JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

THE STUDY ON COMPREHENSIVE RIVER WATER MANAGEMENT PLAN IN JABOTABEK

FINAL REPORT

VOLUME I

EXECUTIVE SUMMARY

MARCH 1997

NIKKEN CONSULTANTS, INC.
NIPPON KOEI CO., LTD.

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The Final Report consists of the following:

VOLUME I : EXECUTIVE SUMMARY

VOLUME II : MAIN REPORT (MASTER PLAN)

VOLUME III : MAIN REPORT(FEASIBILITY STUDY)

VOLUME IV : ANNEXES I

ANNEX 1	Socio-economy and Economic Evaluation
ANNEX 2	Geology
ANNEX 3	River Survey
ANNEX 4	Topographic Mapping
ANNEX 5	Hydrology
ANNEX 6	Flood Control

VOLUME V : ANNEXES II

ANNEX 7	Urban Flooding and Drainage
ANNEX 8	Design and Cost Estimate
ANNEX 9	Water Resources and River Water Quality
ANNEX 10	Environment
ANNEX 11	Comprehensive River Water Management Plan
ANNEX 12	Institutions

VOLUME VI : SUPPORTING PAPERS

VOLUME VII : DATA BOOK I
(River Survey and Topographic Mapping for Master Plan)

VOLUME VIII : DATA BOOK II
(River Survey and Topographic Mapping for Feasibility Study)

The costs are estimated based on October 1995 price level and the average exchange rate in October 1995. The average exchange rate in October 1995 is as follows:

US$ 1.00 = Rp.2,281
¥ 1.00 = Rp.22.70

PREFACE

In response to a request from the Government of the Republic of Indonesia, the Government of Japan decided to conduct a master plan and feasibility study on Comprehensive River Water Management in JABOTABEK and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Indonesia a study team headed by Mr. Toshikatsu Imai of NIKKEN Consultants, Inc. and composed of members from NIKKEN Consultants, Inc. and Nippon Koei Co., Ltd., three times between July 1995 and March 1997.

The team held discussions with the officials concerned of the Government of Indonesia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the team.

March 1997

Kimio Fujita
President
Japan International Cooperation Agency

March 1997

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Fujita,

Letter of Transmittal

We are pleased to submit to you the master plan and feasibility report on the Study on Comprehensive River Water Management Plan in JABOTABEK in the Republic of Indonesia. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as the formulation of flood control master plan and urgent flood control project. Also included are comments made by the Ministry of Public Works of the Government of Indonesia during technical discussions on the draft report which were held in Jakarta.

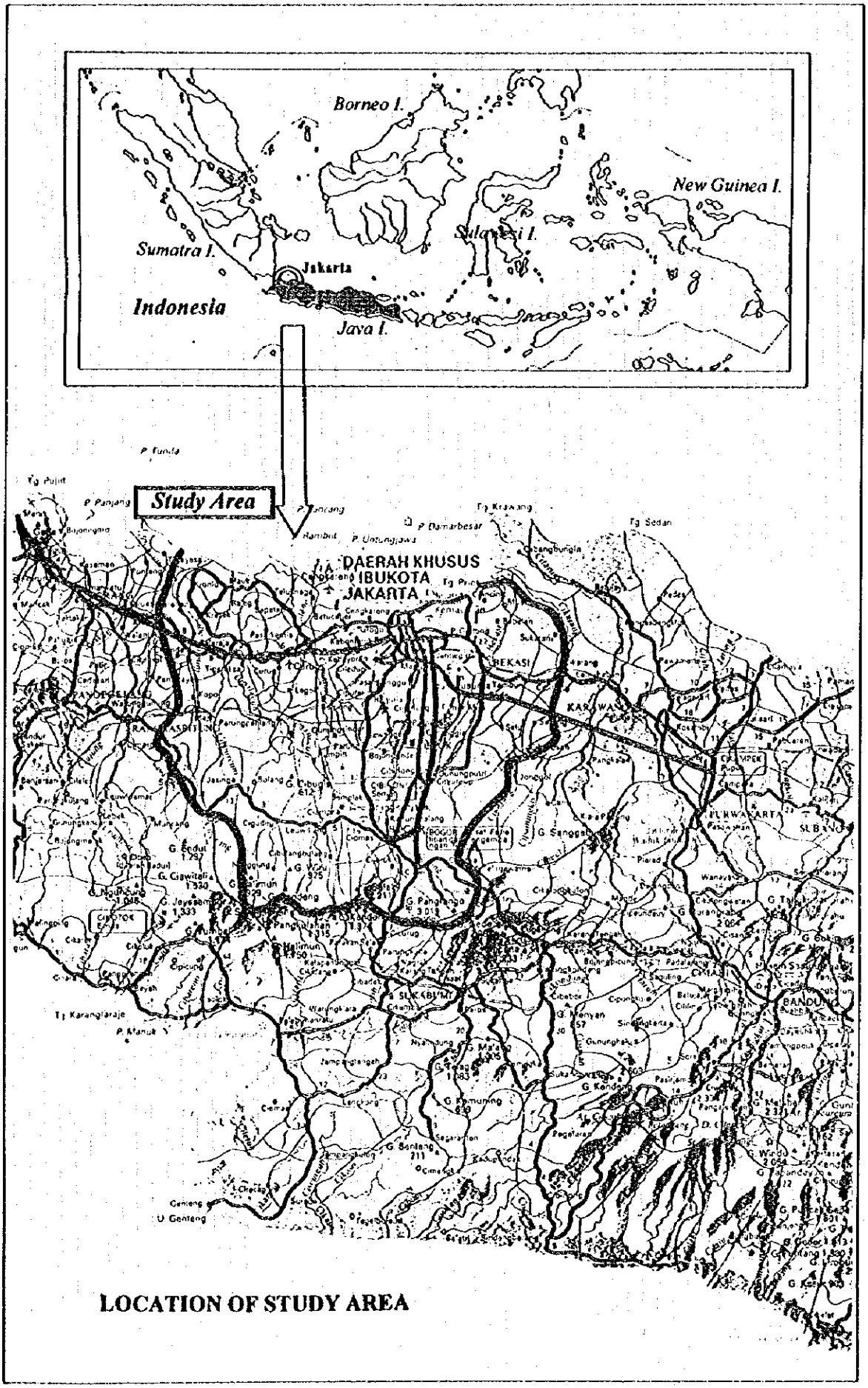
This report presents a scheme of flood control in the basins of the river systems of the Western Banjir Canal and the Cisadane river as the urgent flood control project to mitigate flood damage in DKI Jakarta and the suburbs in Kabupaten Tangerang. The project is proved to be technically viable, economically feasible, socially acceptable, and environmentally sound. After completion of the project, not only the direct damage to properties due to flood, but also indirect damage to political, administrative, economic, and social activities in the metropolis of Indonesia will be greatly decreased.

In view of the urgency of flood control in DKI Jakarta and the suburbs, and the need for socio-economic development of Indonesia as a whole, we recommend that the Government of Indonesia implement this Project as a top priority.

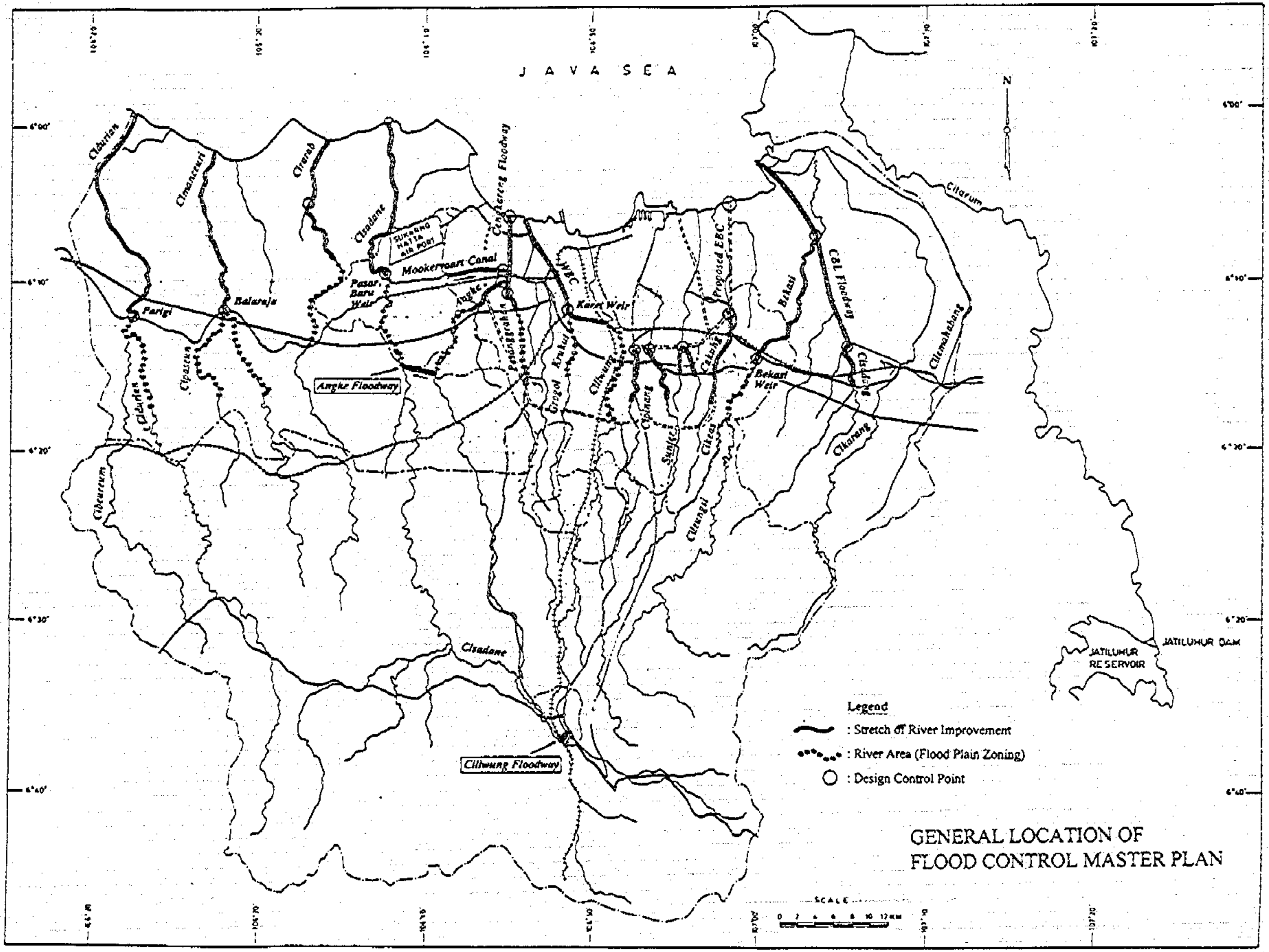
We wish to take this opportunity to express our gratitude to your Agency, the Ministry of Foreign Affairs, and the Ministry of Construction. We also wish to express our deep gratitude to the Ministry of Public Works and other authorities concerned of the Government of Indonesia for the close cooperation and assistance extended to us during our investigations and study.

