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THE FEASIBILITY STUDY
ON
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WATER RESOURCES DEVELOPMENT PROJECT

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SUPPORTING REPORT ([illegible])

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JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

REPUBLIC OF INDONESIA
DIRECTORATE GENERAL OF
WATER RESOURCES DEVELOPMENT
MINISTRY OF PUBLIC WORKS

THE FEASIBILITY STUDY
ON
CIDANAU-CIBANTEN
WATER RESOURCES DEVELOPMENT PROJECT

FINAL REPORT

VOLUME III

SUPPORTING REPORT (1)

24049

June, 1992
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

This Report consists of

Volume I	*Summary Report*
Volume II	*Main Report*
Volume III	*Supporting Report (1)*
Volume IV	*Supporting Report (2)*
Volume V	*Data Book*

Appendix - A	*Topography*
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APPENDIX - A
TOPOGRAPHY

APPENDIX - A
TOPOGRAPHY

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1. General

The topographic survey work in this study was divided into three categories as follow.

i) Photogrammetric mapping with a scale of 1/5,000 for the Cidanau basin area of 30 km^2 using aerial photograph with a scale of 1/20,000 (Fig. A-1)

ii) Topographic survey surrounding the existing Krenceng reservoir

- Control point survey surrounding the existing Krenceng reservoir
- Hydrographic survey in the existing Krenceng reservoir
- Cross section survey along the existing Krenceng dam

iii) Topographic survey for the proposed Beroeng diversion tunnel site

- Leveling survey between the existing Krenceng dam and Beroeng diversion tunnel site
- Longitudinal survey along the Beroeng diversion tunnel route
- Longitudinal survey along the Beroeng intake weir site

2. Photogrammetric Mapping Work

2.1 General

The photogrammetric mapping work was commenced in middle of January, 1991 and completed in middle of March, 1991.

2.2 Control Point Survey

Control point survey was carried out to identify the absolute coordinates of the newly established control points in the target area by means of the Global Positioning System, GPS, taking advantage of the geodetic satelite. The number of the control points observed by GPS is ten as given in Fig. A-2.

2.3 Levelling Work

The levelling work was carried out for making the altitude of the newly established ten control points.

2.4 Aerial Triangulation

The aerial triangulation which is the adjustment computation to seek conformity among the aerial photographs in terms of scale by availing the results of control point survey and levelling work was carried out using the aerial triangulation block adjustment programme as the initial work of the map preparation.

2.5 Plotting and Editing

The topographic maps on a scale of 1 to 5000 was prepared with plotting machines based on the results of aerial triangulation and field survey. Principal contour lines were drawn with a 5 m interval for 1 to 5000 scale topographic maps.

The topographic maps prepared in this study are separately compiled in the Data Book.

3. Topographic Survey surrounding the Krenceng Reservoir

3.1 General

The topographic survey surrounding the Krenceng reservoir which consists of control point survey,hydrographic survey and cross section survey was commenced in beginning of August, 1991 and completed in end of August, 1991. The additional control survey and cross section survey were carried out in mid December, 1991 to mid January, 1992.

3.2 Control Point Survey

The control point survey surrounding the existing Krenceng reservoir, around 8 km is carried out so as to check the storage volume above the water surface level of the existing reservoir, NHWL.22.50 m.

During the survey, August in 1991, the reservoir water surface is kept at around El.20.50 m.

3.3 Hydrographic Survey

The hydrographic survey in the existing Krenceng reservoir is carried out so as to check the storage volume below the water surface level of the existing reservoir, NHWL.22.50 m.

The water depth for about 70 points were checked.

3.4 Cross Section Survey

The cross section survey along the existing Krenceng dam is carried out so as to obtain the topographic conditions for the existing Krenceng dam and socio-environmental aspect for its downstream and to plan the heightening of Krenceng dam.

The cross section survey was made by about 100-150 m intervals.

The survey area from the dam crest of the existing Krenceng dam to the downstream is made up to 100 m considering the downstream toe of the heightening of Krenceng dam.

The topographic maps prepared in this study are separately compiled in the Data Book.

4. Topograpic Survey for Proposed Beroeng Diversion Tunnel

4.1 General

The topographic survey for the proposed Beroeng diversion tunnel which consist of levelling survey between the existing Krenceng dam and the proposed Beroeng diversion tunnel site and longitudinal survey along the route of diversion tunnel and the intake weir was commenced in mid December, 1991 and completed. in mid January, 1992.

