4. MASTER PLAN

4.1 Flood Control Plan

Optimum Flood Control Plan

The selection of appropriate flood control plan between dam and retarding basin is carried out through a comparison of required costs for flood mitigation effect. The comparative study shows that the dam is economically more advantageous than the retarding basin. The construction costs of river improvement and dam applied singly or in combination with each other are also compared. The results of the comparison shows that the river improvement with dam construction is economical for Deli and Percut rivers, while dam construction only is economical for Ular River and river improvement only is economical for the other rivers. (Refer to Supporting Report on Flood Control.)

In accordance with the results of the foregoing comparative studies, the optimum flood control plan for each river are summarized as follows:

Optimum Flood Control Plans

River (Project Scale)	Optimum Flood Control Facility	Total Cost (in mill. Rp.)
1. Belawan (50-Yr)	River Improvement (21.7 km)	31,261
2. Deli (100-Yr)	River Improvement (34.7 km), Floodway (3.85 km) and Namobatang Flood Control Dam	173,983
3. Percut (100-Yr)	River Improvement (26.5 km) and Lausimeme Flood Control Dam	68,771
4. Serdang (50-Yr)	River Improvement (25.4 km)	114,675
5. Ular (50-Yr)	Karai Flood Control Dam	16,076
6. Belutu (50-Yr)	River Improvement (32.7 km)	56,401
7. Padang (50-Yr)	River Improvement (27.0 km)	100,544

Flood Control Dam

Namobatang Dam in the Deli River, Lausimeme Dam in the Percut River and Karai Dam in the Ular River are selected as optimum flood control structures through the formulation of the optimum flood control plan.

The required flood control capacity at each selected dam site is calculated by flood regulation analysis based on the optimum flood control plan. The flood regulation method and required flood control capacity are shown in Fig. 4-1.

As for the type of dam for flood control purpose, a concrete gravity dam with gated spillway is the most advantageous. Small diversion works during construction time can be made and dam body is structurally advantageous against overflow flood in comparison with other types. Consequently, the required construction cost is led to the minimum. The principal features of flood control dams at the three (3) dam sites mentioned above are summarized in Table 4-1, and their general drawings are shown in Figs. 4-2, 4-3 and 4-4.

4.2 Water Supply Plan

Possible Reservoir for Water Supply

Only three (3) dams; namely, Tembengan on the Belawan River, Namobatang on the Deli River and Lausimeme on the Percut River, are potential sources to supply water to Medan City, because of their locations and effective storage capacity. Summarizing the water resource facilities such as aqueducts and reservoirs, the following are technically and economically viable to ensure municipal water supply for Medan City:

Water Resource Facilities

Water Resource Facility	Dimension	Newly Developed Supply Capacity (m^3/s)
Tembengan Dam	Storage Capacity = 21.0 MCM	2.5 (216,000)*
Namobatang Dam	Storage Capacity = 11.0 MCM	1.65 (142,500)*
Lausimeme Dam	Storage Capacity = 29.5 MCM	3.7 (319,680)
Belumai Aqueduct	Length = 9.0 km Diameter = 1,500 mm	2.6 (224,640)
Ular Aqueduct	Length = 30.5 km Diameter = 2,000 mm	6.1 (527,040)

Note: Figures in parentheses are in m^3/d.
* Newly developed supply capacity.

Optimum Combination of Facilities

The municipal water demand of 21,300 m^3/d in Tebing Tinggi City in the target year 2010 will be fully supplied by the surface flow of the Padang River. That in Medan City of approx. 770,000 m^3/s will be assured mostly by the new water sources such as reservoirs and aqueduct/transbasin diversion. Since about 60,000 m^3/d will be supplied from groundwater by means of springs and deep wells, 710,000 m^3/d has to come from the new water sources.

To select the appropriate facilities among the alternative water sources, cost efficiency of the facilities is examined, as follows:

Cost Efficiency of Water Supply Facilities

Water Resources Facility	Newly Developed Supply Capacity (MCM/yr)	Construction Cost (mil. Rp.)	Cost Efficiency (Rp./m^3/yr)
Tembengan Dam	79	90,000	1,139
Namobatang Dam	52	46,000	885
Lausimeme Dam	117	21,000	1,066
Belumai Aqueduct	82	49,000	598
Ular Aqueduct	192	226,500	1,180

From the estimated cost efficiency of the facilities and early project realization considering the present condition of water utilization system, the following three (3) facilities are proposed to fully meet the municipal water demand in Medan City in the target year 2010:

(a) Lausimeme Dam
(b) Namobatang Dam
(c) Belumai Aqueduct

Water Supply Dam

In accordance with the optimum combination of water supply facilities, Lausimeme Dam and Namobatang Dam are selected to be the promising water supply dams. The required dam heights of these two (2) dams are determined based on the relation between the required storage capacity mentioned above and reservoir storage curves.

As for the type of dam, taking account of the geological condition of dam foundation and the required dam heights, a rockfill type is selected for water supply dam. The principal features of these dams are as presented in Table 4-2 and summarized as follows:

Principal Features of Dams

Dam Site	Reservoir Capacity (MCM)		Dam Height (m)	Construction Cost (mill. Rp.)
	Water Supply Capacity	Sedimentation Capacity		
Namobatang	11.0	0.45	39.0	46,034
Lausimeme	29.5	0.55	73.5	124,652

Note: Sedimentation capacity is estimated for 50 years of project life.

4.3 Multipurpose Dam Development

Integrated Development Plan

The flood control and water supply plans are formulated at the target year 2010. Structures and facilities are incorporated in the respective plans and there are facilities to be commonly utilized by both plans. Therefore, an integrated plan is considered in the master plan.

Among the facilities considered in both plans, the Namobatang and Lausimeme dams are to be utilized for flood regulation and water supply in Medan. The capacity and construction cost allotted for the respective purposes and the integrated plan are estimated as follows:

Water Supply Capacity and Construction Cost

Name of Dam	Flood Control		Water Supply		Integrated Plan	
	Capacity (MCM) *1	Const. Cost (mil.Rp)	Capacity (MCM) *2	Const. Cost (mil.Rp)	Capacity (MCM) *2	Const. Cost (mil.Rp)
Namobatang	2.60	23,339	11.00	46,035	14.60	63,554
Lausimeme	2.80	21,182	29.50	124,652	33.40	141,344

Note: *1 presents the flood control capacity by applying gated spillway
*2 presents the flood control capacity by applying non-gated spillway

As shown in the above table, the total construction cost amounts to Rp. 63,554 million for Namobatang Dam and Rp. 141,344 million for Lausimeme Dam, if both the flood control and water supply plans are integrated. Since the construction cost is reduced by 8 to 10% by integrating the plans, the proposed dams are to have multiple functions of flood control and water supply.

Multipurpose Dam

Based on the integrated development plan mentioned above, Namobatang Dam and Lausimeme Dam are planned as multipurpose dams of the rockfill type with non-gated spillway (refer to Fig. 4-5). Their principal features and reservoir capacity allocation are shown in Table 4-3 and in Fig. 4-6.

General drawings of Namobatang Dam and Lausimeme Dam are presented in Fig. 4-9 and Fig. 5-6, respectively. Regarding Lausimeme Dam, more detailed study is carried out and the results are compiled in Section 5 of this report, since Lausimeme Multipurpose Dam is selected as one of the components of the urgent project.

Features of Dams

River	Dam Site	Reservoir Capacity (MCM)		Dam Height (m)	Construction Cost (mil. Rp.)
		Flood Control Capacity	Sediment Capacity		
Deli (100-Yr)	Namobatang	3.6	11.0	43.0	63,555
Percut (100-Yr)	Lausimeme	3.9	29.5	74.5	141,344

Note: Figures in parentheses present the project scale of the master plan.

5. LAUSIMEME MULTIPURPOSE DAM

5.1 Reservoir Capacity Allocation

Based on the master plan study, reservoir storage capacity is allocated to sedimentation capacity, municipal water supply capacity and flood control capacity.

Sedimentation Capacity

Annual sediment yield in the catchment area of Lausimeme Dam is estimated at 105 m^3/km^2/year (refer to the Supporting Report on Sediment Control Plan). Sedimentation capacity is derived from the said annual sediment yield for 50 years of project life multiplied by the catchment area of 105 km^2, as follows:

Vs = *annual sedimentation yield x 50 years x catchment area*
= 105 x 50 x 105
≒ 550,000 m^3

Municipal Water Supply Capacity

The required reservoir capacity at the dam site is estimated at 29,500,000 m^3 applying the intake rate of 3.7 m^3/s.

Intake Rate	:	$Q = 3.7$ m^3/s
Municipal Water Supply Capacity	:	Vm = 29,500,000 m^3

Flood Control Capacity

Flood control capacity is determined by flood regulation method in compliance with the flood control plan.

Generally, dam planning is formulated taking account of the maximum development scale and/or ultimate target development scale at the proposed dam site to avoid stepwise construction method which requires complicated and duplicated construction works. Therefore, even for the urgent project, flood control planning of Lausimeme Multipurpose Dam is conducted following the flood control master plan with project safety scale of 100-year return period.

Flood control capacity is calculated by different regulation methods, as follows (refer to Fig. 4-5):

(1) Natural Regulation Method (w/ non-gated spillway)

Max. Inflow Discharge	:	280 m^3/s (100-yr standard project flood)
Max. Outflow Discharge	:	60 m^3/s

Flood Control Capacity (incl. 20% allowance) : 3,900,000 m^3

(2) Fixed Discharge Regulation Method (w/ gated spillway)

Max. Inflow Discharge : 280 m^3/s (100-yr standard project flood)

Max. Outflow Discharge : 60 m^3/s

Flood Control Capacity (incl. 20% allowance) : 2,800,000 m^3

5.2 Selection of Dam Type

Natural Condition

(1) Topography and Geology

The Lausimeme dam site is located at Sibiru Biru along the Sernai River, one of the tributaries of the Percut River in the upper reaches. The site is about 35 km south of the center of Medan City and about 58 km from the estuary.

This dam site has a U-shaped topography, and there are residual hills projecting from plateaus made of Toba tuff on both sides. The geometry of the valley in relation to the summit on the left bank is estimated at 2.6.

Hard bedrock with few cracks is almost continuously observed on the left bank, while it is sparsely distributed on the right bank. Talus deposits partly cover the lower portion of the right bank slope.

(2) Dam Foundation

For geological investigation in this study, drilling at three (3) points along the proposed dam axis (left bank, riverbed and right bank) was conducted together with in-situ permeability test and laboratory tests. A geological longitudinal profile along the dam axis is shown in Fig. 5-1 and their information are compiled in the Supporting Report on Geology.

According to the results of geological investigation, values on unconfined compressive strength of test pieces range from 20 kg/cm^2 to 50 kg/cm^2, and in-situ permeabilities of 10 to 20 Lugeons were observed for foundation with joints. Foundation characteristics show insufficient shearing resistant strength to construction of a relatively high concrete dam, although the condition is not so serious for the construction of a fill-type dam which has generally wide adaptability to geological condition. As for permeability of this dam foundation, it is considered that there is no severe problem since most of the foundation condition can be improved by means of ordinary cement grouting.

(3) Construction Material

The gorge at the dam site becomes flat at about 500 m downstream and an abundant supply of river deposit such as cobbles, gravel and sand exists. These river deposits have been used as subbase construction materials for roads and as concrete aggregates.

As for embankment materials for a rockfill dam consisting of soil and rock, it is a little difficult to obtain a sufficient volume near the dam site. However, rock material is expected to occur in the upper reaches of the catchment area about 5.0 km away from the dam site, not always distributed abundantly, and soil material will be taken from the weathered rock mass of pyroclastics and lavas and/or Toba tuff, which are sparsely scattered.

(4) Impounding Reservoir

A relatively large saddle portion exists on the left bank of the reservoir immediately upstream of the dam site. This condition will make it practically impossible to construct an impounding reservoir with a large storage capacity, although a gorge of some 100 m deep exists at the site. From the economical point of view, therefore, it can be considered to be a reasonable development scale of the dam that an impounding reservoir with an area of less than 2.0 km^2 and a storage capacity of about 30 MCM are to be developed with the construction of a dam with some 70 m in height. (Refer to Fig. 5-2.)

Proposed Dam Type

Considering the geological condition of the dam site mentioned above and multipurpose development by construction of Lausimeme Dam with some 70 m in height, a rockfill type with center core is selected to be the most applicable type for a multipurpose dam.

5.3 Selection of Spillway Type

A non-gated spillway will be adopted for a rockfill dam at Lausimeme under the following considerations:

(a) A non-gated spillway has no probability of flooding caused by human error, although a gated spillway generally has a tendency to bring mis-operation under the circumstances that arrival time of flood runoff at the dam site is quite short due to the small catchment area and its topographic condition.

(b) Adoption of a non-gated spillway is a practical measure to avoid man-made flood, since a gated spillway basically requires orderly and quick gate operation in the case that the flood control capacity of proposed reservoir is relatively small in comparison with its catchment area.

(c) By applying a non-gated spillway, easier and more economical maintenance works can be expected, although initial construction cost of dam with a non-gated spillway is more compared with that of a gated spillway.

Consequently, the flood control capacity of 3,900,000 m^3, which is produced applying natural flood regulation method with non-gated spillway as mentioned above, is allocated to the proposed Lausimeme reservoir. (Refer to Fig. 4-5.)

5.4 Preliminary Design

Dam and Reservoir

In designing Lausimeme Dam, the Japanese criteria entitled "Manual for River Works in Japan (Draft)" prepared by the Ministry of Construction of Japan is basically adopted.

(1) Dam Height

The freeboard of 2.0 m provided above the design flood water level includes the following:

Wind Wave	:	1.0 m
Freeboard specifically provided for fill-type dam	:	1.0 m
Total	:	2.0 m

Consequently, the crest elevation is determined at EL. 256.5 m and the dam height comes to 74.5 meters assuming that the dam foundation elevation is EL. 182.0 m.

(2) Stability Analysis of Dam Embankment

The stability analysis of dam is carried out for the preliminary design of typical embankment section for checking sliding failure. Safety against sliding failure is examined as a rule by applying the slice method to the slip circle surface. The safety factor is more than 1.2.

Stability calculation is made for the following cases:

(a) Surcharge water level with 50% of standard earthquake acceleration (Ek = 0.06)
(b) Normal water level with 100% of standard earthquake acceleration (Ek = 0.12)

The calculation is made for a typical cross section applying assumptions and constants used empirically. As a result, the slope gradient is determined as 1:2.8 for the upstream and 1:2.3 for the downstream faces. The results of stability analysis and applied design condition are shown in Fig. 5-3.

The principal features of the dam embankment are summarized as follows:

Type of Dam	:	rockfill dam with center core
Height	:	74.5 m
Crest Length	:	195 m
Crest Elevation	:	EL. 256.5 mn
Dam Foundation	:	EL. 182.0 m
Embankment Volume	:	1,750,000 m^3

(3) Foundation Treatment

Although the bedrock of the proposed dam site is not continuously homogeneous, it has a sufficient bearing capacity for the foundation of a fill dam.

As to the permeability, most of the dam foundation rock show impervious characteristics except some portions of the right bank and the riverbed. Consequently, for the foundation treatment, adoption of generally accepted grouting such as curtain grouting and blanket grouting is planned.

(4) Impounding Reservoir

The principal features of the proposed reservoir are summarized as follows:

Catchment Area	:	105 km^2
Impounding Surface Area	:	1.7 km^2 (at Surcharge Water Level)
Sediment Capacity	:	550,000 m^3 (for period of 50 years)
Water Supply Capacity	:	29,500,000 m^3 (Intake Rate, 3.7 m^3/s)
Flood Control Capacity	:	3,900,000 m^3 (incl. 20% allowance)
Total Storage Capacity	:	33,950,000 m^3

The allocation of reservoir capacity and its corresponding reservoir water level is presented in Fig. 5-4.

Related Structures

(1) Spillway

A spillway will be installed on the left bank at the dam site. The spillway is designed to be a non-gated side overflow weir to avoid human operation error, namely a man-made flood, taking account the arrival time of flood runoff and the type of dam. The principal features of the overflow section of the spillway are as follows (Refer to Fig. 5-5):

Type	:	Non-gated Side Overflow Weir
Overflow Section	:	14.4 m wide at NWL and 30.6 m wide at SWL

The foregoing features are determined based on the following conditions:

(a) For Dam Design (without routing)

Max. Inflow Discharge	:	360 m^3/s (200-Yr. return period with 20% allowance)
Max. Outflow Discharge	:	360 m^3/s

(b) For Flood Regulation (with routing)

Max. Inflow Discharge	:	280 m^3/s (standard project flood, 100-Yr return period)
Max. Outflow Discharge	:	60 m^3/s

(2) Diversion Works

A temporary diversion works during dam construction is planned applying a diversion tunnel below the left abutment of the dam body. The design discharge of the tunnel is 180 m^3/s which corresponds to a flood of a 20-year return period. The principal features are as follows:

Design Discharge	:	180 m^3/s
Type	:	Horseshoe-shaped Section, 6.0 m in diameter
Length	:	500 m with 1% of longitudinal gradient

(3) Intake Facilities

Intake facilities are designed in such that the intake volume of 3.7 m^3/s is possible at the low water level of the reservoir. An intake tower will be constructed at the mouth of the temporary diversion tunnel running through the abutment of the left bank of the dam, and the intake water flows through this tunnel. After completion of the dam, this tunnel will be used as the intake channel to release water to the downstream. The location of these related structures is as shown in Fig. 5-6.

(4) Land Acquisition and House Evacuation

Fourteen (14) hectares of land consisting of 6 ha of paddy fields and 8 ha of dry fields is to be acquired, and 12 houses are to be evacuated to implement the project. These properties are located mainly at Kp. Kualasawan, about 2.0 km upstream of the dam site.

5.5 Construction Schedule and Cost Estimate

<u>Construction Schedule</u>

The entire construction period will last for 4 years. The construction schedule covering all the stages is shown in Fig. 5-7.

(1) Work Plan

Rockfill dam construction work largely consists of the earth work which is bulky in volume, concentrated in work load and needs fine quality in its finish. Such requirements having been taken into consideration, the work plan for dam construction will be studied at the detailed design stage, based on the climatological, particularly, the available rainfall data.

At present, since conspicuous rainy period is not specified in the monthly rainfall patterns at the representative rainfall stations around the proposed dam site, most of the work will be continuously done all through the year. However, temporary diversion works will be started avoiding the slightly rainy season from September to December.

Basically, all work will be executed by applying the two-shift system every day to facilitate effective dam construction.

(2) Construction Material

(a) Embankment Material

The major portion of the dam construction is earth work. The embankment volume is 1,750,000 m^3 in total. The required embankment volume of dam by zone is summarized as follows:

Rock Material	:	1,100,000 m^3
Filter Material	:	300,000 m^3
Core Material	:	350,000 m^3
Total	:	1,750,000 m^3

Findings of the present survey show rock material of microdiorite is available at places in the upper reaches about 5.0 km from the dam site. Core materials of soil will be taken from weathered rock mass of pyroclastics and lavas sparsely scattered around the dam site.

Aggregates for concrete, and fine aggregates for the filter material are available in the river deposit about 500 m downstream of the dam site.

(b) Concrete Material

Concrete of about 20,000 m^3 is required for the construction of spillway, intake structure and diversion tunnel. The requirements for cement in the dam construction work, including that for grouting work amount to approx. 7,000 tons.

Estimated Cost

(1) Construction Cost

The total construction cost of Lausimeme Multipurpose Dam comprise civil works, administration, engineering services cost, compensation cost, and 10% physical contingencies.

The total cost will be Rp. 141.3 billion, out of which RP. 91.3 billion is of foreign currency and RP. 50.0 billion of local currency. The breakdown of the construction cost is tabulated in Table 5-1.

(2) Operation, Maintenance and Replacement Cost

Dam Operation, maintenance and replacement cost will mainly comprise administration cost and direct construction cost. As an annual operation and maintenance cost for the whole period of the project life, approx. Rp. 0.9 billion is estimated, including some replacement cost for equipment.

6. WATER TRANSMISSION SYSTEM

6.1 *Water Transmission Method*

Water transmission from the Lausimeme Dam is planned as herein described.

(1) General Condition

The following three (3) schemes of transmission system are considered on the assumption that water released from the Lausimeme Dam is conveyed to the nearest treatment plant existing at Deli Tua.

Plan A: Water is transmitted from Lausimeme Dam through the Percut river channel provided with a connecting channel or pipeline to Deli Tua Treatment Plant, or directly by a new channel or pipeline from the dam to the treatment plant.

Plan B: Water is transmitted from Lausimeme Dam through the upper tributaries of Deli River to the treatment plant.

Plan C: Water is transmitted from the Lausimeme Dam on the same concept as Plan B, but through the planned Medan Floodway from Percut River to Deli River, then from Deli River to the treatment plant.

(2) Transmission Route

In the preliminary study, the optimum water transmission route is selected based on "Plan A", the most practical water transmission system. Based on this plan, the following four (4) alternative routes are studied (see Fig. 6-1). The estimated head between the lowest intake level at the dam and at the treatment plant is 200 m.

Alternative 1: Direct connection between the dam and the treatment plant: A *transmission tunnel of about 3.0 km from the dam to the existing road will* be excavated and then a pipeline of 14 km will be installed along the existing road to the plant.

Alternative 2: Intake of dam released water at Nomorindang, about 6.0 km downstream of the dam site in the Percut River: Nomorindang is located at the point where the existing Sibiru Biru Road closes nearest the river. Since the elevation of the riverbed is lower by about 40 m that the existing Sibiru Biru Road, pumping equipment is required for the river water intake.

Alternative 3:	Basically, the same water transmission concept as Alternative 2: The intake point in the Percut River is located at Selamat 1, about 15 km downstream of the dam site. Although access from the Percut River to the existing Sibiru Biru Road by the existing access road is easy, pumping equipment is required to offset the elevation difference of about 20 m between the Percut riverbed and the access road.
Alternative 4:	Based on the same concept of water transmission system as Alternative 2 and Alternative 3: The intake point on Percut River is set at Lantasan which is also located in Deli Tua 20 km downstream of the dam site. Pumping equipment is required to offset the elevation difference of about 10 m between the Percut riverbed and the existing Sibiru Biru road.