Very truly yours,

Toshikatsu Imai
Team Leader
The Study on
Comprehensive River Water
Management Plan in JABOTABEK

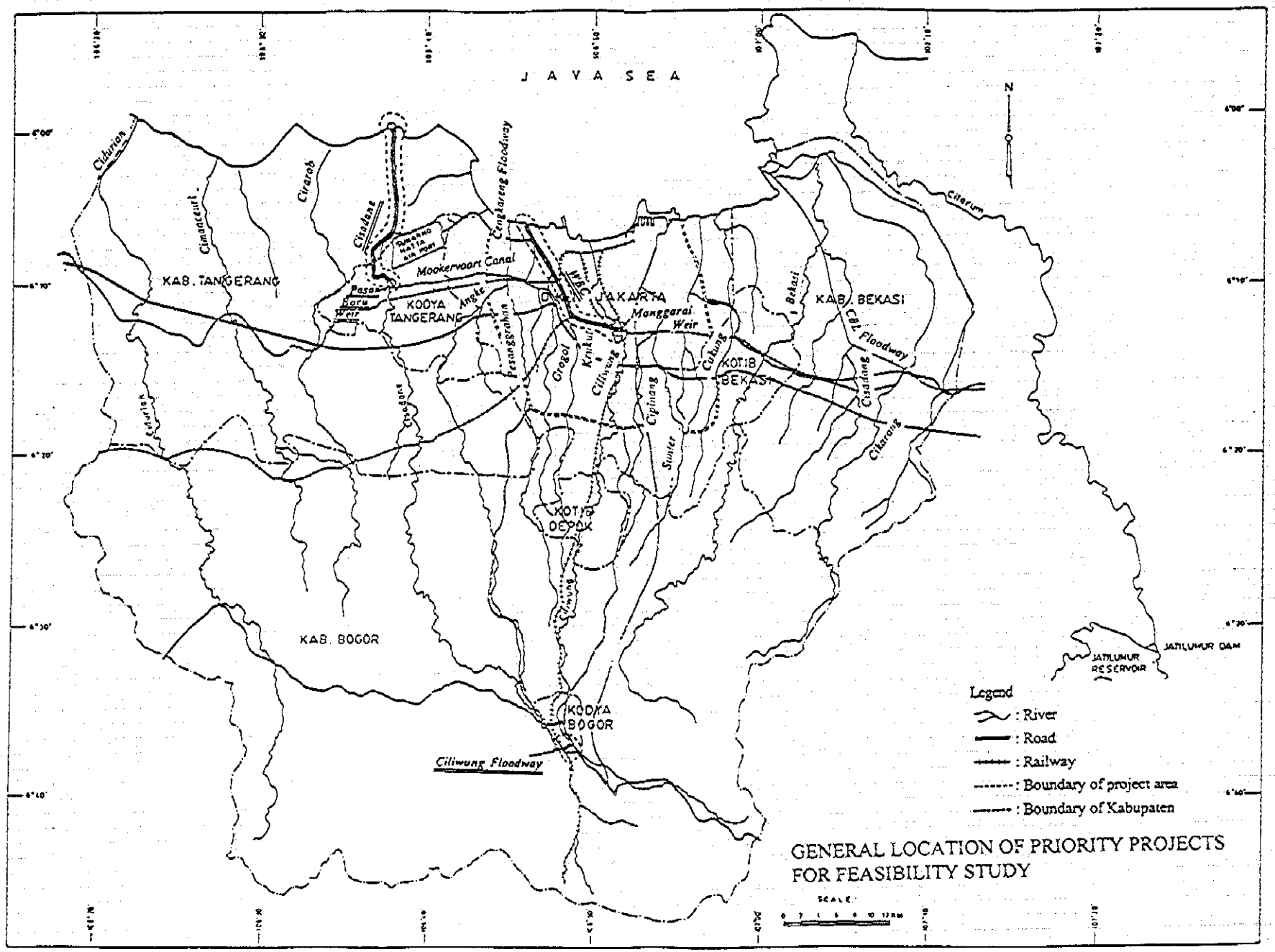


LOCATION OF STUDY AREA



Legend
: Stretch of River Improvement
: River Area (Flood Plain Zoning)
: Design Control Point

GENERAL LOCATION OF
FLOOD CONTROL MASTER PLAN


JAVA SEA
N
Ciburian
Cimanceuri
Ciarab
Cisadane
Cengkareng Floodway
Mookervaart Canal
KAB. TANGERANG
Pasar Baru Weir
KODYA TANGERANG
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SCALE

THE REPUBLIC OF INDONESIA

THE STUDY ON COMPREHENSIVE RIVER WATER MANAGEMENT PLAN IN JABOTABEK

SUMMARY

1. FLOOD CONTROL MASTER PLAN

1.1 Framework

1) Study Area : (6,070 km^2; JABOTABEK area including Jakarta metropolis, Bogor, Tangerang and Bekasi)
2) Target Year : 2025
3) Beneficiary Area : 1,620 km^2
4) Beneficiary Population
   1995 : 6.5 million people
   2025 : 11.3 million people
5) Land Use : commercial, industry, residential and agricultural area, and mountains and forests (Jakarta metropolis and the suburbs)
6) Industries : center of administration, commerce, industry, agriculture and fisheries

1.2 Outline of Project

(1) Structural Measures

1) Cidurian river system (25-year design scale)
   a) river improvement of downstream reaches,
   b) project cost = Rp. 227 billion (¥ 10.0 billion, project implementation : 2017 - 2023)
2) Cimanceuri river system (25-year design scale)
   a) river improvement of downstream reaches,
   b) project cost = Rp. 108 billion (¥ 4.9 million, project implementation : 2020 - 2025)
3) Cirarab river system (25-year design scale)
   a) river improvement of downstream reaches,
   b) project cost = Rp. 27 billion (¥ 1.2 billion, project implementation : 2012 - 2016)
4) Cengkareng Floodway system (100-year design scale)
   a) i) river improvement of the Cengkareng floodway, ii) downstream reaches of the Angke and Pesanggrahan rivers, and the Mookervaart canal, and iii) construction of the Angke floodway from the Angke to the Cisadane rivers
   b) project cost = Rp. 858 billion (¥ 37.8 billion, project implementation : 2011 - 2025)
5) Western Banjir Canal (100-year design scale) & Cisadane River system (50-year design scale)

a) i) river improvement of the Western Banjir Canal, ii) downstream reaches of the Cisadane river, and iii) construction of the Ciliwung floodway from the Ciliwung to the Cisadane river
b) project cost = Rp. 767 billion (¥ 33.8 billion, project implementation : 1997 - 2011)

6) Eastern Banjir Canal System (100-year design scale)
a) i) construction of the Eastern Banjir Canal, ii) river improvement of downstream reaches of the Cipinang, Sunter, Jatikramat, Buaran and Cakung rivers
b) project cost = Rp. 1,931 billion (¥ 85.1 billion, project implementation: 2003 - 2017)

7) CBL Floodway system (50-year design scale)
a) river improvement of downstream reaches of CBL floodway, Bekasi and Cisadang rivers
b) project cost = Rp. 220 billion (¥ 9.7 billion, project implementation : 2013 - 2019)

The total project cost is estimated at Rp. 4,138 billion (¥ 182 billion).

(2) Non-structural Measures

1) watershed management,
2) flood plain management by flood risk map,
3) preparation of flood forecasting and warning system,
4) establishment of institutions and organization, and
5) social and school education on flood control

The overall features of the flood control master plan are shown in Table S1.

1.3 Evaluation

The flood control master plan of each river system and the priority are evaluated as shown in Table S1 not only from the economic feasibility by economic internal rate of return (EIRR) but also from comprehensive viewpoint such as social background, technical aspect, project cost, environment, etc.

The master plan projects for the river systems of the Western Banjir Canal and the Cisadane river are evaluated to be economically highly feasible and socially strongly required, and are given the highest priority. Following those projects, the projects for the river systems of the proposed Eastern Banjir Canal and the Cengkareng floodway are evaluated to be high priority projects from the same viewpoint.

According to the result of initial environmental examination, negative impact to environment resulting from the implementation of the project might be limited. Those are the temporary ones such as noise, vibration, and the increase of suspended solid in river water due to river excavation and dredging during construction period.

It is evaluated that the implementation of each project will decrease the flooding and inundation in the objective area and contribute to the improvement of environment such as

betterment of public welfare, enhancement of land use, etc. in addition to the direct protection of human life and properties.

1.4 Selection of Priority Projects

As evaluated in Table S1, the river improvement of the Western Banjir Canal and the Cisadane river systems are selected as the priority projects.

2. FEASIBILITY STUDY OF PRIORITY PROJECTS

2.1 Framework

1) Beneficiary Area : 230 km^2
2) Beneficiary Population
   1995 : 1.29 million people
   2025 : 1.86 million people
3) Land Use : commercial, industry, residential and agricultural areas (Jakarta metropolis and the suburbs)
4) Industries : center of administration, commerce, finance ,industries, agriculture, education, agriculture and fisheries

2.2 Optimum Scale for Urgent Flood Control Project (1st Stage Project)

Implementation of the priority projects selected form the master plan study needs a big amount of project cost. Accordingly, effective stepwise implementation of the projects is required. Comparison of several safety degree alternatives is studied for the optimum scale of urgent flood control project here. As a result, the urgent flood control project to be implemented immediately as 1st stage project and the optimum scale are proposed to be as follows:

1) River improvement of the Western Banjir Canal
   (design discharge of 100-year design scale, which is the same as that of the master plan)
2) River improvement of the Cisadane river
   (25-year design scale; 50-year design scale is adopted in the master plan)
3) Construction of Ciliwung floodway (2 tunnels : capacity of 600 m^3/s, temporarily design discharge is 300 m^3/s)

As for the construction of the Ciliwung floodway among the above scheme, the two tunnels proposed in the master plan are to be constructed in advance during the stage of the urgent flood control project. The design discharge to the two tunnels is proposed temporarily to be 300 m^3/s in accordance with the river improvement of the Cisadane river in downstream reaches with 25-year design scale.

The construction of 2 tunnels in advance is proposed with the consideration to the demerits such as various procedures, increase of the cost, negative impact of giving inconvenience to the surrounding residents and the others to be accompanied by future additional works.

2.3 Outline of Urgent Flood Control Project (1st Stage Project)

(1) Structural Measures

1) River improvement works of the Western Banjir Canal : 16.9 km
2) River improvement works of the Cisadane river : 15.0 km
3) Construction of the Ciliwung Floodway
   (a) Total length : 1,040 m
   (b) Inner diameter : 8.0 m
   (c) Length of tunnel : 913 m
   (d) Discharge capacity : 600 m^3/s; 300 m^3/s per 1 channel

(2) Non-structural Measures

Establishment of flood warning system along the Ciliwung and the Cisadane rivers.

(3) Project Cost

The total financial project cost for the urgent flood control project (1st stage project) is estimated as follows:

1) Foreign currency : Rp. 534,178 million (¥ 23,532 million)
2) Local currency : Rp. 560,966 million

Total cost is Rp. 1,095 billion (¥ 48,244 million).

Here operation and maintenance cost and replacement cost of equipment such as gate leaves during the project life are estimated at Rp. 2,384 million per year and Rp. 2,542 million respectively.

2.4 Evaluation

Economic internal rate of return (EIRR) of the urgent flood control project (1st stage project) is estimated at 13.1 %.

The project would greatly contribute to the prosperity of social and economic activities and the people's welfare in Jakarta metropolis as the center of the political and socio-economic activities in Indonesia.

