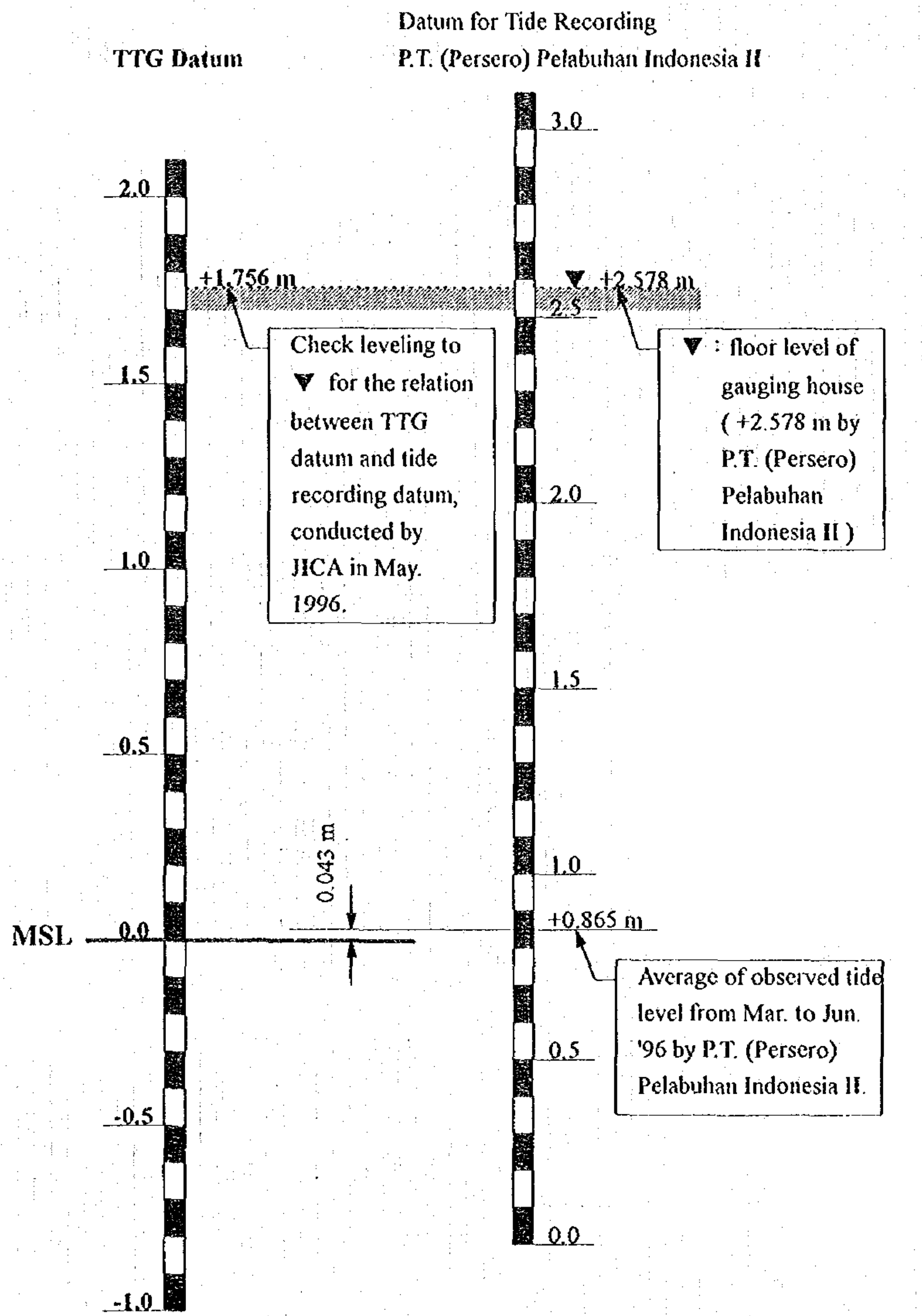

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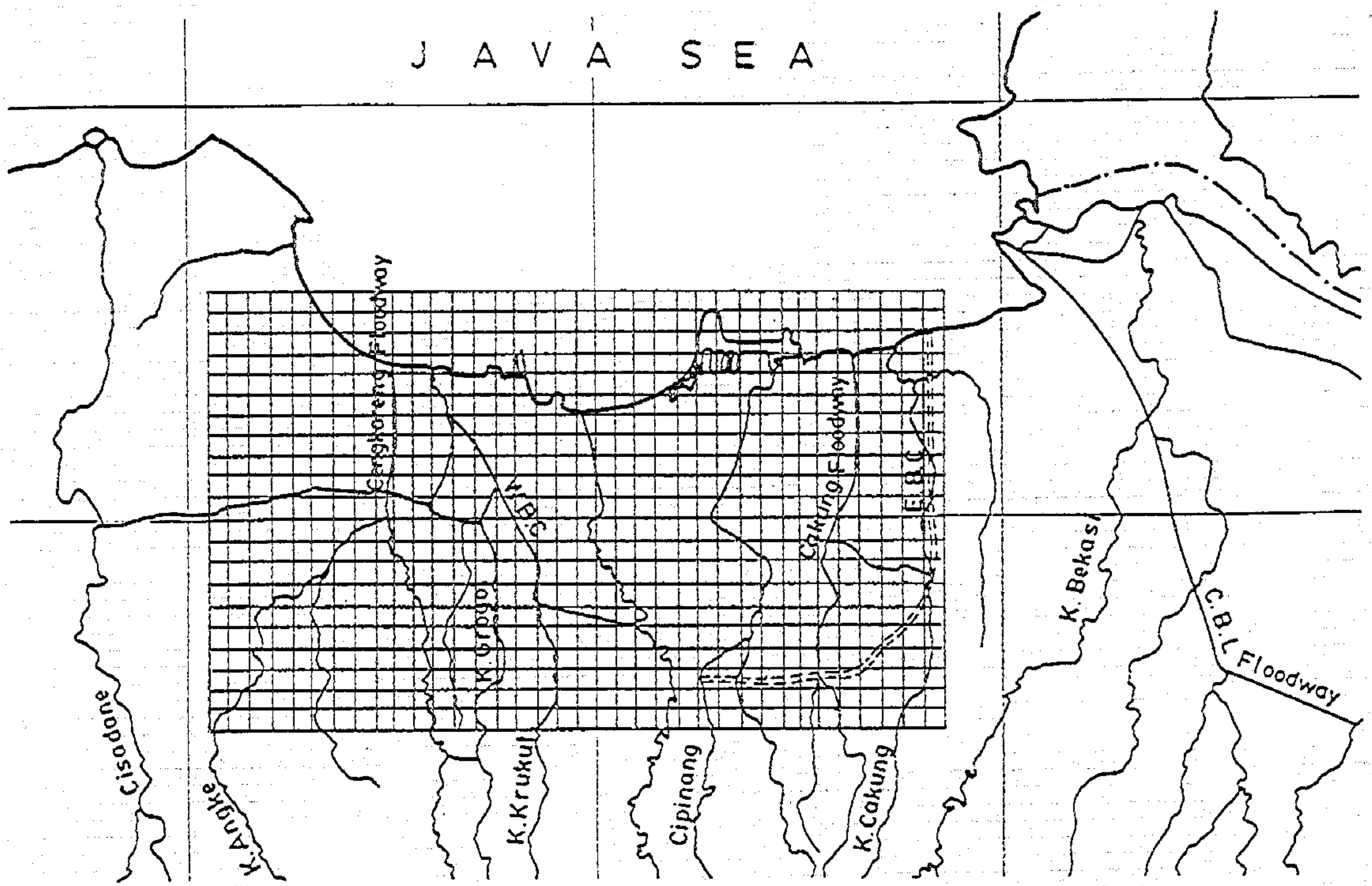

