ANNEX - 6

WATER RESOURCES DEVELOPMENT

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1. Objective Water Resources Development Projects

The Study of water resources development in terms of urban water supply toward year 2020 aims to select and recommend project(s) to be implemented after the Wonorejo Dam Project. For the selection of the most prospective project properly out of water resources development projects to be executed in or around the Brantas river basin, the Study deals with such projects that is related to the development of water supply for the Brantas river basin, especially domestic water for Surabaya and its vicinity area. The objective projects are only the development plans formulated in the previous studies and new project identification is not considered for water resources development. The related projects would be categorized according to the status of the projects and locations: (i) Existing development plans in the Brantas river basin, (ii) Existing dam and reservoirs in Brantas river basin in view of more efficient use, and (iii) Existing development plans outside the Brantas river basin.

1.1 Existing Development Plans in the Brantas River Basin

Most of the projects classified in this category were identified and preliminarily studied in the previous master plan studies conducted in 1973 by OTCA and 1984 by JICA. Only a few projects have proceeded to the feasibility study and detailed design stages. The present status of these projects are outlined below according to available information for the Study:

No.	Project Name	Status	River(Basin)	Objectives	Effective Storage Vol. (mil.m^3)
(1)	Beng Dam (pump up)	MP	Beng, (Brantas)	WS, IR, HP	147
(2-1)	Kedungwarak Dam (pump up)	MP	Kedungwarak(Widas)	WS, IR	54
(2-2)	Ketandan Dam (interbasin)	MP	Ketandan(Widas)	IR	12
(3)	Semantok Dam	MP	Semantok(Widas)	IR, FC	40
(4)	Kuncir Dam	MP	Kuncir(Widas)	IR, FC, HP	23
(5)	Babadan Dam (interbasin)	MP	Bendokrosok	WS, FC, HP	84
(6)	Tugu Dam	FS	Keser(Ngrowo)	WS, IR, FC	21
(7-1)	Karangkates4-5	FS	Brantas	HP	-
(7-2)	Kesamben Dam	FS	Brantas	HP	6
(8)	Lesti III Dam	DD	Lesti .	IR, HP, SC	4
(9)	Genteng I Dam	MP	Genteng(Lesti)	WS, HP, SC	70
(10)	Kepanjen Dam	MP	Brantas	HP,SC	0.5
(11)	Lumbangsari Dam	MP	Brantas	HP, SC	0.9
(12)	Konto II Dam	MP	Konto	IR, FC, HP, SC	63

Note WS:Urban water supply, IR:Irrigation, FC:Flood control, HP:Hydropower, SC:Sediment control, MP:Master plan study, FS:Feasibility study, DD:Detailed design

Source: Widas Flood Control and Drainage Project, Part-I Study(1985)
Widas Flood Control and Drainage Project, Part-II Study(1986)
Review Feasibility Study and Environmental Impact Analysis Tugu Dam(1995)
Survai, Investigasi Desain Detail Pada Proyek Bendungan Lesti III, 1983
Review Detail Design, Survey and Investigation Work for Lesti III Project, 1994

The summary of the project features of the existing plan and locations are presented in Table

A6-1 and Figure A6-1, respectively.

1.2 Existing Dam and Reservoirs in the Brantas River Basin

The existing dam and reservoirs, which have storage capacity of runoff regulation, are the Sungguruh dam, the Sutami and Lahor dams, the Wlingi dam and the Lodoyo dam in the Brantas river as well as the Selorejo dam in the Konto river and the Bening dam in the Bening river. Among the above dam/reservoirs, only the Sutami and Lahor dams have an inter-seasonal regulating capacity to supply stored water in dry season. Features of the existing dams/reservoirs are summarized in terms of water storage function as follows:

Dam /Reservoir	River	Catchment Area(km2)	Purposes	Effective Storage (mil. m3)	Water Supply
Sungguruh	Brantas	1,593	HP	2.5(1.2)	
Sutami Lahor	Brantas Brantas	2,050 160	WS, IR, HP, FC	253.0(149.7) 29.4(26.5)	Domestic and Industrial water Irrigation(35,000 ha)
Wlingi	Brantas	2,884	HP, IR	5.2(1.4)	Irrigation(13,600 ha)
Lodoyo	Brantas	3,014	HP	(2.3)	
Selorejo	Konto	90	IR, HP, FC	50.1(44.5)	Irrigation(5,700 ha)
Bening	Bening	238	IR, HP	28.4(28.0)	Irrigation(9,120 ha)

Note: Effective storage shows those soon after completion and the latest survey result by PJT in parenthesis respectively

1.3 Existing Development Plans Outside Brantas River Basin

The water resources in East Java other than the Brantas river basin, which will be exploitable for the water use in East Java urban area are presently identified as the Umbulan Spring located around 65 km southeast from Surabaya city, and water resources of the Lower Solo river.

(1) Umbulan Spring

(a) Location

The Umbulan Spring which includes a major spring and several minor springs is located in Pasuruan Regency, Subdistrict of Winongan, village of Umbulan, which is south east of Pasuruan city on the lower slopes of Mt.Bromo at an elevation of about 27 m. About 2 km east of the Umbulan Spring, rather small scale spring of Sunbur Mega and Sruwi are located also on the lower slopes of Mt.Bromo.

(b) Background of the Project

The Umbulan Spring was first developed for water supply by the Dutch in the early part of this century when small diameter pipelines were constructed to Pasuruan and toward Surabaya.

The Government of Indonesia and local Government have agreed to implement the project(the Umbulan Bulk Water Supply Project) in 1986 for further development of the Umbulan Spring as a source for clean water supply. Then in 1987, the Clean Water Local Company(PDAB East Java) was formed on the basis of the agreement.

The implementation arrangement for the project has been reviewed by a two phase Project Technical Assistance funded by the IBRD. The Preliminary Project Preparation Report (draft final report)under phase-I was prepared in March 1995.

(c) Present Discharge Capacity

According to the previous study, rather steady discharge with a slight seasonal fluctuation has been expected throughout a year. Discharge amounts over 5.0 m^3/sec have been recorded since 1987 and 5.3 m^3/sec has been recorded recently, out of which only 705 l/sec has been supplied for the domestic water, irrigation and fishery, as follows:

PDAM Surabaya		110 l/s
PDAM Pasuruan		65 l/s
Irrigation	(Saluran Timur)	170 l/s
	(Saluran Utara)	190 l/s
Fishery		170 l/s
Total		705 l/s

Other springs near from the Umbulan Spring are Sunbur Mega, Sruwi and Samut springs of which discharge are observed at 1.48m^3/s, 0.49m^3/s, and 0.40 m^3/s, respectively. A part of the Sunbur Mega discharge is transmitted to Pasuruan but most of discharges of three springs are flown into Rejoso river.

(d) Proposed Umbulan Bulk Water Supply Project

It is said that the implementation works may be commenced hopefully within 1997 based on the Minutes of Understanding agreed early 1997 between PDAB and the private investors. Available information for the Study are only general project components and expected production with the following allocation:

(i) Project component

The project is to transmit clean water from Umbulan to Wonocolo reservoir to serve three PDAMs along the route to Surabaya with an average of 4 m^3/s, 24 hours a day.

The major components are as follows:

- Intake facilities at Umbulan Spring
- Transmission facilities including pipes with a diameter of 60 inches and control equipment
- Distribution facilities to PDAM including offtake, branch channel and control equipment
- Wonocolo reservoir with a capacity of 25,000 m^3

(ii) Allocation of additional water (source; Selayang pandang Proyek Air Bersih Umbulan)

			(l/sec)
i)	Pasuruan Regency(PDAM Pasuruan)		95
ii)	Industrial Estate in Pasuruan		140
iii)	PDAM Sidoarjo;	Sidoarjo Porong	140
		Sidoarjo Kota	280
		Sidoarjo Taman	325
		Sidoarjo Waru	325
iv)	PDAM Gresik		700
v)	PDAM Surabaya		2,045
	Total		4,050

According to the above source, the present water allocation will be maintained by using the existing transmission facilities except for irrigation and fishery.

Other information including implementation schedule and project cost is not available for the Study.

(2) Existing Water1 Supply Projects and Plans in Lower Solo River Basin

Outline of the existing water supply projects or projects including water supply component in the Lower Solo river basin and Lamong river which basin is located eastern side of the Solo river are summarized below based on the information from the Bengawan Solo River Basin Project Office and related previous study reports:

Project /Plan	River	Status of Project	Water Supply
Sembayat Barrage	Solo	D/D Finished	7.0 m^3/s to Surabaya, Gresik and Bangkalan(Madura)
Jabung Retarding Basin	Solo	D/D On-going	5.0 m^3/s to Gresik
Private Water Supply	Solo	Existing	1,000 l/s to P.T.Petrokimia
Lamong I	Lamong	Existing	100 l/s to Gresik
Lamong II	Lamong	D/D On-going	100 l/s to Gresik
Lamong Reservoir	Lamong	Preliminary study	Gresik

(a) **Sembayat Barrage**

The Sembayat Barrage project in the Lower Solo river basin is planned to supply for irrigation, fishery, domestic and industrial waters and to prevent salt-water intrusion.

(i) Location and Development Scale

The proposed Sembayat Barrage will be located at Sukowati village, Kecamatan Bungah, Kabupaten Gresik, East Java, which location is approximately 34 km upstream from the Solo river mouth as shown in Figure A6-2. The barrage will be of gated weir with total width of 300 m. The reservoir will have gross and effective storage volumes of approximately 53 million m^3 and 32 million m^3, respectively as well as surface area of 1,280 ha. The inundation area is expected to cover a village residential area of about 30 ha and agricultural area of 460 ha, according to the Feasibility Report on Sembayat Barrage Project (1990).

This project may have difficulty purchasing the flood plain lands, which lie within the existing flood dike along the length of the long storage.

(ii) Previous Study

- Feasibility Study of the Sembayat Barrage Development Plan, the Solo River Basin Development Project(1990)
- Detailed Design of the Sembayat Barrage Development Project (1992)

Design of the barrage was incorporated but none for water transmission facility.

(iii) Water Supply

According to the feasibility study report, the discharge of 18 m^3/sec could be allocated by the Sembayat Barrage in dry season as follows:

i)	Irrigation water	6.28	m^3/s
	- Left bank side (3,752 ha)	(1.126	m^3/s)
	- Right bank side (17,181 ha)	(5.154	m^3/s)
ii)	Fish pond water	2.72	m^3/s
iii)	Domestic and Industrial water	7.00	m^3/s
iv)	Maintenance flow for downstream	2.00	m^3/s

(iv) Domestic and Industrial Water Supply Project

The raw water of 7.0 m^3/s is planned to be transmitted to Surabaya and its vicinity area through 30 km pipeline. A new treatment plant will be facilitated in the Waduk Manyar, about 13 km from the barrage site.

The water will be allocated for the following three users:

i)	PDAM Gresik	2.13	m^3/s
ii)	PDAM Surabaya	2.07	m^3/s
iii)	Kabupaten Bangkalan	2.80	m^3/s
	Total	7.00	m^3/s

(b) Jabung Retarding Basin

The Lower Solo River Improvement Project comprises three components, namely Dike system, Floodway and Jabung Retarding Basin including Babat Barrage. The Jabun retarding basin and Babat barrage works are under detailed design and will be constructed as Phase II of the Project. The locations of the Jabung retarding basin and the Babat barrage are illustrated in Figure A6-3.

After the completion of Phase II development, the following water storage might be available for the dry season water requirement though allocation of water is not specified yet:

	Storage Capacity (million m^3)	Requirement
Floodway	2.9	Dry season requirement around Sedayu Lawas in coastal area
Reservoir of Babat Barrage	25.3	Water supply to downstream reaches of the Solo river
Jabung Retarding Basin	112	- do -

2 Selection of Promising Projects

2.1 First Screening Criteria of Objective Projects

(1) Objective of Development Plan

The objective of plan formulation of the water resources development in the Study is to select adequate projects in terms of the water supply for the urban water demand including domestic and industrial ones. In order to meet with the above objectives, the following screening procedure is proposed:

(a) Main objective of the proposed projects shall be urban water supply.

(b) Other development scheme including Hydropower, Irrigation, and Flood control will not be evaluated in this study. Several projects presented in the preceding chapter, which may be prospective for the other development objectives are recommended to be studied in the other studies.

(c) Lead time of the project shall be considered.

(2) Present Situation of Water Resources Development

The Wonorejo Dam Project is to be functioning in the year 2000 as next the water supply source in the Brantas river basin to add a capacity of 5.75 m^3/s in the dry season. And then the water push back scheme also being implemented in the Wonorejo Dam Project will be added by 2.27 m^3/s to the Brantas water supply sources in 2003. This additional supply capacity, 8.02 m^3/s in total, shall be considered as committed schemes in the plan formulation.

2.2 Selection of Prospective Projects

(1) Projects of Existing Development Plans

Out of projects identified and studied in the previous studies, the following projects presented in a column have a main objective of water supply development:

No.	Project Name	Status	River (Basin)	Objectives	Effective Storage (mil.m^3)
(1)	Beng Dam (pump up)	MP	Beng, (Brantas)	WS, IR, HP	147
(2-1)	Kedungwarak Dam(pump up)	MP	Kedungwarak (Widas)	WS, IR	54
(2-2)	Ketandan Dam (interbasin)	MP	Ketandan (Widas)	IR	12
(3)	Semantok Dam	MP	Semantok (Widas)	IR, FC	40

(to be continued)

No.	Project Name	Status	River (Basin)	Objectives	Effective Storage (mil.m^3)
(4)	Kuncir Dam	MP	Kuncir (Widas)	IR, FC, HP	23
(5)	Babadan Dam (interbasin)	MP	Bendokrosok	WS, FC, HP	84
(6)	Tugu Dam	FS	Keser (Ngrowo)	WS, IR, FC	21
(7-1)	Karangkates4-5	FS	Brantas	HP	-
(7-2)	Kesamben	FS	Brantas	HP	6
(8)	Lesti III	DD	Lesti	IR, HP, SC	4
(9)	Genteng I	MP	Genteng (Lesti)	WS, HP, SC	70
(10)	Kepanjen	MP	Brantas	HP,SC	0.5
(11)	Lumbangsari	MP	Brantas	HP, SC	0.9
(12)	Konto II	MP	Konto	IR, FC, HP, SC	63

Note :WS:Urban water supply, IR:Irrigation, FC:Flood control, HP:Hydropower, SC:Sediment control,

MP:Master plan study, FS:Feasibility study, DD:Detailed design

Out of 12 proposed projects, 5 projects are assessed as promising projects for urban water supply scheme, while some of promising projects may have some difficulty for realization not only technical difficulties but also land acquisition and resettlement problem.

(2) Existing Dam and Reservoirs

In view of the development objective and storage capacity of the existing dam and reservoirs, only Sutami and Lahor dam and reservoirs are studied further in view of water supply.

Other dam and reservoirs also have serious sediment problems, however those reservoirs have no long-term regulating capacity, which is required for the water supply in dry season.

The Selorejo dam reservoir has functioned for water supply for irrigation, flood control and hydropower generation. It is said that water release from reservoir through hydropower plant is fully consumed by the irrigation water use along the Konto river itself. It is confirmed by the Study Team that river channel of the Konto river has no water at all near Kertosono even early dry season; early middle of July 1997. In view of this, it is considered that the Selorejo dam does not contribute to the water supply capacity of the Brantas river main stretch.

(3) Projects Outside Brantas River Basin

It seems that the Umbulan Bulk Water Supply Project will commence its construction procedure soon however no definite time schedule for implementation is available for the Study, as well as no required project cost.

The Sembayat Barrage Project and the Jabun Retarding Basin and Floodway Project in the Lower Solo basin has finished its detailed design by local fund and being under detailed design, respectively. In view of these projects implementation status, these two projects of river facilities portion might be implemented earlier than those proposed in the Brantas river basin.

However, the Sembayat Barrage Project has only preliminary plan of water allocation and no definite design of water conveyance facility with water treatment plant are available. In view of this, the situation seems to be similar to proposed projects in the Brantas river basin.

Jabun Retarding Basin and Floodway project is judged not to be a prospective scheme as long as urban water supply purpose is concerned, especially as an independent scheme in such reason that:

(a) Water intake at the site seems to be not feasible since it requires rather complicated facilities and operation. To intake at the Sembayat Barrage the released water from the Jabun retarding basin is more preferable.

(b) Irrigation water requirement in downstream reaches area is of rather priority.

(c) It is said that several plans of irrigation water supply are conceivable in the upstream reaches of the project site though such plan need water pump-up facilities.

The Umbulan Bulk Water Supply Project and the Sembayat Barrage Project are maintained in the list for further evaluation.

2.3 Second Screening for Selection of Candidate Projects

(1) Selection Criteria

Second screening evaluation is based on the unit water costs and related indices such as unit construction cost (total construction cost per developed water volume for a dry season) and unit operation cost (specific operation cost per developed water volume for a dry season). The prospective projects are selected on the unit water cost. The project with minimum unit water cost is recommended as the next project to the Wonorejo Dam Project.

(2) Available Water Resources for Development

Available water resources for urban water supply during dry season are preliminarily estimated by the following assumption:

(i) Dry season is defined from June to November for 180 days.

(ii) Available supply capacity(in volume) is defined as smaller one either of the effective storage capacity of a reservoir or accumulative available discharge volume for 180 days.

2.3.1 Existing Proposed Projects in the Brantas River Basin

(1) Supply Capacity

Exploitable water resources by development of the promising projects are summarized as follows:

No.	Project Name	Objective	Effective Storage of Reservoir (mil.m^3)	Available Water Resources during Dry Season(Jun. to Nov.) Discharge(m3/s)	Total Capacity (mil.m^3)
(1)	Beng Dam (pump up)	WS, IR, HP	147	9.5	147
(2)	Kedungwarak Dam(pump up)	WS	54	3.5	54
(5)	Babadan Dam (interbasin)	WS, FC, HP	84	5.4	84
(6)	Tugu Dam	WS, IR, FC	21	2.15	21
(9)	Genteng I	WS, HP, SC	70	4.5	70

WS:Urban water supply, IR:Irrigation, FC:Flood control, HP:Hydropower, SC:Sediment control, MP:Master plan study, FS:Feasibility study, DD:Detailed design

In the Beng dam case, available storage volume is equivalent to the discharge of 10.3 m^3/s. However 9.5 m^3/s is presumed based on pumping-up capacity preliminarily designed in the previous study.

(2) Construction and Operation/Maintenance Costs

(a) Construction Cost

Preliminary estimate of the construction cost of dam scheme including water pump-up storage facilities is undertaken by the Study based on the work quantity worked out in the previous studies and unit price updated in June 1997 price. The construction cost of water treatment plant is also included.

(i) Unit Price

The unit prices applied in the Definite Design Study for Wonorejo Dam Project (1992) are applied in the Study to review construction cost. Each unit price is updated in 1996 price level applying assumed escalation rate of 3% and 8% for foreign and local currency portions, respectively. The unit prices in 1992 and escalated one for 1996 are shown in Table A6-2.

(ii) Construction Cost

Construction cost for 5 schemes including the Beng dam, Kedungwarak dam, Babadan dam, Genteng dam and Konto II dam are estimated on the basis of unit price and work quantity as presented in Table A6-3. While Semantok dam, which work quantities are not available, is estimated of its total construction cost by escalating cost estimated in the previous study as well as the Tugu dam which current cost is based on the review feasibility study in 1994.

(iii) Operation and Maintenance Costs

Annual operation and maintenance cost of dam and related facilities are estimated by applying a certain rate against the direct construction cost. Applied rate in the Study are presented as follows:

- Civil works : 0.5 % of direct construction cost
- Electrical and Mechanical works : 3.0 % of direct construction cost

Other than the annual operation and maintenance cost stated above, electrical operation cost to operate water pumping-up facilities and clean water production cost are particularly incorporated in the Study.

The construction cost estimated in the Study including dam and related facilities as well as water treatment plant are shown below, which also shows annual operation costs including electricity consumption rate for pump-up schemes and treatment cost for clean water production of the individual scheme:

(unit : Rp.million in June 1997)

No.	Project Name	Construction Cost(Rp.mil. in 1997)				Annual Operation/Maintenance Cost			
		Dam etc.	Pump-up Facilities	Water Treatment Plant	Total	O/M	Electricity	Treatment	Total
(1)	Beng Dam (pump up)	87,114	46,260	269,410	399,948	2,044	2,538	44,323	48,905
(2)	Kedungwarak Dam(pump up)	18,512	62,440	99,257	180,209	1,952	3,259	16,330	21,541
(5)	Babadan Dam	427,454	-	153,139	580,593	1,786	-	25,194	26,980
(6)	Tugu Dam	152,804	-	60,972	213,776	764	-	10,031	10,795
(9)	Genteng I	271,542	-	127,617	399,159	1,379	-	20,995	22,374

Note : (1) Rp.118/kWh is applied for the electricity consumption cost
(2) Rp.300/m^3 is applied for clean water production cost

(3) Land Acquisition and Resettlement Requirement

Prior to the construction works, due activities of land acquisition and resettlement of the existing houses shall be involved in the project works by the project implementing agency. To estimate the land compensation and resettlement requirement in the Study, the Study Team carried out field reconnaissance of respective project sites including proposed dam construction site and reservoir area and have collected related information including number of houses or population in the construction area, area by land use, appropriate unit costs and so forth.

