No. 52

Japan International
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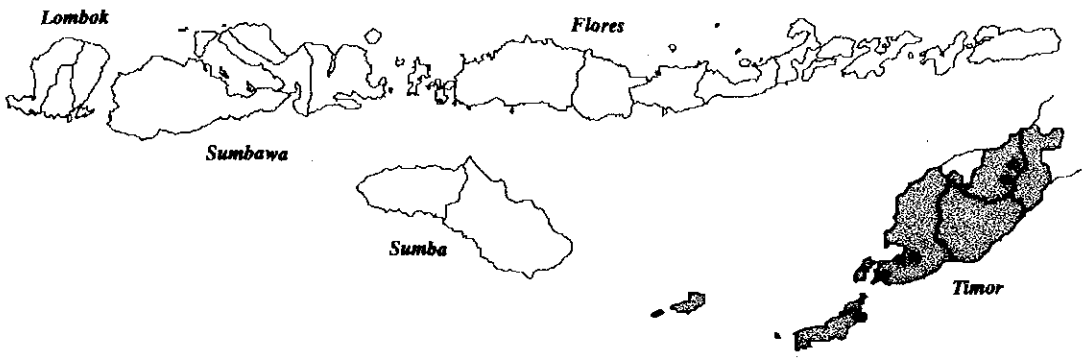
Directorate General of
Water Resources Development,
Ministry of Public Works

The Study on The Embung Development Project (Small Scale Impounding Pond Development Project) in East Nusa Tenggara and West Nusa Tenggara in The Republic of Indonesia

Final Report
(Volume 3)

Feasibility Study Report
on
Six Embung Development Projects
in
Timor Island in East Nusa Tenggara



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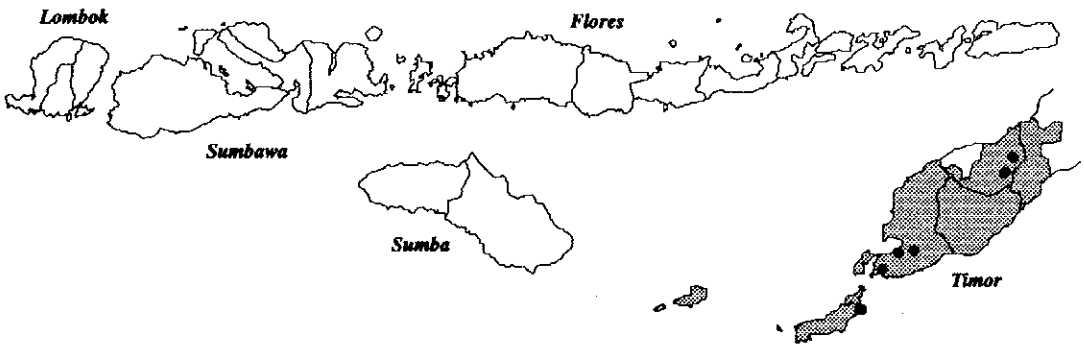

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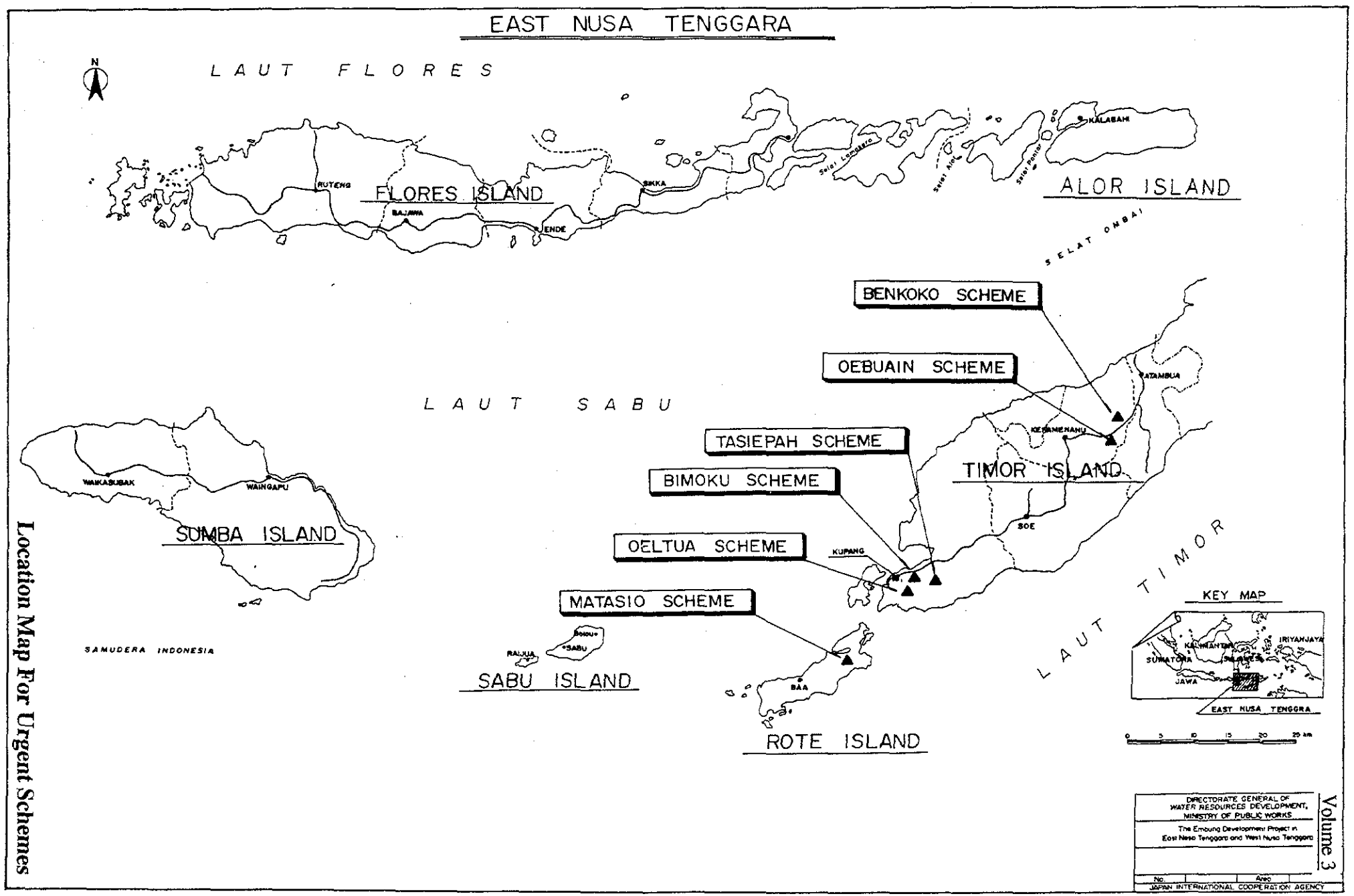

Location Map For Urgent Schemes

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT, MINISTRY OF PUBLIC WORKS

The Embung Development Project in East Nusa Tenggara and West Nusa Tenggara

No. | Area

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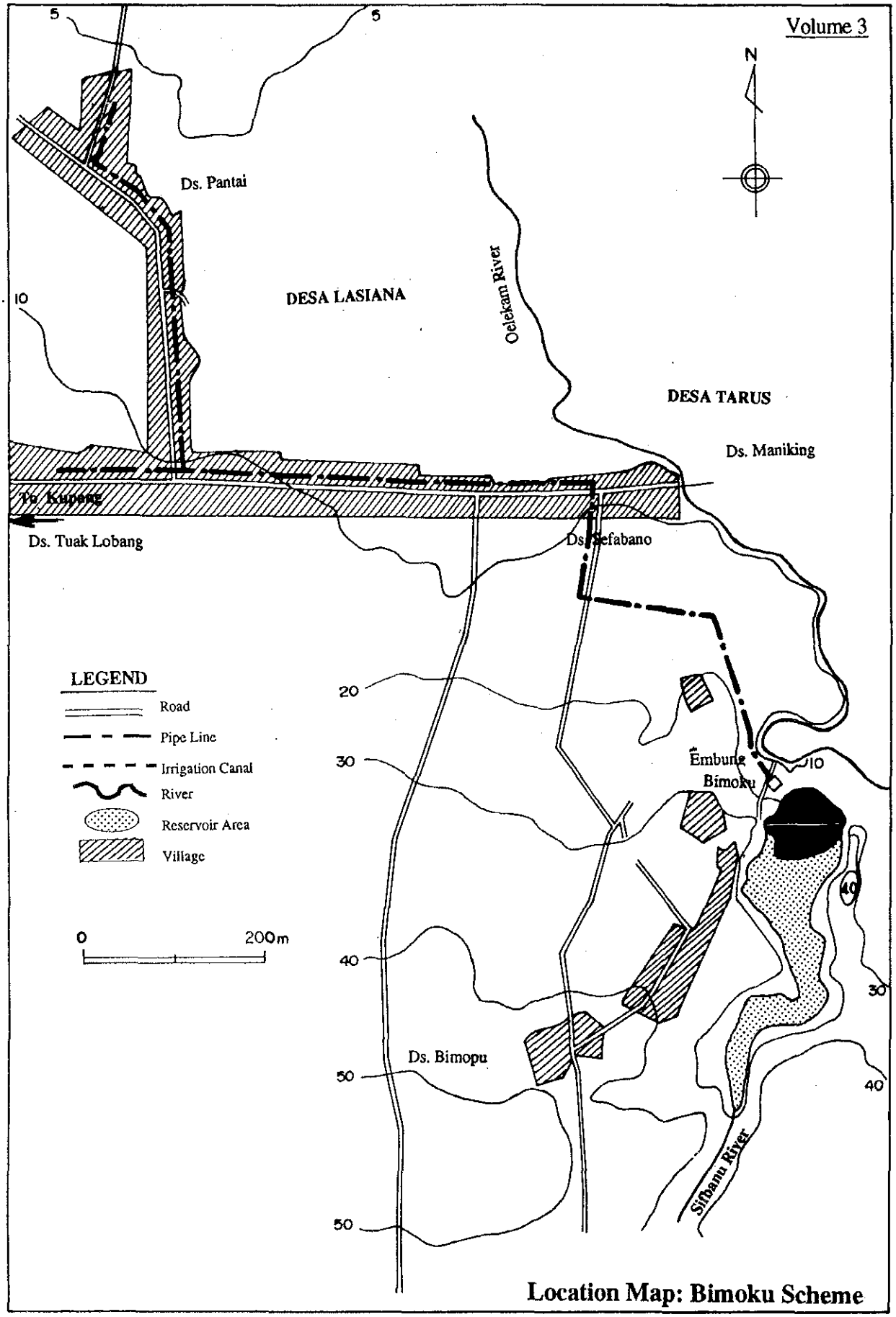
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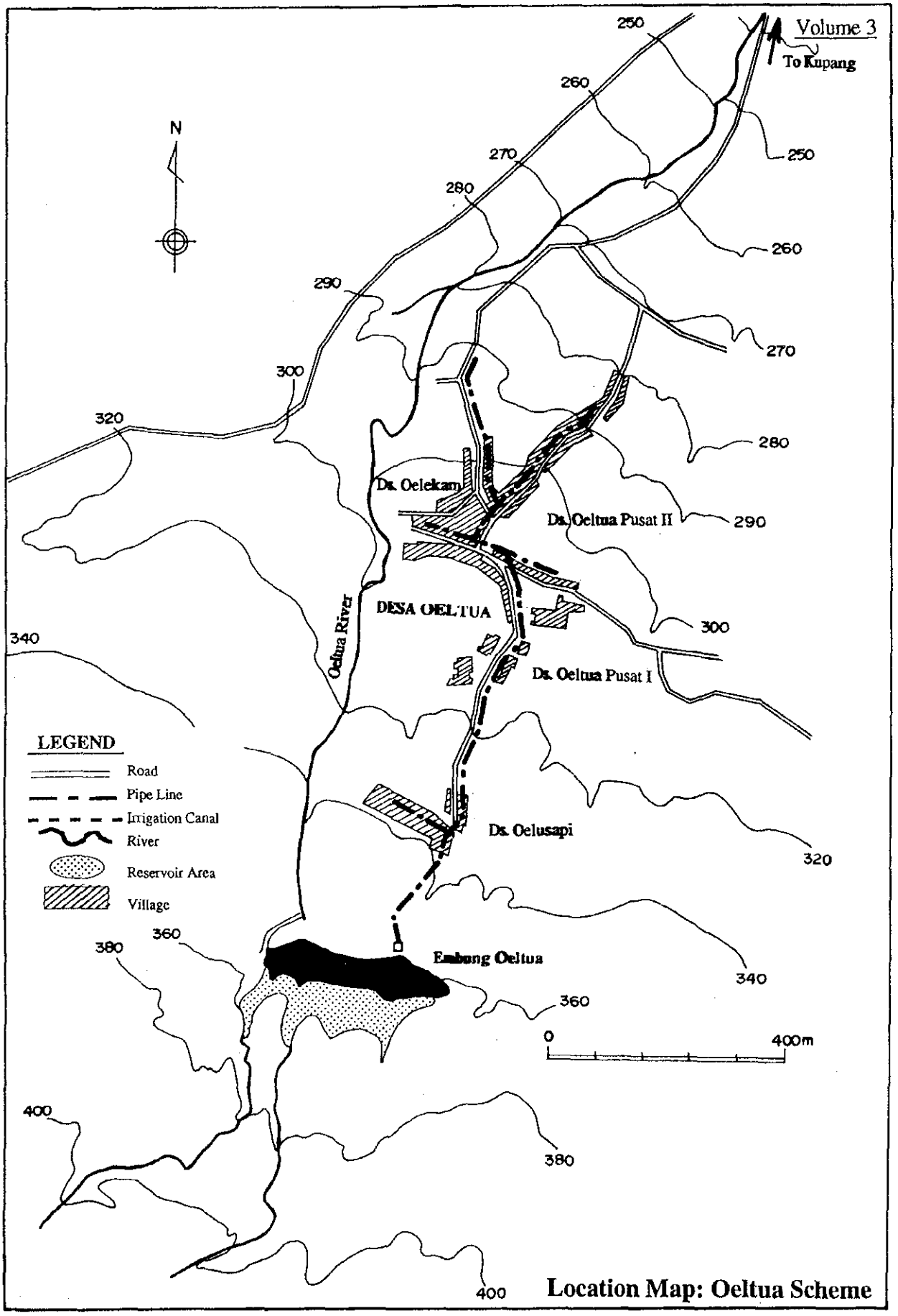
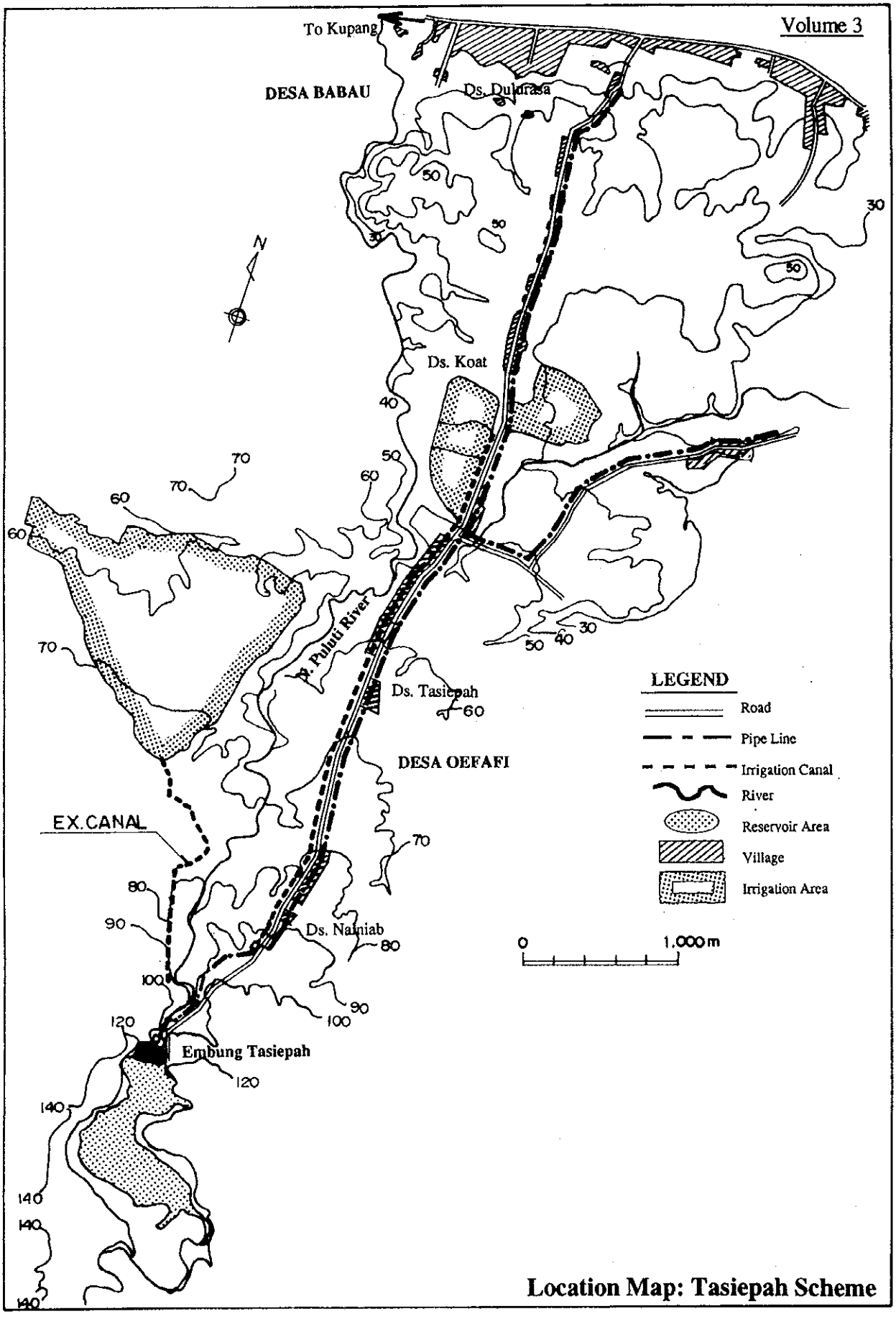
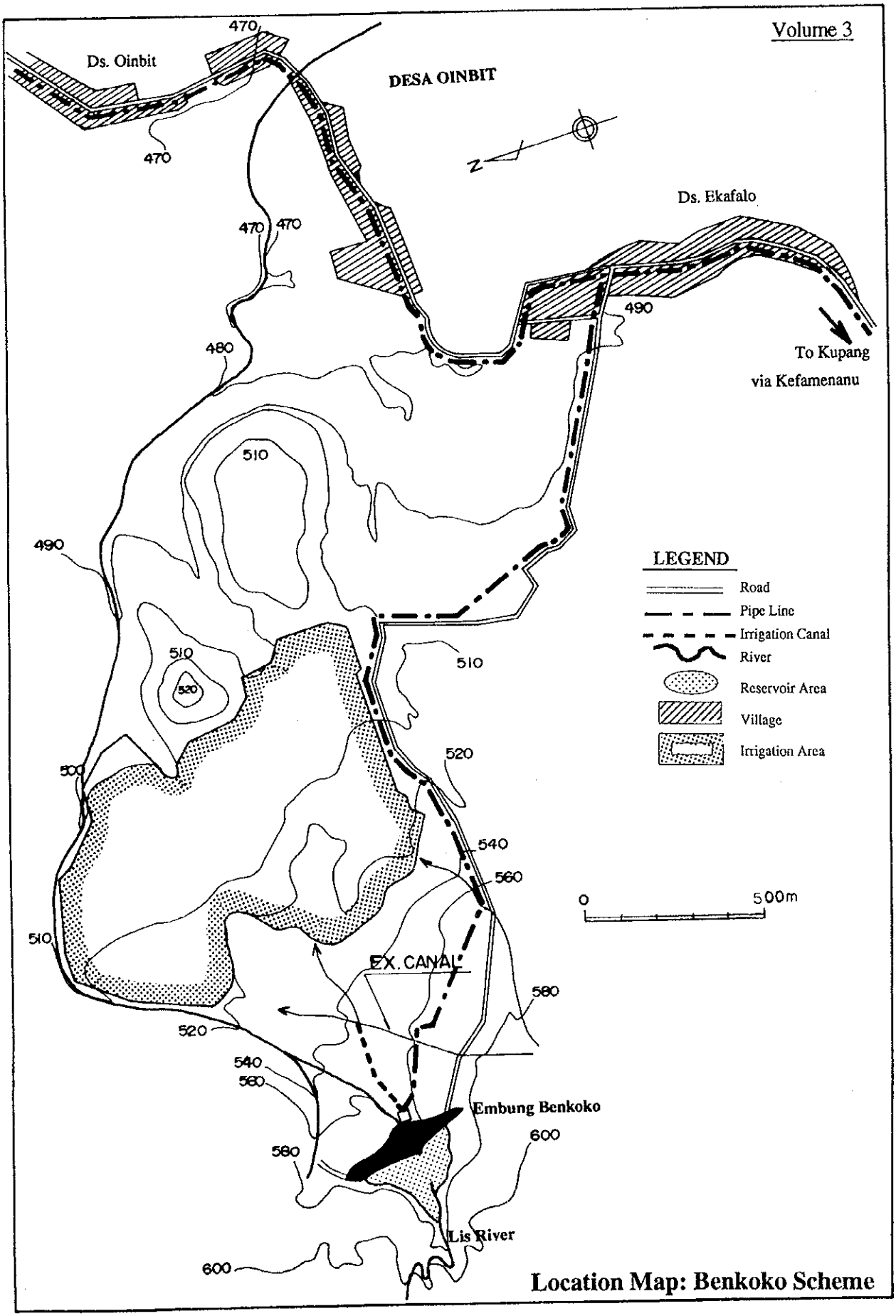
Ds. Pantai
DESA LASIANA
Oelekam River
DESA TARUS
Ds. Maniking
To Kupang
Ds. Tuak Lobang
Ds. Sefabano
LEGEND
Road
Pipe Line
Irrigation Canal
River
Reservoir Area
Village
0
200m
Embung Bimoku
Ds. Bimopu
Sifbanu River
Location Map: Bimoku Scheme