4.2 Levelling Survey

The levelling survey between the existing Krenceng dam and the proposed Beroeng diversion tunnel, about 5 km is carried out so as to shift the bench mark on the existing Krenceng dam.

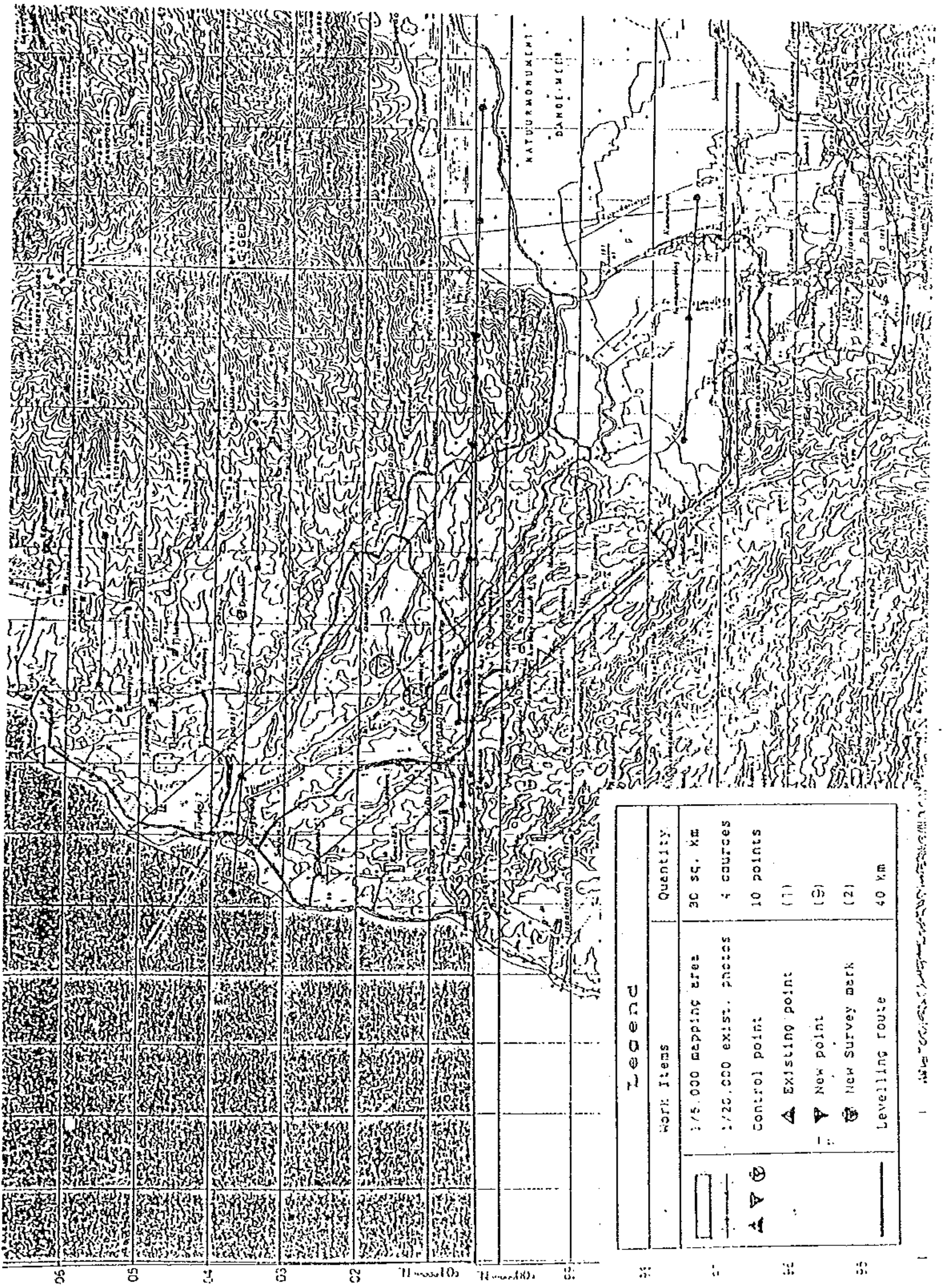
4.3 Longitudinal Survey along the Route of Beroeng Diversion Tunnel

The longitudinal survey along the route of Beroeng diversion tunnel is carried out so as to obtain the profile of route and check the formation height of both Beroeng river and Krenceng river.