Based on the observations and information obtained through the field reconnaissance and presently available data which are very limited, the a certain conditions are assumed for the estimation of land acquisition and resettlement in dam site and reservoir area.

(a) Present Condition of the Project Site

(i) Beng dam project

The dam site is located in a narrow and shallow valley about 2 km long. Near the dam site, no cultivated land is found but forest area only where no house is located.

In the reservoir area, which is the upstream of the narrow valley, low and flat lands are extending where crop field is rather well developed including field for maize, tobacco, peanuts, banana and scarce upland paddy field. According to observations, about half of the reservoir area(650 ha) may be assumed to be for such crop field

In the reservoir area, a village is located with estimated number of houses of 1,200 in 1984 at dam crest elevation of El. 59.0 m. It looks that this village has been developed according to the reconnaissance observation and due to improvement of transportation road. The Study assumes that present number of houses may be about 1,500 by high increasing rate of approx.2.0 % annum.

(ii) Kedungwarak dam project

The dam site is located in the narrow valley with the opening of 115 m at the elevation of 173 m. Near the dam site, only forest area is found without house. About 3.5 m wide provincial road is passing by the valley. The road will not be submerged under the reservoir but some portion might be necessary to relocate.

In the reservoir area, which is a part of Mgluyu district, low and flat lands are extending where crop field is well developed including field for tobacco, peanuts, banana and upland paddy field. According to observations, about half of the reservoir area(330 ha) is assumed to be for such crop field.

In the reservoir area, a village located in the left bank of the Kedungwarak river will need resettlement. Data on total number of houses in the reservoir area is not available though it seems to be less than one fourth of that in the Beng reservoir. The Study assumes a resettlement requirement to be 350 houses.

(iii) Genteng I dam project

The dam site is in the narrow gorge between Mt. Nawang of 496 m high in the right bank and a mountain of 463 m high in left bank. About 5 m width of provincial road crossing the river in the dam construction site shall be relocated.

The reservoir area is extended in the hilly and mountainous area. Scarce and small-scale upland paddy field was observed along the rivers. Conservative assumption of 10 % of reservoir area seems to require land compensation as cultivated area.

In the reservoir area, no house was found in the site reconnaissance conducted by the Study Team. Then 10 houses per 1 km^2 are assumed to estimate resettle requirement, that is 40 houses in the Genteng I reservoir area.

(b) Unit Cost of Land Compensation and Resettlement

Based on the respective costs used or applied in some projects or master plan study in the Brantas river basin and others as shown in Table A6-4, the following unit costs are applied in the Study:

		Estimate in the Study	
1. Land Compensation			
Cultivated Field	:	Rp.130	million / ha (Beng, Kedungwarak)
		Rp.100	million / ha (Others)
Others (non-cultivated)	:	Rp. 50	million / ha (Beng, Kedungwarak)
		Rp. 40	million / ha (Others)
2. Resettlement			
- Beng, Kedungwarak	:	Rp.10	million /house
- Others	:	Rp. 8	million / house

(c) Land Compensation and Resettlement Cost of the Projects

The land compensation cost and resettlement cost of the respective projects are estimated as follows based on the requirement and unit cost estimated in the Study:

	Beng Dam		Kedungwarak Dam		Genteng I Dam		Babadan Dam		Tugu Dam	
	Q'ty	Cost (Rp.mil.)	Q'ty	Cost (Rp.mil.)	Q'ty	Cost (Rp.mil.)	Q'ty	Cost (Rp.mil.)	Q'ty	Cost (Rp.mil.)
Land Compensation										
Cultivated Field(ha)	650	84,500	330	42,900	40	4,000	100	10,000	40	4,000
Others(ha)	650	32,500	330	16,500	370	14,800	150	6,000	56	2,240
Total(ha)	1,300	117,000	660	59,400	410	18,800	250	16,000	96	6,240
Resettlement (houses)	1,500	15,000	350	3,500	40	320	30	240	180	1,440
Total		132,000		62,900		19,120		16,240		7,680

(4) Unit Water Cost

The unit water cost is worked out for the promising 5 projects applying a discount rate of 12% per annum. and price level as of June 1997.

No.	Project Name	Total Supply Capacity in mil. m^3	Total Const. Cost (Rp.mil.)	Land /Resettlement Cost (Rp.mil.)	Annual Operatin Cost (Rp.mil.)	Unit Water Cost (Rp./ m^3)
(1)	Beng Dam(pump up)	147	399,948	132,000	48,905	889
(2)	Kedungwarak Dam(pump up)	54	180,209	62,900	21,541	1,091
(5)	Babadan Dam	84	580,593	19,120	26,980	1,403
(6)	Tugu Dam	21	213,766	16,240	10,795	2,177
(9)	Genteng I	70	399,159	7,680	22,374	1,199

(5) Selection of Candidate Projects for Implementation

According to the preliminary analysis, unit water costs presented in the preceding paragraph shows that the following projects are economically advantageous as implementation candidates:

(i) Beng Dam

(ii) Kedungwarak Dam

(iii) Genteng I Dam

2.3.2 Existing Dam and Reservoirs

(1) Present Sedimentation and Storage Capacity

According to the hydrological study of the Study, the latest surveyed sediment volume in the Sutami reservoir has reached to about 78 million m^3 as of 1997. Increment of sediment volume of the reservoir foreseen in future is about 4.5 million m^3 per annum.unless unforeseen inflow by big flood is encountered.

The effective storage volumes of the Sutami and Lahor reservoir have been worked out in the Study as of 1997 at 146.6 million m^3 and 26.2 million m^3, respectively. Total effective storage at year 2020 of the Sutami and Lahor dams is estimated at about 154 million m^3 which is equivalent to annual decrease of effective storage at about 0.63 million m^3/annum. This moderate sediment inflow could be maintained by providing appropriate countermeasures, which are discussed in Chapter V.7 of the Main Report.

(2) Necessity of Reviewing Sutami Dam Operation Rule

The dam operation rule is to be reviewed by giving a high priority on domestic and industrial water supply purposes. The present rule is advantageous for the hydropower generation in view of generation efficiency, which needs water level to be kept at a rather high level.

According to the recent operation record of the Sutami and Lahor dams as summarized in Table A6-5, the water level at the beginning of dry season has kept at almost EL.272.5 m except in June 1987. While the lowest water level for 10 years was recorded at EL.259.18 m in November 1994. Those two years of 1987 and 1994 are said to be rather serious drought years, however, operated water levels were not so different from the other regular years.

The present effective storage capacity of the Sutami dam between the high water level(El.272.5 m) and the operating low water level(El.260.0 m) is about 94.5 million m^3. Additional 52 million m^3 is presently reserved which has been seldom used. To use this capacity more flexibly shall be incorporated in modification of the operation rule.

In order to use limited water resources in the Brantas river basin, a modification of reservoir operation rule of the Sutami dam should be reviewed in the Study although it might sacrifice the hydropower energy output.

2.3.3 Projects Outside Brantas River Basin

The projects to be evaluated are (i) the Umbulan Bulk Water Supply Project, and (ii) the Sembayat Barrage Project as projects outside the Brantas river basin. The features of the projects have been discussed in preceding sections.

(1) Development Scale of Water Resources

The major component of the projects of each project and its status are summarized as follows:

Project	Component	Supply Capacity in Dry Season	
		Discharge	Total Volume
Umbulan Bulk Water Supply	Pump, Pipeline, Reservoir, etc.	3.9 m^3/sec	60.7 mil. m^3
Sembayat Barrage	Barrage Pipeline, Water treatment plant	7.0 m^3/sec	108.8 mil. m^3

(2) Development Cost

Available construction cost is only that of the previous study by which current cost is estimated just conservatively, while the current implementation cost is not available for the Study. The Sembayat Barrage Project has only cost of the barrage in the detailed design level in 1992 price level, while the other component's cost depends on the estimate of the feasibility study.

Total construction cost is approximately estimated in June 1997 price level and the operation costs of the pump facility is incorporated in the evaluation. Construction and operation cost for water treatment plant of the Umbulan Bulk Water Supply Project have been disregarded to make a cost comparison on same basis with other proposed projects since the Umbulan Bulk Water Supply Project has an advantage to develop clean water from the Umbulan Spring without treatment.

(unit : Rp.million in June 1997)

Project Name	Construction Cost(Rp.mil. in 1997)				Annual Operation/Maintenance Cost			
	Barrage	Pipeline	Treatment Plant	Total	O/M	Electricity	Treatment	Total
Umbulan Bulk Water Supply	-	270,500	(0)*	270,500	8,115	5,500	-	13,615
Sembayat Barrage	164,729	158,250	266,760	589,739	5,571	38,000	4,480	48,051

Note : * Water treatment cost of the Umbulan Bulk Water Supply Project is excluded for comparison.

(3) Unit Water Cost

Project Name	Total Supply Capacity (in mil. m^3)	Total Const. Cost (Rp.mil.)	Land /Resettlement Cost (Rp.mil.)	Annual Operat'n Cost (Rp.mil.)	Unit Water Cost (Rp./ m^3)
Umbulan Bulk Water Supply	60.7	270,500	3,380	13,615	907
Sembayat Barrage	108.8	589,739	85,058	48,051	1,387

(4) Selection of Candidate Projects

The Umbulan Bulk Water Supply Project has an advantage to use clean spring water, which may disregard related costs of prime water treatment.

In addition to the economic aspect, the project is recognized by the related agencies as the committed project for implementation which commissioning year is expected to be by year 2005. In view of this situation of the Umbulan Bulk Water Supply Project, the Study assumes that the project will be commissioned in appropriate time after the Wonorejo Dam Project.

The Sembayat Barrage Project seems to be rather expensive one for urban water supply due to long water conveyance pipeline. Furthermore in view of uncertainty of budget availability and construction schedule, its implementation will be considered in the program to be after the projects in the Brantas river basin.

2.3.4 Committed and Recommended Projects

The committed and recommended(proposed) projects and its supply capacities are summarized as follows:

Priority	Project	Status	Supply Capacity(mil. m^3)	Discharge(m^3/sec)
1.	Wonorejo Dam	Under const.	89.4	5.75
1.	Wonorejo Push-back Scheme	Under const.	35.3	2.27
2.	Umbulan Bulk Water Supply	Committed	60.7	4.27
3.	Beng Dam	Recommended	147.0	9.45
4.	Kedungwarak Dam	Proposed	54.0	3.5
4.	Genteng I Dam	Proposed	70.0	4.5
5.	Sembayat Barrage	Proposed	108.8	7.0
Total			587.5	36.74

3. Recommended Development Projects

3.1 Next Project to Wonorejo and Other Promising Projects

The main portions of the on-going Wonorejo Multipurpose Dam Project will be completed in 2000 and it will serve as new water sources for domestic and industrial water supply for Surabaya area. The Push-back scheme in the project will provide additional water in dry season from 2003. Supply capacity of the dam and the Push-back scheme in dry season (6 months, June thru November) considered in the Study are 5.75 m^3/sec and 2.27 m^3/sec respectively in terms of discharge or 59.4 million m^3 and 35.3 million m^3 respectively in terms of the total supply capacity.

The main objective of the water resources development study in the Study is to recommend a next project to the Wonorejo Multipurpose Dam Project in water supply aspect.

The Study has recommended the Beng dam project as next project to be developed to meet increasing water demand especially in Surabaya area. The Beng dam project is selected as the most prospective one in water supply aspect only. Out of some prospective projects, the Beng dam has been selected as the most economical one in terms of the unit water cost.

Other than the Beng dam project, the Kedungwarak dam and the Genteng I dam projects have been evaluated as prospective ones out of the existing project plans in the Brantas river basin. Either or both project(s) will be required to be developed after the Beng dam project in case that additional supply capacity would be required to meet water demand towards 2020.

3.2 Construction and Operation/Maintenance Costs of the Projects

The construction cost of the prospective projects including Beng dam, Kedungwarak dam and Genteng I dam have been estimated by introducing unit prices applied in the Definite Design Study on Wonorejo Multipurpose Dam Project(1992) which are updated in the Study to price level in June 1997 and work quantities worked out in the previous master plan study. The estimated construction cost of respective projects are shown in Table A6-3 including direct construction cost, engineering services cost, administration services cost and physical contingency.

The construction cost as well as the annual operation and maintenance costs are summarized as follows:

(Rp.million)

Construction Cost	Beng Dam	Kedungwarak Dam	Genteng I Dam
1. Direct Dam Construction Cost	65,871	13,998	205,325
(1) Civil Construction Cost	(54,857)	(13,646)	(193,225)
(2) Mechanical Construction Cost	(2,056)	(352)	(3,099)
(3) Electrical Construction Cost	(8,957)	(0)	(9,001)
2. Engineering Cost (1. x 10 %)	6,587	1,400	20,532
3. Administration Cost (1. x 5 %)	3,294	700	10,266
I Base Cost for Dam (1.+2.+3.)	75,751	16,097	236,124
II Physical Contingency (I x 15 %)	11,363	2,415	35,419
III Total Construction Cost for Dam and Related Facilities (I+II)	87,114	18,512	271,542
IV Pump-up Facilities	46,260	62,440	-
V Water Treatment Facilities	269,410	99,257	127,617
VI Total Construction Cost of the Project (III + IV + V)	399,948	180,209	399,159

Annual O/M Cost	Beng Dam	Kedungwarak Dam	Genteng I Dam
(1) Dam Civil Works (1.(1) x 0.5 %)	270	67	957
(2) Mechanical Works (1.(2) x 3 %)	69	12	104
(3) Electrical Works ((1.(3)) x 3 %)	317	0	318
(4) Pump-up Facilities (IV x 3 %)	1,388	1,873	-
(5) Electricity	2,538	3,259	-
(6) Total for Dam & Pump-up Facilities	4,582	5,211	1,379
(7) Water Treatment Plant (Clean Water Production Cost)	44,323	16,330	20,995
Annual Total of O/M Cost ((6) + (7))	48,905	21,541	22,374

Note : (1) Rp.118/kWh is applied for the electricity consumption cost

(2) Rp.300/m^3 is applied for clean water production cost

4 Water Resources Development Plan

4.1 Water Demand in 2020

The study on water demand forecast towards the year 2020 is made in the Study. Total water demand in the Brantas river basin in 2020 is shown below in terms of annual total and half year total during June to November which period is defined as the drought season:

Annual Net Total Demand	:	2,642 million m^3
Net Total Demand in Drought Season	:	1,310 million m^3

4.2 Alternative Measures to Cope with Future Water Demand

In the Study, the water resources development plan aims to meet water supply requirement in 2020 to cover foreseen water deficit to be caused in a drought season (normally from June to November) of a drought year. The Study selected discharge record in 1977 as the ten-year-drought discharge for which conceivable measures shall be taken not to cause water supply deficit against forecasted water demand in 2020.

The naturalized river discharge in 1977 obtained through the hydrological analysis in the Study shows its general feature as follows:

Annual Total Naturalized Flow	:	5,808 million m^3
Naturalized Flow in Drought Season	:	819 million m^3

As seen in the above, annual flow volume exceeds much the demand in 2020, while about 634 million m^3 of deficiency in 6 months is conceived in the drought season. In order to supply such deficit, the existing water storage dam and several projects are considered as countermeasures.

(1) Existing Dam (Sutami and Lahor Reservoirs)

Estimated effective storage volume in 2020 of the Sutami and Lahor dams in total is as follows:

HWL:272.5 m - LWL 260 m	:	97 million m^3
HWL:272.5 m - LWL 246m(Sutami) /253 m(Lahor)	:	136 million m^3

Estimate of the effective storage volume in 2020 was preliminarily based on the present volume according to the latest survey in August 1997 and rather moderate sediment inflow rate obtained from recent several years' record. This moderate sediment inflow could be continued depending on the Sengguh dam's sand trapping capacity. However, the present study on maintenance of the reservoir capacity by dredging of sedimentation in the reservoir has concluded a big amount of dredging cost. Following the cost comparative study, the above figures have been worked out without consideration of future sand trapping capacity of the Sengguh dam.

(2) Wonorejo Multipurpose Dam Project and Umbulan Bulk Water Supply Project

In addition to the Sutami and Lahor dams, the following project under construction and committed for implementation will be expected to supply water to Surabaya and other area as follows:

Wonorejo Multipurpose Dam Project	:	89.4	million m^3 in 2000
(under construction)		35.3	million m^3 in 2003
Umbulan Bulk Water Supply(Committed):		60.7	million m^3 by 2005

(3) Proposed Development Projects

As described in the preceding section, the Study identified the following three prospective projects in the Brantas river basin out of which the Beng dam project is recommended as the next project to the on going Wonorejo Multipurpose Dam Project. The capacity of those dams in terms of the supply capacity in 6 months drought period and its construction cost excluding the water treatment facilities are as follows:

Project		Capacity	Construction Cost
Beng Dam	:	147 million m^3	Rp. 133,374 million
Genteng I Dam	:	70 million m^3	Rp. 271,542 million
Kedungwarak Dam	:	54 million m^3	Rp. 80,952 million

The construction cost stated above includes those for dam, related mechanical and electrical equipment and facilities, pump-up facilities, and engineering services cost, administrative services cost and physical contingencies. The construction cost for the water treatment plant and the annual operation and maintenance costs of the whole project are not included therein.

(4) Water Saving Measure in Irrigation Water Demand

The Study has proposed water saving by concrete canal lining to decrease seepage loss in the main and secondary canals of the irrigation system. Based on the FAO study, the assumption were made for respective irrigation systems in the Brantas river basin that irrigation efficiency will be improved by the following rate by canal lining as follows:

- Lodoagung system 6.5 % (irrigation efficiency : 50 % to 56.5 %)
- Brantas Delta system 3.5 % (irrigation efficiency : 50 % to 53.5 %)
- Other systems 5.0 % (irrigation efficiency : 50 % to 55.0 %)

An unit cost of canal lining has been calculated at Rp.2,735,000 per ha which is applied for the following irrigation systems:

	Irrigation Area (ha)	Demand in Drought Season (million m^3)	Possible Saving in Drought Season (million m^3)	Construction Cost (Rp. million)
Brantas Atas	1,170	10.08	0.92	3,200
Brantas Bawah	1,330	9.11	0.83	3,638
Molek	3,710	24.92	2.27	10,147
Lodoagung	11,180	95.96	11.04	28,585
Mrican Kanan	15,907	165.56	15.05	43,506
Mrican Kiri	12,090	127.53	11.59	33,066
Brantas Kiri Kediri	510	3.49	0.32	1,395
Jatimlerek	1,920	11.86	1.08	5,251
Menturus	3,320	36.52	3.32	9,080
Jatikulon	600	3.58	0.33	1,641
Delta Brantas	24,210	194.86	12.75	66,214
Subtotal				205,723
Physical Contingency(15 %)				30,858
Total	75,947	683.47	59.50	236,581

It is expected that the gross total demand of irrigation water in drought season could be saved by about 59.5 million m^3 in 2020 demand basis by concrete lining of main and secondary canals in the Brantas basin as a whole.

(5) Water Saving Measure in Industrial Water Demand

The Study has examined possible water recycling rate to improve water use efficiency of industrial water referring to the practice in Japan. Assumption used in the Study of the water recycling rate by industry to be achieved by 2020 are shown below:

Industry	:	Sugar	Paper	General	Whole
Rate of Recycling	:	45 %	43 %	52 %	49 %

In terms of gross demand of industrial water in 2020, about 242 million(annual) m^3 and 144.5 million m^3 (semi-annual; June to November) are respectively assumed to be decreased. Required cost for improvement of water use efficiency has been not estimated yet, however such cost is supposed to be shouldered by respective factories.

(6) Effective Water Resources Development and Water Saving Measures

Water demand in the drought season and supply measures including the existing, construction on going, implementation committed and proposed are summarized as follows as well as water saving measures:

	Water Demand	Water Resources and Water Saving			
		Development Capacity	Capacity Accumulated	Construction Cost	Unit Water Cost
	(million m^3)	(million m^3)	(million m^3)	(Rp.million)	(Rp/ m^3)
Net Total Demand in Drought Season (2020)	1,355				
Naturalized Flow in Drought Period (10-year drought year: Jun. - Nov. excld. excess)		716	716		
Existing Dams (estimated capacity as of 2020)					
Sutami/Lahor Dams(WL:272.5 ñ 260.0)		97	813		
Sutami/Lahor Dams(WL:260.0 ñ 246.0)		39	(852)		
Wonorejo Multipurpose Dam Project					
Wonorejo Dam		89.4	902 (941)		
Push-back Scheme		35.3	938 (977)		
Umbulan Bulk Water Supply(Committed)		60.7	998 (1,037)		
Water Saving Measures(Net saving Demand)					
Irrigation(Canal Lining : proposed)		44.6	1,043 (1,082)	236,581	922
Industry(Water Recycling : proposed)		28.9	1,072 (1,111)	-	
Water Resources Development(proposed)					
Beng Dam(dam & pump-up)		147	1,219 (1,258)	133,374	889
Genteng I Dam(dam)		70	1,289 (1,328)	271,542	1,199
Kedungwarak Dam(dam & pump-up)		54	1,343 (1,382)	80,952	1,091

Note : (1) Naturalized flow in drought period shows total discharge during 6 months of drought period excluding discharge in excess of demand in every 10 days.