6.2 Features and Cost of Water Transmission System

The main facilities and the estimated construction cost of the water transmission system alternatives are summarized as follows based on the design intake discharge of 3.7 m^3/s.

Alternative Plan	Water Transmission System	Construction Cost (in mill. Rp.)
Alternative 1	Transmission Tunnel, Ø2m, 3.0 km	12,000
	Pipeline, Ø2m, 14.0 km	15,000
	Total	27,000
Alternative 2	Pump Equipment, Head 30m, 1,800 KW	16,000
	Pipeline, Ø1.5m, 11.0 km	8,000
	Total	24,000
Alternative 3	Pump Equipment, Head 20m, 1,200 KW	12,000
	Pipeline, Ø1.5m, 5.0 km	3,700
	Total	15,700
Alternative 4	Pump Equipment, Head 10m, 600 KW	10,000
	Pipeline, Ø1.5m, 3.0 km	2,200
	Total	12,200

6.3 Optimum Water Transmission System

Although Alternative Plan 1 (direct connection by pipeline) is an ideal and reliable water transmission system and there is no need to pay special attention to water transmission loss and pollution, the required construction cost is extremely higher than those of other alternatives. On the other hand, Alternative Plan 4 (nearest intake point to the existing treatment plant) is the most economical water transmission system among the alternatives, although various supplementary anxieties such as water loss, pollution, illegal use, etc., are considered. Alternative Plan 4 is then selected as the optimum water transmission system because of the least construction cost.

TABLES

Table 2-1 POSSIBLE RETARDING BASIN SITES AND THEIR FEATURES

River System	Location	Catchment Area Km2	Dike Height m	Impounding Surface Area Km2	Gross Storage Capacity MCM	Required Dike Length * m	Type of Retarding Basin
Belawan	Sembahe Baru	155	3	3.9	7.8	300	Exacavated Basin
Serdang	Punden	262	3	0.8	1.6	1000	Natural Basin
Belutu	Bakaran Batu	243	3	6.7	13.4	500	Natural Basin
Padang	Tebing Tinggi	414	3	2.5	5.0	200	Exacavated Basin

Note : * Embankment will be placed on the boundaries.

Table 3-1 POSSIBLE DAM SITES AND THEIR FEATURES

Possible Dam Site	River System/ River	Location	Catchment Area (km2)	Distance from Estuary (km)	Road Distance from Medan/ Tebing Tinggi (km)	Present Condition		
						Topographic/ Geological	Land Use	Access
Tembengan	Belawan/Belawan	N3°27'E98°33'	76	60	25, Medan	Wide gorge	Paddy	No Good
Namobatang	Deli/Petani	N3°21'E98°37'	93	58	30, Medan	Wide gorge	Paddy	Good
Lausimeme	Percut/Seruai	N3°21'E98°39'	105	50	32, Medan	Narrow gorge Hilly land	Forest Dry field	No Good
Beranti	Serdang/Belumai	N3°21'E98°43'	159	52	33, Medan	Narrow gorge Hilly land	Forest Dry field	No Good
Buaya	Ular/Buaya	N3°21'E98°52'	428	44	60, Medan 45, T.Tinggi	Wide gorge	Paddy	Good
Karai	Ular/Karai	N3°21'E98°54'	500	44	65, Medan 38, T.Tinggi	Wide gorge	Paddy	No Good
Sibakudu	Belutu/Belutu	N3°14'E98°53'	64	60	35, T.Tinggi	Wide gorge	Paddy	No Good
Sampanan	Padang/Padang	N3°12'E99°03'	370	48	24, T.Tinggi	Wide gorge	Plantation	Fair

Table 3-2 POSSIBLE WATER PRODUCTION CAPACITY AT EACH DAMSITE

Damsite	1) Topograph-ically Possible Reservoir Storage Capacity (MCM)	2) Sedimen-tation Capacity *1 (MCM)	3)=1)-2) Possible Effective Storage Capacity (MCM)	4) Annually Secured Effective Storag Capacity *2 (MCM)	5) Reservoir Yield Capacity (incl. existing water supply capacity) *3 (m/3)	6) Discharge Duration (existng flow regime, 95%) *4 (m/3)	7)=5)-6) Possible Water Production Capacity (m/3)	8) Droughtest Year (1969-1988) *5 (Year)
Tembengan	25.0	2.3	22.7	12.5	1.8	1.0	0.8	1988
Namobatang	15.0	0.9	14.1	14.1	2.9	1.6	1.3	1975
Lausimeme	60.0	1.1	58.9	19.5	3.4	1.8	1.6	1975
Beranti	15.0	8.0	7.0	7.0	4.0	2.4	1.6	1975
Buaya	48.0	21.4	26.6	26.6	14.0	10.2	3.8	1975
Karai	85.0	25.0	60.0	60.0	17.5	11.9	5.6	1975
Sibakudu	45.0	1.3	43.7	12.4	2.5	1.6	0.9	1973
Sampanan	31.0	18.5	12.5	12.5	11.5	9.2	2.3	1973

Note :

*1 Accumulated sedimentation volume for a period of 100 years.

*2 On condition that each reservoir is planned to be annually recovered to full.

*3 Reservoir yield capacity is shown in Fig. 3-2.

*4 Discharge duration of 95% is considered as nearly equivalent to existing water supply capacity at each damsite.

*5 Droughtest year is selected considering the minimum discharge of flow regime of 95% and 99% at each damsite during the period from 1969 to 1988.

Table 3-3 TECHNICAL AND ECONOMICAL COMPARISON OF PLANNED DAMS

River System	Damsite	1) Catchment Area (km2)	2) Topographically Possible Reservoir Storage Capacity (MCM)	3) Sedimentation Capacity *1 (MCM)	4)=2)-3) Possible Effective Storage Capacity (MCM)	5) Annually Secured Effective Storage Capacity *2 (MCM)	6)=3)+5) Required Total Reservoir Storage Capacity (MCM)	7) Required Dam Height For 6) (m)	8) Impounding Surface Area For 6) (km2)	9) Quantity of Required Dam Body For 7) *3 (1000 m3)	10) Estimated Construction Cost For 9) (Billion Rp)	11)=10)/5) Estimated Construction Cost/Annually Secured Effective Storage Capacity (1000 Rp/m3)
Belawan	Tembengan	76	25.0	2.3	22.7	12.5	14.8	33	1.4	953	76.2	6.1
Deli	Namobatang	93	15.0	0.9	14.1	14.1	15.0	41	0.8	672	53.8	3.8
Percut	Lausimeme	105	60.0	1.1	58.9	19.5	20.6	61	1.1	750	60.0	3.1
Serdang	Beranti	159	15.0	8.0	7.0	7.0	15.0	38	0.9	668	53.4	7.6
Ular	Buaya	428	48.0	21.4	26.6	26.6	48.0	19	4.1	296	23.8	0.9
Ular	Karai	500	85.0	25.0	60.0	60.0	85.0	30	8.0	360	28.8	0.5
Belutu	Sibakudu	64	45.0	1.3	43.7	12.4	13.7	18	2.3	189	15.1	1.2
Padang	Sampanan	370	31.0	18.5	12.5	12.5	31.0	34	2.4	382	47.4	3.8

Note : *1 Accumulated sedimentation volume for a period of 100 years.
*2 On condition that each reservoir is planned to be annually recovered to full.
*3 Quantity estimated considering a dam type as rock-fill.

Table 4-1 PRINCIPAL FEATURES OF FLOOD CONTROL DAMS

Description	Namobatang Flood Control Dam	Lausimeme Flood Control Dam	Karai Flood Control Dam
Dam			
- Type of Dam	Concrete Gravity Dam	Concrete Gravity Dam	Concrete Gravity Dam
- Catchment Area	93 km2	106 km2	500 km2
- Height	24 m	35.5 m	23.5 m
- Crest Length	270 m	143 m	200 m
- Crest Elevation	EL 208.0 m	EL 217.5 m	EL 78.5 m
- Dam Foundation Level	EL 184.0 m	EL 182.0 m	EL 55.0 m
- Dam Body Volume	53,000 m3	49,000 m3	30,000 m3
Reservoir			
- Design Flood Water Level (DFWL)	EL 206.5 m	EL 216.0 m	EL 77.0 m
- Surcharge Water Level (SWL)	EL 206.0 m	EL 215.5 m	EL 75.5 m
- Sedimentation Level (LWL)	EL 200.0 m	EL 198.0 m	EL 73.0 m
- Reservoir Surface Area at SWL	0.3 km2	0.3 km2	5.0 km2
- Gross Storage Capacity	3,050,000 m3	3,350,000 m3	18,100,000 m3
- Flood Control Capacity	2,600,000 m3	2,800,000 m3	5,600,000 m3
- Sedimentation Capacity (50 Years)	450,000 m3	550,000 m3	12,500,000 m3
Spillway			
- Type	Overflow Spillway with Gates	Overflow Spillway with Gates	Overflow Spillway with Gates
- Dam Design Discharge	270 m3/s(200-Yr Return Period)	300 m3/s(200-Yr Return Period)	560 m3/s(200-Yr Return Period)
- Fixed Volume Regulation Method	80 % cut	80 % cut	40 % cut
Inflow Discharge	250 m3/s(100-Yr Return Period)	280 m3/s(100-Yr Return Period)	500 m3/s(50-Yr Return Period)
Outflow Discharge	50 m3/s	60 m3/s	300 m3/s
- Flow Section at SWL	9 m in width	10 m in width	40 m in width
Diversion Works			
- Dam Body Inside Channel	1.5 m in Dia.	1.5 m in Dia.	2.0 m in Dia.
Compensation			
- House Evacuation	180 Houses	1 House	20 Houses
- Land Acquisition	12 ha of paddy field 1 ha of dry field	0 ha of paddy field 1 ha of dry field	25 ha of paddyfield 15 ha of dryfield
Construction Cost (Million Rp.)			
1. Civil Works	12,012	11,222	8,977
2. Administration	841	786	628
3. Engineering Service	7,005	6,968	4,309
4. Compensation	1,360	282	700
5. Physical Contingency	2,122	1,924	1,461
Total	23,340	21,182	16,075

Table 4-2 PRINCIPAL FEATURES OF WATER SUPPLY DAMS

Description	Namobatang Water Supply Dam	Lausimeme Water Supply Dam
Dam		
- Type of Dam	Rockfill Dam with Center Core	Rockfill Dam with Center Core
- Catchment Area	93 km2	106 km2
- Height	39 m	73.5 m
- Crest Length	300 m	175 m
- Crest Elevation	EL 223.0 m	EL 255.5 m
- Dam Foundation Level	EL 184.0 m	EL 182.0 m
- Embankment Volume	540,000 m3	1,500,000 m3
Reservoir		
- Design Flood Water Level (DFWL)	EL 221.0 m	EL 253.5 m
- Normal Water Level (NWL)	EL 218.0 m	EL 250.5 m
- Sedimentation Level (LWL)	EL 200.0 m	EL 198.0 m
- Reservoir Surface Area at NWL	0.7 km2	1.6 km2
- Gross Storage Capacity	11,450,000 m3	30,050,000 m3
- Water Supply Capacity	11,000,000 m3	29,500,000 m3
- Sedimentation Capacity (50 Years)	450,000 m3	550,000 m3
Spillway		
- Type	Side-Channel Spillway (Non-gated)	Side-Channel Spillway (Non-gated)
- Dam Design Discharge	320 m3/s(200-Yr Return Period, with 20% allowance)	360 m3/s(200-Yr Return Period, with 20% allowance)
- Flow Section at NWL	35 m in width	41 m in width
Diversion Works		
- Diversion Tunnel	5 m in Dia. 180 m in length	6 m in Dia. 470 m in length
Compensation		
- House Evacuation	220 Houses	12 Houses
- Land Acquisition	14 ha of paddy field 3 ha of dry field	6 ha of paddy field 8 ha of dry field
Construction Cost (Million Rp.)		
1. Civil Works	30,906	93,600
2. Administration	2,163	6,552
3. Engineering Service	7,100	11,074
4. Compensation	1,680	2,094
5. Physical Contingency	4,185	11,332
Total	46,034	124,652

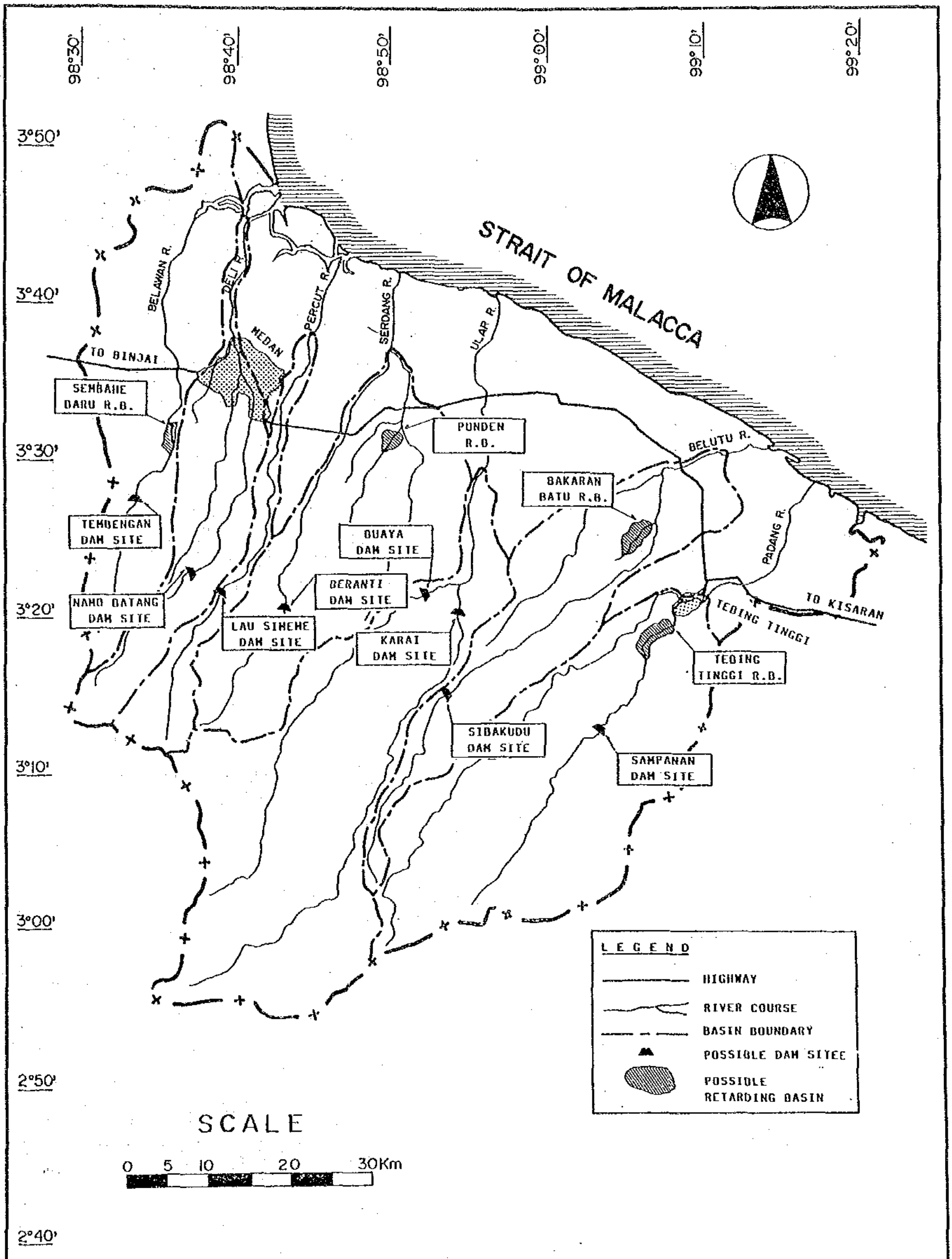
Table 4-3 PRINCIPAL FEATURERS OF MULTIPURPOSE DAMS

Description	Namobatang Multipurpose Dam	Lausimeme Multipurpose Dam
Dam		
- Type of Dam	Rockfill Dam with Center Core	Rockfill Dam with Center Core
- Catchment Area	93 km2	106 km2
- Height	43 m	74.5 m
- Crest Length	330 m	195 m
- Crest Elevation	EL 227.0 m	EL 256.5 m
- Dam Foundation Level	EL 184.0 m	EL 182.0 m
- Embankment Volume	720,000 m3	1,750,000 m3
Reservoir		
- Design Flood Water Level (DFWL)	EL 225.0 m	EL 254.5 m
- Surcharge Water Level (SWL)	EL 223.0 m	EL 252.5 m
- Normal Water Level (NWL)	EL 218.0 m	EL 250.5 m
- Sedimentaion Level (LWL)	EL 200.0 m	EL 198.0
- Reservoir Surface Area at SWL	0.8 km2	1.7 km2
- Gross Storage Capacity	15,050,000 m3	33,950,000 m3
- Flood Control Capacity	3,600,000 m3	3,900,000 m3
- Water Supply Capacity	11,000,000 m3	29,500,000 m3
- Sedimentation Capacity (50 Years)	450,000 m3	550,000 m3
Spillway		
- Type	Side-Channel Spillway (Non-gated)	Side-Channel Spillway (Non-gated)
- Dam Design Discharge	320 m3/s(200-Yr Return Period, with 20% allowance)	360 m3/s(200-Yr Return Period, with 20% allowance)
- Flood Reguration Method	Natural Regulation Method	Natural Regulation Method
Max. Inflow Discharge	250 m3/s(100-Yr Return Period)	280 m3/s(100-Yr Return Period)
Max. Outflow Discharge	50 m3/s	60 m3/s
- Flow Section at NWL	3.2 m in width	14.4 m in width
- Flow Section at SWL	42.0 m in width	30.6 m in width
Diversion Works		
- Diversion Tunnel	5 m in Dia. 240 m in length	6 m in Dia. 500 m in length
Compensation		
- House Evacuation	240 Houses	12 Houses
- Land Acquisition	18 ha of paddy field 5 ha of dry field	6 ha of paddy field 8 ha of dry field
Construction Cost (Million Rp.)		
1. Civil Works	42,401	102,234
2. Administration	2,968	7,156
3. Engineering Service	10,288	16,861
4. Compensation	2,120	2,244
5. Physical Contingency	5,778	12,849
Total	63,555	141,344

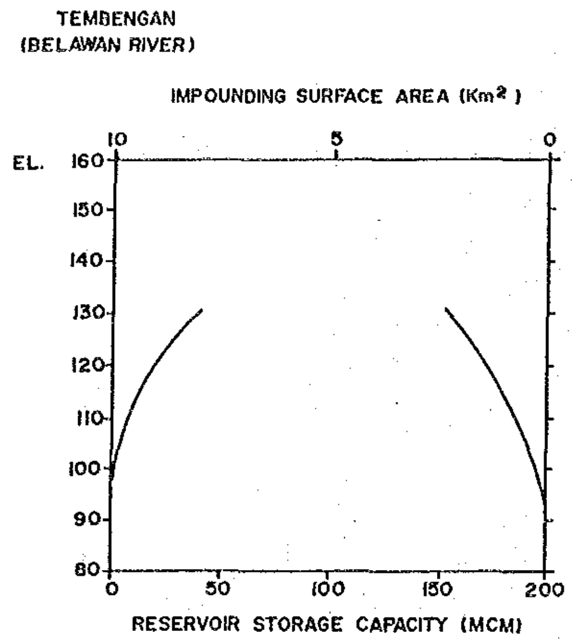
Table 5-1 CONSTRUCTION COST OF LAUSIMEME MULTIPURPOSE DAM

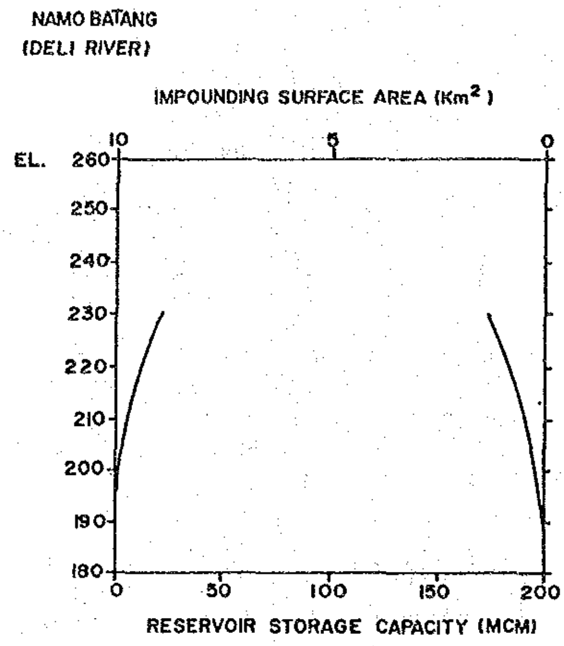
Work Items	Unit	Quantity	Unit Price (Thousand Rp.) F.C.	Unit Price (Thousand Rp.) L.C.	Amount (Million Rp.) F.C.	Amount (Million Rp.) L.C.	Total (Million Rp.)
1. Civil Works					56,038	29,157	85,195
- Excavation	m3	150,000			654	329	983
Common	m3	135,000	3.8	1.7	513	230	
Rock	m3	15,000	9.4	6.6	141	99	
- Embankment	m3	1,750,000			44,800	25,200	70,000
Core Material	m3	350,000	10.6	3.8	3,696	1,344	
Rock Material	m3	1,400,000	29.4	17.0	41,104	23,856	
- Spillway (R.C. Concrete)	m3	4,000	300.0	100.0	1,200	400	1,600
- Foundation Treatment (Grouting)	m	6,000	113.0	37.0	678	222	900
- Intake Structure (R.C. Concrete)	m3	2,000	300.0	100.0	600	200	800
- Headrace Channel (R.C. Concrete)	m3	14,000	300.0	100.0	4,200	1,400	5,600
- Diversion Tunnel	m	500	6,125.0	2,625.0	3,063	1,313	4,375
- Relocation Road	m	2,500	337.5	37.5	844	94	938
2. Preparatory Works(20% of 1)	L/S	1			11,208	5,831	17,039
Total(1+2)					67,246	34,988	102,234
3. Administration(7% of 1+2)	L/S	1			0	7,156	7,156
4. Engineering Services					15,759	1,102	16,861
- Remuneration					9,180	0	9,180
D/D (Pro.A)	M/M	140	30,000.0	0.0	4,200	0	
D/D (Pro.B)	M/M	180	6,000.0	0.0	1,080	0	
S/V (Pro.A)	M/M	100	30,000.0	0.0	3,000	0	
S/V (Pro.B)	M/M	150	6,000.0	0.0	900	0	
- Direct Cost	L/S	1			2,754	1,102	3,856
- Topographical Survey (Ground Survey)	m2	300,000	10.0	0.0	3,000	0	3,000
- Geotechnical Investigation					825	0	825
Seismic Prospecting	m	5,000	5.0	0.0	25	0	
Core Drilling	m	4,000	200.0	0.0	800	0	
5. Compensation					0	2,244	2,244
- Land Acquisition					0	2,220	
Paddy Field	ha	6	0	80,000	0	480	
Dry Field	ha	8	0	30,000	0	240	
Open Space	ha	150	0	10,000	0	1,500	
- House Evacuation	houses	12	0	2,000	0	24	
Total (1 to 5)					83,005	45,490	128,495
6. Physical Conti.(10% of 1 to 5)					8,300	4,549	12,849
G.Total (1 to 6)					91,305	50,039	141,344

