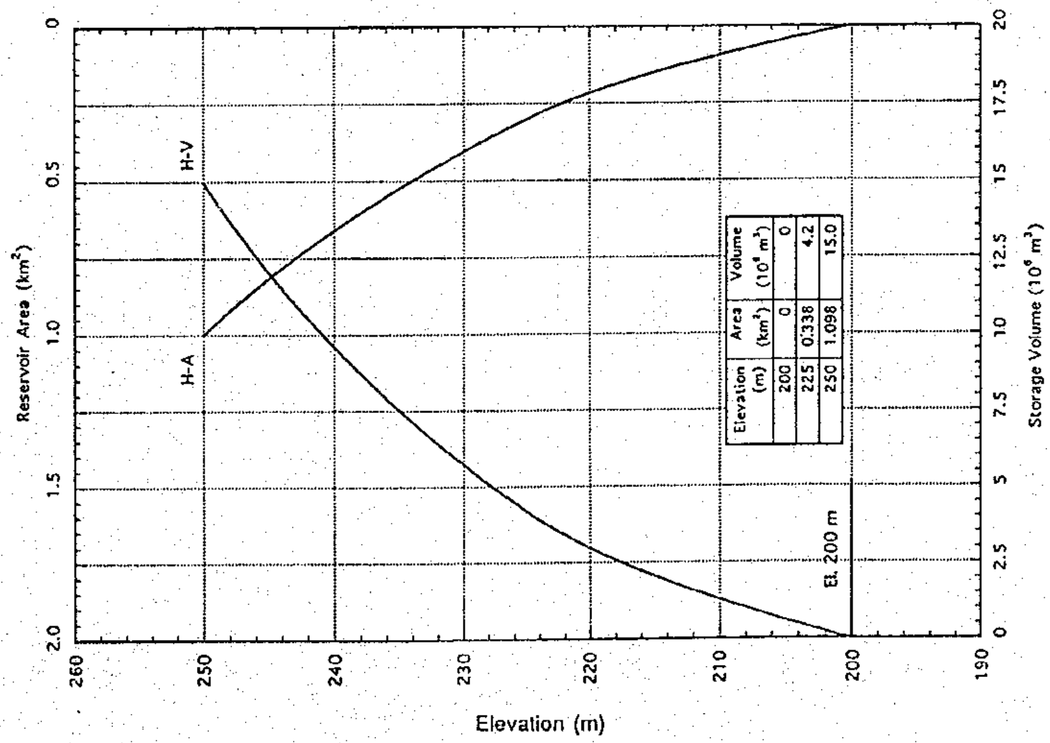
THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.1.4 (1/5) ELEVATION-AREA-CAPACITY CURVES
JAPAN INTERNATIONAL COOPERATION AGENCY	

Kampar Kiri No.1 Dam



Elevation (m)	Area (km²)	Volume ($10^6 m^3$)
35	0	0
40	0.894	2.2
50	1.949	16.5
60	4.524	48.8
70	11.321	128.0
80	17.061	270.0
90	24.586	478.2
100	33.711	769.7
110	46.380	1170.1
120	58.012	1692.1
130	73.068	2347.5

Kototengah Dam

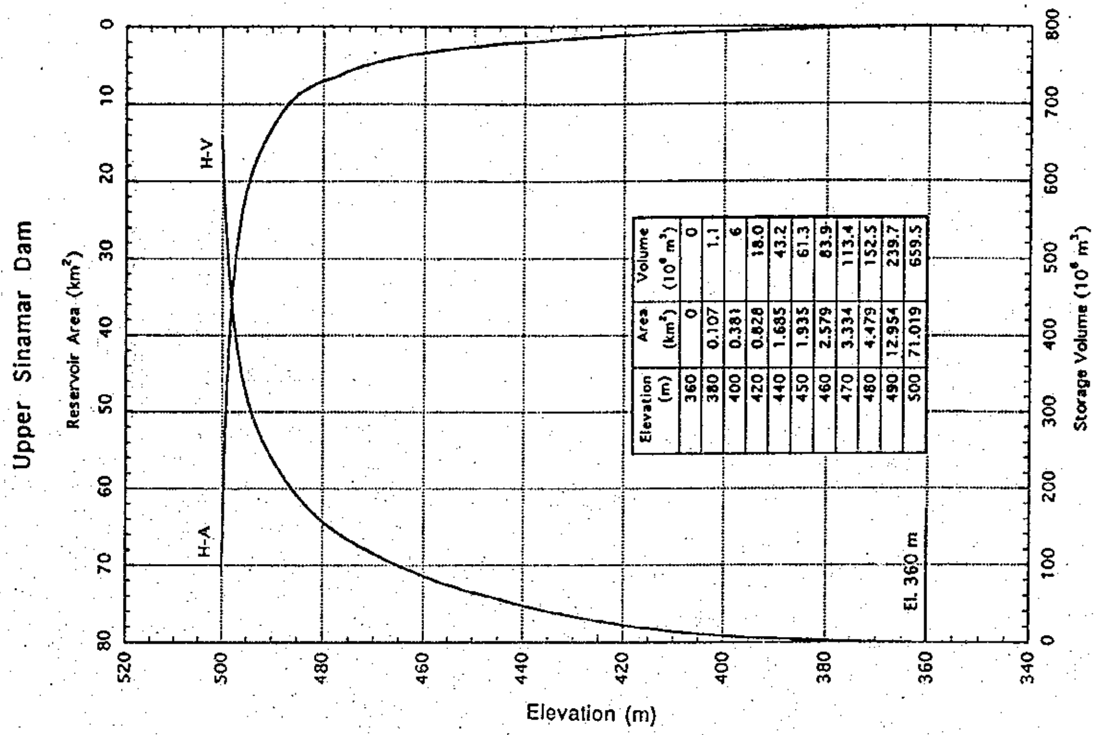


Elevation (m)	Area (km²)	Volume ($10^6 m^3$)
200	0	0
225	0.338	4.2
250	1.098	15.0

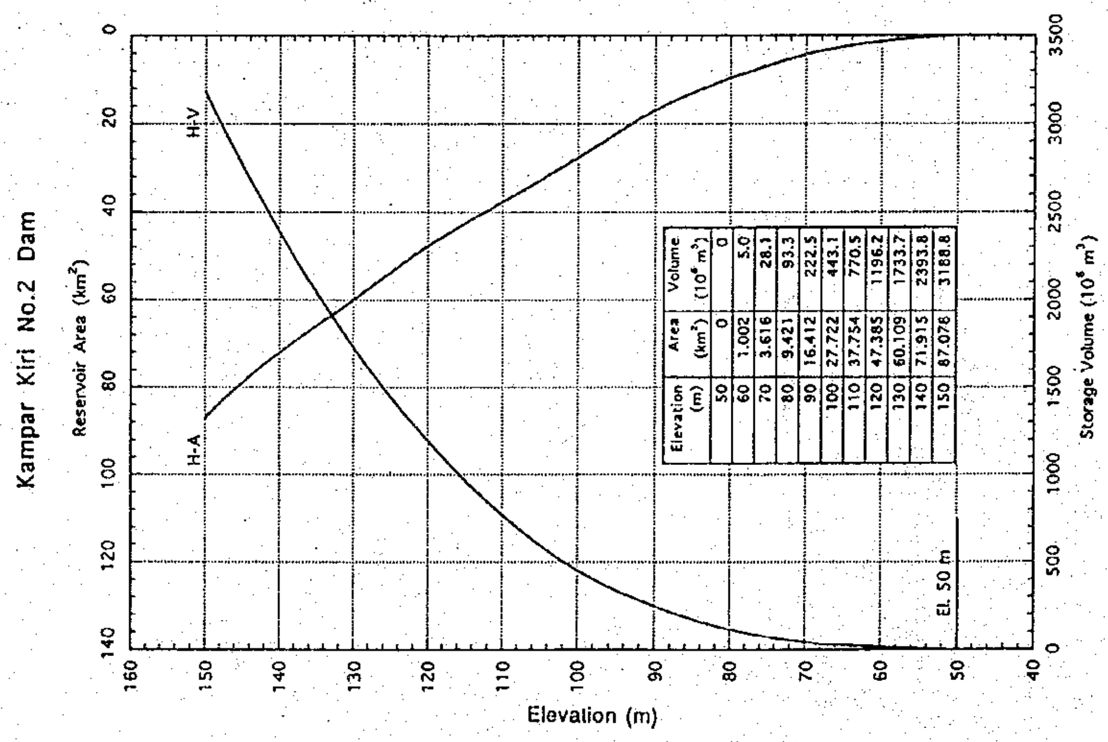
THE STUDY ON
KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT
IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. XII.1.4 (2/5) ELEVATION-AREA-CAPACITY CURVES



Elevation (m)	Area (km²)	Volume (10⁶ m³)
360	0	0
380	0.107	1.1
400	0.381	6
420	0.828	18.0
440	1.685	43.2
450	1.935	61.3
460	2.579	83.9
470	3.334	113.4
480	4.479	152.5
490	12.954	239.7
500	71.019	659.5

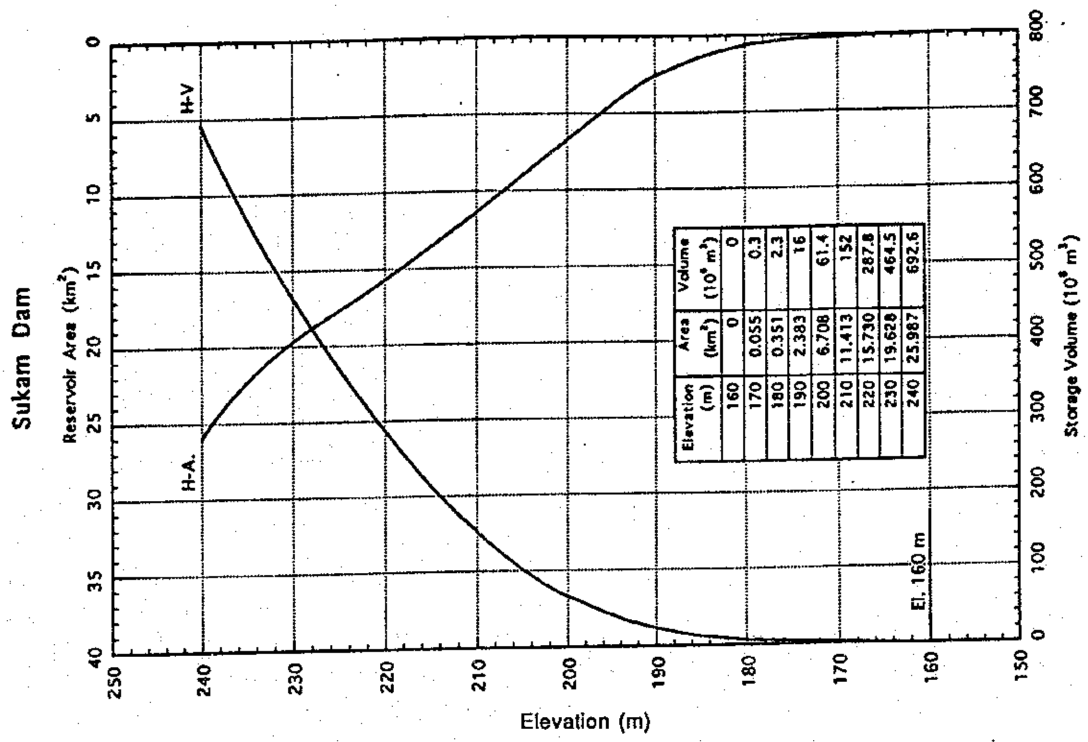


Elevation (m)	Area (km²)	Volume (10⁶ m³)
50	0	0
60	1.002	5.0
70	3.616	28.1
80	9.421	93.3
90	16.412	222.5
100	27.722	443.1
110	37.754	770.5
120	47.385	1196.2
130	60.109	1733.7
140	71.915	2393.8
150	87.076	3188.8

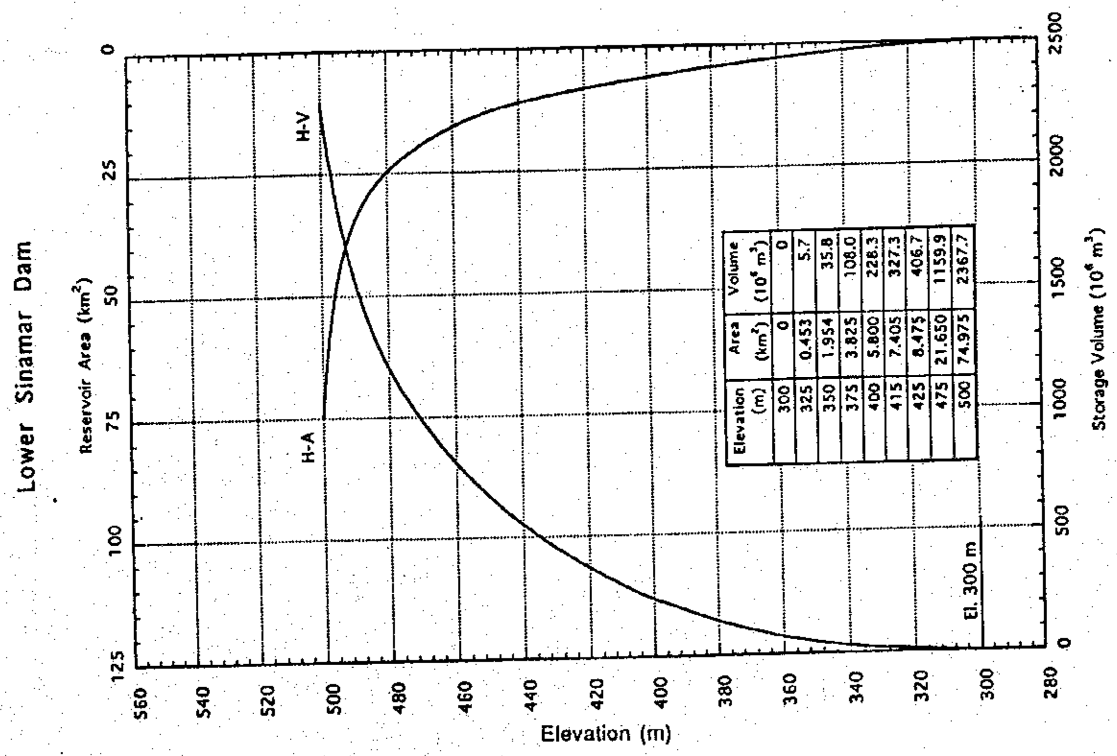
THE STUDY ON
KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT
IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. XII.1.4 (3/5) ELEVATION-AREA-CAPACITY CURVES



Elevation (m)	Area (km²)	Volume (10⁶ m³)
160	0	0
170	0.055	0.3
180	0.351	2.3
190	2.383	16
200	6.708	61.4
210	11.413	152
220	15.730	287.8
230	19.628	464.5
240	25.987	692.6

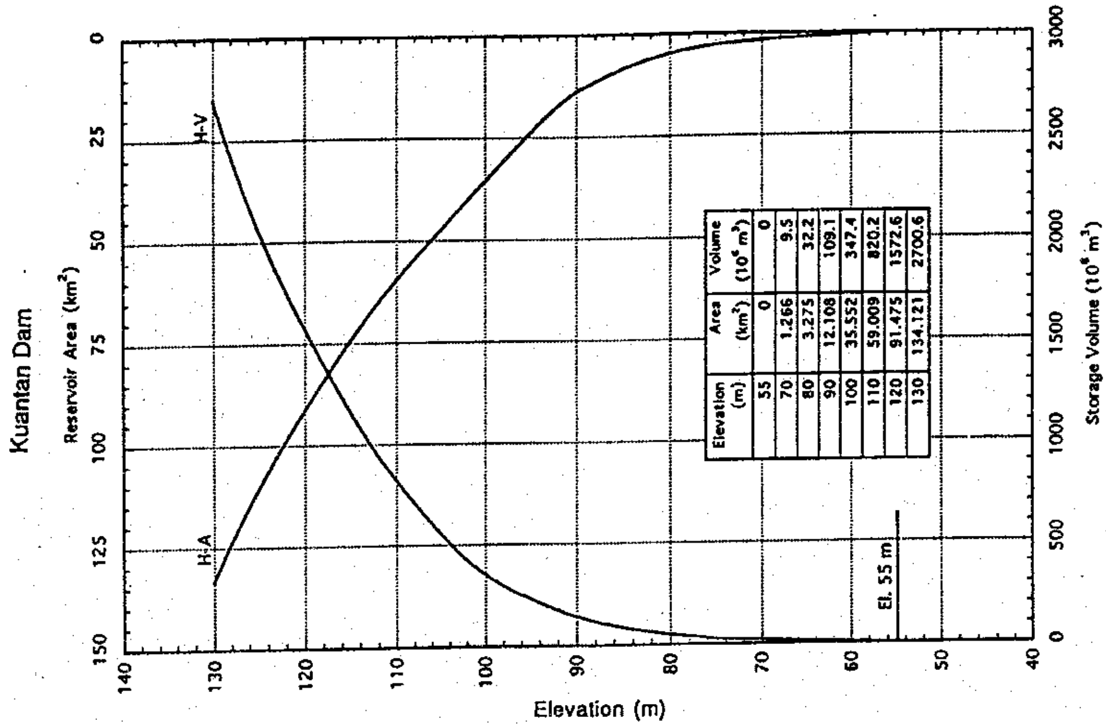


Elevation (m)	Area (km²)	Volume (10⁶ m³)
300	0	0
325	0.453	5.7
350	1.954	35.8
375	3.825	108.0
400	5.800	228.3
415	7.405	327.3
425	8.475	406.7
475	21.650	1159.9
500	74.975	2367.7

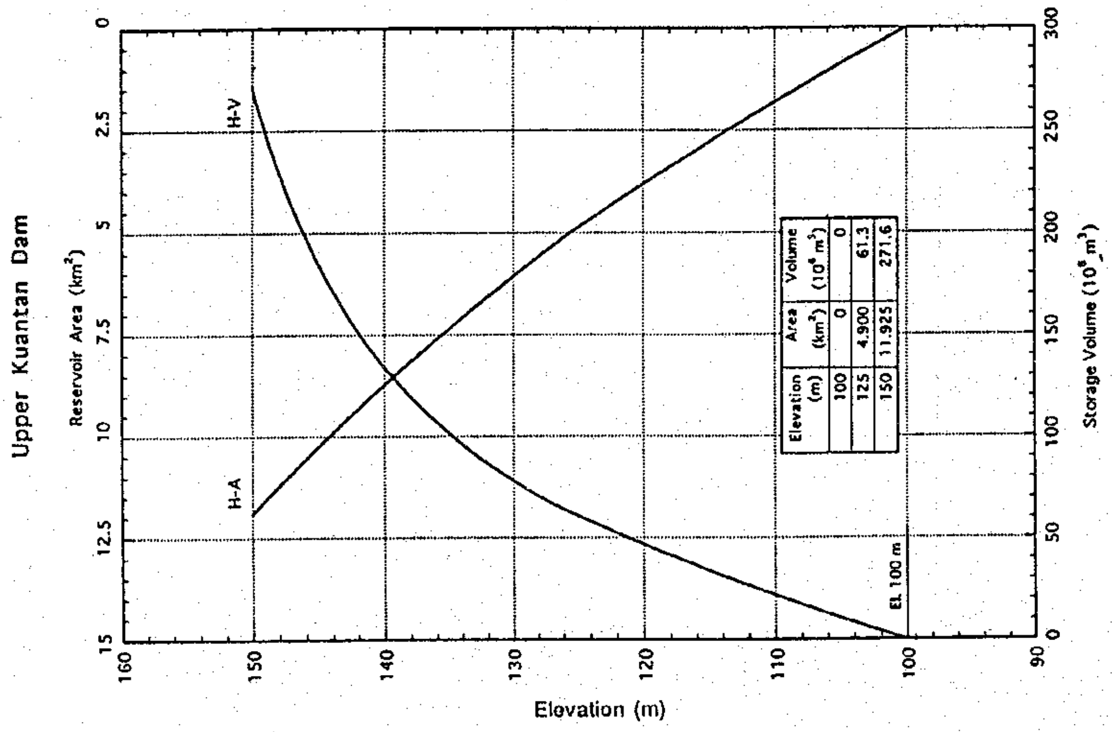
THE STUDY ON
KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT
IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. XII.1.4 (4/5) ELEVATION-AREA-CAPACITY CURVES