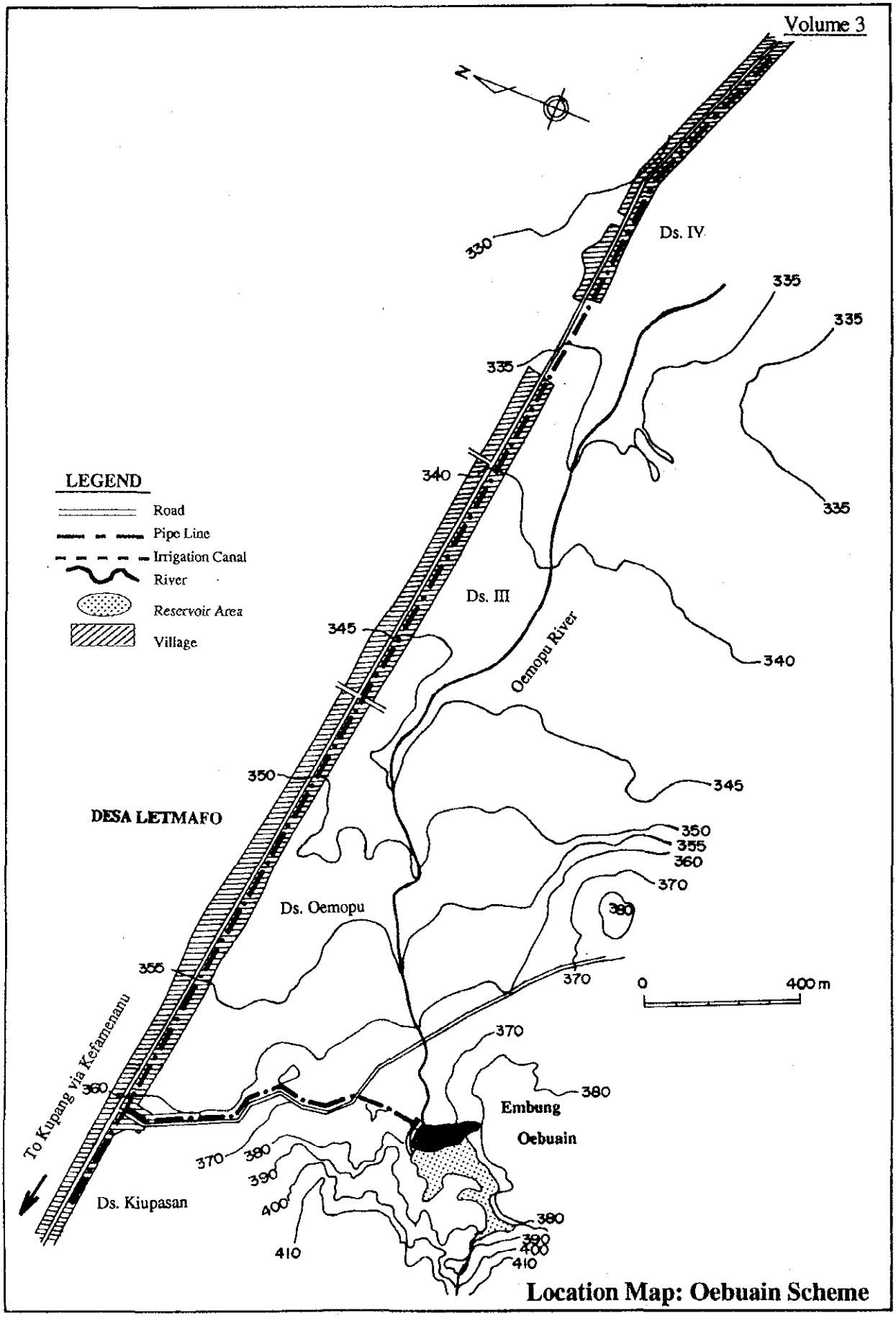
Location Map: Oeltua Scheme



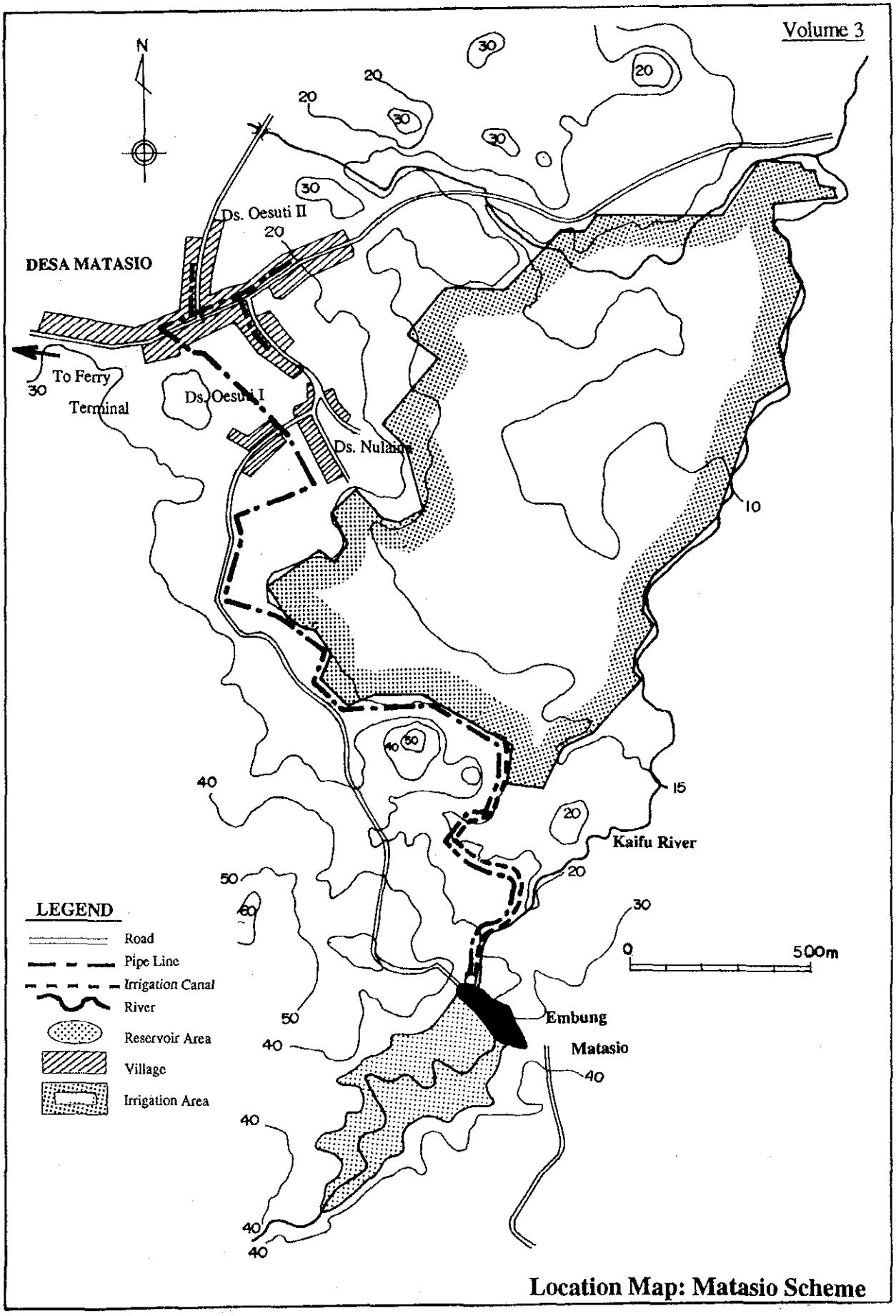
Location Map: Tasiepah Scheme



Location Map: Benkoko Scheme



Location Map: Oebuain Scheme



Location Map: Matasio Scheme

THE STUDY
ON
THE EMBUNG DEVELOPMENT PROJECT
(SMALL SCALE IMPOUNDING POND DEVELOPMENT PROJECT)
IN
EAST NUSA TENGGARA AND WEST NUSA TENGGARA
IN
THE REPUBLIC OF INDONESIA

FINAL REPORT

VOLUME 3

Feasibility Study Report on Six Embung Development Projects

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1. INTRODUCTION

1.1 The Report

This feasibility report is prepared as a part of the Final Report in accordance with the Scope of Work for the Study on the Embung Development Project (Small Scale Impounding Pond Development Project) in East Nusa Tenggara and West Nusa Tenggara in the Republic of Indonesia (the Study) agreed upon between the Directorate General of Water Resources Development(DGWRD) of the Ministry of Public Works and Japan International Cooperation Agency (JICA) on October 15, 1993. This report presents the result of technical feasibility and socio-economic justification study on urgent development of six Embungs in the Province of East Nusa Tenggara (NTT), consisting of three parts; Main Text (Volume 3), six Annexes (Volume 6), and Drawings (Volume 7). The Main Text describe briefly the results of technical feasibility and socio-economic justification study, while the six Annexes and the Drawings give the details of planning, preliminary design, cost estimate made on the feasibility study level and socio-economic justification for each Embung development project.

1.2 The Feasibility Study

The feasibility study is conducted for urgent development of six Embungs: Bimoku, Oeltua and Tasiepah Embungs located in the vicinity of Kupang, the provincial capital of NTT; Benkoko and Oebuain Embungs situated in the eastern part of NTT; and Matasio Embung located in Rote island. In undertaking the Study, special attention is paid to identify basic human needs (BHN) from the socio-economic viewpoint and to assess development potential of each Embung from the technical point of view. Based on the Study, immediate implementation programs are prepared for Embung which can be recommended to be developed.

1.3 Work Performed

Field works for the feasibility study were conducted in Indonesia for three months between April and June 1994 followed by office works in Japan for two months from June to August. Major work items done during this period are summarized below:

- Field work done in Indonesia covers (a) field investigation in each Embung site and beneficiary area, (b) identification of prevailing constraints against improvement of living condition and agricultural productivity, and (c) preparation and explanation of the Progress Report (I).

- Office works done in Japan consist of (a) formulation of an optimum development plan based on the results of examination on development needs for domestic,

livestock and irrigation water supply as well as development potential of Embungs (b) preparation of preliminary design of major facilities, (c) preparation of operation and maintenance (O&M) plan of major facilities, (d) preparation of implementation schedule, (e) estimation of cost and benefit, (f) economic evaluation, socio-economic justification and environmental assessment, and (g) preparation of the Interim Report.

The work quantities of field investigations entrusted to Indonesian Consultants are shown in Table 1.1.

2. BACKGROUND

2.1 Provincial Background

The area of NTT covers about 47,350 km^2, being located in the chain of islands forming the Lesser Sundas. It includes three main islands; Sumba, Flores and the western part of Timor, and a number of smaller islands. The administrative division of NTT is composed of 12 Regencies (Kabupaten), and further divided into one City (Kota Administrasi) and 114 Districts (Kecamatan) with 1,743 Villages (Desa) as the lowest administration unit. The total population and household of NTT were 3.36 million and 634,300, respectively, in 1993 and the population density was 71 person/km^2. The Gross Regional Domestic Product (GRDP) in NTT was Rp. 1,632 billion at current market price in 1993. Per capita GRDP was Rp. 491,600 being 35% of the national average.

The climate of NTT is distinctly dry, which is a consequence of the physiological location and orientation of the islands with respect to the prevailing circulation of air masses and wind movements. The north coast of Timor and central Lomblen are arid with mean annual rainfall of less than 1,000 mm and on average eight months with rainfall of less than 100 mm. Most of Sumba, Timor, Alor, Pantar, Lomblen, Solor and eastern and northern Flores are dry. In each island, coastal areas are subject to scarcity of rainfall.

The existing major communication facilities in NTT consist of 14 airports, 11 seaports, roads with a length of 14,081 km in total and 9,840 telephone sets. Electricity produced and sold in 1993 was 103 MWh and 95 MWh, respectively. The road network is formed of asphalt road of 4,209 km, gravel road of 3,182 km and earth road of 6,690 km.

In NTT, springs or rivers are predominant drinking water sources on which 56% the whole households rely, while 19% gets piped water and 25% depends on wells or pumps. In terms of the domestic water supply condition, a total of 31,877 customers was provided with piped water and their water consumption amounted to 9.8 million m^3 in 1993. These customers include public and private offices, shops, hospitals, hotels and so on other than urban people paying water charge of Rp. 3,001 million in total.

In NTT, agriculture is the most important sector gaining Rp. 769 billion and contributing 47.1% of GRDP at current market price in 1993 and is the main income source of rural areas. Number of farm labor force was estimated to be about 1.31 million accounting for 78% of the total working people in 1993.

The present land use for crop production in NTT amounted to 1,039,400 ha comprising wet paddy field of 129,700 ha, dry upland field of 388,400 ha, estate crop field of 459,900 ha

and fruit field of 61,400 ha as at 1993. In addition, there were shifting cultivation area of 140,600 ha, temporary fallow land of 492,400 ha and grassland of 783,500 ha. The cropping intensity of wet paddy field estimated is only 69% because of existence of idle paddy field of 40,000 ha caused by prolonged and severe dry months and short wet season. Besides only 4% of wet paddy field are under technical irrigation system at present. This figure is extremely low comparing to the national average of 23%.

In NTT, major crops grown are rice and Palawija crops such as maize, cassava and sweet potato. The total harvested areas of these crops in 1993 was 83,700 ha for wet paddy, 58,000 ha for upland paddy, 206,500 ha for maize, 72,400 ha for cassava and 12,100 ha for sweet potato. Recently, beans have become popular as new Palawija crops with the harvested areas of 21,800 ha for mungbean, 3,900 ha for soybean and 7,500 ha for groundnut. The planted areas of major estate crops in 1993 were 164,300 ha for coconut, 80,200 ha for cashew nut, 65,100 ha for candle nut, 49,700 ha for coffee, 33,400 ha for areca nut, 29,200 ha for kapok, 20,800 ha for cocoa, 10,900 ha for clove as a whole. The wet paddy cultivation is concentrated in the wet season while limited in the dry season due to water availability. In the dry season, Palawija crops are mainly cultivated in the wet season.

The production of wet paddy and upland paddy in 1993 amounted to 377,600 tons of paddy and the converted amount of rice was 245,400 tons. Per capita production of rice in 1993 was estimated to be 73 kg/year. This is remarkably lower than the national Pelita V target of per capita consumption of 138 kg/year and the provincial Pelita V target of 105 kg/year. It is therefore considered that starchy Palawija crops are cultivated for staple food of local people due to shortage of rice and play a valuable role for food security in NTT.

There exist 133 irrigation schemes under the management of the Provincial Department of Public Works Service (DPUP) of NTT. The designed irrigation area is 73,942 ha in total. Its breakdown by type of water source facility is: 104 weirs covering 66,780 ha, 13 Embungs commanding 3,392 ha and 16 groudwater and spring water sources covering 3,770 ha. According to the grade of irrigation system, it is classified into three groups; 49 technical irrigation systems of 27,425 ha, 16 semi-technical irrigation systems of 7,296 ha and 68 non technical irrigation systems of 39,221 ha. The average size of command area is 556 ha as a whole and that of Embung scheme is 290 ha.

In NTT, Sumba and Timor islands have traditionally played an important role in functioning as cattle feeder stock areas for other regions in Indonesia and are also playing a new role in supplying live cattle to Jakarta and Surabaya to meet increasing market demand of beef meat. The number of livestock as at 1993 amounted to 767,700 cows, 187,100 buffaloes, 170,200 horses, 650,000 goats and sheep, 1,453,600 pigs, 6,426,200 domestic hens and 595,900 layers in total. These livestock are distributed to the respective main islands

with a wide variation according to the difference of natural circumstances and inhabitants' religious backgrounds.

2.2 Selection of Representative Schemes

In order to select typical samples for making technical, economical and social assessment of water resource development potential by means of constructing Embung, it is indispensable to categorize 157 candidate schemes from such viewpoints as the present condition of farming system and irrigation water source facilities as well as inhabitants' needs for the future water use in each candidate scheme area. For this purpose, the inventory survey was carried out twice under the Study. By referring to information obtained through the inventory survey, three kinds of criteria have been established to categorize the candidate schemes.

The first criteria is to classify the present farming system into the following three types focusing upon the level of irrigated cropping:

- Type a : fallow, rainfed cropping on dry upland, single cropping of rainfed wet paddy or single cropping of irrigated paddy to a partial extent, having the cropping intensity of up to 100%;
- Type b : single cropping of irrigated paddy fully for the wet season and rainfed Palawija crops partly to fully for the dry season, having the cropping of more than 100%; and,
- Type c : two cropping of the wet season paddy and the dry season Palawija crops partly to fully under irrigated condition, double cropping of irrigated paddy, single cropping of the wet season paddy and double cropping of the dry season Palawija crops under irrigated condition, or double cropping of irrigated paddy coupled with the dry season Palawija crops under either irrigated or rainfed condition, having the cropping intensity of 200% to 300%.

The second criteria is to classify the present status of irrigation water source facilities into the following three types taking into account the location of water intake facility:

- Type A : No irrigation water intake facility;
- Type B : Intake facility available on the source river of the candidate Embung; and,
- Type C : Intake facility available on the different river and conveying water to the downstream irrigation area of the candidate Embung.

The third criteria is to classify the utilization type of water to be newly developed by the candidate Embung based on inhabitants' intention to the future use of new water source facility:

- Type 1 : Permanent source of irrigation, domestic and livestock water;
- Type 2 : Permanent source of irrigation and livestock water;

- Type 3 : Permanent source of irrigation and domestic water; and,
- Type 4 : Permanent source of irrigation water.
- Type 5 : Permanent source of domestic and livestock water or one of these two purposes.

Through the categorization of 157 candidate schemes based on the above-mentioned criteria, 6 schemes are selected representing typical categories as shown below.