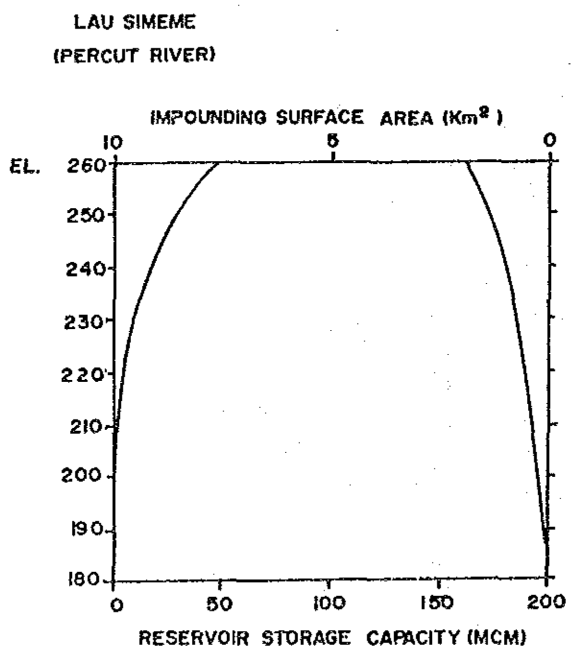
FIGURES

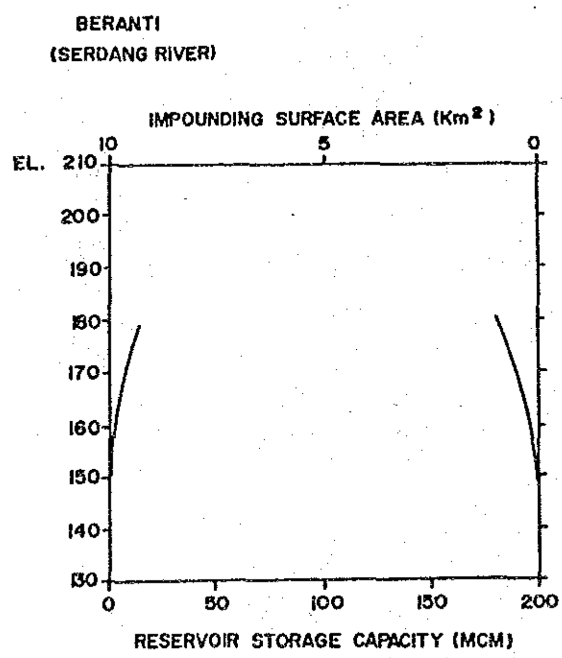


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	LOCATION OF POSSIBLE DAM SITES AND RETARDING BASIN SITES
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.3-1



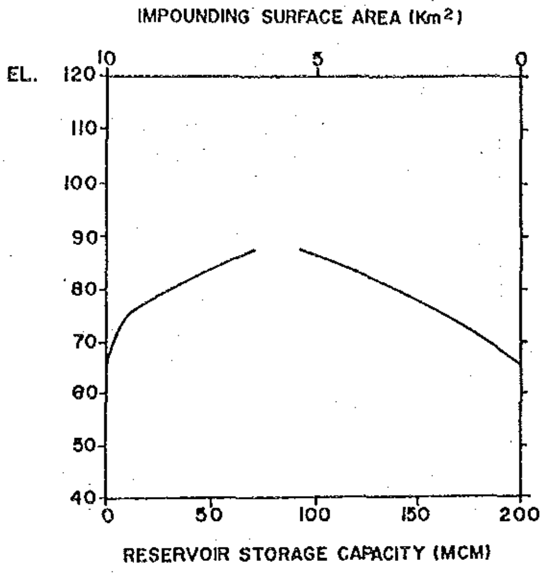




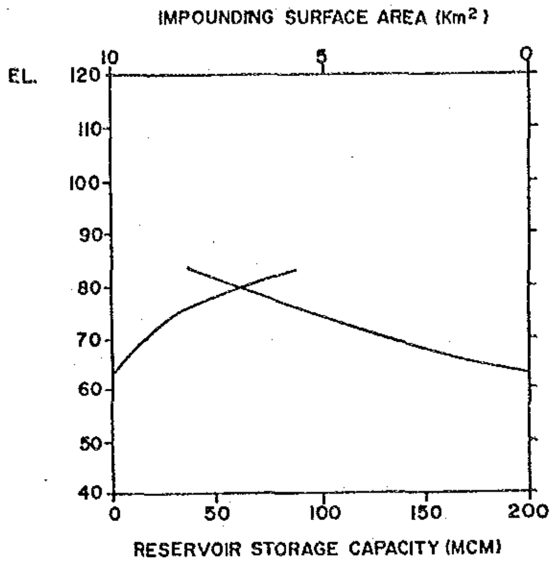


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	RESERVOIR STORAGE CAPACITY CURVE
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.3-2(1/2)

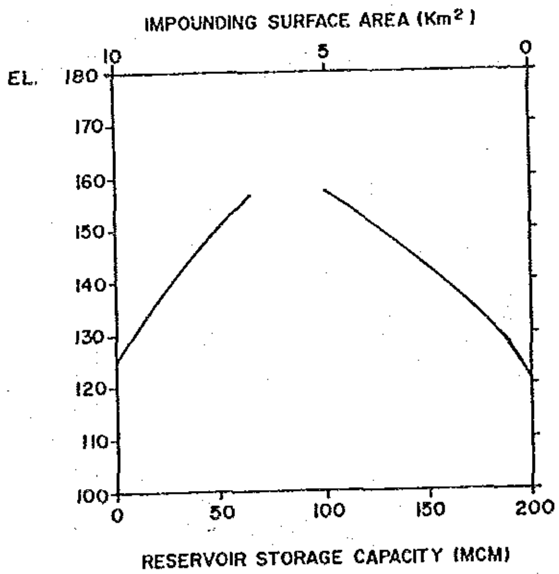
BUAYA
(ULAR RIVER)



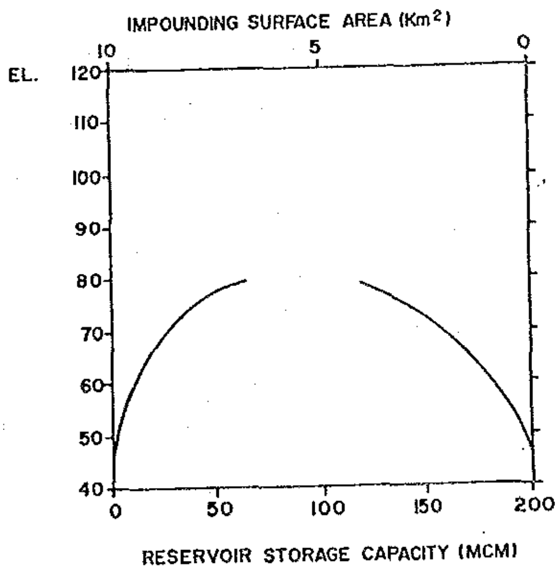
KARAI
(ULAR RIVER)



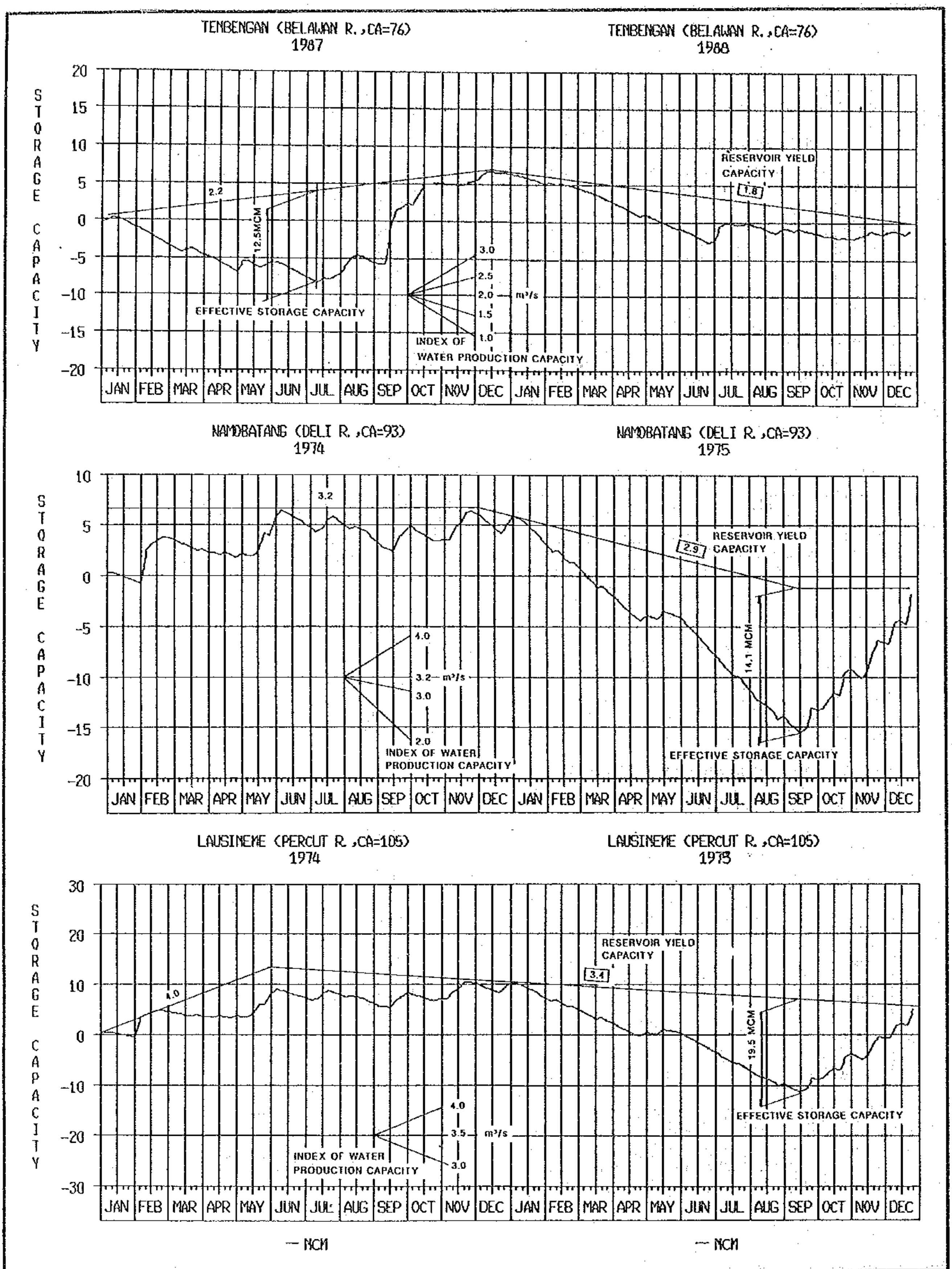
SIBAKUDU
(BELUTU RIVER)



SAMPANAN
(PADANG RIVER)



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	RESERVOIR STORAGE CAPACITY CURVE
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.3-2(2/2)

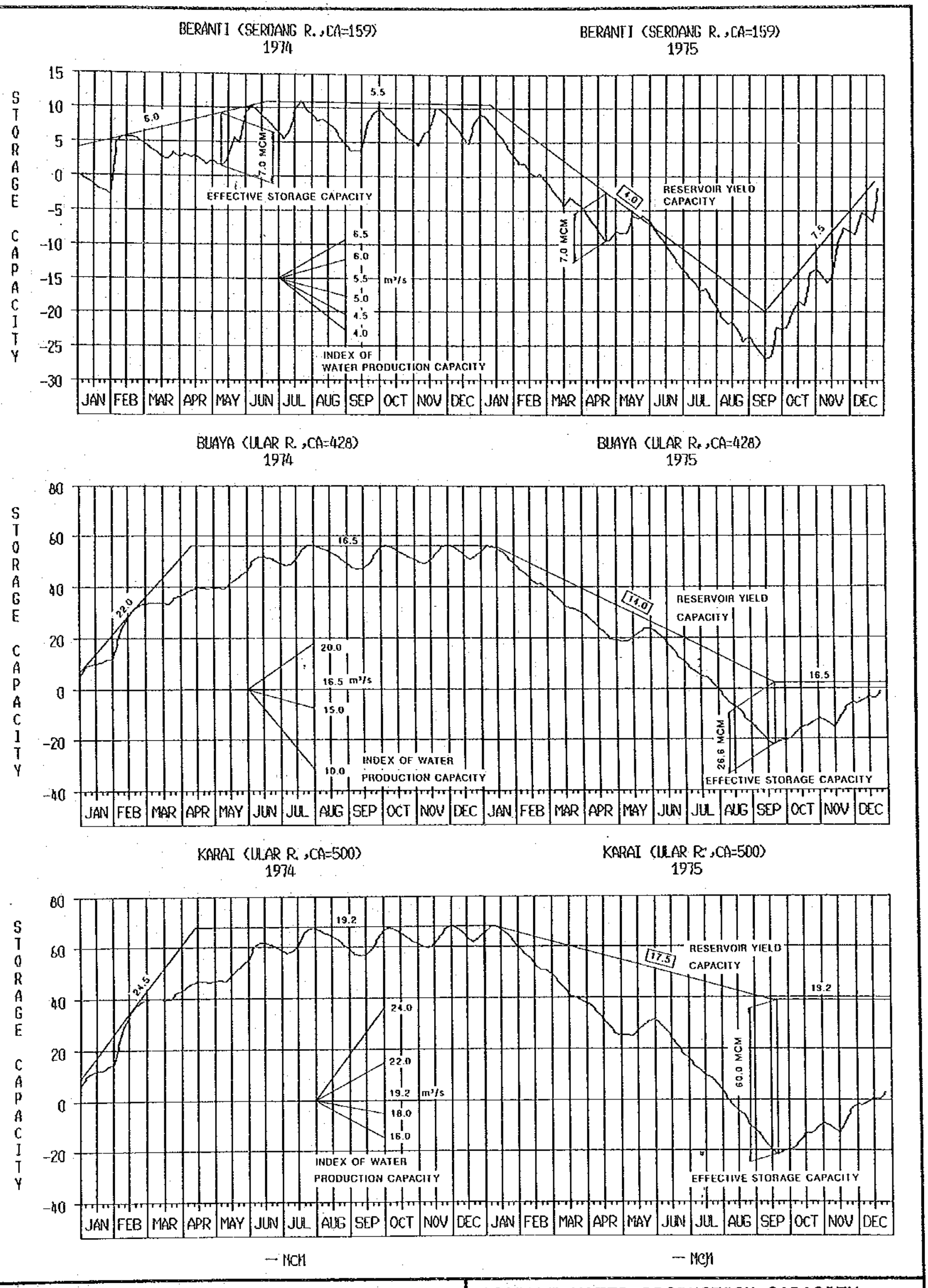


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT
IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

POSSIBLE WATER PRODUCTION CAPACITY
BY MASS CURVE CALCULATION

Fig.3-3(1/3)

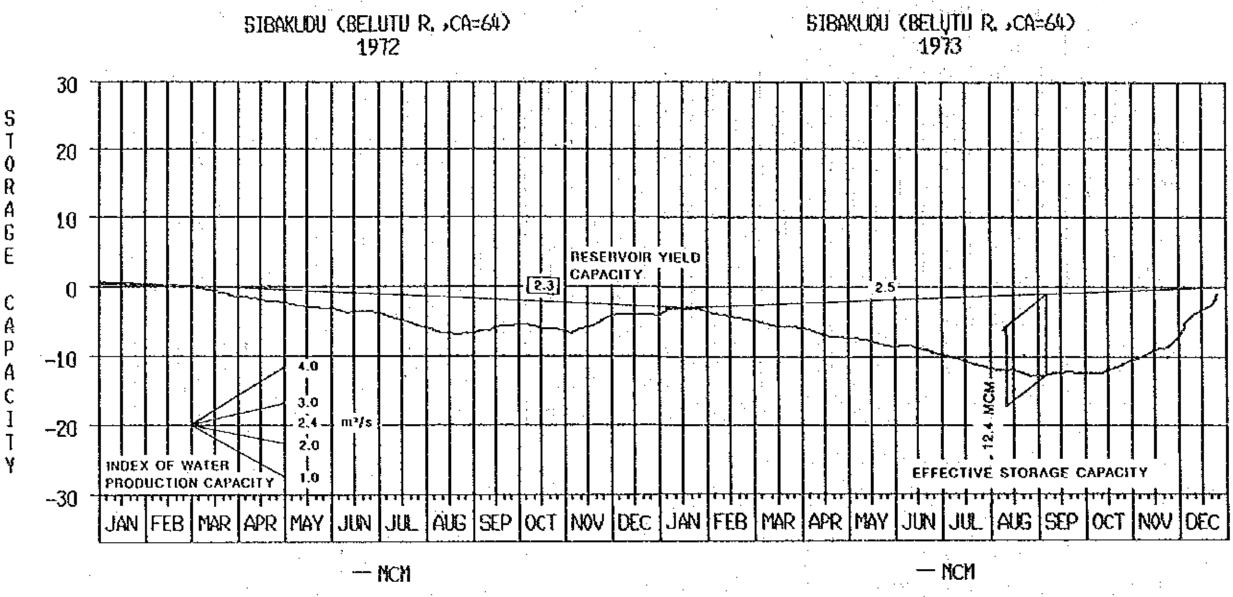


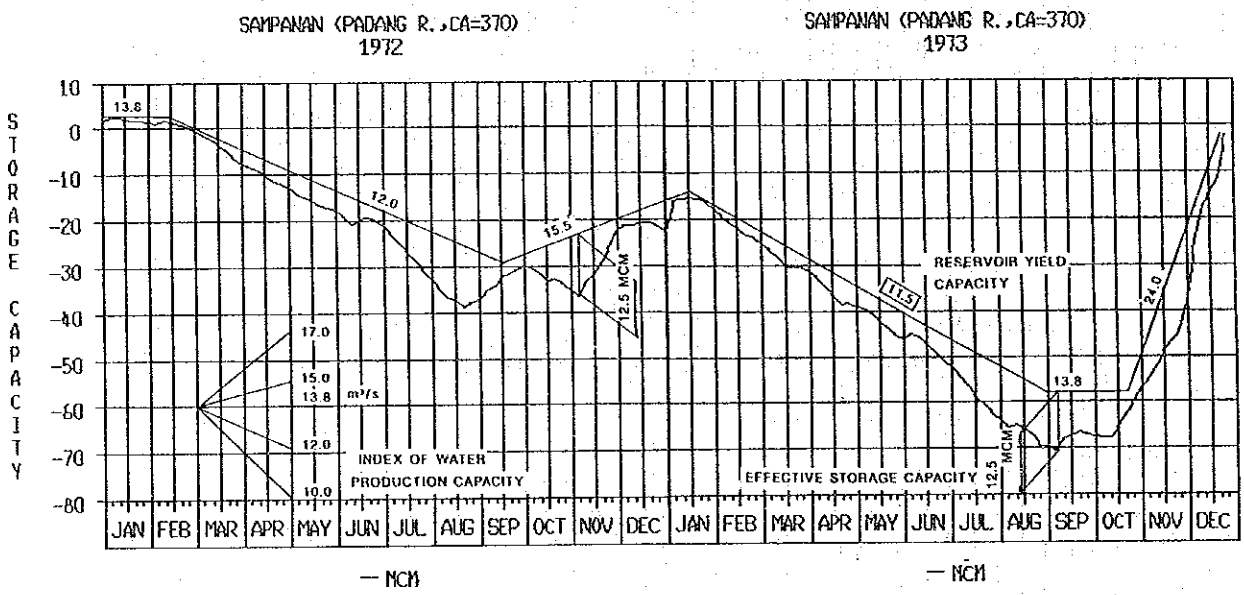
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

POSSIBLE WATER PRODUCTION CAPACITY BY MASS CURVE CALCULATION

Fig.3-3(2/3)





THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT
IN THE REPUBLIC OF INDONESIA

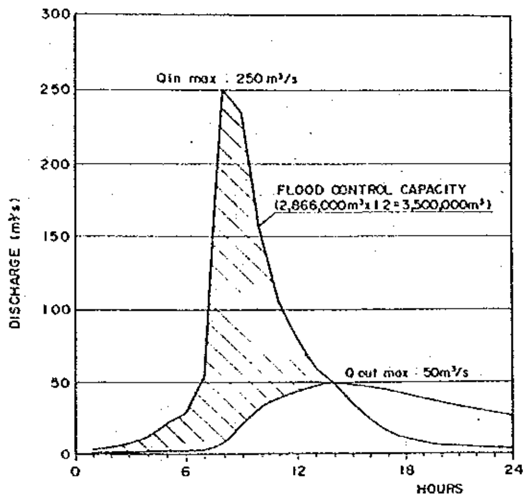
JAPAN INTERNATIONAL COOPERATION AGENCY

POSSIBLE WATER PRODUCTION CAPACITY
BY MASS CURVE CALCULATION

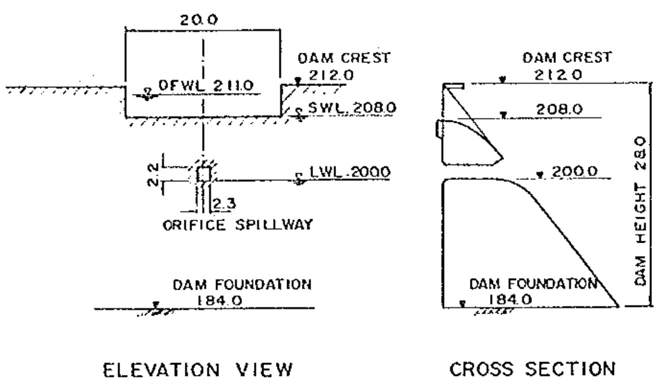
Fig.3-3(3/3)