Figure 11.1 OBJECTIVE AREA OF FLOOD RISK MAP

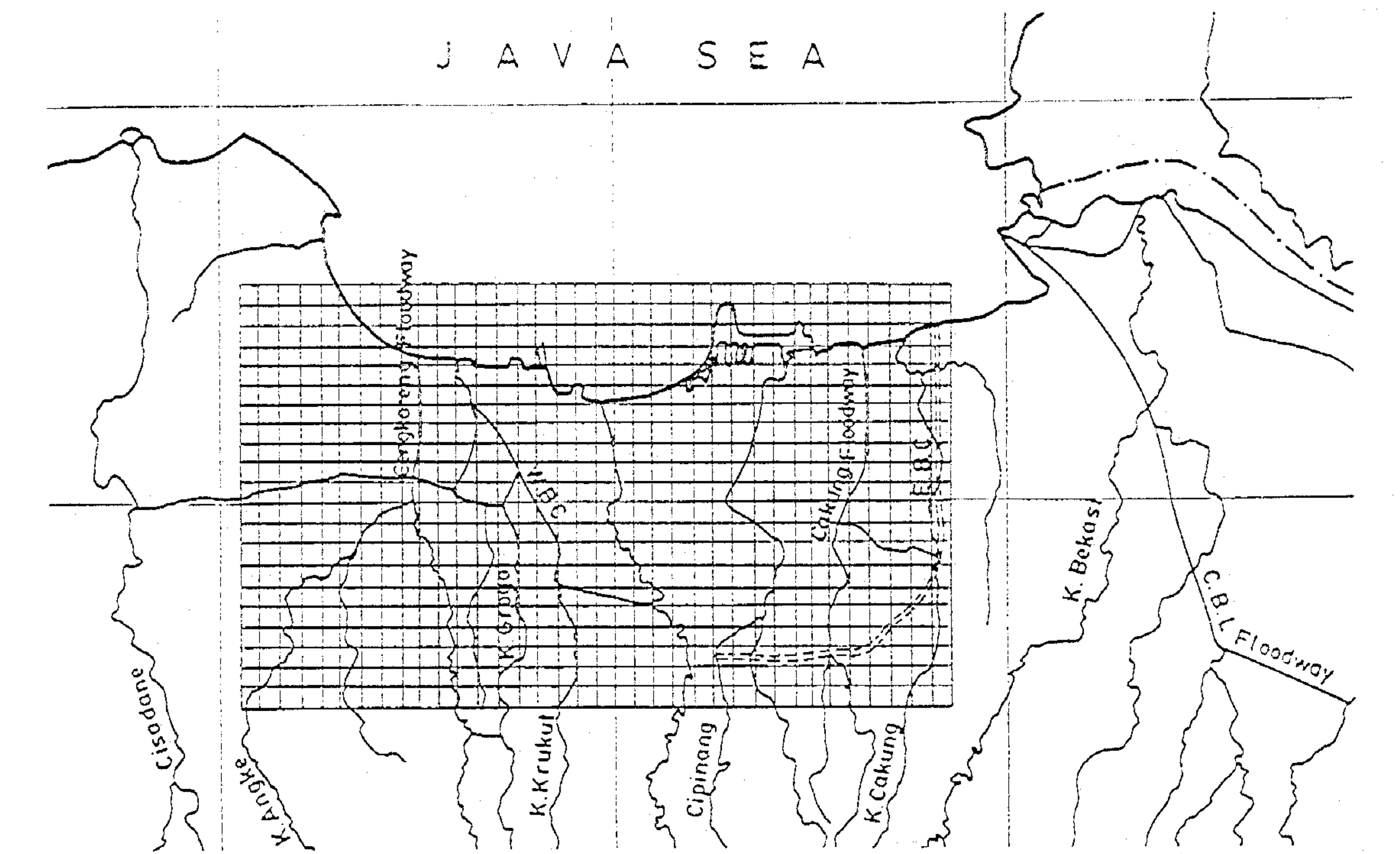

Figure 11.1 OBJECTIVE AREA OF FLOOD RISK MAP

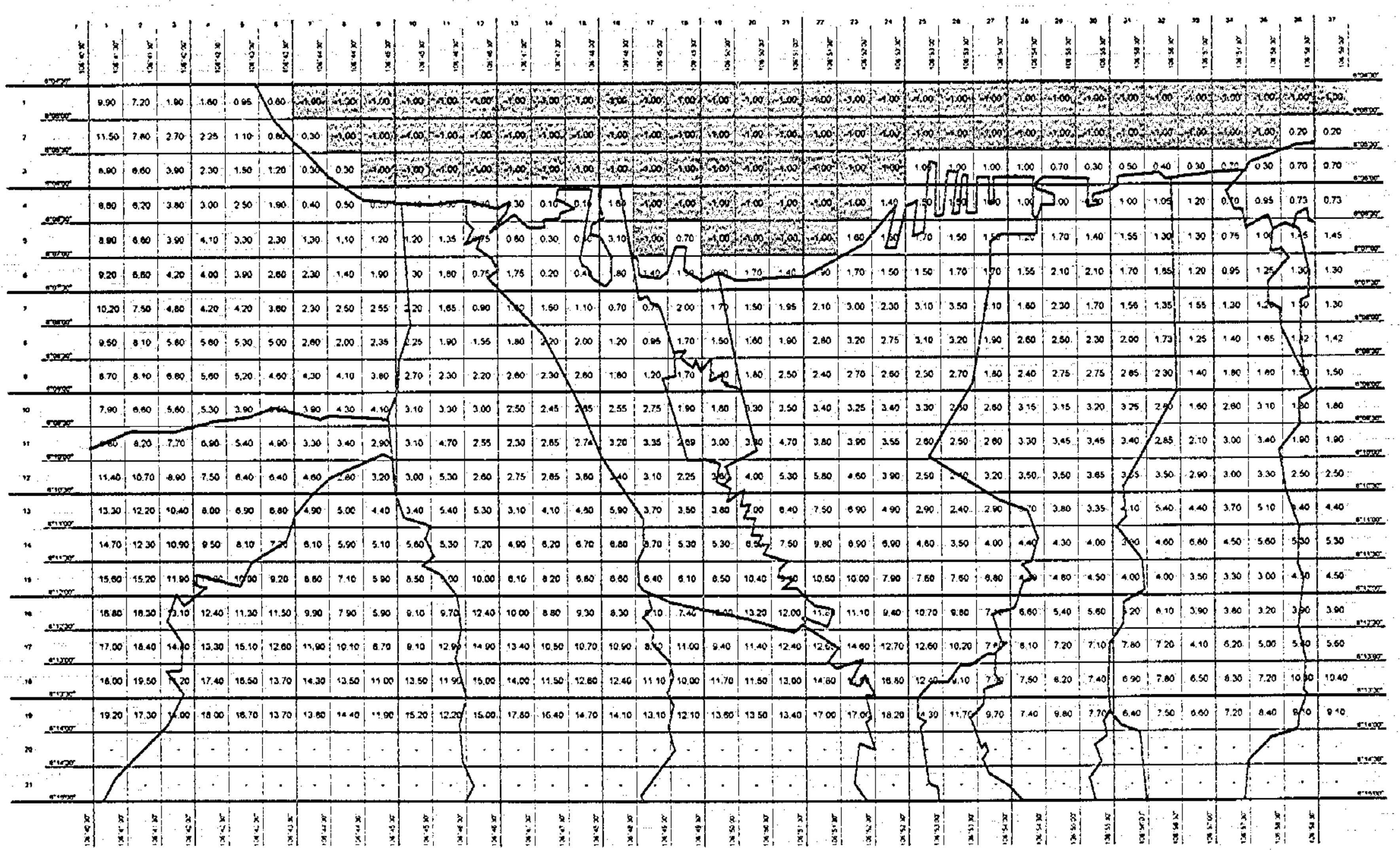

Figure 11.2 AVERAGE GROUND ELEVATION OF EACH MESH BLOCK

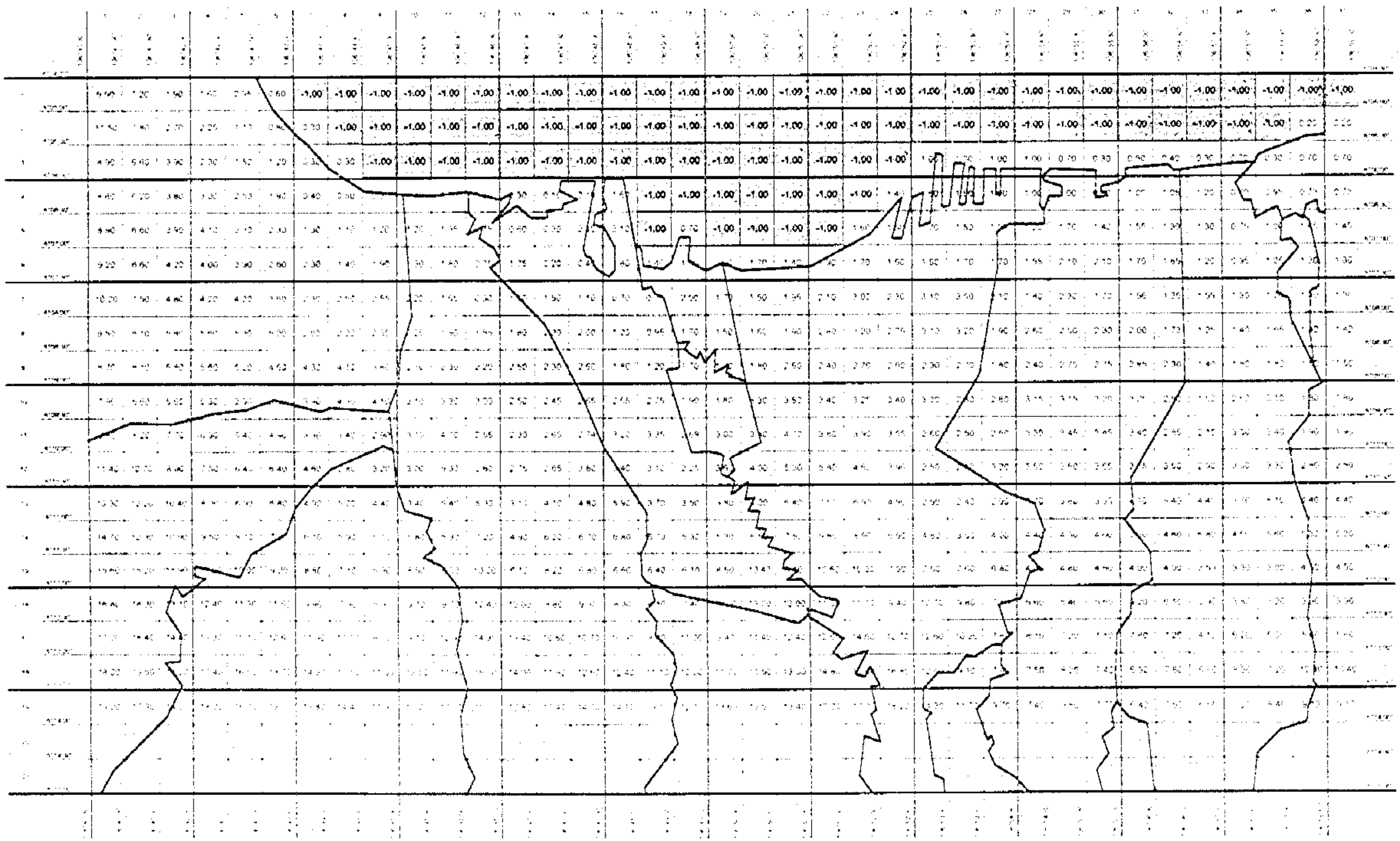

Figure 11.2 AVERAGE GROUND ELEVATION OF EACH MESH BLOCK

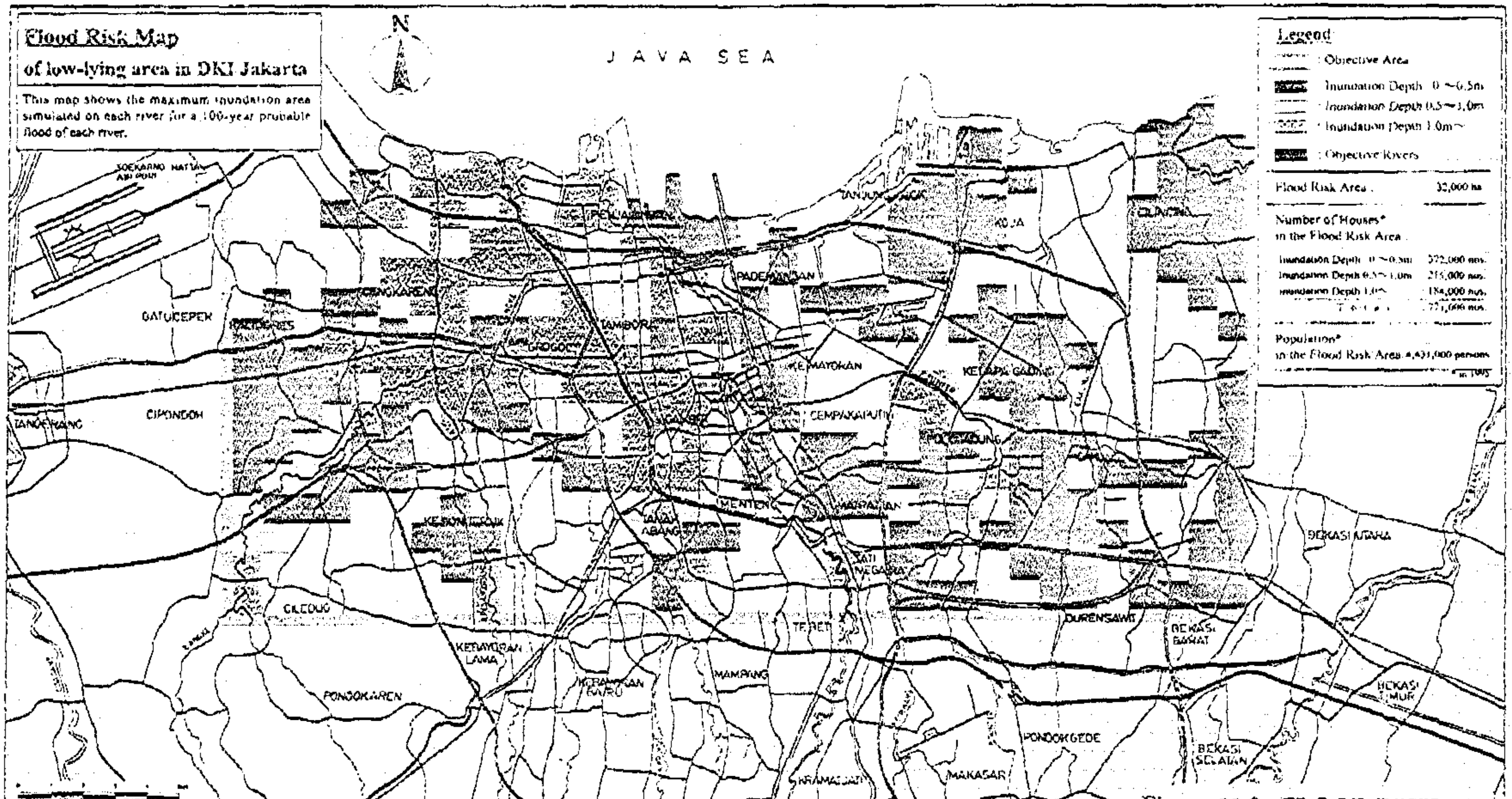

Figure 11.3 FLOOD RISK MAP

THE STUDY ON COMPREHENSIVE RIVER WATER MANAGEMENT PLAN IN JABOTABEK JAPAN INTERNATIONAL COOPERATION AGENCY

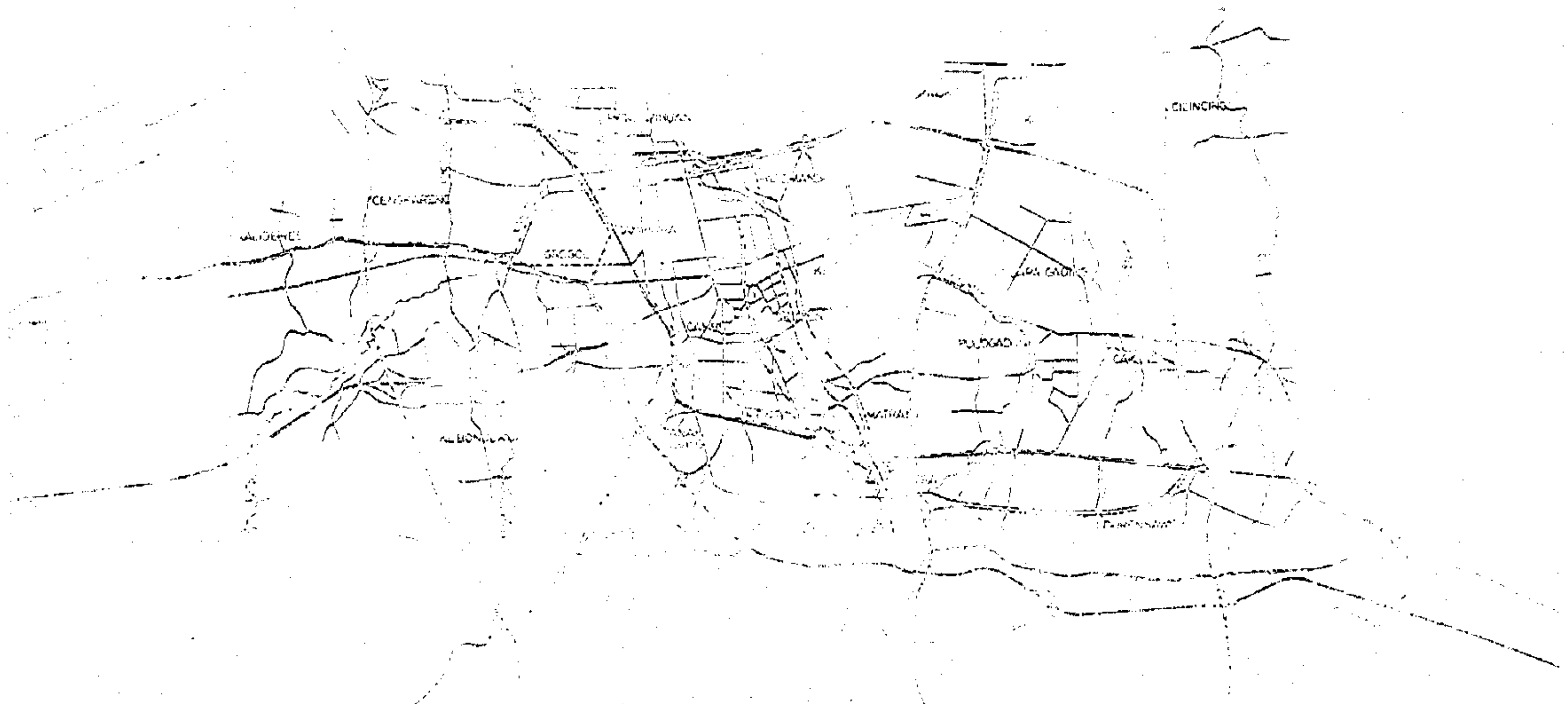

Figure II.3 FLOOD RISK MAP

ANNEX 6

FLOOD CONTROL

THE STUDY
ON
COMPREHENSIVE RIVER WATER MANAGEMENT PLAN
IN
JABOTABEK

ANNEX 6 : FLOOD CONTROL

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1 GENERAL

This ANNEX 6 (Flood Control) compiles the basic data, concepts, calculations, and detailed study results to establish the Flood Control Master Plan in the Study Area (6,070 km^2) and the detailed study results to conduct the Feasibility Study for the selected priority projects.

The contents of the report are as follows:

- Chapter 2 describes previous studies and plans related to flood control so far collected in the present study;
- Chapter 3 describes present situations of the Study Area with respect to watersheds, river system, flooding condition and carrying capacities of river channels;