Classification of 6 Representative Schemes by Category

Scheme	Province	Island	Water Source Facility	Farming System	Future Water Use
Bimoku	NTT	Timor	a	A	5
Oeltua	NTT	Timor	a	A	5
Tasiepah	NTT	Timor	b	B	3
Benkoko	NTT	Timor	a	B	1
Oebuain	NTT	Timor	a	A	5
Matasio	NTT	Rote	a	B	3

3. PRESENT SITUATION OF THE PROJECT AREAS

3.1 Natural Condition

(1) Location and topography

Of the six urgent Embung development projects, Bimoku site is located in the Kecamatan Kupang Tengah near Kupang, Oeltua and Tasiepah sites in the Kecamatan Kupang Timur in the vicinity of Kupang, Benkoko and Oebuain sites in the Kecamatan Insana in the easternmost part of NTT, and Matasio site in the Kecamatan Rote Timur on Rote island. The location of each site is shown below.

Location of Embung Site

Embung	Island	Direction and Distance from Kupang (km)	Coordinates of Site		Village (Desa)
			East Longitude	South Latitude	
Bimoku	Timor	East : 12	123°41'43"	10°08'50"	Lasiana, Tarus
Oeltua	Timor	East : 20	123°40'51"	10°13'56"	Oeltua
Tasiepah	Timor	East : 30	123°46'48"	10°10'00"	Oefafi, Babau
Benkoko	Timor	Northeast : 155	124°44'28"	9°22'45"	Oinbit
Oebuain	Timor	Northeast : 140	124°36'33"	9°26'30"	Letmafo
Matasio	Rote	Southwest : 50	123°29'18"	10°37'60"	Matasio

(2) Climate and hydrology

The wet season usually starts from late November and ends early April in each project area. Rainfall pattern is specified by concentrated heavy rains occurring two or three times during the wet season. The average annual rainfall varies from 1,000 mm in Benkoko and Oebuain sites to 1,190 mm in Matasio site and 1,470 mm in the remaining three sites. The maximum 24 hours rainfall record is 58 mm in Benkoko and Oebuain sites, 120 mm in Matasio site and 120 mm in the other sites. The followings indicate climatic features of each project area.

Climatic Features of Embung Site

Embung	Mean Annual Temperature (°C)	Mean Relative Humidity (%)	Average Sunshine Hour (hrs/day)		Average Wind Velocity (km/hr)
			Wet Season	Dry Season	
Bimoku	27.4	72.8	4 to 5	7 to 8	0.4
Oeltua	27.4	72.8	4 to 5	7 to 8	0.4
Tasiepah	27.4	72.8	4 to 5	7 to 8	0.4
Benkoko	25.4	87.0	4 to 5	7 to 8	2.0
Oebuain	25.4	87.0	4 to 5	7 to 8	2.0
Matasio	27.4	72.8	4 to 5	7 to 8	0.4

The water source river of each Embung site is listed below. There is no gauging station on the respective rivers. The river resume reflects the monthly rainfall pattern. Due to deforestation in the catchment area of each river, sedimentation on the river bed is common along the river stretch.

Water Source River of Embung

Embung	Source River	River System	Catchment Area (km^2)
Bimoku	Sifbanu	Oelekam	0.20
Oeltua	Oeltua	Oelekam	0.82
Tasiepah	N. Pulti	N. Pulti	32.10
Benkoko	Lis	Maubesi	2.30
Oebuain	Oemopu	Maubesi	0.80
Matasio	Kaifu	Kaifu	5.00

(3) Geology

Among the six project areas, Bimoku, Oeltua and Tasiepah Embung sites are underlain by siltstone called Noele Formation of the Tertiary and Coralline limestone, terrace deposits and recent river deposits of the Quaternary. The Coralline limestone is highly porous and composed of sandy limestone and coral limestone. Benkoko and Oebuain sites are underlain by claystone called Bobonaro Complex of the Tertiary and thick debris of the Quaternary being composed of coral limestone, alluvial terrace deposits and recent river deposits. Matasio site is underlain by Bobonaro Complex, terrace deposits and coral limestone. Table 3.1 shows comparison of the respective geological formations.

(4) Soils and land use

Soils in the cultivated and cultivable land in each project area are structured with silty to sandy clay in Bimoku and Oeltua, silty clay loam in Tasiepah, silty clay to silty clay loam in Benkoko, sandy clay to sandy in Oebuain and clay to silty clay in Matasio. Soils in Tasiepah, Benkoko and Matasio areas become sticky when wet and very firm when dried. Due to high presence of exchangeable cations, soil reaction is slightly alkaline. Response to fertilizer application is high because of poor soil fertility caused by lack of organic matters in the top soil.

The present land use for agricultural purpose in the six project areas is summarized below. In addition, most inhabitants grow vegetables and tree crops in a small piece of home yard for their home consumption.

Present Land Use in Project Area

Unit : ha

Project Area	Wet Paddy Field	Dry Upland	Estate Crop Field	Grassland and Idle Land	Total
Bimoku	10	276	0	0	276
Oeltua	7	95	175	105	382
Tasiepah	177	120	0	0	297
Benkoko	237	390	40	11	678
Oebuain	150	229	7	70	456
Matasio	140	25	10	120	295

3.2 Social Condition

(1) Demographic condition

The demographic condition in each project area as at 1993 is presented below. The ethnic condition is: heterogeneous and originated from the native Timor in Bimoku; dominated by the native Timor and mixed with few people from Rote, Sabu and Belu in Oeltua and Tasiepah; of the native Timor as majority and mixed with few people from Belu in Benkoko and Oebuain; and heterogeneous and originated from the native Rote in Matasio. The majority of inhabitants are Protestant and engaged in agriculture. Their average education attainment is primary school grade.

Demographic Condition in Project Area

Project Area	Total Population	No. of Household	Average Family Size
Bimoku	2,392	576	4.2
Oeltua	1,645	332	4.9
Tasiepah	1,305	278	4.7
Benkoko	1,779	356	5.0
Oebuain	1,500	278	5.4
Matasio	1,305	116	4.2

(2) Domestic water supply

The existing water source facilities for domestic and livestock use in the six project areas consist of: public water basin, tank and well as well as private well in Bimoku; public and private well and spring in Oeltua; well and irrigation headwork in Tasiepah; and public well and spring in Benkoko, Oebuain and Matasio. All water sources except for springs go dry during a part or full of the dry season. When water source dries up, inhabitants are usually provided with their drinking water by public water tankers. The average walking distance to carry water from source facilities is 36 m in Bimoku, 500 m in Oeltua, 363 m in Tasiepah, 6,500 m in Benkoko, 1,560 m in Oebuain and 135 m in Matasio. Table 3.2 shows the present situation of domestic water use in each project area.

(3) Social infrastructures

The main access from Kupang to each project area is the trans-Timor road leading to Dili of the Timor Timur Province for Bimoku, Oeltua, Tasiepah, Benkoko and Oebuain. To Matasio, the main access is a ferry connecting Kupang with Rote island. Rural electricity supply is available in Bimoku, Oeltua and Tasiepah areas. In each project area, no hospital is available, but community health sub-center and health integrated post are established to provide inhabitants with health care services to the minimum extent.

Most of rural people have no facilities for bathing, defecating, and washing inside their houses. Instead, they are using river bed and water for bathing and washing purposes as well as giving water to their livestock. Also, they have privately their own toilet outside or use public toilets. Under such circumstances, they are often suffering from various waterborne diseases.

3.3 Agricultural Condition

(1) Agriculture and livestock

In the six project areas, available farm land resources have not been utilized to the fullest extent due mainly to short period of the wet season and lack of irrigation water sources. Predominant crops in the six project areas are maize and cassava followed by paddy and beans. These crops are grown under the rainfed condition during the wet season. The planted areas and production of major crops are shown in Table 3.3.

Normally, the wet paddy field is prepared by an animal-drawn plough and harrow. The high yielding rice variety of IR 64 is commonly used, while little fertilizers are applied as usual. No serious plant pests are reported under the hot and dry weather condition, and farmers put insecticide if necessary. Harvesting is principally done by family labor force with an additional input of hired labors. Farming practices for growing dry upland crops are very simple and primitive with direct sowing on harrowed field and no fertilizer application.

The livestock population in each project area as at 1993 is summarized below.

Livestock Population in Project Area

Project Area	Cow and Buffalo	Horse	Goat and Sheep	Pig	Chicken and Duck
Bimoku	350	27	257	471	719
Oeltua	484	7	14	469	1,260
Tasiepah	580	75	208	300	150
Benkoko	725	312	255	542	584
Oebuain	244	12	43	330	679
Matasio	159	6	400	300	150

(2) Irrigation

Irrigation facilities are available in Tasiepah, Benkoko and Matasio areas. Irrigation water sources are river for Tasiepah and spring for Benkoko and Matasio. In Tasiepah, there are one permanent intake weir commanding 110 ha in net and two temporary intake weirs irrigating a total of 26 ha in net. As this permanent intake weir with 1.6-km long canal is severely deteriorated, a part of commanding area has been provided with irrigation water. In Benkoko, the net irrigation area of 70 ha is commanded by the existing system drawing spring water through a series of pipeline and open channel. In Matasio, farmers use spring water for irrigating their wet paddy field by simple irrigation method.

(3) Agro-economy

Agricultural extension services are provided to farmers through field extension workers of the existing rural extension center. Due to limited operational budget, however, farmers usually receive less frequent visiting services of field extension workers. Farmers are organized as memberships of Agricultural Cooperative (KUD). But KUD's branches in each Project area is not so active at present so that farmers buy their necessary farm inputs from local markets or merchant shops. Agricultural credits are available in the service network of the Indonesian People's Bank (Bank Rakyat Indonesia/BRI) offering short-term credits to cover one crop season and a mid-term credit of five years to support farmers' small investments. However, farmers access to such services are restricted because of small farming size in general and lack of transportation means in some project areas located in remote places. The outstanding bank credits in NTT amounted to Rp. 165,226 million as a whole in 1992, comprising investment credit of 14%, capital investment of 71% and consumption investment of 15%. Of the total bank credit, 61% was lent to customers in Timor and Rote islands including small enterprises whose share was 12%.

Responsible agency for water resources and Irrigation development in each project area is the Provincial Water Resources Service (Sub Dinas Pengairan) of the Provincial Public

Works Service (DPUP). The Governor of NTT principally controls DPUP and further DGWRD of the Ministry of Public Works directs DPUP through its Provincial Office (Kanwil) in terms of technical issues and development budget from the Central Government. As illustrated in Figure 3.1, several project offices are established under DPUP to undertake project implementation as well as operation and maintenance of project facilities. Of these, water resources development and watershed management works for the six Embung projects are the responsibility of Timor Water Resources Development and Conservation Project Office (PPKSA Timor). The organization of PPKSA Timor is shown in Figure 3.2. After completion of Embung construction works, O&M Project Office is in charge of O&M works.

Food production in the six project areas is consumed for farmers' own use and partly sold to local markets or middlemen of Kupang when farmers need cash. The present condition of farmers' home economy clarified through the agro-economy survey conducted under the Study is summarized below. Among 58 respondents, 23 farm households manage to keep their family budgets in black, while family finances of other 35 farm households are straitened and they usually make up deficits on allowance received from relatives and family members or extra cash income by working away from home.

Present Condition of Farmers' Home Economy

Unit : Rp. 1,000

Project Area	Average Annual Income	Average Annual Expenditure	Surplus or Deficit
Bimoku	1,564	1,883	-319
Oeltua	877	1,220	-313
Tasiepah	745	1,126	-381
Benkoko	1,302	1,154	148
Oebuain	827	1,034	-207
Matasio	1,222	1,521	-299

4. DEVELOPMENT NEEDS AND CONCEPTS

4.1 Development Needs

In the six project area, it is common for a total of 9,109 inhabitants to carry water from available water sources to their homes at the average distance of 1,780 m during the wet season and for 4,853 inhabitants to receive the minimum volume of water from public tankers for their own use during the dry season when all water sources dry up every year. Such water shortage condition has caused infectious diseases and damaged their health. Furthermore, it has prevented farmers' willingness to introduce improved crop production system and to expand or construct irrigation facilities.

The pressing necessity of inhabitants in each project area is to meet BHN aiming at improvement of their living conditions paying special attention to solve water shortage problems derived from lack of perennial water sources. In addition, the inhabitants are eager to get sufficient water for maintaining their livestock which are their sources of nutrition and cash income.

The available land resources suitable for agricultural use amount to 2,099 ha in the six project areas. Of these, sizable wet paddy field which is located in the downstream area of the proposed Embungs covers 380 ha in total comprising 10 ha in Bimoku, 160 ha in Tasiepah, 70 ha in Benkoko and 140 ha in Matasio. In Bimoku, however, there is no water resource development potential with the necessary scale to meet irrigation water demand. With the condition that irrigation water can be secured, therefore, these irrigable land resources in Tasiepah, Benkoko and Matasio can be expected to be utilized to the maximum extent by practicing the following proposed cropping patterns.

Proposed Cropping Patterns

Project Area		Wet Season Crop	Growing period	Dry Season Crop	Growing Period
Tasiepah	(Left bank)	Paddy	Nov. 21 to Apr. 30	Beans	Apr. 16 to Aug. 5
	(Right bank)	Paddy	Dec. 21 to May 30	Beans	May 16 to Sept. 5
Benkoko	(Paddy field)	Paddy	Dec. 5 to May 15	Red onion	June 1 to Aug. 30
	(Upland)	Corn/beans (Rainfed)		Red onion	June 1 to Aug. 30
Matasio	(Paddy field)	Paddy	Dec. 5 to May 15	Maize	May 16 to Sep. 25
				Beans	May 16 to Sept. 5

4.2 Water Demand

The estimated per capita domestic water consumption at present is about 25 lit/day on an average in the six project areas, which is far below the regional levels of 123 lit/day for NTT

and 144 lit/day for the Kabupaten Kupang. The future water demand comprises domestic water for inhabitants and livestock water in the six project areas and irrigation water in Tasiepah, Benkoko and Matasio. In the draft Pelita VI (1994/95 to 1998/99), the Provincial Government of NTT has set various goals of meeting BHN by 1998. In terms of domestic and livestock water supply, the target is set at 60 lit/day/capita for rural people and 40 lit/day /head for cow.

In comparison with the present level of water consumption and taking into consideration limited availability of water resources in the six project areas, the target year to reach the above water supply levels is to set in 2003/04, the last year of Pelita VII, under the Study. Also, the above per capita water supply target of 60 lit/day is to include drinking, bathing, defecating, washing, gardening and unaccounted-for water. The future population of inhabitants and livestock in the target year is estimated by the Study following the projected population growth rates made by the Provincial Statistic and Livestock Offices.

Regarding daily water consumption of livestock other than cow, unit water requirement assumed in "The Study for Formulation of Irrigation Development Program in the Republic of Indonesia" is employed; 40 lit/head/day for buffalo, 5 lit/head/day for sheep/goat, 6 lit/head/day for pig and 0.6 lit/head/day for poultry. That for horse is assumed to be 40 lit/head/day.

Irrigation water demand is estimated by referring to the standard quoted in "Irrigation Design Standard, KP-01" of DGWRD. In estimating annual unit diversion requirement of irrigation water, the proposed cropping pattern, crop consumptive use, evapotranspiration, crop coefficient, effective rainfall and irrigation efficiency are taken into consideration for wet paddy and Palawija crops. Further, land preparation water, layer water demand and percolation loss are counted for wet paddy crop.

The details of water demand calculation for each project are presented in the Volume 6.

(1) Domestic water demand

The future population in the target year of 2003/04 is projected for each project area. The future water demand is calculated by multiplying the target per capita water supply amount by the projected population. The projected population and annual water demand amount to 11,191 persons and 245,083 m^3, respectively, in the six project areas with the breakdown as shown below.

Projected Domestic Water Demand

Project Area	Projected Population (person)	Projected Water Demand (m^3/year)
Bimoku	3,019	66,116
Oeltua	2,077	45,486
Tasiepah	1,645	36,026
Benkoko	1,773	38,829
Oebuain	2,101	46,012
Matasio	576	12,614

(2) Livestock water demand

The future livestock population in the target year of 2003/04 is projected for each project area. The future water demand is calculated by multiplying the target unit water supply requirement by the projected livestock population. The projected livestock water demand for the target year of 2003/04 amounts to 11,464 m^3 in the project area and the breakdown is shown below.

Projected Livestock Water Demand

Project area	Projected Livestock Population (head)					Projected Livestock Water Demand (m^3/year)
	Cow/Buffalo	Horse	Goat/Sheep	Pig	Chicken/Duck	
Bimoku	455	31	376	756	1,361	9,735
Oeltua	627	7	21	752	2,384	11,464
Tasiepah	750	87	598	451	2,260	14,794
Benkoko	936	361	371	868	1,104	21,756
Oebuain	317	14	63	529	1,286	6,388
Matasio	200	7	582	481	285	5,201

(3) Irrigation water demand

The annual unit diversion requirement of irrigation water for Tasiepah, Benkoko and Matasio is summarized below.

Unit Irrigation Water Requirement

Project Area		Crop	Annual Unit Diversion Requirement (m^3/ha)
Tasiepah	Left bank	Paddy	8,210
		Beans	6,260
	Right bank	Paddy	9,830
		Beans	6,730
Benkoko		Paddy	10,930
		Red onion	3,090
Matasio		Paddy	10,010
		Maize	8,920
		Beans	6,370

4.3 Development Constraints

In and around each area, inhabitants depend their water sources on perennial springs, seasonal surface flow and perennial or seasonal groundwater. However, the existing water supply sources are considerably insufficient to meet their BHN throughout a year. The only one practical countermeasure expected in each project area is to realize a possibility of developing Embungs as water reservoir on its water source river.

In developing potential water resources through construction of Embung on the water source river, it is said that there are not so much serious limitations in terms of topography, hydrology, environment and socio-economy, while there are some weak points in geological condition derived from presence of coral limestone. In the western part of Timor island, 92 small Embungs have already been developed for domestic and livestock water supply, and another 11 Embungs in Sumba and Rote islands for domestic and irrigation water supply. The average height of these Embungs is 7.15 m for the case of domestic water supply and 8.75 m for the case of irrigation water supply. Under such situation, however, technical know-how to construct higher Embung at a site with geological weak points has not been accumulated yet in both the public and private sectors in NTT.

4.4 Development Concepts and Approach

In order to correct economic imbalance between NTT and other provinces in harmony with the national policy, it is prerequisite to give the highest priority over improvement of infrastructures related to BHN and the second priority to betterment of agricultural production basis in rural areas of NTT. Among others, special attention should be paid to how to solve chronic water shortage problems under the dry weather condition peculiar to NTT.

The objective of water resources development through construction of Embung is to supply domestic and livestock water to inhabitants for meeting their BHN to the maximum

extent as well as to provide irrigation water for utilizing their farm land resources to a large extent. Such water resource development will be able to contribute to improve BHN, alleviate poverty and achieve a balanced development in rural areas of NTT.

In 1986 and 1992, the former Provincial Irrigation Service (PRIS) of NTT carried of surveys to identify possible sites of Embung and availability construction materials. Through these surveys, possible sites to construct Embung were found on the Oelekam, N. Oulti, Maubesi and Kaifu river systems. In the initial stage of the Study, therefore, water resources development potential at these sites has been examined from the viewpoints of topography, geology, soil engineering and hydrology. If the examination results reveal that there is possibility of newly creating permanent water source, then development strategies of each Embung are to be worked out based on optimization of development scale and confirmation of technical feasibility on Embung development. In the end, development impacts are to be assessed from social and environmental viewpoints as well as from an economic consideration if necessary.

5 EXAMINATION OF EMBUNG DEVELOPMENT POTENTIAL

5.1 Topographic Condition

The original sites identified through the previous identification studies by PRIS of NTT are reviewed from the topographical viewpoints including mapping works under the Study. As a result, the PRIS's selection of the original Embung sites except for Tasiepah are reconfirmed to be appropriate. The original site of Tasiepah is relocated to a new site of 200 m upstream taking into consideration better geological condition found by field reconnaissance done in the initial stage of the Study. The shape and width of valley and topographically maximum height at each Embung site are shown below.