UNIT : m

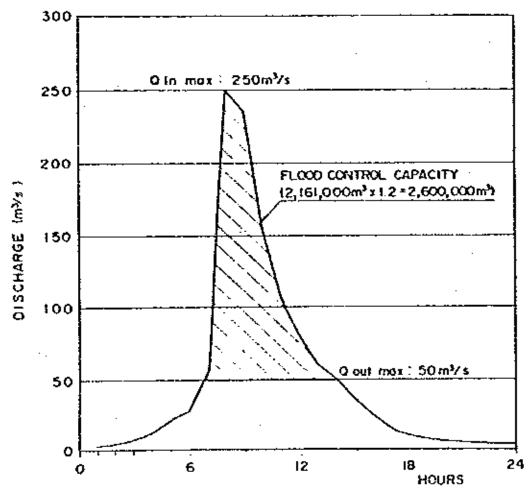
FLOOD REGULATION BY NON-GATED SPILLWAY



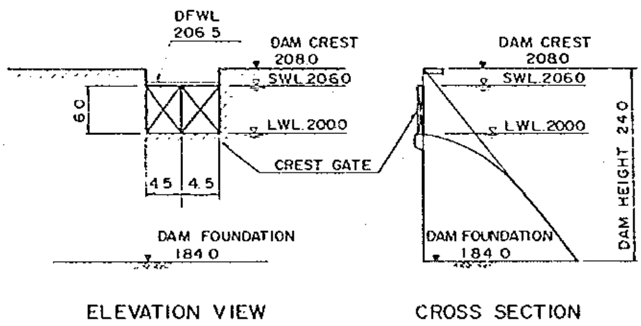
NON-GATED SPILLWAY



FLOOD REGULATION BY GATED SPILLWAY



GATED SPILLWAY

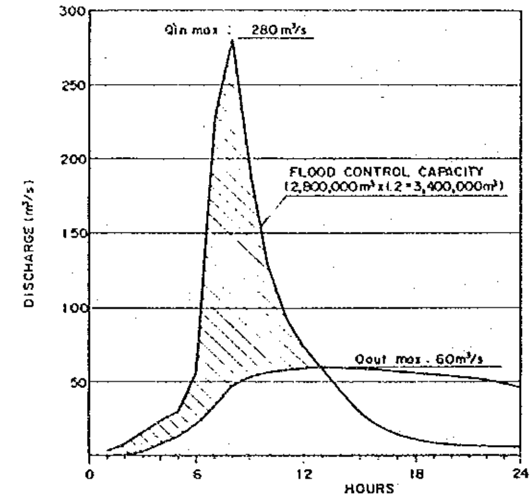


NAMOBATANG FLOOD CONTROL DAM

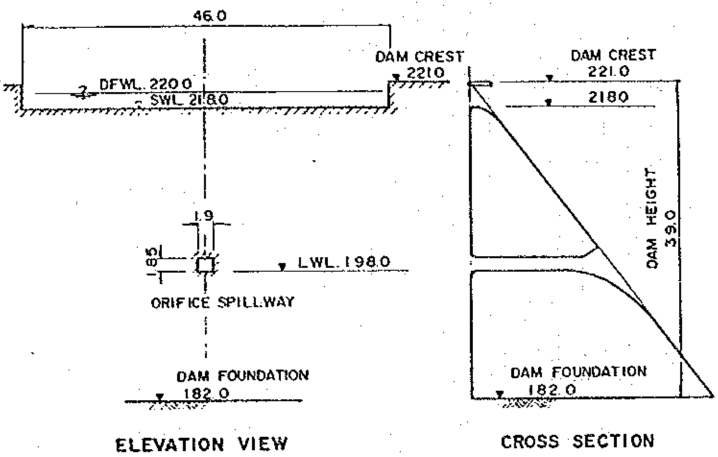
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	FLOOD REGULATION METHOD AND REQUIRED FLOOD CONTROL CAPACITY OF FLOOD CONTROL DAMS Fig.4-1(1/3)
JAPAN INTERNATIONAL COOPERATION AGENCY	

UNIT : m

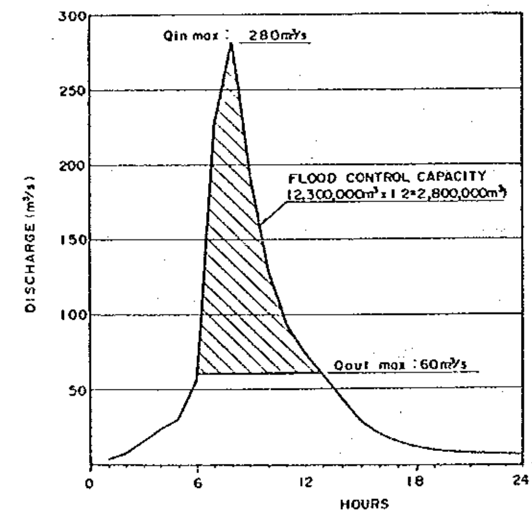
FLOOD REGULATION BY NON-GATED SPILLWAY



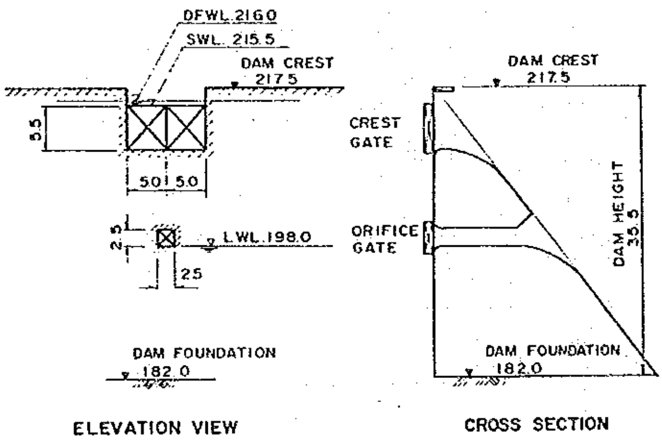
NON-GATED SPILLWAY



FLOOD REGULATION BY GATED SPILLWAY

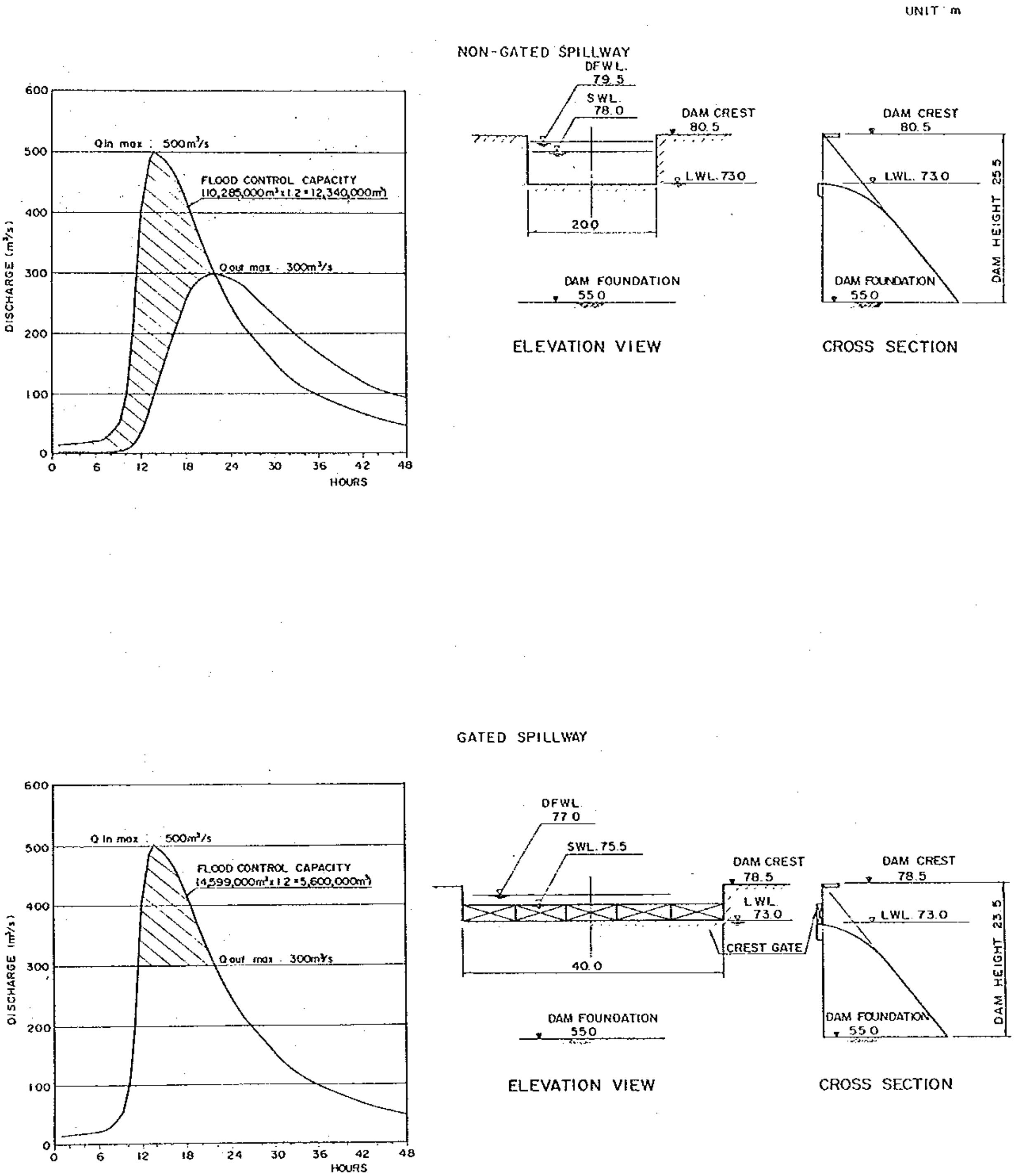


FULL-GATED SPILLWAY



LAUSIMEME FLOOD CONTROL DAM

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	FLOOD REGULATION METHOD AND REQUIRED FLOOD CONTROL CAPACITY OF FLOOD CONTROL DAMS Fig.4-1(2/3)
JAPAN INTERNATIONAL COOPERATION AGENCY	

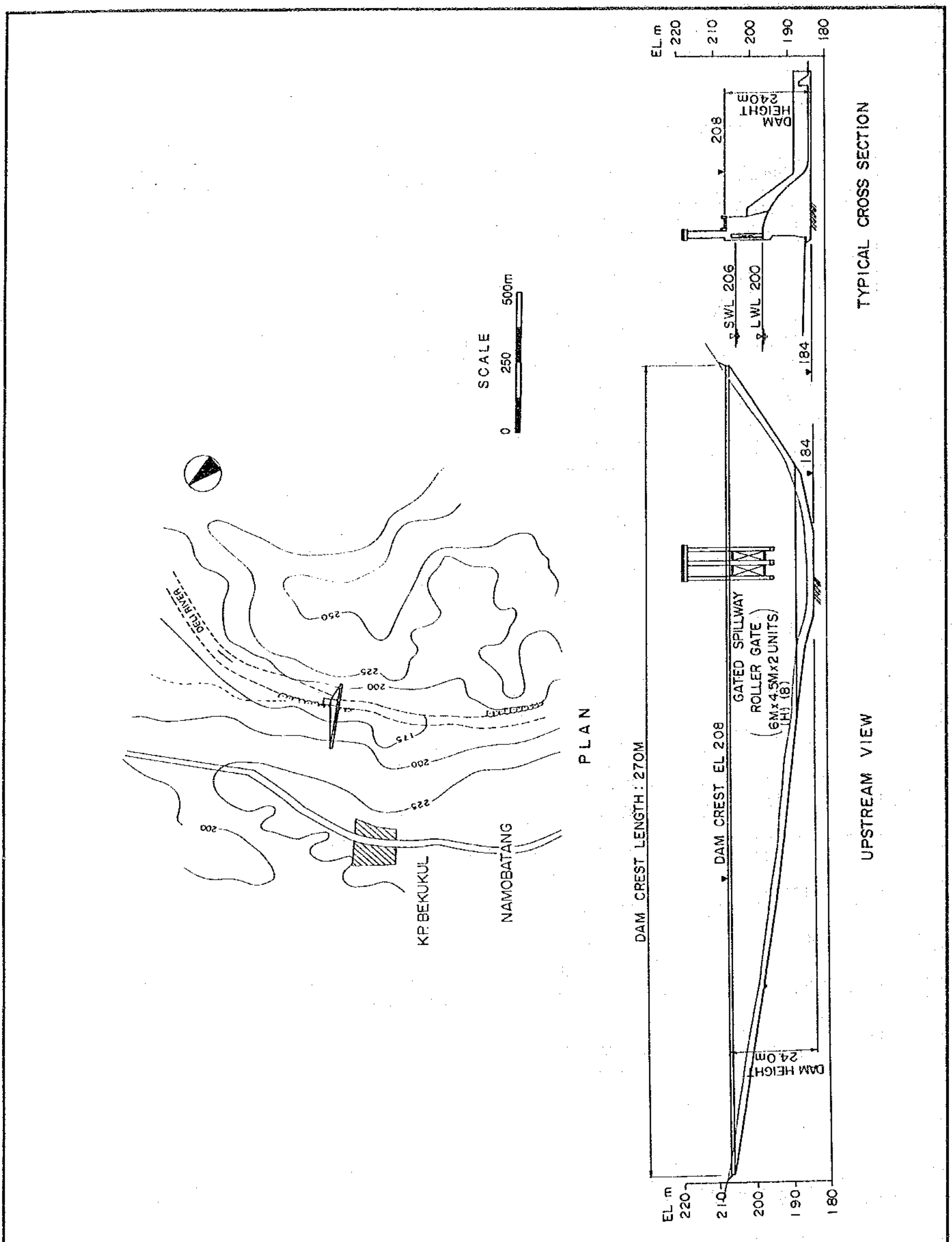


KARAI FLOOD CONTROL DAM

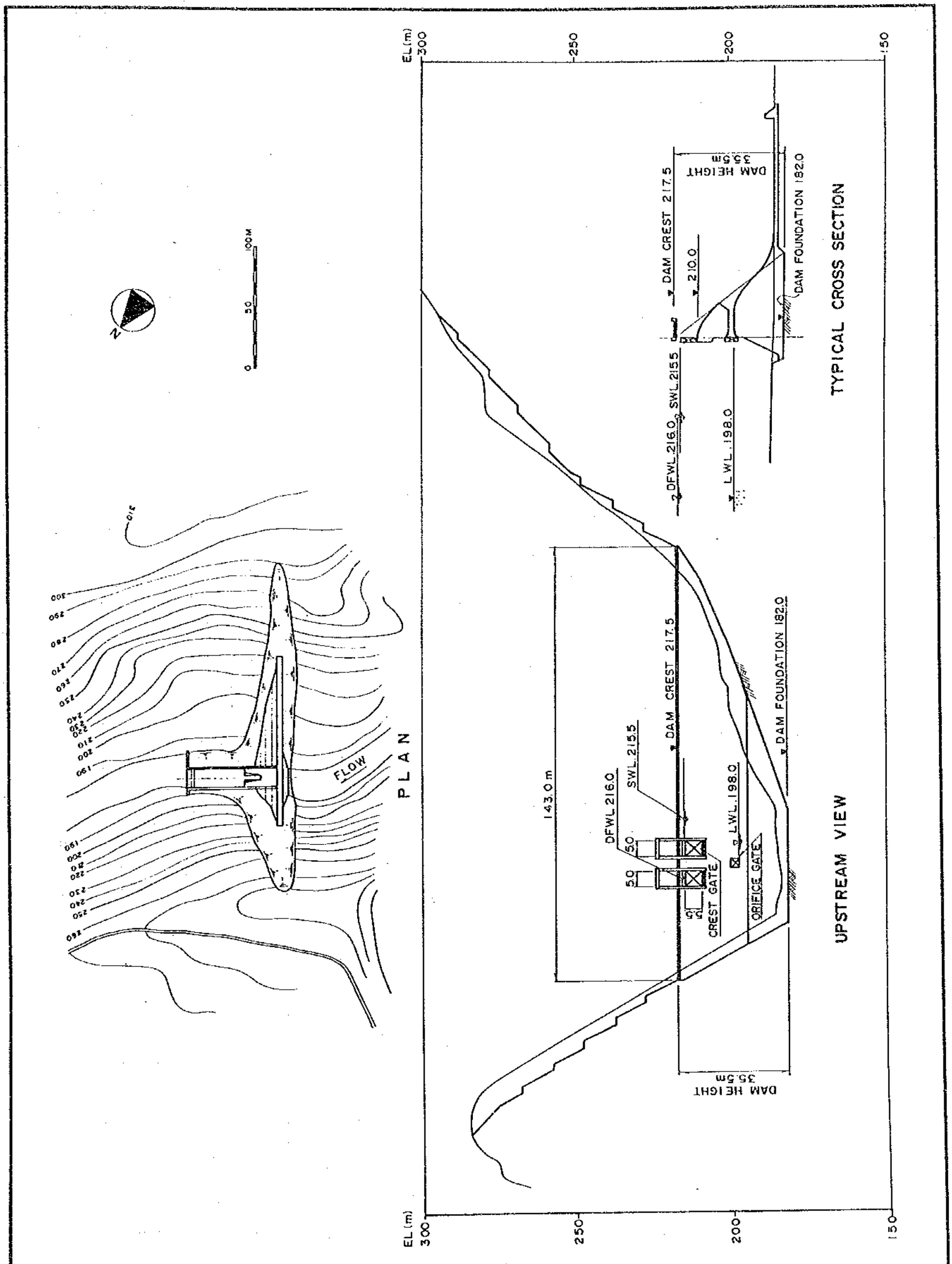
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

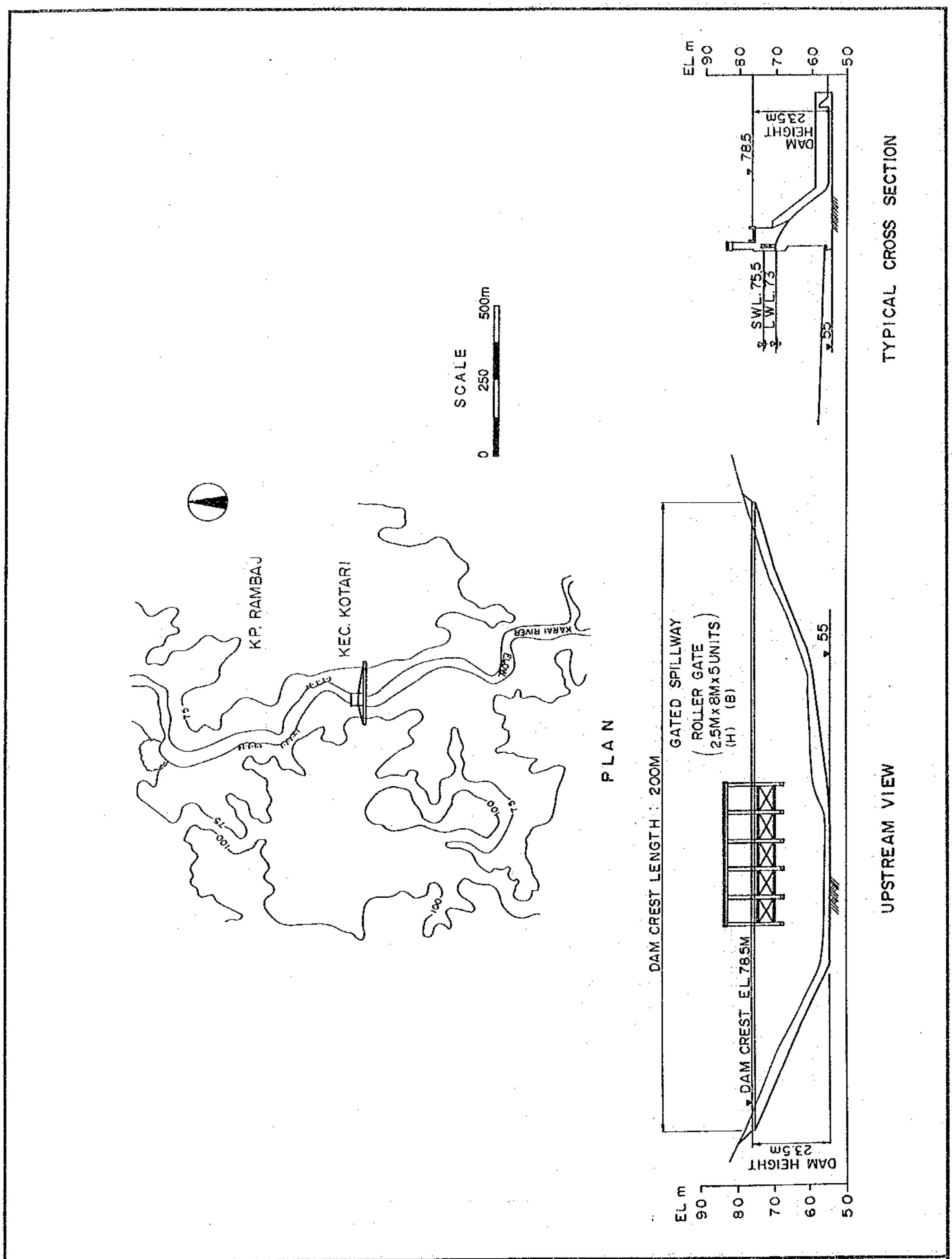
FLOOD REGULATION METHOD AND REQUIRED FLOOD CONTROL CAPACITY OF FLOOD CONTROL DAMS Fig.4-1(3/3)



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	21 GENERAL DRAWING OF NAMOBATANG FLOOD CONTROL DAM
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.4-2



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	GENERAL DRAWING OF LAUSIMEME FLOOD CONTROL DAM
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.4-3