(2) Accumulated capacity shown in a parenthesis shows that including the reservoir storage capacity between El.260.0 m and El.246.0 m in the Sutami and Lahor dams.

(3) Construction costs above show those excluding water treatment plant.

(4) Unit water cost is estimated based on the total construction cost including that of water treatment plant, land acquisition and resettlement costs and operation and maintenance cost.

Water demand in 2020 is forecasted in the Study at 1,355 million m^3 as shown in the table. To cope with this demand, the water resources by the projects including existing, under construction and committed ones are available for 998 million m^3(or 1,037 million m^3 in case that storage in the Sutami dam would be used up to the water level of 246 m). Insufficient supply capacity of about 320 million m^3 should be covered by the proposed water resources development projects and projects to implement water saving measures.

Development of the Beng dam project is firstly recommended to cover water deficit to be expected in the year 2020 in case of 10 year drought year. However, the Beng dam project is still insufficient for the 2020 demand and another water resources development would be required. Either of the Kedungwarak dam project or the Genteng I dam project should be considered, however, priority of development will be subject to the further stage study. The Genteng I dam project is tentatively proposed as the second one in the Study to develop after the Beng dam project, although it has economic disadvantage, according to the following reasons:

(i) Rather big supply capacity than the Kedungwarak dam project

(ii) Hydropower development will be included in the project

(iii) Advantageous location of the dam, which is at upstream, reaches of the Sutami dam.

Water saving project such as irrigation canal lining and industry water recycling need rather high cost for implementation, however those economic index in terms of the unit water cost is almost same as that of proposed water resources development in case of 10 years construction period.

The Study recommends to implement not only water resources development projects but also projects to decrease future water demand.

Operation of the Sutami and Lahor dams is recommended to use storage capacity effectively until WL.246.0 m(Sutami) in case of severe drought condition. The storage between WL.260.0 m(present operating minimum waterlevel) and WL.246.0 m shall be effectively utilized in the later period of the drought season. In such case, storage capacity should be restored earlier in the succeeding rainy season.

While in the normal year, it is preferable to keep storage capacity under WL.260.0 m as reserve capacity for unforeseen severe drought condition.

4.3 Project Implementation Program

The implementation program of the water resources development project consists of the following projects:

(1) Wonorejo dam project (under construction)

The project will be commissioned in 2000 and the push-back scheme will be in the year 2003.

(2) Umbulan bulk water supply project (construction committed)

The Umbulan Bulk Water Supply Project would be commissioned by year 2005.

(3) Beng dam project(proposed)

The Beng dam project should be completed within the year 2009 and to be available in 2010 for water supply.

(4) Genteng I dam project and/or Kedungwarak dam project(proposed)

The project(s) should be implemented between the years 2010 and 2020.

(5) Canal lining project of the existing major irrigation systems(proposed)

The construction is proposed for 10 years starting from the year 2010.

Required costs for the implementation of the proposed projects is summarized as follows:

(Unit : million Rp.)

	Construction Cost	Land and Resettlement	Annual Operation / Maintenance	Water Treatment Plant
Beng Dam	133,374	132,000	4,582/year	269,410
Genteng I Dam	271,542	19,120	1,379/year	127,617
Kedungwarak Dam	80,952	62,900	5,211/year	99,257
Canal Lining	236,581	-	2,366/year	-
Total	722,449	214,020	13,538/year	496,284

Note: Annual O/M cost does not include that for water treatment plant.

The implementation programs of the above projects are presented in Figure A6-4.

4.4 Action Plan

The action plan for a period of 1999 to 2004 for the projects included in the implementation program consists of the following activities:

(1) Preliminary investigation and survey for the Beng dam project

(a) Hydrological investigation in the project area : 1999 - 2005

(i) Waterlevel and discharge at dam site

(ii) Rainfalls in the catchment area

(iii) Waterlevel at the proposed intake site in the Brantas river

(b) Investigation of the intake site in the Brantas river and water pump-up line between the intake and Beng dam sites : 1999

(c) Investigation of land use and resettlement requirement in the project area : 1999 - 2000

(2) Pre-feasibility studies and Feasibility

(a) Arrangement of the technical assistance for the Pre-feasibility studies and Feasibility : 1999

(b) Pre-feasibility studies for the Beng dam, Genteng dam and Kedungwarak dam projects and Feasibility study for the Beng dam project : 2000 - 2001

(3) Implementation

(a) Fund arrangement for implementation : 2002

(b) Selection of the consultants for the implementation : 2002 - 2003

(c) Detailed design services for the Beng dam project : 2003 - 2004

(d) Procurement of the contractor(s) for the Beng Dam project : 2005

Table A6-1 Feature of the Proposed Water Resources Development Scheme (1/12)

Project : Beng Dam

Purposes of Development (*)

- * Supply of Domestic and Industrial Water
- * Irrigation Water Supply
- - Flood Control
- * Hydropower Generation
- - Sediment Control

Scheme : Single dam scheme, Water to be pumped up from Brantas river in rainy season

Location : 10 km west of Ploso City, 5 km from confluence of Brantas river

River Basin : Brantas river River : Beng river

Catchment Area(km^2)		:	134.0	Average Runoff(m^3/sec)	:	3.68
Reservoir	High Water Level(El., m)	:	73.0	Low Water Level(El., m)	:	52.0
	Gross Storage Capacity(mil. m^3)	:	160.0	Effective Storage Capacity(mil. m^3)	:	147.0
	Surface Area at HWL(km^2)	:	13.0			
Dam	Type	:	Earthfill			
(Main)	Crest Elevation(El.,m)	:	59.0	Crest Length(m)	:	170.0
	Dam Height(m)	:	48.0	Embankment Volume(1,000m^3)	:	366.1
Spillway	Crest Elevation(El., m)	:	55.0	Crest Width(m)	:	95.0
Diversion	Design Discharge(m^3/sec)	:	400.0			
Tunnel	Diameter(m)	:	2 x 5.5	Length(m)	:	500.0
Intake	Dimension		10 m wide	7 m high		
Headrace	Diameter(m)	:	4.0-5.0	Length(m)	:	395.0
Surge Tank	Type	:	Port type	Riser Shaft Dia.(m)	:	10.0
Penstock	Diameter(m)	:	4.0	Length(m)	:	45.0
Power	Average Firm Discharge(m^3/sec)	:	10.0	Max. Plant Discharge(m3/sec)	:	48.0
/ Energy	Gross Head(m)	:	38.0	Rated Head(m)	:	30.0
	Installed Capacity(MW x nos.)	:	12.0	Annual Energy(GWh)	:	10.4
Pump up and Waterway						
	Distance(m)	:	4,600	Gross Head(m)	:	42
	Intake Discharge(m^3/sec)	:	9.7			

- Brantas riv. to Canal	: L= 50 m	Pump Capacity :	833 kW	Annual Energy	:	3,018 MWh
- Open Canal	: L= 2,600 m					
- Canal to Reservoir	: L= 2,000 m	Pump Capacity :	5,104 kW	Annual Energy	:	18,496 MWh

Domestic and Industrial Water Supply Plan

- to Surabaya and vicinity area during dry season ; approx. 9.5 m^3/sec (6 months)

Irrigation Water Supply

- Beng irrigation scheme ; 3,200 ha

Resettlement/Compensation

- approx. 650 ha of crop field and upland paddy field
- 1,200 houses as of 1984

Project Cost(billion Rupiah in 1984 price level)

- Direct Construction Cost	:	47.2 (incld. pipeline and pump station), 26.4 for dam cost
- Administration/Engineering	:	7.1
- Physical Contingency	:	7.0
- Resettlement/Compensation Cost		
- Water Treatment Plant	:	

Source : Widas Flood Control and Drainage Project, Part-I Study(1985)

Table A6-1 Feature of the Proposed Water Resources Development Scheme (2/12 - 1)

Project : Kedungwarak Dam

Purposes of Development (*)

* Supply of Domestic and Industrial Water
* Irrigation Water Supply
- Flood Control
- Hydropower Generation
- Sediment Control

Scheme : - Dam scheme, water to be pumped up from Widas river in rainy season
- Water transfer scheme to Ketandan dam for Irrigation as alternative

Location : 13 km from confluence of Widas river

River Basin : Widas river — River : Kedungwarak river

Catchment Area(km^2)		32.0	Average Runoff(m^3/sec)	:	0.68
Reservoir	High Water Level(El., m) :	170.0	Low Water Level(El., m)	:	152.0
	Gross Storage Capacity(mil. m^3) :	57.0	Effective Storage Capacity(mil. m^3) :		54.0
	Surface Area at HWL(km^2) :	6.5			
Dam	Type :	Earthfill			
(Main)	Crest Elevation(El.,m) :	173.0	Crest Length(m)	:	115.0
	Dam Height(m) :	32.0	Embankment Volume(1,000m^3)	:	216.0
Spillway	Crest Elevation(El., m) :	170.0	Crest Width(m)	:	20.0
Diversion	Design Discharge(m^3/sec) :	198.0			
Tunnel	Diameter(m) :	5.0	Length(m)	:	300.0
Intake	Dimension	m wide	m high		
Headrace	Diameter(m) :		Length(m)	:	
Surge	Type :		Riser Shaft Dia.(m)	:	
Penstock	Diameter(m) :		Length(m)	:	

Power and Energy

Average Firm Discharge(m^3/sec) :		Max. Plant Discharge(m3/sec)	:	
Gross Head(m) :		Rated Head(m)	:	
Installed Capacity(MW x nos.) :		Annual Energy(GWh)	:	

Pump up and Pipe line

Distance(m) :	12,600	Gross Head(m)	:	127.5
Intake Discharge(m^3/sec) :	4.2			

- Brantas riv. to Canal	: L= 50 m	Pump Capacity :	515 kW	Annual Energy :	1,866 MWh
- Open Canal	: L= 7,600 m				
- Canal to Reservoir	: L= 5,000 m	Pump Capacity :	7,160 kW	Annual Energy :	25,752 MWh

Domestic and Industrial Water Supply Plan
- to Surabaya and vicinity area during dry season ; approx. .3.5 m^3/sec (6 months)

Constraints of Development
- Max. dam development scale cannot be attained due to water availability in the catchment and in Widas river

Resettlement
approx. 330 ha of crop field and upland paddy field

Project Cost(billion Rupiah in 1984 price level)
- Total Construction Cost : 41.5 (incld. pipeline and pump station), 5.89 for dam cost
- Water Treatment Plant :
- Resettlement/Compensation Cost :

Source : Widas Flood Control and Drainage Project, Part-I Study(1985)

Table A6-1 Feature of the Proposed Water Resources Development Scheme (2/12 - 2)

Scheme : Ketandan Dam

Purposes of Development (*)

- Supply of Domestic and Industrial Water
* Irrigation Water Supply
- Flood Control
- Hydropower Generation
- Sediment Control

Scheme	:	Inter-basin scheme to receive water from Kedenwarak reservoir				
Location	:					
River Basin :	Widas river			River :	Ketandan river	
Catchment Area(km^2)		:		Average Runoff(m^3/sec)	:	
Reservoir	High Water Level(El., m)	:	134.0	Low Water Level(El., m)	:	117.5
	Gross Storage Capacity(mil. m^3)	:	14.0	Effective Storage Capacity(mil. m^3)	:	11.7
	Surface Area at HWL(km^2)	:				
Dam	Type	:				
(Main)	Crest Elevation(El.,m)	:	138.6	Crest Length(m)	:	
	Dam Height(m)	:		Embankment Volume(1,000m^3)	:	
Spillway	Crest Elevation(El., m)	:	134.0	Crest Width(m)	:	40.0
Diversion	Design Discharge(m^3/sec)	:				
Tunnel	Diameter(m)	:	2.0	Length(m)	:	
Intake	Dimension			m high		
Headrace	Diameter(m)	:		Length(m)	:	
Surge Tank	Type	:		Riser Shaft Dia.(m)	:	
Penstock	Diameter(m)	:		Length(m)	:	
Power and Energy						
	Average Firm Discharge(m^3/sec)	:		Max. Plant Discharge(m3/sec)	:	1.2
	Gross Head(m)	:		Rated Head(m)	:	28.5
	Installed Capacity(MW x nos.)	:	0.27	Annual Energy(GWh)	:	

Domestic and Industrial Water Supply Plan

Irrigation Water Supply
- Lengkong area ; 1,328 ha
- Tretes South area ; 1,180 ha

Ressetlement
Forest owned by Ministry of Forest

Project Cost(billion Rupiah in 1984 price level)

- Construction Cost	:	14.96 (including irrigation facilities), 10.84(for transbasin and dam only)
- Administration/Engineering	:	3.74
- Phisical Contingency	:	3.26
- Water Treatment Plant	:	
- Ressetlement/Compensation Cost	:	3.0

Source : Widas Flood Control and Drainage Project, Part-II Study(1986)

Table A6-1 Feature of the Proposed Water Resources Development Scheme (3/12)

Scheme : Semantok Dam

Purposes of Development (*)

- Supply of Domestic and Industrial Water
* Irrigation Water Supply
* Flood Control
- Hydropower Generation
- Sediment Control

Scheme : Single dam scheme

Location : 10 km upstream from confluence of Widas riv.

River Basin : Widas river   River : Semantok river

Catchment Area(km²)		: 61.0	Average Runoff(m³/sec)	:	1.50
Reservoir	High Water Level(El., m)	: 96.5	Low Water Level(El., m)	:	80.0
	Gross Storage Capacity(mil. m³)	: 43.5	Effective Storage Capacity(mil. m³)	:	40.0
	Surface Area at HWL(km²)	: 4.5			
Dam	Type	: Earthfill			
(Main)	Crest Elevation(El.,m)	: 100.0	Crest Length(m)	:	3,570.0
	Dam Height(m)	: 43.0	Embankment Volume(1,000m³)	:	5,284.0
Spillway	Crest Elevation(El., m)	: 96.5	Crest Width(m)	:	30.0
Diversion	Design Discharge(m³/sec)	: 266.0			
Tunnel	Diameter(m)	:	Length(m)	:	
Intake	Dimension	m wide	m high		
Headrace	Diameter(m)	:	Length(m)	:	
Surge Tank	Type	:	Riser Shaft Dia.(m)	:	
Penstock	Diameter(m)	:	Length(m)	:	

Power and Energy

Average Firm Discharge(m³/sec)	:	Max. Plant Discharge(m3/sec)	:	
Gross Head(m)	:	Rated Head(m)	:	
Installed Capacity(MW x nos.)	:	Annual Energy(GWh)	:	

Domestic and Industrial Water Supply Plan

Irrigation Water Supply
- Widas extension area ; 2,250 ha

Ressetlement
approx.230 ha of paddy field

Project Cost(billion Rupiah in 1984 price level)
- Construction Cost : 73.167
- Ressetlement/Compensation Cost :
- Water Treatment Plant :

Source : Widas Flood Control and Drainage Project, Part-I Study(1985)

Table A6-1 Feature of the Proposed Water Resources Development Scheme (4/12)

Scheme : Kuncir Dam

Purposes of Development (*)

- Supply of Domestic and Industrial Water
* Irrigation Water Supply
* Flood Control
* Hydropower Generation
- Sediment Control

Scheme	:	Single dam scheme					
Location	:	15 km south-west of Nganjuk town,					
River Basin :		Widas river		River :	Kuncir river		
Catchment Area(km^2)			: 70.0	Average Runoff(m^3/sec)		:	4.91
Reservoir	High Water Level(El., m)	:	446.0	Low Water Level(El., m)		:	418.0
	Gross Storage Capacity(mil. m^3)	:	30.5	Effective Storage Capacity(mil. m^3)		:	22.5
	Surface Area at HWL(km^2)	:	1.3				
Dam	Type	:	Rockfill				
(Main)	Crest Elevation(El.,m)	:	450.5	Crest Length(m)		:	870.0
	Dam Height(m)	:	100.0	Embankment Volume(1,000m^3)		:	6,850.0
Spillway	Crest Elevation(El., m)	:	446.0	Crest Width(m)		:	95.0
Diversion	Design Discharge(m^3/sec)	:	440.0				
Tunnel	Diameter(m)	:	6.0	Length(m)		:	630.0
Intake	Dimension		7.5 m wide	10 m high			
Headrace	Diameter(m)	:		Length(m)		:	
Surge Tank	Type	:		Riser Shaft Dia.(m)		:	
Penstock	Diameter(m)	:	1.0-1.3	Length(m)		:	110.0
Power and Energy							
	Average Firm Discharge(m^3/sec)	:	-	Max. Plant Discharge(m3/sec)		:	6.6
	Gross Head(m)	:	88.0	Rated Head(m)		:	79.0
	Installed Capacity(MW x nos.)	:	4.3	Annual Energy(GWh)		:	28.3

Domestic and Industrial Water Supply Plan

Irrigation Water Supply
approx. 22.5 mil.m^3/annum.

Ressetlement
approx. 65 ha of paddy field
very few

Technical problem
Owing to the unfavourable topographic condition, this scheme is not prospective

Project Cost(billion Rupiah in 1984 price level)

- Direct Construction Cost	:	56.73
- Administration/Engineering	:	8.52
- Phisical Contingency	:	9.79
- Water Treatment Plant	:	

Source : Widas Flood Control and Drainage Project, Part-I Study(1985)

Table A6-1 Feature of the Proposed Water Resources Development Scheme (5/12)

Scheme : Babadan Dam

Purposes of Development (*)

- * Supply of Domestic and Industrial Water
- \- Irrigation Water Supply
- * Flood Control
- * Hydropower Generation
- \- Sediment Control

Scheme	: Transbasin scheme				
Location	: 8 km west from Kediri City, 5 km from confluence of Brantas riv.				
River Basin :	Bendokrosok river		River :	Bendokrosok river	
Catchment Area(km^2)	:	20.0(own)	Average Runoff(m^3/sec)	:	1.4 + 5.4
Reservoir High Water Level(El., m)	:	175.0	Low Water Level(El., m)	:	130.0
Gross Storage Capacity(mil. m^3)	:	100.0	Effective Storage Capacity(mil. m^3)	:	84.0
Surface Area at HWL(km^2)	:	2.5			
Dam Type	:	Rockfill			
(Main) Crest Elevation(El.,m)	:	179.0	Crest Length(m)	:	880.0
Dam Height(m)	:	80.0	Embankment Volume(1,000m^3)	:	8.3
Spillway Crest Elevation(El., m)	:	175.0	Crest Width(m)	:	55.0
Diversion Design Discharge(m^3/sec)	:	160.0			
Tunnel Diameter(m)	:	2 x 3.5	Length(m)	:	900.0
Intake Dimension		m wide	m high		
Headrace Diameter(m)	:		Length(m)	:	
Surge Tank Type	:		Riser Shaft Dia.(m)	:	
Penstock Diameter(m)	:		Length(m)	:	
Power and Energy					
Average Firm Discharge(m^3/sec)	:		Max. Plant Discharge(m3/sec)	:	
Gross Head(m)	:		Rated Head(m)	:	
Installed Capacity(MW x nos.)	:	9.4	Annual Energy(GWh)	:	28.1

Trans Basin Scheme

	Rivers	Catchment Area(km2)	Tunnel Length (m)
Left side	3	34.3	5,200
Right side	2	57.0	3,800
Total	5	91.3	9,000

Domestic and Industrial Water Supply Plan

- 84 mil. m^3/annum.