Topographic Condition of Embung Site

Embung	Shape of Valley	Width of Valley (m)	Topographically Maximum Height (m)
Bimoku	Rather deep/narrow	90	14.0
Oeltua	Shallow/wide	350	12.0
Tasiepah	Deep/rather wide	200	36.0
Benkoko	Rather deep/wide	400	19.5
Oebuain	Rather deep/rather wide	200	20.0
Matasio	Deep/wide	300	17.0

5.2 Geological Condition

The geological investigation conducted at the six Embung sites under the Study consists of core drilling, field permeability test, standard penetration test and unconfined compression test. Table 5.1 shows the engineering geological features of each Embung site and the detailed information is presented in the Volume 6. Through the investigation in the field, it is confirmed that the both abutments at the original site of Tasiepah Embung are composed of coral limestone layer with very high permeability. Accordingly, the new site is selected instead of the original site.

The coefficient of permeability of the foundation rocks varies from 2.8×10^{-5} to 9.8×10^{-6} cm/s for Noele Formation, 4.3×10^{-4} to 3.8×10^{-6} cm/s for Coralline limestone, 2.2×10^{-5} to 7.1×10^{-7} cm/s for Bobonaro Complex and 6.9×10^{-2} to 2.4×10^{-7} cm/s for debris. Such permeability values reveal that ordinary to special care against for seepage or leaking the water from the reservoir through dam foundation or the abutments is taken into consideration in the design of the foundation treatment. The results of the standard penetration and unconfined compression tests also suggest to pay special attention to determine the type of dam.

In each reservoir area, no major fault and landslide are recognized in the field. It is however prospected that water leakage occurs through bedding rocks with heterogeneous permeability. Therefore, careful consideration is required to introduce effective countermeasures for water leakage.

5.3 Availability of Embankment Materials

Under the Study, material surveys are performed to clarify quantity and quality of embankment materials by field test pitting and laboratory test. As presented in the Volume 6, the results of test show that soils in and around each reservoir area are usable as embankment materials.

In due consideration of the results of the above soil mechanical investigations, the borrow area to obtain earth materials is selected in the reservoir area of each Embung. Additional borrow areas selected are hilltops along the Bimoku reservoir, hill slope at the downstream of Oeltua Embung and downstream riverbed for Oebuain and Matasio Embungs. Main features of embankment materials are summarized in Table 5.2.

The selected sites to obtain sand and gravel materials for the filter of the dam embankment and concrete aggregates are the N. Pulti and Takari rivers for Bimoku, Kasmuti and Baun rivers for Oeltua, the N. Pulti river for Tasiepah, the Noelmina and Maubesi rivers for Benkoko, Maubesi and Noel Mina rivers for Oebuain, and seashore for Matasio.

5.4 Availability of Water Resources

(1) Catchment yield

As no discharge record is available for the water source river, runoff at each Embung site is estimated by using the rainfall record near each site: Penfui rainfall station for Bimoku, Oeltua and Tasiepah; Kefamenanu rainfall station for Benkoko and Oebuain; and Namodale rainfall station for Matasio. These rainfall stations have rainfall records continuing 10 to 28 years and representing catchment rainfall. A runoff coefficient adopted is 0.30 considering the characteristics of each catchment area and available hydrological analysis data for Timor island. The details of estimation of the half monthly discharge is presented in Volume 6 and its summary is shown below.

Monthly Discharge at Embung Site

Embung	Catchment Area (km^2)	Mean Monthly Discharge ('000 m^3)												Annual
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Bimoku	0.20	24	22	13	4	1	1	1	0	0	0	6	14	86
Oeltua	0.82	99	90	53	15	5	3	2	0	1	2	25	58	353
Tasiepah	32.10	3,876	3,512	2,055	593	193	115	89	0	31	95	97	2,286	13,814
Benkoko	2.30	167	164	126	72	66	37	37	27	33	39	70	140	978
Oebuain	0.80	41	49	48	35	16	14	4	4	0	2	5	15	233
Matasio	5.00	431	356	429	30	74	17	8	7	0	0	74	284	1,710

(2) Floods

To determine the design discharge of the structures, the flood analysis is made by adopting the rational formula in due consideration of the availability of flood records and the size of catchment area under the Study. The details of this analysis is presented in the Volume 6. The estimated probable flood for each Embung is summarized below.

Probable Flood at Embung Site

Unit : m^3/s

Embung	Return Period						
	1 in 2 year	1 in 5 year	1 in 10 year	1 in 20 year	1 in 50 year	1 in 100 year	1 in 200 year
Bimoku	5	7	9	11	15	18	21
Oeltua	13	20	25	31	40	48	57
Tasiepah	113	175	225	278	359	428	504
Benkoko	19	26	31	36	43	49	56
Oebuain	8	11	13	15	18	21	24
Matasio	20	24	26	28	31	33	34

(3) Sediment load and water quality

As no data on sediment load is available for each source river, the sedimentation rate is assumed to be 0.5 $mm/km^2/year$ for the six Embungs taking into account the characteristics of catchment areas and referring to the previous study on Sumbawa water resources development.

According to the results of laboratory test on water quality of samples taken at each Embung site in June 1994, it can be considered that water quality often declines during the dry season due to contamination by inhabitants' and livestock's defecating activities.

6. EMBUNG DEVELOPMENT PLAN

6.1 Optimization of Development Scale

Aiming to determine the optimum development scale of each Embung, the reservoir operation is simulated for alternative dam heights. In carrying out the simulation on the half monthly basis, attention is paid to; inflow to reservoir , water losses from the reservoir caused by evaporation, flow of water over the spillway, outflow needed for domestic water, outflow needed for livestock water, outflow needed for irrigation water, volume of water in the reservoir at the beginning of the simulation period, and volume of water in the reservoir at the end of the simulation period. The simulation model is presented in the Volume 6 in detail.

Priority of water use is put to domestic water, livestock water and irrigation water in order. The reservoir capacity is to have 100% dependability to meet the domestic and livestock water demand and 80% dependability for irrigation water demand. It is assumed that the minimum water level coincides with 0.50 m above the lowest water level for securing a capacity of sedimentation volume for 25 years in the reservoir, while the maximum water level is equal to the crest elevation of spillway.

The result of reservoir operation for each Embung is depicted in Figures 6.1 to 6.6. The optimum development scale is determined as described below:

- Bimoku : The reservoir water level is impossible to return to the full water level during the wet season if the dam height is higher than 14.0 m. Accordingly, the optimum development scale is set up at the maximum dam height of 14.0 m with the effective storage capacity of 51,250 m^3. However, this effective storage capacity can meet the domestic water demand only;

- Oeltua : The reservoir water level is impossible to return to the full water level during the wet season if the dam height is higher than 11.5 m. Accordingly, the optimum development scale is set up at the maximum dam height of 11.5 m with the effective storage capacity of 81,200 m^3. This effective storage capacity can meet the water demand for domestic and livestock use;

- Tasiepah : Even if Embung is developed to meet the domestic and livestock water demand, the minimum dam height requires 21.0 m to match the probable flood discharge from the catchment area of 32.1 km^2. The effective storage capacity of 646,000 m^3 in this case can meet not only the domestic and livestock water demand but also cover irrigation water demand for growing the wet season paddy in 160 ha. In order to irrigate available wet paddy field to the maximum extent for the both wet and dry seasons, the dam height needs to be raised to 26.0 m and the effective storage capacity requires to be increased to 1,996,000 m^3. The reservoir water level is impossible to return to the full water level during the wet season if the dam height is higher than 36.0 m. From the topographic viewpoint, it is possible to construct Tasiepah Embung at this dam height of 36.0 m with the effective storage capacity of 7,096,000 m^3. It is proposed that the optimum development scale is set up at 26.0 m because Embung development priority is

given over the fulfillment of BHN firstly and irrigation next within the beneficiary area;

- Benkoko : If Embung is developed to meet only the domestic and livestock water demand, the minimum dam height is 12.5 m with the effective storage capacity of 10,000 m^3. To utilize available land resources, the dam height needs to be raised to at least 16.5 m for irrigating wet paddy field of 35 ha to grow the wet season paddy and the dry season Palawija crop. As available water resources are sufficient to increase planted area of the dry season Palawija crop, the optimum development scale is set up at the dam height of 19.5 m with the effective storage capacity of 170,000 m^3;

- Oebuain : The reservoir water level is impossible to return to the full water level during the wet season if the dam height is higher than 12.0 m. Accordingly, the optimum development scale is set up at the maximum dam height of 12.0 m with the effective storage capacity of 58,800 m^3. This effective storage capacity can meet the water demand for domestic and livestock use; and,

- Matasio : If Embung is developed to meet only the domestic and livestock water demand, the minimum dam height is 10.0 m with the effective storage capacity of 315,000 m^3. In this case, surplus water can cover irrigation water demand for irrigating wet paddy field of 40 ha during the wet season. The reservoir water level is impossible to return to the full water level during the wet season if the dam height is higher than 11.0 m. Accordingly, the optimum development scale is set up at the maximum dam height of 11.0 m with the effective storage capacity of 445,000 m^3. The irrigated paddy field can be increased to 75 ha for the wet season.

6.2 Delineation of Beneficiary Area

According to the optimum development scale of each Embung, the beneficiary areas are finally delineated. In this delineation, the first priority is given to meet BHN by providing the beneficiary people with their domestic and livestock water and, if surplus water is available in the reservoir operation, the second priority is put to utilize the remaining storage water for irrigation purpose. Due to the limited effective storage capacity of Bimoku Embung, a part of project area is delineated as the beneficiary area and the beneficiary inhabitants are provided with only domestic water. In due consideration of service areas by the existing water distribution system in Benkoko, a part of the project area is commanded by the proposed water distribution system. The number of beneficiary inhabitants and livestock and the area to be irrigated in the six project areas are summarized below.

Population and Irrigation Paddy Field in Beneficiary area

Project Area	Inhabitants (person)	Livestock (head)					Irrigated Area (ha)	
		Cow/ Buffalo	Horse	Goat/ Sheep	Pig	Chicken/ Duck	Wet Season	Dry Season
Bimoku	1,825	0	0	0	0	0	0	0
Oeltua	2,077	627	7	21	752	2,384	0	0
Tasiepah	1,645	750	87	598	451	2,260	160	160
Benkoko	935	456	118	235	289	711	35	70
Oebuain	1,773	317	14	63	529	1,268	0	0
Matasio	576	200	7	582	481	285	75	0

6.3 Embung Development Plan

Following the results of the examination of Embung development potential and the optimization study of Embung development scale, the proposed development plan of each Embung is formulated. In terms of dam type, homogeneous earthfill type is applied in due consideration of the foundation strength and the availability of embankment materials. As for the proposed countermeasures for water leakage in the reservoirs except for Matasio, it is proposed to adopt earth blanket to cover the reservoir areas of Bimoku, Oeltua, Benkoko and Oebuain so as to keep the water tightness of permeable layer in the reservoirs. As for Tasiepah, it is proposed to adopt concrete wall to protect water leakage through coral limestones in a part of the reservoir area.

7. PRELIMINARY DESIGN OF FACILITIES

7.1 Preliminary Design of Embung

The main components of each Embung are main dam, spillway, river diversion conduit, outlet works and leakage protection works. In order to provide an optimum storage capacity, the full supply level (F.S.L.) is determined by using the reservoir storage curve of each Embung. The height of Embung is determined considering F.S.L., overflow depth of spillway and freeboard.

Preliminary design works for each Embung are carried out based on the following basic concepts and procedures. The details are presented in the Volume 6.

(1) Freeboard

The freeboard of Embung is designed taking into account the rise of the reservoir water surface due to extraordinary flood discharge and wave uprush on the dam slope. Under the Study, the designed freeboard comprises 5% of height from the river bed to the designed flood level and allowance of 1.0 m.

(2) Stability of dam slope

The upstream and downstream embankment slopes of the main dam are determined considering the result of stability analysis. The required minimum safety factor for the stability of the embankment is 1.2 for all cases. Seismic coefficient of 0.15 is applied to the calculation under the F.S.L. condition of Embung. This coefficient is decided in due consideration of designed seismic coefficient applied to Embung and irrigation projects in NTT. A slip circle method is used for the stability analysis. The basic concept of this method is to check whether the resisting moment of the force along a presumed slip circle line exceeds the driving moment caused by gravity and seismic forces or not.

(3) Horizontal filter drain and toe rock drain

In order to reduce the seepage line within the dam body under the F.S.L. condition, horizontal filter drain (drainage mattress) and toe rock drain are provided below the dam body and the toe portion of the main dam.

(4) River diversion during construction

River diversion works are required during performing the embankment works of the main dam of all Embungs for the dry season. The design discharge of river diversion channel is decided on the basis of the flood discharge with a return period of 1 in 5 years during the dry season from May to November. River can be effectively and economically made by providing a random-filled cofferdam and utilizing one or two lanes of concrete conduit.

(5) Spillway

A spillway is planned to be provided on the right or left abutment of each Embung. The spillway is composed of overflow weir, throughway, shuteway and downstream channel. The non-gated overflow weir is designed to cope with the inflow design flood determined for 100 year probable flood. A bridge is considered over the throughway of the spillway if required.

(6) Outlet works

Outlet works are provided to release the impounded water to the downstream beneficiary water users and consist of intake structure, pipe line and valve house. The intake structure is located above the sediment deposition level of each Embung. Fixed trashracks are provided on the intake structure. Cast iron pipe is connected from the intake structure to the valve house along the river diversion conduit. The valve house is constructed near the downstream toe of each Embung consisting of check valve and flow meter to control the released water.

(7) Leakage protection works

There are several kinds of leakage protection works such as rubber sheet facing work, concrete facing work, earth blanket work, and so on to protect water leakage from the reservoir area. The leakage protection method is selected for each Embung taking into careful consideration the required construction cost for leakage protection works, the construction methods of leakage protection works, the topographic, geological and soil mechanical conditions in the reservoir area, the socio-economic condition around Embung, and so on. The leakage protection works applied to each Embung are summarized below:

- Bimoku, Oeltua, Benkoko and Oebuain : Soils in the reservoir area can be used as blanket materials for the leakage protection. Earth blanket works with a thickness of 2.0 m are to be executed in the whole reservoir area;
- Tasiepah : Coral limestone zone existing on the ridge of reservoir area below F.S.L. is faced by concrete lining with a thickness of 50 cm and anchor bars; and,
- Matasio : No leakage protection works are required.

Main features of the six Embungs are shown in Table 7.1 and summarized below.

Main Features of Embungs

Item	Unit	Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio
Catchment area	km^2	0.2	0.8	32.1	2.3	0.8	5.0
Dam height	m	14.0	12.0	26.0	19.5	12.0	11.0
Crest length	m	90.0	340.0	200.0	413.0	180.0	297.0
Reservoir area	m^2	13,200	25,750	345,000	38,800	21,000	160,000
Effective storage capacity	m^3	51,250	81,200	1,996,000	170,000	58,800	445,000
Embankment volume	m^3	31,000	200,000	267,000	221,000	80,000	110,000
Design flood discharge of spillway	m^3 /s	18	48	428	49	21	33
Crest width of spillway	m	6.2	8.7	50.0	12.4	7.3	9.1

7.2 Preliminary Design of O&M Road for Embung

There exist well conditioned access roads to Bimoku, Oeltua and Oebuain Embung sites. While, no all weathered road is available in and around Tasiepah, Benkoko and Matasio Embung sites. It is therefore planned to provide O&M roads to these three sites aiming at smooth undertaking of O&M works after completion of Embungs. Main features are summarized below.

Main Features of O&M Road

Item	Unit	Tasiepah	Benkoko	Matasio
Required length	km	7.33	3.20	2.00
Width	m	4.0	4.0	4.0
Pavement		Gravel	Gravel	Gravel
Cross drain	Nos.	1	8	5

7.3 Preliminary Design of Water Distribution Facilities

The main components of water distribution facilities to inhabitants and livestock in the beneficiary area of each Embung are pipe lines, division boxes with filter system for inhabitants, division boxes for livestock and related structures of pipelines.

Preliminary design works for each water distribution system are carried out based on the following concepts and the details are presented in the Volume 6.

- Distribution facilities to the beneficiary areas are laid out taking into consideration the effective storage capacity of each Embung, topographic condition of each Project area, village boundary and the existing water supply facilities;
- Water demand for inhabitants and livestock are fully reflected in the preliminary design of pipeline and the layout of division boxes in the beneficiary areas;

- Pipeline system with pressure flow is taken up for water distribution network from each Embung to its beneficiary area. Pipes are laid along the existing roads as much as possible from the viewpoint of easy O&M of pipeline system. Pipes are laid under the ground with a depth of 50 cm;

- Division boxes for inhabitants are arranged based on the water demand in each beneficiary area, water conveyance distance between a division box and its users' houses and topographic condition of a site for constructing a division box. The designed capacity of division box for inhabitants is 6,000 lit to cover daily water demand of 100 persons.

- Division boxes for livestock are arranged in a separate places from the division boxes for inhabitants to reduce risks such as contamination of water quality in and damages to division boxes for inhabitants, and so on. The designed capacity of division box for livestock is 900 lit to meet daily water demand of 22 heads of cattle indicating the total number of cow converted from the number of the respective livestock;

- Related structures of pipelines such as check valves, air valves and blowoffs are set taking into account the topographic condition along and layout of each pipeline system; and,

- High Density PVC pipes are used for the water supply in due consideration of the safety against unexpected high pressure to the pipes, the steep and undulating topographic condition and the easiness to get the materials in Indonesia.

The design discharge of pipeline is decided on the basis of the unit water demand of inhabitants and livestock as well as the projected population of inhabitants and livestock for the beneficiary area of each Embung. Main features of the pipeline system are shown Table 7.2 and summarized below.

Main Features of Pipeline System

Item	Unit	Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio
Design discharge	lit/s	1.27	1.80	1.60	0.95	1.46	0.56
Total length of pipeline	km	1.47	1.63	9.63	5.40	4.22	4.04
Total number of related facilities	Nos.	24	58	68	46	39	23

7.4 Preliminary Design of Irrigation Facilities

The main components of water distribution facilities to the beneficiary irrigation areas of Tasiepah, Benkoko and Matasio Embungs are irrigation inlet box, concrete flume type canal, aqueduct, cross drain and irrigation division boxes. Preliminary design works for irrigation facilities are carried out based on the following basic concepts and the details are presented in Volumes 6-3, 6-4, and 6-6.

- Irrigation canals are laid from the outlet of each Embung to the head of beneficiary irrigation area by an open channel as much as possible from the economical viewpoint;

- Canal alignment for gravity irrigation system is designed in harmony with the present environmental circumstances; and,
- On-farm irrigation service facilities of the beneficiary areas are to be improved or upgraded by beneficiary farmers themselves.

In Tasiepah, irrigation water for the beneficiary area on the left bank is diverted at the valve house in the reservoir and then discharged to the river. It is again diverted from the existing weir and then led to the paddy field through the existing canal. These existing weir and canal need to be rehabilitated. While, irrigation water is led by the pipeline together with the domestic and livestock water from the reservoir to an irrigation inlet box and then conveyed separately to the beneficiary area by a concrete flume type open canal.

Main features of the irrigation water distribution system are shown in Table 7.3 and summarized below.

Main Features of Irrigation Water Distribution System

Item	Unit	Tasiepah		Benkoko	Matasio
		Left bank	Right bank		
Design discharge	lit/s	130	70	50	100
Irrigation inlet box	Nos.	0	1	1	1
Concrete flume type canal	km	0	3.1	0.3	1.0
Irrigation diversion box	Nos.	0	3	3	1

8. EMBUNG CONSTRUCTION PLAN

8.1 Construction Plan of Embung

In order to secure smooth implementation of each project, it is planned to carry out Embung construction works by using heavy equipment. The proposed construction plan for major construction items are described in general and its details are presented in the Volume 6.