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

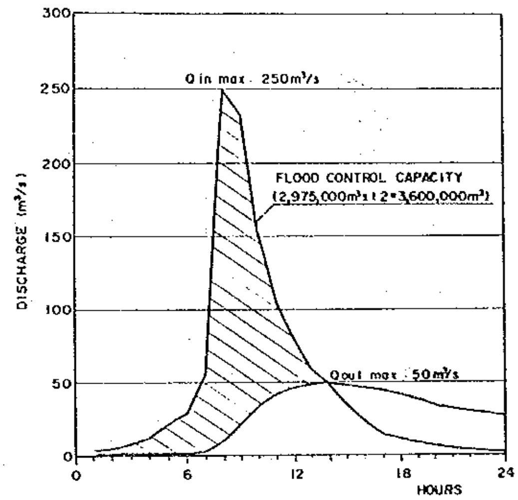
JAPAN INTERNATIONAL COOPERATION AGENCY

GENERAL DRAWING OF KARAI FLOOD CONTROL DAM

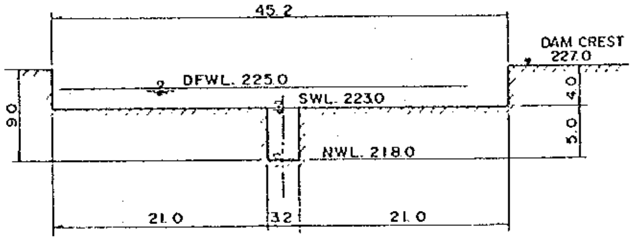
Fig.4-4

UNIT : m

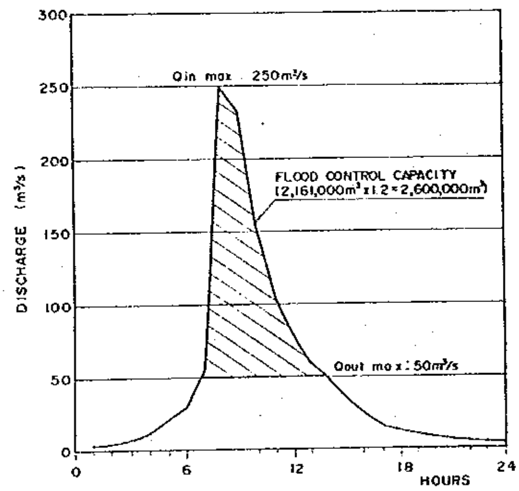
FLOOD REGULATION BY NON-GATED SPILLWAY



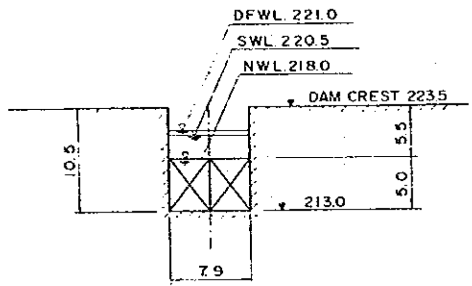
NON-GATED SPILLWAY



FLOOD REGULATION BY GATED SPILLWAY



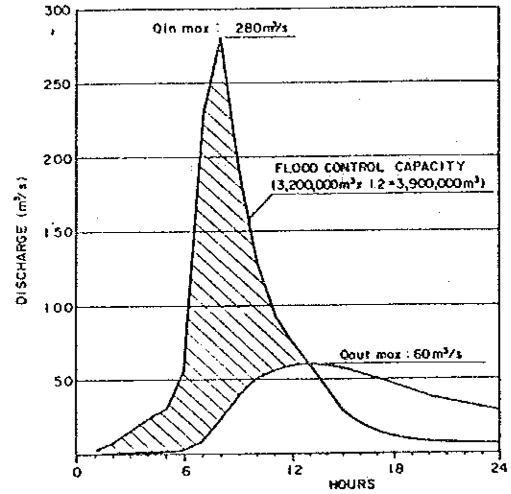
GATED SPILLWAY



NAMOBATANG MULTIPURPOSE DAM

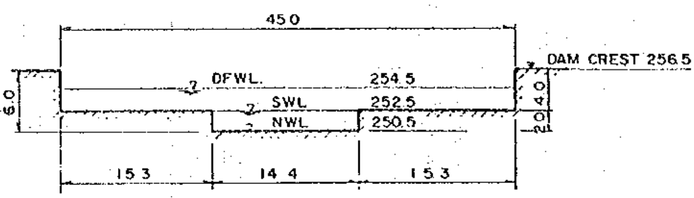
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	FLOOD REGULATION METHOD AND REQUIRED FLOOD CONTROL CAPACITY OF MULTIPURPOSE DAMS Fig.4-5(1/2)

FLOOD REGULATION BY NON-GATED SPILLWAY

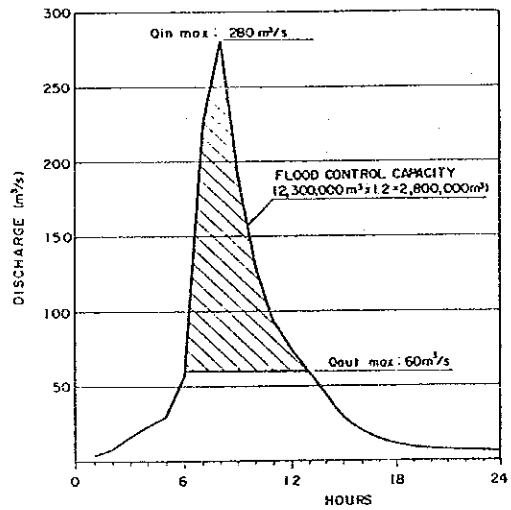


NON-GATED SPILLWAY

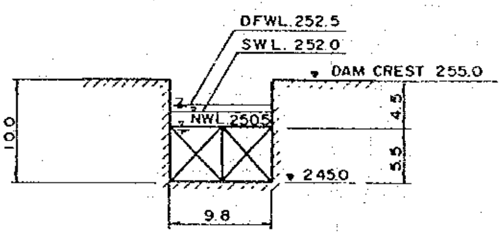
UNIT : m



FLOOD REGULATION BY GATED SPILLWAY

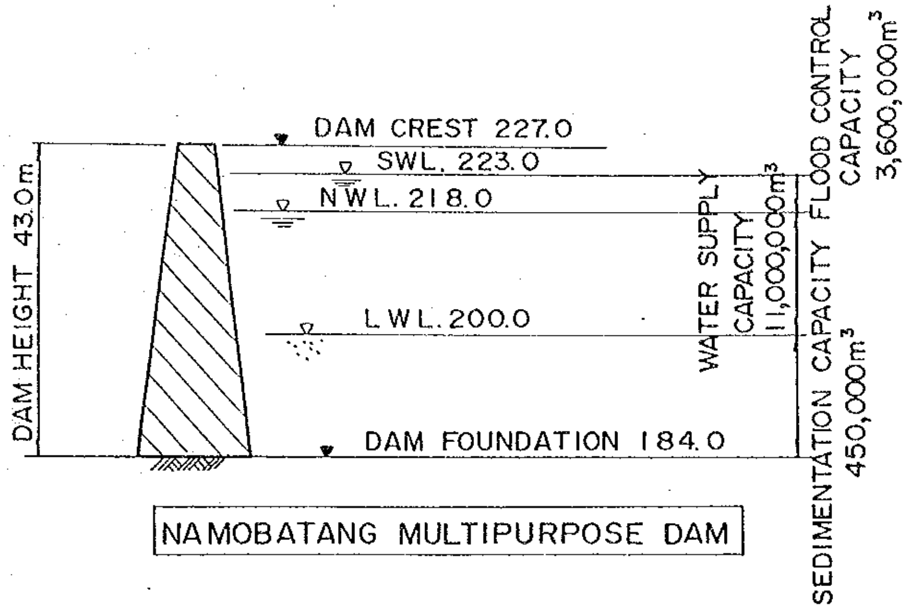


FULL-GATED SPILLWAY

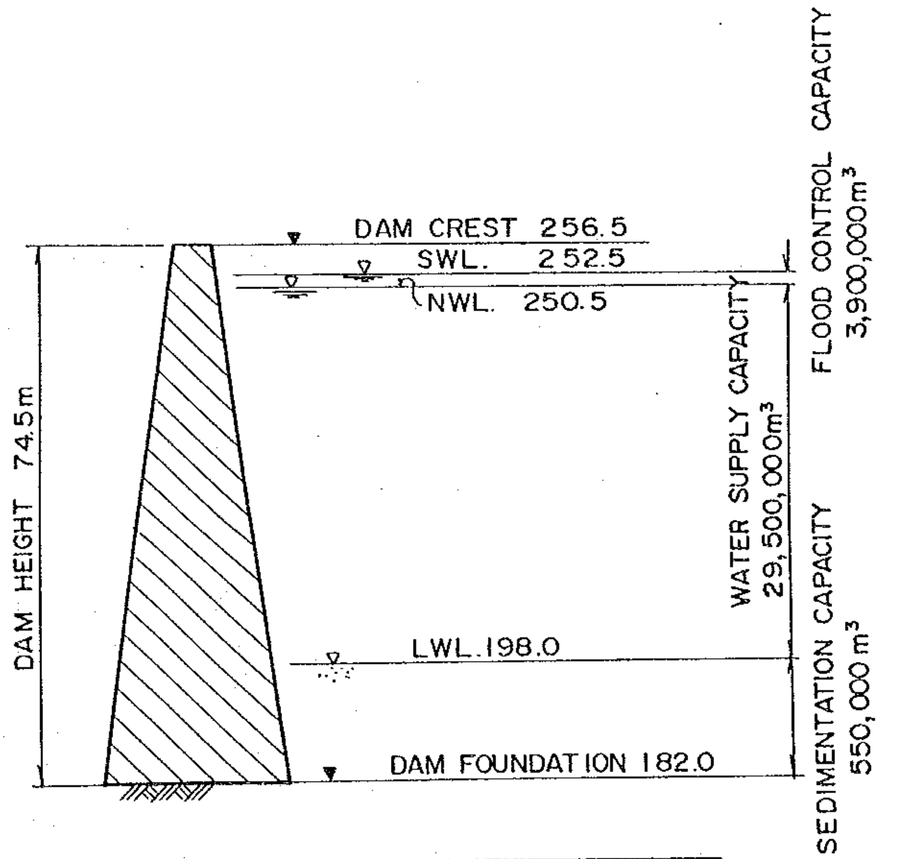


LAUSIMEME MULTIPURPOSE DAM

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	FLOOD REGULATION METHOD AND REQUIRED FLOOD CONTROL CAPACITY OF MULTIPURPOSE DAMS Fig.4-5(2/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	

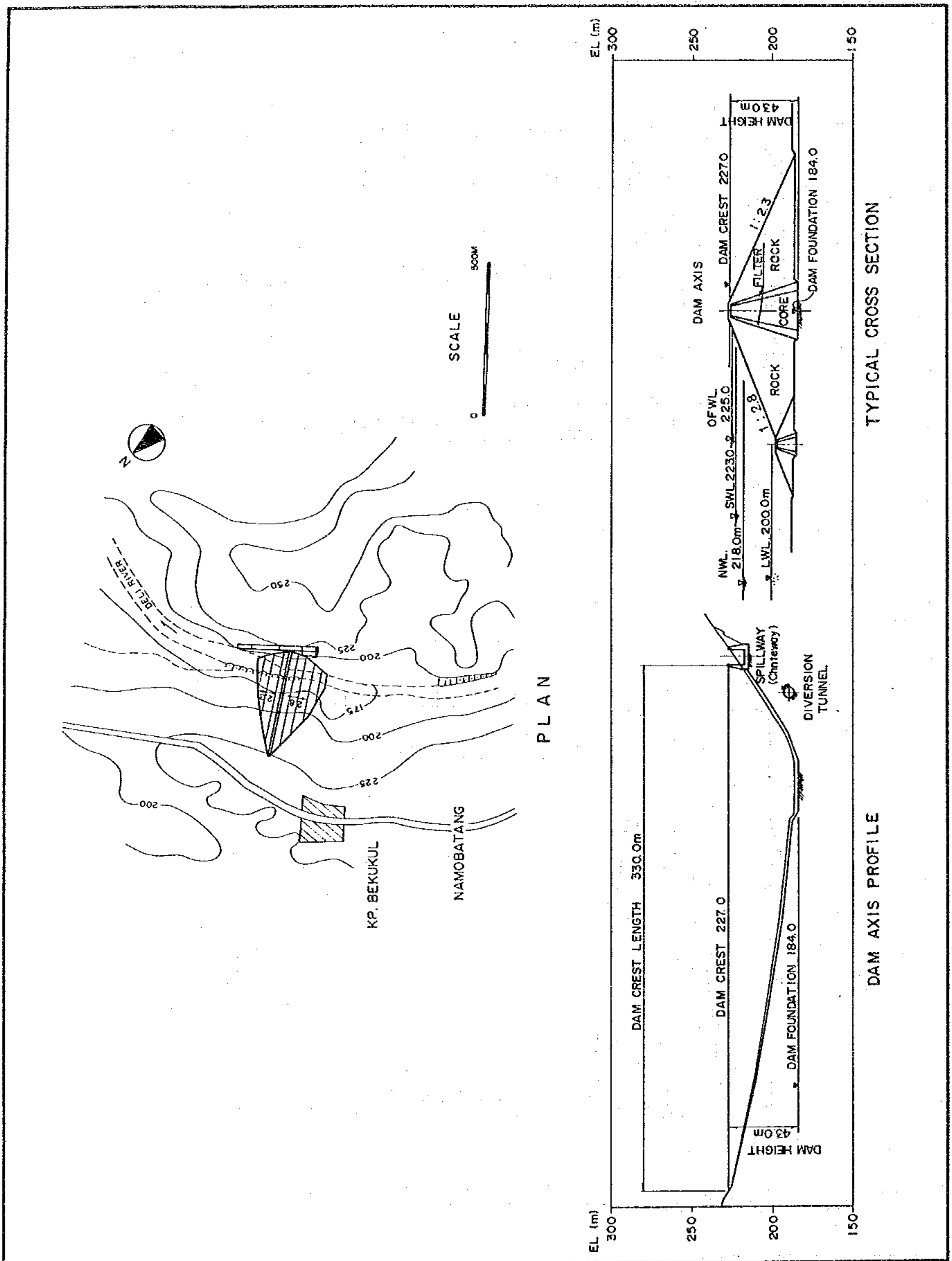


NAMOBATANG MULTIPURPOSE DAM

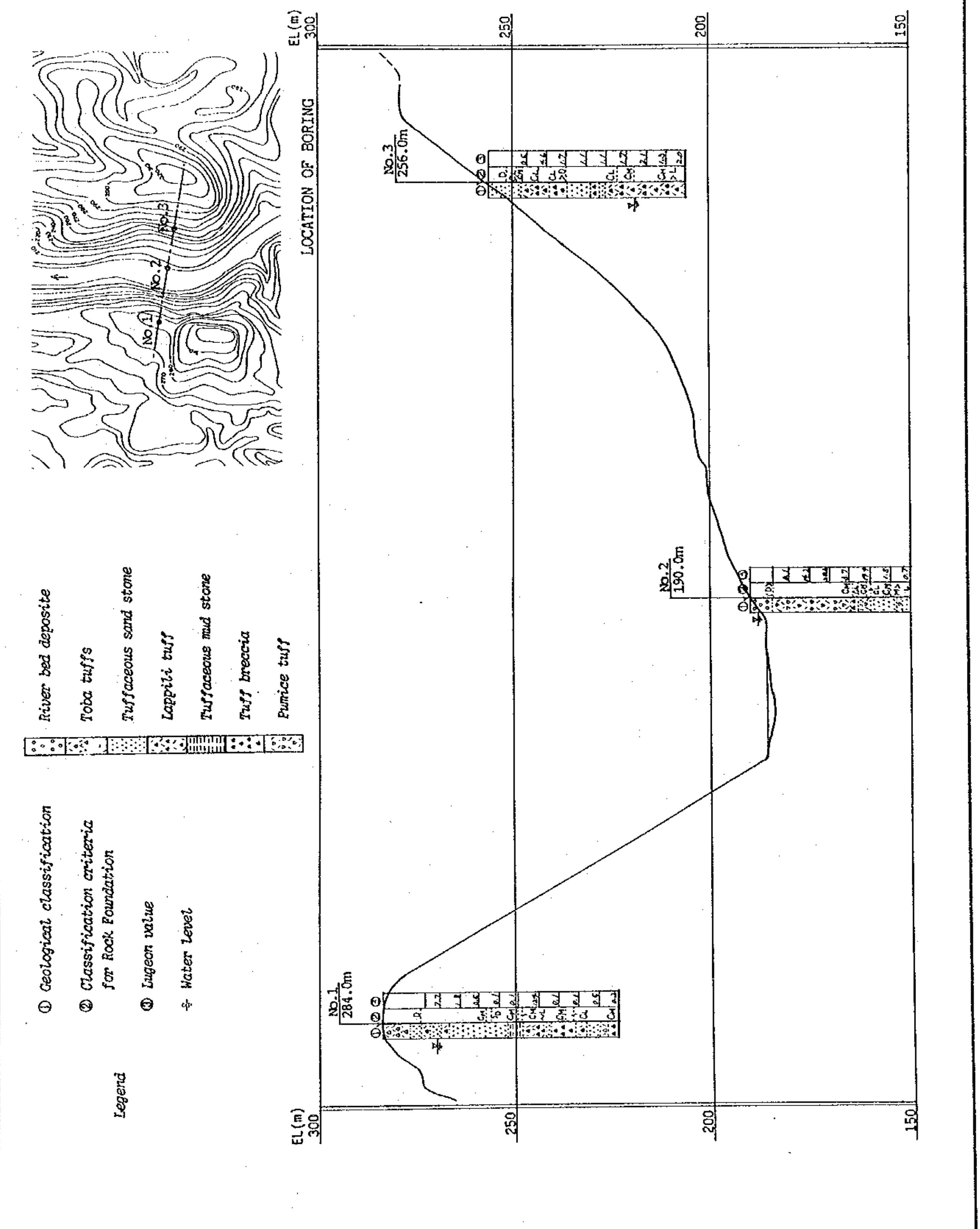


LAUSIMEME MULTIPURPOSE DAM

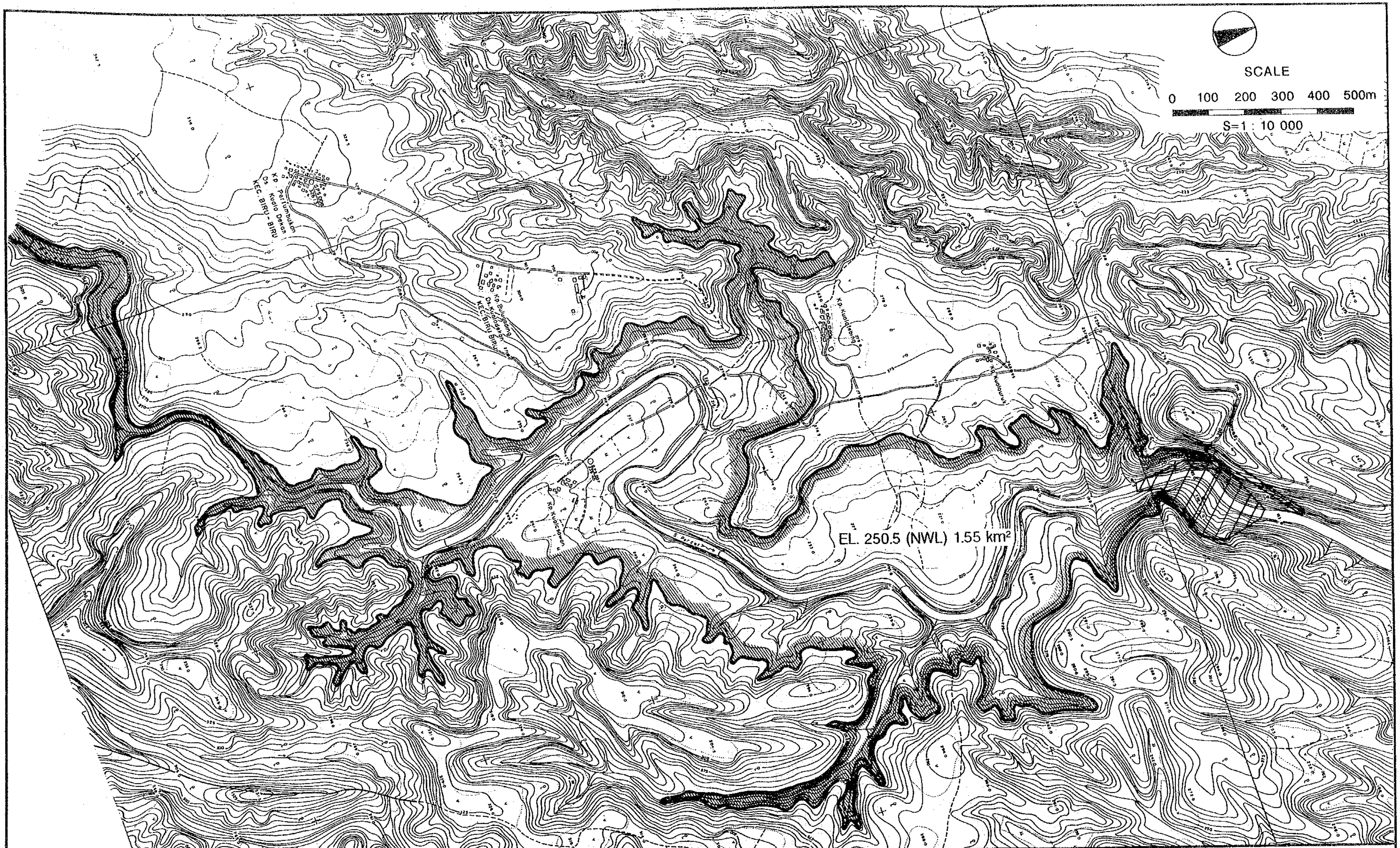
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA / JAPAN INTERNATIONAL COOPERATION AGENCY	RESERVOIR CAPACITY ALLOCATION FOR MULTIPURPOSE DAMS Fig.4-6



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	GENERAL DRAWING OF NAMOBATANG MULTIPURPOSE DAM
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.4-7



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	GEOLOGICAL LONGITUDINAL PROFILE ALONG DAM AXIS AT LAUSIMEME DAM SITE
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.5-1