The project would cause some environmental negative impacts especially during the construction stage. Accordingly the monitoring organization for the environmental aspect would need to be organized to decrease the impact as much as possible.

2.5 Implementation Plan

The urgent flood control project (1st stage project) is proposed to be implemented stepwise as follows:

1) 1st phase (scheduled year : detailed design 1997 - 1998, construction 2000 - 2003)
   (a) river improvement of the Cisadane river
   (b) construction of the Ciliwung floodway

2) 2nd phase (scheduled year : detailed design 2002 - 2003, construction 2004 - 2008)
   (a) river improvement of the Western Banjir Canal

2.6 2nd Stage Project

The supplemental works for the master plan level after completion of the urgent flood control project (1st stage project) is called as 2nd stage project. The succeeding supplemental works consist of the river improvement of the Cisadane river for upgrading of safety level from 25-year to 50-year design scale.

The 2nd stage project is desirable to be implemented soon after completion of the 1st stage project as follows:

1) river improvement of the Cisadane river for 50-year design scale
   (scheduled year : detailed design 2007 - 2008, construction 2010 - 2011)

Here, the whole project cost and EIRR including the 1st and 2nd stage projects are estimated at RP. 1,169 billion (¥ 51,503 million) and 13.2 % respectively.

3. RECOMMENDATION

In view of the serious direct and indirect damages and confusion due to the big flooding in January and February 1996 in DKI Jakarta, it is proposed that the urgent flood control project be implemented very soon as an urgent scheme.

Table S1 OVERALL EVALUATION OF MASTER PLAN

River System	1 Cidunan	2 Cimanceuri	3 Cirarab	4 Cengkareng Floodway	5 Western Banjir Canal + Cisadane	6 Eastern Banjir Canal	7 CBL Floodway	8 Non-structural Measures
Outline of Plan (Improvement Length)	River improvement 32km	River improvement 22km	River improvement 12km	River improvement and Angke floodway 22km	River improvement and Ciliwung floodway 38km	River improvement and Eastern Banjir Canal 57km	River improvement 50km	Flood forecasting and warning system,
Implementation Program (year)	2018-2023	2022-2025	2013-2016	2013-2025	1997-2008/2008-2011	2005-2017	2014-2019	flood risk map,
Beneficial Population in 2025 (1000 nos) point	495 1	605 3	144 1	2,505 5	1,865 5	4,119 7	1,607 5	institutions,
Beneficial Area(km^2)	180	240	70	120	230	210	520	flood fighting system,
Land Use in 2025 point	Agriculture 1	Agriculture 1	Agriculture 1	Residential Area 5	Gov. Ind. & Comm. 9	Res. & Industrial 7	Agri. & Residential 3	public education,
Return Period of Design Flood(year)	25	25	25	100	100 and 50	100	50	school education,
Financial Project Cost (Rp. billion) point	227 3	108 3	27 3	858 2	767 2	1,931 0	220 3	etc.
Financial Land/House Cost (Rp. billion) point	87 10	59 10	12 10	295 8	305 8	943 2	88 10	
EIRR (%) point	3.8 0	- 0	12.1 6	14.6 6	16.1 6	20.6 6	6.2 2	
Technical Evaluation point	Ordinary 2	Ordinary 2	Ordinary 2	Complicated 1	Complicated 1	Ordinary 2	Ordinary 2	
Social Beneficial Impact point	small 1	small 1	small 1	big 5	very big 7	big 5	middle 3	
Environmental Impact point	not affect 2	might affect 0	not affect 2	not affect 2	not affect 2	not affect 2	might affect 0	
Project Status	F/S: not available	F/S: not available	F/S: not available	D/D: partly available	D/D: partly available	Partly implemented	F/S: not available	
Overall Point	20	20	26	34	40	31	28	
Priority Projects for F/S					◎			

Evaluation Criteria

Land Use	Financial Project Cost	Land & house cost	EIRR	Beneficial Population	Technical Evaluation	Social Beneficial Impact	Environmental Impact
1: Agriculture	0: 1,500<X	0: 1,000<X	0: X< 5	1: X<500	1: Complicated	1: small	0: might affect
3: Agri. & residential	1: 1,000<X<1,500	2: 800<X<1,000	2: 5<X<10	3: 500<X<1000	2: Ordinary	3: medium	2: not affect
5: Residential	2: 500<X<1,000	4: 600<X<800	4: 10<X<12	5: 1000<X<3000		5: big	
7: Resid. & Industrial	3: X<500	6: 400<X<600	6: 12<X	7: 3000<X		7: very big	
9: Gov.,Ind.& Comm.		8: 200<X<400					
		10: X<200					

*1) I/P: Implementation Program, Gov. : Governmental Office Area, Comm.: Commercial Area, Ind.: Industrial Area, Agri.: Agricultural Area, Land/house Cost: Land acquisition/house compensation cost

*2) The project costs here are all those estimated on the master plan level

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1 INTRODUCTION

1.1 Introduction

The study area that extends to the City of Jakarta and its surrounding area, covering 6,070 km^2 as shown in Figures 1 to 3, is situated on the plain formed by numerous rivers originated at rainy mountains. The plain is vulnerable to flooding and the City of Jakarta and its surrounding area have been suffering from flooding damages.

During last few decades, the area has experienced continuous increase in population and economic activities resulting in a chronic deficiency of infrastructure including flood control works. The remarkable activation of economic development in the area created a strong demand of lands for industrial, commercial and residential purposes causing intensification and expansion of urbanization. As a result, the following problems related to river water have arisen in the area:

1) Potential damage of flooding has increased over the area;
2) Land acquisition in the urbanized area has become so difficult that part of the master plan formulated in 1973 may not be implemented without modification;
3) Pollution of water in rivers and drains has steadily advanced, and an increased supply of flushing water is needed especially during dry season; and
4) Demand of municipal and industrial water is rapidly increasing and is also spreading over the area.

With this background, the Government of Indonesia requested the Government of Japan to undertake this Study on Comprehensive River Water Management Plan in JABOTABEK.

The Scope of Work for the Study on Comprehensive River Water Management Plan in JABOTABEK was agreed upon between Directorate General of Water Resources Development, Ministry of Public Works, the Government of Indonesia and Japan International Cooperation Agency (hereinafter referred to as JICA) of the Government of Japan on February 2, 1995.

1.2 Objectives of the Study

The objectives of the Study are to formulate a master plan for flood control as a part of the comprehensive river water management plan in JABOTABEK and to conduct a feasibility study for priority projects selected from the flood control master plan.

1.3 Study Area

The study area covers DKI Jakarta and 3 districts of Tangerang, Bogor and Bekasi of the West Java province, namely the river basins between those of Cikarang and Cidurian rivers which is about 6,070 km^2 wide as shown in Figure 1. The area is called as JABOTABEK area.

1.4 Target Year

The target year of the study is set up to be 2025 that corresponds to the target year of JABOTABEK Water Resources Management Study (JWRMS) in 1994.

2 BACKGROUND

2.1 Socio-Economy

(1) National Development Plan

The Government of Indonesia set a target of an annual economic growth rate of 3.4 % for the agricultural sector, 9.4 % for the industrial sector, 6.0% for other sectors and 6.2 % in total in its sixth National Development Plan (1994-1998). The plan also aims to increase per capita annual income to more than US$ 1,000.

(2) Gross Domestic Products (GDP)

Gross domestic product (GDP) in 1993 was Rp. 302,018 billion (approximately US$ 144 billion) and GDP per capita in 1993 was Rp. 1,609,997 (approximately US$ 770). Annual growth rates of GDP since 1989 were high from 6.5 % to 7.2 % on 1983 constant price basis. GDP per capita is also increasing with annual growth rate from 4.7 % to 5.2 % in the same period.

(3) Administrative Unit, Population, and RGDP of the Study Area

Administrative units, population, and the gross regional domestic products in the objective area are summarized below:

Administrative Unit	Area (km^2)	Population in 1990	RGDP in 1993 (Rp. billion)
DKI Jakarta	661	8,227,746	50,999
Kab. Bogor	2,770	3,738,868	4,814
Kodya Bogor	22	271,341	544
Kab. Tangerang	1,301	2,764,988	1,980
Kodya Tangerang	-	-	2,258
Kab. Bekasi	1,401	2,104,392	4,359

(4) Present Land Use

Urbanization in JABOTABEK area is rapidly progressing. Urban area in JABOTABEK area as of 1995 is shown below. Present overall land use as of 1995 is shown in Figure 4.

District	Whole Area (km^2)	Urbanized Area (km^2)	Ratio of Urbanized Area (%)
DKI Jakarta	661	382	58
Tangerang	1,301	148	11
Bekasi	1,401	38	3
Bogor	2,792	88	3

2.2 Topography and Geology

(1) Topography

The Study Area can be divided geomorphologically into four zones: mountainous area, hilly area, valley plain area and coastal plain area.

Mountainous area above the 150 m contour line is located south of Kab. Bogor and includes the high volcanoes Salak (2,211 m) and Pangrango (3,019 m).

Hilly area between the contour lines of 150 m and 6 m spreads out in a wide fan from south to north. The area has been dissected by many rivers having eroded deep and clearly defined valley.

Valley plain area along the river course in hilly area has been formed by dissection of rivers; the boundaries between the hilly area are generally very clear. This area has relatively flat surface and long/narrow shape; the meanderings of rivers have been developed in the area.

Alluvial coastal plain below the 6 m contour line is very flat and swampy. Some old sand dunes have been distributed running parallel to the coastline. The elevation of inland old sand dunes are about 6 m above the sea-level corresponding to the high sea-level period of about 6,000 years ago.

(2) Geology

West Java can be divided physiographically and structurally into four belts (Bemmelen, 1949) extending in the east-west direction and from south to north as 1) Southern mountains of West Java, 2) Bandung zone, 3) Bogor zone, 4) Lowland plain of Jakarta.

The geology in the Study Area is composed of alluvial of the Holocene (mainly in the lowland plain), terrace deposit of the Pleistocene (mainly alluvial fan in the Bogor zone and lowland plain), tufaceous sedimentary rocks of the Pliocene to Miocene (mainly in the Bogor zone) and southern volcanoes of the Miocene.

The geological map of the Study Area is shown in Figure 5.

2.3 Meteorology and Hydrology

(1) Air Temperature

General features of the air temperature in the Study Area is shown below by selecting typical stations in the area:

Location	Maximum	Mean	Minimum
Tanjung Priok (coastal plain area)	30.3°C	27.0°C	24.5°C
Citeko (mountainous area)	25.2°C	21.2°C	18.9°C

As seen in the above, there exists distinct difference of air temperature between the coastal plain area and the mountainous area, but seasonal variations in both areas are not much distinct.

(2) Rainfall

Annual rainfall depth is about 1,800 mm in coastal plain, 2,500 mm in hilly area and more than 3,500 mm in mountainous area in the Study area.

Monthly rainfall falls much in January and December and falls less in June to August. Monthly rainfall in mountainous area is, generally not so less in dry season, but that in coastal plain area is very less in dry season.