(1) Preparatory works

The preparatory works consist of preparation of temporary buildings, construction plant, repair shop, power and water supply systems, communication system, construction of access and haul roads, and so on. The temporary buildings comprise office, quarters, workshop, warehouse and storage yard. For each Embung, the required floor space of temporary building is 1,200 m^2 for every 15 staff and 100 laborers and the required land area for temporary building and yard is 2,500 m^2.

(2) River diversion works

To release the river flow in the dry season during which embankment works of the main dam are undertaken, the river diversion conduit is laid under the excavated foundation of the main dam. Considering the proposed location of the outlet works and the topographic condition of the site, the river diversion conduit is arranged either the left or right bank side of the river. After completion of embankment works of the main dam, the whole stretch of the river diversion conduit is to be plugged by concrete.

(3) Main dam works

Following the completion of foundation excavation works and river diversion conduit arrangement, embankment works of the main dam are started as soon as possible in order to complete embankment works within one dry season. Excavation works of embankment materials at borrow areas are carried out by 21-ton class bulldozers. Excavated materials are loaded by 1.2-m^3 wheel loader and hauled to the embankment site by 11-ton dump trucks. At the site, embankment materials are spread by 21-ton bulldozer in a layer of 20 cm in thickness and then compacted by 10-ton class tire roller.

Riprap placement works are simultaneously undertaken with embankment works of the main dam. Rock materials are placed by 0.6-m^3 backhoe, and large voids need to be filled with smaller rock fragments. Riprap protection works are manually finished according to the designed slope and thickness.

(4) Spillway construction works

After completion of the preparatory works, excavation of spillway is performed by 21-ton bulldozer for flat portion and 1.2-m^3 backhoe for steep slope shuteway portion. Concrete placing works for spillway structures are carried out by using 20-ton class truck crane with 1.0-m^3 concrete bucket and concrete pump with a capacity of 20m^3/hr. Major concrete works need to be completed before starting to impound water in the reservoir so as to release the flood discharge in the next wet season.

(5) Outlet works

Outlet works are carried out to construct inlet structure above the inlet portion of the river diversion conduit and to install a cast iron pipe along the river diversion conduit up to valve house. The cast iron pipe is connected to check valve and flow meter in the valve house.

(6) Leakage protection works

Earth blanket works as the proposed leakage protection measure are undertaken for all Embungs except for Tasiepah and Matasio. The earth blanket with a thickness of 2.0 m is carpeted up to F.S.L. of the reservoir area. The ground of reservoir area is loosened by using 21-ton bulldozer and 3.7-m motor grader. The foundation of earth blanket is graded and trimmed smoothly by using 11-ton bulldozer and 3.7-m motor grader. Earth blanket materials are selected from the reservoir area or the borrow area, checking quality of soils in the field and undertaking trial embankment works at the site. Qualified earth blanket materials are compacted by using 21-ton bulldozer and 10-ton tire roller.

Concrete lining works are proposed as a leakage protection measure against coral limestone zone extending along the right bank of Tasiepah Embung site and reservoir. To construct the concrete protection wall with a thickness of 0.5 m, the surface of coral limestone zone is stripped and excavated by using 21-ton bulldozer and 3.7-m motor grader for flat portion and 1.2-m^3 backhoe for steep slope portion. Then, anchor bars are installed by using leg drill and D 25 reinforcement bars with mortar injection. Concrete is carried by using 3.0-m^3 agitator truck from a batching plant to the site and then placed by using 20-ton truck crane with 1.0-m^3 concrete bucket or concrete pump with a capacity of 20 m3/hr.

(7) Construction materials and equipment

Required quantities of the major construction materials for each Embung are summarized below.

Required Quantities of Construction Materials

Materials	Unit	Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio
Earthfill material							
- Main dam	m^3	30,000	200,000	267,000	221,000	80,000	110,000
- Blanket	m^3	34,000	68,000	0	102,000	56,000	0
Filter material							
- Horizontal drain	m^3	1,500	11,500	8,000	20,000	5,000	11,000
- Rip rap portion	m^3	800	2,500	2,000	2,900	900	1,800
Rock material							
- Riprap protection	m^3	1,700	5,500	5,200	7,800	2,400	4,800
- Toe rock fill	m^3	1,000	2,500	2,000	3,100	1,100	2,200
Concrete							
- Cement	ton	600	760	3,340	950	380	660
- Reinforcement bars	ton	50	65	265	66	22	43
- Aggregates	m^3	1,500	2,000	8,400	2,400	1,000	1,700

Required number of major construction equipment and plant for the six Embungs is shown in Table 8.1.

8.2 Construction Plan of Water Distribution and Irrigation Facilities

Construction works of water distribution and irrigation facilities are carried out in parallel with the construction works of Embung. Compared with the construction of Embung, work quantities and the scale of facilities are rather small and most part of construction works can be manually carried out. Heavy construction equipment is thus used for clearing, stripping, excavating, embanking and paving works of mainly O&M roads and if necessary water distribution and irrigation facilities.

8.3 Construction Schedule

The construction schedule of each Embung is determined on the basis of the following conditions and assumptions:

- All the construction works are carried out by contractor(s) selected through the competitive bidding(s);
- The construction plan is formulated taking into account the mode of construction, the completion target of construction works, the site, weather and topographic conditions, the availability of laborers, construction materials and equipment, and so on. The mechanized construction method is principally adopted and supplemented by ordinary construction method locally practiced;
- It is assumed that, for every year, 200 working days are available for undertaking earthfill embankment works, 270 days for filter drain and toe rock works, and 300 days for concrete works in view of the daily rainfall distribution in each Project area. For every working day, 8-hour shift is applied; and,

- The embankment works for the main dam are carried out during only the dry season and completed within one dry season to secure quality and profitability of construction works.

Major items considered in determining the construction schedule are described below:

- Mobilization and preparatory works : Detailed design and tendering works are carried out for about 10 months. Successful contractor's construction equipment and key staff are mobilized to the project site immediately after the "Notice to Proceed" is received by the contractor. Following the mobilization, the preparatory works are commenced to set out all structures at the project site and to construct temporary access to the major structural sites. These two works require about four months. In order to carry out the embankment works during the dry season of the second year, the detailed design works need to be commenced at the beginning of the first year;

- Excavation works : Excavation works need to be commenced at the river diversion conduit, main dam foundation and spillway sites following the preparatory works;

- Embankment works : After concrete works of river diversion conduit are finished, embankment works of the main dam and concrete works of spillway are started and simultaneously completed by the end of one dry season;

- Reservoir water impounding : Reservoir water impounding works are started from the beginning of the wet season after completion of the main dam embankment and spillway construction works. According to rainfalls in November and December, the impounding water will rise up to F.S.L. and can be supplied to the beneficiary areas in January. Therefore, the total construction period requires 14 months each for constructing Bimoku, Oeltua, Benkoko, Oebuain and Matasio Embungs and 26 months in case of Tasiepah Embung because of larger work quantities of construction works; and,

- Water distribution system and irrigation facilities : Construction works of water distribution system and irrigation facilities are executed in parallel with the Embung construction works.

The proposed construction schedule for each Embung is presented in Volume 6. If the six Embungs are constructed in a form of one package for the period of five years, construction works of Bimoku, Oeltua and Matasio Embungs are carried out in the second year and those of Benkoko and Oebuain Embungs are performed in the third year followed by Tasiepah Embung construction works in the fourth and fifth year. The overall construction schedule is shown in Figure 8.1.

8.4 Institutional Arrangement for Project Implementation

(1) Responsible organization for project implementation

In the course of project implementation, DPUP NTT, after getting approval from DGWRD, will direct its PKSA Timor Project Office to commence undertaking of detailed

investigation and design works of the proposed Embungs. Based on cost estimate, DPUP will disburse budget for land acquisition as well as construction of Embung and related facilities to the PKSA Project Office using development budget allocated from the Central Government. Before starting construction work, land acquisition will be carried out by the PKSA Project Office. Supervision of construction works, being entrusted to a contractor through tendering, will be also the responsibility of the PKSA Project Office. Figures 3.2 depicts the organizational structure of the PKSA Timor Project Office under DPUP NTT.

(2) Technical resources input

In due consideration of the current availability of engineers and technical staff as well as the annual target of project implementation in the PKSA Project Office, it is necessary to utilize technical resources outside DPUP to the full extent for enabling the Project Office to realize its target. In this connection, undertaking of detailed investigation and design works as well as construction supervision need to be entrusted to consultants aiming to secure smooth implementation of the project in accordance with the implementation program made by the PKSA Project Office and approved by DUPU.

(3) Organization for O & M

After completing all implementation works of Embung, DPUP will have to submit its completion report of the project to the Minister for Public Works through DGWRD and therefrom the notice of project completion will be transferred to the Minister for Home Affairs. After receiving the Home Affairs Minister's direction, the Governor of NTT Provinces will order DPUP NTT to take a necessary action for operation and maintenance of the newly completed project facilities. Following this, the both DPUP will direct its Provincial Project Office for Operation and Maintenance to arrange O&M works with the Provincial Government's budget allocation to the relevant DPUP Kabupaten Offices.

(4) Water User's Association (P3A)

If no P3A has been established yet in each beneficiary area, agencies concerned at provincial and district levels will have to promote organization of beneficiary farmers into P3A and to train them by using training materials and modules prepared by the Water User Training Program under DGWRD.

9. COST ESTIMATE

9.1 Basic Assumption of Cost Estimate

Cost estimate of the proposed project works is made on the feasibility level based on the following basic assumptions:

- All the civil works of the each project are performed by contractor(s), selected through the competitive bidding, on the contract basis;
- For physical contingency, 15% of the total amount of direct construction, administration and engineering costs is appropriated, while 10% of the total cost is added as price contingency;
- The direct construction cost is estimated on the basis of work quantities of the proposed construction works and unit price of each work item. The unit price is estimated for each work item taking into account the market price as of June 1994 and referring to data collected from the on-going projects in NTT. The unit price includes delivery cost of construction materials and equipment to each project site;
- For engineering service cost to cover detailed design and construction supervision works by consultants, around 15% of the direct construction cost is appropriated;
- For the contract tax as a value added tax imposed by the GOI, around 10% of the total contract cost is appropriated;
- Administration cost covers staff salary and office running cost of PRWS's responsible section to manage implementation of each project. Taking into account the actual condition of on-going projects in NTT, around 5% of the direct construction cost is appropriated;
- Land acquisition cost is estimated to be 0.5% of the direct construction cost. The both administration and land acquisition costs need to be borne from the budget of the Government of Indonesia;
- The cost estimated excludes other associated costs necessary for strengthening extension services, organizing water users' association, improving social infrastructures and so on because these costs have to be arranged by the Government of Indonesia; and
- The currency used for the cost estimate is Indonesian Rupiah (Rp.).

9.2 Project Cost

The project cost is composed of direct construction cost, administration cost, engineering service cost, physical contingency, contract tax, land acquisition cost and price contingency. The details of cost estimate for each Embung are presented in the Volume 6. The project cost estimated on the feasibility level is shown in Table 9.1 and summarized below.

Summary of Project Cost

Unit : Rp. million

	Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio	Total
Direct construction cost	2,032	4,645	13,587	5,705	2,419	3,154	31,542
Preparatory works	97	221	647	272	115	150	1,502
Embung embankment	1,754	4,203	10,860	5,050	2,075	2,565	26,507
Water distribution facilities	181	221	639	198	229	147	1,615
O&M road	-	-	162	111	-	82	355
Irrigation facilities	-	-	1,279	74	-	210	1,563
Administration cost	102	232	679	285	121	158	1,577
Engineering services	305	697	2,038	856	363	473	4,732
Physical contingency	366	836	2,446	1,027	435	568	5,678
Contract tax	270	618	1,807	759	322	420	4,196
Land acquisition	10	23	68	29	12	16	158
Price contingency	308	705	2,063	866	367	479	4,788
Total	3,393	7,757	22,688	9,526	4,040	5,267	52,671

9.3 Operation and Maintenance Cost

The O&M cost covers salary of O&M staff, maintenance cost of project facilities, material and labor costs for repairing works and running cost of project facilities. For the O&M cost, 0.5% of the Project cost is appropriated amounting to Rp. 2,634 million every year.

10. PROJECT JUSTIFICATION

10.1 Benefits Attributable to Embung Development

In general, it is considered that direct benefits attributable to development of water resources by constructing Embung in NTT are derived from water supply to people living and livestock being raised in chronic water shortage areas as well as to irrigation of farm land resources. The water supply benefit anticipated in the beneficiary areas of six Embungs comprise two main portions: reduced time for fetching water from distant sources and reduced health problems or morbidity. But it is impossible to quantify such benefits attributable to improvement of the existing water supply system for the domestic and livestock use in the beneficiary areas. It is also hard to evaluate in quantitative manner the values of prospected gains by utilizing newly available working time and those of decreased incidence of water borne diseases.

The irrigation benefits in the beneficiary areas of Tasiepah, Benkoko and Matasio Embungs are principally derived from increased crop production attributable to stable irrigation water supply, full utilization of available farm land resources and optimum farm input supply. These benefits can be quantified by incremental net production value which is obtained in estimating the net production values under the "With Project" and "Without Project" conditions.

10.2 Satisfaction of BHN

Under the Study, the benefits to be born from satisfaction of BHN by creating new water resources are to be indicated as the value of water and the investment amount to each beneficiary inhabitant. The investment amount is given by deducting the administration and land acquisition costs from the project cost, because these costs will be born from the Government budget. Further, the investment cost is allocated to two portions taking into account the result of optimization study; one to meet BHN and the other to cover the irrigation water demand. The value of effective storage water is obtained by dividing the investment amount by the effective storage capacity, while that of supplied water is given by dividing the investment amount by the annual supply amount of domestic and livestock water. The number of livestock is converted to the equivalent number of cows according to the respective unit water consumption rates. Then, this equivalent number of cows is converted to the number of inhabitants based on the conversion rate of 0.67 obtained from the ratio of the both unit water consumption amounts.

The following shows the value of effective storage water to be created by each Embung and the investment amount to the respective beneficiary people.

Water Value and Investment Amount to Beneficiary People

Item	Unit	Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio
Effective storage capacity	'000 m^3	51.25	81.20	1,996.00	170.00	58.80	445.00
Beneficiary inhabitants	person	1,825	2,077	1,645	935	1,773	576
Beneficiary livestock (equiv. head of cow)		0	785	1,013	657	438	356
Total beneficiaries	person	1,825	2,603	2,324	1,375	2,066	815
Annual water supply amount	'000 m^3	39.97	56.95	50.82	30.08	45.22	17.81
Total Project cost	million Rp.	3,393	7,757	22,688	9,526	4,040	5,267
Investment cost	million Rp.	3,254	7,437	12,906	4,255	3,873	3,897
Value of effective storage water	'000 Rp./m^3	63.5	91.6	6.5	25.0	65.9	8.8
Value of supplied water	'000 Rp./m^3	81.4	130.6	254.0	141.5	85.6	218.8
Investment amount							
Inhabitants only	million Rp.	1.78	3.58	7.85	4.55	2.18	6.76
Total beneficiary	million Rp.	1.78	2.86	5.55	3.09	1.87	4.78

In case of the beneficiary area of Matasio Embung, the existing water sources are also used by many stock breeders living outside of the project area. After completion of the proposed Matasio Embung, another 975 heads of cow can be expected to get drinking water from the existing water sources. Therefore, the investment amount to the total beneficiary people reduces to Rp. 2.65 million.

10.3 Economic Consideration

(1) Economic cost

The financial costs are to be converted into the economic costs by applying the economic conversion factor (ECF) established by DGWRD in 1985. The ECFs applied are 0.71 for civil works and tertiary irrigation system development, 1.00 for O&M equipment, 0.90 for engineering service and supporting works, 0.80 for O&M costs. All the transfer payments are not included into the economic cost.

(2) Economic benefit

In Volumes 6-3, 6-4, and 6-6, basic data necessary for undertaking economic evaluation are presented including the price structures of paddy, Palawija crops and fertilizers, economic crop budget and net production value. In the three proposed reservoir areas, there is no loss of productive and foregone benefits due to inundation of the area after completion of Tasiepah, Benkoko and Matasio Embungs. The benefits will accrue from the initial year after

completion of the project. Taking the present agricultural situation and farmers capability into account, build-up period is assumed to be five years.

(3) Economic evaluation

The estimated economic cost and benefit as at July 1994 are summarized in Table 10.1 and the economic internal rate of return (EIRR) is examined as shown in Volumes 6-3, 6-4, and 6-6. Due to BHN satisfaction oriented development plans of Tasiepah, Benkoko and Matasio, EIRR of less than 1% for the three projects indicates that irrigation investment is not economically viable. However, these proposed irrigation projects utilizing the available water resources to the maximum extent would still have a significant positive impact on the development of the economically depressed areas in NTT.

(4) Farm budget analysis

With development of Embung and improvement of irrigation system, the annual net on-farm income of farmers holding a unit farm size of 1.0 ha can be expected to increase by Rp. 868,500 in the beneficiary area of Tasiepah Embung, Rp. 1,308,500 in Benkoko and Rp. 426,200 in Matasio. Such improvement of their farm budget would give much incentive for farmers to make further investment in improvement of their living standard and also could increase their payment capacity enabling beneficiary farmers to pay irrigation water charge.

10.4 Environmental Impact Assessment

By referring to "Environmental Guidelines for Agricultural and Rural Development Projects of JICA Development Study", prospected environmental impacts of Embung development are assessed according to the following procedure:

- To identify the scope of environmental impact assessment;
- To choose environmental issues in due consideration of the project components and demarcation of places where environmental issues occur;
- To identify actual environmental aspects and impacts;
- To assess potential environmental aspects and impacts, both positive and negative;
- To suggest mitigatory measures against negative environmental impacts; and,
- To identify environmental issues authorized by "Guidelines for Selecting Environmental Impacts Analysis Management (AMDAL) Procedure for Projects of the Ministry of Public Works, Republic of Indonesia".

As described in the Volume 6, the results of environment impact assessment reveal that there exist no major negative environmental impacts by constructing Embungs in the project areas. In each catchment area, however, many rural people have cut down trees for their firewood, carried out shifting cultivation and grazed cattle, resulting in reduction of water conservation, acceleration of soil erosion and further increase in sedimentation inflow into the new reservoirs. Another negative impact to occur in the future is contamination of the reservoir water by defecating activities of inhabitants and grazed cattle.

The proposed mitigatory measures against the above are to promote afforestation and reforestation of the catchment areas as well as to protect the reservoir by enclosing with a fence.

Primary information necessary for environmental assessment to be made on the Indonesian rule is compiled in the Volume 6.

10.5 Contribution to Women in Development

With provision of permanent water source facilities, women and children of 1,718 families in the six project areas can be quite free from their daily hard job to carry their domestic water at the average distance of 1,780 m. As a result, women will be able to utilize the saved time for improving their activities in relation to not only agriculture and livestock but also small business and cottage industry. Since housewives in the project areas manage their family budgets, increasing family's income would encourage women in investing surplus in improvement and diversification of their economic activities.

11. CONCLUSION AND RECOMMENDATIONS

11.1 Conclusion

The six Embungs, Bimoku, Oeltua, Tasiepah, Benkoko, Oebuain and Matasio, have been identified as the urgent water resource development schemes in NTT aiming to meet BHN for upgrading the living standard of inhabitants in all the project areas and to supply irrigation water to the beneficiary areas of Tasiepah, Benkoko and Matasio Embungs. The present Study is made to confirm technical feasibility and socio-economic impact of each project.

The project works consist of such major structural components as the main dam with spillway, water leakage protection measures, and domestic, livestock and irrigation water distribution systems. All of these components have to be implemented without missing any component for the purpose of achieving the development objectives.