The topographic maps prepared in this study are separately compiled in the Data Book.

FIGURES

Fig. A-1



Photogrammetric Mapping Area

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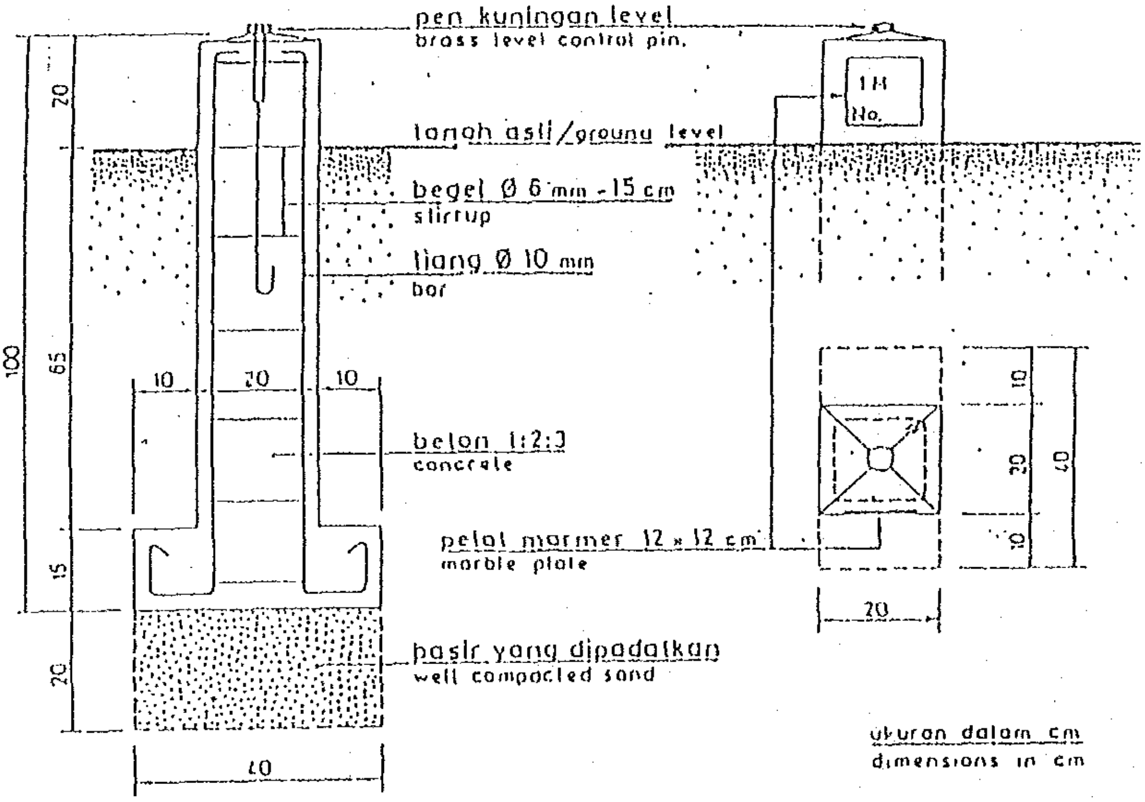
Configuration of New Survey Mark



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APPENDIX - B
HYDROLOGY

APPENDIX - B
HYDROLOGY

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1. General

The Project area is situated in the North Banten region of West Java Province and has a tropical climate with marked wet and dry seasons. The west monsoon dominates the area with abundant rainfall from December to March and the east monsoon appears with less rainfall from June to September. April to May and October to November belong to transitional periods.

The project area has two main river basins; one is the Cidanau river and the other is the Cibanten river.

The Cidanau river takes its rise among Mt. Karang, embracing Rawa Danau in the middle reaches, and drains to Sunda Strait. The catchment basin consists of many small tributaries which confluence in a swamp inside the old Danau caldera. This swamp, Rawa Danau, acts as a source of the Cidanau main river. Rawa Danau is located in the Rawa Danau nature reserve, part of which is forest and fresh water swamp area. There exists an intake weir for Krakatau steel works near its estuary.