(3) Probable Rainfall

Analyses on annual maximum probable daily areal rainfall for the basins of the Ciliwung river including that of the Krukut river and of the Cisadane river, and on annual maximum probable daily point rainfall at BMG Jakarta station have been conducted. These probable rainfalls for several return periods are summarized below:

(Unit: mm)

	2-year	5-year	10-year	25-year	50-year	100-year
Point Rainfall	98 (100%)	135 (100%)	160 (100%)	192 (100%)	215 (100%)	238 (100%)
Ciliwung at Ratujaya (215km^2)	63 (65%)	85 (62%)	99 (61%)	116 (61%)	129 (60%)	142 (60%)
Ciliwung at Karet (421km^2)	67 (69%)	86 (63%)	98 (61%)	114 (59%)	125 (58%)	137 (57%)
Cisadane (1,411km^2)	49 (50%)	67 (50%)	79 (49%)	94 (49%)	105 (49%)	116 (49%)

(4) Influence of Urbanization to Flood Runoff

The influence of future urbanization to flood runoff is estimated as follows by using established flood runoff model. The future flood runoff peak is estimated to be increased by about 50 % in average with that of the present.

Probable Flood Peak unit : m^3/s

River Systems	Design Scale (year)	Present Land Use (1995) <A>	Future Land Use (2025) <B>	B/A
Cidurian river	25	380	645	1.70
Cimanceuri river	25	249	282	1.13
Cisadane river	50	1368	1571	1.15
Cengkareng Floodway	100	242	616	2.55
Western Banjir Canal	100	444	602	1.36
CBL Floodway	50	521	774	1.49

(5) Tide

According to the hourly tide record from 1985 to 1995 at Tanjung Priok station and from 1988 to 1994 at Sunda Kelapa station, monthly maximum and minimum sea levels relative to monthly mean sea level are as follows:

Typical Tide	Tanjung Priok Station	Sunda Kelapa Station
Average Monthly Maximum	Mean Sea Level + 0.580 m	Mean Sea Level + 0.620 m
Average Monthly Minimum	Mean Sea Level - 0.558 m	Mean Sea Level - 0.556 m

2.4 Rivers and Related Structures

2.4.1 River Systems

The Study Area can be generally divided into 8 independent river basins and residual basins which include urban drainage area in DKI Jakarta encompassed by the Western and proposed Eastern Banjir Canals:

1. Cidurian River Basin (803 km^2)
2. Cimanceuri River Basin (570 km^2)
3. Cirarab River Basin (161 km^2)
4. Cisadane River Basin (1,411 km^2)
5. Cengkareng Floodway System Basin (459 km^2)
6. Western Banjir Canal System Basin (421 km^2)
7. Proposed Eastern Banjir Canal System Basin (207 km^2)
8. CBL Floodway System Basin (1,135 km^2)
9. Residual Basins and Urban Drainage Area in DKI Jakarta (903 km^2)

Total (6,070 km^2)

The present river systems in the Study Area are as schematically shown in Figure 6. General longitudinal profiles of the rivers are shown in Figure 7.

2.4.2 Related Structures

(1) Bridge

Number of existing bridges located along the objective reaches of rivers for flood control in DKI Jakarta is 232 road bridges and 12 railway bridges. The number of bridges by river is as follows:

River Name	Number of Bridges		River Name	Number of Bridges	
	Road	Railway		Road	Railway
Mookervaart	27	-	Sunter	29	1
Angke	2	-	Buaran	12	-
Pesanggrahan	4	1	Cakung	21	-
Grogol	29	1	Cengkareng Floodway	13	1
Krukut	28	0	Sodetan Grogol	2	-
Ciliwung	35	5	Western Banjir Canal	15	3
Cipinang	15	-			
				232	12

(2) Pumping Station

In the DKI Jakarta, eighteen pumping stations are existing for the urban drainage purpose. Its total installed capacity is 121.8 m^3/s. The pumping stations under construction are in 4 locations and 39.7 m^3/s in its total capacity. The locations of those pumping stations are shown in Figure 8.

2.4.3 Drainage

(1) Urban Drainage in DKI Jakarta

The whole area of DKI Jakarta is divided into the following three(3) regions which are further divided into ten(10) drainage zones:

Region	Drainage Zone	Catchment Area(ha)	Drainage System
I. Western Region	Zone - 1	11,300	Cengkareng Floodway
	Zone - 2	4,500	Grogol - Sekretaris
II. Central Region	Zone - 3	500	Muara Karang
	Zone - 4	17,350	Ciliwung - Banjir Canal
	Zone - 5	1,900	Pluit
	Zone - 6	1,100	Ciliwung - Gunung Sahari
III .Eastern Region	Zone - 7	2,760	Sentiong - Pademangan
	Zone - 8	1,250	Sunter Utara(Barat)
	Zone - 9	12,575	Sunter - Cipinang
	Zone - 10	8,050	Buaran - Cakung

Figure 9 shows the above zones and drainage systems.

(2) Urban Drainage in JABOTABEK Urban Area

Tangerang and Bekasi cities have no urban drainage systems yet but are partly provided with the isolated local drain channels.

Local water in central area of Tangerang city on the right bank of the Cisadane river is drained off towards the Mookervaart canal, local water in Tangerang city on the left bank of the Cisadane river is mostly drained off to the Sabi river.

Local water in the Bekasi city is mostly drained off to the Bekasi river or to its tributaries.

2.5 Flooding

(1) Flooding in DKI Jakarta

Many and large areas in the DKI Jakarta have been suffering from serious flooding and inundation of long duration due to various factors. The habitual inundation areas are shown in Figure 10.

Major inundation factors identified are summarized as follows:

(a) The area is located in low-lying area or in flood plain.
(b) Insufficient carrying capacity of the rivers and the existing drainage system.
(c) Improvement/Construction works are not completed yet.
(d) Backwater effect of a river on the related drainage canal(s).
(e) Clogging of canal with soil and/or garbage sediment.
(f) Progress of land subsidence by excessive abstraction of groundwater.

(2) Flooding in Kotamadya Tangerang

The habitual inundation area in Kotamadya Tangerang is shown in Figure 11. The main reasons of the inundation are as follows:

(a) Drainage of this area toward the Cisadane river is difficult since water level of the river is always dammed up by the Pasar Baru barrage.
(b) Backwater effect of the Cisadane river to the Sabi river during a flood of the Cisadane river.

(3) Flooding in Tangerang, Bekasi, and Bogor Area

The major reasons of the inundation in these areas are as follows:

(a) overflow from rivers;
(b) inadequate land use in valley plain along the river functioning as a natural retarding basin;
(c) landside water inundation of tributary due to the influence of backwater effect of the main stream;
(d) overflow from local drainage channels due to the insufficient capacities; and
(e) flooding caused by the operation and maintenance of irrigation facilities such as intake weir, gate and irrigation canal.

Past flooding conditions in Tangerang, Bekasi, and Bogor areas are shown in Figures 12 to 14 respectively.

2.6 Water Resources and River Water Quality

(1) Surface Water Use

(a) Water Conveyance System

Water conveyance systems to supply raw water in JABOTABEK area are as shown in Figure 15.

(b) Municipal and Industrial Water Use

The surface water amount taken in for M&I water use from the major rivers in JABOTABEK area is 28,364 l/s in total. As for commercial use, according to JWRMS estimate, total water demands in commercial and service sectors corresponds to about 20 % to 40 % of the municipal water demands.

(c) Irrigation Water Use

The major irrigation systems in JABOTABEK area are, Prosijat, Prosida-Cisadane, Empang, Cidurian-Rancasumur, Cicinta, and Katulampa systems, and the total irrigation area as of 1990 is 118,821 ha.

(2) Groundwater Use for Municipal and Industrial Water Supply

According to JWRMS, the water amount of 15.4 m^3/s is abstracted in DKI Jakarta and 15.3 m^3/s in Botabek area as of 1992. According to the feasibility study on Cisadane River Basin Development Project, the safe yield is estimated to be 3.6 m^3/s in DKI Jakarta and 15.3 m^3/s in Botabek area.

(3) River Water Quality

According to the river water quality investigation by the Study Team in October 1995, it may be concluded that the water quality in downstream reaches of the rivers flowing down in Jakarta and Bogor has been deteriorated by intrusion of domestic and industrial waste water.

(4) Land Subsidence

According to survey results by DKI Jakarta, the lowered areas between 1974/1978 to 1993/1994 with a significant degraded depth of about more than 60 cm are as follows:

Location	Difference between Elevation from 1974/1978 to 1993/1994	Drainage System
Jl. Daan Mogot in Kec. Jakarta Barat	0.6 m to 1.0 m	Mookervaart canal
Jl. Pangeran Jayakarta in Kec. Jakarta Pusat	0.6 m to 0.9 m	Ciliwung river
Jl. Perintis Kemerdekaan in Kec. Jakarta Timur	0.6 m to 0.7 m	Sunter river

According to the result of the preliminary simulation by JWRMS on the future extent of land subsidence, land subsidence is predicted to further be progressed till 2025 even if the groundwater abstraction is stopped in 1995, and lowered depth, currently 50 cm to 100 cm, will become about 200 cm in 2025. Also, If there will be no restriction, lowered depth will exceed 400 cm.

2.7 River Water Monitoring System

Present river water monitoring system for flood control in JABOTABEK area is as shown in Figure 16.

Establishment of Supervisory Control and Data Acquisition (SCADA) System is now underway for the purpose of flood control in the Ciliwung - Cisadane River Basin Development Project as shown in Figure 17.

2.8 Biological Environment

The nature conservation areas in JABOTABEK area are, 1) Gunung Gede Pangrango National Park, 2) Pancaran Mas, 3) Muara Angke, 4) Gunung Halimun, 5) Dungus Iwul, 6)

Yani Lapa. The situation of fauna and flora in the major conservation areas is summarized as follows:

(1) Gunung Gede Pangrango National Park

The Gunung Gede Pangrango national park is covered by montane tropical rainforest and is the undisturbed example of the Java rainforest. Of 450 bird species present in the Java island, about 250 species inhabit the Park.

(2) Nature Reserve Pancaran Mas

Nature Reserve Pancaran Mas with an area of 6 ha is located in Depok and is inhabited by species of birds such as *Pynonotus aurigaster, Sturnus contrajalla, Oriolus chinensis,* and reptilian such as *Bungarus candidus, Phyton sp, Dryophis sp, Ptyas sp.*

(3) Nature Reserve Muara Angke

Nature Reserve Muara Angke with an area of 15.4 ha is located at the outfall of the Western Banjir Canal. There is a small mangrove area, remnant of a vegetation which was formerly common in the north coast of the Java island. About 56 bird species inhabit the area.

(4) Nature Reserve Gunung Halimun

Nature Reserve Gunung Halimun is an area of 40 ha around the Mt. Halimun in Bogor and is mainly covered by *Castana argentea, Altingia excelsa, Podocarpus imbricatus, Quercus sp, Nyssa javanica, Schima walichii, Agathis sp, Pinus merkusii, Swietenia mahagony, Tectona grandis,* etc.

With respect to fauna, the area is inhabited by the species of *Hylobates moloch, Presbytis ayagula, Panthera pardus, Felis pardus, Felis bengalensis, Muntiacus muntjak,* etc.

2.9 Institutions

2.9.1 Related Regulations

(1) Law No. 11 year 1974 on Water Resources

Law No.11 year 1974 on Water Resources is the basic regulation that is the emanation from the Constitution 1945. This Law stipulates provisions pertaining to planning consisting of : 1) water resources management plan, 2) water resources plan, 3) water resources development plan.