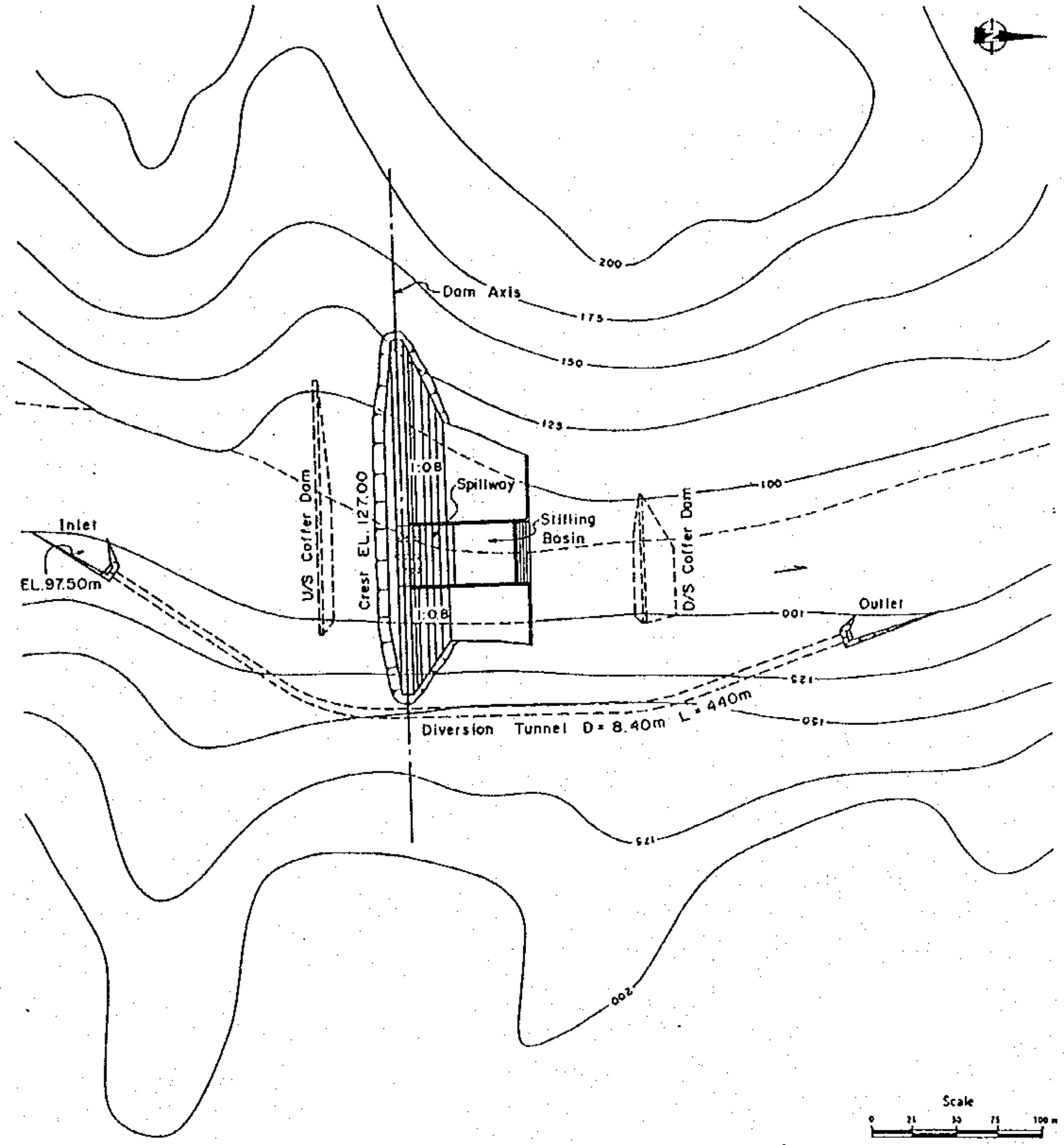


Elevation (m)	Area (km²)	Volume (10⁶ m³)
55	0	0
70	1.266	9.5
80	3.275	32.2
90	12.108	109.1
100	35.552	347.4
110	59.009	820.2
120	91.475	1572.6
130	134.121	2700.6

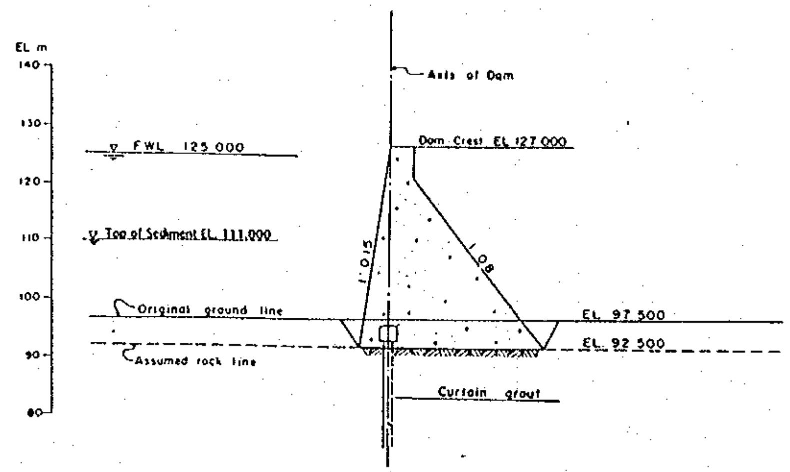


Elevation (m)	Area (km²)	Volume (10⁶ m³)
100	0	0
125	4.900	61.3
150	11.925	271.6

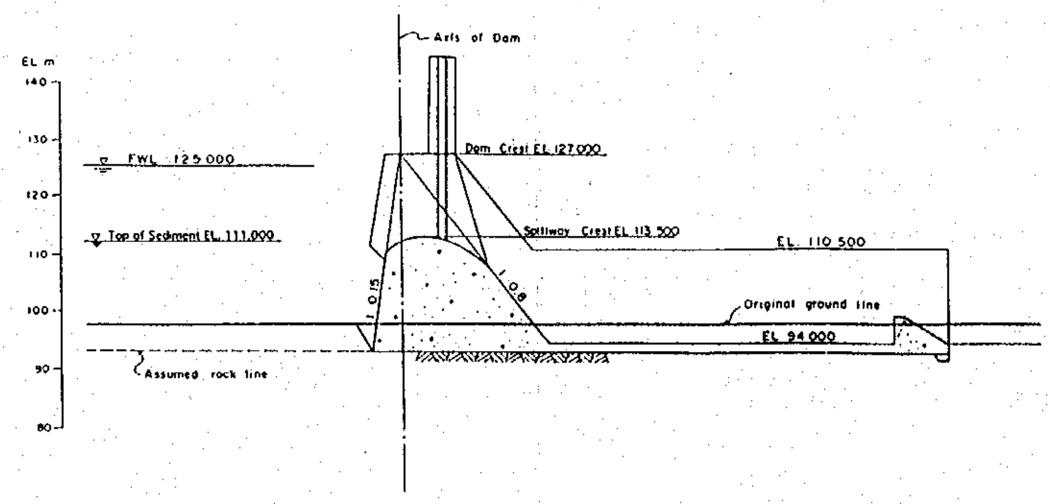
THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.1.4 (5/5) ELEVATION-AREA-CAPACITY CURVES
JAPAN INTERNATIONAL COOPERATION AGENCY	



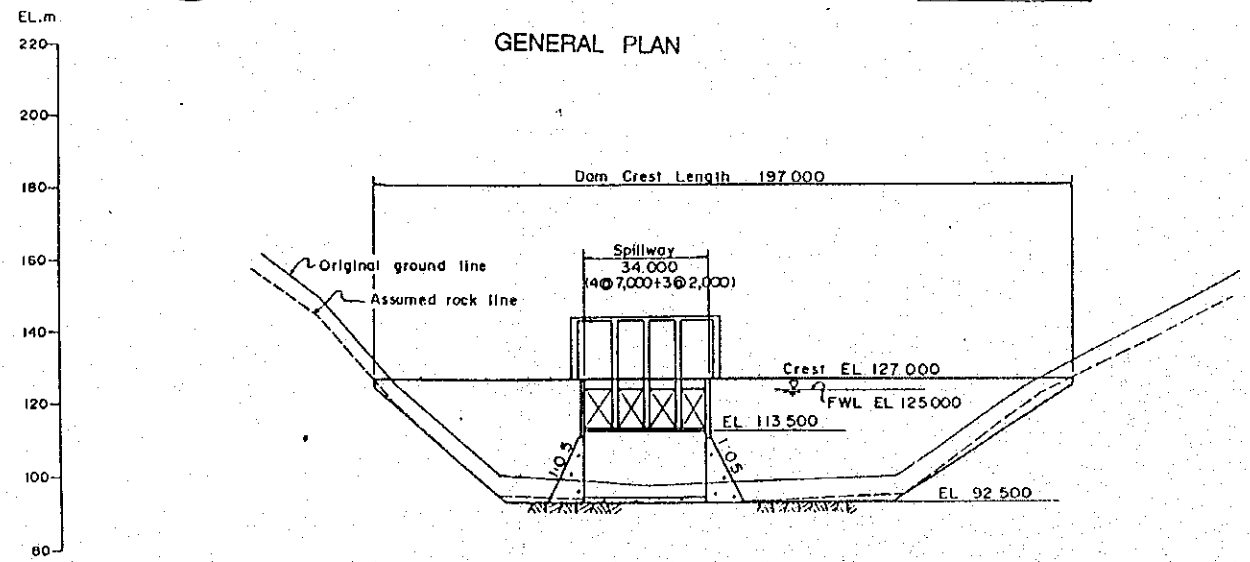
GENERAL PLAN



TYPICAL CROSS SECTION OF DAM

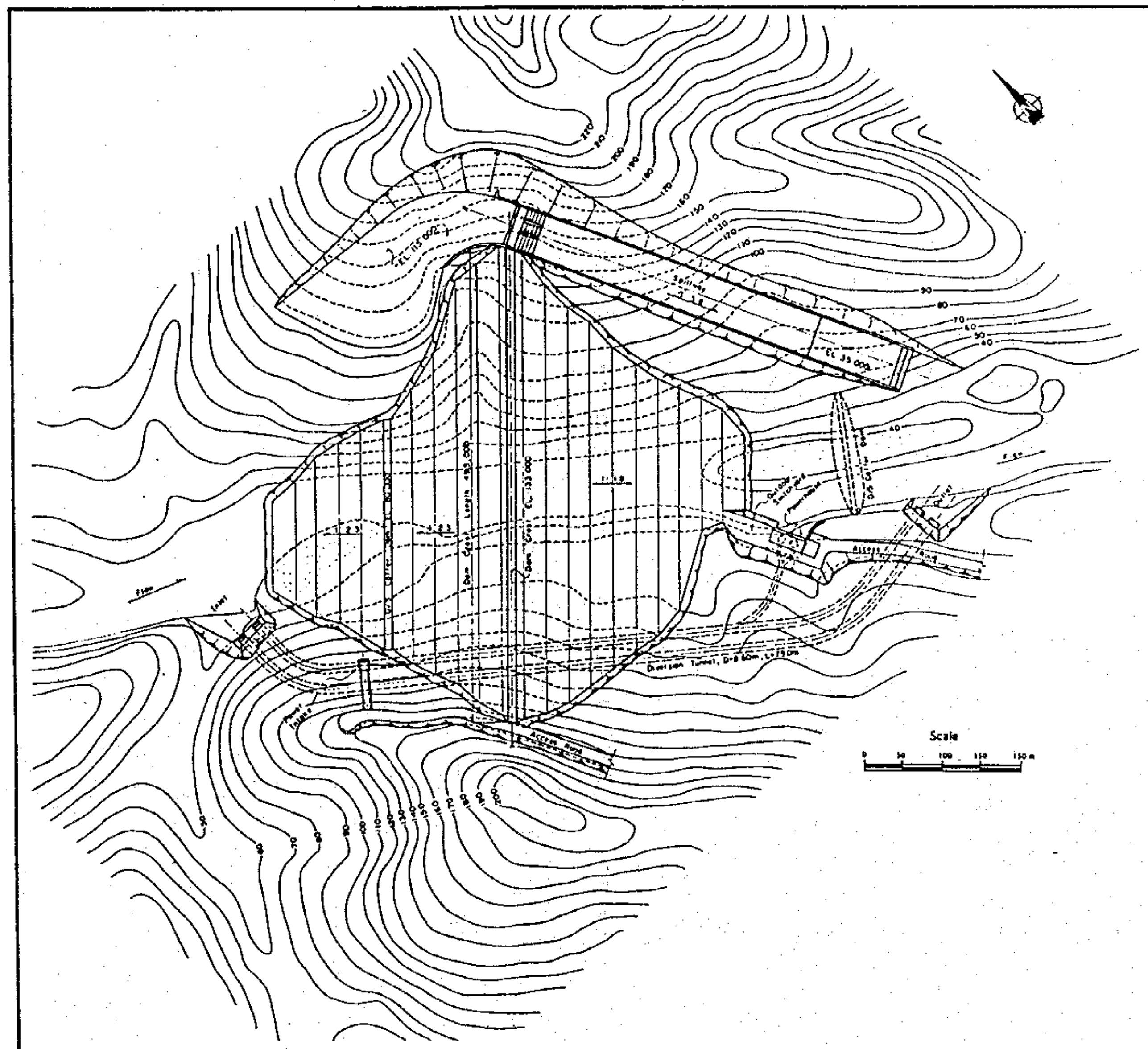


PROFILE OF SPILLWAY

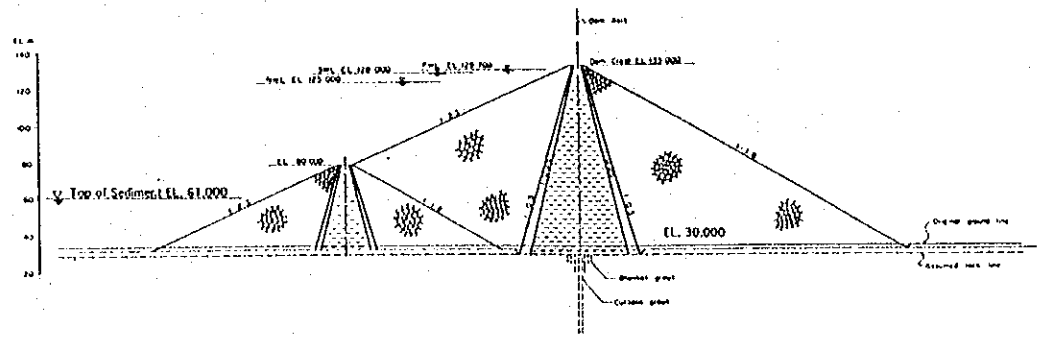


DOWNSTREAM ELEVATION

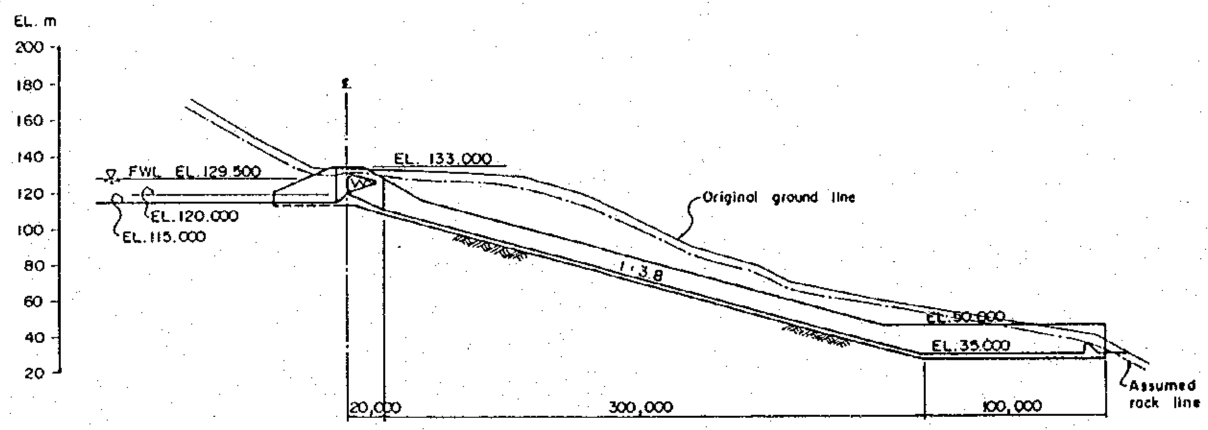
THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.2.1 (1/6) STRUCTURAL LAYOUT PLAN OF POSSIBLE DAMS (KAPOERNAN DAM)
JAPAN INTERNATIONAL COOPERATION AGENCY	