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

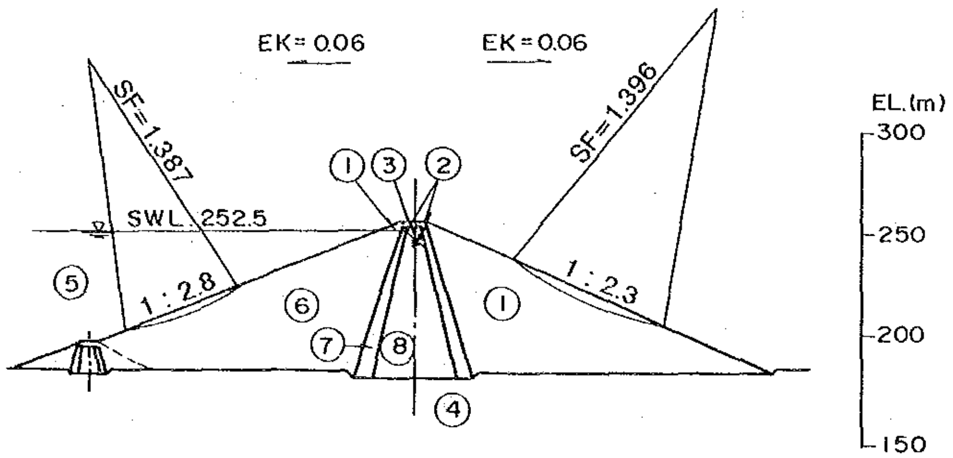
JAPAN INTERNATIONAL COOPERATION AGENCY

PROPOSED IMPOUNDING RESERVOIR AREA OF LAUSIMEME MULTIPURPOSE DAM

Fig.5-2

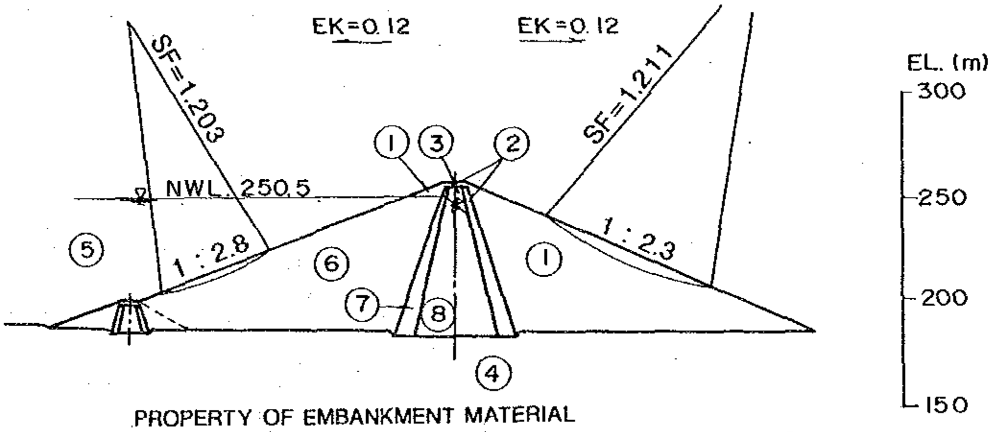
(1) CASE 1

SURCHARGE WATER LEVEL WITH EARTHQUAKE ACCELERATION (EK=0.06)



(2) CASE 2

NORMAL WATER LEVEL WITH EARTHQUAKE ACCELERATION (EK=0.12)



PROPERTY OF EMBANKMENT MATERIAL

	Unit Weight (t/m³)	Cohesion (t/m)	Angle (ø)	Material
①	1.9	0	35°	Rock
②	1.9	0	30°	Filter
③	1.8	1.5	20°	Core
④	2.0	0	30°	Foundation
⑤	1.0	0	0	Water
⑥	2.1	0	35°	Saturated Rock
⑦	2.1	0	30°	Saturated Filter
⑧	1.9	1.5	20°	Saturated Core

NOTE : EK : Seismic Coefficient

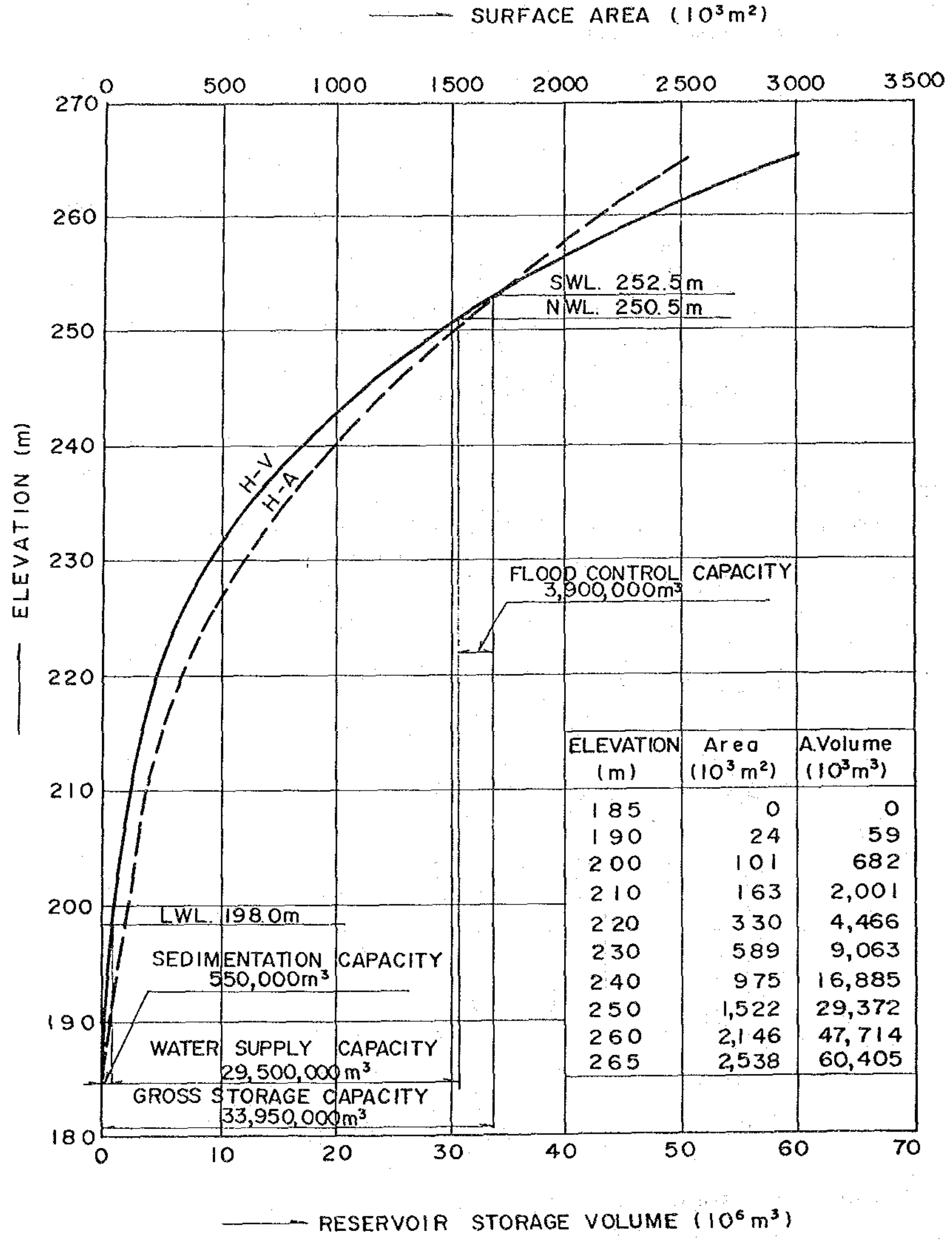
SF : Safety Factor

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

STABILITY ANALYSIS OF LAUSIMEME MULTIPURPOSE DAM

Fig.5-3



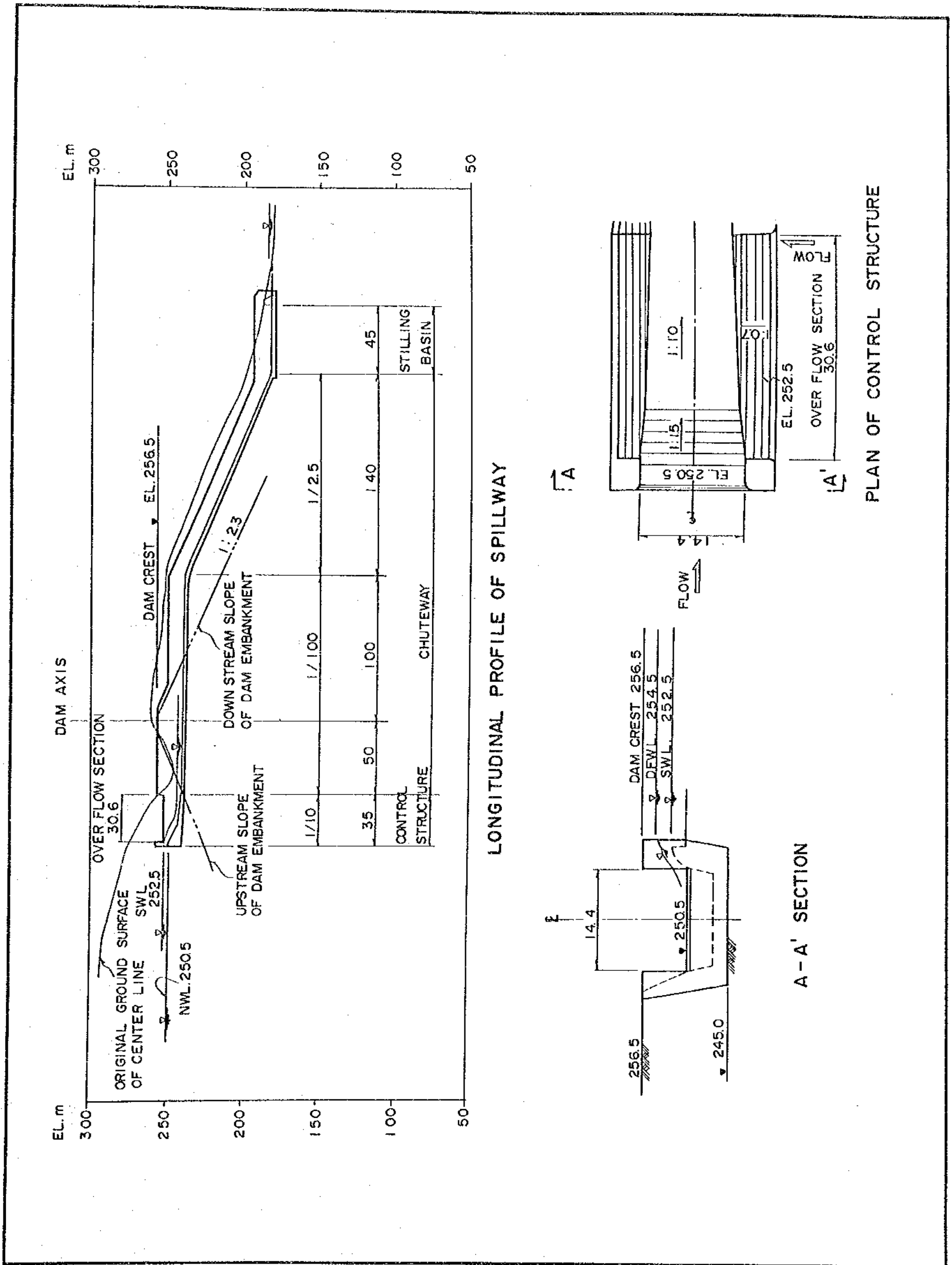
ELEVATION (m)	Area (10³ m²)	A.Volume (10³m³)
185	0	0
190	24	59
200	101	682
210	163	2,001
220	330	4,466
230	589	9,063
240	975	16,885
250	1,522	29,372
260	2,146	47,714
265	2,538	60,405

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

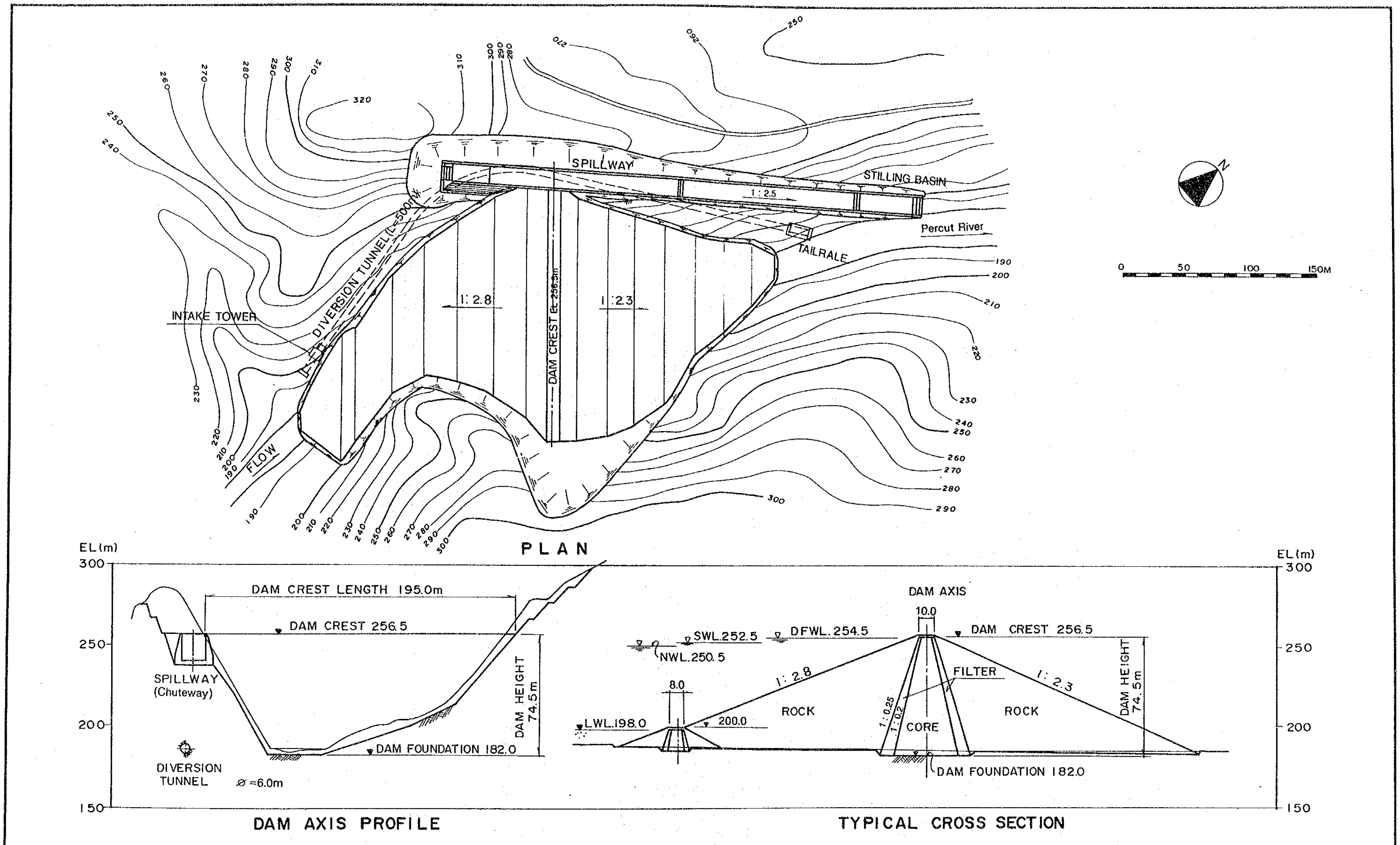
JAPAN INTERNATIONAL COOPERATION AGENCY

RESERVOIR STORAGE CAPACITY CURVE OF LAUSIMEME MULTIPURPOSE DAM

Fig.5-4



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	GENERAL DRAWING OF PROPOSED SPILLWAY Fig.5-5



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

GENERAL DRAWING OF LAUSIMEME MULTIPURPOSE DAM

Fig.5-6

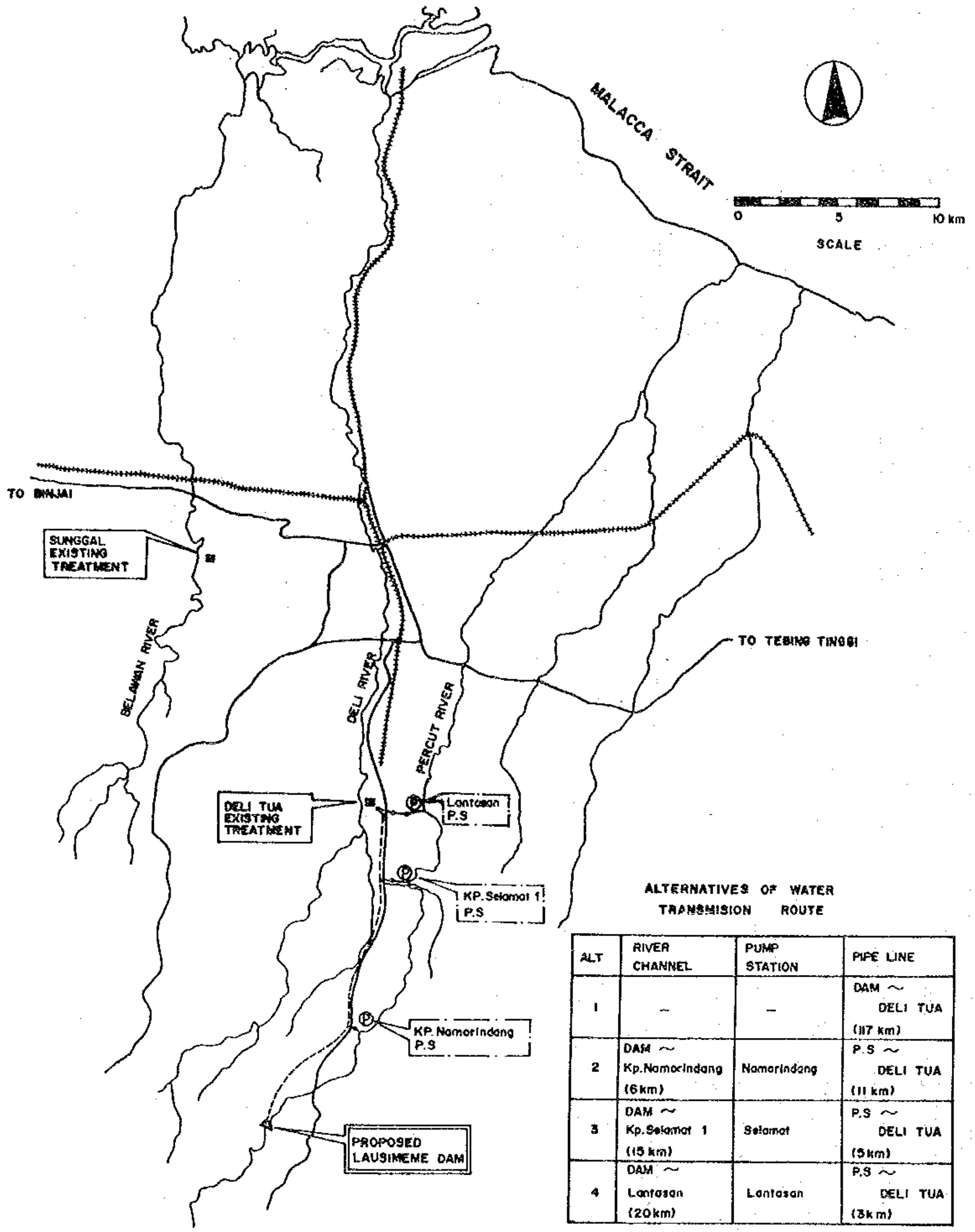
WORK ITEM	QUANTITY	UNIT	YEAR			
			IST	2ND	3RD	4TH
1. PREPARATORY WORKS	L/S	-				
2. CIVIL WORKS						
2.1 Excavation	150,000	m3				
2.2 Foundation Treatment (Grouting)	6,000	m				
2.3 Embankment	1,750,000	m3				
2.4 Concrete Works	20,000	m3				
2.5 Diversion Tunnel (Dia. 6 m)	500	m				
2.6 Relocation Road	2,500	m				
2.7 Building Works	L/S	-				

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT
IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

CONSTRUCTION SCHEDULE OF LAUSIMEME
MULTIPURPOSE DAM

Fig.5-7



ALTERNATIVES OF WATER TRANSMISION ROUTE

ALT	RIVER CHANNEL	PUMP STATION	PIPE LINE
1	–	–	DAM ~ DELI TUA (17 km)
2	DAM ~ Kp.Namorindang (6 km)	Namorindang	P.S ~ DELI TUA (11 km)
3	DAM ~ Kp.Selamat 1 (15 km)	Selamat	P.S ~ DELI TUA (5 km)
4	DAM ~ Lantasan (20 km)	Lantasan	P.S ~ DELI TUA (3 km)

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

ALTERNATIVES OF DAM WATER TRANSMISSION ROUTE

Fig.6-1

RI

RIVER IMPROVEMENT

STUDY ON BELAWAN-PADANG
INTEGRATED RIVER BASIN DEVELOPMENT

SUPPORTING REPORT

RIVER IMPROVEMENT

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SUPPORTING REPORT

RIVER IMPROVEMENT

1. INTRODUCTION

The main study objectives for the river improvement plan are the following:

(a) To know the existing condition of river channels through field investigation, data collection and non-uniform flow calculation;

(b) To propose the master plan of river improvement;

(c) To propose the optimum river improvement plan for the selected urgent project through comparative study on alternatives;

(d) To formulate the construction plans of the proposed river improvement works; and

(d) To estimate the construction costs of the proposed river improvement works of the master plan and the urgent project.

2. EXISTING CONDITIONS OF RIVER CHANNEL

2.1 Existing River Channel

The lower and middle stretches of each river have been mainly provided with dikes (refer to Fig. 2-1). However, the dikes of these rivers are not adequate to ensure safety against floods, except Ular River which had an extensive river improvement works. River sections are mostly excavated channels with single cross-sections of 20 to 50 m wide, while compound cross sections are seen along the downstream stretches of Percut, Serdang, Ular, Belutu and Padang rivers. The river channels have no bank protection works such as revetment and/or groin even near river bridges or intake structures. Therefore, the rivers are still left in poor condition against scouring and seepage.