(2) Law No. 22 year 1982 on Water Resources Management

As implementing legislation of Law No. 11/1974, Government Regulation No. 22 year 1982 on Water Resources Management was issued. This Government Regulation contains

provisions such as: 1) principles of public utility, harmony and conservation, 2) one unity of water resources management area based on a river territory, 3) development plan on water resources to be provided by the Minister of Public Works, 4) the authority and responsibility for implementation of coordination of water management by the Minister of Public Works.

(3) Government Regulation No. 35 on Rivers

Government Regulation No. 35 on Rivers was issued in 1991, also as implementing legislation of Law No. 11/1974. This Regulation stipulates provisions on authority and responsibility of river management including provisions pertaining to construction, demolition, conversion of structures crossing or standing in river area.

2.9.2 Related Agencies

(1) Ministry of Public Works

Authority and responsibility of water resources management is undertaken by the Government, and the implementation is conducted by the Minister in charge of water affairs. The Minister in charge of water affair is the Minister of Public Works.

(2) Director General of Water Resources Development

The management of water and water sources is kept by the Minister of Public Works. The day to day management is implemented by Director General of Water Resources Development.

Directorate of Planning and Programming is in charge of feasibility study of water resources development project and give guidance to implementation agencies in respect of program arrangement, determination of development implementation priority and funding arrangement. Directorate of Water Resources Management and Conservation is in charge of supervision and guidance on data collection, survey, study, investigation, and master plan formulation. For construction and supervision, Directorate of Technical Guidance and Directorate of Implementation Guidance are in charge.

The interrelationship task between the Project and Directorate General of Water Resources Development is illustrated in a scheme as seen in Figure 18.

(3) Ciliwung-Cisadane River Basin Development Project

Accordingly the Ciliwung-Cisadane River Basin Development Project is a delegated authority of the Director General of Water Resources Development to conduct the activities pertaining water and water sources management including flood control in the Ciliwung-Cisadane River Basin.

(4) Other Parties

Non-structural measures for comprehensive river water management are watershed management, establishment of flood fighting system, flood plain management by using flood risk map, public education, school education, etc. In this context, the Ministry of Forest, Ministry of People Welfare, Ministry of Education, Ministry of Home Affairs, and the local government are related agencies for river water management.

3 FORMULATION OF FLOOD CONTROL MASTER PLAN

3.1 Framework in 2025

(1) Population

The past and estimated future population in the study area is shown below:

unit : thousand

Area	1971	1980	1985	1990	1995	2000	2005	2010	2015	2020	2025
DKI Jakarta	3,927	6,445	7,766	8,210	8,964	9,730	10,487	11,178	11,912	12,688	13,502
Bekasi	832	1,124	1,401	2,073	2,697	3,348	4,066	4,802	5,670	6,282	6,534
Tangerang	1,067	1,488	1,881	2,724	3,570	4,506	5,504	6,523	7,732	8,575	8,892
Bogor	1,865	2,748	3,343	3,949	4,805	5,674	6,533	7,407	8,397	9,180	9,681

(2) Land Use

(a) Area for Urbanization (1990 - 2025)

The estimated area for urbanization is shown below:

unit : km^2

Area	1995	2005	2010	2015	2020	2025
DKI Jakarta	158	536	689	689	689	689
Bekasi	28	413	488	576	637	622
Tangerang	158	396	469	556	617	639
Bogor	85	543	618	699	764	805

The area in DKI Jakarta includes the area for future reclamation area.

(b) Estimated Future Land Use in 2025

The estimated future land use in 2025 is shown in Figure 19. Urbanization in JABOTABEK area in 2025 is estimated as follows:

District	Whole Area (km^2)	Urbanized Area (km^2)	Ratio of Urbanized Area (%)
DKI Jakarta	689	689	100
Tangerang	1,301	622	48
Bekasi	1,401	639	46
Bogor	2,792	805	29

(3) Regional Gross Domestic Products

Regional gross domestic products (RGDP) in JABOTABEK area in future are estimated with the assumption that annual average growth rate is 7 % as targeted in the second twenty -five year long-term development plan (PJP II) and shown below. Here those in Kabupaten and Kodya Tangerang are included in Tangerang, and those in Kabupaten and Kodya Bogor are included in Bogor.

	Year	Unit	DKI Jakarta	Bekasi	Tangerang	Bogor	Total
(a) RGDP in 1993 price	1995	Rp. Billion	59,175	4,991	4,852	6,135	75,153
	2000	- do -	82,996	7,000	6,805	8,604	105,405
	2010	- do -	163,266	13,769	13,387	16,925	207,347
	2025	- do -	450,457	37,990	36,935	46,696	572,078
(b) Per-capita RGDP	1995	Rp. Million	6.6	1.8	1.3	1.3	3.7
	2000	- do -	8.6	2.1	1.5	1.5	4.5
	2010	- do -	14.6	2.9	2.1	2.3	6.9
	2025	- do -	33.4	5.8	4.2	4.8	14.8

3.2 Basic Concepts of Plan Formulation

(1) Planning Conditions

Flood control master plan is formulated for the target year of 2025. The objective rivers and the design scales are shown in Figure 20.

(2) Basic Planning

(a) Comprehensive Flood Control

In order to keep the function of the objective area as the mainstay of national socio-economy, a new concept of flood control in the area, the comprehensive flood control, extending the view point to the whole watershed and introducing non-structural methods other than the structural methods is introduced in formulating the flood control master plan in JABOTABEK. The concept of comprehensive flood control is schematically shown in Figure 21.

(b) Zoning of Basin by Flood Control Function

Principally the Study Area is zoned by flood control function to 1) water retention zone, 2) retarding zone, and 3) low-lying zone as objective area for flood control as shown in Figure 22.

3.3 Proposed Flood Control Master Plan

3.3.1 Structural Measures

The incorporated structural measures in the flood control master plan for JABOTABEK area are schematically shown together with the design discharge distribution in Figure 23.

The longitudinal profiles and the standard cross-sections of the objective reaches of the river improvement works of the objective rivers are shown in Figure 24.

3.3.2 Non-Structural Measures

Non-structural measures for flood control master plan in JABOTABEK are watershed management, flood plain management, public information and education, and flood damage mitigation by establishing conveyance system of information on flood to the public. Public education includes the education of people by campaign through mass-media, distribution pamphlet, and others, and education of school children by using sub-textbook on flood control and functions of rivers. Flood damage mitigation includes establishment of flood fighting organization by riverine societies to reduce the flood damage as much as possible.

3.4 Project Evaluation

3.4.1 Economic Evaluation

Applied foreign exchange rates are as the figure as of October 1995, as follows:

US$ 1 = Rp. 2,281, ¥ 1 = Rp. 22.70

Economic evaluation of projects are conducted from the economic viewpoint of viability (EIRR). The estimated economic benefits, costs, and EIRRs are as follows:

River System	Economic Annual Mean Benefit (Rp. Million)	Economic Cost (Rp. million)	EIRR (%)
1. Cidurian river	7,295	144,861	3.8
2. Cimanceuri river	931	54,042	<0
3. Cirarab river	2,098	15,772	12.1
4. Cisadane river	8,419	176,052	3.3
5. Cengkareng floodway	87,792	520,388	14.6
6. Western Banjir Canal + Cisadane river	77,396	456,332	16.1
7. Eastern Banjir Canal	228,798	916,747	20.6
8. CBL floodway	9,988	138,200	6.2

3.4.2 Initial Environmental Examination (IEE)

The following items are selected for the IEE:

Social Environmental Issues	Nature Environmental Issues	Environmental Pollution Issues
- Resettlement - Impairment of the transportation system - Communities - Encroachment on historical Assets - Inundation of mineral resources	- Encroachment into precious ecosystem - Aesthetics & landscapes - Change of river flow regime - Watershed erosion and sedimentation	- Air pollution and noise - Deterioration of water quality

The results of initial environmental examination are shown in Table 1.

According to the result, negative impact to environment resulting from the implementation of the project might be limited. Those are the temporary ones such as noise, vibration, and the increase of suspended solid in river water due to river excavation and dredging during construction period.

It is evaluated that the implementation of each project will decrease the flooding and inundation in the objective area and contribute to the improvement of environment such as betterment of public welfare, enhancement of land use, etc. in addition to the direct protection of human life and properties.

3.4.3 Overall Evaluation

Overall evaluation of the flood control master plan is shown in Table 2 from the view point of project cost, land acquisition cost, beneficiaries, land use, technical evaluation, social impact and others.

The master plan projects for the river systems of the Western Banjir Canal and the Cisadane river are evaluated to be economically highly feasible and socially strongly required, and are given the highest priority. Following those projects, the projects for the river systems of the proposed Eastern Banjir Canal and the Cengkareng floodway are evaluated to be high priority projects from the same viewpoint.

3.5 Implementation Program

Implementation program is prepared in consideration of priorities of projects, duration of feasibility study, duration of procedure for detailed design, duration of detailed design, past disbursement schedule for implementation of flood control projects, and others.

Proposed implementation schedule of the proposed flood control master plan is prepared as shown in Figure 25.

3.6 Selection of Priority Projects

(1) Criteria

Selection of priority projects are conducted from the view point of :

1) Financial project cost is within the moderate amount.
2) Land acquisition/house compensation cost is small.
3) Beneficiaries are many.
4) Land use in 2025 is important.
5) Economic internal rate of return (EIRR) is high.
6) Implementation of the project is easy with less technical issue.
7) Social beneficial impact is big.
8) Implementation of the project is easy with less environmental issue.

(2) Selected Projects

In consideration of the above criteria, overall evaluation of flood control master plans is conducted as shown in Table 2 with other project features. The first priority project for the feasibility study is assessed to be the improvement of the Western Banjir Canal system and the Cisadane river system.

4 FEASIBILITY STUDY

4.1 Framework in 2025

1) Beneficiary Area : 230 km^2
2) Beneficiary Population
   1995 : 1.29 million people
   2025 : 1.86 million people
3) Land Use : commercial, industry and residential areas, and agricultural areas (Jakarta metropolis and the suburbs)
4) Industries : center of administration, commerce, finance ,industries, agriculture, education, agriculture and fisheries

4.2 Priority Projects

(1) General

The Western Banjir Canal is to be improved to increase the carrying capacity. But since the Western Banjir Canal is located in the densely populated area of DKI Jakarta, the widening of the river is very difficult from the view point of people's relocation.

Accordingly the river improvement of the Western Banjir Canal is planned in the present right of way to avoid people's relocation as much as possible. But the river improvement of the Western Banjir Canal in the present right of way would not cover the design discharge of 100-year flood. Therefore it is also planned to divert a flood in the upstream basin of the

Western Banjir Canal to the Cisadane river. For that purpose, it is planned to construct a floodway from the Ciliwung to the Cisadane river in Bogor city.

At the same time, the Cisadane river is to be improved in due consideration of artificial flood from the Ciliwung river.

(2) Objectives of Priority Projects

The objectives of the projects are :

1) flood damage mitigation in the western part of DKI Jakarta, and
2) flood damage mitigation of the downstream basin of the Cisadane river.

The projects cover:

1) river improvement of the Western Banjir Canal,
2) construction of the Ciliwung floodway, and
3) river improvement of the Cisadane river in the downstream reaches.

4.3 Background

4.3.1 Projects Sites

(1) The Western Banjir Canal

The Western Banjir Canal (WBC) is located in the western part of DKI Jakarta. The objective reaches of WBC is located in totally urbanized area. The area, population, and population density of DKI Jakarta as of 1990 are, 661 km^2, 8.23 million persons, 12.5 thousand /km^2 respectively.