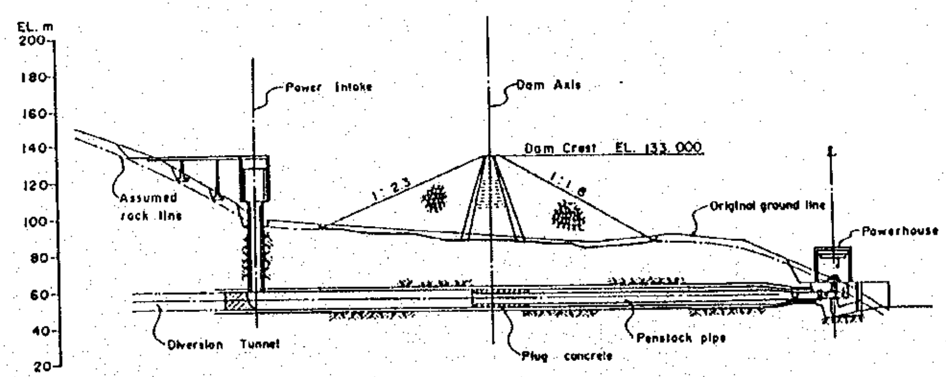
GENERAL PLAN



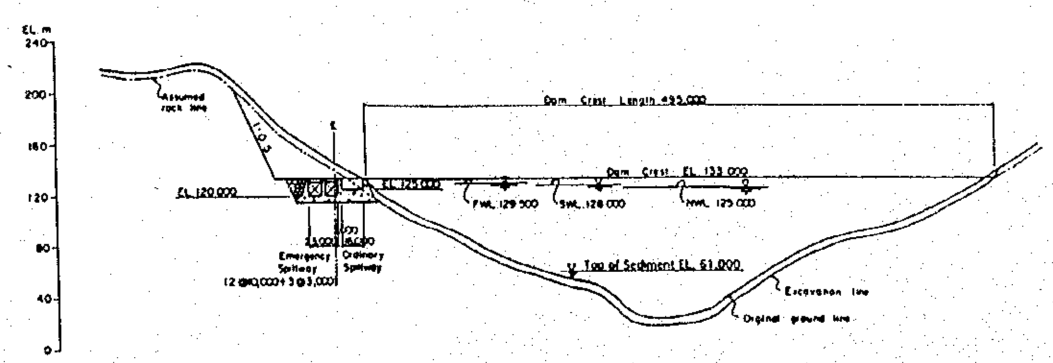
TYPICAL CROSS SECTION OF DAM



PROFILE OF SPILLWAY

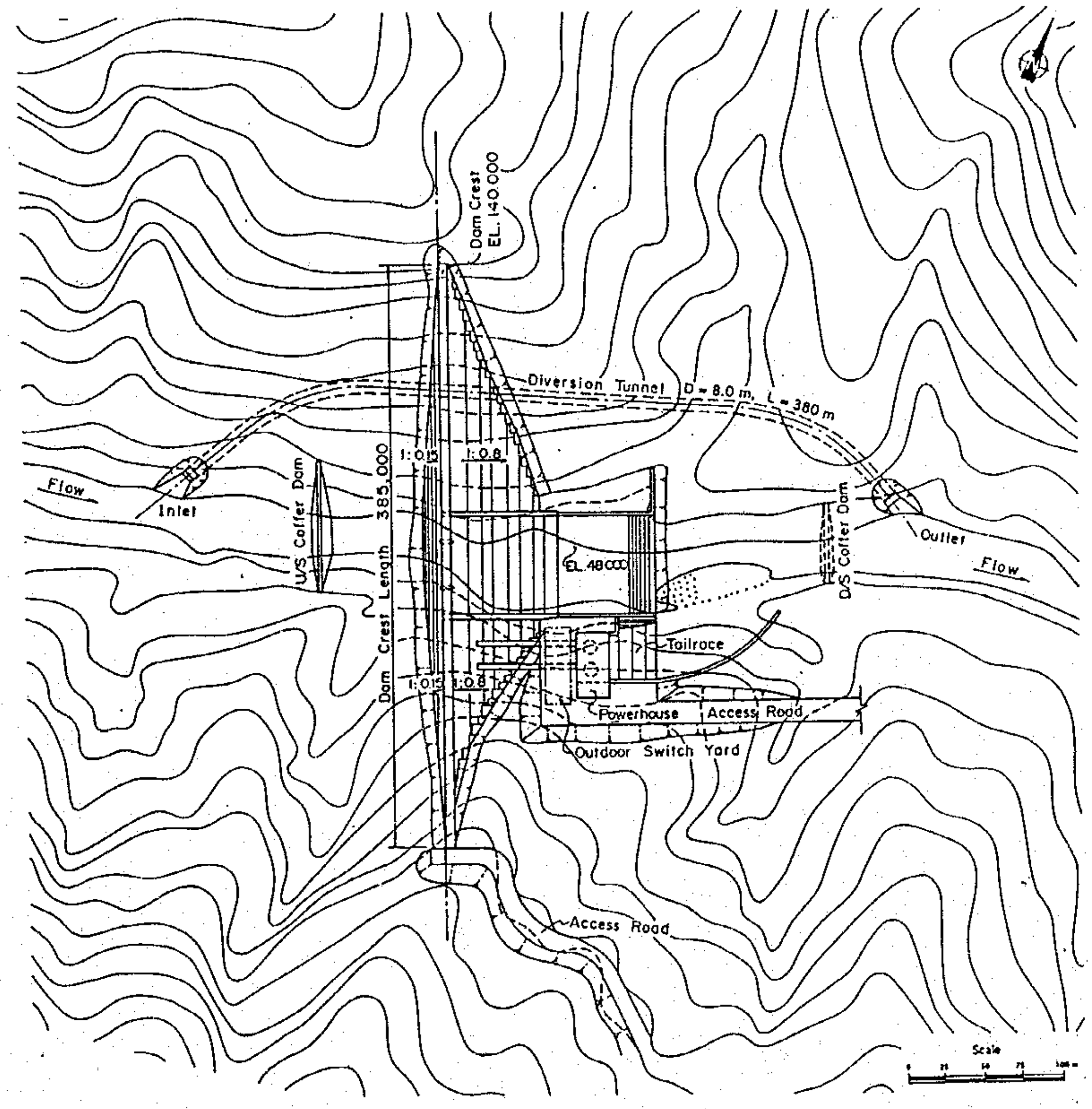


PROFILE OF POWER LINE

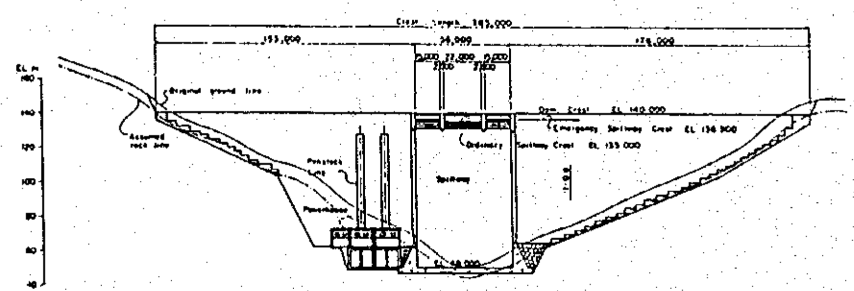


PROFILE

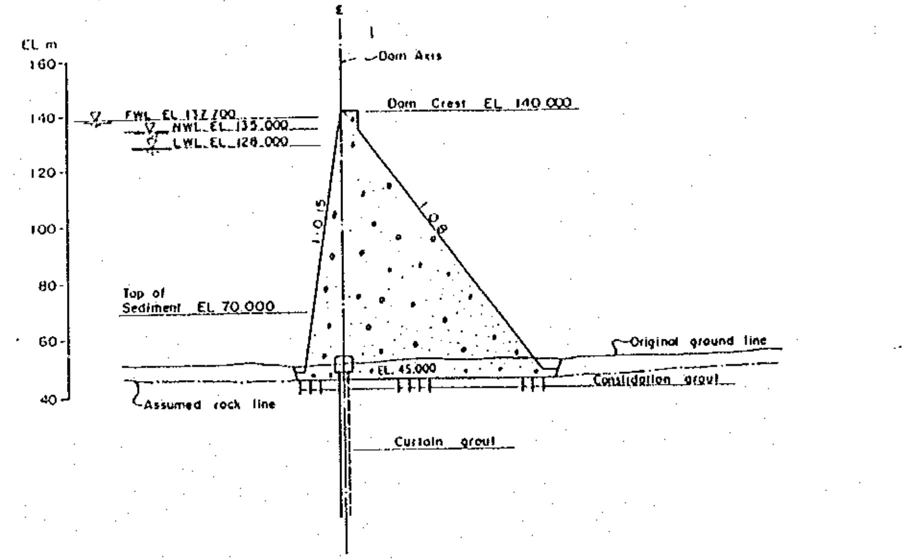
THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.2.1 (2/6) STRUCTURAL LAYOUT PLAN OF POSSIBLE DAMS (KAMPAR KIRI NO. 1 DAM)
JAPAN INTERNATIONAL COOPERATION AGENCY	



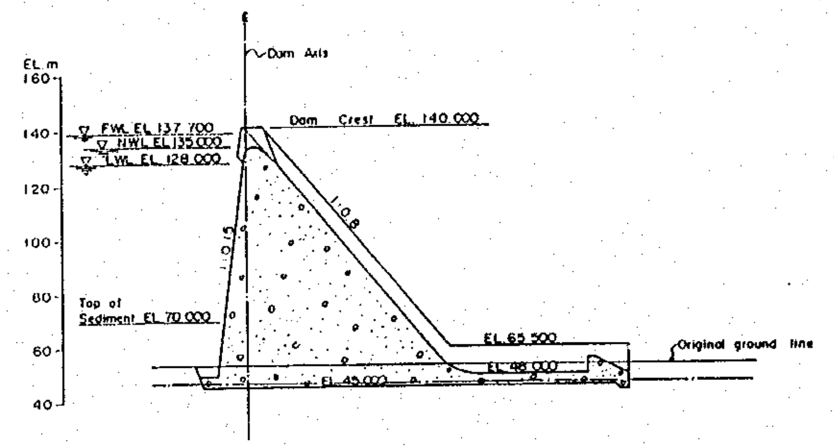
GENERAL PLAN



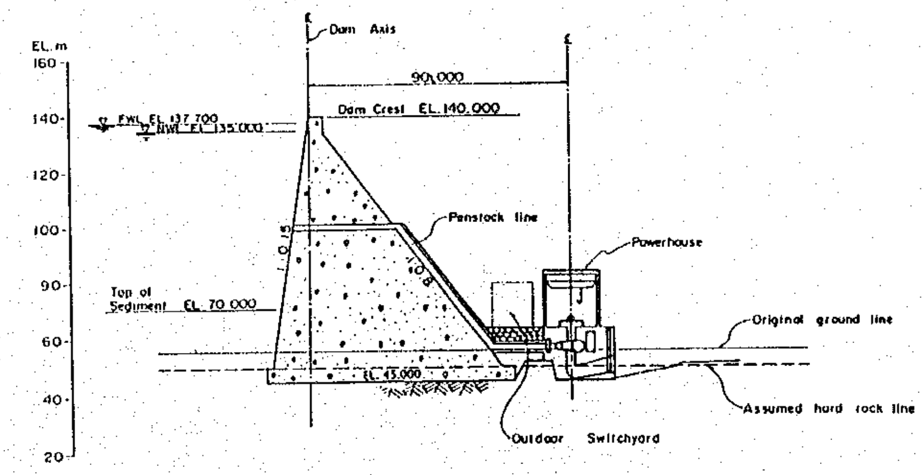
DOWNSTREAM ELEVATION



TYPICAL CROSS SECTION OF DAM

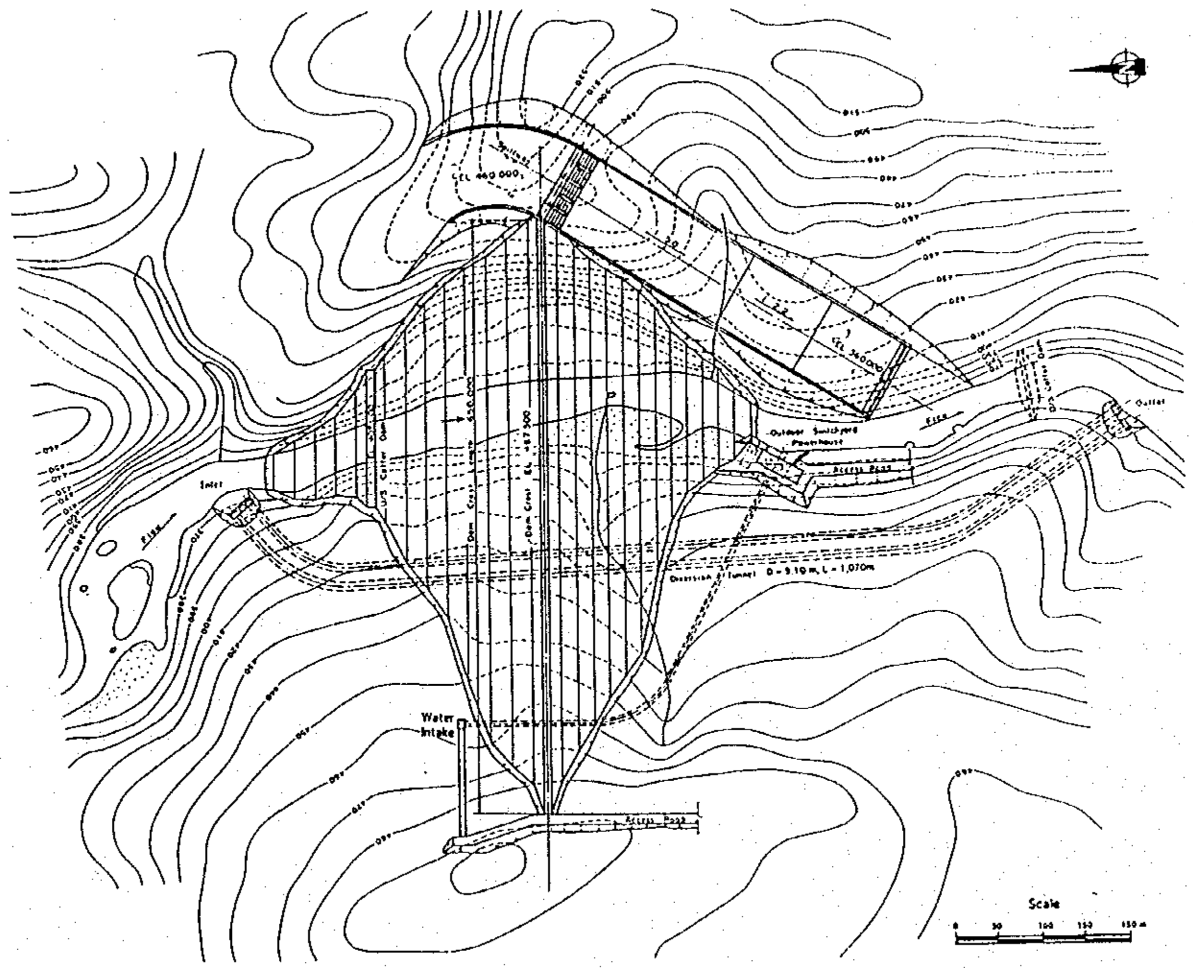


PROFILE OF SPILLWAY

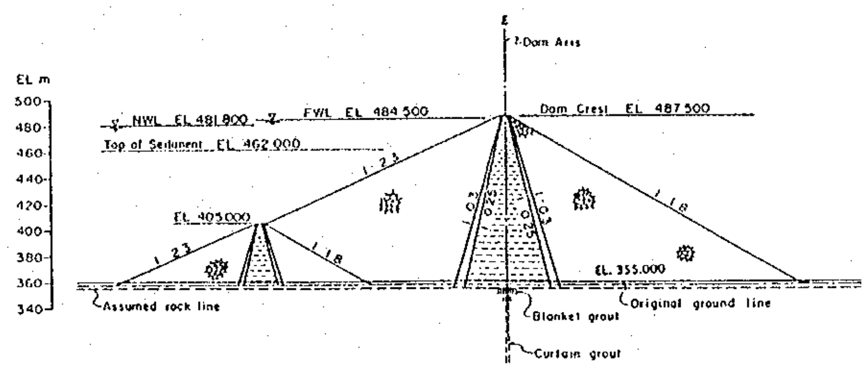


PROFILE OF POWER LINE

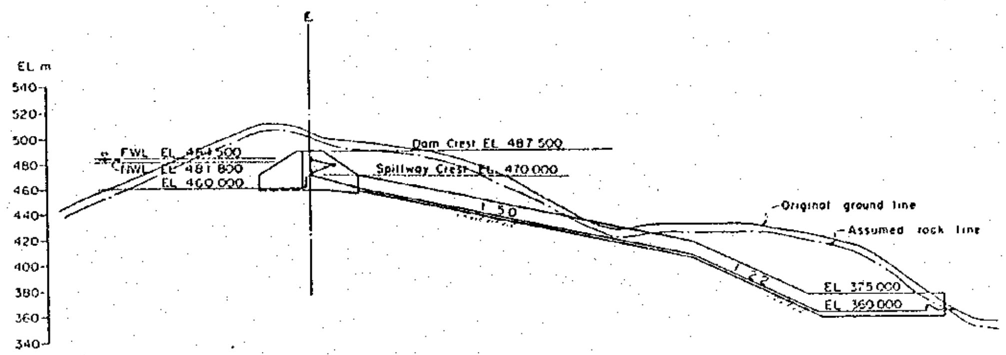
THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. XII.2.1 (3/6) STRUCTURAL LAYOUT PLAN OF POSSIBLE DAMS (KAMPAR KIRI NO. 2 DAM)