As the results of the Study, it is clarified that construction of each of the project components is technically possible and the project is socially and socio-economically desirable for enabling 8,831 inhabitants to get permanent water source, to be quite free from daily hard job to carry their domestic water at the average distance of around 1,800 m and to decrease frequency of water born disease. Through irrigation water supply to the three beneficiary areas, it is expected to increase wet paddy production by 2,430 tons, mungbean by 1,920 tons and red onion by 5,175 tons as a whole, and also to increase farm income by Rp. 868,500 in the beneficiary area of Tasiepah Embung, Rp. 1,308,500 in Benkoko and Rp. 426,200 in Matasio for a unit farm size of 1.0 ha.

The required period to design and construct Embung together with water distribution facilities is 24 months for the five Embungs and 36 months for Tasiepah. In case that the six Embungs are constructed in a package form, the total period of the project implementation needs five years. The total project cost is estimated to be Rp. 52,671 million in total, if development of the six Embungs are simultaneously implemented.

In due consideration of the result of the Study and the request background by the GOI, it is therefore concluded that all the project are worthy of urgent implementation.

11.2 Recommendations

As concluded by the Study, it is recommended that necessary steps for the implementation of all the projects are to be immediately taken. Such steps will be composed of administrative issues and technical matters.

Main issues of the administrative matters to be taken up will be the determination of executing agency, the procurement of necessary fund in foreign currency and the preparation of budget in domestic currency as a counterparts fund.

Necessary technical matters to be made are composed of introduction of advanced technology and management know-how in terms of smooth construction of higher Embung on permeable foundation for shorter period. As the projects aim to supply raw water for domestic, livestock and irrigation use, it is recommended to take necessary action for performing appropriate watershed and reservoir water management works including afforestation and protection against entry of inhabitants and livestock in and around the reservoir so as to maintain water quality at desirable level.

In NTT, maximum utilization of limited water resources is prerequisite to support the upgrade of social infrastructures to satisfy BHN and to accelerate regional economic development. Paying special attention to considerable water resources potential of the proposed Tasiepah Embung, therefore, it is also recommended to undertake additional feasibility study on development of Tasiepah Embung at the maximum scale with the dam height of 36.0 m and the effective storage capacity of 7.096 million m^3 giving the priority to the comparison of the both cases; irrigation water supply oriented development in the neighboring river basins and urban water supply oriented development to meet water demand in Kupang, the capital of NTT.

Volume 3

The Study on The Embung Development Project in East Nusa Tenggara and West Nusa Tenggara

Feasibility Study on Six Embung Development Projects

Tables

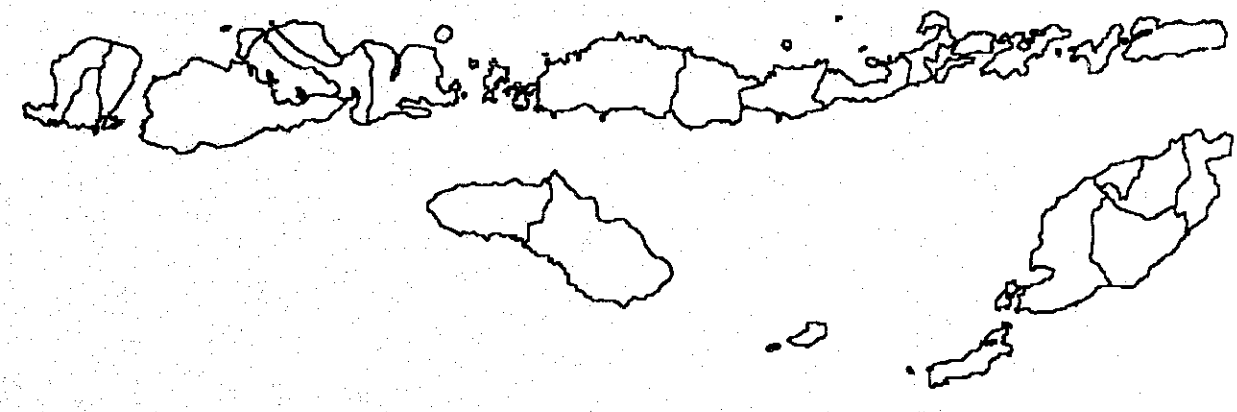

Table 1.1 Actual Results of Field Survey Entrusted to Local Consultants

	Unit	Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio	Total
Topographic Survey								
Scale 1/500	ha	9	11	34	5	3	5	67
Scale 1/5000	ha	100	70	880	320	190	210	1,770
Geological Survey								
Core Boring	m	165	125	280	160	130	170	1,030
Standard Penetration Test	Nos.	56	35	123	125	25	135	499
Field Permeability Test	Nos.	33	25	56	32	26	34	206
Soil Test	Nos.	6	8	11	9	6	11	51
Rock Test	Nos.	2	2	2	2	2	2	12
Material Survey								
Test Pit	Nos.	5	5	5	5	5	5	30
Sample for Laboratory Test	Nos.	20	20	20	20	20	20	120
Farm Economy Survey								
Sample farm households	Nos.	10	10	10	10	10	10	60
Water Quality Test								
Water Samples	Nos.	4	4	4	4	4	4	24

Table 3.1 Main Features of Geological Formation

Name of Stratum	Enbung Site	Rock Facies	Consolidation	Color	Characteristics	Engineering Geological Features	Standard Penetration N-value	Coefficient of Permeability cm/s
Bobonaro Complex	Benkoko Oebuain Matasio	Claystone to Claystone with exotic blocks (crystalline limestone and calcarious shale)	Soft rock (hard rock for exotic blocks)	Dark grey to dark red	Chaotic rock formed of olistostrome originated from submarine landslide deposits	No water leakage and foundation problem	10 to 50	6.1 x 10-5 to 2.4 x 10-7
Noele Formation	Bimoku Oeltua Tasiepah	Siltstone	Soft rock	Whitish grey	Sandy marl interdedded with sandstone, conglomerate and tuff	No water leakage and foundation problem	19 to 50	2.8 x 10-5 to 2.3 x 10-6
Coralline Limestone	Bimoku Oeltua Tasiepah	Coral limestone	Medium hard rock	Milky white to yellowish white	Highly porous and mederately hard rock formed of raised coral reef	Water leakage problem	16 to 50	5.8 x 10-3 to 1.1 x 10-5
	Matasio	Sandy limestone	Soft rock	Milky white to yellowish white	Secondary deposit distributed under coral limestone	Wide variation of permeability with water leakage problem in limited part of layer	12 to 50	4.3 x 10-4 to 3.8 x 10-6
Debris	Benkoko Oebuain	Soils with gravel	Sediments	Dark brown to brownish grey	Secondary deposits overlying the Bobonaro Formation and formed of mud flow	Wide variation of permeability with water leakage problem in limited part of layer	10 to 50	6.9 x 10-2 to 2.4 x 10-7
Terrace Deposits	Tasiepah	Gravel with soils	sediments	Dark brown to brownish grey	Uncosolidated and highly permeable	Water leakage problem	12 to 26	-

Table 3.2 Present Domestic and Livestock Water Use

Type of Water Source	Unit	Bimoku	Oeltua	Tasieph	Benkoko	Oebuain	Matasio
Public Water Basin and Tank							
No. of facility	Nos.	5 (2*)	1	-	-	-	3
No. of users	person	569	1,159	-	-	-	338
	family	123	262	-	-	-	80
Average distance	m	33	590	-	-	-	250
No. of livestock	head	36	0	-	-	-	0
Public Well and Grant Well							
No. of facility	Nos.	5 (1*)	2*	9	14	5	-
No. of users	person	78	209	228	1,779	218	-
	family	18	42	48	356	39	-
Average distance	m	47	250	140	35	34	-
No. of livestock	head**	119	88	436	1,159	91	-
Pipeline to Public Water Tank and Water Faucet***							
No. of facility	Nos.	1***	-	-	1	1	-
No. of users	person	4	-	-	<1,779>	207	-
	family	1	-	-	<356>	40	-
No. of livestock	head**	2	-	-	0	-	-
Private Well							
No. of facility	Nos.	214*	14*	3	-	-	2 & <3>
No. of users	person	1,234	135	44	-	-	83/<96>
	family	310	27	9	-	-	20/<22>
Average distance	m	16	42	139	-	-	10/<15>
No. of livestock	head**	206	0	25	-	-	0/<0>
Spring and Artesian Well***							
No. of facility	Nos.	-	-	1***	26	5	-
No. of users	person	-	-	39	<1,779>	255	-
	family	-	-	9	<356>	48	-
Average distance	m	-	-	500	7,040	985	-
No. of livestock	head**	-	-		<1,159>	230	247
River							
No. of facility	Nos.	1	-	1	-	-	14
No. of users	person	106	-	110	-	-	0
	family	32	-	23	-	-	0
Average distance	m	100	-	917	-	-	6
No. of livestock	head**	132	552	305	-	<321>	0
No Specific Water Source, and Water suppied by Public Tanker or taken from River/Spring***							
No. of users	person	291	142	884	-	820***	67***
	family	65	28	189	-	151***	16***
No. of livestock	head**	0	0	0	-	0	0

Remarks : * ; Water source destroyed, dried up during the dry season or contaminated by mud water during the wet season.

** ; All livestock are converted to number of cow according to unit water consumption rate.

*** ; Indicating numbers of facilities and users in the Project Area.

Source : JICA Water Use Survey

Table 3.3 Present Cultivated Area and Crop Production

Crop	Unit	Bimoku	Oeltua	Tasieph	Benkoko	Oebuain	Matasio
Cultivable land	ha	286	277	297	667	386	175
Cropped Area							
Wet paddy							
- Irrigated	ha	0	7	73	0	0	0
- Raifed (Wet season)	ha	10	0	0	152	0	60
- Raifed (Dry season)	ha	0	0	0	52	25	0
Maize	ha	276	75	222	365	220	3
Groundnut	ha	0	15	0	0	5	0
Mungbean	ha	0	0	0	0	4	0
Cassava	ha	0	5	0	15	0	0
Tuber crops	ha	0	0	0	0	215	0
Coconut	ha	0	0	0	0	7	10
Total cropped area	ha	286	102	295	584	476	73
Cropping Intensity	%	100	37	99	88	123	42
Yield							
Wet paddy							
- Irrigated	ton/ha	-	1.70	1.75	-	-	-
- Raifed (Wet season)	ton/ha	1.50	-	-	1.20	-	2.25
- Raifed (Dry season)	ton/ha	-	-	-	1.50	1.70	-
Maize	ton/ha	0.40	1.40	1.80	2.40	1.10	2.00
Groundnut	ton/ha	-	1.00			0.75	-
Mungbean	ton/ha	-	-	-	-	0.80	-
Cassava	ton/ha	-	4.00	-	4.60	-	-
Tuber crops	ton/ha	-	-	-	-	8.00	-
Crop Production							
Wet paddy							
- Irrigated	ton	0	12	128	0	0	0
- Raifed (Wet season)	ton	15	0	0	182	0	14
- Raifed (Dry season)	ton	0	0	0	78	43	0
Upland paddy	ton	0	0	0	0	0	0
Maize	ton	110	105	400	876	242	6
Groundnut	ton	0	15	0	0	4	0
Mungbean	ton	0		0	0	3	0
Cassava	ton	0	20	0	69	0	0
Tuber crops	ton	0	0	0	0	1,720	0

Source : JICA Agro-economy Survey

Table 5.1 Engineering Geology for Each Embung SIte

Site	Foundation	N - Value	Permeability (cm/sec)	Problem
Bimoku	Noele Formation; Siltstone	19～50	2.8 x 10-5 ～9.8 x 10-6	None
	Coralline limestone; sandy limestone	12～50	7.4 x 10-5 ～1.6 x 10-5	Minor Water Leakage
Oeltua	Coralline limestone; sandy limestone	11～50	4.3 x 10-4 ～3.8 x 10-6	Water Leakage
Tasiepah	Noele Formation; Siltstone	22～50	8.5 x 10-6 ～2.3 x 10-6	None
	Coralline limestone; coral limestone	23～50	4.6 x 10-4 ～1.7 x 10-5	Major Water Leakage
	Terrace deposits; gravel with soil	12～26	-	Water Leakage
Benkoko	Bobonaro Complex; claystone	14～50	2.2 x 10-5 ～2.4 x 10-7	None
	Debris; soil with gravel	10～41	6.9 x 10-2 ～2.4 x 10-7	Water Leakage
Oebuain	Bobonaro Complex; claystone	16～46	3.8 x 10-5 ～8.5 x 10-7	None
	Debris; soil with gravel	36～50	8.4 x 10-3 ～2.2 x 10-5	Water Leakage
Matasio	Bobonaro Complex; claystone	10～49	6.1 x 10-5 ～7.1 x 10-7	None
	Coralline limestone; coral limestone	16～48	1.1 x 10-5	Major Water Leakage

Table 5.2 Main Features of Embankment Materials

Item		Scheme					
		Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio
Water content	%	21.92	26.88	31.59	23.09	56.28	25.88
Unit weight	g/cm3						
Maximum dry density	g/cm3	1.639	1.475	1.426	1.687	1.568	1.599
Optimum moisture content	%	20.38	22.74	28.77	18.73	22.74	21.98
Specific gravity	g/cm3	2.57	2.61	2.62	2.56	2.65	2.55
Liquid limit	%	48.56	53.73	70.87	45.25	60.39	61.73
Plastic limit	%	17.48	33.31	28.79	16.88	21.09	22.83
Plasticity index	%	31.08	28.58	36.08	28.37	39.30	38.90
Shrinkage limit	%	24.33	21.74	24.92	19.09	25.79	20.95
Angles of internal friction	℃	25	28	22	28	29	26
Cohesion (UU)	kg/cm2	1.305	0.991	1.618	1.556	1.146	0.734
Permeability	cm/sec	2.41E-06	2.01E-06	2.51E-06	2.96E-06	4.10E-06	2.05E-06
Passing of #200 sieve	%	44 to 93	54 to 94	55 to 86	39 to 68	66 to 82	32 to 97
Classification of soil		CL	CH	CL	CL	CH	CH

Source : JICA Study Team's estimate based on the test results

Table 7.1 Main Features of Embungs

Item	Unit	Embung					
		Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio
Reservoir							
- Catchment area	km2	0.20	0.82	32.10	2.30	0.80	5.00
- Full supply level (F.S.L.)	El.	24.00	362.50	109.00	576.00	375.00	32.00
- Minimum operation level (M.O.L)	El.	16.50	357.80	100.20	568.00	371.00	27.30
- Effective storage capacity	m3	51,250	81,200	1,996,000	170,000	58,000	445,000
- Dead storage capacity	m3	3,750	12,800	504,000	34,000	13,200	85,000
- Gross strage capacity	m3	55,000	94,000	2,500,000	204,000	72,000	530,000
- Sediment deposition level	El.	16.00	357.20	99.20	567.40	370.40	26.80
Main dam (homogeneous earthfill)							
- Height above river bed	m	14.00	12.00	26.00	19.50	12.00	11.00
- Crest elevation	El.	27.00	366.00	113.80	579.50	378.00	35.00
- Crest length	m	90.00	340.00	200.00	413.00	180.00	297.00
- Crest width	m	7.00	6.00	8.00	7.00	6.00	6.00
- Upstream slope		1:3.5	1:4.0	1:3.5	1:3.5	1:4.0	1:4.0
- Downstream slope		1:3.0	1:3.0	1:3.0	1:3.0	1:3.0	1:3.0
- Total embankment volume	m3	31,000	200,000	267,000	221,000	80,000	110,000
Spillway							
- Design flood (1/100)	m3/s	20.00	50.00	430.00	50.00	21.00	33.00
- Type		Non gated overflow	Non gated overflow	Non gated overflow	Non gated overflow	Non gated overflow	Non gated overflow
- Crest elevation of overflow weir	El.	24.00	362.50	109.00	576.00	375.00	32.00
- Width of overflow weir	m	6.20	8.70	50.00	12.40	7.30	9.10
- Discharge capacity	m3/s	20.00	20.00	43.00	50.00	21.00	33.00
- Length	m	89.00	107.00	210.00	132.00	95.00	120.00
River diversion							
- Design flood (1/5 year in dry season)	m3/s	2.00	5.50	49.40	15.70	6.70	7.00
- Conduit, Box culvert (B*H*Nos.)	m	-	-	1.7 x 1.7 x 2	-	-	-
Pipe culvert (Dia. * Nos.)	mm	900 x 1	1,100 x 1	-	1,200 x 2	1,200 x 1	1,200 x 2
Outlet works							
- Inlet structure	m	1.0 x 1.0	1.0 x 1.0	1.0 x 1.0	1.0 x 1.0	1.0 x 1.0	1.0 x 1.0
- Pipe diameter	mm	40.00	50.00	400.00	200.00	65.00	300.00
Leakage protection works							
- Type		Earth Blanket	Earth Blanket	Concrete Lining	Earth Blanket	Earth Blanket	-
- Covering area	El.	24.00	362.50	-	576.00	375.00	-
	m2	13000.00	25000.00	12000.00	39000.00	21000.00	-
- Thickness	m	2.00	2.00	0.50	2.00	2.00	-

Table7.2 Main Features of Water Distribution Facilities

Item		Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio
Annual Water demand	m3/year	39,970	56,950	50,820	30,080	45,220	17,810
Design discharge	lit./sec	1.27	1.80	1.60	0.95	1.46	0.56
Required length of pipes							
Dia. 400 mm	km	-	-	1.05	-	-	-
Dia. 75 mm	km	1.34	-	-	-	-	3.72
Dia. 65 mm	km	0.13	-	2.98	-	3.95	0.32
Dia. 50 mm	km	-	0.81	5.60	5.40	0.27	-
Dia. 40 mm	km	-	0.82	-	-	-	-
Total	km	1.47	1.63	9.63	5.40	4.22	4.04
Required related facilities							
Check valve	Nos.	2	6	6	5	3	5
Air valve	Nos.	2	2	5	3	2	1
Blow off	Nos.	1	-	2	2	1	1
Division box for inhabitants	Nos.	19	21	17	10	18	6
Division box for livestock	Nos.	-	29	38	26	15	10
Total	Nos.	24	58	68	46	39	23

Table 7.3 Main Features of Irrigation Facilities

Tasiepah	Benkoko	Matasio
Irrigation facilities required are as follows : Left bank area - Valve house with irrigation inlet box : 1 No. (including in the facilities for Embung) - Rehabilitation of the existing weir - Rehabilitation of the existing canal with related structures around 1.6 km Right bank area - Pipe line used together with domestic water supply : Approx. 1.0 km (including in the facilities for domestic water supply) - Irrigation inlet box : 1 No. - Concrete flume type canal with a base width of 0.5 m : Approx. 3.1 km - Cross drain : 2 Nos. - Irrigation division box : 3 Nos.	Irrigation facilities required are as follows : - Valve house : 1 No. (including in the facilities for Embung) - Irrigation inlet box : 1 No. - Concrete flume type canal with a base width of 0.5 m : Approx. 330 m - Cross drain : 1 No. - Irrigation division box : 3 Nos.	Irrigation facilities required are as follows : - Valve house : 1 No. (including in the facilities for Embung) - Irrigation inlet box : 1 No. - Concrete flume type canal with a base width of 0.5 m : Approx. 1.0 km - *Aqueduct* : 1 No. - Cross drain : 3 Nos. - Irrigation division box : 1 No.