(2) The Cisadane River

The Cisadane river is located in Kodya Tangerang and Kabupaten Tangerang. The objective reaches of the Cisadane river are mostly located in Kabupaten Tangerang. The area, population, and population density of Kabupaten Tangerang as of 1990 are 1,301 km^2, 2.76 million persons, and 2.1 thousand persons/km^2 respectively. The urbanization of Kabupaten Tangerang is 11 % as of 1990 and is estimated at 48 % in 2025.

(3) The Ciliwung Floodway

The Ciliwung floodway is proposed to be constructed in Bogor city. The proposed route of the Ciliwung floodway is totally urbanized. The area, population, and population density of Kodya Bogor as of 1990 are 22 km^2, 271 thousand persons, and 12.3 thousand persons/km^2 respectively. The general location of the Ciliwung floodway is shown in Figure 26.

4.3.2 Geology

The alluvial and alluvial fan are the majority to subsurface layers of the geology of the Western Banjir Canal site.

Most of the subsurface layers in the project area of the Cisadane river belongs to alluvial. This deposit unit can be considered as very soft to soft soil and very loose to loose soil.

The geology of the Ciliwung floodway tunnel route is mainly composed of younger volcanic rocks which consists of old deposit, lahar and lava, etc. mostly highly weathered and poorly cemented.

The geological profiles of the Ciliwung floodway route is shown in Figure 27.

4.3.3 Environment

There exist Batutulis village near the outlet site of Ciliwung floodway. This village is located in the Keraton, Pajajaran Kingdom zone. Many types of historical assets symbolizing the prosperity of the Kingdom of Keraton, Pajajaran have been discovered around this area. Therefore it is probable that some cultural and historical assets will be found during the construction period.

4.3.4 On-going Flood Control Plans

The following projects are planned to be started in 1997 with Project Type Sector Loan by OECF; these works will be executed in line with the present study.

1) channel excavation of the Western Banjir Canal for the length of 8 km,
2) embankment improvement of the Western Banjir Canal for the length of 18 km,
3) drainage improvement of the Ciliwung Drain for 8.4 km,
4) rehabilitation of slide gates of the Pasar Baru barrage on the Cisadane river by 7 units.

4.3.5 Review of Design Discharge Distribution of WBC

Design discharge distribution of the Western Banjir Canal is revised from that studied in the master plan stage. The main point of revise is that the design discharge distribution of the Ciliwung river to the Ciliwung drain is decreased from 75 m^3/s to 50 m^3/s. Accordingly the design discharge distribution of the Western Banjir Canal is revised to the following:

1) Estuary to Angke drain : 500m^3/s
2) Angke drain to Krukut river : 470 m^3/s
3) Krukut river to Manggarai barrage : 360 m^3/s

4.3.6 Channel Conditions for Reclamation

Sea coast reclamation plans, so called PANTURA DKI Jakarta and KAPUKNAGA, are now

underway. The objective reaches are tentatively from around the estuary of the Western Banjir Canal to around the estuary of the Cirarab river. The reclamation width towards the sea will be 2.5 km in average.

Here study results are presented on the conditions of the channels to be prepared in the reclaimed area as the continuation of the present rivers, so that they would not cause any raise of the design high water level in the flood control master plan in JABOTABEK.

River	Required river width at the future estuary (m)	River width at the present estuary in the master plan (m)
Cisadane River	248	192
Cengkareng Floodway	133	120
Western Banjir Canal	147	100

(3) The Western Banjir Canal

The channel in the reclaimed area as the extension of the Western Banjir Canal should have the width of low water channel of at least 100 m at the new estuary against the width of 53 m in the master plan to avoid the raise of the design high water level in the master plan.

4.4 Optimum Scale for Urgent Flood Control Project (1st Stage Project)

Implementation of the priority projects selected form the master plan needs a big amount of project cost. Accordingly, effective stepwise implementation of the projects is required. Comparison of four safety degree alternatives is studied for the optimum scale of urgent flood control project as shown in Table 3. As a result, the urgent flood control project to be implemented immediately as 1st stage project and the optimum scale are proposed to be as follows::

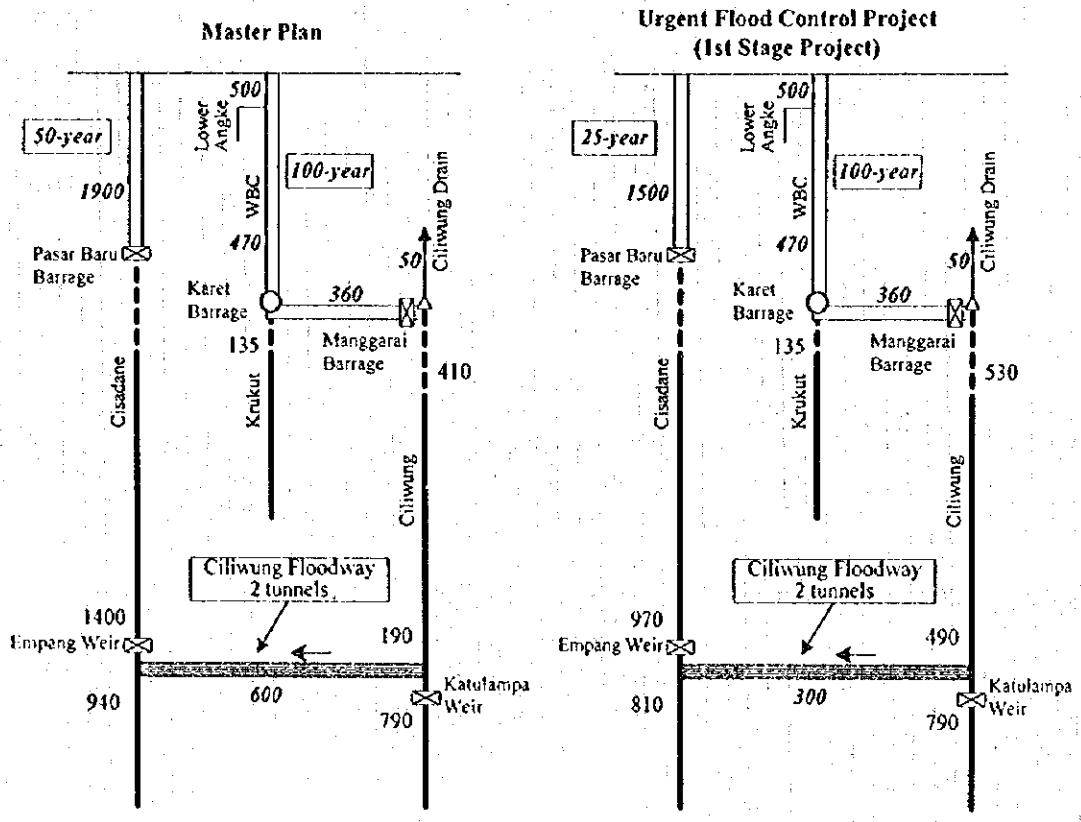
1) River improvement of the Western Banjir Canal
   (design discharge of 100-year design scale, which is the same as that of the master plan)
2) River improvement of the Cisadane river
   (25-year design scale; 50-year design scale is adopted in the master plan)
3) Construction of Ciliwung floodway (2 tunnels : capacity of 600 m^3/s, temporarily design discharge is 300 m^3/s)

As for the construction of the Ciliwung floodway among the above scheme, the two tunnels proposed in the master plan are to be constructed in advance during the stage of the urgent flood control project. The design discharge to the two tunnels is proposed temporarily to be 300 m^3/s in accordance with the river improvement of the Cisadane river in downstream reaches with 25-year design scale.

The construction of 2 tunnels in advance is proposed with the consideration to the demerits such as various procedures, increase of the cost, negative impact of giving inconvenience to the surrounding residents and the others to be accompanied by future additional works.

The following studies hereunder are conducted for this Urgent Flood Control Project (1st Stage Project).

The design discharge distribution thus proposed is as follows:



4.5 Preliminary Design for Urgent Flood Control Project (1st Stage Project)

4.5.1 Western Banjir Canal

(1) Basic Concept

The major concepts of river improvement of the Western Banjir Canal are as follows:

1) the river improvement plan should be prepared in the present right of way to avoid the land acquisition and land compensation as much as possible,
2) the embankment should be protected with revetment or others to be durable even overtopping of flood occurs,
3) freeboard should be rather more than the minimum standard in due consideration of future possible land subsidence.

(2) Basic Features

The plan, and design longitudinal and cross-sectional profiles of the Western Banjir Canal are shown in Figures 28 to 30.

(3) Proposed Project Works

The major required project work items and quantities in the urgent flood control project for the priority projects are as follows:

	Work Item	Unit	Quantity
1.	Land Aquisition and Compensation		
	Land aquisition	ha	0.0
	House	nos.	0
2.	Channel Improvement (L=16.9 km)		
	Preparatory	ls	1
	Excavation and dredging	m^3	1,354,000
	Embankment	m^3	110,000
	Low and high water channel revetments (around tributaries and related structures)	m^2	17,100
	Low water channel revetment (water colliding front, steep slope)	m^2	24,700
	Embankment protection		
	-Wet masonry	m^2	72,300
	-Sod facing	m^2	42,900
	Asphalt pavement of embankment crown	m^2	25,100
	Drop structure	nos.	0
	Construction of new drainage structure	nos.	4
	Improvement of existing drainage structure	nos.	3
	Reconstruction of existing bridges	nos.	7
	Construction of New Opening at Manggarai Barrage	nos.	1

4.5.2 Cisadane river

(1) Basic Concept

The major concepts of river improvement of the Cisadane river are as follows:

1) design high-water level should be the same one between the present project and the later master plan level project,
2) widening and excavation of low-water channel should be avoided as much as possible in due consideration of present stability of side slope, minimum maintenance cost, and preservation of the natural environment, and
3) riverside forest should be preserved as much as possible in due consideration of the

function as energy dissipater of flood force to the embankment.

(2) Basic Features

The plan, and design longitudinal and cross-sectional profiles of the Cisadane river are shown in Figures 31 to 33.

(3) Proposed Project Works

The major required project work items and quantities in the urgent flood control project for the priority projects are as follows:

	Work Item	Unit	Quantity
1.	Land Aquisition and Compensation		
	Land aquisition	ha	45.3
	House	nos.	460
2.	Channel Improvement (L=15.0 km)		
	Preparatory	ls	1
	Excavation and dredging	m^3	825,000
	Embankment	m^3	913,000
	Low water channel revetment	m^2	8,400
	Drop structure	nos.	0
	Construction of new drainage structure	nos.	3
	Improvement of existing drainage structure	nos.	2
	Reconstruction of bridge	nos.	0

The number of houses to be expropriated were counted by using the topographic maps with a scale of 1:5,000 prepared by the Study Team in 1996.

4.5.3 Ciliwung Floodway

(1) Location

The location of the Ciliwung floodway is proposed to be the place where the distance between the Ciliwung and Cisadane rivers is nearly the shortest in Bogor city.

(2) Basic Concept

The major concepts of construction of Ciliwung floodway are as follows:

1) two tunnels should be constructed,
2) the flow inside the tunnel should be of non-pressure flow type,
3) minimum overburden of the tunnel should be more than outside diameter of the tunnel,

4) desilting basin to minimize sediment inflow to the tunnel should be provided, and
5) silting basin and/or energy dissipater should be provided for outlet facilities.