Irrigation Water Supply

Ressetlement

approx. 125 ha of paddy field

approx. 125 ha of upland field

Project Cost(billion Rupiah in 1984 price level)

- Direct Construction Cost	:	105.9
- Administration/Engineering	:	15.9
- Phisical Contingency	:	18.3
- Water Treatment Plant	:	
- Ressetlement/Compensation Cost	:	

Source : Widas Flood Control and Drainage Project, Part-I Study(1985)

Table A6-1 Feature of the Proposed Water Resources Development Scheme (6/12)

Scheme : Tugu Dam

Purposes of Development

- * Supply of Domestic and Industrial Water
- * Irrigation Water Supply
- * Flood Control
- - Hydropower Generation
- - Sediment Control

Scheme : Single dam scheme

Location : Upstream of Nglinggis village, Kec.Tugu, Kab. Trenggalek

River Basin : Ngrowo river | River : Keser river

Catchment Area(km^2) :			47.7	Average Runoff(m^3/sec)	:	1.4
Reservoir	High Water Level(El., m)	:	198.0	Low Water Level(El., m)	:	168.0
	Gross Storage Capacity(mil. m^3)	:	25.2	Effective Storage Capacity(mil. m^3)	:	21.2
	Surface Area at HWL(km^2)	:	0.96			
Dam	Type	:	Rockfill			
(Main)	Crest Elevation(El.,m)	:	203.0	Crest Length(m)	:	595.0
	Dam Height(m)	:	63.0	Embankment Volume(1,000m^3)	:	3,491.0
Spillway	Crest Elevation(El., m)	:	198.0	Crest Width(m)	:	70.0
Diversion	Design Discharge(m^3/sec)	:	251.0			
Tunnel	Dimension(m)	:	(3) x 3 x 3	Length(m)	:	226.0
Intake	Dimension		6 m wide	3 m high		
Headrace	Diameter(m)	:		Length(m)	:	
Surge Tank	Type	:		Riser Shaft Dia.(m)	:	
Penstock	Diameter(m)	:		Length(m)	:	
Power and Energy						
	Average Firm Discharge(m^3/sec)	:		Max. Plant Discharge(m3/sec)	:	
	Gross Head(m)	:		Rated Head(m)	:	
	Installed Capacity(MW x nos.)	:		Annual Energy(GWh)	:	

Domestic and Industrial Water Supply Plan

2.15 m^3/s in dry season to Surabaya and its vicinity area thru close conduit from Sember Gayam weir to Wudu river

Irrigation Water Supply

Substitute irrigated area : 250 ha

Ressetlement

180 households, small paddy fields only

(downstream alternative (C.A.=88.3 km^2)with 5 villages, 1,600 households)

Project Cost(billion Rupiah in 1994 price level)

- Construction Cost	:	96.644
- Administration/Engineering	:	10.618
- Phisical Contingency	:	11.67
- Water Treatment Plant	:	
- Ressetlement/Compensation C(	:	

Source : Review Feasibility Study and Environmental Impact analysis Tugu Dam (1995)

Table A6-1 Feature of the Proposed Water Resources Development Scheme (7/12 - 1)

Scheme : Karangkates IV, V

Purposes of Development (*)

- Supply of Domestic and Industrial Water
- Irrigation Water Supply
- Flood Control
- * Hydropower Generation
- Sediment Control

Scheme	:	Expansion of Power Generation Facilities				
Location	:	Left Abutment of the Existing Sutami Dam				
River Basin :		Brantas river		River :	Brantas river	
Catchment Area(km^2)	:	2,210.0		Average Runoff(m^3/sec)	:	
Reservoir	High Water Level(El., m) :	272.5		Low Water Level(El., m)	:	246.0
	Gross Storage Capacity(mil. m^3) :	343.0		Effective Storage Capacity(mil. m^3)	:	
	Surface Area at HWL(km^2) :	7.9				
Dam	Type :	Rockfill				
(Main)	Crest Elevation(El.,m) :	278.0		Crest Length(m)	:	750.0
	Dam Height(m) :	100.0		Embankment Volume(1,000m^3)	:	6,020.0
Spillway	Crest Elevation(El., m) :			Crest Width(m)	:	50.0
Diversion	Design Discharge(m^3/sec) :					
Tunnel	Diameter(m) :			Length(m)	:	
Intake	Dimension	7.6 m wide		7.6 m high		
Headrace	Diameter(m) :	7.6		Length(m)	:	551.5
Surge Tank	Type :	Port type		Riser Shaft Dia.(m)	:	13.0
Penstock	Diameter(m) :	2 x 4.5		Length(m)	:	279.0
Power and Energy						
	Average Firm Discharge(m^3/sec) :			Max. Plant Discharge(m3/sec)	:	137.4
	Gross Head(m) :			Rated Head(m)	:	82.5
	Installed Capacity(MW x nos.) :	2 x 50.0		Annual Energy(GWh)	:	

Domestic and Industrial Water Supply Plan

Irrigation Water Supply

Ressetlement

Project Cost(billion Rupiah in 1996 price level)

- Construction Cost	:	188.218
- Administration/Engineering	:	18.922
- Phisical Contingency	:	20.704
- Water Treatment Plant	:	
- Ressetlement/Compensation Cost	:	

Source : Feasibility Study of Kesamben HEPP(1997)

Table A6-1 Feature of the Proposed Water Resources Development Scheme (7/12 - 2)

Scheme : Kesamben Dam

Purposes of Development (*)

- Supply of Domestic and Industrial Water
- Irrigation Water Supply
- Flood Control
- * Hydropower Generation
- Sediment Control

Scheme	:	Single dam scheme					
Location	:	10.3 km downstream of Sutami Dam					
River Basin :		Brantas river		River :	Brantas river		
Catchment Area(km²)		:	2,274.0	Average Runoff(m³/sec)		:	65.1
Reservoir	High Water Level(El., m)	:	180.5	Low Water Level(El., m)		:	
	Gross Storage Capacity(mil. m³)	:	6.6	Effective Storage Capacity(mil. m³)		:	6.2
	Surface Area at HWL(km²)	:	0.9				
Dam	Type	:	Gated Weir				
(Main)	Crest Elevation(El.,m)	:	171.0	Crest Length(m)		:	30.0
	Dam Height(m)	:	11.5	Embankment Volume(1,000m³)		:	-
Spillway	Crest Elevation(El., m)	:		Crest Width(m)		:	
Diversion	Design Discharge(m³/sec)	:	954.0				
Tunnel	Diameter(m)	:		Length(m)		:	393.0
Intake	Dimension	7.2 m wide		7.2 m high			
Headrace	Diameter(m)	:		Length(m)		:	
Surge Tank	Type	:		Riser Shaft Dia.(m)		:	
Penstock	Diameter(m)	:		Length(m)		:	
Power and Energy							
	Average Firm Discharge(m³/sec)	:		Max. Plant Discharge(m3/sec)		:	308.9
	Gross Head(m)	:		Rated Head(m)		:	13.7
	Installed Capacity(MW x nos.)	:	2 x 18.5	Annual Energy(GWh)		:	

Domestic and Industrial Water Supply Plan

Irrigation Water Supply

Ressetlement

Project Cost(billion Rupiah in 1996 price level)

- Construction Cost	:	160.15
- Administration/Engineering	:	16.02
- Phisical Contingency	:	17.62
- Water Treatment Plant	:	
- Ressetlement/Compensation Co	:	

Source : Feasibility Study of Kesamben HEPP(1997)

Table A6-1 Feature of the Proposed Water Resources Development Scheme (8/12)

Scheme : Lesti III Dam

Purposes of Development(*)

- Supply of Domestic and Industrial Water
* Irrigation Water Supply
- Flood Control
* Hydropower Generation
* Sediment Control

Scheme	:	Single dam scheme				
Location	:	Bridge in Tawangrejeni village				
River Basin :		Lesti river		River :	Lesti river	
Catchment Area(km^2) :			382.2	Average Runoff(m^3/sec)	:	
Reservoir	High Water Level(El., m)	:	342.5	Low Water Level(El., m)	:	341.5
	Gross Storage Capacity(mil. m^3)	:	7.4	Effective Storage Capacity(mil. m^3)	:	4.0
	Surface Area at HWL(km^2)	:	1.1			
Dam	Type	:	Rockfill			
	Crest Elevation(El.,m)	:	346.0	Crest Length(m)	:	390.0
	Dam Height(m)	:	30.0			
	Embankment Volume(1,000m^3)	:	146.4			
Spillway	Crest Elevation(El., m)	:	336.9	Crest Width(m)	:	
	Capacity(m^3/sec)	:	1,146.0			
Diversion Tunnel	Design Discharge(m^3/sec)	:	547.0			
	Diameter(m)	:		Length(m)	:	
Intake	Dimension	m wide		m high		
Headrace Tunnel	Diameter(m)	:		Length(m)	:	
Surge Tank	Type	:		Riser Shaft Dia.(m)	:	
Penstock	Diameter(m)	:		Length(m)	:	
Power and Energy						
	Average Firm Discharge(m3/sec)	:		Max. Plant Discharge(m3/sec)	:	62.6
	Gross Head(m)	:		Rated Head(m)	:	23.2
	Installed Capacity(MW x nos.)	:	3 x 4.2	Annual Energy(GWh)	:	27.4

Domestic and Industrial Water Supply Plan

Irrigation Water Supply

4,520 ha	Right side of the river	1,462 ha
	Right side of the river	3,058 ha

Ressetlement

Scarce

Project Cost

- Total Construction Cost(excld. irrigation facilities; $1,000 in 1983 price level) 34,072
- Total Construction Cost (irrigation facilities; billion Rp. in 1994 price level) 20.236
- Ressetlement/Compensation Cost :

Source : 1. Survai, Investigasi & Desain Detail Pada Proyek Bendungan Lesti III , 1983
2. Review Detail Design, Survey and Investigation Work for Lesti III project, 1994

Table A6-1 Feature of the Proposed Water Resources Development Scheme (9/12)

Project : Genteng I Dam

Purposes of Development (*)

* Supply of Domestic and Industrial Water	* Hydropower Generation
- Irrigation Water Supply	* Sediment Control
- Flood Control	

Scheme : Transbasin scheme

Location : 2 km southeast of Dampit

River Basin : Lesti river — River : Genteng river

Catchment Area(km^2)		: 98.7 + 61.8		Average Runoff(m^3/sec)	:	10.1
Reservoir	High Water Level(El., m)	:	436.0	Low Water Level(El., m)	:	408.5
	Gross Storage Capacity(mil. m^3)	:	86.0	Effective Storage Capacity(mil. m^3)	:	70.0
	Surface Area at HWL(km^2)	:	4.1			

Transbasin Scheme	Catchment area(km2)	Tunnel length(km)
K.Juwok-K.Gangsil	7.0	1.00
K.Gangsil - K.Genteng	20.0	0.75
K.Manjung	35.0	2.00

Dam	Type	:	Rockfill			
(Main)	Crest Elevation(El.,m)	:	441.0	Crest Length(m)	:	460.0
	Dam Height(m)	:	82.0	Embankment Volume(1,000m^3)	:	3,000.0
Spillway	Crest Elevation(El., m)	:	436.0	Crest Width(m)	:	130.0
Diversion	Design Discharge(m^3/sec)	:	916.0			
Tunnel	Diameter(m)	:	2 x 7.5	Length(m)	:	700.0
Intake	Dimension		5 m high	8 m wide		
Headrace	Diameter(m)	:	4.4	Length(m)	:	70.0
Surge Tank	Type	:		Riser Shaft Dia.(m)	:	
Penstock	Diameter(m)	:	2.1 - 3.1	Length(m)	:	250.0
Power and Energy						
	Average Firm Discharge(m^3/sec)	:	10.7	Max. Plant Discharge(m3/sec)	:	38.0
	Gross Head(m)	:	72.0	Rated Head(m)	:	63.0
	Installed Capacity(MW x nos.)	:	18.6	Annual Energy(GWh)	:	54.9

Domestic and Industrial Water Supply Plan
70 mil. m^3/anum

Sediment Control
0.32 mil. m^3/annum

Resettlement
Scarce

Other Technical Issues

Project Cost(billion Rupiah in 1984 price level)

- Direct Construction Cost	:	68.9
- Administration/Engineering	:	10.3
- Physical Contingency	:	11.9
- Water Treatment Plant	:	
- Resettlement/Compensation Cost	:	

Source : Widas Flood Control and Drainage Project, Part-I Study(1985)

Table A6-1 Feature of the Proposed Water Resources Development Scheme (10/12)

Scheme : Kepanjen Dam

Purposes of Development (*)
- Supply of Domestic and Industrial Water
- Irrigation Water Supply
- Flood Control
* Hydropower Generation
* Sediment Control

Scheme	:	Run-of-river type hydropower development					
Location	:	20km south of Malang City, 5 km upstream of the Sengguruh dam					
River Basin :		Brantas river		River :	Brantas river		
Catchment Area(km^2)		:	912.0	Average Runoff(m^3/sec)		:	23.6
Reservoir	High Water Level(El., m)	:	316.5	Low Water Level(El., m)		:	314.0
	Gross Storage Capacity(mil. m^3)	:	1.3	Effective Storage Capacity(mil. m^3)		:	0.5
	Surface Area at HWL(km^2)	:	0.24				
Dam	Type	:	Earthfill				
(Main)	Crest Elevation(El.,m)	:	320.0	Crest Length(m)		:	150.0
	Dam Height(m)	:	20.0	Embankment Volume(1,000m^3)		:	70,000.0
Spillway	Crest Elevation(El., m)	:	306.5	Crest Width(m)		:	27.0
Diversion	Design Discharge(m^3/sec)	:	600.0				
Tunnel	Bottom Width(m)	:	10.0	Length(m)		:	250.0
Intake	Dimension		10 m wide	11.5 m high			
Headrace	Diameter(m)	:		Length(m)		:	
Surge Tank	Type	:		Riser Shaft Dia.(m)		:	
Penstock	Diameter(m)	:	4.0	Length(m)		:	90.0
Power and Energy							
	Average Firm Discharge(m^3/sec)	:	7.5	Max. Plant Discharge(m3/sec)		:	36.0
	Gross Head(m)	:	22.5	Rated Head(m)		:	20.3
	Installed Capacity(MW x nos.)	:	6.0	Annual Energy(GWh)		:	32.5

Domestic and Industrial Water Supply Plan

Irrigation Water Supply

Ressetlement
river course only

Project Cost(billion Rupiah in 1984 price level)

- Construction Cost	:	15.67
- Administration/Engineering	:	2.35
- Phisical Contingency	:	2.70
- Water Treatment Plant	:	
- Ressetlement/Compensation Cost	:	

Source : Widas Flood Control and Drainage Project, Part-I Study(1985)

Table A6-1 Feature of the Proposed Water Resources Development Scheme (11/12)

Scheme : Lumbangsari Dam							
Purposes of Development (*)							
- Supply of Domestic and Industrial Water				* Hydropower Generation			
- Irrigation Water Supply				* Sediment Control			
- Flood Control							
Scheme	:	Run-of-river type hydropower development					
Location	:	12km south of Malang City, 9 km upstream of the Kepanjen damsite					
River Basin :		Brantas river		River :	Brantas river		
Catchment Area(km²)			: 842.0	Average Runoff(m³/sec)		:	29.4
Reservoir	High Water Level(El., m)	:	374.5	Low Water Level(El., m)		:	373.0
	Gross Storage Capacity(mil. m³)	:	5.7	Effective Storage Capacity(mil. m³)		:	0.9
	Surface Area at HWL(km²)	:	0.7				
Dam	Type	:	Earthfill				
(Main)	Crest Elevation(El.,m)	:	378.0	Crest Length(m)		:	200.0
	Dam Height(m)	:	28.0	Embankment Volume(1,000m³)		:	126.0
Spillway	Crest Elevation(El., m)	:	365.0	Crest Width(m)		:	27.0
Diversion	Design Discharge(m³/sec)	:	560.0				
Tunnel	Bottom Width(m)	:	12.0	Length(m)		:	270.0
Intake	Dimension	13 m wide		11.5 m high			
Headrace	Diameter(m)	:		Length(m)		:	
Surge Tank	Type	:		Riser Shaft Dia.(m)		:	
Penstock	Diameter(m)	:	5.0	Length(m)		:	75.0
Power and Energy							
	Average Firm Discharge(m³/sec)	:	12.6	Max. Plant Discharge(m3/sec)		:	60.0
	Gross Head(m)	:	23.5	Rated Head(m)		:	21.8
	Installed Capacity(MW x nos.)	:	10.8	Annual Energy(GWh)		:	46.9
Domestic and Industrial Water Supply Plan							
Irrigation Water Supply							
Ressetlement river course only							
Project Cost(billion Rupiah in 1984 price level)							
- Construction Cost		:	25.65				
- Administration/Engineering		:	3.85				
- Phisical Contingency		:	4.42				
- Water Treatment Plant		:					
- Ressetlement/Compensation Cc		:					

Source : Widas Flood Control and Drainage Project, Part-I Study(1985)

Table A6-1 Feature of the Proposed Water Resources Development Scheme (12/12)

Scheme : Konto II Dam

Purposes of Development (*)

- Supply of Domestic and Industrial Water
* Irrigation Water Supply
* Flood Control
* Hydropower Generation
* Sediment Control

Scheme	:	Transbasin scheme				
Location	:	3 km downstream from Pujon, 10 km upatream from Solorejo dam				
River Basin :		Konto river		River :		Konto river
Catchment Area(km^2)		: 107+61.0		Average Runoff(m^3/sec)	:	5.06 + 2.09
Reservoir	High Water Level(El., m)	:	1,000.0	Low Water Level(El., m)	:	944.0
	Gross Storage Capacity(mil. m^3)	:	73.0	Effective Storage Capacity(mil. m^3)	:	63.0
	Surface Area at HWL(km^2)	:	22.0			
Transbasin Scheme						
	Upstream of K.Brantas and K.Konto					
	Catchment Area(km^2)	:	61.0	Tunnel Length(m)	:	7,900.0
Dam	Type	:	Rockfill			
(Main)	Crest Elevation(El.,m)	:	1,004.0	Crest Length(m)	:	585.0
	Dam Height(m)	:	120.0	Embankment Volume(1,000m^3)	:	9,300.0
Spillway	Crest Elevation(El., m)	:	1,000.0	Crest Width(m)	:	130.0
Diversion	Design Discharge(m^3/sec)	:	400.0			
Tunnel	Diameter(m)	:	2 x 4.5	Length(m)	:	945.0
Intake	Dimension		8 m high	5 m wide		
Headrace	Diameter(m)	:	3.5	Length(m)	:	5,525.0
Surge Tank	Type	:	Port Type	Riser Shaft Dia.(m)	:	8.0
Penstock	Diameter(m)	:	2.5	Length(m)	:	1,645.0
Power	Average Firm Discharge(m^3/sec)	:	5.0	Max. Plant Discharge(m3/sec)	:	24.0
/Energy	Gross Head(m)	:	350.0	Rated Head(m)	:	310.0
	Installed Capacity(MW x nos.)	:	31 x 2	Annual Energy(GWh)	:	179.6

Irrigation Water Supply

63 mil. m^3/anum

Sediment Control

10 mil. m^3/anum

Ressetlement

Scarce

OtherTechnical Issues

Transbasin development will be favourable for power generation purpose due to much power head, however, runnoff for Brantas main reaches from such basin will be decreased

Project Cost(billion Rupiah in 1984 price level)

- Direct Construction Cost	:	153.30
- Administration/Engineering	:	23.00
- Phisical Contingency	:	26.45
- Water Treatment Plant	:	
- Ressetlement/Compensation Cost	:	

Source : Widas Flood Control and Drainage Project, Part-I Study(1985)

Table A6-2 Unit Price Applied in Wonorejo Dam Project

(Price Level in 1992 for Definite Plan Study and Updated for June 1997)

Description	Unit	Unit Price('92)			Unit Price('97)		
		F.C(Yen)	L/C(Rp.)	Rp. Equiv.	F.C(Yen)	L/C(Rp.)	Rp. Equiv.
EXCAVATION							
Open, Common	m^3	324	2,123	7,307	338	3,121	10,353
Open, Wea. rock	m^3	480	3,093	10,773	501	4,547	15,260
Open, Rock	m^3	727	4,374	16,006	758	6,430	22,657
Open, Trench	m^3	571	3,216	12,352	596	4,728	17,472
Tunnel, All classes	m^3	6,736	42,174	149,950	7,026	61,996	212,345
Tunnel, Shaft&inclined	m^3	7,060	43,642	156,602	7,364	64,154	221,734
Backfill	m^3	481	2,929	10,625	502	4,306	15,042
EMBANKMENT							
Dam Embankment, Core	m^3	563	3,155	12,163	587	4,638	17,204
Dam Embankment, Filter	m^3	550	3,242	12,042	574	4,766	17,042
Dam Embankment, Coarse filter	m^3	514	2,797	11,021	536	4,112	15,584
Dam Embankment, Random	m^3	481	2,929	10,625	502	4,306	15,042
Dam Embankment, Rock	m^3	1,042	4,819	21,491	1,087	7,084	30,342
Dam Embankment, Selected rock	m^3	1,172	5,464	24,216	1,222	8,032	34,191
CONCRETE WORKS							
Concrete, Open Structure	m^3	5,113	61,657	143,465	5,333	90,636	204,759
Concrete, Tunnel Structure	m^3	8,033	76,548	205,076	8,378	112,526	291,824
Formwork, Open structure	m^2	753	7,538	19,586	785	11,081	27,888
Formwork, Tunnel structure	m^2	2,985	4,103	51,863	3,113	6,031	72,657
Reinforcement bars	ton	69,380	537,936	1,648,016	72,363	790,766	2,339,341
DRILLING&GROUTING							
Drilling, Consolidation, Tunnel	m	1,206	6,188	25,484	1,258	9,096	36,015
Drilling, Curtain, Tunnel	m	7,993	22,120	150,008	8,337	32,516	210,922
Drilling, Blanket&consoli. Dam	m	5,782	38,399	130,911	6,031	56,447	185,502
Drilling, Curtain, Dam	m	6,938	46,078	157,086	7,236	67,735	222,592
Backfill grouting	m^3	10,175	52,708	215,508	10,613	77,481	304,589
Grouting, Consolidation, Tunnel	ton	49,498	269,302	1,061,270	51,626	395,874	1,500,679
Grouting, Curtain, Tunnel	ton	49,498	269,302	1,061,270	51,626	395,874	1,500,679
Grouting, Blanket&consoli. Dam	ton	49,498	269,302	1,061,270	51,626	395,874	1,500,679
Grouting, Curtain, Dam	ton	49,498	269,302	1,061,270	51,626	395,874	1,500,679
OTHERS							
Rockbolt(25 mm dia)	m	2,673	6,019	48,787	2,788	8,848	68,510
Permanent steel support	ton	131,143	379,786	2,478,074	136,782	558,285	3,485,423
Shotcrete	m^2	2,907	19,035	65,547	3,032	27,981	92,866
Structural Steel	ton	253,200	1,800,000	5,851,200	264,088	2,646,000	8,297,475
MAIN DISTRIBUTION PIPE							
Diameter 700 mm	m	0	596,376	596,376	0	876,673	876,673
800 mm	m	0	674,181	674,181	0	991,046	991,046
900 mm	m	0	752,184	752,184	0	1,105,710	1,105,710
1000 mm	m	0	1,026,654	1,026,654	0	1,509,181	1,509,181
1100 mm	m	0	1,128,491	1,128,491	0	1,658,882	1,658,882
1200 mm	m	0	1,226,312	1,226,312	0	1,802,679	1,802,679
1300 mm	m	0	1,324,329	1,324,329	0	1,946,764	1,946,764
1400 mm	m	0	1,425,340	1,425,340	0	2,095,250	2,095,250
1500 mm	m	0	1,523,150	1,523,150	0	2,239,031	2,239,031
1600 mm	m	0	1,767,955	1,767,955	0	2,598,894	2,598,894
1800 mm	m	0	2,147,754	2,147,754	0	3,157,198	3,157,198
WATER TREATMENT PLANT							
		mil Y.	mil. Rp.				
Plant Capacity	m^3/sec	866	6,150	19,998	903	9,041	28,359