Table 8.1 Minimum Number of Construction Equipment

(Required for Each Embung Construction)

	Equipment	Capacity	Minimum Number of Equipment
1.	Bulldozer	21 ton	2
2.	Wheel loader	1.2 m3	1
3.	Backhoe	1.2 m3	2
4.	Backhoe	0.6 m3	3
5.	Dump truck	11 ton	12
6.	Dump truck	7 ton	3
7.	Tyre roller	10 ton	1
8.	Motor grader	3.7 m	1
9.	Water tanker (Sprinkler)	6 kl	1
10.	Leg drill	2.8 m3/min	2
11.	Sinker	3.3 m3/min	2
12.	Air compressor	14 m3/min	1
13.	Batching plant	0.75 m3*1	1
14.	Agitator	3.2 m3	2
15.	Concrete bucket	1.0 m3	2
16.	Concrete vibrator	-	3
17.	Track crane	20 ton	1
18.	Water pump, Dia 200 mm	3.7 kw	2
19.	Welder	300 A	2
20.	Diesel generator	80 KVA	2
21.	Truck	7 ton	4
22.	Truck with crane	6 ton	1
23.	Pickup car	-	4
24.	Jeep	-	4
25.	Concrete pump	20 m3/hr	1

Source : JICA Study Team estimate

Table 9.1 Summary of Project Cost

Item	Project Cost (Million Rp.)					
	Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio
I. Direct Construction Cost	2,032	4,645	13,587	5,705	2,419	3,154
1.1 Preparatory Works	97	221	647	272	115	150
1.2 Embung Construction						
1) Main dam	330	1,991	2,578	2,241	811	1,171
2) Spillway	868	1,149	4,505	1,234	457	997
3) Intake, outlet & diversion channel	118	123	745	280	159	164
4) Seepage protection works	279	558	2,045	836	459	0
5) Miscellaneous	159	382	987	459	189	233
Sub-total of 1.2	1,754	4,203	10,860	5,050	2,075	2,565
1.3 Domestic Water Supply						
1) Pipe line	32	21	419	81	65	81
2) Division boxes	133	180	162	99	143	53
3) Miscellaneous	16	20	58	18	21	13
Sub-total of 1.3	181	221	639	198	229	147
1.4 Embung Operation and Maintenance Road	0	0	162	111	0	82
1.5 Irrigation Facilities	0	0	1,279	74	0	210
II. Administration Cost	102	232	679	285	121	158
III. Engineering Services	305	697	2,038	856	363	473
Sub-total of I, II & III	2,438	5,574	16,304	6,846	2,903	3,785
IV. Physical Contingency	366	836	2,446	1,027	435	568
Sub-total of I, II, II, & IV	2,804	6,410	18,750	7,872	3,338	4,353
V. Contract Tax	270	618	1,807	759	322	420
VI. Land Acquisition/Compensation Cost	10	23	68	29	12	16
Sub-total I, II, III, IV, V & VI	3,084	7,051	20,625	8,660	3,672	4,788
VII. Price Contingency	308	705	2,063	866	367	479
GRAND TOTAL	3,393	7,757	22,688	9,526	4,040	5,267

Source : JICA Study Team estimate

Table 10.1 Summary of Economic Costs and Benefits for Economic Evaluation (June 1994 price level)

(Unit : Rp. million)

Item	Tasiepah Embung	Benkoko Embung	Matasio Embung	Total
1. Cost Allocation (Financial Cost)				
1.1 Investment Cost	22,688	9,526	5,267	37,481
(a) Domestic and Livestock Water Supply	12,906	4,255	3,897	21,058
(b) Irrigation Water Supply	8,848	4,879	1,153	14,880
1.2 Administrative Cost born from Counter Budget	934	392	217	1,543
2. Economic Investment Cost for Irrigation				
1.1 Direct construction cost				
(a) Embung	3,013	2,110	361	5,484
(b) Irrigation Water Distribution System	908	53	149	1,110
Sub-total	3,921	2,163	510	6,594
1.2 Engineering services	745	411	97	1,253
1.3 Physical contingency	700	386	91	1,177
Total investment cost	5,366	2,960	698	9,024
1.5 Annual disbursement				
1st Year	285	158	44	487
2nd Year	1,591	2,802	654	5,047
3rd Year	3,490	0	0	3,490
4th Year	0	0	0	0
5th Year	0	0	0	0
3. Annual O&M cost				
3.1 Embung, intake and pipe (0.5% Of 1.1)	20	11	3	33
4. Economic irrigation benefit				
4.1 Annual net production value (see Table 8-5)				
(a) With project net benefit	171.9	151.4	52.0	375.3
(b) Without project net benefit	33.0	0.6	16.0	49.6
4.2 Incremental net benefit (= a - b)	138.9	150.8	36.0	325.7
5. Negtive benefit	0	0	0	0

Volume 3

The Study on The Embung Development Project
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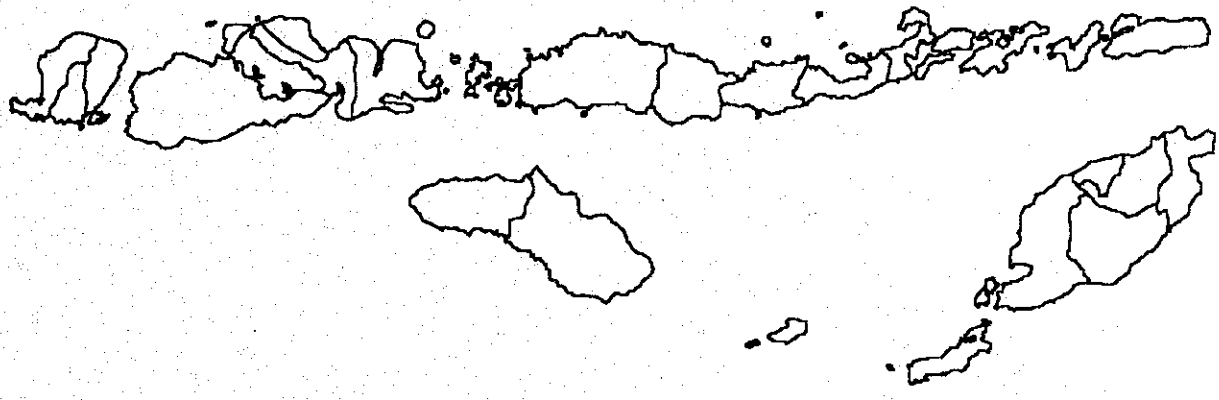
Six Embung Development Projects