The longitudinal gradient of all rivers in flat lands is 1/1,000 or smaller, especially small (1/3,000 to 1/5,000) in the lower reaches of the Belutu and Padang rivers.

The main river structures are bridges. As many as 50 bridges have been constructed across Deli and Percut rivers which flow through Medan City, while there are a few on the other rivers.

Major road bridges crossing the river channels have been constructed at higher elevation than surrounding grounds. However, a bridge abutment juts out into a river channel and thus decreasing the river width, forming a bottleneck. Consequently, the flow capacity of these sections is much reduced compared with those of other sections upstream or downstream. In addition, since the intake weirs on the lower stretches of Percut, Serdang and Padang rivers are fixed ones with a high crest, they also reduce the flow capacity of the rivers due to backwater effect.

2.2 River Improvement Works

All rivers considerably meander except in the river sections where some improvement works were undertaken. River improvement works were mainly earth dikes with little channel excavation and bank protection.

River improvement works in the study area have been executed mostly by the DPUP. Improvement works on the Deli River including other flood control works for Medan City started in 1990 under MUDP II. (Refer to the Supporting Report on Flood Control Plan.)

2.3 Flow Capacity

Flow capacity is estimated for the six (6) rivers except Ular River of which river improvement works have been completed with a design discharge of 800 m^3/s.

The estimated water levels by non-uniform flow calculation are shown in Fig. 2-2 and the flow capacities corresponding to the lower height of the left and right banks (minus a desired freeboard for diked sections) are presented in Fig. 2-3. The following are the summaries of the flow capacities of the existing channels.

(1) Belawan River

Belawan River has a comparatively large capacity of some 300 m^3/s along all stretches, although a short stretch with a flow capacity of less than 200 m^3/s exists 15 km upstream of the river mouth. The upper stretch from the national road has a flow capacity of more than 400 m^3/s which corresponds to almost a 10-year flood discharge.

(2) Deli River

The middle and upstream stretches, for which river improvement works have not been executed yet, suffer from a low flow capacity of 50 to 200 m^3/s.

The lowest stretch from the river mouth to Labuhan Deli Bridge (DE.5), in which river improvement of dredging and embankment has been reportedly completed with a design flood discharge of 455 m^3/s, has a lesser flow capacity of 350 to 450 m^3/s. A comparatively large flow capacity greater than a 10-year flood discharge is expected from the deep valley-shaped channel upstream of DE.33.

(3) Percut River

The undiked section of about 3.0 km from the river mouth has a relatively small flow capacity of about 50 m^3/s. The upper diked 11 km long stretch has a flow capacity of 100 to 150 m^3/s. The remaining further upstream stretch has a deep excavated channel of which flow capacity ranges from 150 to 350 m^3/s.

(4) Serdang River

The undiked section of about 2.0 km from the river mouth has a small capacity of 50 m^3/s. The upstream stretch to the confluence with Batugingging River has a flow capacity of 150 to 250 m^3/s. Belumai River has a greater flow capacity of 100 to 800 m^3/s and the flow capacity of the other tributary, Batugingging River, is calculated to be as small as 10 m^3/s.

(5) Belutu River

The river has an earth dike on the left side. It is shallow at only about 1.0 m deep, and the riverbed gradient is as small as 1:5,000. The flow capacity is less than 100 m^3/s for most stretches.

(6) Padang River

Padang River also suffers from low flow capacity. The lower stretches from the national road (PA.24) form a diked compound cross section with a channel width of 150 to 350 m, but their flow capacities are less than 200 m^3/s because of their shallow channels and gentle riverbed gradient. Some sections near the river mouth have a low flow capacity of less than 50 m^3/s.

The upper stretch from the road with a single cross section has a flow capacity of about 200 m^3/s.

3. PROPOSED RIVER IMPROVEMENT PLAN

3.1 Design Criteria

The river improvement and floodway plan in this study is prepared according to the Japanese criteria entitled "Manual for River Works in Japan (Draft)" prepared by the Ministry of Construction of Japan. The following are the planning conditions applied for the river improvement and floodway.

(1) Alignment

Alignment of the river course is designed to have less meandering and to require less land acquisition and house evacuation. The existing river course with some meandering is, however, maintained and widened in case the channel is stable and deep. For the river section with sufficient width, the width is maintained in consideration of the retarding effect.

(2) High Water Level

The design high water level is set at the same level as the ground elevation or the existing dike. The height of embankment would be generally set within about 3.0 m, to minimize damage potential.

Flood water level is determined by hydraulic calculation. With regard to Manning's roughness coefficient for non-uniform calculation, 0.035 is generally applied except improved stretches with a single cross section where a value of 0.030 is applied.

The mean high water spring recorded at the Belawan Port is adopted as the estuary tidal level which means a starting water level of non-uniform flow calculation, as presented in Fig. 3-1.

(3) Riverbed Profile

The design riverbed profile principally follows the existing average riverbed profile to avoid imbalanced scouring and sedimentation and to minimize relocation and modification of the existing river structures. The ratio of riverbed gradient between the upper and lower stretches is basically set at less than 1:2 to assure stability of the river channel.

(4) Cross Section

A wide and compound cross section with high and low water channels is principally employed to minimize the embankment height and to assure channel stability. A single cross section is, however, employed for river stretches located in residential/urban areas. The side slope of cross sections is set at 1:2 in general.

(5) Dike

The standard design sections of river dike corresponding to the design flood discharge and dike heights are shown in Fig. 3-2. Earth embankment is adopted in principle, although there are some restrictions on land acquisition for constructing earth dikes.

A freeboard which is the margin of height maintained between the top of the dike and the design high water level to prevent overtopping and wave wash, is provided, as shown in Fig. 3-2.

A crown width of dike should be adequate to serve as a road for facilitating transportation of materials during construction, operation and maintenance stages and to prevent seepage corresponding to the design flood discharge from the river.

A side slope on both landside and riverside of dikes is designed as 1:2 in general. Berms are provided along slopes of a high dike as an erosion prevention measure and also to improve stability of the side slopes. The width of the berms is not less than 3 m. The slopes are protected with sodding, as shown in Fig. 3-3.

In order to minimize land acquisition and house evacuation, a concrete parapet wall is employed as a backwater dike for tributaries in densely populated urban areas. The standard drawing is shown in Fig. 3-3.

(6) Revetment

In case that a bank slope is required to be steeper than 1:2, a revetment of wet masonry is provided for stability of the bank and protection against water flow, as shown in Fig. 3-3. The slope is designed at 1:1.5.

A revetment is also necessary to protect the earth dike to be provided in a remarkably curved stretch where turbulent flood water flow is expected to affect the dike.

If the length of revetment in bank slope direction is longer than 10.0 m, a berm with a width of not less than 1.0 m is provided on the slope.

(7) Inspection Road

An area with a width of 3.0 m from the bank shoulder is acquired as an inspection road. The area is not only for transportation of materials during construction and maintenance works but also for flood fighting activities.

An inspection road is not required where a dike is provided because the dike crown could serve as an inspection road.

(8) Other Major Structures

(a) Bridges

Bridges which have a length not enough for the design river width and/or a beam height with an inadequate clearance from the design high water level are principally reconstructed.

(b) Water Intake Facility

Modification of existing intake facilities are considered when necessary.

(c) Drainage Facility

Sluices/water gates are proposed at junctions of drainage channels to a river, which will have a new dike.

Drainage pipes are installed in new dikes and channel banks to ensure drainage of surrounding urban areas.

3.2 Master Plan

Project Scale

The project scale for the master plan is set up to be a 50-year return period for five (5) rivers, namely Belawan, Serdang, Ular, Belutu and Padang. For the Deli-Percut River System in which the two rivers are connected by a floodway, the project scale of a 100-year return period is applied in consideration that the rivers pass through the highly populated and developed areas of Medan City.

Features of River Improvement

The proposed alignments and typical cross sections of the seven (7) rivers are as shown in Fig. 3-4, and the proposed longitudinal profiles are also given in Fig. 3-5. The work quantity and construction cost is summarized in Table 5-6.

(1) Belawan River

The proposed dike is aligned to envelop meandering sections. Therefore, the proposed cross sections are generally compound types. A single cross section is employed for a deep channel portion in the middle stretches.

(2) Deli and Percut Rivers

Due to the difficulty of land acquisition, a single cross section is employed for the proposed improvement stretch of Deli River. For the Percut River, a compound cross section is applied from the river mouth to Bandar Setia (PE.11) and a single cross section is for the upper stretch. The construction of floodway from the Deli River to the Percut River is identified to be possible on account of the topographic condition and land use along and around the said two (2) rivers. The possible route is selected in the upstream area of Medan City as plotted in Fig. 3.4.

(3) Serdang River

A compound cross section is employed for the mainstream of Serdang River and a tributary, Batugingging River. Belumai River, another tributary, is proposed to be a single cross section since the existing river channel is steep and deep.

(4) Ular River

Widening of low flow channel is the only practical means to increase flow capacity of the improved channel.

(5) Belutu River

The proposed dike is aligned to envelop meandering sections for the lowest stretch from the river mouth to Tanjung Bringin (BE.9). Therefore, a compound cross section is applied to this stretch and the upstream stretch from the confluence with the Rambung River.

(6) Padang River

A compound cross section is employed for the lower stretches from the national road (PA.24) where land use is mainly of paddy and plantation fields. For the upper stretches a single cross section is employed to minimize land acquisition and house evacuation in Tebing Tinggi City.

3.3 Urgent Project

Project Scale

Through the priorities and implementation schedule, the high priority and urgent flood control projects are selected as follows:

Urgent Flood Control Projects

Project Area	Project Scale
Deli-Percut River	30-year return period
Padang River	10-year return period

The project scale is proposed at a 30-year return period for the Deli-Percut River, and at a 10-year return period for Padang River from the social and economical viewpoints.

Project Formulation

The urgent project consists of river improvement for Deli and Percut rivers, and construction of Medan Floodway and Lausimeme Dam in the Deli-Percut River System. The target stretches for river improvement are set from the river mouth to Titi Kuning for Deli River and from the river mouth to Medan Floodway for Percut River. The improvement lengths are 37.4 km for the Deli River and 28.0 km for Percut River, while Medan Floodway is 3.8 km long.

The design flood discharges of the urgent project (30-year return period) are almost equivalent to those of the Master Plan (100-year return period) for the proposed target stretches. Therefore, it is economically advantageous to implement the improvement works with the design flood discharge for the Master Plan even under the urgent project stage.

The urgent project for Padang River is only the river improvement works. The target stretch with a length of 29.5 km is set from the river mouth to the confluence point with Sibarau River. The design discharge for the stretch is 630 m^3/s.

The urgent project is summarized as follows:

(1) Deli River Improvement

Target Stretch	Distance	Design Discharge
River Mouth to Sikambing River	22.9 km	460 m^3/s
Sikambing River to Babura River	5.3 km	400 m^3/s
Babura River to Titi Kuning	9.2 km	200 m^3/s

(2) Percut River Improvement

Length of 28.0 km with the design discharge of 350 m^3/s

(3) Floodway

Length of 3.8 km (Titi Kuning to Tembakau) with the design discharge of 120 m^3/s

(4) Padang River Improvement

Length of 29.5 km with the design discharge of 620 m^3/s

<u>Features of Proposed River Improvement</u>

The river improvement plan for the urgent project is formulated on the basis of the design criteria presented in Section 3.1. The major work quantities are summarized as follows:

Work Quantities of Urgent River Improvement

Item	Deli River	Percut River	Padang River	Medan River
1. Target Stretch (km)	37.4	28.0	29.5	3.8
2. River Width (m)	30-80	30-80	80-100*	30-60
3. New Dike (km)	46.6	20.0	29.5	0.7
4. Rehabilitation of Existing Dike (km)	16.0	25.6	26.2	0
5. Revetment (km)***	44.3	1.3	2.2	8.3
6. Bridge (unit)	19	13	6	7
7. Gate/Sluiceway	5	4	4	0
8. Drain Pipe (pc.)	97	56	14	0
9. Weir	0	1	1	2
10. Land Acquisition (ha)	46	131	128	78
11. House Evacuation (unit)	762	409	252	122

* Single Cross Section
** Compound Cross Section
*** Revetment for bridge is included.

The work quantity and construction cost for the urgent project is summarized in Table 5-8. The details for each river and the floodway are as follows.

(1) Deli River

(a) Alignment

Land acquisition for river improvement has been attained by the PPS.SU in the downstream stretches from the confluence with Sikambing River (DE.20). To minimize further land acquisition, the alignment is designed along the acquired area, where the PPS.SU has planned two (2) cut-off channels with a length of 355 m and 1,350 m which will shorten the river channel by 90 m and 590 m, respectively.

In the lower stretch from the tollway (DE.0) to DE.4 where river improvement of embankment and dredging has been reportedly completed with a design discharge of 455 m^3/s, the existing left dike is to be set back by 5.0 m because a deficiency of flow capacity has been identified in the study.

In principle, the proposed alignment follows the existing one also in the upper stretches except that two (2) cut-off channels is proposed to be employed in the upstream stretch from the confluence with Babura River. The two cut-off channels will shorten the existing river channel by 360 and 590 m as follows:

Cut-Off Channel

No.	Stretch	Channel Length (m)	
		Existing	Cut-Off
1.	DE.27+350 to DE.27+930	530	220
2.	DE.29+30 to DE.29+760	730	140

The proposed alignment and longitudinal profile are presented in Figs. 3-6 and 3-7.

(b) Cross Section

A single cross section is employed for all the stretches to minimize house evacuation and land acquisition. A side slope of 1:2 is employed in principle, except along the stretches from Titi Papan Bridge (DE.11) to H. Juanda Bridge (DE.30). Along the 19 km long middle stretches in the densely populated residential and industrial areas, a side slope of 1:1.5 is employed together with a revetment of wet masonry. A revetment is also made in the conspicuously curved stretches in the lower stretches below Titi Papan Bridge.

(c) Tributaries

To cope with backwater effects from Deli River, a parapet concrete wall is constructed on the banks of the major tributaries, Sikambing and Babura rivers. The length of the backwater stretch is 2,400 m for Sikambing River and 100 m for Babura River.

(2) Percut River

(a) Alignment

The proposed alignment is designed to follow the existing one, and no cut-off channel is applied.

The proposed alignment and longitudinal profile are presented in Figs. 3-8 and 3-9.

(b) Cross Section

A compound cross section is employed in the lower stretch from the river mouth to Bandar Setia (PE.11) where surrounding areas are used mainly as paddy, plantation or open space. A new dike is provided near the river mouth and partially narrow sections are widened by setting back the existing dikes.

The upper channel from Bandar Setia forms a narrow deep valley. For this stretch up to Medan Floodway (PE.28), a single cross section is employed with some widening of channel, because the surrounding areas have been newly urbanized in the expansion of Medan City.

For the whole 28.0 km stretch from the river mouth to Medan Floodway, a side slope of 1:2 is employed. Since the existing steep side channel slope is comparatively stable even in the remarkably curved reaches, no revetment is provided except several short reaches near bridges and the floodway.

(c) Bandar Sidoras Intake Weir

The existing 4.0 m high fixed weir is reconstructed to a movable type weir made of rubber to assure the design flow capacity during floods. The drawing of the proposed movable weir is presented in Fig. 3-19.

(d) Pavement

A 1,970 m stretch of the paved road which runs on the left riverside for a small fishing port near the rivermouth will be buried in the proposed new dike from PE.2 to PE.4. In order to compensate it, pavement shall be employed on the landside foot of the new dike.

(3) Padang River

(a) Alignment

The proposed alignment is generally designed to follow the existing one. The uppermost stretch of the confluence with Sibarau River forms a conspicuous meander and is to be short-cut by 750 m with a 200 m cut-off channel.

To avoid a high design flood water level, widening of channel and setting back of dike are applied. The existing dikes, mostly the left dikes which are comparatively wider and higher, is proposed to be strengthened and heightened to minimize the construction cost of setting back of dike. Therefore, the setting back of dike will be made by widening the river width towards the right bank side.

The proposed alignment and longitudinal profile are presented in Figs. 3-10 and 3-11.

(b) Cross Section

A compound cross section is applied for the lower stretches from the river mouth to the national road (PA.24) and a single cross section is from PA.24 to Sibarau River (PA.30). Channel side slope is set at 1:2 for the whole improvement stretch, and revetment is proposed for the remarkably curved reaches in the urban area of Tebing Tinggi City and the new cut-off channel.

(c) Tributary

The right tributary, Bahilang River (PA.26) is flowing in the low urban area of Tebing Tinggi City and suffers from inundation due to backwater from Padang River. To cope with backwater, a parapet concrete wall is provided on the banks of the 600 m long stretch of Bahilang River.

(d) Paya Lombang Intake Weir

The existing 3.0 m high fixed weir is reconstructed to a movable rubber weir like the Bandar Sidoras Intake Weir of Percut River. The drawing is given in Fig. 3-20.

(4) Medan Floodway

(a) Alignment

The economical route, Titi Kuning to Tembakau which requires less house evacuation is identified as shown in Fig. 3-12. The floodway length is about 3.8 km and about 100 houses are to be evacuated. The longitudinal profile is given in Fig. 3-13.

(b) Cross Section

A side slope of 1:1.5 is employed for all the stretches together with a revetment of wet masonry. The typical cross section is presented in Fig. 3-14.

(c) Diversion Works

Two (2) fixed weirs are proposed as a diversion structure in Deli River channel and at the inlet of the floodway, to secure the design diversion in which about 40% of a 30-year return period flood (320 m^3/s) in the upstream of Deli River is diverted into the floodway. An orifice is provided in the weir of Deli River to guarantee maintenance flow to the downstream in ordinary time.

The drawing of the proposed diversion structure is presented in Fig. 3-15 and the rating curves are given in Fig. 3-16.

(d) Inundation Area

The upper stretch will be affected by backwater from the diversion structures. The design inundation area is identified on the basis of non-uniform calculation as shown in Fig. 3-17, and summarized as follows:

Design Inundation Area

Item	Quantity
1. Affected Length (km)	3.2
2. Inundation Area (ha)	58.0
- Plantation (Palm Oil)	3.1
- Agricultural Area	4.5
- Open Space	50.4
3. House Evacuation (unit)	25.0

(5) Related Structures

(a) Revetment

A total 690,000 m^2 of wet masonry is to be provided as revetment of side slope protection for the proposed river improvement works. As foot protection of the revetment a total 95,000 m^2 of gabion mattress is provided to avoid scouring. The locations of the proposed revetment and foot protection are presented in Tables 3-1 and 3-2.

(b) Bridge

A total of 36 existing bridges are affected and to be reconstructed by the proposed river improvement works. In addition, 9 bridges are newly constructed across the new cut- off channels and floodway. The lists of the existing bridges and the bridges to be constructed for the urgent project are presented in Tables 3-3 and 3-4, and the standard drawings are given in Fig. 3-18.

(c) Weir

The two existing fixed weirs of Bandar Sidoras Intake of Percut River and Paya Lombang Intake of Padang River are proposed to be reconstructed into a new movable weir made of rubber. The drawings are presented in Figs. 3-19 and 3-20.

(d) Sluice and Drain Pipe

Sluices/water gates are proposed at junctions of drainage channels to the river, which will have new dike. They are designed so as to be operated manually with a small maintenance cost. Three (3) intake sluices along Padang River are relocated from the existing sites due to the widening of river channel and the construction of new dike. Other ten (10) sluices in the Deli and Percut rivers are proposed to be newly constructed to avoid spill-out river flood.

A total of 167 drain pipes shall be newly installed in the new dikes and channel banks to ensure drainage of the urban areas of Medan and Tebing Tinggi cities.

The list of the sluices/water gates and drain pipes to be constructed is presented in Table 3-5, and their standard drawings are given in Figs. 3-21, 3-22 and 3-23.

4. PRELIMINARY DESIGN

4.1 Alternative River Improvement Plan

Preliminary design of river improvement works is made in consideration of the most advantageous alternative.

Deli River

(1) Widening of Downstream Stretch

In the lowest stretch from the river mouth to Labuhan Deli Bridge (DE.5), river improvement of dredging and embankment has been completed with a design flood discharge of 455 m^3/s. According to the non-uniform flow calculation conducted in this study, however, the stretch upstream of the tollway (DE.0) still suffers from inadequate flow capacity of as low as 350 to 400 m^3/s. Hence, further improvement is required to confine the design flood discharge of 460 m^3/s.

According to the geological survey results, the soil condition is so bad that heightening of the existing dikes is very difficult. Therefore, widening or deepening of the existing channel are applied and the following two alternatives are considered as shown in Fig. 4-1:

Alternative Case 1: Setting back of the existing left dike by 5.0 m with a side slope of 1:2 and no revetment

Alternative Case 2: Excavation/dredging of channel applying a sheet pile revetment to keep the existing river width

Although Case 1 requires setting back of the existing dike which has been completed, it is economically more advantageous than Case 2; hence, it is proposed as the viable improvement plan. The construction costs of the two cases are presented in the following table and the breakdown is given in Table 4-1.

Construction Cost of Alternatives

Alternative	Description	Construction Cost* (in Mill. Rp.)
Case 1	Setting back of dike	6,234
Case 2	Existing river width	26,215

* Costs for Administration and Engineering Services are excluded.

(1) Cut-off Channel for Upstream Stretch

Conspicuous meanderings are observed in the middle and upstream stretches of Deli River. A meandering stretch is generally inferior in flow capacity and anticipated to cause unusual bank erosion resulting in breaching of dike. In addition, river improvement for a long meandering channel is costlier than a short- cut channel.

For the lower stretches from the confluence point with Sikambing River (PE.20), two (2) cut-off channels of 355 m and 1,350 m in length have been planned from DE.13 to DE.16 and land acquisition for the purpose has already been attained by the PPS.SU.

In the upper stretches from the confluence point where land acquisition has not been started yet, six (6) applicable cut-off channels are considered as shown in Fig. 4-2. The proposed longitudinal profiles for the plans following the existing channel and applying the six cut-off channels are shown in Fig. 4-3.