Table A6-3 Construction Cost Estimate (1/4)

Project : Beng Dam

	WORK	Unit	Quantity	Unit Price (10^3 Rp.)	Amount (10^6 Rp.)	Note
			Price Level : June 1997			
I.	**CONSTRUCTION COST**					
1.	**Civil Works**				54,857	
1-1	Preparatory Works	L.S.			3,336	
1-2	Diversion Works					
	(1) Excavation (earth)	m³	8,600	10.4	89	
	(rock)	m³	12,900	22.7	292	
	(tunnel)	m³	33,600	212.4	7,135	
	(2) Steel Support	ton	350	3,485.4	1,220	
	(3) Concrete	m³	13,740	291.8	4,009	
	(4) Reinforcement Bar	ton	687	2,339.3	1,607	
	(5) Consolidation Grout (D)	m	3,170	36.0	114	
	(G)	ton	22	1,500.7	33	
	Subtotal				14,500	
1-3	Dam					
	(1) Excavation (earth)	m3	52,000	10.4	538	
	(rock)	m3	52,000	22.7	1,178	
	(2) Embankment (earth & filter)	m3	484,700	17.0	8,259	
	(rock)	m3	17,000	30.3	516	
	(3) Curtain & Blanket Grout(D)	m	10,600	222.6	2,360	
	(G)	ton	74	1,500.7	111	
	Subtotal				12,851	
1-4	Spillway					
	(1) Excavation (earth)	m³	108,600	10.4	1,124	
	(rock)	m³	162,900	22.7	3,691	
	(2) Concrete	m³	28,100	204.8	5,755	
	(3) Reinforcement Bar	ton	562	2,339.3	1,315	
	(4) Backfill	m³	18,500	15.0	278	
	Subtotal				12,163	
1-5	Waterway					
	(1) Excavation (earth)	m³	3,000	10.4	31	
	(rock)	m³	2,000	22.7	45	
	(tunnel)	m³	8,200	212.3	1,741	
	(2) Steel Support	ton	82	3,485.4	286	
	(3) Concrete	m³	6,700	291.8	1,955	
	(4) Reinforcement Bar	ton	337	2,339.3	788	
	(5) Consolidation Grout(D)	m	1,500	36.0	54	
	(G)	ton	11	1,500.7	16	
	Subtotal				4,824	
1-6	Power house					
	(1) Excavation (earth)	m³	14,800	10.4	153	
	(rock)	m³	22,200	22.7	503	
	(2) Concrete	m³	8,000	204.8	1,638	
	(3) Reinforcement Bar	ton	400	2,339.3	936	
	(4) Architectural Works	L.S.			1,915	
	(5) Utility Works	L.S.			2,029	
	Subtotal				7,173	
2.	**Metal Works**				2,056	
2-1	Gate, Screen	ton	94	8,054.6	757	
2-2	Penstock	ton	236	4,510.6	1,064	
2-3	Hollow Jet Valve	ton	12	19,550.0	235	
3.	**Generating Equipment incld. T/L**	L.S.			8,957	
	TOTAL of I.				65,871	
4.	Engineering Services				6,587	
5.	Administration (5% of I.)				3,294	
6.	**BASE COST (I.+4.+5.)**				75,751	
7.	Physical Contingency				11,363	
	GRAND TOTAL (6.+ 7.)				87,114	

Source (Quantity) : Widas F/C & D/R Study
Unit Price : Definitive Plan Study on Wonorejo Multipurpose Sam Project (1992)
Updated to June 1997 price level by this study

Table A6-3 Construction Cost Estimate (2/4)

Project : Kedungwarak Dam

WORK		Unit	Quantity	Unit Price (10' Rp.)	Amount (10' Rp.)	Note
			Price Level : June 1997			
I.	**CONSTRUCTION COST**					
1.	Civil Works				13,646	
1-1	Preparatory Works	L.S.			776	
1-2	Diversion Works					
	(1) Excavation (earth)	m3	23,000	10.4	238	
	(rock)	m3	23,000	22.7	521	
	(tunnel)	m3	7,800	212.4	1,656	
	(2) Steel Support	ton	90	3,485.4	314	
	(3) Concrete	m3	3,600	291.8	1,051	
	(4) Reinforcement Bar	ton	140	2,339.3	328	
	(5) Consolidation Grout (D)	m	0	36.0	0	
	(G)	ton	0	1,480.6		
	Subtotal				4,107	
1-3	Dam					
	(1) Excavation (earth)	m3	35,000	10.4	362	
	(2) Embankment (earth)	m3	188,000	17.0	3,204	
	(filter)	m3	16,000	17.0	273	
	(riprap)	m3	12,000	34.2	410	
	(3) Curtain & Blanket Grout(D)	m	8,700	222.6	1,937	
	(G)	ton	61	1,500.7	91	
	Subtotal				6,277	
1-4	Spillway					
	(1) Excavation (earth)	m3	26,000	10.4	269	
	(rock)	m3	26,000	22.7	589	
	(2) Concrete	m3	5,700	204.8	1,167	
	(3) Reinforcement Bar	ton	114	2,339.3	267	
	(4) Slope protection	m2	2,800	69.2	194	
	Subtotal				2,486	
1-5	Waterway					
	(1) Excavation (earth)	m3	0	10.4	0	
	(rock)	m3	0	22.7	0	
	(tunnel)	m3	0	212.4	0	
	(2) Steel Support	ton	0	3,485.4	0	
	(3) Concrete	m3	0	291.8	0	
	(4) Reinforcement Bar	ton	0	2,339.3	0	
	(5) Consolidation Grout(D)	m	0	36.0	0	
	(G)	ton	0	1,500.7		
	Subtotal				0	
1-6	Power house					
	(1) Excavation (earth)	m3	0	10.4	0	
	(rock)	m3	0	22.7	0	
	(2) Concrete	m3	0	204.8	0	
	(3) Reinforcement Bar	ton	0	2,339.3	0	
	(4) Architectural Works	L.S.			0	
	(5) Utility Works	L.S.			0	
	Subtotal				0	
2.	Metal Works				352	
2-1	Steel pipe	ton	13	4,510.6	59	
2-2	Hollow Jet Valve	ton	15	19,550.0	293	
3.	Generating Equipment incld. T/L	L.S.			0	
	TOTAL of I.				13,998	
4.	Engineering Services (10% of I.)				1,400	
5.	Administration (5% of I.)				700	
6.	**BASE COST (I.+4.+5.)**				16,097	
7.	Physical Contingency				2,415	
	GRAND TOTAL (6.+ 7.)				18,512	

Source (Quantity) : Widas F.C &D.R Study
Unit Price : Definitive Plan Study on Wonorejo Multipurpose Sam Project (1992)
Updated to June 1997 price level by this study

Table A6-3 Construction Cost Estimate (3/4)

Project : Genteng I Dam

			WORK	Unit	Price Level : June 1997			Note
					Quantity	Unit Price (10^3 Rp.)	Amount (10^6 Rp.)	
I.	CONSTRUCTION COST							
1.	Civil Works						193,225	
1-1	Preparatory Works			L.S.			11,021	
1-2	Diversion Works							
	(1) Excavation (earth)			m3	55,000	10.4	580	
		(rock)		m3	56,000	22.7	1,269	
		(tunnel)		m3	82,000	212.4	17,413	
	(2) Steel Support			ton	610	3,485.4	2,126	
	(3) Concrete			m3	28,000	291.8	8,170	
	(4) Reinforcement Bar			ton	1,000	2,339.3	2,339	
	(5) Consolidation Grout(D)			m	0	36.0	0	
		(G)		ton	0	1,500.7		
	Subtotal						31,897	
1-3	Dam							
	(1) Excavation (earth)			m3	185,000	10.4	1,925	
		(rock)		m3	80,000	22.7	1,813	
	(2) Embankment (core)			m3	494,000	17.2	8,497	
		(filter)		m3	142,000	17.0	2,420	
		(rock)		m3	2,484,000	30.3	75,365	
	(3) Concrete			m3	7,000	204.8	1,433	
	(4) Reinforcement Bar			ton	210	2,339.3	491	
	(5) Curtain & Blanket Grout(D)			m	34,000	222.6	7,568	
		(G)		ton	238	1,500.7	357	
	Subtotal						99,869	
1-4	Spillway							
	(1) Excavation (earth)			m3	100,000	10.4	1,035	
		(rock)		m3	200,000	22.7	4,530	
	(2) Concrete			m3	61,500	204.8	12,593	
	(3) Reinforcement Bar			ton	1,230	2,339.3	2,877	
	(4) Slope protection			m2	5,300	69.2	367	
	Subtotal						21,402	
1-5	Waterway							
	(1) Excavation(rock)			m3	7,000	22.7	159	
		(shaft)		m3	4,100	221.7	909	
	(2) Steel Support			ton	24	3,485.4	84	
	(3) Concrete			m3	5,400	291.8	1,576	
	(4) Reinforcement Bar			ton	110	2,339.3	257	
	(5) Consolidation Grout(D)			m	2,800	36.0	101	
		(G)		ton	20	1,500.7	29	
	Subtotal						3,115	
1-6	Power house							
	(1) Excavation (earth)			m3	19,500	10.4	202	
	(2) Concrete			m3	5,500	204.8	1,126	
	(3) Reinforcement Bar			ton	270	2,339.3	632	
	(4) Backfill			m3	1,500	10.4	16	
	(5) Slope Protection			m2	600	69.2	42	
	(6) Architectural Works			L.S.			1,545	
	(7) Utility Works			L.S.			1,647	
	Subtotal						5,208	
1-7	Transbasin Scheme							
	(1) Intake weir			L.S.			3,876	
	(2) Connection tunnel			L.S.			15,850	
	(3) Miscellaneous						987	
	Subtotal						20,713	
2.	Metal Works						3,099	
2-1	Gate, Screen			ton	42	8,054.6	338	
2-2	Penstock			ton	547	4,510.6	2,467	
2-3	Hollow Jet Valve			ton	15	19,550.0	293	
3.	Generating Equipment incld. T/L			L.S.			9,001	
	TOTAL of I.						205,325	
4.	Engineering Services (10% of I.)						20,532	
5.	Administration (5% of I.)						10,266	
6.	BASE COST (I.+4.+5.)						236,124	
7.	Physical Contingency						35,419	
	GRAND TOTAL (6.+ 7.)						271,542	

Source (Quantity) : Widas F/C &D/R Study
Unit Price : Definitive Plan Study on Wonorejo Multipurpose Sam Project (1992)
Updated to June 1997 price level by this study

Table A6-3 Construction Cost Estimate (4/4)

Project : Babadang Dam

WORK	Unit	Quantity	Unit Price (10^3 Rp.)	Amount (10^6 Rp.)	Note
		Price Level : June 1997			
I. CONSTRUCTION COST					
1. Civil Works				319,317	
1-1 Preparatory Works	L.S.			18,925	
1-2 Diversion Works					
(1) Excavation (earth)	m³	30,000	10.4	311	
(rock)	m³	10,000	22.7	227	
(tunnel)	m³	26,300	212.0	5,576	
(2) Steel Supon	ton	442	35.0	15	
(3) Concrete	m³	9,600	291.8	2,801	
(4) Renforcement Bar	ton	480	2,339.3	1,123	
(5) Consolidation Grout (D)	m	6,000	36.0	216	
(G)	ton	42	1,500.7	63	
Sub-total				10,331	
1-3 Dam					
(1) Excavation (earth)	m³	313,900	10.4	3,249	
(rock)	m³	313,800	22.7	7,111	
(2) Embankment (random)	m³	176,900	15.0	2,661	
(core)		821,300	17.2		
(filter)		529,100	17.0		
(rock)	m³	6,788,500	30.3	205,963	
(3) Curtain & Blanket Grout(D)	m	67,500	222.6	15,025	
(G)	ton	473	1,500.7	709	
(4) Concrete	m3	5,100	204.8	1,044	
Sub-total				235,762	
1-4 Spillway					
(1) Excavation (earth)	m³	78,000	10.4	807	
(rock)	m³	117,000	22.7	2,650	
(2) Concrete	m³	20,000	204.8	4,095	
(3) Renforcement Bar	ton	400	2,339.3	936	
Sub-total				8,488	
1-5 Waterway	L.S.			808	
1-6 Power house	L.S.			2,877	
1-7 Transbasin Scheme					
(1) Intake weir	L.S.			6,460	
(2) Connection tunnel	L.S.			35,665	
Sub-total				42,125	
2. Generating Equipment incld. T/L	L.S.			3,900	
TOTAL of 1.				323,217	
4. Engineering Services (10% of I.)				32,322	
5. Administration (5% of I.)				16,161	
6. BASE COST (I.+4.+5.)				371,699	
7. Phisical Contingency				55,755	
GRAND TOTAL (6.+ 7.)				427,454	

Source (Quantity) : Widas F/C & D/R Study

Unit Price : Definitive Plan Study on Wonorejo Multipurpose Sam Project (1992)

Updated to June 1997 price level by this study

Table A6-4 Unit Cost of Land Compensation and Resettlement

	Assumption in the Study		Reference		
			Project / Study	Condition	Unit Cost
Land Compensation					
Cultivated Field	Beng Dam , Kedungwarak Dam	: Rp. 130 million / ha	Wonorejo Dam (Const.)	-	Rp.110 million/ha
	Genteng I Dam	: Rp. 100 million / ha	Lesti III(D/D)	Estimate in 1994	Rp. 25 million /ha
Others (non-cultivated)	Beng Dam , Kedungwarak Dam	: Rp. 50 million / ha	Sungguruh Dredging Spoil Bank	-	Rp.100 million/ha
	Genteng I Dam /Others	: Rp. 40 million / ha	PKB estimate		
			- Beng Dam Kedungwarak Dam	-	Rp.130 million/ha
			- Genteng I/Others	-	Rp.100 million/ha
Resettlement	Beng Dam , Kedungwarak Dam	: Rp. 10 million / house	JABOTABEK Water Resources ManagementStudy (M/P)	Rural Area(1995)	Rp. 7 million/house
	Genteng I Dam	: Rp. 8 million / house			

Table A6-5 Reservoir Operation Record of Sutami and Lahor Dams (1987 - 1996)

		INFLOW	OUTFLOW				WATERLEVEL	
		Inflow Volume (million m³)	Turbine Flow Vol. (million m³)	Others (million m³)	Total (million m³)	Energy Output (GWh)	June 1 / Dec.1	Nov. 30 /May 31
1987-1988	D; June - Nov.	582.2	690.0	0.0	690.0	125.4	270.84	264.03
	R: Dec. - May	1,876.8	1,737.4	33.1	1,770.5	338.2	-	272.73
1988-1989	D; June - Nov.	682.6	819.5	0.4	819.9	155.5	272.34	261.78
	R: Dec. - May	1,587.8	1,431.2	4.6	1,435.8	303.2	262.73	272.33
1989-1990	D; June - Nov.	976.0	1,131.9	10.3	1,142.2	155.5	272.80	-
	R: Dec. - May	1,422.0	1,225.2	4.9	1,230.1	237.6	260.74	272.23
1990-1991	D; June - Nov.	611.1	771.3	0.1	771.4	148.3	272.23	259.91
	R: Dec. - May	1,437.3	1,275.2	1.2	1,276.4	248.9	259.89	272.34
1991-1992	D; June - Nov.	726.6	678.5	0.0	678.5	133.8	272.36	261.58
	R: Dec. - May	1,693.4	1,437.0	94.4	1,531.4	289.1	261.47	272.42
1992-1993	D; June - Nov.	1,085.9	1,165.1	1.9	1,167.0	220.7	272.34	262.74
	R: Dec. - May	1,927.8	1,746.4	75.2	1,821.6	349.5	263.47	272.35
1993-1994	D; June - Nov.	726.2	836.8	4.7	841.5	160.6	272.43	260.51
	R: Dec. - May	1,825.1	1,566.1	128.3	1,694.4	313.8	261.30	272.49
1994-1995	D; June - Nov.	626.8	750.6	0.0	750.6	142.0	272.50	259.18
	R: Dec. - May	1,480.5	1,337.4	5.6	1,343.0	258.0	259.01	272.41
1995-1996	D; June - Nov.	862.1	928.6	1.9	930.5	168.5	272.40	266.12
	R: Dec. - May	1,775.3	1,618.8	68.3	1,687.1	315.7	265.88	272.45
1996-1997	D; June - Nov.	833.0	944.6	0.0	-	177.4	272.40	259.64
	R: Dec. - May	-	-	-	-	-	-	-