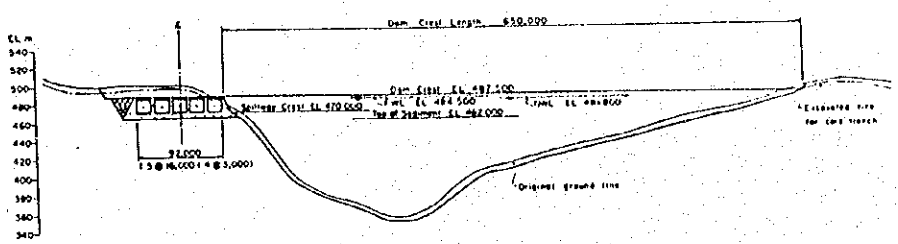
GENERAL PLAN



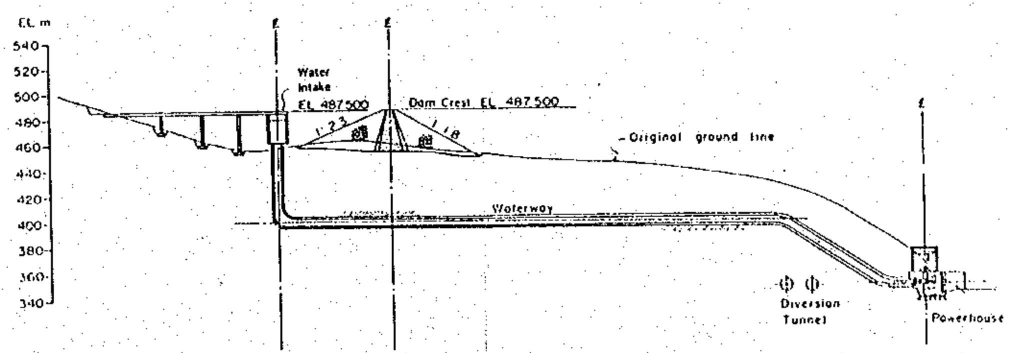
TYPICAL CROSS SECTION OF DAM



PROFILE OF SPILLWAY

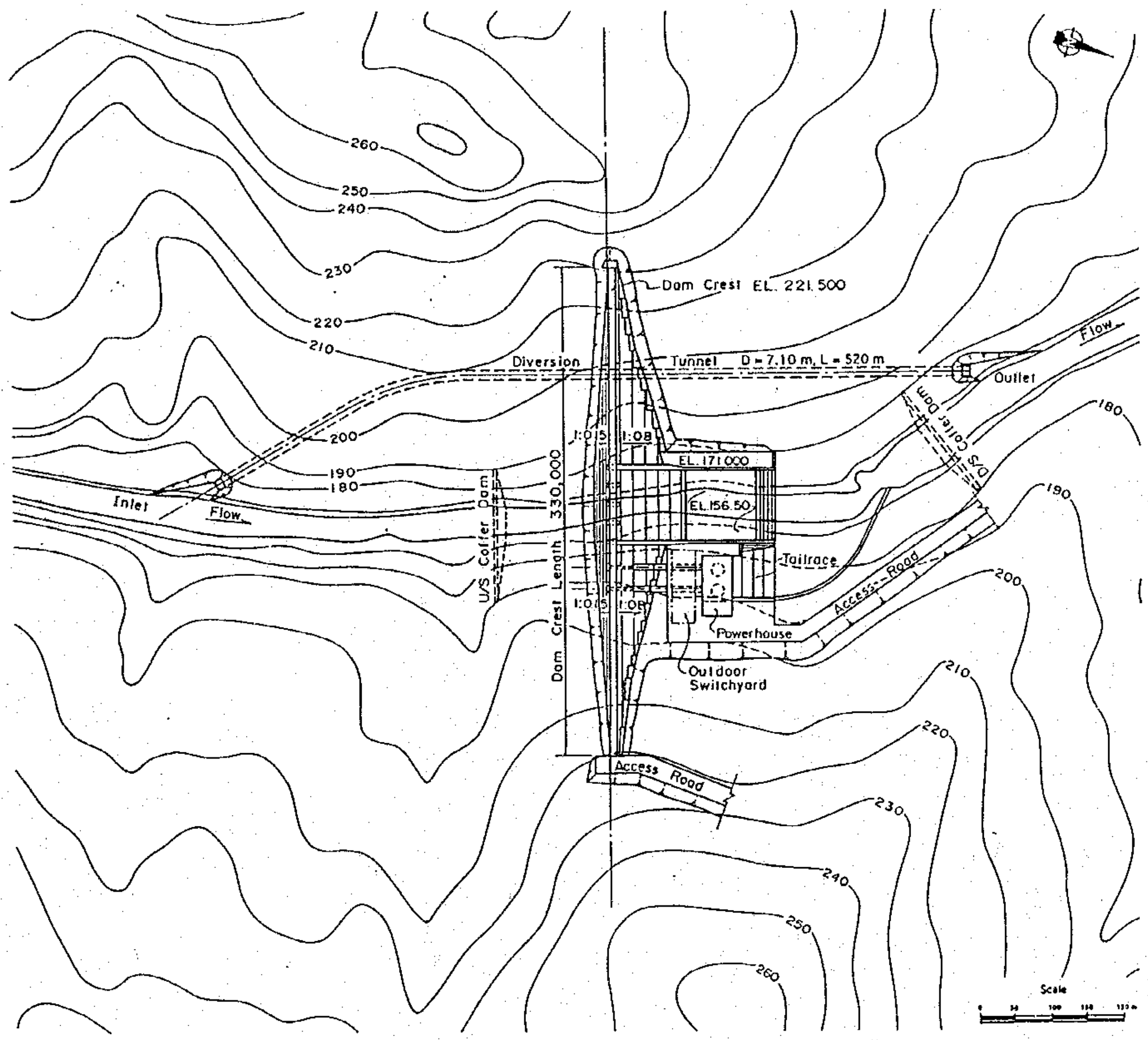


PROFILE

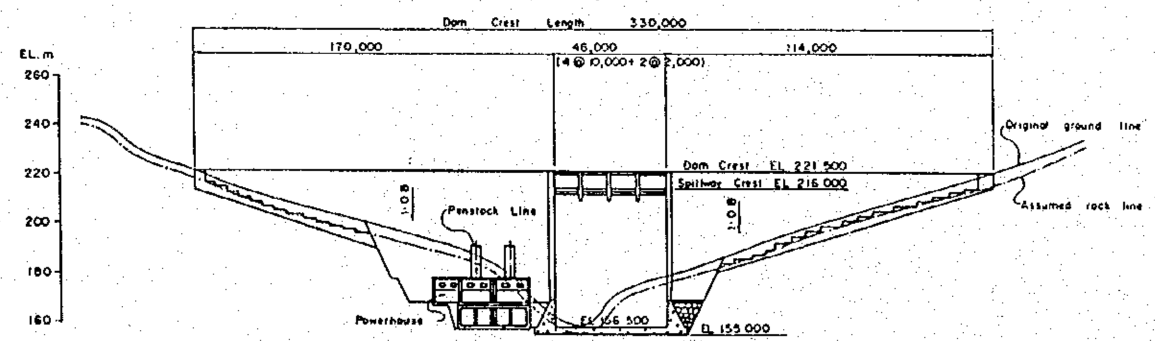


PROFILE OF POWER LINE

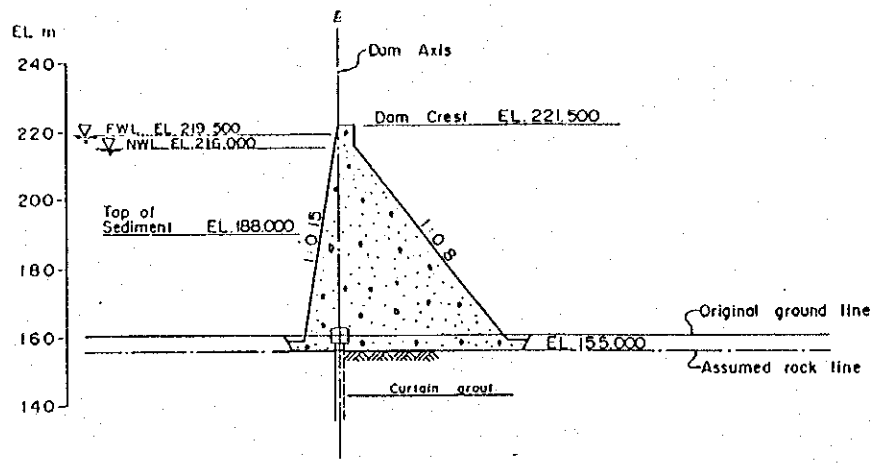
THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.2.1 (4/6)	STRUCTURAL LAYOUT PLAN OF POSSIBLE DAMS (UPPER SINAMAR DAM)
JAPAN INTERNATIONAL COOPERATION AGENCY		



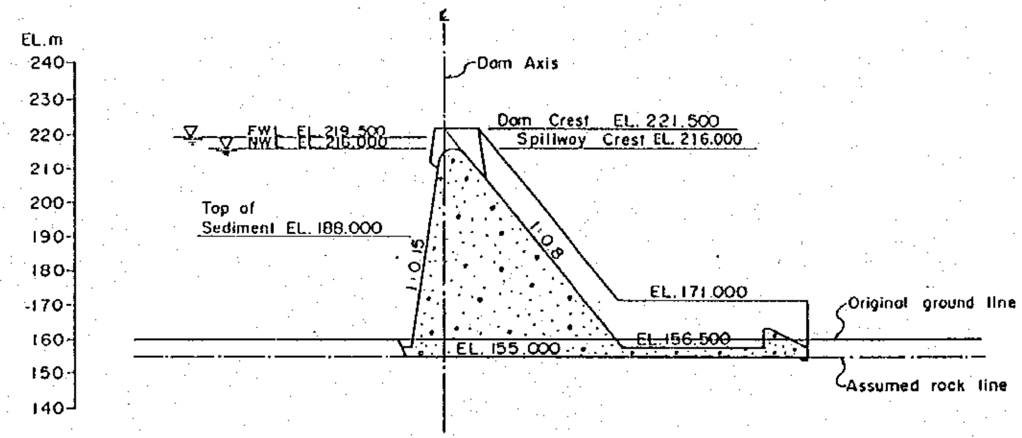
GENERAL PLAN



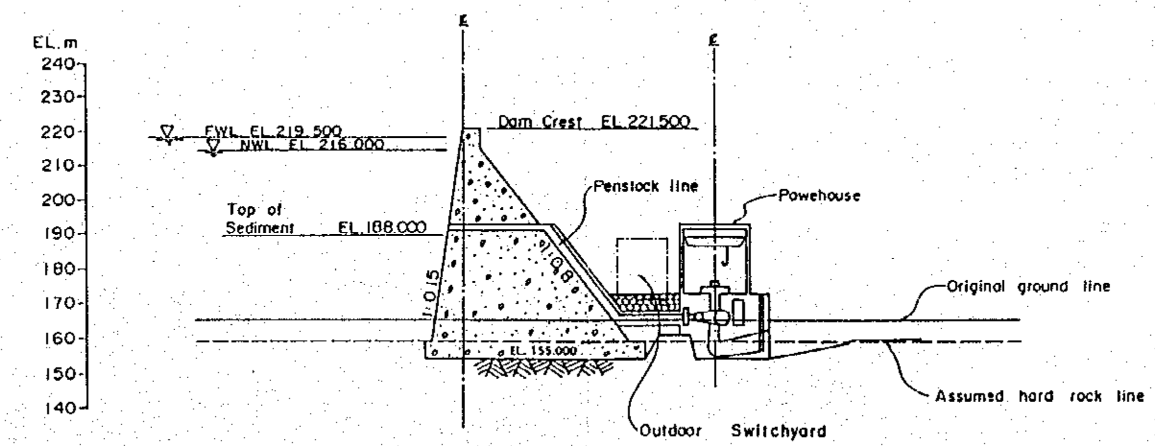
DOWNSTREAM ELEVATION



TYPICAL CROSS SECTION OF DAM

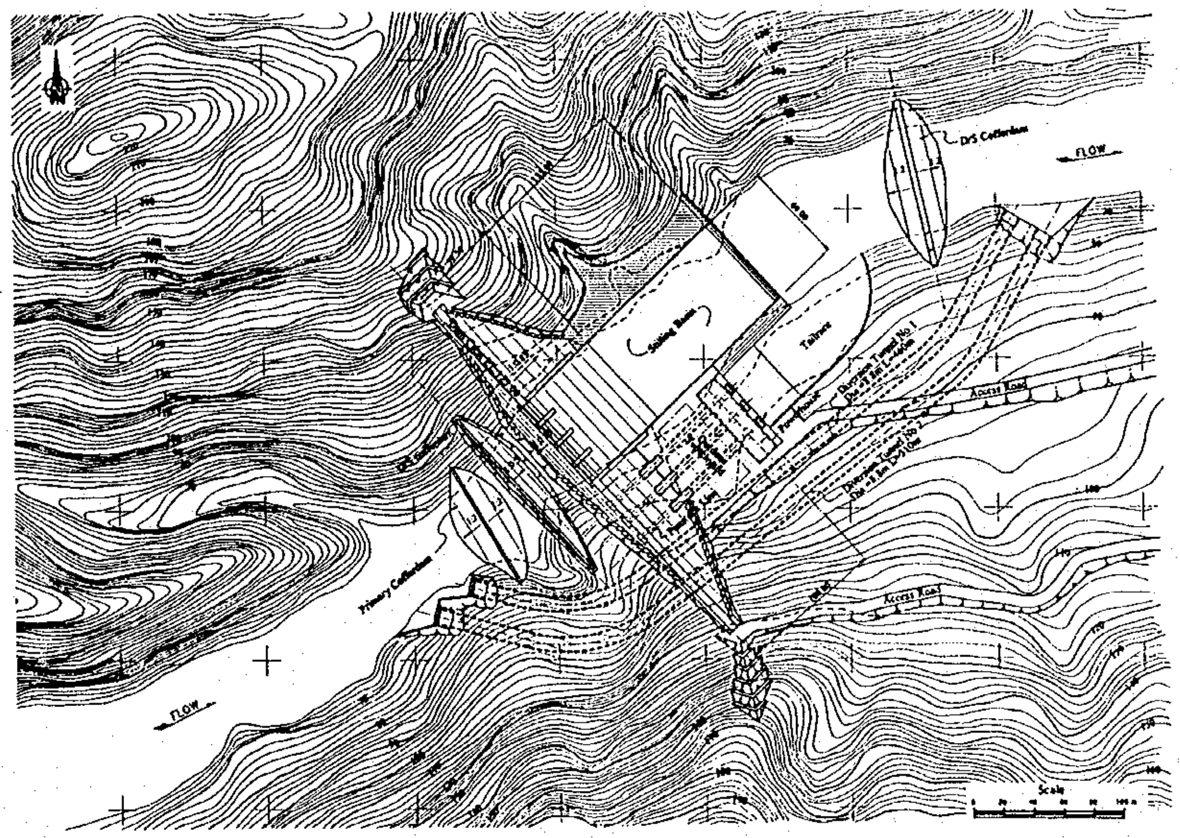


PROFILE OF SPILLWAY

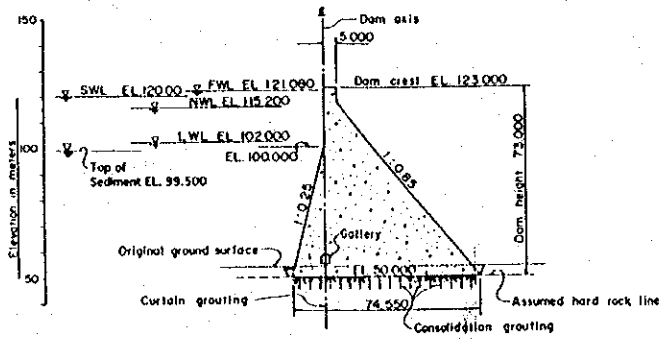


PROFILE OF POWER LINE

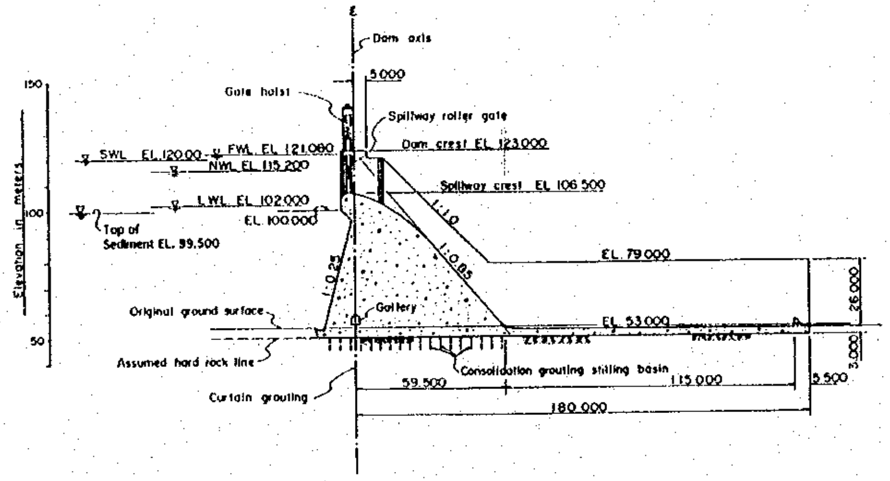
THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. XII.2.1 (5/6) STRUCTURAL LAYOUT PLAN OF POSSIBLE DAMS (SUKAM DAM)



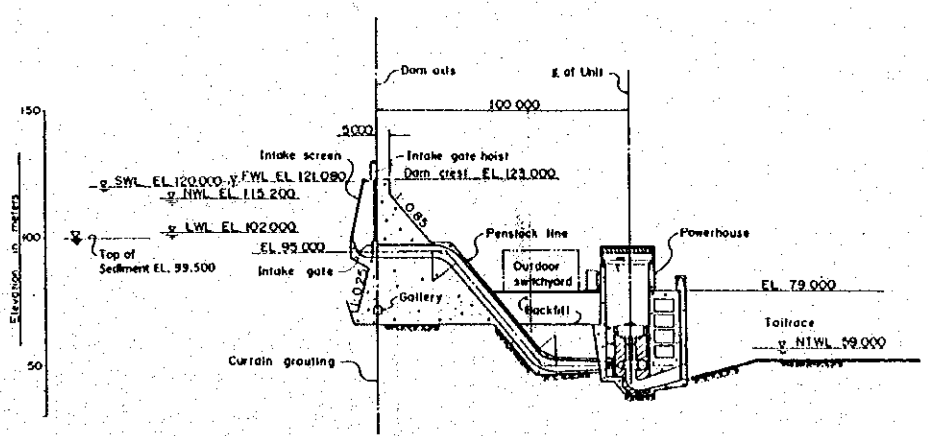
PLAN



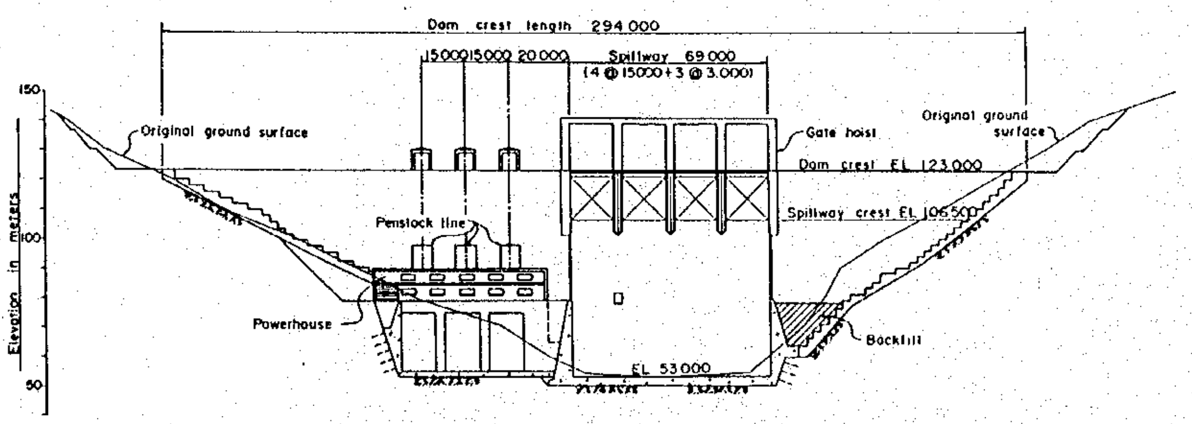
TYPICAL NON-OVERFLOW SECTION



TYPICAL OVERFLOW SECTION



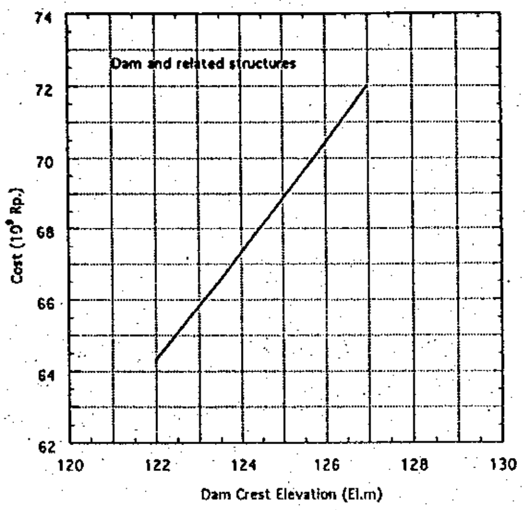
PROFILE OF WATERWAY



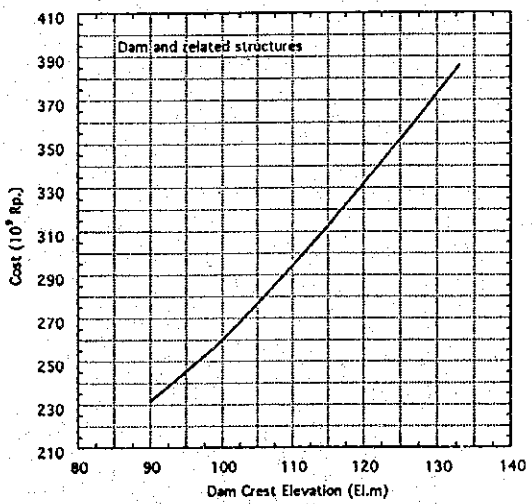
DOWNSTREAM ELEVATION

THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.2.1 (6/6) STRUCTURAL LAYOUT PLAN OF POSSIBLE DAMS (KUANTAN DAM)
JAPAN INTERNATIONAL COOPERATION AGENCY	