- Chapter 4 compiles the study results for the formulation of the Flood Control Master Plan and for the selection of priority projects for the Feasibility Study;
- Chapter 5 describes the study result to conduct the Feasibility Study for the selected priority projects as Urgent Flood Control Project (1st Stage Project); and
- Chapter 6 describes the recommendations for flood control.

2 PREVIOUS STUDIES AND PLANS

2.1 General

Flooding and drainage problem have been big problems for a long time in the city of Jakarta, since basically the city of Jakarta at that time was located mainly on flood plains of rivers that geologically had been formed by flooding of rivers. The present Jakarta city has developed onto the diluvial terrace in its southern part.

On the other hand, the city of Bogor has been located along far upstream reaches of rivers where the rivers form very deep valley in hilly or mountainous areas where basically no flooding and drainage problem occurred.

Cities of Tangerang and Bekasi have been located just on the upstream side of flood plains of rivers. Accordingly the situation had been nearly the same with that of Bogor. But the agricultural land has been developed in the flood plains of rivers in Kabupatens of Tangerang and Bekasi where flooding and drainage problem could occur.

With these situations, the effort of flood control and drainage in Jabotabek area has been rather concentrated in the city of Jakarta. Previous studies and plans related to flood control and drainage are, consequently, mostly related to Jakarta, even though the situations is changing due to the expansion of urbanization from Jakarta area to flood plain areas of Kabupatens of Tangerang and Bekasi.

Table 2.1 shows the reports related to flood control and drainage in Jabotabek area so far collected in the present Study. Among these, major studies and projects related to flood control are briefly described in the following sub section.

2.2 Studies and Projects

(1) Western Banjir Canal

Western Banjir Canal was constructed in 1920 as a floodway to divert flood of the Ciliwung river from Manggarai to Muara Angke along the western border of the Jakarta city at that time. The floodway also aimed to collect floods of the Krukut, Cideng and other small rivers to protect an area of 2,500 ha. The Ciliwung and other rivers were flowing through the center or western part of Jakarta and were causing flooding problems so often.

(2) Pumping Stations and Interceptor Canal of Pesanggrahan River

In 1965, a special task force of the Central Government was established in the Department of Public Works and Electric Power by Presidential Decree to assist the Municipality of Jakarta. The main tasks were to free the capital city of Indonesia from inundation (short-term program), and to prepare a drainage system for Greater Jakarta within a framework of the development plan for the city (long-term program).

After review of the then situation, pumping stations of Pluit, Setiabudi, Melati, and Tomang Barat with retarding reservoirs, and Interceptor Canal of the Pesanggrahan river (Grogol Pesanggrahan Interceptor) were constructed together with the improvement bridges which formed bottlenecks of the river channels, in 1973.

(3) Master Plan for Drainage and Flood Control of Jakarta

During the period of 1972 to 1973, study on Master Plan for Drainage and Flood Control of Jakarta was conducted under the technical assistance of the Netherlands. The study was completed in 1973.

The conclusion of the study on flood control was as follows:

- Flood control for greater Jakarta should be basically achieved by construction of two floodways enclosing a large part of the city and collecting floods of rivers coming down from the hills to divert them around the low-lying city towards the Java Sea.