Note D: Drought season R: Rainy season

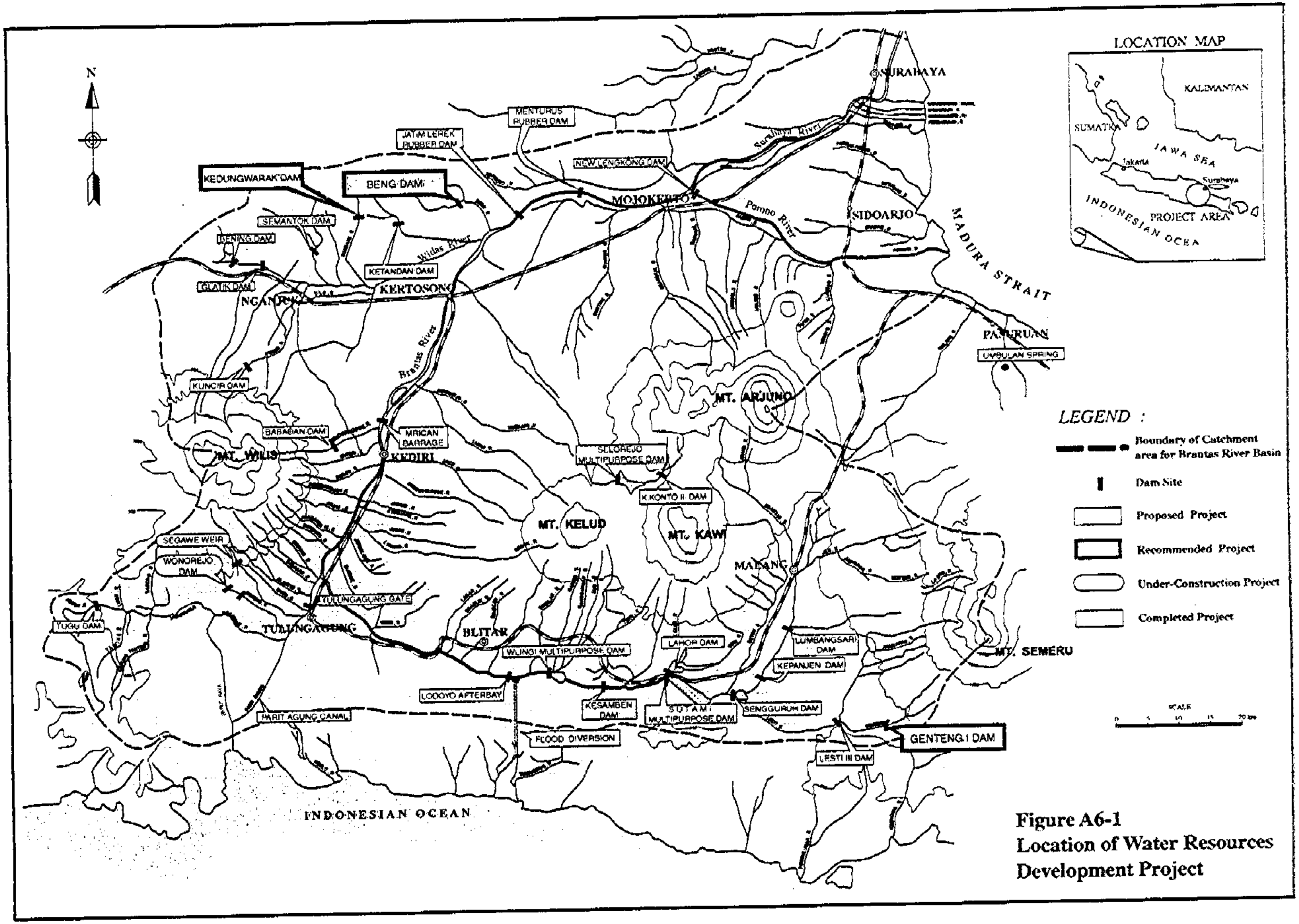
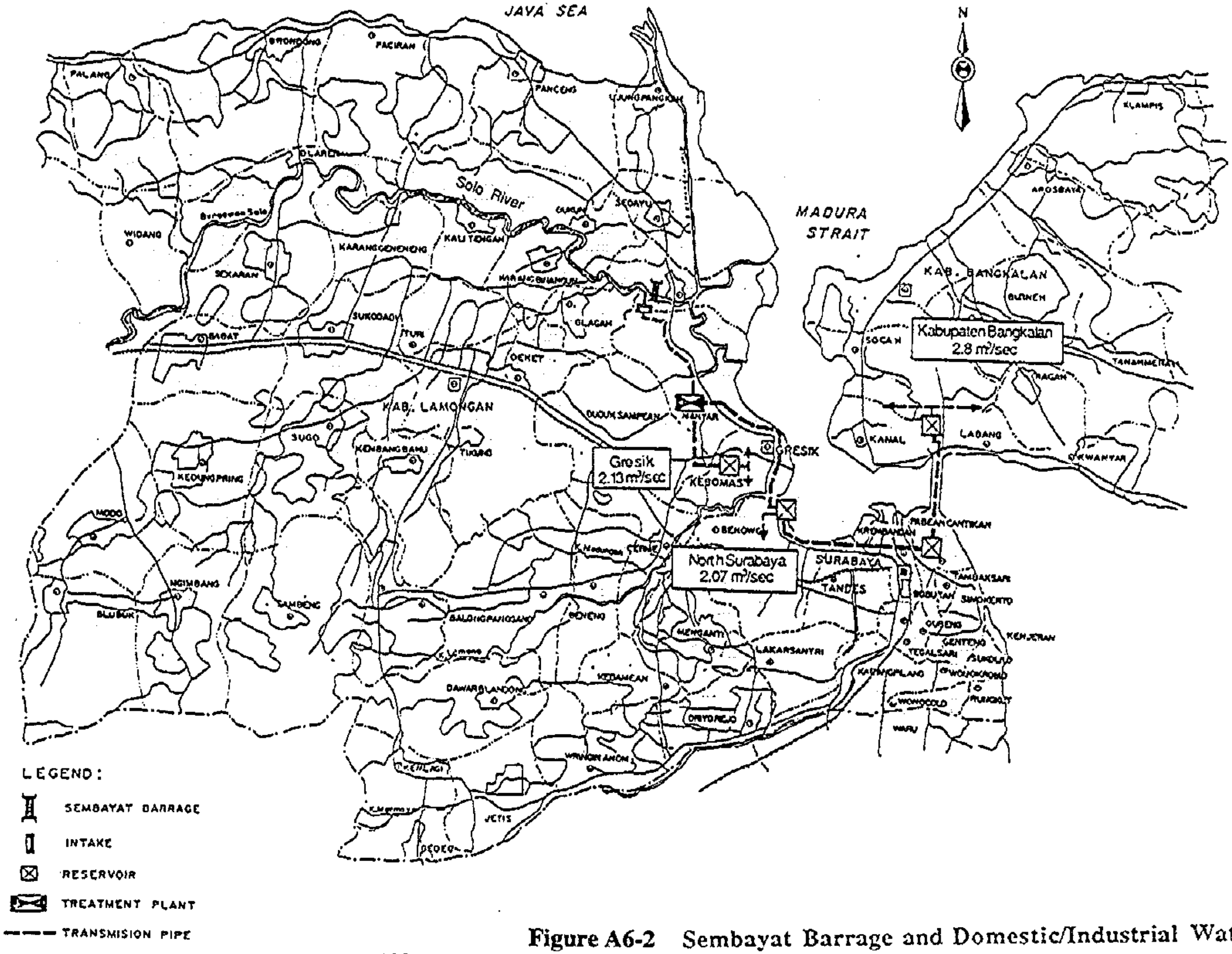


Figure A6-1
Location of Water Resources Development Project



Source :Feasibility Report on Sumbayat Barrage Project, December 1990

Figure A6-2 Sembayat Barrage and Domestic/Industrial Water Supply

Source : Definite Plan Report on Jabung Retarding Basin
and North Diversion Floodway Integrated Study, April 1994

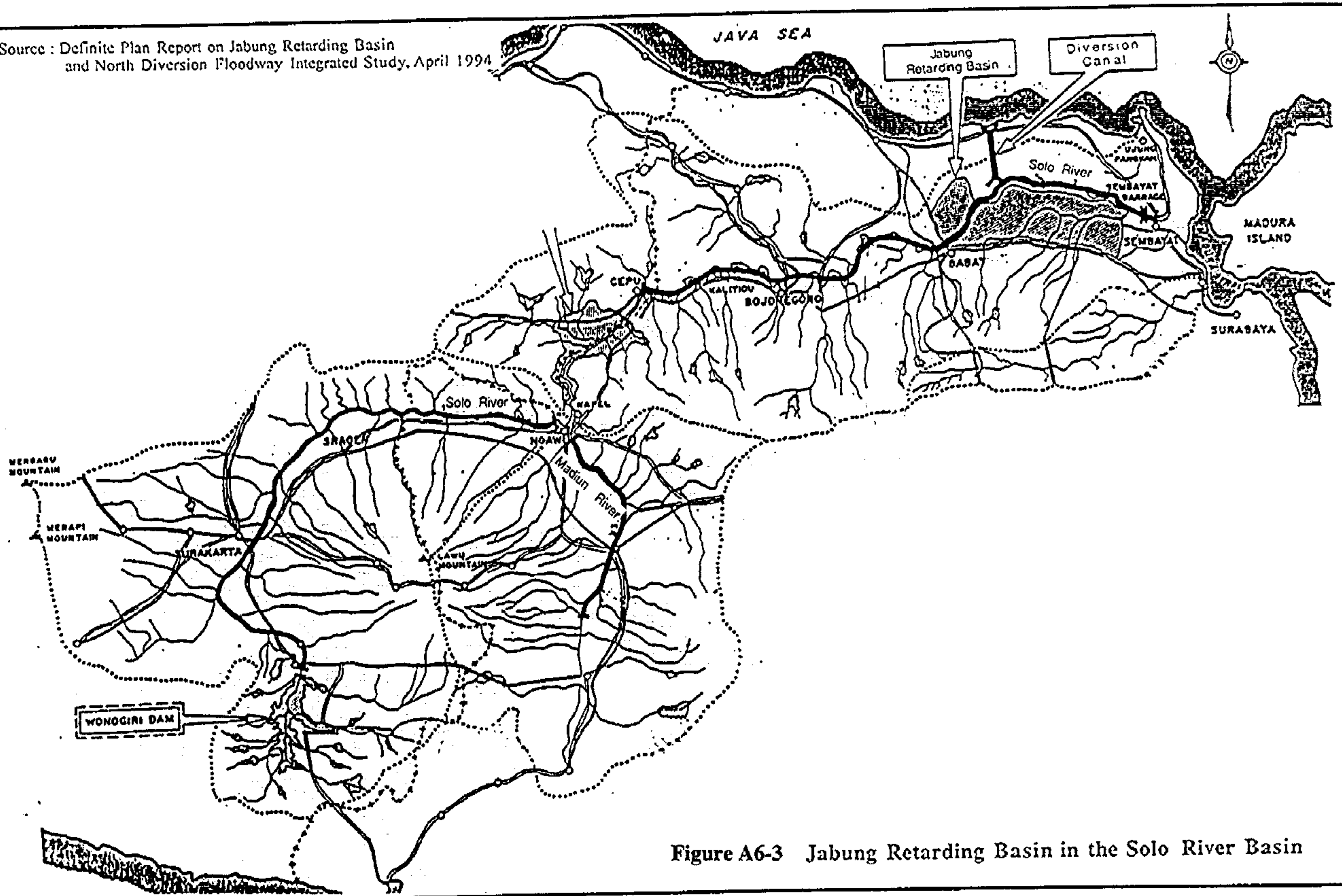


Figure A6-3 Jabung Retarding Basin in the Solo River Basin

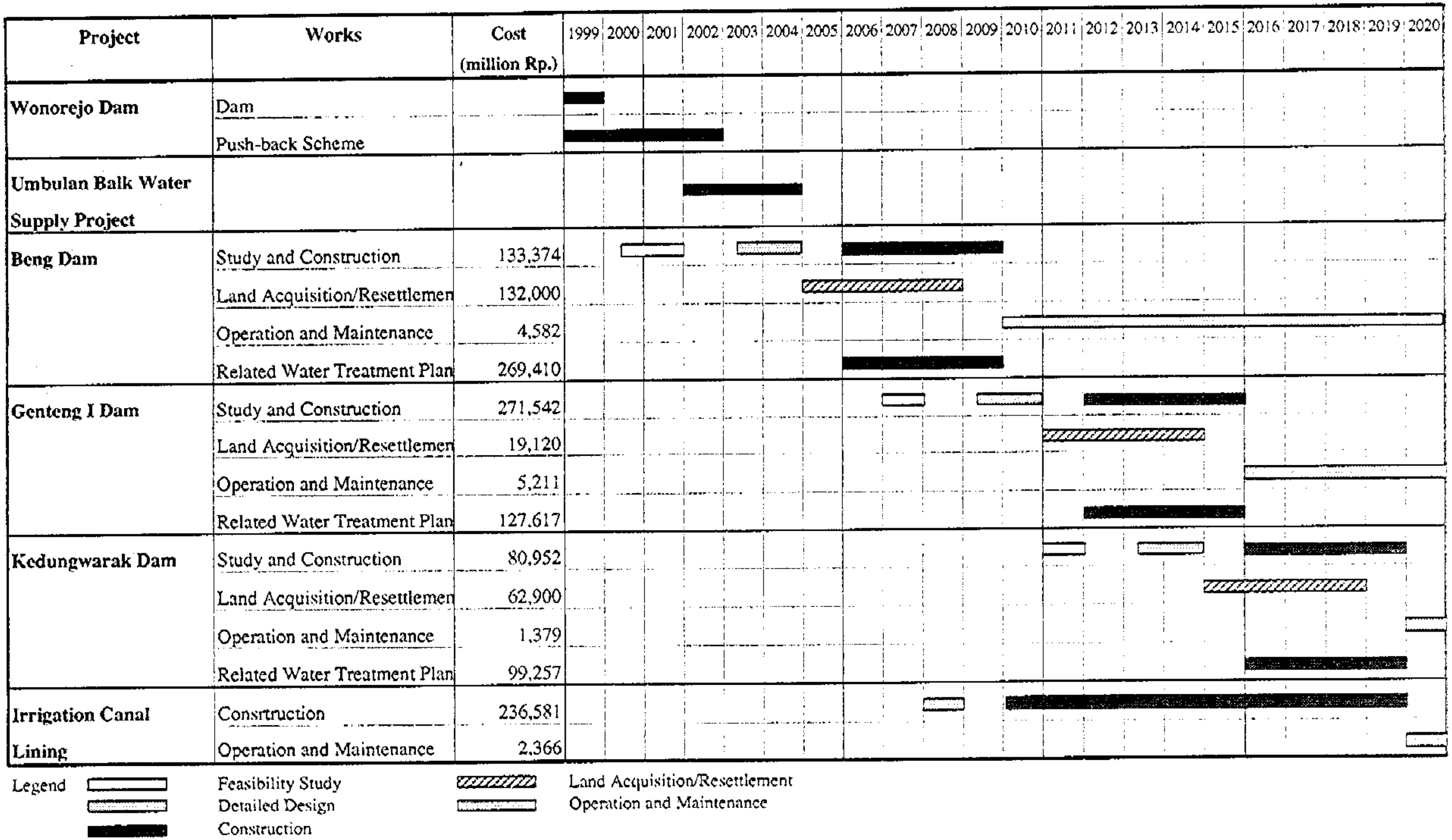


Figure A6-4 Implementation Progrm for Water Resources Development Projects

ANNEX – 7

RIVER FACILITIES

ANNEX - 7 RIVER FACILITIES

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1 Present Condition of River Facilities

Many kinds and large numbers of river facilities exist in the river courses of the Brantas river basin. They are classified into dam/reservoir, weir, dike, revetment, drainage culvert, retarding basin, groundsill, bridge, water intake, siphon, sabo dam, sand pocket, sea dike and sea dike gate. Among them, major facilities, directly related to the water management of the Brantas and Surabaya rivers, are taken up in this study. Locations of the major river facilities are shown in Figure A7-1.

(1) Dam and Reservoir

There are six dams in the Brantas river basin. Four dams, namely the Wlingi, Sutami, Lahor and Sengguruh dams are located in the upstream part of the Brantas River. The Selorejo dam and Bening dam are located in the Konto river basin and the Widas river basin, respectively. The Sutami reservoir is connected with the Lahor reservoir by a connection tunnel. Two reservoirs, therefore, are functioning as one reservoir. General features of the dams/reservoirs are shown in Table A7-1. Designed functions of the dams/reservoirs are summarized below.

Name	Flood Control	Power Generation	Low Water Enhancement		Others
			Irrigation	Domestic, Industrial	
Wlingi	-	X*1	X*2	-	X*3
Sutami	X	X*1	X	X	-
Lahor	X	X*1	X	X	-
Sengguruh	-	X*1	-	-	-
Selorejo	X	X	X	-	-
Bening	-	X	X	-	-

Note, *1: Peak power generation.
*2: Creation of water head for irrigation.
*3: Temporary storage of the erupted material from Mt. Kelud.

After the completion of the construction, the functions as fishery and recreation have become additional functions of the original ones for the dams/reservoirs, especially for the Sutami, Lahor, Selorejo and Bening dams.

The operation rules of these dams are summarized in Table A7-2. Actual operation of dams/reservoirs is now carried out in accordance with the "POLA OPERASI WADUK – WADUK" (POLA, operation pattern of reservoirs) decided by the Water Management Committee in line with three flow patterns predicted for respective rainy and dry seasons.

Performances of actual operation of six dams in late two years are presented in Figure A7-2 and tables below.

Water enhancement

Unit: Million m^3

Name of Dam	1995	1996
Sutami and Lahor	176.6	128.2
Bening	17.6	15.1
Selorejo	38.0	31.2

Source: Calculated by the Study Team based on the operation records.

Power generation

Unit: GWh

Name of Dam	1995	1996
Wlingi	160.3	154.9
Sutami and Lahor	484.6	461.8
Sengguruh	73.8	75.8
Bening	-	-
Selorejo	24.8	22.6

Source: Perusahaan Umum Jasa Tirta (PJT).

Note: Above values are based on PT PLN Payment.

The dams have been relatively well operated and maintained through the efforts by the authorities concerned to keep the essential function. However, the following problems to be solved still remain.

Sedimentation of Reservoir

According to the late survey results from PJT, effective storage capacities of the reservoirs are as follows:

(Unit: Million m^3)

Name of Reservoirs	Const. Year	Survey	Gross Storage			Effective Storage		
			Original	Survey	%	Original	Survey	%
Wlingi	1976	1996	24.0	5.0	21	5,200	1,412	27
Sutami	1972	1997	343.0	*183.4	53	253.0	*146.6	58
Lahor	1977	1995	36.1	32.9	91	29.4	26.5	90
Sengguruh	1988	1996	21.5	3.4	15	2.5	1.2	47
Selorejo	1970	1993	62.3	48.8	78	50.1	44.5	89
Bening	1982	1993	32.9	31.7	96	28.4	28.0	99

Source: PJT

Note *: calculated by the Study Team

After the eruption of Mt. Kelud in February 1990, the Wlingi reservoir was completely filled with sediment deposits. To resume the power generation, the dredging of reservoir, flushing by the spillway gates and construction of sediment bypath channel was conducted from 1990 to1996.

As for the Sengguruh reservoir, dredging works are being carried out continuously, to secure the equipment for power generation. Dredging volumes of the Sengguruh reservoir are summarized below. The volumes are not much, compared with sediment volume since the completion of construction.

Dredging Volume in Sengguruh (unit: Thousand m^3)

Year	By PJT	By Contract	Total
1993	69.5	-	69.5
1994	63.1	-	63.1
1995	50.0	350.0	400.0
1996	-	233.6	233.6

Source: PJT

Sedimentation of reservoirs became a serious problem for the Wlingi, Sutami and Sengguruh reservoirs. To secure the function of the reservoirs, establishment of basic concept on the sedimentation of the reservoirs seems to be required, as well as the study on the sedimentation in reservoirs.

Shortage of Inflow

According to the operation records, inflow to the Bening dam/reservoir is smaller than the designed one during dry season. Irrigation water supply from the Bening dam is conducted under the restricted condition. In addition, power generation is almost stopped. To use existing water resources in a maximum extent, revision of the operation rule is needed.

Enceng Gondok (Water Hyacinth)

In the Sengguruh and Wlingi reservoirs, Enceng Gondok grows thickly and chronically, due to eutrophication of water. To secure the gate operation, the said Enceng Gondok are removed by manpower continuously, the removed Enceng Gondok are burned on the bank of reservoir after drying of the Enceng Gondok. It is difficult to stop Enceng Gondok to grow completely, therefore, treatment/disposal method of removed Enceng Gondok shall be established as soon as possible.

Hollow Jet Valve

In the Sutami dam, the hollow jet valve is installed to discharge water from the dam up to the reservoir water level of El. 227.6 m. However, this hollow jet valve has been never operated. The hollow jet valve is only facility to discharge water below LWL of the reservoir. Therefore, it is recommendable to operate the hollow jet valve at least twice a year in order to examine its function.

(2) Weir

Thirteen major weirs are constructed in the Brantas river basin, and their original functions are summarized below:

Name of Weir	River	Function
Bangil Tak spillway gate	Brantas	Flood control (excess flood to Bangil Tak canal).
New Lengkong dam	Brantas	Water supply (irrigation, domestic, industrial)
Menturus rubber dam	Brantas	Water supply (irrigation)
Jatimlerek rubber dam	Brantas	Water supply (irrigation)
Mrican barrage	Brantas	Water supply (irrigation)
Lodoyo dam	Brantas	Afterbay of Wlingi dam Power generation
Jagir dam	Wonokromo	Water supply (irrigation, domestic, industrial)
Gunungsari dam	Surabaya	Water supply (irrigation, domestic, industrial)
Mlirip gate	Surabaya	Water supply (irrigation, domestic, industrial) Flood control for Surabaya river Navigation
Gubeng dam	Mas	Water supply (irrigation, domestic, industrial) Navigation
Wonokromo sluice	Mas	Water supply (irrigation, domestic, industrial) Flood control for Mas river Navigation
Tulungagung gate	Parit Agung	Irrigation water supply to Brantas river in dry season
Tulungagung inlet gate / tunnel	Parit Agung	Flood control Power generation

Most of the weirs are the water diversion facilities and have no storage capacities. Among them, however, the Lodoyo dam and Tulungagung inlet gate/tunnel have storage capacities. The storage capacity of the Lodoyo dam is used to regulate the river flow from the Wlingi dam and the hydroelectric power generation, and that of the Tulungagung inlet gate is for the hydroelectric power generation.

The Mlirip gate, Gubeng dam and Wonokromo sluice have the navigation locks. According to the local people around the sites, the navigation locks have not been used for a long time. Therefore, function of the navigation locks seems to be changed to the aspect of recreation, culture preservation and education, etc.

Five weirs in the Surabaya and Mas river basins have the function of irrigation. On the other hand, these river basins have been urbanized and industrialized rapidly. Therefore, the function of irrigation will be changed into the environmental or industrial one such as the maintenance, flushing and industrial water supply.

Outline of the operation rules of thirteen weirs is presented in Table A7-3. As shown in the table, the operation rules of eleven weirs are not revised after the construction or rehabilitation of the weirs. And two weirs consist of the Bangil Tak spillway and the Tulungagung gates are not yet established their operation rules. Past performances of the weirs in late two years are as presented in Figure A7-3 and A7-4.

Based on the actual operation performance, it can be said these weirs are relatively well operated and maintained. However, the problems, which might accelerate the deterioration of function, are indicated as below.

Name of Weir	Problem
Bangil Tak spillway gate	No use (No excess design flood)
New Lengkong dam	Enceng Gondok
Jatimlerek rubber dam	Frequent deflation from rubbers (under rehabilitation)
Lodoyo dam	Enceng Gondok, Unregulated outflow due to decrease of effective storage and operation of power generation oriented.
Jagir dam	Superannuated gate system, Water level over normal impounding HWL due to request from domestic water distributor, Rubbish.
Gunungsari dam	Enceng Gondok, Sedimentation due to backwater.
Mlirip gate	Superannuated stoplog (under rehabilitation), Enceng Gondok.
Gubeng dam	Sedimentation due to backwater, Rubbish.
Tulungagung gate	No use (No function before construction of Wonorejo dam)

Out of them, the Enceng Gondok around the New Lengkong dam and the Mlirip gate are removed by public oriented activity led by the Governor every year. Therefore, those are not serious problem for the operation and maintenance. Structures of the Jatimlerek rubber dam and the Mlirip gate are being rehabilitated by the Brantas River Basin Development Project (PKB, Proyek Pengembangan Wilayah Sungai Kali Brantas). And the sediment around the Gunungsari dam and Gubeng dam are being removed by the PJT. In addition, the Wonorejo dam is being constructed, therefore, the Tulungagung gate will work after the completion of the Wonorejo dam.