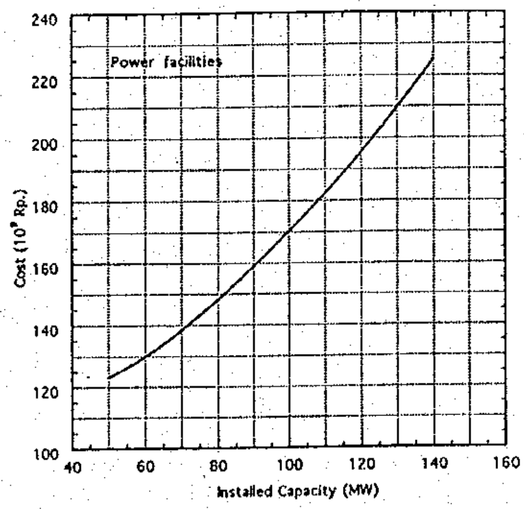
Kapoernan Dam



Kampar Kiri No.1 Dam



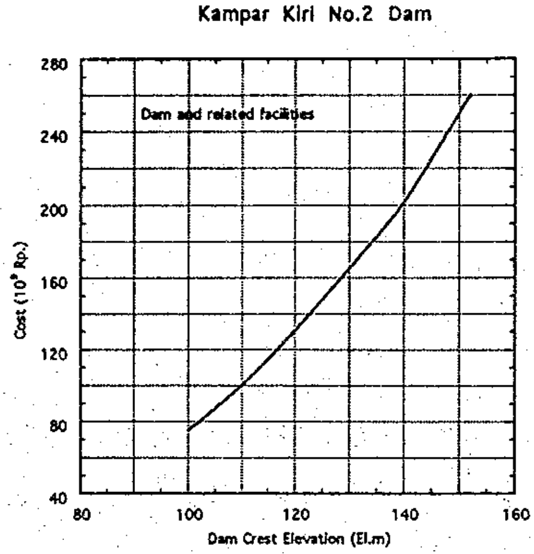
Kampar Kiri No.1 Dam

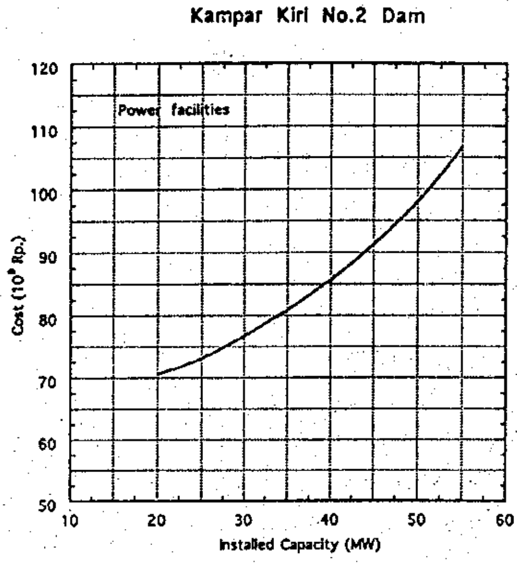


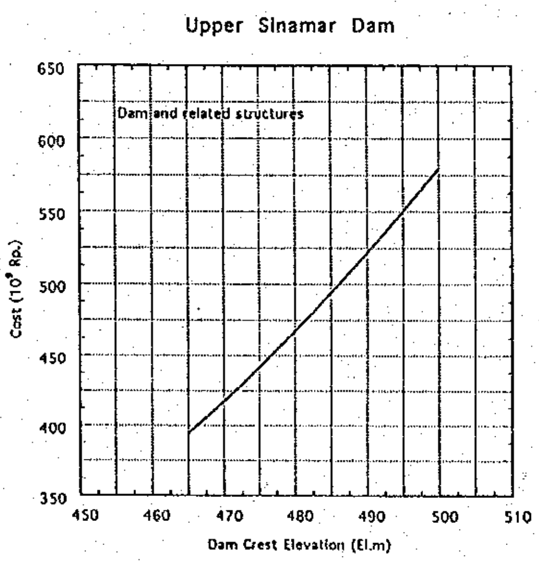
THE STUDY ON
KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT
IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. XII.2.2 (1/3) COST CURVES OF POSSIBLE DAMS







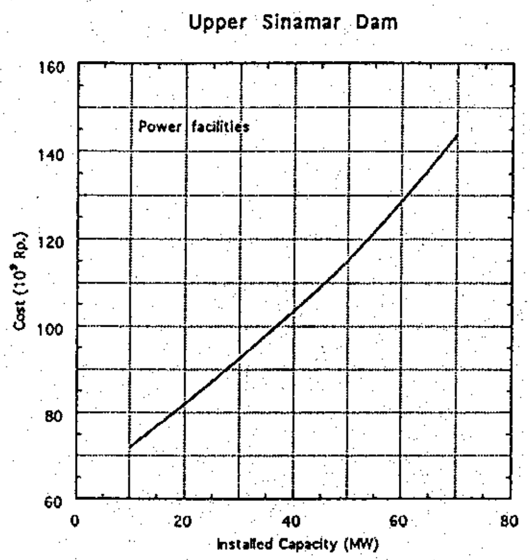


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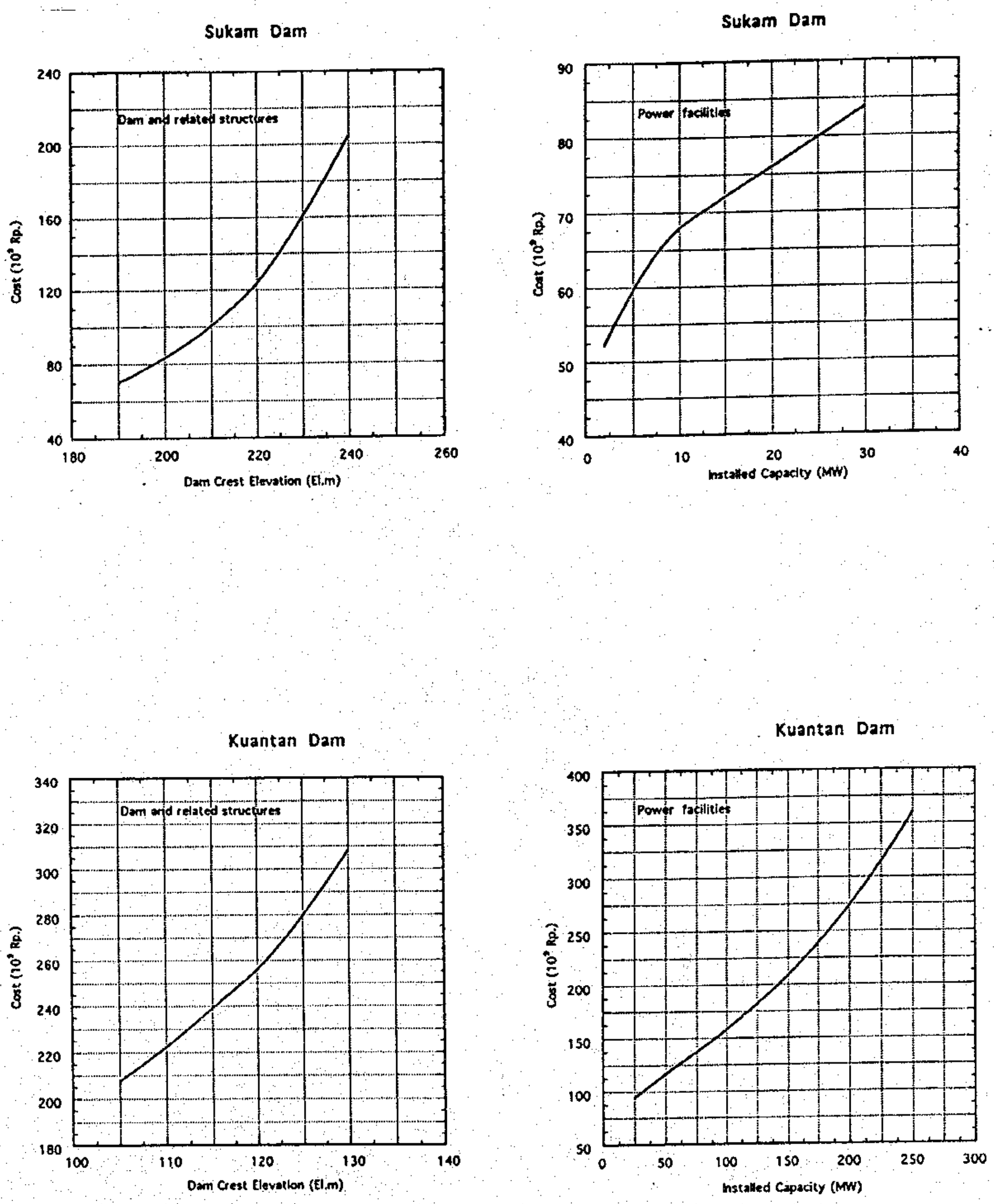
Fig. XII.2.2 (2/3) COST CURVES OF POSSIBLE DAMS



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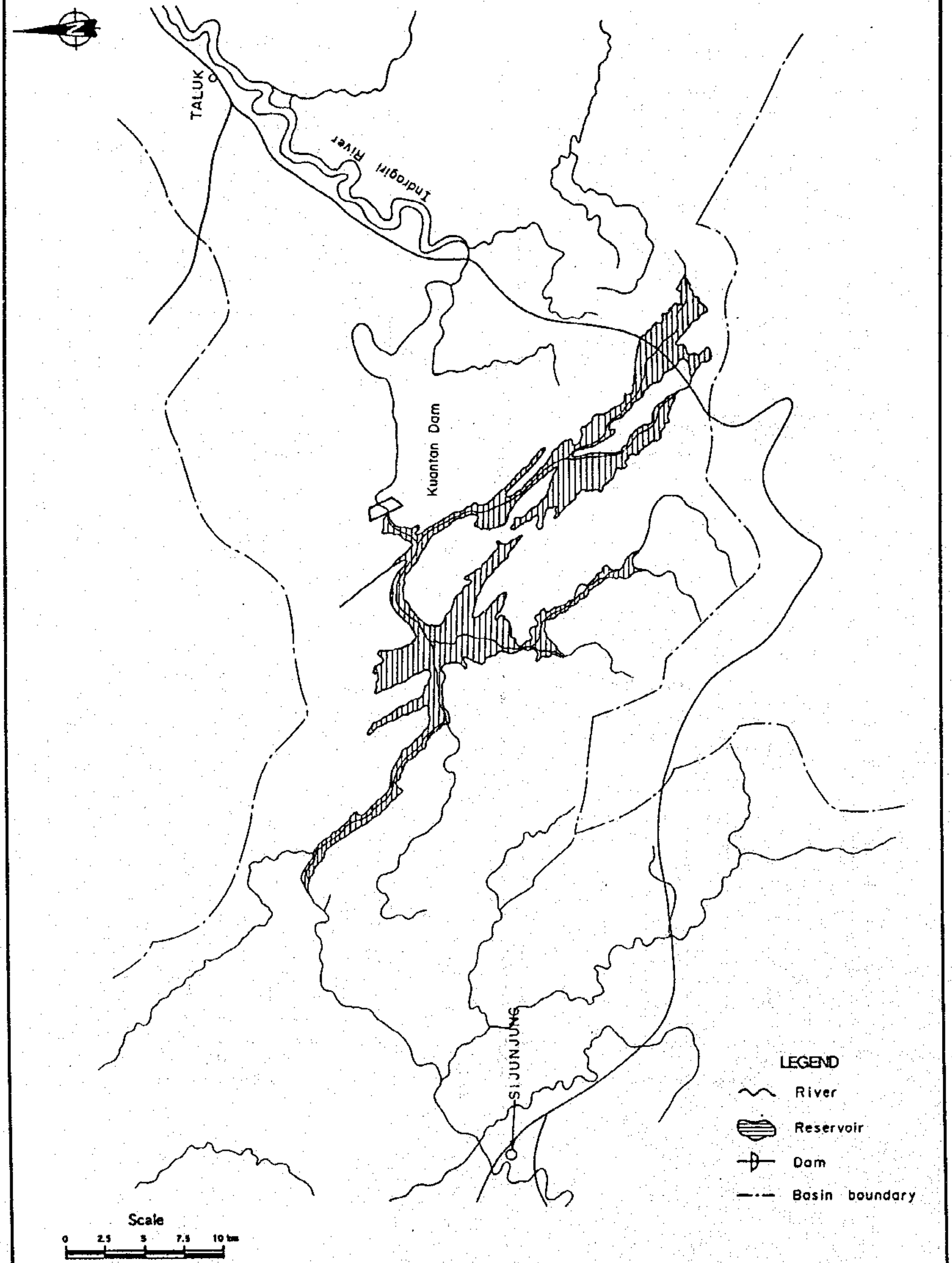

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Fig. XII.3.1 RESERVOIR AREA OF KUANTAN DAM

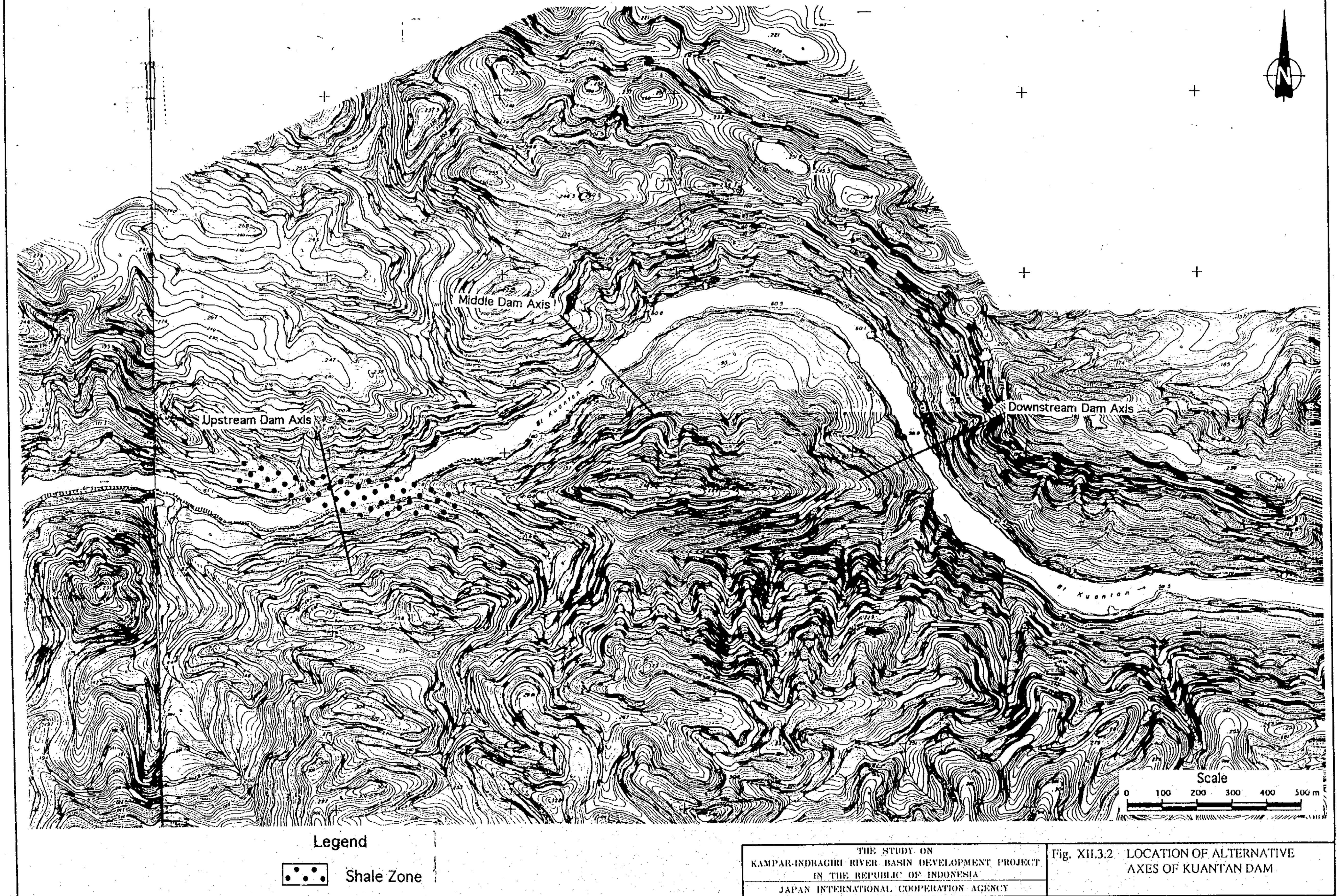

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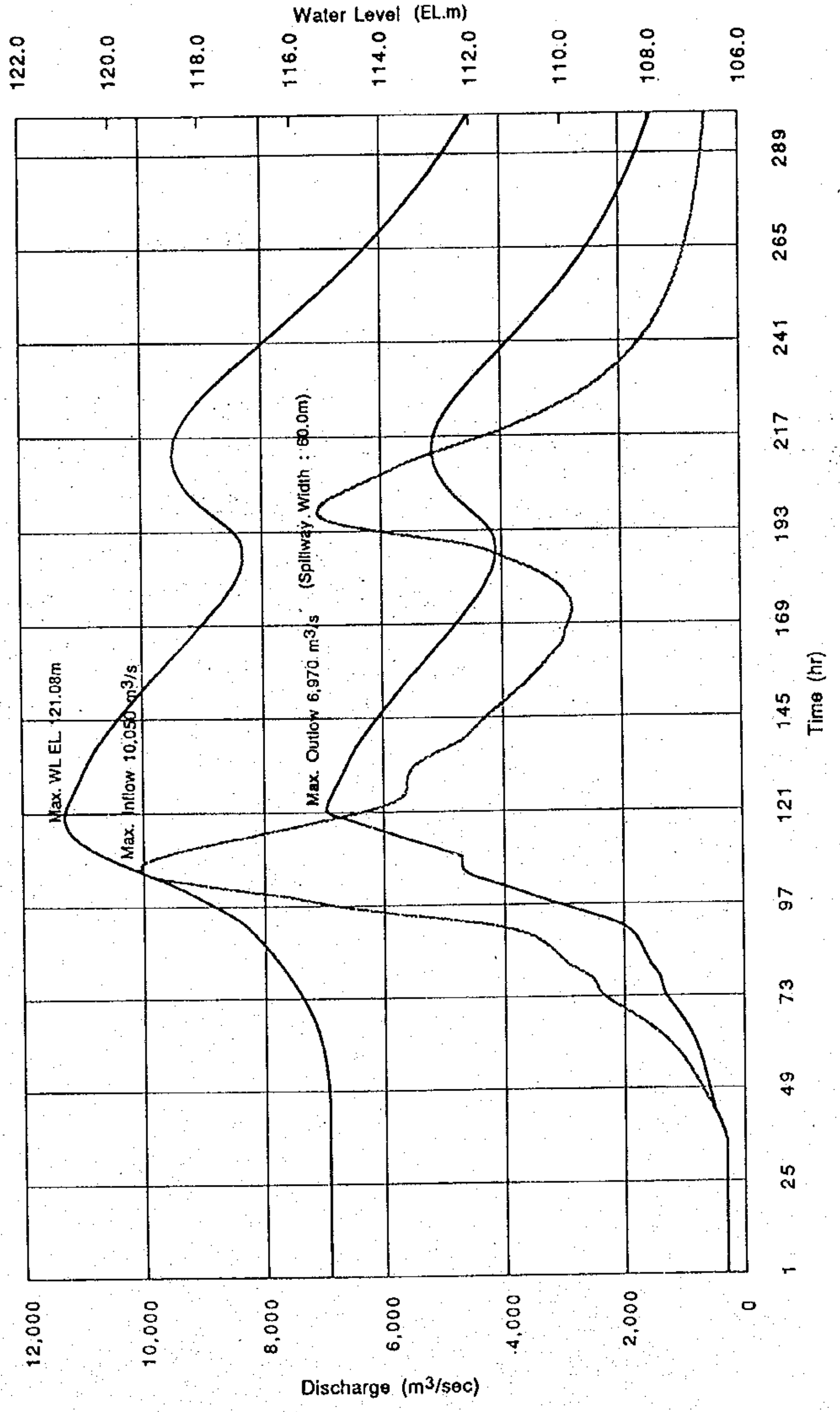
Fig. XII.3.2 LOCATION OF ALTERNATIVE AXES OF KUANTAN DAM



THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.3.3 FLOOD ROUTING RESULT OF KUANTAN DAM
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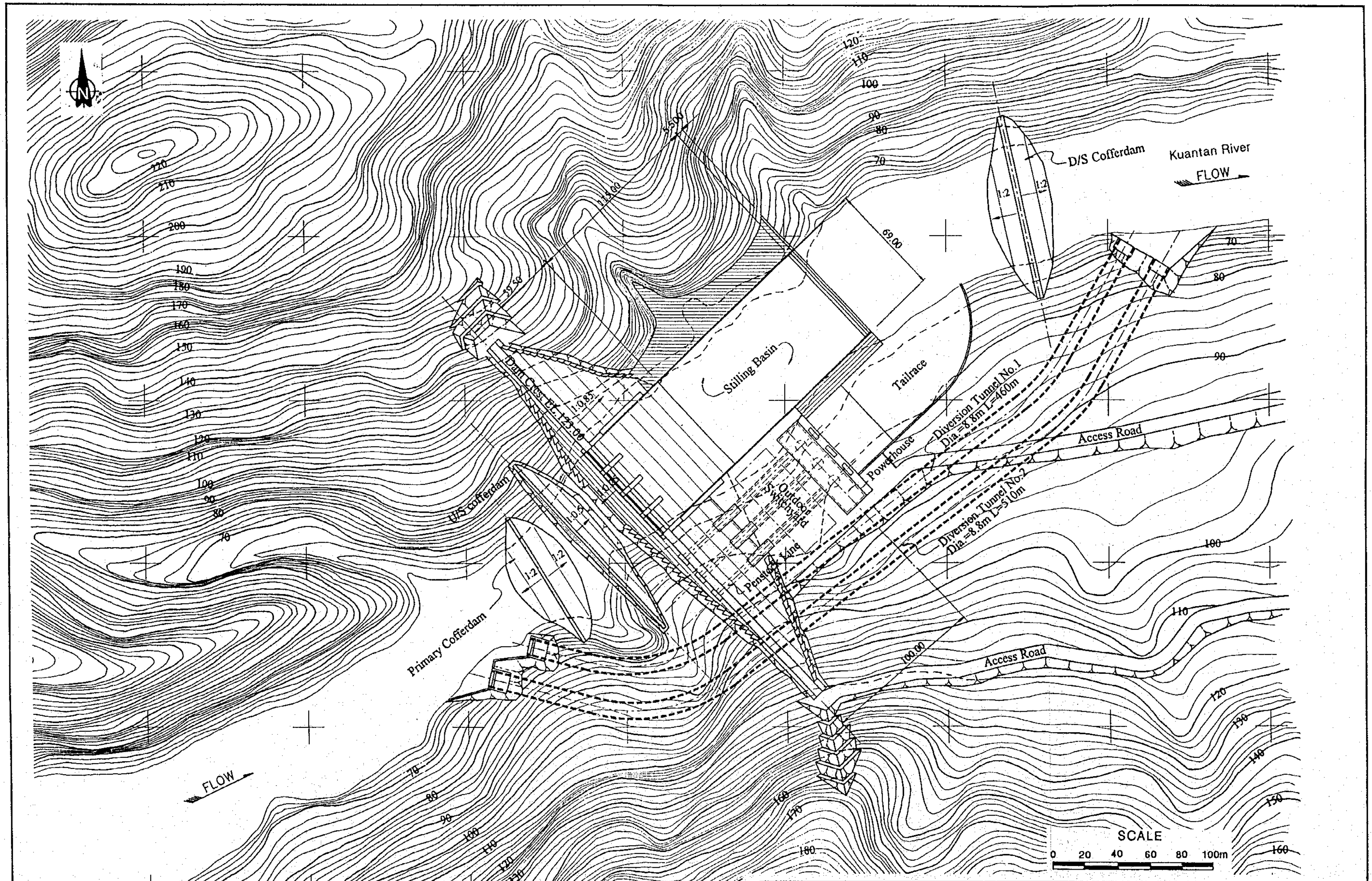

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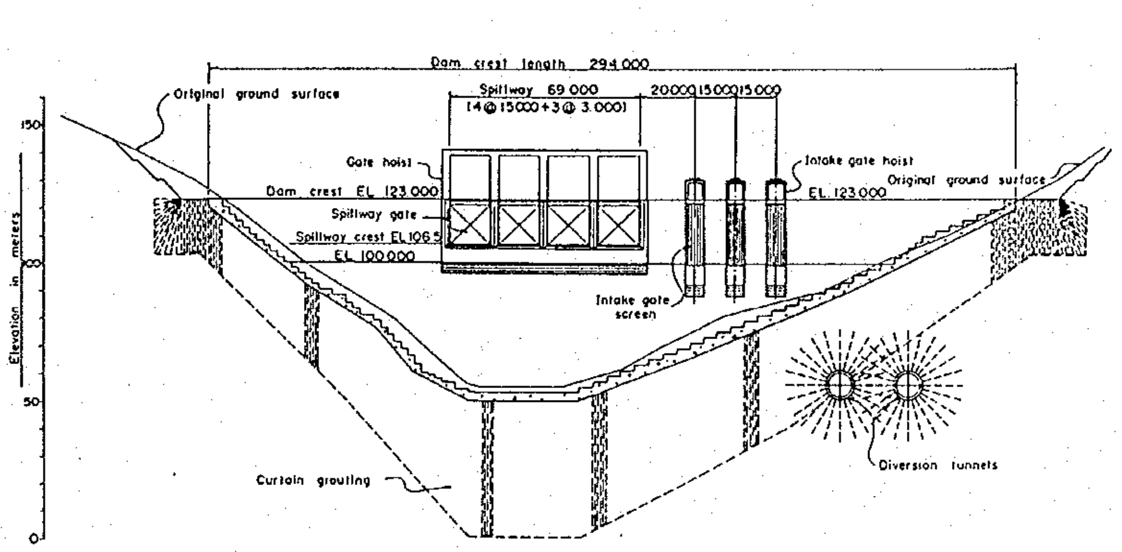
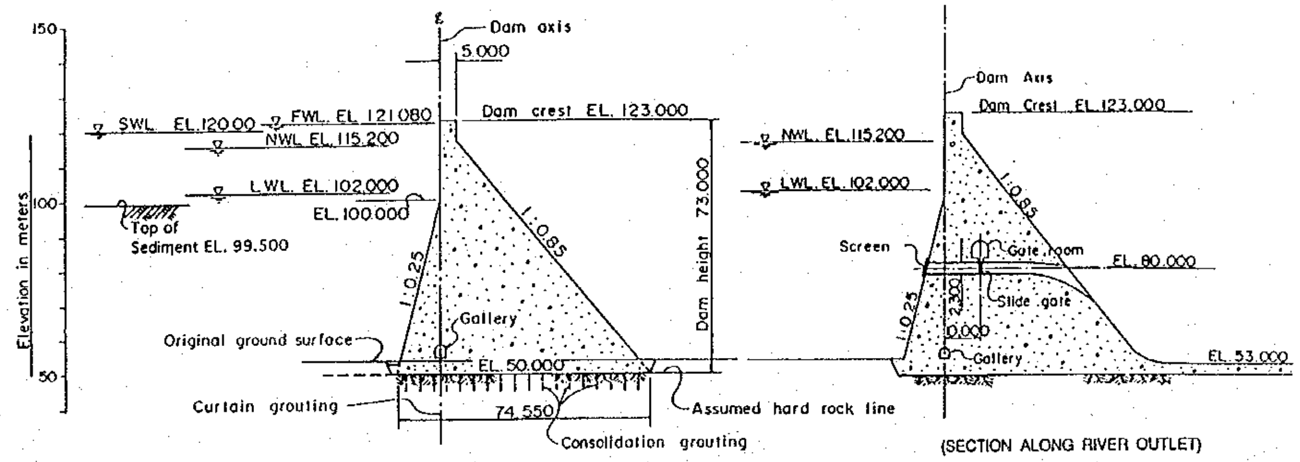
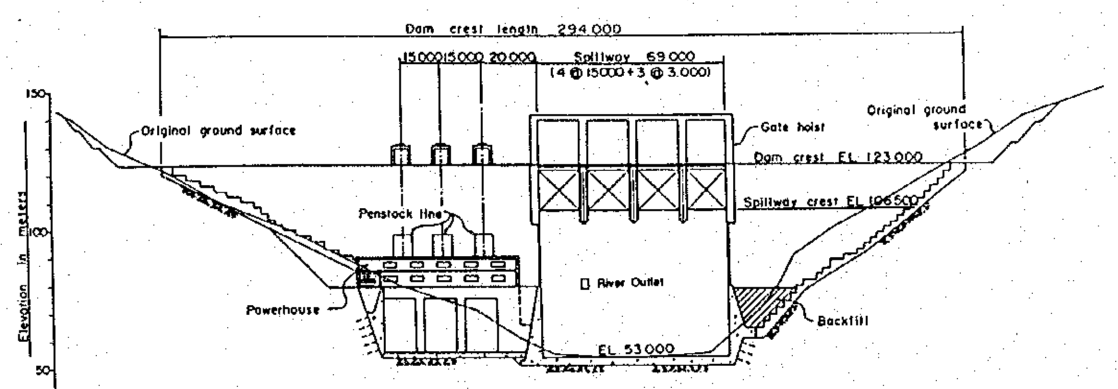
Fig. XII.3.4 (1/4) PRELIMINARY DESIGN OF KUANTAN DAM,(GENERAL PLAN)



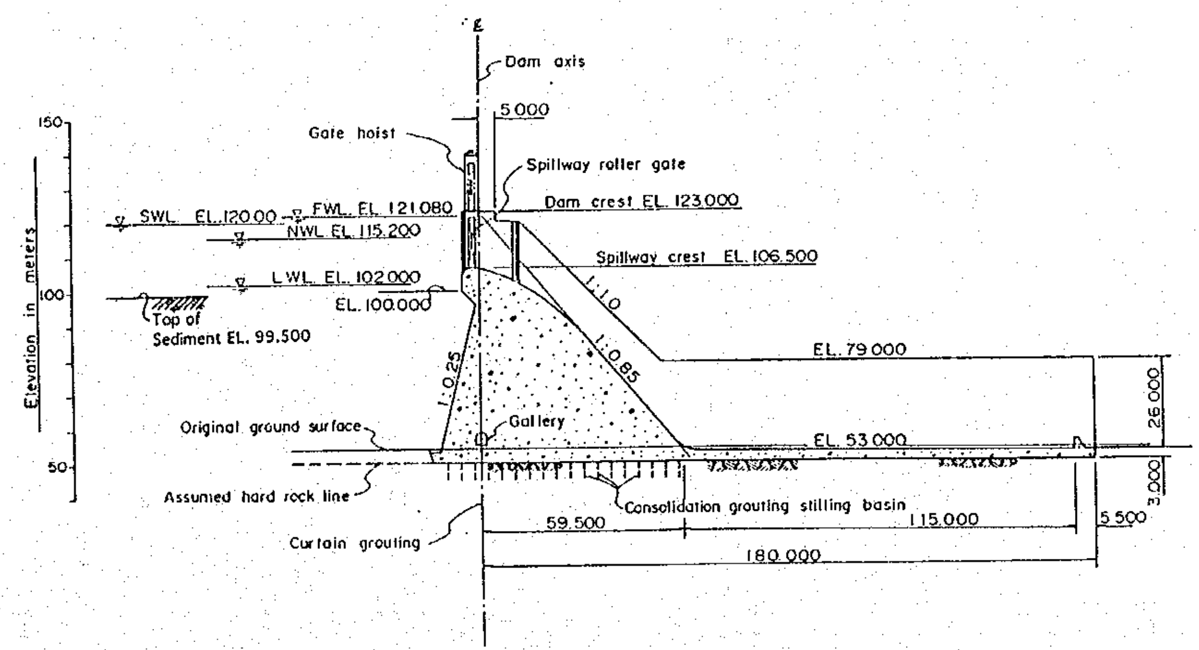
UPSTREAM ELEVATION



TYPICAL NON-OVERFLOW SECTION



DOWNSTREAM ELEVATION



TYPICAL OVERFLOW SECTION

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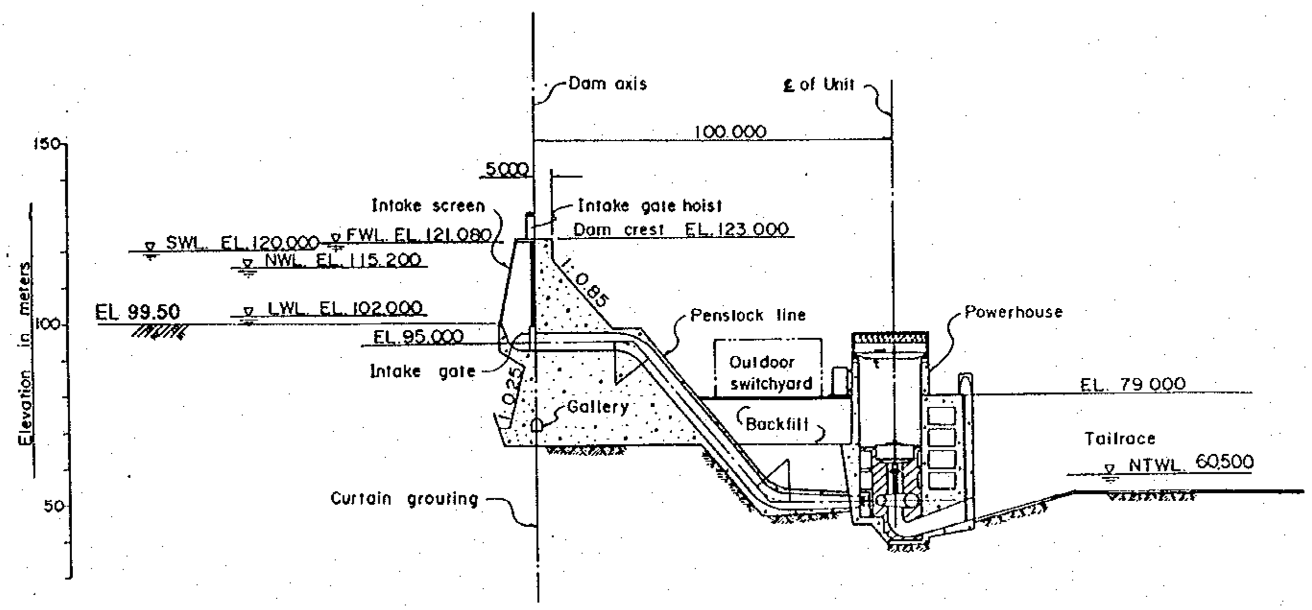
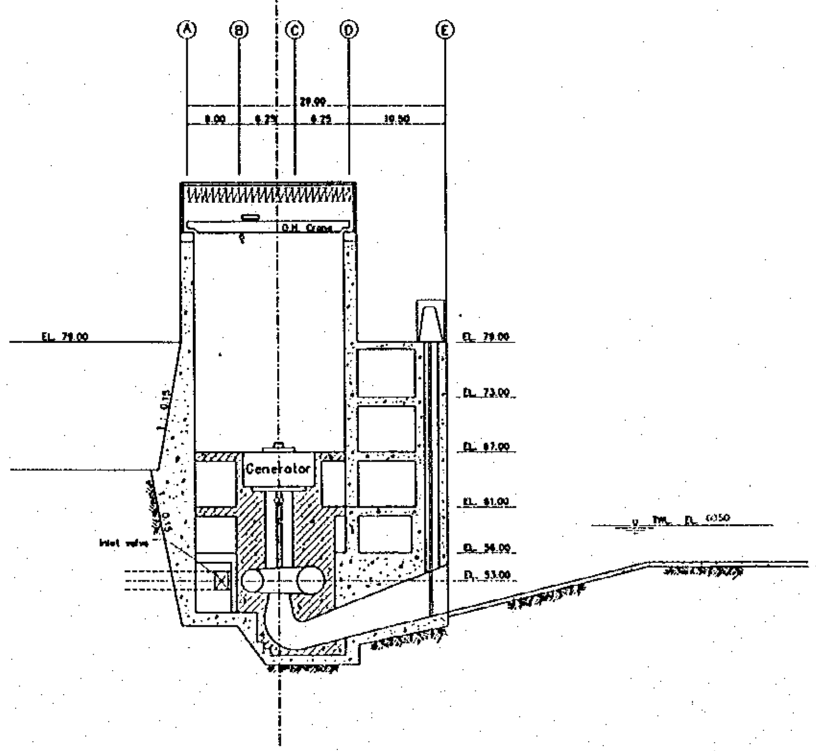
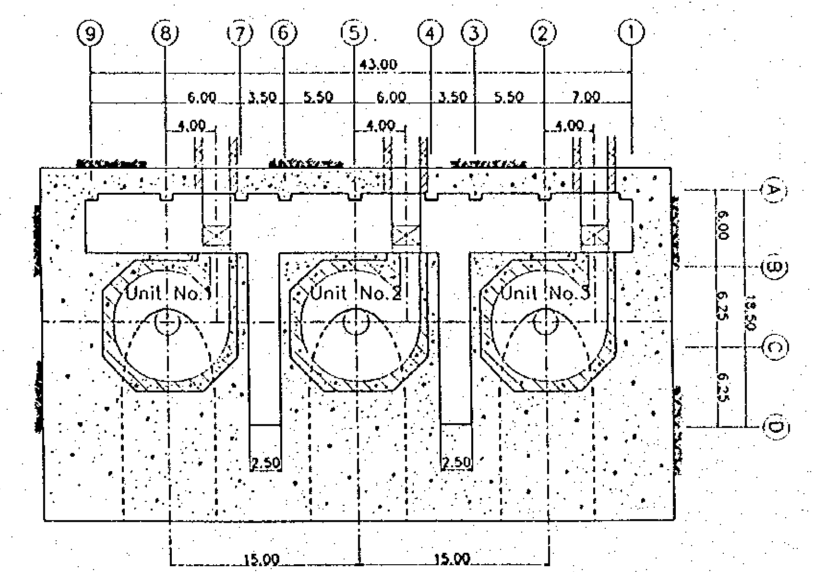