The Cibanten river takes its rise among Mt. Karang, flowing northernward, and drains to Banten bay. Serut(proposed dam site) is located upstream of Serang and has a catchment area of 73.15 km^2. A location map is shown in Fig. B-1.

The meteorological and hydrological study have the objectives as follows:

1) Analysis of meteorological characteristics of the Project area.
2) Estimation and analysis of the stream flow (low water and flood) in order to facilitate planning of water supply and spillway design.
3) Analysis of sediment load from the viewpoint of capability of sediment storage in reservoir.

2. Climatic and Hydrological Data

Two meteorological stations, at Padarincang and Serang are located in the Cidanau and the Cibanten river basins, respectively. Their locations are shown in Fig. B-2. Considering the location, the period of available data, etc., the data at Serang meteorological station will be usable for this project.

There are 18 rainfall gauging stations by PMG and 4 rainfall gauging stations by P3SA, in total 22 stations, in and around the study area. Their locations are shown in Fig. B-2.

There are 2 water-level gauging stations in the project area. One is Kubang Baros station on the Cidanau river located immediately downstream from Rawa Danau. The other is Serut station on the Cibanten river upstream from Serang. Both stations are installed and observed by P3SA. Their locations are shown in Fig.B-2.

3. Climatic and Hydrological Conditions in the Project Area.

3.1 Climate

The meteorological station at Serang by PMG is selected as the representative station considering its location, the period of available data, etc.. The daily meteorological data at Serang station are aggregated into monthly data as shown in Fig. B-3.

The mean annual temperature is 26.7°C at Serang with a mean annual range of 1.0°C. The mean monthly temperature at Serang is summarized as follows:

(1971 - 1989) (°C)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
26.2	26.5	26.6	26.9	27.0	26.6	26.3	26.4	26.7	27.2	27.1	26.6	26.7

The relative humidity is high ranging from 77% to 84% almost throughout the year. There is no significant variation from month to month. The mean monthly relative humidity is summarized as follows:

(1971 - 1989) (°C)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
84	83	83	82	82	80	80	78	78	77	78	81	80

The mean monthly wind velocity at Serang ranges between 4.2 and 4.9 knots or 2.2 and 2.5 m/sec. There is no significant variation from month to month. The mean monthly wind velocity is summarized as follows :

(1971 - 1989) (knots)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
4.5	4.8	4.6	4.3	4.2	4.2	4.2	4.5	4.6	4.5	4.9	4.8	4.5

The mean sunshine duration at Serang ranges between 5 to 6 hours per day in dry season and 3 to 4 hours per day in rainy season.

(1974 - 1989) (hours/day)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
2.9	3.4	4.3	4.9	5.0	4.9	5.8	5.8	5.7	4.8	4.1	3.5	4.6

3.2 Rainfall

There are about 40 rainfall gauging stations belonging to PMG in the North Banten area, however, considering the data availability, gauge location and data collection, finally 18 rainfall gauging stations by PMG and 4 rainfall gauging stations by P3SA, in total 22 stations, are used for the study.

The situation of available rainfall data is listed in Table B-1. Average annual rainfall from 1970 to 1990 is listed in Table 4.2 (1) and (2). The annual isohyetal map is shown in Fig. B-4.

Correlation of annual rainfall is calculated and listed in Table B-3., based on the results of rainfall analysis.

The Monthly rainfall pattern at Serang, Padarincang and Kepuh are shown in Fig. B-5.

3.3 Runoff

The following 2 water-level gauging stations are presently operated in the Cidanau and the Cibanten rivers respectively.

Name of River	Name of Station	Catchment area (km^2)	Operation	Installed date
Cidanau	Kubang Baros	199.50	P3SA	1980
Cibanten	Serut	73.15	P3SA	1977

There was a water-level gauging station at Curug Butong (Kubang Baros) in the Cidanau river, however, the station was abandoned in 1937.

The situation of available water level data is listed in Table B-4.

At Kubang Baros water-level gauging station, according to the discharge measurement conducted 67 times from 1979 through 1990 by P3SA, the relation between water-level and discharge has been calculated as follows:

$$Q = -0.16 + 16.99\ h + 7.91\ h^2$$

At Serut water-level gauging station, according to the discharge measurement conducted 94 times from 1978 through 1990 by P3SA, the relation between water-level and discharge has been calculated as follows:

$$Q = 0.9775 - 6.6815h + 20.321h^2$$

Where Q ; discharge in m^3/s
h ; water level in meter

During the field work in this survey the additional discharge measurement was carried out by the Study Team at Kubang Baros (Cidanau, 6 times in rainy season and 5 times in dry season) and at Serut (Cibanten,6 times in rainy season).