As for the Bangil Tak spillway gate, no usage of gate is a good matter. Because there are no excess design floods and no serious flood damage. On the other hand, the Bangil Tak spillway gate has no operation rule. And many parts of the waterside lands in the Bangil Tak canal, those are downstream stretches from the gate, are being used as the truck farms, houses, school, etc. Therefore, to prepare the material for judgement of gate operation by the higher authorities during the excess design flood, it is required to study the following matters:

- to grasp the land use around the Bangil Tak canal,
- to study legal aspect of land use in the Bangil Tak canal,
- to calculate the relationship of the discharges between the main river and the gate,
- to estimate damages by the outflow discharge of the gate and

- to establish of operation rule of gate.

In addition, the Bangil Tak canal shall be designated legally as the floodway/retarding basin by the DGWRD, considering above study results.

(3) Dike, Revetment, Drainage Culvert, Retarding Basin and Groundsill

To drain floodwaters safely, the flood control facilities such as the dike, revetment, drainage culvert, retarding basin and groundsill are constructed and are being operated and maintained. Locations of the facilities are shown in Figure A7-1, and the existing conditions of the structures are summarized below.

Dike

The dikes are constructed along the river course in the stretches from the Kediri City to the river mouth. And the inspection road is mostly provided on the top or side of the dikes. Most of dikes are in good condition, because of the rehabilitation works in late years. However, the dikes from the Ploso town to the Kediri City are required to repair, because of the small-scale collapses and cutting of foot by sand mining activities.

Revetment

To protect the dikes from the flood and to control the flood flow, a large number of revetments are constructed in the river course and made of concrete block, wet masonry, dry masonry and gabion. Most of the revetments are still in good condition, but the revetments located at the downstream site of the Jagir dam and the Menturus rubber dam are collapsed and broken.

Drainage Culvert

In general, most of the drainage channels in the Brantas river basin flow into the tributaries by the open channel, and the tributaries join the mainstream of the Brantas River with the open channel. Therefore, there are only five major drainage culverts in the Brantas basin, that are, three in the Porong River, one in the Brantas River and one in the Surabaya River. The drainage culvert in the Surabaya River is constructed with the pumping station which has a capacity of 10.0 m^3/s. These five culverts are still in good condition.

Retarding Basin

According to the Master Plan in 1985, three controllable retarding basins in the Widas river basin and one natural retarding basin in the upstream basin of the Brantas River were planned by using the existing natural retarding basins. The controllable retarding basins are not completed yet. At present, the natural retarding basins are changed from swamp to dry land, therefore, cultivation is seen in a part of the natural retarding basins. Publicity activities seem to be required for the easy implementation of the future construction.

Groundsill

To protect the river facilities from the river bed degradation, four groundsills are constructed. Three groundsills are well functioning and in good condition, but the groundsill located in the downstream site of the Porong Toll Road Bridge is not functioning, because the concrete blocks are washed away.

(4) **Bridge**

There are thirty (30) bridges in the stretches from river mouth of the Porong River to the Sengguruh dam of the Brantas River as shown in Figure A7-1. They are relatively well maintained through the efforts of the authorities concerned. However, the following matters can be said.

- The groups of piles are mostly used for the piers of the bridges. These piers are a cause of turbulence in the flood flow. It is desirable to use the piers of elliptic type in case of reconstruction.

- The Ploso Railway Bridge and the wrecked piers downstream of the Porong Railway Bridge are not used. The authorities concerned shall demolish these.

(5) **Water Intake**

Major water intake facilities including the intake pumping stations along the Brantas River are presented in Figure A7-1. After completion of the Menturus, Jatimlerek and Mrican weirs, the condition of the intake facilities for the irrigation was changed. Present conditions of the intake facilities are summarized as below.

Name of Intake	Purpose	Condition	Intake under new system
Voor II canal	Irrigation	Being used	Voor II canal
Voor I canal	Irrigation	Being used	Voor I canal
Ajinomoto (P)	Industry	Being used	-
Losari	Irrigation	Not used	Menturus
Gedek	Flood control	Not used	-
Gempolkerep (P)	Industry	Can not be used	Gempolkerep
Gumbongan	Irrigation	Can not be used	Menturus
Kedungsari (P)	Irrigation	Can not be used	Kedungsari
Watespinggir (P)	Irrigation	Can not be used	Menturus
Keboan	Irrigation	Can not be used	Menturus
Menturus	Irrigation	Being used	Menturus
Bebekan	Irrigation	Can not be used	Jatimlerek
Tapen (P)	Industry	Can not be used	Jatimlerek
Gotan	Irrigation	Not used	Jatimlerek
Jatimlerek	Irrigation	Being used	Jatimlerek
Bunder I (P)	Irrigation	Being used	Bunder I

Name of Intake	Purpose	Condition	Intake under new system
Tunggorono	Irrigation	Can not be used	Turitunggorono
Turipinggir	Irrigation	Can not be used	Turitunggorono
Pengkol	Irrigation	Can not be used	Pengkol
Kedungkudi (P)	Industry	Being used	Kedungkudi
Bunder II (P)	Irrigation	Can not be used	Bunder II
Besuk	Irrigation	Can not be used	Besuk
Banjarsari	Irrigation	Not used	Warujayeng
Warujayeng	Irrigation	Being be used	Warujayeng
Turitunggorono	Irrigation	Being used	Turitunggorono
(P)	Industry	Being used	-
Old Mrican	Irrigation	Being used	Warujayeng
Lodagung	Irrigation	Being used	Lodagung

Note (P) is a pump station.

*[1] Source: "A Water Quality Monitoring and Pollution Control Program for Brantas River Basin Master Plan" Volume 12 MAIN INTAKE.

It can be said the intake facilities, which are not necessary to use, shall be demolished, in the viewpoint of the flood control.

Based on the operation record, past performances of the major intakes are shown in Table A7-4 and the yearly intake discharges are summarized below.

Unit: Million m^3

Name of Intake	1995		1996	
	Pola	Actual	Pola	Actual
Voor I and II canals	685.79	1153.43	653.09	1161.98
Mlirip	630.72	1581.06	632.45	1326.21
Menturus	53.44	49.32	54.12	84.28
Jatimlerek	30.28	29.09	29.08	35.14
Warujayeng	235.14	256.89	231.15	232.29
Turitunggorono	226.14	250.91	246.98	250.55
Lodagung	242.42	239.82	245.17	246.39

According to the actual performance, residual water is almost allocated to the intakes in the downstream area of the Basin. It is urgently required to establish the rule for allocation of the residual water and forecasting system of the low flow discharge in the basin.

(6) Siphon

There are two siphons in the Porong and Brantas River, that are, Bangil Tak siphon for the irrigation and the Watudakon siphon for the flood control. Locations of the siphons are shown in Figure A7-1. Both siphons are in good condition through the rehabilitation works.

(7) Sabo Dam and Sand Pocket

The sabo dams and sand pockets are constructed in three areas of the Brantas river basin. The numbers of the sabo dams and sand pockets and the responsible agencies of the construction, operation and maintenance are summarized below.

Area	Number of Dam/Pockets	Construction By	O & M By
Upper basin of Sengguruh dam	5	PKB, PJT	PJT
Mt. Kelud area	127	PGKS	PGKS
Upper Basin of Selorejo dam	30	PKB, PJT	PJT

Source: PJT, PGKS

The number of sabo dams and sand pockets is 162 in total, and they are almost full of sediment.

(8) Sea Dike and Sea Dike Gate

From the northern part to the eastern part of Surabaya City, there are seven gates and the continuous sea dike. Their major function is to prevent the sea water intrusion to the land. In addition, the Morokrembangan Boezem and the gate are also constructed in the northwestern part of Surabaya City, to ease the drainage condition to the sea.

The sea dikes are still in good condition, but the sea dike gates except one gate are deteriorated and has less function due to the corrosion of metal parts, clogging with stones and trash. The sea dike gates require repair and/or renewal. The Morokrembangan Boezem and the gate are relatively well maintained through the rehabilitation works.

2 Present Organization for Operation, Maintenance and Rehabilitation (OMR)

2.1 Responsible Agency

Executing agencies responsible for OMR of the above-mentioned river facilities are divided into eight authorities, except the sugar factories that own the trolley bridges. Out of those, PJT is basically responsible for the rivers and most of the river structures. PLN is responsible for power generating equipment including the penstocks, DPU Pengairan for the intake facilities of irrigation and drinking water, PKB for large-scale rehabilitation works, PGKS for the sabo facilities around Mt. Kelud.

Executing agencies responsible for OMR of the river facilities are summarized below.

Facility	Executing Agency		
	Operation	Maintenance	Rehabilitation
1. Dam/Reservoir	PJT	PJT	PJT, PKB
- Dam/Reservoir	PJT	PJT	PJT, PKB
- Power Generation	PLN	PLN	PLN
2. Weir	PJT, DPU Pengairan	PJT	PJT, PKB
3. Dike Revetment, etc.	PJT	PJT	PJT, PKB
4. Bridge			
- Road	DPU Bina Marge, PJM	DPU Bina Marga PJM	DPU Bina Marga PJM
- Railway	PERUMKA	PERUMKA	PERUMKA
- Trolley	Sugar Factory	Sugar Factory	Sugar Factory
5. Water Intake	PJT, DPU Pengairan	PJT, DPU Pengairan	PJT, PKB DPU Pengairan
6. Siphon	DPU Pengairan	DPU Pengairan	PKB
7. Sabo Dam/Sand Pocket	PJT, PGKS	PJT, PGKS	PJT, PKB, PGKS
8. Sea Dike/Gate	DPU Pengairan	DPU Pengairan	DPU Pengairan, PKB

PJT: Perusahaan Umum Jasa Tirta

PKB: Proyek Brantas

PLN: Perseroan Terbatas Perusahaan Listrik Negara

PGKS: Proyek Gunung Kelud dan Semeru

DPU Pengairan: Dinas Pekerjaan Umun Pengairan (Propinsi Jawa Timur)

DPU Bina Marga: Dinas Pekerjaan Umum Bina Marga (Propinsi Jawa Timur)

PJM: Perseroan Terbatas Jasa Marga

PERUMKA: Perusahaan Umum Kereta API

2.2 Organization for OMR in PJT

(This section was described based on the organization as of August 1997.)

As mentioned above, most of the river facilities are operated and maintained by PJT. Within the organization of PJT (refer to the ANNEX 12. Organization Development of PJT in the Supporting Report II), two bureaus perform planning including development, programming and monitoring of the OMR works. That is, Research and Development Bureau for planning including development, and Programming and Controlling Bureau for programming and monitoring. Two divisions mainly perform the actual OMR works for the river facilities in accordance with the planning and programming established by above two bureaus. Responsibilities and objective facilities for two divisions are described as follows.

Division of Upstream Water Service

- OMR works of the river facilities from the confluence of the Ngrowo River and the Brantas River to the Sengguruh dam, including the Selorejo dam.
- Monitoring and control of water supply, water quality, sand mining and land utilization
- Major facility
  Sub Division of Upstream Water Services 1: Sengguruh dam, Sutami dam and Lahor dam
  Sub Division of Upstream Water Services 2: Wlingi dam, Lodoyo dam and Selorejo dam
  Sub Division of Upstream Water Services 3: Tulungagung gate, Tulungagung outlet gate and tunnels.

Division of Downstream Water Service

- OMR works of the river facilities from the confluence of the Ngrowo River and the Brantas River to the river mouth of the Porong River, including the Surabaya and Mas rivers.
- Monitoring and control of water supply, water quality, sand mining and land utilization.
- Sub division and Major facility
  Sub Division of Downstream Water Services 1: Bening dam, Mrican Barrage, Menturus rubber gate.
  Sub Division of Downstream Water Services 2: New Lengkong dam, Mlirip gate.
  Sub Division of Downstream Water Services 3: Gunungsari dam, Gubeng dam.

Table A7-5 shows the number of staff in the two divisions by the activity and the table below summarize the numbers of staff and vehicles.

(Unit: nos.)

Sub Division	Staff	Vehicle	
		Car	Motorcycle
Upstream Water Service 1	45	9	6
Upstream Water Service 2	45	5	3
Upstream Water Service 3	22	2	1
Downstream Water Service 1	53	6	3
Downstream Water Service 2	30	2	2
Downstream Water Service 3	28	9	2

Source: PJT (as of August 1997)

In addition, for the OMR works of the river facilities, the equipment shown in Table A7-6 is prepared. Number of staff and the equipment seem to be enough for the OMR works under the condition that the repair works and the rehabilitation works are carried out by the contracting system.

3 Problem and Recommendation for Present OMR Works of River Facilities

Regarding the present condition of the river facilities and the organization of their OMR works mentioned in above-chapters, the following problems and recommendations are identified and made.

Problems

- At present, five authorities (PJT, PKB, PLN, DPU Pengairan and PGKS) are mainly responsible for the OMR works of the river facilities in the Brantas river basin. However, there is no authority to grasp the present condition of the OMR works for all of the river facilities in the basin. Because there is no overall inventory of the river facilities in the basin.

- Although the dams/reservoirs are the trunk facilities for the water use in the Brantas river basin, there are serious problems to be solved and there are no established measures. It seems that there is no responsible authority to plan and control the OMR works for all of the river facilities in the basin.

- Repairs of the flood control facilities are delayed in comparison with the well-maintained water-use facilities. The cost of these activities would have to be borne by the Government. On the other hand, PJT did not get the national budget (APBN) for maintenance of the flood control facilities. A cause of delay is considered that the allocation of the OMR budget between the flood control and the water use is not definite.

Recommendation

- Overall inventory of the river facilities should be made, to perform the OMR works of the facilities more efficiently and steadily. The inventory shall include the following item.

  a) Name of facilities
  b) Location including map
  c) Authority responsible for the OMR works
  d) Function
  e) Dimension of facilities
  f) General layout of facilities

- One responsible authority of the water resources management should perform the OMR works of major river facilities in the basin. In this aspect, PJT shall become a candidate of this authority.

- The allocation rule of OMR budget should be established. And PJT shall request the national budget for the flood control to the Government.

4 Improvement of Operational Function of The Existing River Facilities

As described in the preceding chapters, there are some problems to hinder the original function of river facilities and those problems are summarized as Table A7-7. Out of them, problems due to sediment in the Sengguruh, Sutami, Wlingi and Lodoyo reservoirs are most serious in consideration of water use.

4.1 Measures for Sediment in Sengguruh and Sutami Reservoirs

(1) Present Condition of Sediment

The Sutami dam is located on the upstream stretches of the Brantas River approximately 35 km south of Malang City and has a catchment area of 2,050 km^2. The Sengguruh dam is located at approximately 14-km upstream site of the Sutami dam and has a catchment area of 1,659 km^2. The original functions of two dams are summarized as follows.

Name of dam	Function
Sengguruh dam	- Peak power generation (by daily use of storage capacity)
Sutami dam	- Flood control (by use of storage capacity from FWL to HWL) - Peak power generation - Water supply for irrigation, domestic and industrial use

According to the previous survey results of the reservoirs by PJT, Longitudinal profiles of two reservoirs are presented in Figures A7-4 and A7-5 and present storage capacities below HWL are summarized below:

Unit: million m^3

Name of Reservoir	HWL	LWL	Compl.	Survey	Gross storage			Effective storage		
					Original	Survey	%	Original	Survey	%
Sengguruh	292.5	291.4	1988	Jul.1996	21.5	3.4	15.8	2.5	1.2	48.0
Sutami	272.5	246.0	1972	Oct.1997	343.0	*183.4*	*53.5*	253.0	*146.6*	*57.9*
Lahor*	272.7	253.0	1977	Oct.1997	36.1	32.9	91.1	29.4	26.5	90.1

Note: * as a reference.

Source: Perum Jasa Tirta. *Italic* figures are estimated by the Study Team.

According to the figures and above table, large reductions of the effective storage volumes are seen in the Sengguruh and Sutami reservoirs.

The Sengguruh dam is single purpose facility. Decrease of the effective storage capacity of the Sengguruh reservoir is only causing decrease of the operation hours of the peak power generation. However, in case of silting up of the Sengguruh reservoir, sediment discharge from the upstream basin will flow into the Sutami reservoir and be deposited therein. The Sutami dam is multi-purpose facility. In addition, The Sutami dam is the only facility on the mainstream of the Brantas River, to enhance water in dry season and to control flood discharge in rainy season. Therefore, decrease of the storage capacity due to sediment in the Sutami reservoir is most serious problem of the water use in the Brantas river basin.

Based on the previous survey results and present dredging works, sediment volumes in the Sengguruh and Sutami reservoirs are re-estimated from the storage volumes by the Study Team as presented in Figure V7-7 and average annual sediment volumes are summarized below:

Name Of Reservoir	Period	Average Annual Sediment		Remarks
		Volume ($10^6 m^3$/year)	Specific (m^3/km^2/year)	
Sengguruh (A=1,659 km2)	1988 – 1993 (5)	3.55	2,138	1988: Completion of construction
	1993 – 1996 (3)	0.90	543	
	1988 – 1996 (8)	2.55	1,539	
Sutami (A=2,050km2)	1977 – 1982 (5)	8.08	3,939	
	1982 – 1987 (5)	5.78	2,818	
	1987 – 1997 (10)	0.90	438	
Sengguruh +Sutami	1987 – 1996 (9)	3.14	1,531	A=2,050 km^2

It is difficult to evaluate the condition of sedimentation exactly since there is no survey carried out at the same period in both dams. However, considering the existing condition of land and field inspection results, the following assumptions can be made up, that is, the sediment yields in the residual area from the Sengguruh dam to the Sutami dam are negligible amounts. And all of the sediment flowing into the Sutami reservoir from the Sengguruh dam is trapped therein. Thus, the following inferences can be drawn based on the survey data from 1987 to 1997

- Annual sediment amount of 3.14 million m^3 in average flows into the Sutami and Sengguruh reservoirs. Therefore, annual sediment inflow to the Sengguruh reservoir can be said to be 3.14 million m3/year.
- Average annual sediment in the Sutami reservoir is 0.90 million m^3.
- Therefore, sand trapping effect of the Sengguruh reservoir is estimated at 2.24 million m3/year (=3.14-0.90).
- Recently, an amount of 0.90 million m^3/year is deposited in the Sengguruh reservoir.
- It could be said that remained amount of 1.34 million m^3/year (=3.14-0.90-0.90) is deposited in the upstream river course of the Sengguruh reservoir.

Regarding material of the sediment deposit, there is an investigation in 1994 in the Sutami reservoir by PJT. Results of this investigation are presented in Figure V7-8. Average value of the sediment deposits is summarized below.

Average value of 60 % passing diameter:	0.24 mm
Averaged specific gravity:	2.36
Content less than 0.074 mm:	13.3 %
Content greater than 0.5 mm	4.1 %

Materials of sediment deposits of the Sutami reservoir consist of fine sand. This fact indicates that almost sediment is transported as the suspended load. According to the field inspection results, material of sediment deposits in the Sengguruh reservoir are same condition in the Sutami reservoir.

Considering the present condition of sediment in two reservoirs, the following matters can be forecasted roughly.

- In case of no countermeasure, the Sengguruh reservoir will be silted up within 4years, considering the remaining storage volume and present annual sediment rate (3.37/0.90=3.74 year).
- After silting up of the reservoir, the Sengguruh dam will be operated limited power generation as run-of- river type hydroelectric power generation.
- Sediment deposit in the Sutami reservoir will increase 3.48 times from 0.90 million m^3/year to 3.14 million m^3/year after silting up of the Sengguruh reservoir.
- Future storage volume of the Sutami reservoir becomes as follows:

Unit: Million m^3

Year	With Sengguruh effect		Without Sengguruh effect		Decrease of effective (2-4)
	1. Gross	2.Effective	3.Gross	4.Effective	
2000	180.7	144.7	180.7	144.7	0.00
2005	176.2	141.6	166.7	135.1	6.6
2010	171.7	138.5	151.0	124.2	14.3
2015	167.2	135.4	135.3	113.3	22.1
2020	162.7	132.3	119.6	102.4	29.9

- Therefore, if there is no sand trapping effect of the Sengguruh reservoir, effective storage volume of the Sutami reservoir will decrease 29.9 million m^3 in the year of 2020.

(2) Review of Previous Study

Since completion of construction of the Sutami dam, sediment is the most serious problem and many discussions and studies have been conducted. Measures for sediment described in those studies are summarized below.