- The Western Banjir Canal was constructed in the same concept in 1920. But the Canal should be extended where it turns to the north at the Karet barrage, further to the west to join the Angke river near Pesing, in order to encompass a lager part of the low-lying extensions of the city on that side. The suburb of Cengkareng, furthest to the west along the coast at that time, was not encompassed. The floodway should collect the floods of Ciliwung, Cideng, Krukut, Grogol, Sekretaris, Pesanggrahan, and Angke rivers to protect the area of 7,500 ha from the flood of 100-year return period. Widening, training, and embankment construction at the reaches of the Angke river would be needed.

- A new eastern floodway is to start at the Cipinang river to encircle the new extensions and important industrial developments to the east of the city. The floodway should collect floods of Cipinang, Sunter, Buaran, Jatikramat, Cakung rivers and protect the area of 16,500 ha from the flood of 100-year return period.

The proposed alignment of the two floodways are shown in Figure 2.1.

(4) West Jakarta Flood Control System Project

Based on the above-mentioned Master Plan, the West Jakarta Flood Control System Project was formulated to improve the flooding situation of a western part of Jakarta. In 1978, in preparation for the implementation of the Western Banjir Canal extension which was proposed in the above-mentioned Master Plan, an inventory survey was made on the people living along the proposed extension alignment of Western Banjir Canal, and on the cost of land acquisition and compensation. Then it was found that these costs had become prohibitive while the resettlement of the people would be a very complex problem. The Government of Indonesia, then, decided to postpone the implementation of the project and to look for an alternative solution.

The Government of Indonesia, through the West Jakarta Flood control System Project, finally decided the plan that should be an alternative for the extension of the Western Banjir Canal presented in the above-mentioned Master Plan, to protect Western Jakarta against floods.

The plan basically consisted of construction of Cengkareng Floodway, construction of Sodetan Grogol-Sekretaris Interceptor, and Sarinah Thamrin Drainage Pumping station (improvement of drainage of Menteng-Sarinah and Melati area).

(5) Cisadane - Jakarta - Cibeet Water Resources Development Plan

Under the mentioned plan study, flood protection study was conducted as an additional scope of work in 1980. The purpose of this additional study was to assess, at a preliminary level, the feasibility of flood damping reservoirs in the upstream basin of Jakarta as an alternative to the Western and Eastern Banjir Canals to decrease the cost of land acquisition.

The proposed flood control structures in the study were Ciliwung dam near Depok, Angke control, Pesanggrahan dam near Ciputat, and Sunter dam near Pondok Gede. Among those Ciliwung dam near Depok proceeded to detailed design in 1986.

(6) Cengkareng Drain System Study

In the period of 1979 to 1981, study on Cengkareng Drain System was conducted under the technical assistance of the Netherlands. The objectives of the study were to review and further elaborate the proposed plans and to design additional drainage works.

The Cengkareng Floodway was designed for a discharge of 100-year return period. The Sodetan Grogol-Sekretaris Interceptor was designed for a discharge of 25-year return period. The Sarinah Thamrin Drainage pumping station (it was called Siantar Pumping station at that time.) was also designed for a discharge of 25-year return period. The locations and the design discharge distributions are shown in Figures 2.2 and 2.3 respectively.

The construction of Cengkareng Floodway was commenced in 1981 by Rupiah finance and completed in 1983.

(7) Cikarang-Bekasi-Laut (CBL) Floodway

This Cikarang-Bekasi-Laut floodway is called CBL Floodway. This was constructed in 1982 to 1985 as Jatiluhur Irrigation Extension Project. The objective of this floodway was to protect the irrigated area of about 2,200 ha in the downstream basins of the Cikarang, Kali Bekasi and other small rivers, The design discharges of this floodway were determined for the return period of 50-years. The design discharge distribution is shown in Figure 2.4.

(8) West Jakarta Flood Control System Project (I)

The project constructed the above-mentioned Sarinah Thamrin Drainage pumping station. The construction started in 1987 and completed in 1991.

(9) West Jakarta Flood Control System Project (II)

The project constructed the above-mentioned Grogol Sekretaris Interceptor. The construction started in 1988 and completed in 1992.

(10) West Jakarta Flood Control System Project (III)

The objectives of the study were to review the detailed design of flood control works of the Lower Angke, Upper Angke, and Upper Grogol river systems to protect the basins of those rivers which were urbanized since then and were remaining area behind the West Jakarta Flood Control System Project (I & II).

The Upper Angke river system here consisted of the Pesanggrahan, Sepak and Upper Angke rivers in the reaches from the Cengkareng Floodway to the crossing points of the toll road between Jakarta and Merak. The Lower Angke river system here consisted of the Angke river in the reaches from the Western Banjir Canal to the Grogol-Sekretaris Interceptor. The Upper Grogol river system here consisted of the Grogol river in the reaches from Jl. Palmerah Barat to Grogol Pesanggrahan Interceptor.

The study was completed in 1990. The construction works of this project have not been started yet.

(11) East Jakarta Flood Control Project

In line with the Master Plan formulated in 1973, the Government of Indonesia proceeded to the flood control in the eastern part of Jakarta in 1987. The project was at first divided into the following 4 stages:

- stage 1: Eastern Banjir Canal, Buaran river
- stage 2: Cipinang river, Sunter river
- stage 3: Eastern Banjir Canal, Cipinang river, Cakung river, Cakung Floodway, Marunda canal
- stage 4: Eastern Banjir Canal, Sunter river, Buaran river, Jatikramat river, Cakung river Petukangan canal

And the detailed designs of the stages 1 and 2 were completed in 1989 and those of stages 3 and 4 were completed in 1990.

But due to the constriction of necessary budget for land acquisition for Eastern Banjir Canal, the Government of Indonesia decided to start the project with the construction works of the Sunter river as the stage I of the project. The project consists of the improvement works of the downstream reaches of the Sunter river assuming that Eastern Banjir Canal would be constructed in future. The project is now on-going. The coverage of the project and the design discharge distribution are shown in Figures 2.5 and 2.6 respectively.

3 RESENT SITUATION

3.1 Topography

The Study Area, that extends to the city of Jakarta and its surrounding areas, is situated on the plain formed by numerous rivers. These rivers originate in southern mountains and flow into the Java Sea which composes the northern boundary of the area. General contour lines in the Study Area are shown in Figure 3.1.

Geomorphologically, the Study Area is divided into four zones:

Mountainous Area

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

Hilly Area

The hilly area between the contour lines of 150 m and 6 m; this area 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; the depth of valley generally correspond to the scale of river.

Valley Plain Area

The valley plain area along the river course in hilly area; this 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.