Equations of water-level to discharge relations have been accordingly updated for each of two water-level stations, using the additional discharge measurement data.

In order to improve the equation of original discharge rating curve at Kubang Baros, 78 data in total (67 times by P3SA, 11 times by the study team) are used with the adoption of the least square method.

The equation of the revised discharge rating curve at Kubang Baros is decided as follows:

$$Q = 0.2644 + 12.3782h + 12.7466h^2 \qquad h \leq 0.80m$$
$$Q = 28.8366 - 52.1277h + 47.5274h^2 \qquad 0.80m < h$$

The revised discharge rating curve at Kubang Baros (Cidanau) is shown in Fig. B-6.

The equation of the revised discharge rating curve at Serut is decided as follows:

$$Q = 0.5076 - 6.4715h + 22.7219h^2$$

Where Q ; discharge in m^3/s
h ; water level in meter

In the above revised discharge rating curve, 100 data in total (94 times by P3SA, 6 times by the Study team) are used. The revised discharge rating curve at Serut (Cibanten) is shown in Fig. B-7.

Water-level and discharge measurement data at Kubang Baros and Serut are listed in Table B-5 (1) to B-5 (2) and Table B-6 (1) to B-6 (3) respectively.

Hydrological data from 1980 through 1990 are prepared for the purpose of water balance study. The missing discharge data are interpolated by assuming that the missing data between both actual data is changed by a straight line.

The monthly discharge pattern at Kubang Baros and Serut are shown in Fig. B-8.

The summary of hydrological data at both Kubang Baros and Serut gauging stations are listed in Table B-7.

4. Low Flow Analysis

4.1 General Procedure

In this study, the required storage capacities for alternative dams are decided by water balance analysis. Hydrological conditions for water balance calculation are as follows:

1) River maintenance flow

The main purpose of this study is the comparison of alternative dams and is not the detail examination. The river maintenance flow for downstream Anyer and Beroeng intake weir is considered during dry season.

2) Evaporation

Evaporation is not considered at this stage.

3) Sedimentation

Sediment in each river are estimated as follows:

Cibanten river	900 m^3/km^2/year
Cidanau river	500 m^3/km^2/year
Krenceng river	900 m^3/km^2/year

4) Irrigation

The Cidanau river has no irrigation system. In the Cibanten river basin, there is an irrigation intake weir, downstream of proposed dam site, to serve the cropping area of 1961 ha in wet season and 566 ha in dry season. Rainfall data of Serang are used to calculate the effective rainfall. For irrigation on the Anyer river, the calculation of the effective rainfall is depended on the rainfall data of Serang.

In the downstream Beroeng and anyer intake, 120 ha and 330 ha are considered during wet season.

4.2 Discharge Data for Proposed Damsites and Intake Weir Sites

Discharge data are available from 1980 through 1990 at Kubang Baros in the Cidanau basin and at Serut in the Cibanten basin.

A series of 5-day mean inflow discharge are used in the water balance study. The discharges for the proposed damsites and intake weir sites, in the Cidanau and the Cibanten basins, are estimated by the ratio of catchment area, however, furthermore the ratio of annual rainfall are taken into account for the points outside the said two river basins.

The conversion ratio for the proposed damsites and intake weir sites and the original discharge data are shown in Table B-8.

The mean inflow discharge data of the 5-day period at Kubang Baros and Serut gauging stations are listed in Table B-9 - B-10 respectively.

Flow duration curves are presented by arranging daily mean discharge data from 1980 to 1990 as shown in Figs. B-9 and B-10. The daily discharges at Kubang Baros and Serut are listed in data book.

5. Flood Runoff Analysis

5.1 General

In this study, synthetic unit hydrograph method[1),2)] is adopted for the flood analysis.

i) Time of Concentration (Tc)

The time of concentration is derived from the nomogram (USBR[1)]).
The parameters in the nomogram, L (length of longest water courses) and H (difference in elevation), for each proposed dam site are listed in Table B-11.

ii) Unit Duration (D)

The unit duration is chosen to be smaller than one-fourth of Tp. The unit duration for each proposed dam site is decided as shown in Table 4.13.

iii) Time to peak (Tp) and Recession Time (Tr)

Tp and Tc are derived from the following equation (USBR[1)]).

$$Tp = 0.6 \times Tc + D/2$$
$$Tr = 1.67 \times Tp$$

[1)] U.S. Bureau of Reclamation: Design of Small Dams.