(a) "Controlling Reservoir Sedimentation in Sengguruh reservoir, Brantas river basin" by D.M. Roedjito & Harianto, PROCEEDINGS OF THE ICOLD SYMPOSIUM /NORWAY /6 July 1995

These measures for sediment were summarized referring to the 1985 Master Plan. The sediment inflow at the Sengguruh was estimated as follows, by use of observation records of the sediment load and runoff discharge:

Unit: million m^3/year

Sub-basin	Suspended load	Bed load	Total
Brantas sub-basin	0.82	0.065	0.89
Lesti sub-basin	1.34	0.031	1.37
Total	2.16	0.096	2.26

Based on the above sediment discharge, life time of the Sengguruh reservoir was estimated to be 20 years in case of no sabo dam during design stage of the Sengguruh dam. To cope with this condition, the following measures were proposed:

Unit: million m^3

Item	Volume
1. Total sediment discharge during 50 years	113
2. Dead storage of Sengguruh reservoir	19
3. Capacity of Check dam: 10 nos. including Lesti III dam	33
4. Reduction of sediment yield by forestation and terracing during 50 years	39
5. Removal of reservoir sediment by dredging	12
6. Sediment inflow to Sutami reservoir	10

(b) Completion Report on Sengguruh Hydropower Project, March 1989

Referring to the estimate during design and the recommendation of 1985 Master plan, following consideration and conclusion were made.

- It is deemed impossible to control the suspended load thoroughly by constructing the proposed 10 sabo dams, considering the diameter of suspended load
- Two check dams are recommended at just upstream sites of backwater of the Sengguruh reservoir in the Lesti River and Brantas River. Trapped sediment is to be removed.
- The capacity of two check dams is not enough to control sediment thoroughly, therefore, the Lesti III dam shall be proposed as supplement.
- As sequence of implementation, the check dam in the Lesti River is recommended to construct first.

Based on the above conclusion, the Wonokerto Check dam was constructed in 1989 at just upstream site of backwater of the Sengguruh reservoir in the Lesti River.

(3) Alternatives

As described before, annual sediment amount of 3.14 million m^3 flows into the Sengguruh and Sutami reservoirs and silts up in the reservoirs. To recover the storage capacities of two reservoirs, therefore, it is required to control sediment more than 3.14 million m^3/year.

Considering enormous volume of sediment, this study concentrates the measures to maintain existing function of the reservoirs.

In general, there are many measures to control sediment in the reservoir, such as reforestation and civil works in the area of sediment yield, sabo dam, check dam and sand bypass channel in the river course, dredging and flushing in the reservoir, etc. In this study, the measures for the Sengguruh and Sutami reservoirs are established based on the following assumptions.

a) Reforestation and civil works in the mountainous area are the most basic and indispensable measures, to stop sediment flowing into rivers. However, those measures take much time and it is difficult to analyze the effects of the measures in this study quantitatively. Considering the existing storage capacity of the Sengguruh dam and requirement of quick response, effects of those measures do not count in this study. It is recommendable to research the effects of such measures quantitatively and to implement reforestation and civil work in the mountainous area based on the research result.

b) Sediment deposits in the reservoirs are fine sands. Based on this fact, it seems impossible to control the fine sands thoroughly by constructing the sabo dams. However, effects of sabo dams are not only storing the sediment, but also decrease the sediment yield. Therefore, construction of sabo dams is indispensable for the basin.

c) In the Master Plan 1985, nine (9) sabo dams were proposed in the upstream area of the Sengguruh dam. In addition, eight (8) sabo dams are proposed to construct in this study. Locations of remained eight sabo dams are selected from the candidate of the dams studied in the 1973 Master Plan. Location of proposed 17 sabo dams are described in ANNEX 2 of Supporting Report I and total storage capacity of sabo dams is 15.1 million m^3.

d) The source of sediment in the reservoirs is the whole upstream area of the Sengguruh dam. Therefore sand bypath channel is not considered.

e) Mechanical dredging are considered to removal of sediment in the reservoirs. Proposed measure of dredging is mentioned later.

Based on the above condition, the following three (3) alternatives are considered as the measures for the reservoirs. Details of alternatives are illustrated in Figure A7-9.

Alt. 1: To maintain existing storage capacities in the Sengguruh and Sutami reservoirs, sediment deposits in the reservoirs will be removed every year by dredging, and the dredged material will be discharged to the Indonesian Ocean by the tunnel. In this alternative, the effective storage volume of the Sutami reservoir is estimated at 146 million m^3 in the year 2020. Dredging volumes of the reservoirs are as follows:

- Dredging in the Sengguruh reservoir: 1.75 million m^3/year
- Dredging/excavation in the Sutami reservoir: 0.70 million m^3/year

Alt. 2: To maintain existing storage capacity in the Sengguruh reservoir and to maintain existing sediment rate in the Sutami reservoir, sediment deposits in the Sengguruh reservoir will be removed every year by dredging, and the dredged material will be discharged to the Indonesian Ocean by tunnel. In this alternative, the effective storage volume of the Sutami reservoir is estimated at 135.3 million m^3 in the year 2020. Development of small dam will be required, instead of the decrease of effective storage capacity of the Sutami reservoir.

Dredging volumes in the Sengguruh reservoir are as follows:

- Dredging in the Sengguruh reservoir: 1.75 million m^3/year

Alt. 3: It is difficult to dispose the dredged material due to the vast volume. Countermeasure in the reservoirs is not carried out. The Sengguruh dam will have limited hydroelectric power generation as the run-of-river type. To secure the hydroelectric power generation of the Sengguruh dam, maintenance dredging will be carried out around the intake of the generator. In this alternative, the effective storage volume of the Sutami reservoir is estimated at 113 million m^3 in the year 2020. Development of small dam will be required, instead of the decrease of effective storage capacity of the Sutami reservoir.

Regarding control of the sediment for the reservoirs, mechanical dredging is basically taken up in this study. Proposed measure for dredging is as follows.

<u>Proposed measure for dredging</u>

a) In rainy season, sediment deposit is removed by mechanical dredging.

b) Regarding the treatment of the dredged material in case of Alt.1 and 2, Sediment conveying tunnel is taken up instead of the spoil bank, Because it is difficult to acquire vast land for a long term dredging. In addition, dredged material is fine sand. Therefore, it seems that the dredged material can not be used for construction material. However, the spoil bank will be required until completing the construction of the sediment-conveying tunnel.

c) In case of Alt. 1 and 2, therefore, dredged slurry from the reservoirs is transported to inlet of sediment conveying tunnel by use of pipelines from dredgers with boosters. Transported slurry with additional water is directly discharged into the Indonesian Ocean Distance from the Sengguruh reservoir to the Indonesia Ocean is about 22.2 km. Proposed route of the sediment conveying tunnel are presented in Figure A7-10.

d) In case of Alt. 3, dredged material from the Sengguruh reservoir is directly discharged to the downstream site of the Sengguruh dam.

(4) Measures for Sediment

For each alternative, the construction cost and the benefit compared with no control against the sediment are estimated, based on the following condition:

a) The measures are considered to start at the year1999.

b) The cost and benefit are estimated by applying price level in 1997.

c) Unit prices of the dredging works are estimated based on those of the previous woks in the Wlingi reservoir, and the following prices are used in the estimate:

Name of reservoir	Dredging depth (m)	Transportation distance (km)	Unit price (Equiv. Rp.)	Remarks
Sengguruh	8 – 12	1.5	11,197	Alt.1,2: 1-5yr, Alt.3
	8 – 12	3.6	13,785	Alt.1,2: 6-22yr
Sutami	8 – 12	2.0	11,378	Alt.1,2: 1-5yr
	8 – 12	10.4	29,684	Alt.1,2: 6-22yr

d) Unit price of the land acquisition for the spoil bank is set to Rp.10,000 based on the actual price around the reservoir.

e) Regarding the dredging works, three (3) shifts of eight (8) hours each are considered with on actual operation time of 17 hours. Operational days of the dredger in rainy season are estimated as follows based on the rainfall record at the Sengguruh dam site during 1990 to 1996:

Item	Rainy Season	Dry Season	Total	Remarks
Calendar day	182	183	365	
Sunday	26	27	53	
National holiday	10	3	13	
Rainfall day (>25mm)	20	5	25	
Workable day for dredging	126	148	274	
Repair for operation	21	24	45	1day for 5days operation
Operation day	105	124	229	

f) Required water for discharging the dredging slurry is mathematically estimated from the sediment transport capacity of the inlet canal of the tunnel. The canal-bed width of the inlet canal is set at 3.0m considering the operation and maintenance activities of the canal. The sediment transport capacity of the inlet canal is presented in Figure A7-11.

g) The sediment-conveying tunnel is considered to have the capacity discharging twice of required water at the 85 percent in depth. Diameters of the tunnel for the alternatives are presented in Figure A7-11.

h) In case of estimation of the benefits, the followings benefits are considered:

Item	Benefit	Remarks
Water supply	Rp. 579 /m^3	Actual payment of PDAM customer
Power Generation		
- Sengguruh: Peak	US$ 126.0 /kw	Source : PT PLN
	US$ 96.95 /kwh	"

Item	Benefit	Remarks
- Sengguruh: Run-of-river	US$ 180.0 /kw	"
	US$ 80.79 /kwh	"
- Sutami: Peak	US$ 86.0 /kw	"
	US$ 93.22 /kwh	"

The estimated costs of the alternatives are presented in Table A7-8. Comparison of the alternatives is shown in Table A7-9 and summarized as follows.

Unit: million Rp.

Item	Alt. 1	Alt. 2	Alt.3
Construction Cost	1,328,602	851,816	142,131
Benefit	1,043,113	906,253	612,053
Benefit – Construction Cost	-285,489	54,437	469,922

Based on this result, Alternative 3 are proposed as the measures for sediment in the Sengguruh and Sutami reservoirs. Therefore, it will be required to consider the new water resources development, instead of the decrease of effective storage capacity in the Sutami reservoir.

4.2 Measures for Sediment in Wlingi and Lodoyo Reservoirs

(1) Present condition of Sediment

The Wlingi and Lodoyo dams are located at the southern skirts of Mt. Kelud in the upstream stretches of the Brantas River. Two dams were constructed for the purpose of efficient use of discharge from the Sutami dam. The original functions of the dams are presented below.

Name of Dam	Function
Wlingi dam	- Peak power generation (by daily use of storage capacity) - Creation of water head for irrigation - Temporary storage of the erupted material of Mt. Kelud.
Lodoyo dam	- Afterbay of the Wlingi and Sutami dam (by daily use of the storage capacity) - Power generation

According to the survey results conducted by PJT, storage capacities of the reservoirs are summarized below. And the longitudinal profiles of two reservoirs are presented in Figure A7-12 and 13, respectively.

Unit: million m^3

Name of Reservoir	HWL	LWL	Compl.	Survey	Gross storage			Effective storage		
					Original	Survey	%	Original	Survey	%
Wlingi	163.5	162.0	1977	Nov.1996	24.00	4.97	20.7	5.20	1.41	27.1
Lodoyo	136.0	125.5	1983	Nov.1996	5.80	2.35	40.5	4.20	1.91	45.5

Source: PJT

Mt. Kelud, which is the main source of the sediment yield of the Wlingi and Lodoyo reservoirs, erupted in February 1990. After this eruption, the Wlingi reservoir were filled up by the sediment and removal works of sediment deposits in the Wlingi reservoir were implemented through several stages of dredging and flushing. Transition of storage capacity of the Wlingi reservoir is shown in Table A7-10, and sediment deposits and removal volumes are summarized below:

Average sediment deposit (1977 – 1990):	1.49 million m^3/year
Average sediment deposit (1993 – 1996):	0.43 million m^3/year
Total volume of sediment deposit:	27.9 million m^3
Total removal volume of sediment deposit:	9.7 million m^3
by dredging:	7.4 million m^3
by flushing:	2.3 million m^3

(2) Review of Previous Study and Measures for Sediment

A lot of previous studies had been carried out after the eruption of Mt. Kelud in February 1990. Out of them, two studies and their main conclusion and suggestion are summarized below.

(a) "Recommendation Report on Countermeasures Against Sediment Inflow to Wlingi Reservoir", July 1990

In this report, sediment yields in 15 years after the eruption was estimated, and some countermeasures including sediment bypass channel were proposed. Estimated sediment yields are summarized below.

Tributary	Annual yield (million m^3/year)		15 years total
	$1^{st} - 3^{rd}$ year	$4^{th} - 15^{th}$ year	(million m^3)
K. Putih	0.80	0.37	6.8
K. Ganggangan	0.53	0.27	4.8
K. Jali	0.41	0.17	3.3
K. Lekso	0.93	0.83	12.8
Un-affected area	0.43	0.43	6.4
Total	3.10	2.07	34.1

(b) "Brantas River Morphological Studies, Final Report", October 1992 and "Comprehensive Study of Sediment Bypass Channel, Final Report", December 1996

These studies were carried out as part of the Brantas River rehabilitation Project. Preliminary evaluation of the existing bypass channel and extensions in downstream and upstream directions had been studied. The main conclusions are described below.

- Regarding to the existing bypass channel, proper protection works are needed to prevent scouring.

- Extending the existing bypass channel in the upstream direction up to K. Semut is hydraulically feasible.
- The extension of the existing bypass channel to the downstream direction is feasible.
- Proposed route of bypass channel extension is presented in Figure A7-14.

Some of the suggested measures by the above reports are carried out up to date as mentioned below.

(a) Existing bypass channel was constructed in 1990, fully diverted K. Putih and K. Ganggangan to K. Siwalan (downstream site of the Wlingi dam).

(b) Detailed design of the bypass channel extension to the downstream site of the Lodoyo dam was completed by PGKS in 1994. And construction works are commenced in 1995.

(c) Check dams, sabo dams and dikes are being constructed year by year by PGKS.

(d) Dredging and flushing in the Wlingi reservoir were held after the eruption in 1990 as described above.

(3) Alternatives

In order to study the countermeasures of the sediment in the reservoirs, the sabo works of Mt. Kelud is the basic matter and the following assumption is considered.

(a) Mt. Kelud is an active volcano with average eruption interval of 15 years.

(b) Thus, the sabo works of Mt. Kelud are indispensable to maintain the present sediment inflow to the reservoirs.

(c) However, it is difficult and seems impossible to control sediment inflow less than existing inflow.

(d) It is considerable that the sediment inflow to the reservoirs will be maintained equal to the present.

Based on the above assumption, the following basic figures are applied to the study.

Item		Remarks
(1) Sediment yield:	2.07 mil.m3/year	
Wlingi reservoir		
(2) Sediment inflow:	1.43 mil. m3/year	
(3) Sediment deposit:	0.43 mil. m3/year	1993 – 1996
(4) Trap efficiency:	30 %	(3)/(2)
Lodoyo reservoir		
(5) Sediment inflow	1.00 mil. m3/year	(2)-(3)

Item		Remarks
(6) Sediment deposit	0.30 mil m3/year	(5)*(7)
(7) Trap efficiency	30 %	same as (4)
Bypass channel (incl. Extension to downstream site of Lodoyo)		
(8) Sediment discharge	0.64 mil. m3/year	K. Putih + K. Ganggangan

To maintain the roles of the Wlingi and Lodoyo dams in the Brantas river basin, the following measures are considered. Details of the alternatives are illustrated in Figure A7-15.

Alt. 1: Present role of each reservoir will be secured by mechanical dredging. That is, the effective storage volumes of two reservoirs will be restored for 5 years and will be maintained thereafter.

Alt. 2: In addition to the Alt. 1, the sediment bypass channel will be extended to the Semut river to reduce sediment inflow into the reservoirs. Proposed route of the sediment bypass channel is presented in Figure A7-14.

Alt. 3: The sediment bypass channel will be extended to the Semut river. After completion of extension, function of the afterbay for the Sutami reservoir will be converted from the Lodoyo reservoir to the Wlingi reservoir. That is, the effective storage capacity of the Wlingi reservoir will be restored until completion of extension of the bypass channel and will be maintained thereafter. Existing effective storage capacity of the Lodoyo reservoir will be maintained until completion of the cannel extension. After that, the Lodoyo dam will be used as the run-of-river type power generation facility.

Proposed measure for dredging are as follows:

a) Sediment deposits will be removed by mechanical dredging.

b) It is difficult to find suitable spoil banks around reservoirs, therefore, dredging slurry from the each reservoir will be transported to the downstream site of tailrace by use of the pipelines from dredgers and will be flushed by the discharge from each dam, in principle.

c) However, dredging volumes during the restoration of reservoirs are estimated to huge amount. The river channel downstream from the reservoirs will be affected by those huge sediment inflows. Therefore, the spoil banks will be required to treat dredged material during the restoration.

(4) Measures for Sediment

For each alternative, the construction cost and the benefit compared, based on the following condition:

a) The measure is considered to start at the year1999.

b) The cost and benefit are estimated by applying price level in 1997.

c) Unit prices of the dredging works are estimated based on those of the previous woks in the Wlingi reservoir, and the following prices are used in the estimate:

Name of reservoir	Dredging depth (m)	Transportation distance (km)	Unit price (Equiv. Rp.)	Remarks
Wlingi	0 – 5	1.5	6,701	Alt.1,2,3 : 1-5yr
	8 – 12	4.5	21,413	Alt.1,2,3 : 6-22yr
Lodoyo	0 – 5	1.5	6,701	Alt.1,2,3 : 1-5yr
	8 – 12	3.0	14,718	Alt.1,2 : 6-22yr
	8 – 12	1.5	11,197	Alt.3 : 6-22yr

d) Unit price of the land acquisition for the spoil bank is set to Rp.10,000 based on the actual price around the reservoir.

e) Regarding the dredging works, three (3) shifts of eight (8) hours each are considered with on actual operation time of 17 hours. Operational days of the dredger in a year are estimated to 229 days as mentioned before.

f) Preliminary design and cost estimate of the construction works for the sediment bypass channel are arranged and applied based on the previous study result of the Brantas Rehabilitation Project carried out by PKB.

g) As the benefits, the followings electric supply benefits are applied based on the information from PT PLN:

Item	Benefit	Remarks
Wlingi: Peak	US$ 94.0 /kw	Alt.1,2: 1-22yr, Alt.1: 1-5yr
	US$ 93.22 /kwh	
Wlingi: Run-of-river	US$ 150.0 /kw	Alt.3: 6-22yr
	US$ 80.79 /kwh	
Lodoyo: run-of-river	US$ 225.0 /kw	Alt 1,2,3: 1-22yr
	US$ 80.79 /kwh	

The estimated costs of the alternatives are presented in A7-11. Comparison of the alternatives is shown in Table A7-12 and are summarized below:

Unit: Million Rp.

Item	Alt. 1	Alt. 2	Alt. 3
Cost (C)	494,548	404,636	256,245
Benefit (B)	1,317,259	1,317,905	1,154,248
B – C	822,711	913,269	898,003

Based on this result, Alternative 2 is proposed as the measures for the sediment of the Wlingi and Lodoyo reservoirs in this study. However, the dredging volumes of the reservoirs are huge amount. In order to decrease of dredging amount, it is recommended to study the actual sediment flushing effect of the Lodoyo reservoir and to establish the operation rule for the sediment flushing.

4.3 Implementation Program of Proposed Works

To perform the above countermeasures, the implementation program shall be as follows.

(1) Construction of sabo dams in Upper Brantas basin.
To decrease sediment inflow into the Sutami dam, this project shall be carried out as soon as possible. The implementation program of this project is shown in the section of V.2 of this report.

(2) Maintenance Dredging in the Sengguruh reservoir.
To secure the electric power generation, the maintenance dredging should be start in the year 1999 and be carried out in rainy season every year. In addition, to implement the works, it is urgently required to establish the new operation rule of the Sengguruh dam as the run-of-river type hydroelectric power generation facility by mutual consent with PT PLN.

(3) Extension of sediment bypass channel to the Semut river
To decrease sediment inflow into the Wlingi reservoir and to save the dredging cost in the Wlingi and Lodoyo reservoirs, this project shall be completed within the year 2003. And to implement the works, it is urgently required to make the detailed design of the bypass channel extension.

(4) Dredging in the Wlingi reservoir.
The restoration of the original effective storage capacity of the Wlingi reservoirs shall be completed within the year 2003. After completion of the restoration of reservoir and completion of extension of the sediment bypass channel, the dredging work for the reduced sediment inflow shall be carried out to maintain the effective storage capacity. For the implementation of the works, it is urgently required to make the dredging plan of the reservoir.

(5) Dredging in the Lodoyo reservoir.
The restoration of the original effective storage capacity of the Lodoyo reservoirs should be completed within the year 2003. After completion of the restoration, the dredging work shall be carried out to maintain the effective storage capacity. For the implementation of the works, it is urgently required to make the dredging plan of the reservoir. In addition, to decrease of dredging amount, it is recommended to study the actual sediment flushing effect of the Lodoyo reservoir and to establish the operation rule for the sediment flushing.

Required costs for the implementation of the proposed works are summarized as follows:

Unit: million Rp.

	Period	Construction Cost	Annual O/M cost
Sengguruh reservoir	1999 – 2020	649/year	-
Sediment Bypass Channel	1999 – 2003	50,729	381/year
Wlingi Reservoir	1999 – 2003	14,428/year	-
	2003 – 2020	7,679/yaer	-
Lodoyo Reservoir	1999 – 2003	9,215/yaer	-
	2003 – 2020	8,933/year	-

The implementation programs of the above projects are presented in Table A7-13.