Coastal Plain Area

The alluvial coastal plain below the 6 m contour line; in this area, which in general is very flat and swampy, the rivers are much less clearly defined and often have shifted their courses; natural levees have been distributed along the river course, on which partial embankments have been constructed; 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. The coastline has moved northwards in historic times due to sedimentation. The width of this coastal plain ranges from 6 to 20 km.

3.2 Watersheds

The watershed division and the measurement of catchment areas of river basins have been carried out by using mainly latest 1:25,000 topographical maps with contour lines of 12.5 m intervals, published in 1990. In the western area such as the Cidurian and Cimanceuri river basins, no 1:25,000 map is available at present. Therefore, the watershed division has been carried out by using 1:50,000 topographical maps with contour lines of 25 m intervals, compiled in 1965 by US Army Map Service on the basis of the maps prepared in 1943/1944. The principal watershed lines are shown in Figure 3.2.

The Study Area, which has an area of 6,070 km^2 in total, is bounded on the south by the watershed line of the mountains south of Bogor, on the north by the Java Sea, on the east by the watershed between the Cilemahabang and Citarum rivers, and on the west by the watershed between the Cidurian and Ciujung rivers.

3.3 Flood Control and Urban Drainage in DKI Jakarta

On September 1, 1994, DGWRD and DKI Jakarta have concluded an agreement on the flood control and urban drainage in DKI Jakarta area. According to the agreement, the main rivers originate in mountainous or hilly areas and related facilities are under the control of DGWRD. Meanwhile, the urban drainage channels which collect local rainfall in the city and related facilities are under the control of DKI Jakarta. The classification of rivers in DKI Jakarta based on the agreement is shown in Figure 3.3.

In this ANNEX 6, the following description covers the rivers operated by DGWRD. The present situation on the urban drainage channels in DKI Jakarta is mentioned in ANNEX 7 (Urban Flooding and Drainage).

In the case of the rivers such as the Cipinang, Sunter, Buaran and Cakung rivers, the river reaches downstream of the proposed Eastern Banjir Canal (EBC) will not receive floods from the upper catchment of the EBC but collect only local rainfall in the urban area. The downstream reaches of these rivers will be treated as urban drainage channels.

3.4 River Systems

Investigation of the topographical maps, previous studies and field reconnaissance have identified the present river systems in the Study Area as schematically shown in Figure 3.4.

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 (refer to Table 3.1):

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)

3.5 Classification of Rivers by Topography

From topography, the rivers are classified into 3 categories; mountainous, hilly and plain rivers:

Mountainous River

The rivers which have mountainous area with elevation above 500 m in upper reaches. The Cidurian, Cimanceuri, Cisadane, Ciliwung and Bekasi rivers are classified into this category.

Hilly River

The rivers which have no mountainous area in upper reaches; originate in hilly area with elevation from 50 m to 300 m. The Cirarab, Angke, Pesanggrahan, Krukut, Sunter, Cisadang, Cikarang rivers, etc. are classified into this category.

Plain River

The rivers in the alluvial plain are classified into this category. The Cengkareng Floodway, Western Banjir Canal, CBL Floodway, Mookervaart canal and Cilemahabang river come under this classification.

General longitudinal profiles of main rivers obtained from 1:25,000/1:50,000 topographical maps are shown in Figure 3.5.

3.6 Characteristics of Rivers and Floodways

Principal dimensions of rivers are tabulated in Table 3.2. Characteristics of each river are mentioned below:

3.6.1 Cidurian River

The Cidurian river is located in the westernmost of the Study Area. The Cidurian river originates in Mt. Kendeng (1,764 m) and flows into the Java Sea; the Cibeureum river, the main tributary, joins the main stream at the upstream of crossing point with the toll road from DKI Jakarta to Merak. The Cidurian river has a catchment area of 803 km^2 and a length of about 130 km at the river mouth. A floodway of about 5 km length was constructed in the early years in this century from Desa Kedaung to the sea; the former river course was abandoned.

In the upper and middle reaches, the Cidurian river has formed deeply dissected valley. On the other hand, it flows through alluvial coastal plain in the lower reaches; natural levees have been distributed along the river course, on which partial embankments have been constructed.

Overall river improvement works have not been carried out yet; only local portion works such as partial embankment for irrigation area, rehabilitation of the embankment, protection works have been executed. On the right bank at Desa Kandawati, a dike breach portion has remained without rehabilitation.

The coastal floodplain has been utilized for agricultural land mainly composed of paddy field.

3.6.2 Cimanceuri River

The Cimanceuri river originates in the low mountains with an elevation of approximately 600 m and flows into the Java Sea; the Cimatuk and Cipaseun rivers, the tributaries, join the main stream at the upstream of crossing point with the toll road from DKI Jakarta to Merak. The Cimanceuri river has a catchment area of 570 km^2 and a length of about 102 km at the river mouth.

In the upper and middle reaches, the Cimanceuri river has formed dissected valley. On the other hand, it flows through alluvial coastal plain in the lower reaches; natural levees have been distributed along the river course, on which partial embankments have been constructed. On the left bank at Desa Cirumpak and right bank at Desa Rancalabuh, dike breach portions have remained without rehabilitation.

The coastal floodplain has been utilized for agricultural land mainly composed of paddy field. In the middle reaches in and around Tigaraksa, large scale urban developments are now in progress.

3.6.3 Cirarab River

The Cirarab river originates in the hilly area with an elevation of only 60 m and flows into the Java Sea. The Cirarab river has a catchment area of 161 km^2 and a length of about 49 km at the river mouth.

In the upper and middle reaches, the Cirarab river has formed shallow dissected valley, whereas in the lower reaches, it flows through alluvial coastal plain. The coastal floodplain has been utilized for agricultural land mainly composed of paddy field.

3.6.4 Cisadane River

The Cisadane river is the largest river in the Study Area, which originates on the northern side slope crowned by Mt. Kendeng (1,764 m), Mt. Perbakti (1,699 m) and Mt. Salak (2,211 m). The river flows through the city of Tangerang and flows into the Java Sea; main tributaries like the Cisindangbarang, Ciampea, Cianten and Cikaniki rivers join the main stream in the upper reaches near Parungbadak. The river basin involves vast mountainous area in the upper catchment, more than half of the basin. The Cisadane river has a catchment area of 1,411 km^2 and a length of about 138 km at the river mouth.