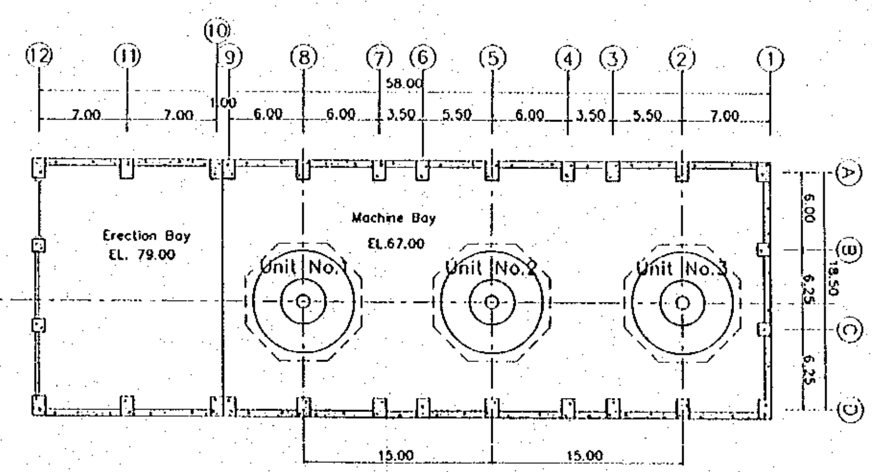
PROFILE OF WATERWAY



TRANSVERSE SECTION OF POWERHOUSE



FLOOR PLAN OF POWERHOUSE AT EL. 53.00 M



FLOOR PLAN OF POWERHOUSE AT EL. 67.00 M

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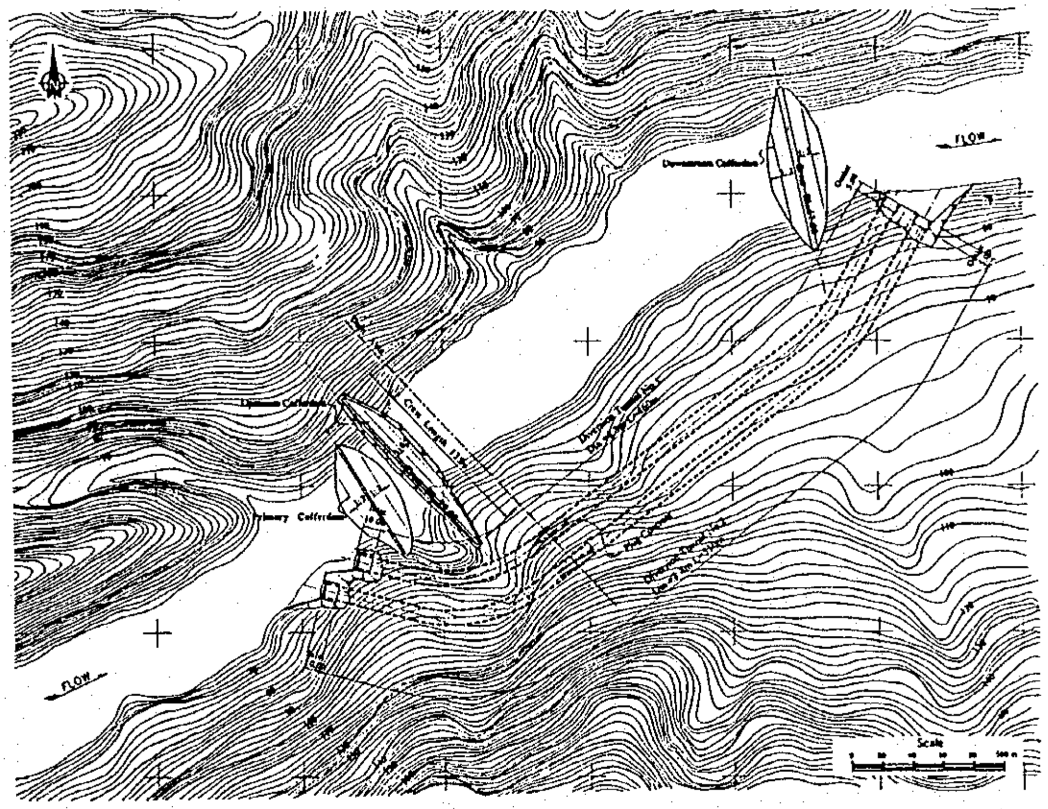
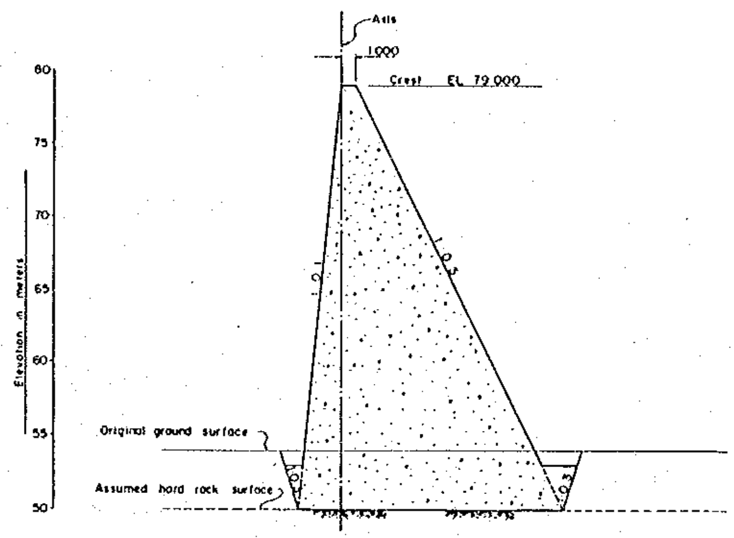
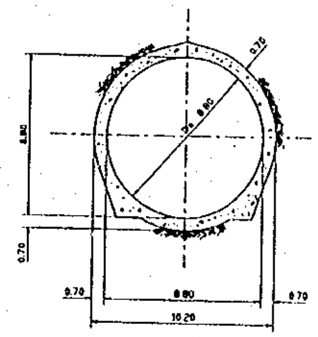


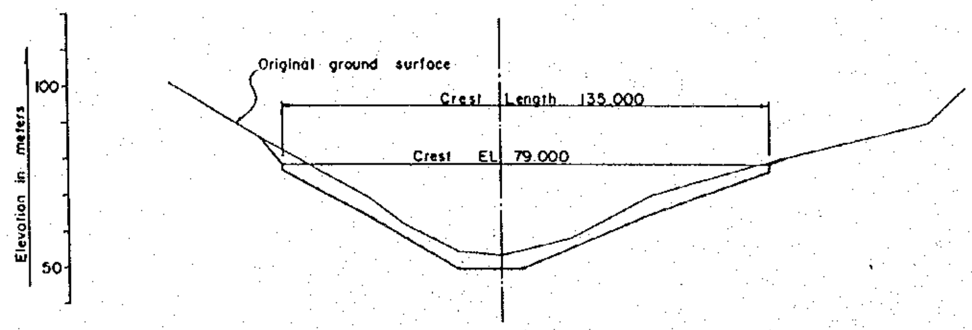
PLAN OF DIVERSION SYSTEM



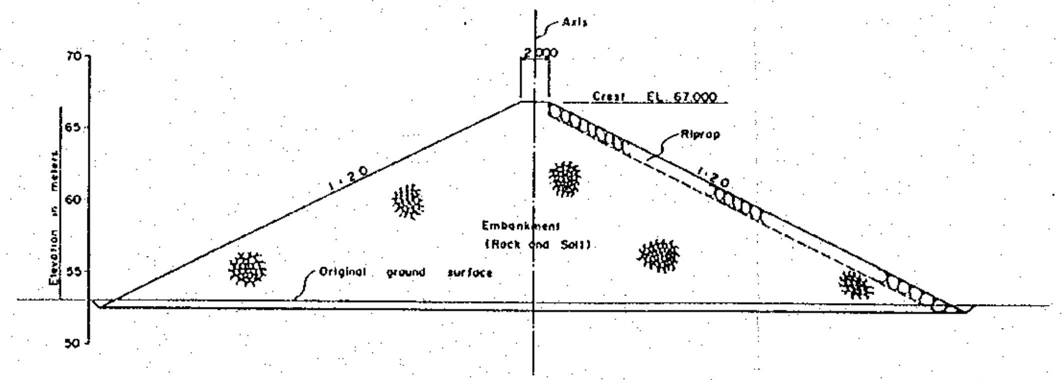
TYPICAL CROSS SECTION OF
UPSTREAM COFFERDAM



TYPICAL CROSS SECTION OF
DIVERSION TUNNEL



PROFILE OF UPSTREAM COFFERDAM



TYPICAL CROSS SECTION OF
DOWNSTREAM COFFERDAM

THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. XII.3.4 (4/4) PRELIMINARY DESIGN OF KUANTAN DAM,(DIVERSION SYSTEM)
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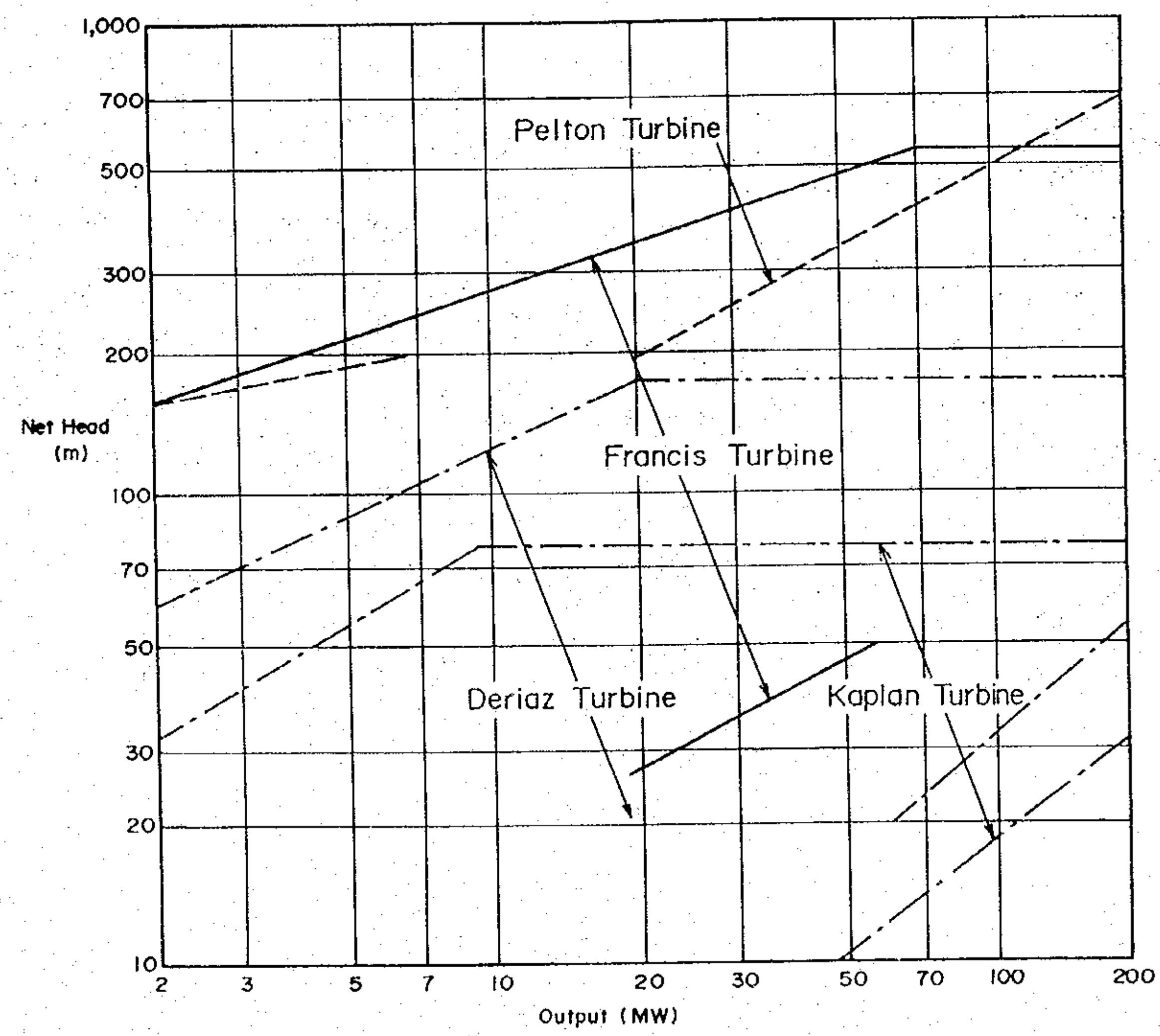

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XIII RIPARIAN STRUCTURE ENGINEERING

SECTOR XIII
RIPARIAN STRUCTURE ENGINEERING

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CHAPTER 1 EXISTING RIPARIAN STRUCTURES

1.1 General

Only a few riparian structures exist along rivers in the Kampar and Indragiri river basins. River channels in both basins still remain as natural streams except some small portions of upper tributaries of the Indragiri River in West Sumatra Province. The existing riparian structures are bank protection works, groins, sabo dams, hydropower dam, intake facilities (weirs and pumping stations for irrigation or domestic water supply), bridges, etc.

1.2 Kampar River Basin

The existing structures of particular significance in or along the Kampar river system are the Kotapanjang Dam for hydroelectric power generation which is now under construction in the Kampar Kanan River and some bridges crossing rivers. Features of existing major bridges are given in Table XIII.1.1, and Fig. XIII.1.1 shows a typical existing bridge structure (Langgam Bridge crossing Kampar River). Major bridges constructed recently consist of upper structure of steel truss and reinforced concrete slab and substructure of reinforced concrete piers supported by pile foundation.

1.3 Indragiri River Basin

The existing riparian structures in the Indragiri river basin are described as below.

(1) Upper Reaches

The upper reaches of tributaries of the Indragiri River located in hilly areas are well-developed. The existing riparian structures are a sabo dam upstream of the Sinamar River, some small scale intake weirs and pumping stations for irrigation, and a number of bridges.

(2) Middle Reaches

The middle reaches of the Indragiri River from Telukkuantan to Rengat, about 280 km long along the river course, is remarkably meandering and both channel banks are seriously eroded. A few hundred meters of concrete revetments supported by concrete piles are provided to protect banks at major towns along the river such as Telukkuantan, Simandolak, Baserah and Rengat. Concrete pile type groins which have a length of 25 m and a width of 2 m were constructed together with revetments at Rengat and Baserah. Construction of revetments and groins is being continuously implemented. Figs. XIII.1.2 and XIII.1.3 show typical existing revetments and groins.

(3) Lower Reaches

Along the lower reaches from Rengat to the river mouth, there are many intake canals for tidal irrigation, some port facilities for inland waterways (especially two big ports, Tembilahan near the estuary and Kualacenake located 20 km downstream from Rengat or 125 km upstream from the estuary), ferry facilities located 110 km upstream from the estuary, and some drinking water intake facilities.

CHAPTER 2 CRITERIA FOR PRELIMINARY DESIGN OF STRUCTURES

2.1 General

Objective structures to be designed except dams are proposed in SECTOR VI, SECTOR VII and SECTOR VIII. Design of dams is discussed in SECTOR XII.

As discussed in SECTOR VI, FLOOD CONTROL PLAN, the plan formulated consists of a combination of such flood control measures as river improvement, retarding basin, floodway and dam. Structures employed as flood control facilities are dikes, channel excavations, slope protection works, groins, outlets, maintenance roads, and bridges. On the other hand, water resources development facilities of intake weirs and main canals to take in water from rivers are proposed in SECTOR VII, IRRIGATION DEVELOPMENT PLAN and SECTOR VIII, WATER RESOURCES DEVELOPMENT PLAN.

2.2 Basic Guidelines, Standards and Criteria

To plan and design the structures for flood control and water resources development except dams, the following guidelines, standards and criteria were applied.

- Flood Control Manual, Vol. I, II and III , DGWRD DPU, 1993
- Irrigation Design Standards, DGWRD DPU, 1986
- Bridge Design Code, BINA MARGA, DPU 1992
- River and Sabo Technical Standard (Draft), Ministry of Construction of Japan

2.3 Criteria for Structural Design

2.3.1 Dike and Maintenance Road

Representative dimensions of dikes and maintenance roads are designed in accordance with the following criteria.

(1) Freeboard

Considering wave run-up and set-up, floating debris, etc., sufficient freeboard shall be provided above a design high water level to prevent overtopping during flood events, because earth dikes are fragile structures against water overtopping.

The table below shows freeboards to be adopted in the Project, corresponding to the magnitude of design discharges. Crest elevations of dikes are determined by adding freeboard onto a design high water level. Additional 0.3 m of freeboard shall be further provided along critical reaches where dikes are higher than 3.5 m.

Design Discharge (m^3/s)	Freeboard (m)
Less than 200	0.5
200 to less than 500	0.8
500 to less than 2,000	1.0
2,000 to less than 5,000	1.2
5,000 to less than 10,000	1.5

(2) Crown Width

The crown width of a dike is a basic dimension. A dike requires a width enough for seepage protection, daily inspection and flood protection activities. The following widths shall be applied in the Project, depending on the magnitude of design discharges.

Design Discharge (m^3/s)	Crown Width (m)
Less than 500	3.0
500 to less than 2,000	4.0
2,000 to less than 5,000	5.0
5,000 to less than 10,000	6.0

(3) Side Slope

The side slopes of dike shall be designed to resist erosion during normal river flow, rainfall and flood events. Since floods in the middle and lower Kampar and Indragiri rivers tend to continue for a week or more, gentle slopes are desirable to prevent seepage through the embankment body or foundation. Side slopes of 1 : 2 (V : H) are generally satisfactory for a well-compacted embankment. When higher dikes are designed, berms are placed for slope stability. The following criteria shall be applied in the design.

Location	Slope Gradient (V : H)	Berm
Landside Slope	1 : 2 for top slope; 1 : 3 for slopes below	Every 4 m in height, 3 m in width
Riverside Slope	1 : 2 for all slopes	Every 6 m in height, 3 m in width

(4) Maintenance Road

Roads shall be provided along both sides of river channels for inspection, maintenance and flood protection activities. The dike crown metaled with gravel 2.5 to 3.0 m wide can be used for maintenance road and it may be used as public roadway for inhabitants of villages and towns along dikes.

(5) Ditch

To smoothly drain landside water and to make dikes stable, ditches shall be provided along the foot of landslide slope of both banks.

2.3.2 River Channel Excavation

Channel excavation is employed to widen or deepen the existing river channels, or for shortcut. The slope gradient of excavated banks is the most important factor. The suitable slope varies from 1 : 1.0 (V : H) to 1 : 3.0 depending on soil conditions.

2.3.3 Slope Protection Works

Slope protection works are proposed along river channel banks subjected to direct attack of the river flow and along dike slopes for protection against scouring and wave wash.

(1) Locations to be Provided

Revetments shall be provided:

- at concave side of meander bends of river; and
- at both downstream and upstream of structures such as intake weirs, outlets, , bridges, etc., where turbulent flow usually occurs.

(2) Height

Crown elevation of slope protection works is set at the same level as a design high water level.

2.3.4 Groin

Groins are flow control structures projecting at a certain distance into the stream at a certain angle to banks. They deflect the flow towards the center of channels, so that scouring is transferred away from the banks and accelerate sediment deposition near banks.

(1) Type

There are two types of groins, permeable and impermeable groins. Permeable groins are generally used for river channels with gentle gradients, while impermeable groins are adopted for river channels with steep gradients. Since rivers in the study area have relatively gentle gradients, a group of permeable groins combined with slope protection is preferable to protect banks on concave sides of meanders.

(2) Direction, Length, and Spacing

The angle, length, and spacing of groins into the stream depend on local conditions, the purpose of the groin, materials to be used, etc. Based on experiences, the direction at right angle to dike is generally adopted and length is generally less than 10% of the river channel width. Spacing between groins is related to the length of the groin. It usually ranges from two to six times the length. For the project in this study, spacing three times the length is applied.

2.3.5 Sluice

In general, tributaries and drainage channels drain rainwater to main rivers by gravity during low flow of the main rivers. Outlets equipped with gates should be provided at joints to prevent backflow of river water during floods of main rivers.

On the other hand, pumping stations are among the alternative measures for areas where gravity drainage cannot be applied by topographical reasons. Since pumping stations need higher investment, operation and maintenance costs, pumping stations are usually constructed in urban areas.

2.3.6 Intake Facilities and Irrigation Canal

Development of river surface water by construction of dams is proposed in the water resources development plan for both the Indragiri and Kampar river basins. To inlet and convey water from rivers to subject areas, intake facilities consisting of weirs, sluices and main canals are provided. Two intake points are proposed, immediately downstream of the Kotapanjang Dam and the proposed Kuantan Dam.

(1) Location of Intakes

Location of the intakes shall be decided in consideration of easy construction, intake water levels, geological conditions, etc.

(2) Basic Requirements of Intakes and Canals

(a) Kuok Intake Weir (Kampar Kanan River)

- Design Flood Discharge : 4,000 m^3/s
- Design Intake Discharge

Unit: m^3/s

Location	Initial Phase	Final Phase
Left Bank	11.31	20.69
Right Bank	4.80	4.80

(b) Lubukjambi Intake Weir (Indragiri River)

- Design Flood Discharge : 3,200 m^3/s

- **Design Intake Discharge:**

Unit: m^3/s

Location	Initial Phase	Final Phase
Left Bank	7.85	19.31
Right Bank	-	17.62

(3) Design Criteria of Main Irrigation Canals

Table XIII.2.1 shows the design criteria of main irrigations canals, indicating flow formula, freeboard and dike crown width based on the Irrigation Design Standards, DGWRD DPU.

2.3.7 Bridge

Some existing bridges including wooden temporary bridges crossing channels are to be reconstructed in accordance with the river improvement works. They shall be designed as permanent bridges using concrete or steel materials.