(3) Basic Features

The major features of the floodway are as follows:

Total length	: 1,040 m
Discharge capacity	: 300 m^3/s per 1 channel
Gradient of channel	: 1/125
Length of tunnel	: 913 m
Diameter of tunnel	: 8.0 m

The design plan, and longitudinal and cross-sectional profiles of the floodway are shown in Figures 34 to 36.

4.5.4 Related Structures

(1) Manggarai Barrage

Manggarai barrage is to be improved to increase the carrying capacity for new design discharge distribution of 360 m^3/s. The basic concept for increasing the capacity is that additional sluiceway is to be constructed on the right side of the existing sluiceways with the same dimension.

The proposed features are shown in Figure 37.

(2) Muara Angke Pumping Station

In line with the river improvement of the Western Banjir Canal, the improvement of the Muara Angke Pumping station is needed. This is to adjust the station with the new design high-water level.

(3) Bridges

Along the Western Banjir Canal, 2 bridges need to be reconstructed due to their lower elevation of girder soffit to the design high-water level. Other 5 bridges need to be reconstructed due to their lower elevation of the girder soffit to cover the necessary freeboard.

4.6 Construction Plan

Construction plan is prepared based on the assumption that the construction works will be mainly conducted under a contract system of which the contractor(s) will be selected through competitive bidding, and the consideration of various conditions of working hours, equipment and material available in the project area, labor forces, geology at the site and others.

The major proposed methods are as follows:

(1) Western Banjir Canal

Spoil bank and other works for temporary use are taken into consideration from the present land use around the river course in due consideration of the heavy traffic situation along the Western Banjir Canal. For the rather upstream reaches, the conventional excavation equipment such as backhoe and clamshell could be utilized but for the downstream reaches, some pump dredger would need to be utilized.

(2) Cisadane River

Since the Cisadane river is presently located mainly in the country side, the access and the other spoil bank are rather easy to find. Conventional method can be utilized.

(3) Ciliwung Floodway

Since the proposed route is located under the densely populated city area of Bogor, no dynamite for blasting can be utilized. In consideration of the geology of the course and ground water situation that is rather high, enclosed type shield tunneling machine should be utilized even though the machine should be imported from other countries where the machine is available. Construction schedule is prepared based on this construction method.

4.7 Non-structural Measures

(1) Flood Risk Map

Flood risk map is prepared on the condition that inundation would occur when failure of dike happens and the failure of dike may occur at any place in the objective reaches of the river during a 100-year probable flood of each river.

The flood risk map shows the maximum simulated inundation area and is prepared for the low-lying area of DKI Jakarta of about 500 km^2 as shown in Figure 38.

(2) Flood Warning System

Flood warning system is proposed for the Cisadane river in due consideration of the artificial flood diversion from the Ciliwung river to the Cisadane river. The basic concept of the system is that flood warning should be given to the people in the river area by warning siren through the communication system.

The system is schematically shown in Figure 39.

4.8 Cost Estimate

The project cost of the urgent flood control project (1st stage project) is estimated at the price

level of October 1995 as follows:

Foreign currency	: Rp.534,178 million (¥23,532 million)
Local currency	: Rp.560,966 million
Total equivalent	: Rp.1,095,144 million

The breakdown is as follows:

Estimated Project Cost

(Unit : Million)

Description	Foreign Currency (Yen)	Local Currency (Rp.)	Total Equivalent (Rp.)
1 Direct Construction Cost	15,010	159,110	499,844
2 Land Acquisition and House Compensation Cost	0	81,702	81,702
3 Sub-total of (1+2)	15,010	240,812	581,546
4 Engineering Services Cost	2,252	23,867	74,977
5 Government Administration Cost	0	29,077	29,077
6 Sub-total of (3+4+5)	17,262	293,756	685,601
7 Physical Contingency	1,726	29,376	68,560
8 Sub-total of (6+7)	18,988	323,132	754,161
9 Price Contingency	4,544	237,834	340,983
10 Total (8+9)	23,532	560,966	1,095,144

Note: exchange rate: Rp.22.70= ¥1.0

Operation and maintenance cost is estimated at Rp.2,384 million per year. Replacement cost of metal works is estimated at Rp.2,542 million.

4.9 Project Evaluation

4.9.1 Economic Evaluation

The economic internal rate of return (EIRR) of the urgent flood control project (1st stage project) is estimated as follows:

1)	Financial cost	: Rp.1,095,144 million (including price contingency)
2)	Economic cost (C)	: Rp.662,211 million
3)	Benefit (B)	: Rp.108,092 million/year
4)	EIRR	: 13.1 %
5)	B/C	: 1.10 (at discount rate of 12 %)
6)	Net present value	: Rp.35,281 million (at discount rate of 12 %)

The result of the sensitivity analysis is as follows:

	Case	EIRR
1)	benefit decreases by 15 %	: 11.5 %
2)	construction cost increases by 15 %	: 11.3 %
3)	for both of 1) and 2)	: 9.9 %

It can be concluded from the above that the project is economically feasible.

4.9.2 Environmental Impact Assessment

(1) Assessment

Regarding the precious ecosystem, since here is no alteration of land around the mangrove forest by the project, no negative impacts to birds and reptiles inhabiting there will be caused.

Regarding the historical assets, there is a possibility that the historical assets of old Kingdom will be found near the outlet facilities during the construction of the Ciliwung floodway. Special attention would be needed when such assets is found.

Regarding the air pollution, noise, and river water quality change during the construction stage, some measures to reduce the magnitude of impacts would be needed. But no significant negative impacts on river water quality is expected by the construction of the Ciliwung floodway. No serious impacts on the ground water would be caused by the construction of tunnel floodway by adopting enclosed shied machine.

Regarding the resettlement of people, a comprehensive public relation/resettlement program needs to be developed in the detailed design stage of the project.

(2) Environmental Management and Monitoring Plan

Based on the environmental impact assessment, the 5 items of noise, impairment of transportation, water quality, groundwater, resettlement, are selected for. A new unit for this environmental management and monitoring plan of the project, should be established in the Ciliwung-Cisadane River Basin Development Project. This unit shall handle the environmental issues during and after the implementation of the proposed schemes.

4.9.3 Overall Evaluation

Economic internal rate of return (EIRR) of the urgent flood control project (1st stage project) is estimated at 13.1 %.

The urgent flood control project would greatly contribute to the prosperity of social and economic activities and the people's welfare in Jakarta metropolis as the center of the political and socio-economic activities in Indonesia.

The project would cause some environmental negative impacts especially during the construction stage. Accordingly the monitoring organization for the environmental aspect would need to be organized to decrease the impact as much as possible.

4.10 Institutions and Organization

(1) Institutions

To be in conformity with the provisions stipulated in the intended legislation, providing policies in implementation to proceed to construction can be obtained through Forum of Coordination based on provisions in Ministerial Regulation of MPW No. 67/ PRT/1993.

(2) Future Organization

Presently the management system of Ciliwung and Cisadane rivers is in accordance with DPS (Daerah Pengairan Sungai - Catchment Area) pattern or Sub River Basin pattern (The River Basin or River Territory is Ciliwung-Cisadane River Basin). Water resources management in the province of West Java is conducted by Public Works Provincial Water Resources Service/Dinas of West Java. On the other hand, in DKI Jakarta, water resources management is conducted by Sub Dinas of Water Management, Public Works Provincial Service/Dinas of DKI Jakarta.

But when the construction of the Ciliwung floodway is completed, the Ciliwung and Cisadane rivers are interconnected to one river system. The river management also has to be modified to one river management system, including the flood control management.

Accordingly before the construction of the floodway, an organization including the river management unit has to be established. This unit is one of the division of Basin Water Resources Management and Development Unit.

Conceivable ways for that are : 1) the function of the present Ciliwung-Cisadane River Basin Development Project be upgraded, or 2) the function of the present Jasa Tirta State Corporation be enlarged to cover the Ciliwung-Cisadane river basin.

4.11 Implementation Plan

The urgent flood control project (1st stage project) is proposed to be implemented stepwise as follows:

1) 1st phase (scheduled year : detailed design 1997 - 1998, construction 2000 - 2003)
   (a) river improvement of the Cisadane river
   (b) construction of the Ciliwung floodway

2) 2nd phase (scheduled year : detailed design 2002 - 2003, construction 2004 - 2008)
   (a) river improvement of the Western Banjir Canal

4.12 2nd Stage Project

The supplemental works for the master plan level after completion of the urgent flood control project (1st stage project) is called as 2nd stage project. The succeeding supplemental works consist of the river improvement of the Cisadane river for upgrading of safety level from 25-year to 50-year design scale.

The 2nd stage project is desirable to be implemented soon after completion of the 1st stage project as follows:

1) river improvement of the Cisadane river for 50-year design scale
(scheduled year : detailed design 2007 - 2008, construction 2010 - 2011)

Here, the whole project cost and EIRR including the 1st and 2nd stage projects are estimated at RP. 1,169 billion (¥ 51,503 million) and 13.2 % respectively.

5 RECOMMENDATIONS

In view of the serious direct and indirect damages and confusion due to the big flooding in January and February 1996 in DKI Jakarta, it is proposed that the urgent flood control project be implemented very soon as an urgent scheme.

The following recommendations regarding flood control, water resources and river water quality are also proposed.

5.1 Flood Control

(1) Restriction of Development along the Western Banjir Canal

As can be seen along the downstream reaches of the WBC now, it is impossible to implement the present Detailed Design of the WBC conducted in 1987 as it is because of the on-going big scale residential development projects within the proposed alignment. Accordingly, it is absolutely necessary to regulate the development strictly within the alignment proposed in the urgent flood control project not to repeat this kind of situation again.

(2) Coordination with KAPUKNAGA

As urgent flood control project, the project includes a plan to construct the embankment along the downstream reaches of the Cisadane river. But the downstream end of the embankment is planned not in consideration of the KAPUKNAGA reclamation project since the detailed design of the development is not available yet. Accordingly the coordination with KAPUKNAGA project for this aspect will be needed for further step of the project.

(3) Eastern Banjir Canal

According to the information on PANTURA DKI Jakarta (reclamation plan along the north coast of Jakarta), they are planning to utilize the Eastern Banjir Canal as the waterway and Roro harbor for the Marunda industrial area with the minimum width of 200m of the Eastern Banjir Canal for the downstream reaches.

If a joint planning and implementation with PANTURA DKI Jakarta is realized for

construction of the Eastern Banjir Canal, land acquisition and implementation costs for its downstream reaches will be greatly decreased for the government. In this case, the construction of the Eastern Banjir Canal would be much more realistic.

Regarding the upstream reaches of the Eastern Banjir Canal, in order to reduce the land acquisition cost, it is conceivable to make a plan to utilize the space over the Eastern Banjir Canal as housing area or an objective area for city redevelopment project. This can be conducted by joint project with private sector.

Accordingly it is recommended that joint planning with PANTURA DKI Jakarta or other private sectors be conducted in early stage for construction of the Eastern Banjir Canal, since the flood control in the eastern part of DKI Jakarta is socially and urgently needed together with the flood control of the eastern part of DKI Jakarta.