Among the six stretches of extreme meandering, two (2) stretches (DE-4 and DE-6) are proposed to be have a cut-off channel after a cost comparison between cut-off channel and improvement of the existing channel. The two cut-off channels shorten the existing ones by 360 m and 590 m, respectively. For the other four (4) stretches, widening of the existing channels is applied to reduce meandering. The breakdown of construction cost is given in Table 4-2, and summarized as follows:

Summary of Construction Cost

No.	Stretch	Existing Channel Length (m)	Existing Channel Const.Cost* (Mill. Rp.)	Cut-Off Channel Length (m)	Cut-Off Channel Const. Cost* (Mill. Rp.)
DE-1	DE.21+160 to DE.22+650	1,490	6,297	790	7,926
DE-2	DE.25+530 to DE.25+900	370	1,948	215	2,639
DE-3	DE.26+380 to DE.26+850	470	1,199	210	2,124
DE-4	DE.27+350 to DE.27+930	580	2,137	220	1,874
DE-5	DE.28+330 to DE.28+750	420	1,216	185	1,970
DE-6	DE.29+30 to DE.29+760	730	2,662	140	1,461

* Costs for Administration and Engineering Services are excluded.

Percut River

(1) Reconstruction of Bandar Sidoras Intake Weir

The existing 4.0 m high Bandar Sidoras Intake Weir which is located in the downstream of Percut River (PE.7) is an obstacle to water flow and may raise floodwater level to overtop the dikes. In order to confine the design flood within the proposed channel, the following two alternative works on the intake weir are considered:

Alternative Case 1: Widening of channel by setting back the existing dikes leaving the existing fixed weir untouched.

Alternative Case 2: Reconstruction of the existing weir into a movable rubber weir (Fig. 3-19).

The proposed rubber weir of Case 2 stands inflated in ordinary time to ensure the desired water level for water intake but automatically becomes deflated to prepare for a coming flood when the flood water exceeds a certain level. If the existing weir is left untouched, the upper 6.9 km stretch is affected by backwater due to the weir, and the existing dikes are to be set back by 100 m at the maximum. The proposed alignments and longitudinal profiles of the two cases are presented in Fig. 4-4 and Fig. 4-5.

The construction cost study shows that the new movable weir plan of Case 2 is more economical than Case 1. Therefore, Case 2 is adopted as an optimum plan. The breakdown of construction cost is presented in Table 4-3, and summarized as follows:

Summary of Construction Cost

Stretch	Item	Existing Fixed Weir Case 1	New Movable Weir Case 2
PE. 7 to PE.14+200	Construction Cost* (mill. Rp.)	12,328	8,987
	Land Acquisition (ha)	37.2	3.8
	House Evacuation (unit)	28	13

* Costs for Administration and Engineering Services are excluded.

(2) Cut-Off Channel of Upstream

The meandering stretch at the Amplus Bridge (PE.25) is worth subjecting to a cost comparison study concerning the cut-off channel plan and the improvement plan of the existing channel. The 840 m existing meandering channel can be shortened with the new 470 m cut-off channel by 370 m as shown in Fig. 4-6. The longitudinal profiles of the proposed two plans are given in Fig. 4-7.

According to the study results, the cut-off channel plan is about three times more costly than the river improvement plan of the existing channel. Therefore, the river improvement is proposed to follow the existing alignment, and remarkably curved sections are widened to ease turbulent flood water flow. The breakdown of construction cost is presented in Table 4-4, and summarized as follows:

Breakdown of Construction Cost

Stretch	Item	Existing Channel Case 1	Cut-Off Channel Case 2
PE.24+470 to PE.25+310	Channel Length (m)	840	470
	Construction Cost* (mill. Rp.)	1,216	3,510
	Land Acquisition (ha)	1.7	2.3
	House Evacuation (unit)	8	20

* Costs for Administration and Engineering Services are excluded.

Padang River

(1) Reconstruction of Paya Lombang Intake Weir

Like the Bandar Sidoras Intake Weir of Percut River, the existing 3.0 m high Paya Lombang Intake Weir is also an obstacle to flood water flow and causes sedimentation in the upper channel. Related to the intake weir, the following two (2) alternatives are considered to confine the design flood discharge within the proposed channel.

Alternative Case 1: Widening of channel by setting back of the existing dikes leaving the existing fixed weir untouched.

Alternative Case 2: Reconstruction of the weir into a movable rubber weir (Fig. 3-20).

The proposed rubber weir is automatically deflated to prepare for a rapid flood when the water level exceeds a certain level. If the existing fixed weir is left untouched, the 5.0 km upper stretch is affected by backwater and the existing channel are required to be widen by some 150 m in the densely populated and highly developed area of Tebing Tinggi City. The proposed alignments and longitudinal profiles of the two (2) cases are presented in Figs. 4-8 and 4-9.

The river improvement plan with the existing fixed weir of Case 1 is not only costlier but also requires more land acquisition and house evacuation than Case 2. Therefore, the reconstruction plan of the weir is proposed from the economical and social viewpoints.

Cost Comparison of Alternatives

Stretch	Item	Existing Fixed Weir Case 1	New Movable Weir Case 2
PA.23 to PA.29+500	Construction Cost* (mill. Rp.)	34,440	24,342
	Land Acquisition (ha)	91.9	26.9
	House Evacuation (unit)	225	121

* Costs for Administration and Engineering Services are excluded.

The breakdown of construction cost is given in Table 4-5.

(2) Cut-Off Channel in Confluence Stretch with Sibarau River

The confluence stretch with Sibarau River, which is located at the upmost stream of the target improvement stretches, forms a conspicuous meandering. To smoothen flood flow and avoid bank erosion, a cut-off channel is applicable as shown in Fig. 4-10. The proposed 200 m cut-off channel will shorten the existing channel by 750 m, and the proposed longitudinal profile is presented in Fig. 4-11.

The construction cost for the two river improvement plans with the cut-off channel and with the existing meandering channel is summarized in the following table. The cut-off channel requires less construction cost and house evacuation and is, therefore, proposed to be employed. The breakdown of construction cost is presented in Table 4-6.

Construction Cost of River Improvement Plans

Stretch	Item	Existing Channel	Cut-Off Channel
PA.24+78 to PA.29+500	Length (m)	5,420	4,970
	Construction Cost* (mill. Rp.)	16,222	15,310
	Land Acquisition (ha)	22.8	20.8
	House Evacuation (unit)	109	99

* Costs for Administration and Engineering Services are excluded.

4.2 Alternative Floodway Plan

Alternatives of the floodway plan are considered as follows.

(1) Route of Floodway

Three (3) applicable routes of the proposed floodway are identified upstream of Medan City through the topographical survey, as shown in Fig. 4-12. Among the three, two routes of Route A and B are both from Titi Kuning to Tembakau. Route A crosses the national road but Route B joins Percut River south of the road crossing the less populated area. Route C connects Deli and Percut rivers with the shortest distance of 2.65 km and runs across the hilly area. The alignment of the three routes are shown in Figs. 4-13 and 4-14.

In consideration of the topographical condition and land use, the following five (5) combinations of channel type and route are identified. Among them, the combination of Route B and open channel of B-1 is the most economical and require less house evacuation. It is, therefore, proposed as the optimum plan. The alignment and longitudinal profiles with typical cross section of the five combinations are presented in Fig. 4-15, and the breakdown of construction cost is given in Table 4-7.

Summary of Construction Cost of Alternatives

Floodway Route			Type	Length (km)	Const. Cost (mil.Rp)	Compensation	
Route	Diver. Point	Join. Point				Land (ha)	House (unit)
A	Titi Kuning	Tembakau (North of Nat'l Rd.)	Open Channel	3.69	26,031	18	196
B-1	Titi Kuning	Tembakau (South of Nat'l Rd.)	Open Channel	3.84	23,860	20	97
B-2	Titi Kuning	Tembakau (South of Nat'l Rd.)	Box Culvert	3.84	60,772	15	66
C-1	Simeme	Singara-gara	Open Channel	2.65	33,149	21	17
C-2	Simeme	Singara-gara	Tunnel	2.65	35,354	2	1

(2) Diversion Works

The diversion works is proposed, based on the following criteria:

(a) The design discharge of 120 m^3/s, which corresponds to about 40% of a 30-year return period flood (320 m^3/s) in the upstream of Deli River, is diverted into the floodway.

(b) In ordinary time except during flood, the whole discharge of Deli River is diverted into its downstream without flow discharge to the floodway to maintain the current water uses in the downstream area.

(c) To avoid a so-called man-made flood, a non-gated structure is employed in consideration of the typical rapid flood of Deli River.

The existing riverbed gradient of Deli River near the diversion point is 1/600, while that of the proposed floodway is as small as 1/2,700. Therefore, the design water level in the upstream of the diversion point is raised to secure a hydraulic head enough to divert the design discharge of 120 m^3/s into the floodway. Moreover, in order to ensure sufficient maintenance flow to the downstream of Deli River in ordinary time, a fixed weir is necessary at the inlet of the floodway.

As applicable plans of diversion works, the following three (3) combinations are proposed and their drawings are presented in Fig. 4-16.

Applicable Plans of Diversion Works

Applicable Plan	Combination of Facility	
	Deli River	Floodway
Type I	Fixed Weir with Orifice	Fixed Weir
Type II	Fixed Weir without Orifice	-do-
Type III	Narrowed Channel	-do-

The fixed weir with an orifice (Type I) is proposed as the optimum structure among the three types from the following reasons:

(a) The narrowed channel (Type III) is much costlier than the fixed weirs of Type I and II as shown in Table 4-8.

(b) A more stable diversion according to the design flood discharge distribution is expected from the overflow diversion of Type I and Type II than the narrowed bottleneck channel.

(c) An orifice provided in the fixed weir body of Type I does not only ensure the maintenance flow to the downstream but also mitigate sedimentation in the upstream.

(d) In the case of the fixed weir without an orifice (Type II), water level of the upstream is usually raised up to the crest level even in non-flood ordinary time. The impounded water is easily contaminated and it may result in deterioration of the neighboring environment.

4.3 Stability Analysis of River Embankment

The stability analysis of river embankment is carried out for the preliminary design.

According to the results of standard penetration test (SPT), the foundation of river embankment in the following downstream stretches of each river is soft and weak. Sliding failure analysis and consolidation analysis are carried out for checking the stability of embankment.

Results of SPT

River	Stretch	SPT (N value)
Deli	River Mouth to Titi Papan (12 km)	Less than 5
Percut	River Mouth to 5 km Upstream (5 km)	- ditto -
Padang	River Mouth to 7 km Upstream (7 km)	- ditto -

Sliding Failure Analysis

Safety of proposed embankment against sliding failure is confirmed by applying the slice method to the slip circle surface. The seismic coefficient is 0.1. The calculation results are summarized as follows (refer to Fig. 4-17):

(1) Deli River

Case	Safety Factor			Allowable Safety Factor
	Deli	Percut	Padang	
1. Seismic	1.04	1.01	1.01	1.0
2. Residual Highwater Level is Maximum	1.25	1.31	1.34	1.0
3. Ordinary	1.52	1.61	1.58	1.2

Consolidation Analysis

The consolidation settlement is calculated by the following formula:

$$S = \frac{Cc}{1 + eo} H \log \frac{Po + \Delta P}{Po}$$

$$T = Tv \frac{D^2}{Cv}$$

where,
- S : Settlement (m)
- Cc : Compression Index
- eo : Void Ratio
- Po : Consolidation Pressure (kg/m^2)
- ΔP : Pressure increment under the n - th load step (kg/m^2)
- H : Thickness of soil layer (m)
- T : Time (Sec)
- Tv : Time Factor on Consolidation
- Cv : Coefficient of Consolidation (m^2/Sec)
- D : Length of Drainage Path (m)

The calculation results are as follows:

Calculation Results of Consolidation Analysis

River	Consolidation Settlement (m)	Settlement Time (Year)
Deli	1.0	16
Percut	0.5	23
Padang	0.3	25

According to the calculation results, maintenance works for embankment is necessary.

5. CONSTRUCTION PLAN AND COST ESTIMATE

5.1 Construction Plan

Conditions for Construction Planning

For the construction planning and scheduling, the following considerations have been taken as the basic concept.

(1) Mode of Construction

Construction is to be carried out by contractors selected through international competitive bidding.

(2) Working Days

Considering the climate, Sundays and national holidays, the annual workable days for construction works are set at 240 days except earthworks and concrete works in the river for which 180 days are available in consideration of the rise of water level in heavy rain.

(3) Temporary Facilities

No special planning on the construction of offices, quarters, warehouses, workshops, water supply system, electric power supply system, communication system, etc., is considered.

(4) Construction Method and Type of Construction Equipment

Construction is to be carried out by improved conventional construction methods using standard types of equipment.

(5) Arrangement of Spoil Bank

Spoil banks for dredged/excavated materials from rivers and foundation of structures are to be temporarily arranged in open space and agricultural area in consideration of the reduction of hauling distance of materials.

Main Work Items

The construction method for main work items are as follows:

(1) Excavation

The excavation of on-land works such as the foundation of embankment, weir, sluice, etc., is planned to be carried out using backhoe/clamshell and/or dump truck.

In case of excavation for submerged portions such as foundation of revetment, weir, sluice, abutment of bridge, etc., coffering of the work site with earth dike and/or steel sheet piles is considered.

(2) Embankment, Earth

Embankment for dikes is to be carried out mainly with suitable materials from borrow pits, except in special cases where embankment is done with excavated/dredged materials after adjusting the water content.

The embankment work is to be carried out using bulldozer and backhoe as excavator/loader in borrow pit, dump truck as hauling equipment, and bulldozer and compactor as spreading and compaction equipment. Sodding is to be finally carried out.

(3) Concrete Works

Concrete works such as mass concrete, reinforced concrete for weir, sluice and gate are to be carried out using a portable concrete plant or ready mixed concrete procured from suppliers nearby, crawler/truck crane with concrete bucket for pouring, and truck mixer.

Concrete forms are to be of steel and of wood forms for special cases only.

(4) Revetment (Wet Stone Masonry)

Revetment materials such as cobblestone, reinforcing bar, concrete aggregates and cement are to be transported using cargo trucks. Concrete is planned to be produced by a portable concrete plant or procured from local suppliers. For constructing revetment of river banks, coffering as a preparatory work is required for portions under water.

Implementation Schedule of Master Plan

Based on the master plan study, the target year of completion is proposed to be the year 2010. Implementation of selected urgent projects is to be completed within 10 years assuming that it will start in 1991.

Priority scheduling of proposed projects is described in the Main Report. The implementation period of each project is proposed in consideration of river condition and the work volume of main works such as excavation, embankment and revetment.

River improvement is generally executed from the down to upstream. However, some embankment works of the upper stream can be done ahead of excavation works of the downstream, if the work would not reduce the flow capacity of the downstream.

The daily work volumes of main work items are assumed as follows:

Excavation	:	4,000 m^3/day
Embankment	:	700 m^3/day
Revetment	:	500 m^3/day

The implementation schedule of the master plan is presented in Fig. 5-1.

Construction Schedule of Urgent Project

The Deli-Percut River is selected as an object of an urgent improvement project. Improvement works consist of the Deli River Improvement Works, the Percut River Improvement Works, Lausimeme Dam Construction, and Medan Floodway Construction. The project scale is a 30-year return period.

The Padang River is also selected for an urgent river improvement project. The project scale is a 10-year return period.

The basic condition to decide the construction period of the urgent project is the same as the one adopted for the master plan. The construction schedules for the urgent projects on the above rivers excluding dam construction after detailed design are described hereinafter (refer to Fig. 5-2).

(1) Deli River

To save on construction period, improvement works on the Deli River are proposed to be executed by dividing the river into three (3) sections; namely, from the river mouth to the confluence with Sikambing River, from the confluence with Sikambing River to that with Babura River, and from that of Babura River to Titi Kuning.

Improvement is mostly carried out from down to upperstream. On the sections near junctions with tributaries such as Sikambing and Babura rivers, the upper and downstream sections of Deli River are simultaneously improved. Some river structures in the upstream such as sluice, drain, bridge and parapet wall are constructed ahead of those in the downstream according to site condition.

(2) Percut River

River improvement is carried out from down to upperstream. Improvement of some river structures such as sluice, drain, bridge and weir as mentioned before will proceed according to the site condition.

(3) Medan Floodway

The fixed weir on the floodway side is first constructed, since this structure does not become an obstacle to the smooth flow of Deli and Percut rivers. Construction of floodway channel is simultaneously completed with the Percut River improvement works.

After completion of the Percut River improvement works and the floodway channel, the fixed weir on the Deli River is constructed to prevent inundation, overflow and excess discharge to Percut River due to backwater. Foundation works of the weir can be started before the completion of the floodway channel and Percut River improvement works.

Half of the fixed weir on the Deli River is to be completed first. The other half of the weir is to be constructed in the next stage, in consideration of the narrow and deep river section and maintenance flow to the downstream of Deli River.

(4) Padang River

River improvement is to be carried out from down to upper stream. Improvement of some river structures such as sluice, drain, bridge and weir as mentioned before will proceed according to the site condition.

5.2 Cost Estimate

Conditions for Cost Estimate

Project cost is estimated on the basis of the design, the construction plan, and the following assumptions and conditions. Constitution of project cost is shown in Fig. 5-3.

(1) Price Level

Price level is as of September 1991.

(2) Currency Conversion Rate

Currency conversion rates among US Dollar (US$), Indonesian Rupiah (Rp.) and Japanese Yen (¥) are as follows:

US$1.00 : Rp. 1,950 : ¥136

(3) Currency of Cost Estimate

Construction cost is estimated in two components, the foreign currency component and the local currency component. Both of the estimated costs are expressed in Indonesian Rupiah using the currency conversion rates stated above.

(4) Construction Base Cost

Construction base cost consists of labor wage, materials cost and equipment cost.

Basic labor wages of foremen, operators, mechanics, concrete workers, carpenters, common laborers, etc., are estimated a shown in Table 5-1.

Basic unit costs of construction materials are canvassed in Medan and the major steel materials are adjusted in consideration of the prevailing market prices in Japan. The list of unit costs of materials is in Table 5-2.

The basic operation cost of equipment is calculated in consideration of the CIF purchase cost, the economic life of equipment, depreciation cost, and rates of maintenance and repair cost. The basic unit costs of construction equipment are shown in Table 5-3.

(5) Government Administration Cost

The cost of project management or administration by the government is assumed at 7% of the construction base cost of civil works.

(6) Engineering Services Cost

Detailed design and construction supervision are to be carried out by an engineering consultant primarily selected by international tendering.

(7) Compensation Cost

(a) For the Master Plan

Compensation cost of land for the master plan is roughly estimated as follows:

Low Density Residential Area	:	25,000 Rp./m^2
High Density Residential Area	:	150,000 "
Paddy Field/Agricultural Area	:	8,000 "
Plantation Area	:	8,000 "
Open Space	:	1,000 "

(b) For the Urgent Plan

The unit cost of compensation items consisting of land acquisition and house evacuation are estimated as follows:

Unit Costs of Compensation Items for Urgent Plan

Compensation Item	Unit Cost
1. Land Acquisition	
(a) Residential Area	
- Deli River (Rp./m^2)	5,000(20,000)
- Percut River (Rp./m^2)	2,000(10,000)
- Floodway (Rp./m^2)	2,000(10,000)
- Padang River (Rp./m^2)	2,000(10,000)
(b) Agricultural Area	
- Paddy Field	8,000
- Plantation (Oil Palm)	8,000
- Plantation (Rubber)	4,000
- Plantation (Cacao)	2,000
- Others	3,000
(c) Fishpond	3,000
(d) Open Space	1,000
2. House Evacuation	
(a) Private House (Mill. Rp./100 m^2)	
- Class A (Conc., 2-3 stories)	51
- Class B (Conc. & wood, 1-storey)	15
- Class C (Wood)*	2
(b) Office Building (3-stories)	76
(c) Factory	100

Note: Costs in parentheses are for urban area.
Conc.: concrete
* in million Rp./50 m^2

(8) Physical Contingency

Physical contingency is estimated at 10% of the foreign and local currency costs.

(9) Price Escalation

Price escalation is considered for only the local currency costs at the annual escalation rate of 8%.

(10) Value Added Tax

Value Added Tax is estimated at 10% of construction cost including contingency and price escalation.

Unit Cost of Construction Works

The construction base cost is estimated on the unit cost basis, multiplying the unit cost of work items by the corresponding work quantities. The unit cost of main construction works is presented in Table 5-4.

Unit cost is estimated based on the construction methods adopted. The breakdown is shown in the attached sheets.

The unit cost of each work item consists of labour, equipment and materials unit cost. Unit cost for each item is estimated by dividing it into foreign and local currency components after examining the contents. The estimated percentage allocation for each unit cost of major items is presented in Table 5-4.

The unit construction cost of weir, sluice, drain, gate and bridge is decided by reviewing those in some construction works in Medan, Lower Jeneberang Project in South Sulawesi and some construction works in Japan.

Construction Cost of the Project

Construction cost consists of the construction base cost, administration cost, engineering services cost, compensation cost and physical contingency.

(1) Construction Cost of Master Plan

The construction cost of the master plan is estimated as shown in Table 5-5. The breakdown of river improvement costs are shown in Table 5-6 and in the attached sheets. The river improvement cost with the project scale of 10-year return period is also shown in Table 5-6.

(2) Construction Cost of Urgent Project

The construction cost of the urgent project described in Table 5-7 is summarized as follows:

Construction Cost of Urgent Project

Project	Total Amount (in Mill. Rp.)
1. Deli-Percut River	
(a) Deli River Improvement	
- River Mouth to Sikambing River	65,880
- Sikambing River to Babura River	38,228
- Babura River to Titi Kuning	15,048
Sub-Total	119,156
(b) Medan Floodway	32,089
(c) Percut River Improvement	47,527
(d) Lausimeme Dam	141,344
Total	340,116
2. Padang River Improvement	73,575
Grand Total	413,691

The breakdown of river improvement cost for the urgent project are shown in Table 5-8 and in the attached sheets.

Annual Disbursement Schedule

The annual disbursement schedules for the master plan and the urgent project are prepared in accordance with the implementation schedules and presented in Tables 5-9 and 5-10.

Operation, Maintenance and Replacement Cost

(1) For the Master Plan

Operation and maintenance cost is estimated on the basis of the rate involved in the construction base cost. The rate is assumed at 1% of construction base cost.

(2) For the Urgent Project

The annual operation, maintenance and replacement cost for the proposed urgent project is estimated as shown in Table 5-11.