Bridges shall be designed with adequate freeboard as described in Subsection 2.2.1. The width of bridge to be reconstructed shall follow the existing width. The Bridge Design Code issued by Bina Marga, DPU was applied to the design of bridges.

CHAPTER 3 PRELIMINARY DESIGN OF STRUCTURES PROPOSED IN OVERALL DEVELOPMENT PLAN

3.1 General

The layout plan of riparian structures proposed in the Overall Development Plan is shown in the river improvement plans presented in SECTOR VI, FLOOD CONTROL PLAN. The following tables list down the project rivers, indicating with "Y" (Yes) the proposed structures in each river basin.

(1) Kampar River Basin

River	Dike	Shortcut/ Excavation	Slope Protection	Groin	Outlet (Sluice)	Intake	Bridge
Kampar	Y	Y	Y	-	Y	-	Y
Kampar Kanan	Y	Y	Y	Y	Y	Y	Y
Kampar Kiri	Y	Y	Y	-	Y	-	-

(2) Indragiri River Basin

River	Dike	Shortcut/ Excavation	Slope Protection	Groin	Outlet (Sluice.)	Intake	Bridge
Indragiri	Y	Y	Y	Y	-	Y	Y
Sinamar	Y	Y	Y	-	Y	-	Y
Lampasi	Y	Y	Y	-	Y	-	Y
Agam	Y	Y	Y	-	Y	-	Y
Lembang	Y	Y	Y	-	Y	-	Y
Sumani	Y	Y	Y	-	-	-	Y
Sukam	Y	Y	Y	-	Y	-	Y
Palangki	Y	Y	Y	-	Y	-	Y

3.2 Dike and Channel Excavation

Structural features of typical dike sections proposed for the projects are shown in Fig. XIII.3.1. The following are structural design points to be considered:

(1) Sodding

Slope protection against damage from wave action, river current, floating debris, rainfall and dryness is required on the slopes of earth dikes. Sodding (grass) is usually employed at both sides of dikes. In case of necessity of special reinforcement, concrete/stone slope protection works (revetment) are provided.

(2) Filter and Ditch

Floods of the lower and middle reaches of the Kampar and Indragiri rivers are of long duration causing seepage through the embankment body or foundation resulting in side slope failures. For seepage and piping control measures, provision of filter materials at landside toe of dike, as well as toe drain, is necessary. Moreover, drain ditches which will function as drainage of inland rainwater shall be provided. Excavated soils of ditches can be used for dike embankment.

(3) Channel Excavation

In general, permanent slopes in cohesive soils shall not be steeper than 1 : 2.0 (V : H). Excavated slopes with cohesionless soil such as sand and gravel produce very flat slopes varying from 1 : 2.0 (V : H) depending on the grading material. In the project, on the basis of field investigations, 1 : 2.0 (V : H) slopes may be applicable for permanent slopes of channel excavation. The spoil materials excavated may be used to construct dikes or to fill abandoned meander loops.

(4) Maintenance Road

Maintenance road shall be metaled with gravel for easier passage.

3.3 Slope Protection Works

In principle, wet stone masonry type with a side slope of 1 : 2 (V : H) embedded into the riverbed against the toe scour is applicable for both lower channel (banks) and high water channel (dikes). On the other hand, combination type consisting of reinforced concrete piles, reinforced concrete panels, and stone masonry will be one of the alternatives in view of easy construction of lower channel slope protection works in case of deep normal water in the lower and middle Kampar and Indragiri rivers. The former is applied to the rivers in the upper reaches of the Indragiri River, while the latter is applied to the middle and lower reaches of both Kampar and Indragiri rivers. Fig. XIII.3.2 shows a typical high water channel and low water channel revetments.

3.4 Groin

Groins are proposed in the lower and middle reaches of the Kampar and Indragiri rivers. Fig. XIII.3.3 shows a typical groin applicable. A group of reinforced concrete piles are recommended as permeable groins, which are widely used in Indonesia. Length of groin is 21 m which is equivalent to 10% of the average river width, and interval of groins is 3 times of length (60 m). Riprap for pile permeable groins should be considered against local scouring.

3.5 Sluice

In accordance with the size of inland drainage areas measured on the topographical map with a scale of 1 : 50,000, the required sluices are classified into 8 types (from Type A, 2.5 m high × 2.4 m wide × 2 spans, to Type H, 3.5 m × 8.0 m × 5 spans). Table XIII.3.1 shows the design flow capacity of each type of ouxtlet with a scale of 5-year return period based on Fig. XIII.3.4 (specific discharge in Indonesia), and Fig. XIII.3.5 shows typical structural sections. Sluices are designed as reinforced concrete structures with steel gates.

3.6 Bridge

As an example for bridges to be reconstructed, a typical steel truss bridge designed on the basis of existing structural profiles is shown in Fig. XIII.3.6.

3.7 Intake Facilities

Generally, three types of intake facilities are considered as alternatives: free intake without weir, intake with weir, and pumping station.

Both intake facilities proposed in the project are required to regulate water released for hydropower generation from the Kotapanjang Dam and the proposed Kuantan Dam. Therefore, as the type of intake facilities, intake with weir is preferable. Details of preliminary design of intake weirs are given in Sections 4.3 and 4.5.

3.8 Main Irrigation Canal

Main irrigation canals which carry water from proposed weirs to target areas are designed with composite lining consisting of heavy masonry foundation with 10 cm thick concrete lining to prevent canal side slope erosion and compacted earth bottom, as shown in Fig. XIII.3.7. Structural dimensions and hydraulic parameters of proposed main canals are indicated in Fig. XIII.3.7 and Table XIII.3.2. These dimensions and parameters were determined assuming that the longitudinal slope of canal is 1/3,000 based on the 1/50,000 topographic maps. A 3.0 m wide gravel metaled inspection road will be provided beside the canal.

CHAPTER 4 PRELIMINARY DESIGN OF STRUCTURES FOR PROPOSED PRIORITY PROJECTS

4.1 General

This chapter presents the preliminary design of riparian structures proposed for the following four priority projects selected for the Feasibility Study.

- Bangkinang Area River Improvement Works in Kampar Kanan River;
- Kuok Intake Weir Construction Works in Kampar Kanan River;
- Rengat Area Flood Protection Works in Indragiri River; and
- Lubukjambi Intake Weir Construction Works in Indragiri River.

4.2 Bangkinang Area River Improvement Works

4.2.1 Existing Conditions

The objective reaches for river improvement are still under natural conditions. There are no riparian structures except two bridges. The present river channel remarkably meanders and is about 150 m wide and 5 to 10 m deep. The area along the channel is mostly developed for paddy cultivation, etc. A national road exists along the right bank of the river and a provincial road runs along the left bank.

4.2.2 Preliminary Design of Structures

The preliminary design of structures for the Initial Phase is as described below. Layout plan of structures is presented in SECTOR VI, FLOOD CONTROL PLAN.

(1) Dike

Dikes to be constructed in the Initial Phase are designed in the same manner as the Overall Development Plan (Final Phase), as described in Section 3.2. Fig. XIII.4.1 shows the typical section of dike. In the final plan, dikes will be heightened on an average of 1.3 m. Soils from the excavation of channel banks and shortcuts will be used for embankment of dikes.

(a) Freeboard

In accordance with the Design Criteria, a freeboard of 1.2 m is adopted because of the design discharge of 2,800 m^3/s. Crest elevations of dike are determined by adding freeboard onto the design high water level. Additional 0.3 meter of freeboard is provided along critical reaches of dike where height is higher than 3.5 meters.

(b) Crown Width

Dike crown width of 5.0 m is applied for dikes in the Initial Phase in accordance with the Design Criteria.

(c) Side Slope

Side slope of 1 : 2.0 (V : H) or 1 : 3.0 is adopted.

(d) Filter

No filter is provided in the Initial Phase in consideration of design discharge, dike height, and reconstruction of filter in the Final Phase.

(2) Maintenance Road

Maintenance road, 3.0 m wide metaled by 0.15 m thick gravel, is provided on top of the dikes (refer to Fig. XIII.4.1).

(3) Slope Protection Works

Wet masonry revetment type slope protection works proposed in the Initial Phase are designed in the same manner as the Overall Development Plan in Section 3.3. Footing alternative B of Fig. XIII.3.2 is applied because of low normal water level.

(4) Groin

A group of concrete pile permeable type groins provided at extreme meandering portions are also designed in the same manner as the Overall Development Plan (refer to Fig. XIII.3.3).

(5) Sluice

Location of the sluices required are determined based on the 1/50,000 scale topographic maps. Sluice types are proposed depending on drainage area as shown in Fig. XIII.4.2, based on Table XIII.3.1. Also, outlets are provided where channel by shortcut remains.

Sluices of the Initial Phase shall be constructed in accordance with the section of dike proposed in the Final Phase, because of the concrete structure lifetime of 50 years.

(6) Bridge

There are two existing bridges, Bankinang Bridge and Danaubingkuang Bridge, crossing the Kampar Kanan River in the Bangkinang Area. Structural type is upper steel truss for superstructure and mass-concrete type pier for substructure. The bridges shall be reconstructed in accordance with the river width (300 m) and the design high water level proposed for a design discharge of 4,000 m^3/s for the Final Phase considering their life time (refer to Fig. XIII.4.3).

4.3 Kuok Intake Weir Construction Works

4.3.1 Location of Intake Weir

The Kuok Intake Weir is proposed in the Kampar River at the foot of the mountains, 6.2 km downstream from the Kotapanjang Dam, as shown in Fig. XIII.4.4, in consideration of the following points.

- The required regulation volume of the weir is $1.6 \times 10^6 m^3$, which is calculated as $36.39\ m^3/s \times 12$ hours x 60 min. $\times$ 60 sec.
- Since the tailrace water level of the Kotapanjang Dam is EL 41.0 m, EL 40.0 m is set to the weir crest.
- Upstream location is desirable considering the increase of possible irrigation area.

Fig. XIII.4.5 shows the storage capacity curve of the proposed Kuok Intake Weir.

4.3.2 Weir Type Alternative

Weir can be classified into two types: movable and fixed type. Fixed type is an obstacle to smooth flow of floods. Movable type is able to pass floods without obstruction by means of operating gates.

Taking flood passage into consideration, movable type weir is adopted. Moreover, movable type weir is classified by gate type into roller gate, radial gate, tilting gate and rubber gate.

Among the above types, the following types can be applicable for the Kuok Intake Weir:

- Roller Gate Type Intake Weir [refer to Fig. XIII.4.6(1/3)]
- Tilting Gate Type Intake Weir [refer to Fig. XIII.4.6(2/3)]
- Rubber Gate Type Intake Weir [refer to Fig. XIII.4.6(3/3)]

Radial gate is excluded from the comparative study because gate pins should be above the high water level.

As a result of the comparative study tabulated in Table XIII.4.1, rubber gate type is selected from the technical and economical viewpoints.

4.3.3 Preliminary Design of Weir

The Kuok Intake Weir is designed to cope with a 50-year return period flood and intake discharges of the overall plan considering its durability. The proposed intake weir with rubber gates is shown in Fig. XIII.4.7.

(1) Basic Design Conditions

The basic design conditions are as given in the table below.

(1) Weir Type	Rubber Gate Weir
(2) Weir Sill Elevation	EL 36.3 m
(3) Weir Crest Elevation	EL 40.0 m
(4) Weir Height	3.7 m
(5) Weir Length	172.0 m
(6) Storage High Water Level	EL 40.0 m
(7) Storage Low Water Level	EL 38.0 m
(8) Storage Capacity Required	$1.6 \times 10^6 m^3$
(9) Intake Discharge	$20.69 m^3/s$ (Left Bank Area) $4.80 m^3/s$ (Right Bank Area)
(10) Design Flood Discharge	$4,000 m^3/s$
(11) High Water Level	EL 45.24 m
(12) Dike Crest Elevation	EL 46.44 m
(13) Riverbed Elevation	EL 36.3 m

(2) Flood Discharge Gate

The flood discharge gate with rubber gates shall have function to smoothly release floodwater at flood time and to reserve water in normal time. Spillway section is 162 m in length and 3.3 m in height.

(3) Flush Gate

Flush gates with roller gates of 5.0 m wide and 4.7 m high are provided on both sides to flush out sediment accumulating infront of inlets in a short time. Bottom elevation of flush gates is 1.0 m lower than the weir sill.

(4) Apron and Riprap

Concrete apron, concrete block and gabion mattress riprap shall be placed downstream, upstream of spillway to prevent scouring of the riverbed.

(5) Inlet

Generally, the reservoir water level is not constant and at the time of floods large amounts of soil, sand and floating debris are transported by the river flow. Therefore, the inlet requires easy control of intake discharge and prevention measures against foreign materials flowing into the canal. For these purposes, control gates, screen, inlet apron, etc., are to be installed.

(6) Foundation

According to the results of drillholes conducted in this study, residual soil layer is designed as bed of shallower foundation of proposed structures. Sheet piles may be required to the bottom of the residual soil layer for seepage prevention.

4.3.4 Main Irrigation Canal

Main irrigation canals proposed in the Initial Phase are shown in Fig. XIII.4.8 and Table XIII.4.2, designed in the same manner as in Section 3.8, Overall Plan.

4.4 Rengat Area Flood Protection Works

4.4.1 Existing Condition

The target area to be protected from floods is located at the right bank of the Indragiri River. It has an area of 21.1 km^2, and composed of two areas, urban area and rural area.

The urban area of Rengat is very close to the Indragiri River and contains commercial and government office areas. Concrete slope protection works and concrete pile groins exist on the right bank. There is an inland water port at Rengat.

The rural area is used for paddy cultivation in dry season. A national road runs along the right bank of the Indragiri River from Pekanbaru to Japura-Rengat-Tembilahan.

4.4.2 Preliminary Design of Structures

To urgently protect the target area from floods, construction of ring dike is proposed in the Initial Phase. Flood control works include the construction of such structures as ring dike (earth dike and concrete wall dike), control gates, drainage pumping station, sluice and road bridge.

(1) Ring Dikes

Alignment of the northern part of ring dikes enclosing the target area including the Rengat urban and rural areas follows the Pekanbaru - Tembilahan national road. Ring dike is generally constructed of earth embankment with a 3 m wide crown, a freeboard of 1.2 m, and 1 : 2.0 (V : H) side slopes (refer to Fig. XIII.4.9). Crown of dike is used as maintenance road.

On the other hand, since the urban area of Rengat is close to the river, it is difficult to construct an earth dike, and height of dike required is low (about 1.2 m, equivalent to freeboard). Therefore, the concrete wall type of dike is proposed as shown in Fig. XIII.4.9.

(2) Maintenance Road

A 2.5 m wide and 0.15 m thick gravel metaled maintenance road is provided on the 3 m wide top of earth dike (refer to Fig. XIII.4.9).

(3) Control Gates and Bridge

Ring dike will cross five existing drainage or intake canals, so that control gates are necessary at these crossing points. Sizes of these control gates are proposed referring to the existing bridges. Structure of control gates consists of reinforced concrete box culverts and sliding steel gates, with concrete pile foundation, as shown in Fig. XIII.4.10. A new bridge is proposed as shown in Fig. XIII.4.11, crossing the ditch along the ring dike.

(4) Sluice

Sluice of the Senggeris River, collecting water inside of the proposed ring dikes and discharging into the Indragiri River, is proposed at the east side of ring dikes. Fig. XIII.4.12 shows the layout of proposed sluice.

The dimensions of sluice (5 spans × 7.0 m wide × 4.2 m high) are determined as follows:

- Catchment Area
  - Residential Area : 2.0 km^2
  - Paddy Field/Unused Area : 19.1 km^2
  - Total : 21.1 km^2
- Design Scale : 5-year return period
- Runoff Calculation : Rational Formula Method

$$Q = \frac{1}{3.6} \cdot f \cdot I \cdot A$$

where:

Q : discharge (m^3/s)
f : runoff coefficient
I : average rainfall intensity within the time lag of flood (mm/hr)
A : catchment area (km^2)

- Runoff Coefficient
  - 0.50 for residential area
  - 0.40 for paddy/unused area
  - 0.41 for total area
- Time Lag

$$T = Ts + Tr$$

$$Tr = Lr/Vr = Lr \times n / \left(Rr^{0.67} \times Ir^{0.5} \right)$$

where;

T	:	time lag of a flood (sec.)
Ts, Tr	:	times for the flood wave propagation through the basin and in the river channel, respectively (sec.)
Lr	:	river channel length (10,300 m)
Vr	:	flow velocity in the river channel (m/s)
n	:	roughness coefficient in the river channel (0.035)
Rr	:	hydraulic radius of the river channel (2)
Ir	:	longitudinal gradient of the river channel (1/2,290)

The time lag for the total catchment area was thus estimated at 3.5 hours, assuming *Ts* as 0.5 hour.

- Rainfall Intensity

  From the rainfall intensity curve for the subject area, the Talbot equation is applied:

$$I = 8{,}273/(T + 31.51)$$
$$I = 34.3 mm / hr$$

Therefore,

Peak discharge is $Qp = \frac{1}{3.6} \times 0.41 \times 34.4 \times 21.1 = 82 m^3/s$

Assuming the flow velocity of sluice is 2.5 m/s and water required sluice gate area is 32.8 m^2 (5 spans × 7.0 m in width), depth is 1 m. Top elevation of gates is the same as the ring dike (EL 7.2 m). Steel roller gate is applicable as gate type.

(5) Drainage Pumping Station

A pumping station with design capacity of 3.0 m^3/s is proposed at eastern side of the area protected by ring dikes where there exist no houses at present.

Total pump head including losses due to screen, pipes, etc., is estimated to be approx. 3.5 m (HWL 6.0 - EL 3.0 + 0.5 m = 3.5 m). The following types of pump are commercially available for the estimated total pump head:

- Horizontal shaft axial flow pump
- Horizontal shaft mixed flow pump
- Vertical shaft axial flow pump
- Vertical shaft mixed flow pump
- Submersible motor pump

Among them, the submersible motor pump (3 units × 1.0 m3/s unit capacity, 700 mm dia.) is recommended for reasons of economical installation cost, ease of construction and ease of operation and maintenance.

Fig. XIII.4.12 shows the layout plan of proposed pumping station. Major facilities of pumping station consist of intake basin, main structure, surge tank, discharge sluiceway, mechanical control house, oil tank, pavement, parking lot, etc.

Pump units are planned to be operated by diesel generator sets at site. Manually collected garbage at screens are carried by horizontal and inclined belt conveyors.

(6) Slope Protection Works

Wet stone masonry revetment type slope protection is provided at the location of the ring dike close to the Indragiri River, outlet/control gate structures, and drainage pumping station. Slopes of embankment shall be generally covered with sodding.

(7) Groin

Eight sets of groins as shown in Fig. XIII.3.3 are provided at the location of the ring dike close to the Indragiri River.

(8) Public Road

Aside from flood control works, the construction of public road connected to the ring road is desired by the local government. Fig. XIII.4.13 shows a typical cross section of public road, with a total width of 7 m consisting of 5 m wide asphalt pavement and 1 m sidewalk on both sides.

4.5 Lubukjambi Intake Weir Construction Works

4.5.1 Location of Intake Weir

Lubukjambi Intake Weir is proposed at the meander bend area near the foot of the mountains, 11.5 km downstream from the proposed Kuantan Dam, as shown in Fig. XIII.4.14, in consideration of the following

- The required regulation volume of the reservoir is 2.2 x $10^6 m^3$, which is calculated as 36.93 m^3/s × 16 hours × 60 min. × 60 sec.
- It is difficult to construct a weir in the existing channel because the water depth of the channel in rainy season is very high (about 10 m).
- From the viewpoint of easy construction, the meander bend area which is proposed to be shortcut is desirable.

Fig. XIII.4.15 shows the storage capacity curve of the proposed Lubukjambi Intake Weir.