Figures



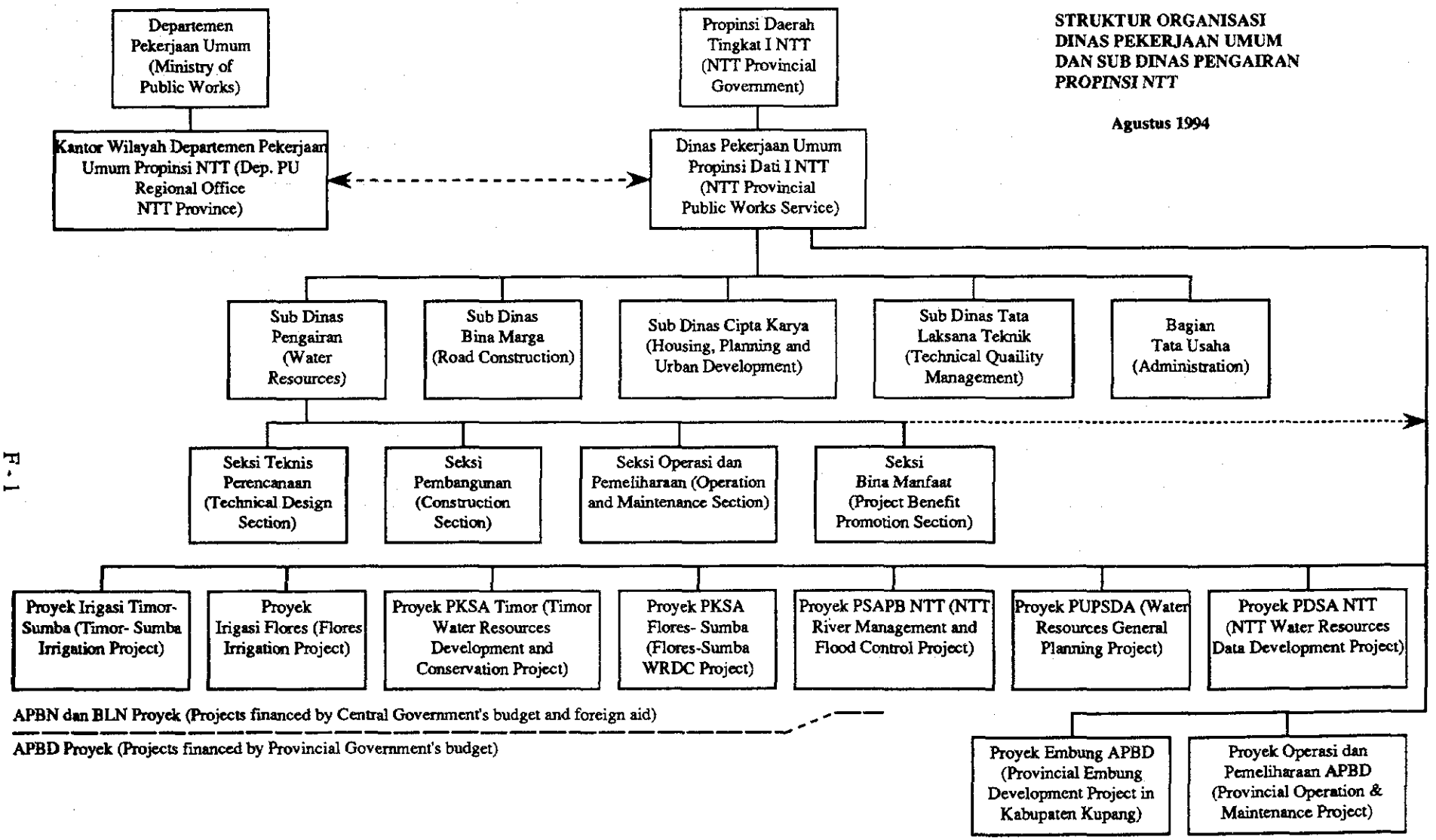


Figure 3.1 Present Organization Chart of PRWS, NTT

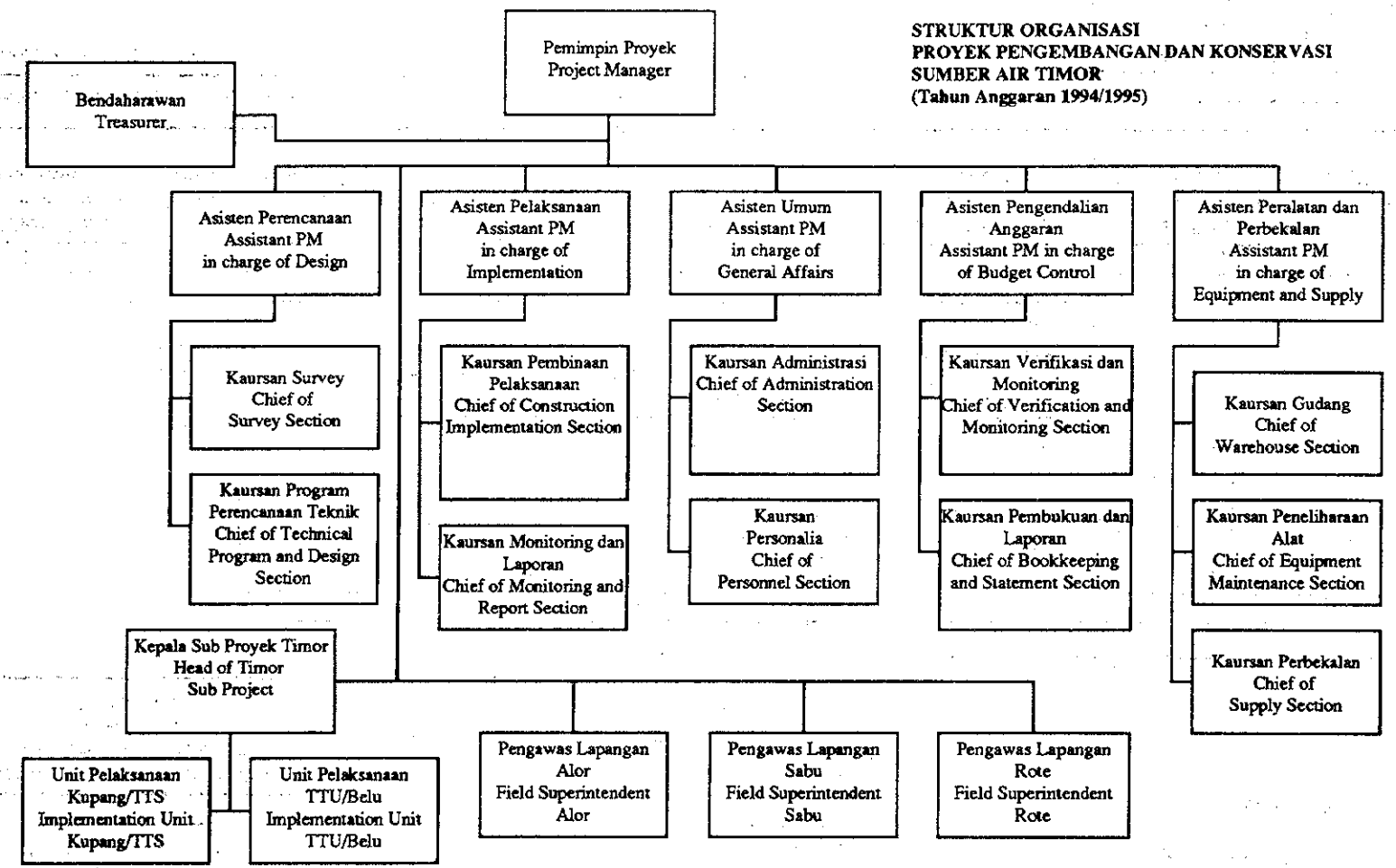


Figure 3.2 Organization Chart of PKSA Timor, NTT

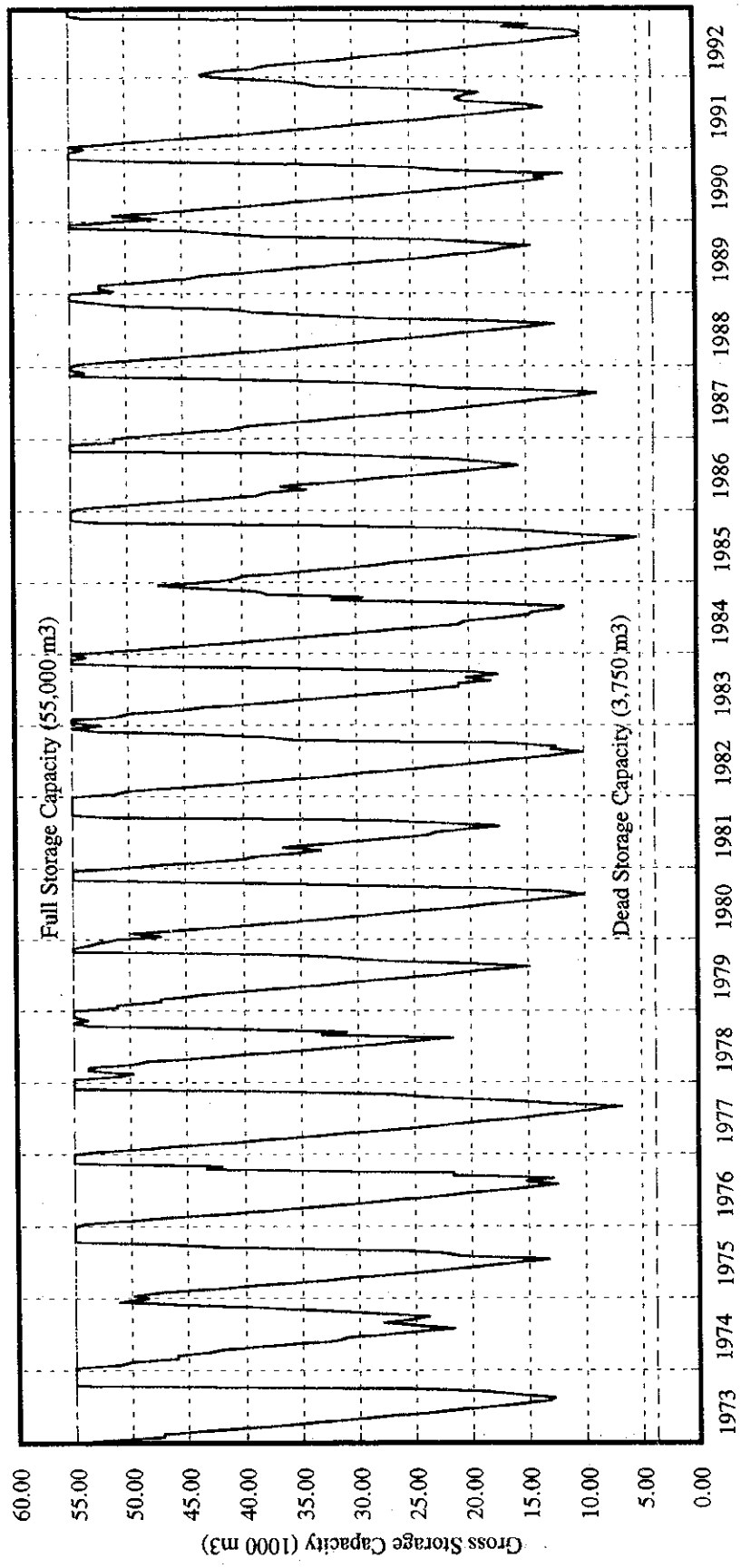


Figure 6.1 Result of Reservoir Operation in Bimoku Embung

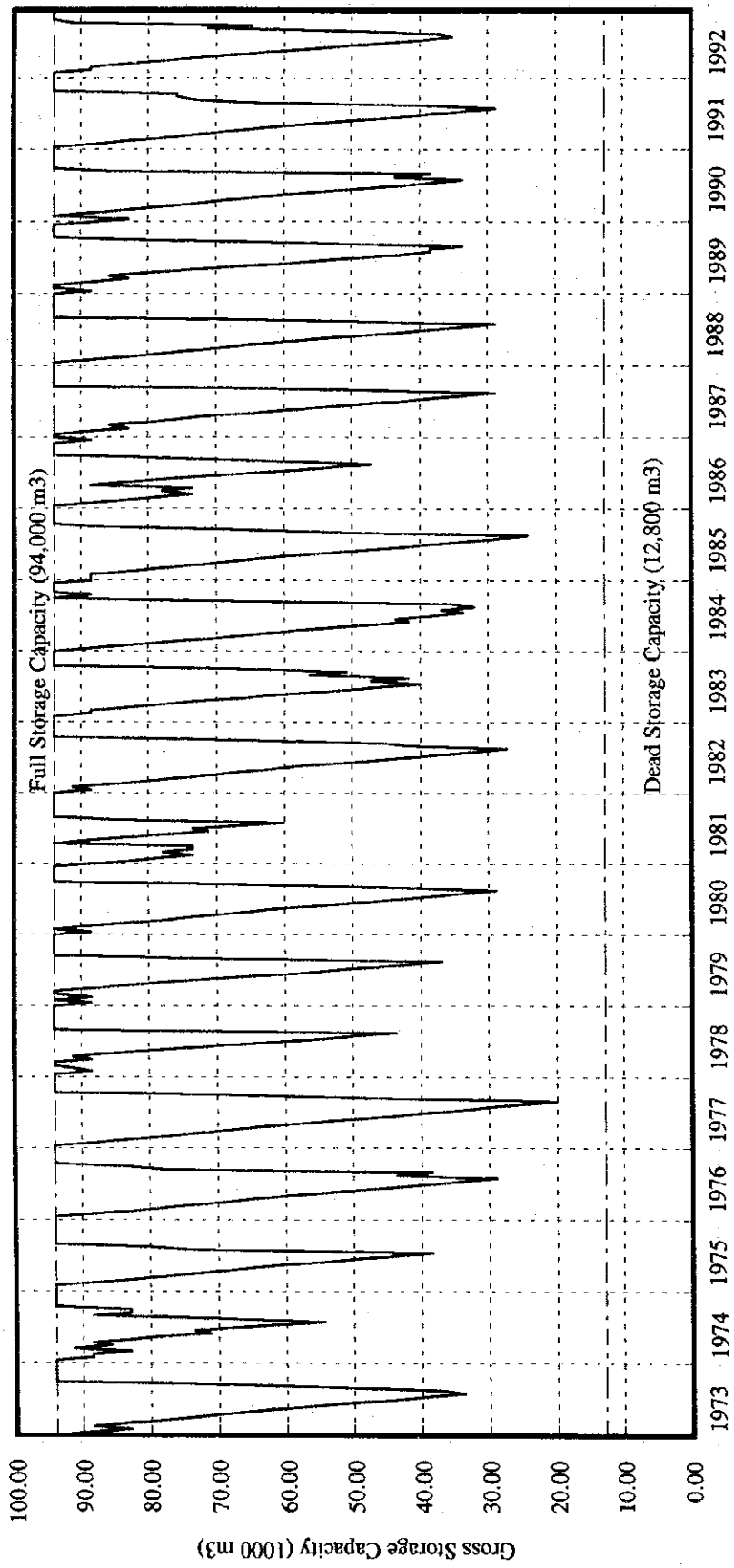


Figure 6.2 Result of Reservoir Operation in Oeltua Embung

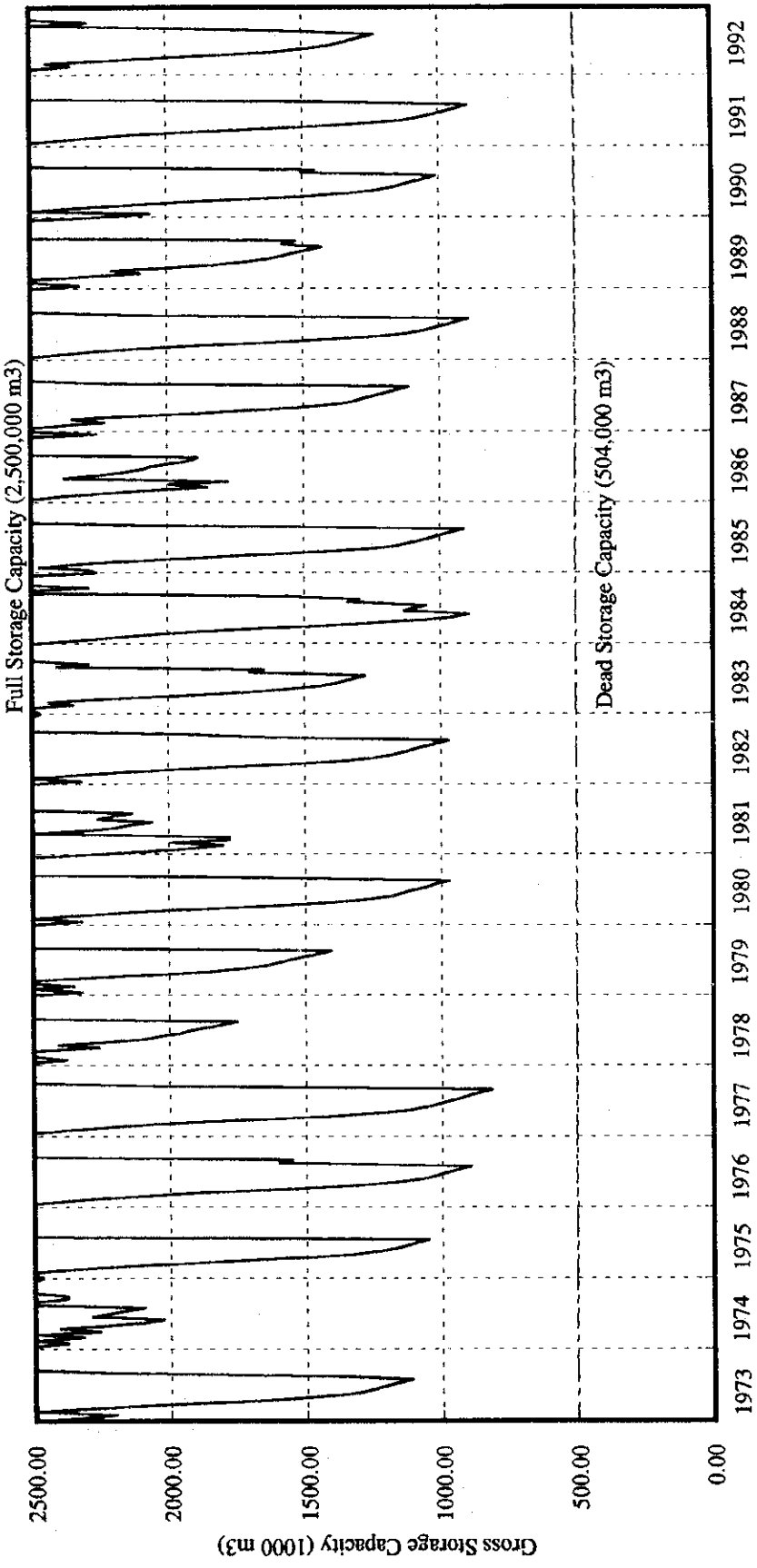


Figure 6.3 Result of Reservoir Operation in Tasiepah Embung

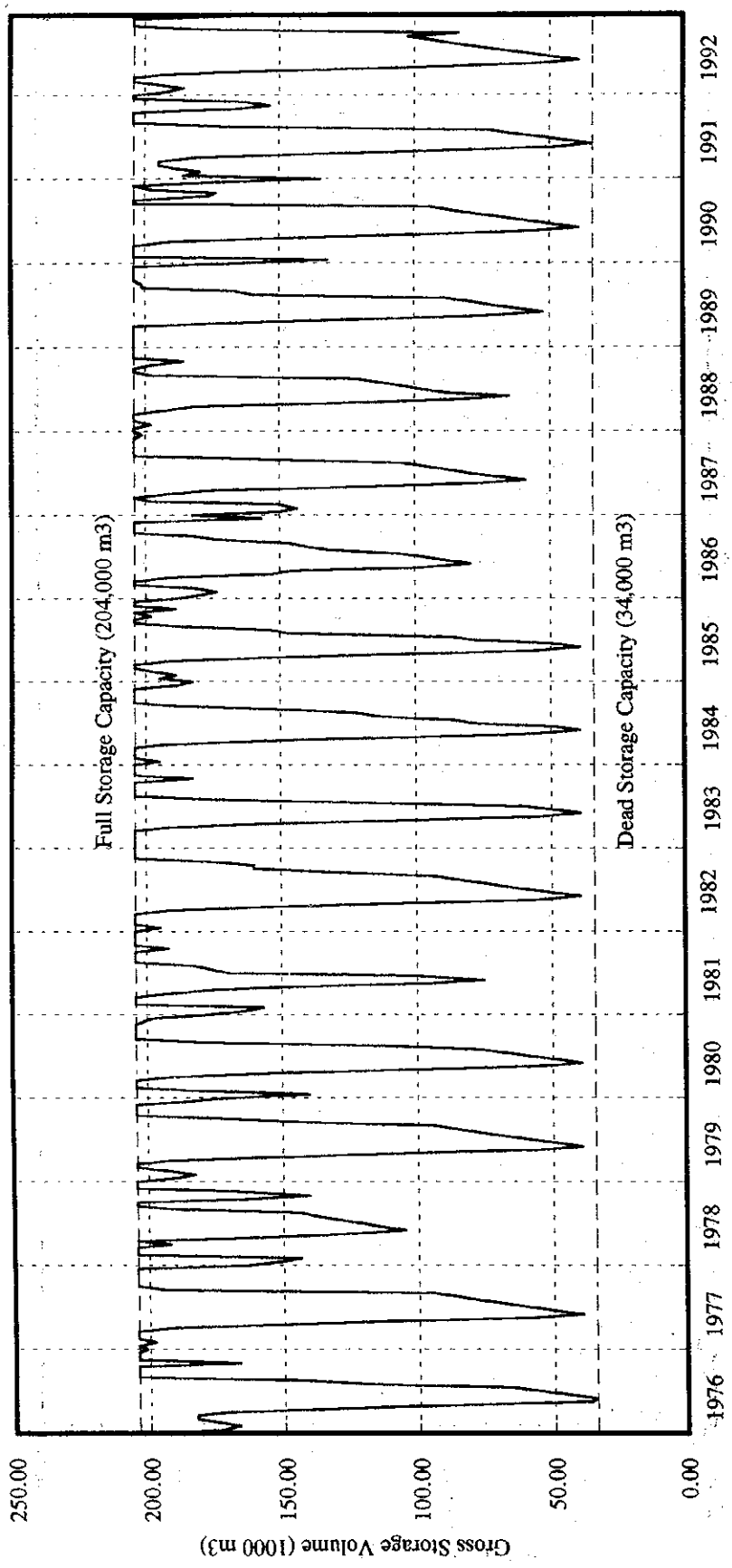


Figure 6.4 Result of Reservoir Operation in Benkoko Embung

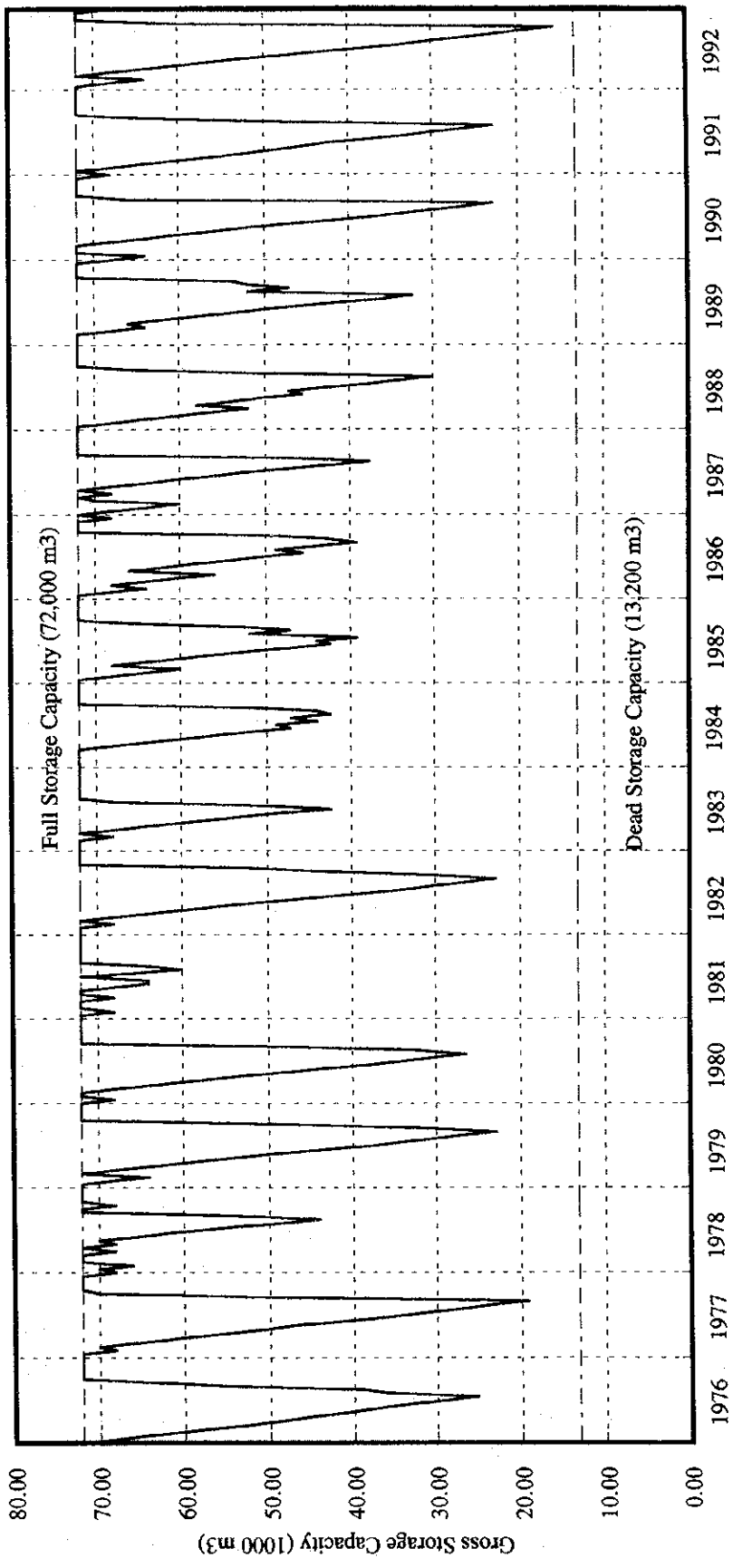


Figure 6.5 Result of Reservoir Operation in Oebuain Embung

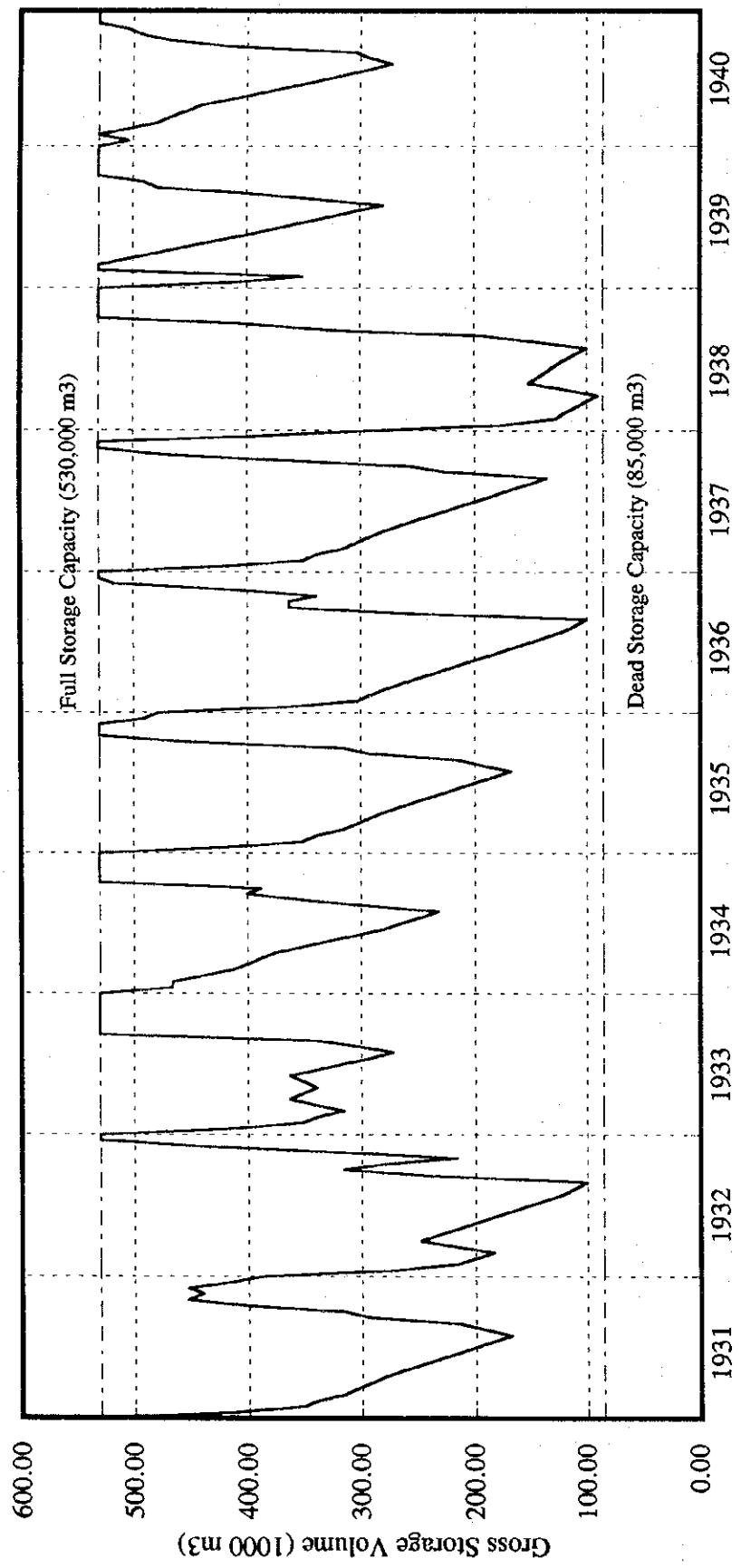


Figure 6.6 Result of Reservoir Operation in Matasio Embung

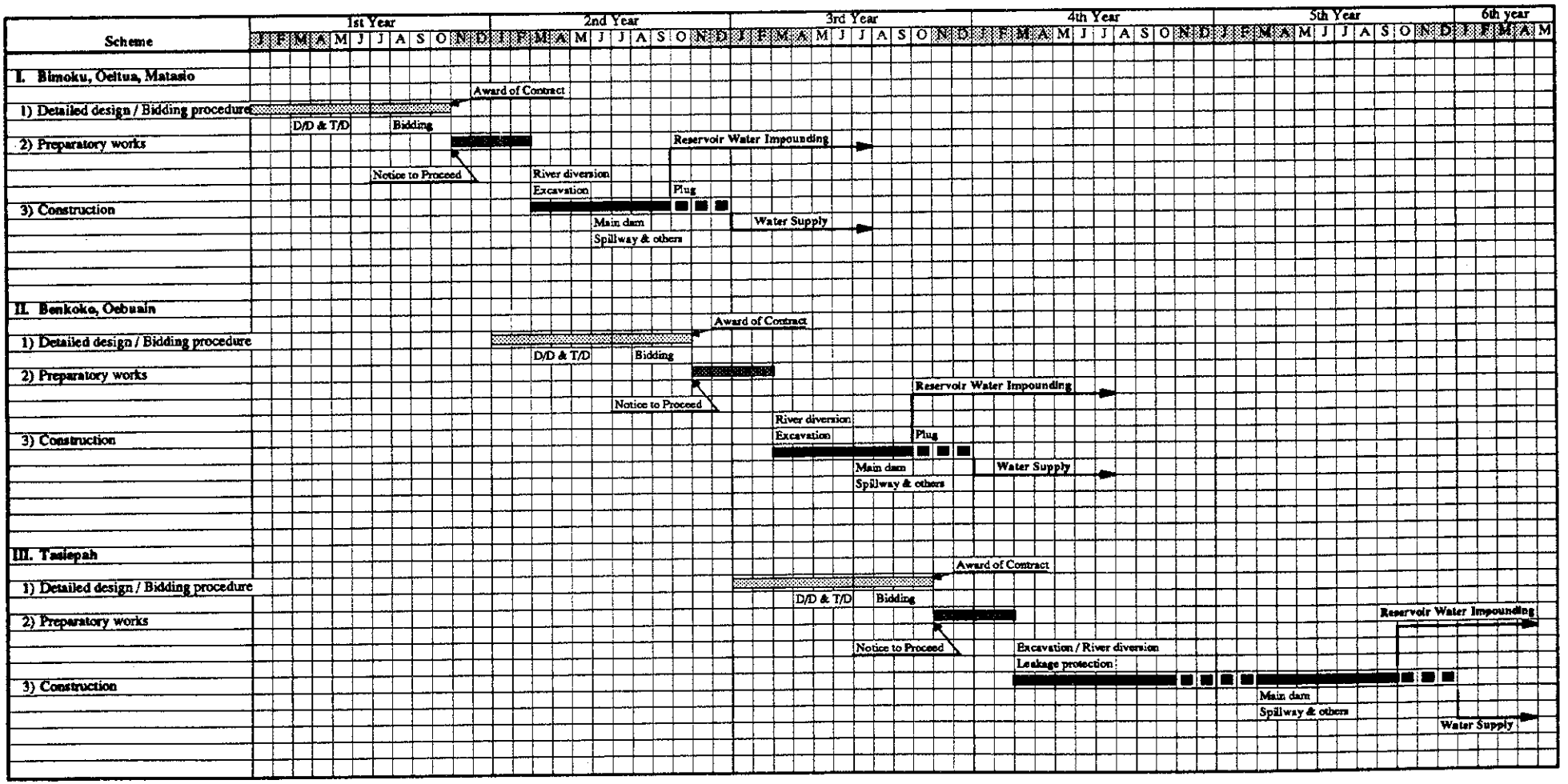


Figure 8.1 Construction Time Schedule

JICA