[2)] Kaul: The Estimation of Design Floods for a Small Reservoir in Indonesia, Water Resources Planning Guideline, No.6, July 1975.

Tp and Tr for each proposed dam site are listed in Table B-11.

iv) Peak Flow (Qp)

The peak flow is calculated by the following equation.

$$Qp = \frac{CA \times 10^6 \times 2}{(Tp + Tr) \times 3{,}600}$$

where CA : catchment area (km^2)
Tp : time to peak (hrs)
Tr : recession time (hrs)
Qp : peak flow (m^3/s)

The peak flow is calculated for each proposed dam by 100 mm unit rainfall. The unit hydrograph patterns for each proposed dam are as follows:

Order (hr)	ratio **	ratio between Kubang Baros and Krakatau Intake	Krenceng dam
1	0	0.	0.
2	0.25	0.5	0.33
3	0.5	1.0	0.67
4	0.75	0.67	1.0
5	1.	0.33	0.8
6	0.857	0.	0.6
7	0.714		0.4
8	0.571		0.2
9	0.429		0.
10	0.286		
11	0.143		
12	0.		

**: Kubang Baros, Cidanau downstream dam site, Cidanau intake and Serut

5.2 Probable Basin Rainfall

The annual maximum daily rainfall data at Serang, Pabuaran, Kepuh and Padarincang are shown in Table B-12. The probable rainfall at Padarincang and Kepuh are calculated by Hazen plot as shown in Fig. B-11. The calculated results are listed in Table B-13.

The catchment rainfall is derived from the point rainfall applying the relation between catchment area and rainfall actually experienced in a large storm occurred in East Java in July 1936. This relation was used in the North Banten master plan study.

Catchment area (km^2)	Conversion ratio from point rainfall to area rainfall
0	100
100	92
250	84
500	73

From the relation mentioned above, the conversion ratio may be estimated at 94% at Serut, 87% at Kubang Baros, proposed downstream dam site and Krakatau intake in the Cidanau river, 99% for the remaining area between Kubang Baros and Krakatau intake, and 99% at Krenceng.

The rainfall duration is assumed as 8 hours with well shaped rainfall distribution. Herein, rainfall intensity is calculated by Mononobe formula which was used in the North Banten master plan study.

$$r = \frac{R}{8} \times \frac{8}{T}^{2/3}$$

where R ; daily rainfall (mm/day)
T ; time (hrs)
r ; rainfall intensity in T

The rainfall pattern is assumed as follows:

Time (hrs)	Ratio
1	0.05
2	0.06
3	0.09
4	0.5
5	0.13
6	0.08
7	0.05
8	0.04

The rainfall losses are assumed as 25 mm for the initial losses and 8 mm/hr for the subsequent catchment losses.

5.3 Probability Analysis

To establish the flood hydrograph for each probability, the synthetic unit hydrograph method is used, applying the model rainfall pattern with 8 hours duration for corresponding probable daily rainfall.

The analyses are made for 4 cases (1/25, 1/50, 1/100 and 1/200) and for 6 alternative dam sites (Kubang Baros, Cidanau proposed downstream dam site, Krakatau intake, between Kubang Baros and Krakatau intake, Serut and Krenceng).

5.4 Probable Peak Flood Discharges at Alternative Dam Sites

The probable peak flood discharges at alternative dam sites are summarized in Table B-14.

5.5 Probable Flood Hydrograph

The probable flood hydrographs are shown in Table B-15 (1) to B-15 (6) and Figs. B-11 to B-17.

6. Sediment

The rate at which sediment will deposit in a proposed reservoir is largely related to erosion of the watershed.

6.1 Sediment Measurements (Suspended load)

In order to assess the amount of sediment into the proposed damsite, the sediment sampling was carried out in February 1991 by the Study Team. The results of sampling are listed in Table B-16.

6.2 Sediment Discharge Rating Curve

The sediment discharge rate is estimated based on the sediment concentration and the flow rate derived from the water-level gauging and the discharge rating curve.