(4) Flood Warning in Rive Area

The middle reaches of the rivers in JABOTABEK area are basically located in the deep valley. And accordingly the area is not included in the area to be protected from flooding in due consideration of the retarding effect to the downstream reaches and small beneficiary area due to its topographical situation.

But many people are already living in the river area. For the time being, it does not seem to be possible to relocate the people so soon. Accordingly the effective flood warning system should be established so that people can evacuate safely with their properties in the houses. Flood warning should be made by using plural measures including TV.

(5) Land Use Restriction in Future River Area

After the finalization of flood control master plan in JABOTABEK area by the authorized agencies, the area to be the river area in future in accordance with the master plan flood control, should be delineated and certain land use regulation should be conducted so that land acquisition in future should not hinder the implementation of the project.

(6) Study on Bridges

Past flooding on January 6 to 8 in 1996 revealed that some bridges form bottle necks to flood flow and some bridge do not seem to have enough freeboard. The soffit level of bridge girder or that of aqueduct do no seem to have enough high elevation. This situation should be examined soon and proper action should be taken.

(7) Establishment of Solid Waste Collection System

Solid waste is deposited at many places or trapped by the river structures along the river course and drainage canal, and it worsens river water quality and river view. Besides, the waste causes reduction of flow capacity of river channels and drainage canals.

To mitigate the mentioned situation, appropriate solid waste collection system is required to be established by DKI Jakarta.

But construction of garbage screen in the midst of rivers at certain place to protect the downstream reaches may become a serious problem to the upstream reaches. Periodical removal of solid waste in rivers during low flow should be conducted. And at the same time, public education and campaign should play an important role for this aspect.

(8) Preservation of Situ-Situ

Lakes and ponds in the JABOTABEK area so called situ-situ in the local dialect, play an important role for flood retention. Situ-situ have, not only the function of flood retention, but also the function of water resources conservation as infiltration place in the basin. Besides the situ-situ also plays an role of giving amenity to the society as recreation place and an role to preserve the fauna and flora in the basin. This has an important significance from the viewpoint of environment.

(9) Regulation of Land Development

The large scale development without appropriate flood retention facilities, not only increases the flood peak flow, but also reduces the basin storage of water resources causing deficit of water resources in the basin or salt water intrusion in groundwater in the area close to the sea.

To avoid these situation, certain legislation should be enacted so that land development should accompany the construction of appropriate flood retention facilities such as flood retention pond, and the rainfall infiltration facilities such as infiltration pavement and the like.

(10) Operation of Barrage

Pasar Baru barrage across the Cisadane river has 10 gates but due to its deterioration, some gates does not function properly. It is estimated that one reason of the deterioration is the rusting caused by biased usage of specific gates.

Accordingly, it is recommended that the operation rule be reconsidered so as to operate all the gate evenly. This recommendation might be applied not only to Pasar Baru barrage but also to Bekasi and Cikarang barrages.

5.2 Water Resources and River Water Quality

(1) Strict Management of Groundwater Use and Provision of Piped Water Supply System and Water Resources Development

Strict management of the groundwater uses is indispensable to mitigate the land subsidence in the northern part of DKI Jakarta, including clarification of safe yield of groundwater based on detailed data on the existing wells and geographical information, and improvement of licensing and registration of water users.

Although the ground water use regulation is issued, it is necessary to analyze and clarify the relationship between the extent of land subsidence and the mentioned regulation.

As a measure against land subsidence, provision of piped water supply system in JABOTABEK area is recommended to be urgently undertaken by the PAM Jaya as proposed by the JWRMS. Also, other possible measures for groundwater recharge enhancement and groundwater tariff are proposed to be implemented together with the mentioned works.

(2) Separation of Polluted Rivers from West Tarum Canal (WTC)

In order to reduce the health risks and operation and maintenance cost in the water treatment plants, especially purification cost, it is recommended to separate The West Tarum Canal from the rivers flowing into the Canal by provision of syphon structure or pipeline conveyance at joining points with these rivers.

While, the intake weirs along the WTC are currently operated mainly for conveying water to DKI Jakarta. Therefore, the gates of these weirs are not effectively operated for smoothly passing flood water, and this is one of causes of flooding in the upstream of weir sites.

From the above, the proposed improvement works will be effective not only for water uses management but also for flood control.

Tables

Table 1 RESULT OF INITIAL ENVIRONMENTAL EXAMINATION

River system	Construction Works										
	Social Environmental Items				Nature Environmental Items					Pollution	
	Resettlement	Impairment of the transportation system	Communities	Encroachment on historical Assets	Inundation of mineral resources	Encroachment into precious ecosystem	Aesthetic & Landscape	Change of river flow regime	Watershed erosion and sedimentation	Air pollution and noise	Deterioration of water quality
Cidurian River	B	D	C	B	D	D	D	D	D	C	A
Cimanceuri River	B	D	C	B	D	D	D	D	D	C	A
Cirarab River	B	D	C	B	D	D	D	D	D	C	A
Cisadane River	B	D	C	B	D	D	D	D	D	B	A
Cengkareng Floodway	B	A	C	B	D	D	D	D	C	A	A
Western Banjir Canal	A	A	C	B	D	B	D	D	D	A	B
Eastern Banjir Canal	A	A	A	B	D	D	D	D	D	A	A
CBL Floodway	B	D	C	B	D	D	D	D	D	B	A

Note: A; Mostly significant item, B; Significant item, C; Significant but relatively minor item, D; No effect is expected.

Table 2 OVERALL EVALUATION OF MASTER PLAN

River System	1 Ciliwung	2 Cimanceuri	3 Cisarab	4 Cengkareng Floodway	5 Western Banjir Canal + Cisadane	6 Eastern Banjir Canal	7 CBL Floodway	8 Non-structural Measures
Outline of Plan (Improvement Length)	River Improvement 32km	River Improvement 22km	River Improvement 17km	River Improvement and Angke floodway 22km	River Improvement and Ciliwung floodway 38km	River Improvement and Eastern Banjir Canal 57km	River Improvement 50km	Flood forecasting and warning system,
Implementation Program (year)	2018-2023	2022-2025	2013-2016	2013-2025	1997-2008/2008-2011	2005-2017	2014-2019	flood risk map,
Beneficial Population in 2025 (1000 nos)	495	605	144	2,505	1,865	4,119	1,607	institutions,
point	1	3	1	5	5	7	5	
Beneficial Area(km^2)	180	240	70	120	230	210	570	flood fighting system,
Land Use in 2025	Agriculture	Agriculture	Agriculture	Residential Area	Gov. Ind. & Comm.	Res. & Industrial	Agri. & Residential	public education,
point	1	1	1	5	9	7	3	
Return Period of Design Flood(year)	25	25	25	100	100 and 50	100	50	
Financial Project Cost (Rp. billion)	227	108	27	858	767	1,931	220	school education,
point	3	3	3	2	2	0	3	etc.
Financial Land/House Cost (Rp. billion)	87	59	12	295	305	943	88	
point	10	10	10	8	8	2	10	
EIRR (%)	3.8	-	12.1	14.6	16.1	20.6	6.2	
point	0	0	6	6	6	6	2	
Technical Evaluation	Ordinary	Ordinary	Ordinary	Complicated	Complicated	Ordinary	Ordinary	
point	2	2	2	1	1	2	2	
Social Beneficial Impact	small	small	small	big	very big	big	middle	
point	1	1	1	5	7	5	3	
Environmental Impact	not affect	might affect	not affect	not affect	not affect	not affect	might affect	
point	2	0	2	2	2	2	0	
Project Status	F/S: not available	F/S: not available	F/S: not available	D/D: partly available	D/D: partly available	Partly implemented	F/S: not available	
Overall Point	20	20	26	34	40	31	28	
Priority Projects for F/S					◎			

Evaluation Criteria

Land Use	Financial Project Cost	Land & house cost	EIRR	Beneficial Population	Technical Evaluation	Social Beneficial Impact	Environmental Impact
1: Agriculture	0: 1,500<X	0: 1,000<X	0: X<5	1: X<500	1: Complicated	1: small	0: might affect
3: Agri. & residential	1: 1,000<X<1,500	2: 800<X<1,000	2: 5<X<10	3: 500<X<1000	2: Ordinary	3. medium	2: not affect
5: Residential	2: 500<X<1,000	4: 600<X<800	4: 10<X<12	5: 1000<X<3000		5: big	
7: Resid. & Industrial	3: X<500	6: 400<X<600	6: 12<X	7: 3000<X		7: very big	
9: Gov.,Ind.& Comm.		8: 200<X<400					
		10: X<200					

*1) I/P: Implementation Program, Gov.: Governmental Office Area, Comm.: Commercial Area, Ind.: Industrial Area, Agri.: Agricultural Area, Land/house Cost: Land acquisition/house compensation cost

*2) The project costs here are all those estimated on the master plan level

Table 3 ALTERNATIVE SCHEMES FOR OPTIMUM SCALE OF PRIORITY PROJECTS

	Alt. 1	Alt. 2	Alt. 2'	Alt. 3
Design Scale	WBC: 100-year, Cisadane: 50-year	WBC: 100-year, Cisadane: 25-year	WBC: 100-year, Cisadane: 25-year	WBC: 50-year, Cisadane: 10-year
Floodway tunnel (unit)	2	1	2	1
Financial Project Cost (Rp. billion)	767 1	672 2	714 2	595 3
EIRR	16.1% 1	18.0% 3	16.4% 2	17.8% 3
Technical Evaluation	(1) Investigation of ground water once, (2) no restriction to existing tunnel and channel, (3) access easy by existing road, (4) inlet weir construction once, (5) temporary works once 3	(1) Investigation of ground water twice, (2)restriction to existing tunnel and channel, (3) access difficult after construction of one tunnel, (4) inlet weir reconstruction needed, (5) temporary works 1	(1) Investigation of ground water once, (2) no restriction to existing tunnel and channel, (3) access easy by existing road, (4) inlet weir construction once, (5) temporary works once 3	(1) Investigation of ground water once, (2) no restriction to existing tunnel and channel, (3) access easy by existing road, (4) inlet weir construction once, (5) temporary works once 1
Environmental Impact	(1) Temporary land use once, (2) affect to ground water once, (3) river water disturbance once, (4) possible impact to historical assets once 3	(1) Temporary land use twice, (2) affect to ground water twice, (3) river water disturbance twice, (4) possible impact to historical assets twice 1	(1) Temporary land use once, (2) affect to ground water once, (3) river water disturbance once, (4) possible impact to historical assets once 3	(1) Temporary land use twice, (2) affect to ground water twice, (3) river water disturbance twice, (4) possible impact to historical assets twice 1
Social Impact	(1) Land acquisition once, (2) transportation of heavy equipment once, (3) affect to groundwater once, (4) noise, vibration, resettlement once, (5) benefit big 3	(1) Land acquisition later more difficult, (2) transportation of heavy equipment twice, (3) affect to groundwater twice, (4) noise, vibration, resettlement twice, (5) benefit middle 1	(1) Land acquisition once, (2) transportation of heavy equipment once, (3) affect to groundwater once, (4) noise, vibration, resettlement once, (5) benefit middle 3	(1) Land acquisition later more difficult, (2) transportation of heavy equipment twice, (3) affect to groundwater twice, (4) noise, vibration, resettlement twice, (5) benefit middle 1
Overall Score	11	8	13 Optimum	9

Note: Estimated financial project cost is on the Master Plan level.