In the upper and middle reaches, the Cisadane river has formed extremely deeply dissected valley. On the other hand, it flows through alluvial coastal plain in the lower reaches; natural levees have been distributed along the river course, on which partial embankments have been constructed.

The fluvial terrace with elevation above 12.5 m has been utilized for the city of Tangerang, and the coastal floodplain has been utilized for agricultural land mainly composed of paddy field and for Sukarno-Hatta airport. In the middle reaches, large scale urbanization, like Modern Land, Lippo Village , Bumi Serpong Damai and others, are extending from Kodya Tangerang southward to Kec. Serpong.

Overall river improvement works have not been carried out yet; only local portion works such as partial embankment for irrigation area, rehabilitation of embankments and protection works have been executed.

The Pasar Baru barrage, which was constructed in 1937 for irrigation and has a width of about 120 m, is always damming up the water level of the Cisadane river by about 10 m. As a result, in the city of Tangerang, upstream of the barrage, water level of the Cisadane river is considerably high.

According to Provincial Department Office of Public Works Tangerang, the condition of the barrage is as follows: the barrage has 10 gates; among those 5 gates can be completely operated, 2 gates can not be operated and 3 gates give only half play to its original function for the reason of maintenance problem. In flooding period, it is feared that the barrage may prevent flood water from flowing down smoothly, consequently may cause inundation in the city of Tangerang.

3.6.5 Cengkareng Floodway System

The Cengkareng Floodway System consists of the floodway, Mookervaart canal, Angke, Pesanggrahan, and Grogol rivers; the canal and rivers should be treated as tributaries of the Cengkareng Floodway. The Cengkareng Floodway System has a catchment area of 459 km^2.

(1) Cengkareng Floodway

In 1983, the Cengkareng Floodway was completed to divert flood of the Mookervaart canal, Angke, Pesanggrahan and Grogol rivers. This floodway, the Grogol Sekretaris Interceptor and Sarinah Thamrin pump station (present Cideng pump station) consist of the alternatives for abandoned extension of the Western Banjir Canal proposed by "Masterplan for Drainage and Flood Control of Jakarta" (NEDECO, 1973). The length of the floodway is about 7.9 km. The Cengkareng barrage for flushing purpose is located downstream of the confluence of the Mookervaart canal.

(2) Mookervaart Canal

In 1920, the Mookervaart canal was constructed for the purpose of navigation and irrigation. However, the canal functions only as a drainage channel at present; the canal is under the control of DGWRD. The canal starts at the sewan gate connecting the Cisadane river in Tangerang; flows eastwards and meets the Cengkareng Floodway. The canal crosses at right angles the Cengkareng Floodway and finally joins the Lower Angke river, however, there is a flushing gate at the confluence with the floodway, east side from the floodway is now treated as an urban drainage channel under the control of DKI Jakarta.

The canal has a catchment area of 67 km^2 at the confluence with the Cengkareng Floodway and a length of about 13 km from the sewan gate to the floodway.

(3) Angke, Pesanggrahan and Grogol Rivers

The Angke and Pesanggrahan rivers originate in the hilly area north of the city of Bogor with an elevation of approximately 225 m and 175m respectively, and join the Cengkareng Floodway. Those rivers have catchment areas of 255 km^2 (including the Sepak river basin) and 107 km^2 and a length of about 82 km and 66 km at the confluence with the Cengkareng Floodway respectively.

The Angke river is divided into 2 parts by the Cengkareng Floodway, namely the Upper and Lower Angke rivers. The upper Angke river, upstream reaches of the floodway, is treated as a river under the control of DGWRD; the Lower Angke river, downstream reaches of the floodway, is treated as an urban drainage channel under the control of DKI Jakarta.

In the upper and middle reaches, the Angke and Pesanggrahan rivers have formed dissected valley; these rivers flows through alluvial coastal plain in the lower reaches. The river courses extremely meander.

The coastal floodplains have been mainly utilized for residential area. The upper and middle reaches will be completely urbanized in the near future.

The Grogol river originates in the hilly area, the suburbs of DKI Jakarta, with an elevation of approximately 100 m. The river has a catchment area of 30 km^2 and a length of about 21 km at the bifurcation of the Grogol Pesanggrahan Interceptor.

In 1973, the Grogol Pesanggrahan Interceptor was constructed to divert flood water of the Grogol river to the Pesanggrahan river. Therefore, the Grogol river is divided into 2 parts; upstream reaches of the interceptor as a river under the control of DGWRD, and downstream reaches of the interceptor as a urban drainage channel under the control of DKI Jakarta.

3.6.6 Western Banjir Canal System

The Western Banjir Canal (WBC) System consists of the present Banjir Canal (Western Banjir Canal), the Ciliwung and Krukut rivers; it has a catchment area of 421 km^2 at the confluence of the Krukut river.

(1) Western Banjir Canal

Flood control and drainage in the city of Jakarta have been a problem from the beginning. In 1918, the present Banjir Canal was constructed, starting at Manggarai on the Ciliwung river, and connecting lower reaches of the Angke river (Muara Angke river), encompassing the city of Jakarta at that time. The purpose of this construction was to collect the floods of the rivers coming down from the mountainous or hilly areas such as the Ciliwung and Krukut rivers and to divert them around the low-lying city towards the Java Sea.

The length of the canal is about 17 km. The Cideng drain under joins the WBC at Setiabudi with gravity drainage. The Grogol drain goes under the WBC through siphon. The Angke drain (Lower Angke river) joins the WBC at Pluit with gravity drainage. These drains are all under the control of DKI Jakarta. The lowest reaches of the WBC extremely meander leaving original alignment of former Angke river. The Manggarai and Karet barrages for mainly flushing purpose are located on the WBC.

(2) Ciliwung River

The Ciliwung river originates on the northern side slope of Mt. Pangrango (3,019 m); it flows through the city of Bogor; it is diverted to the WBC at the Manggarai barrage. The Ciliwung river has a catchment area of 337 km^2 and a length of about 109 km at Manggarai. In the upper reaches of Manggarai, the Ciliwung river has formed deeply dissected gorge and has almost no floodplain excluding near Manggarai. Downstream reaches of the diversion point with the WBC, the river is treated as an urban drainage channel under the control of DKI Jakarta.

(3) Krukut River

The Krukut river originates in the hilly area, the suburbs of DKI Jakarta, with an elevation of about 100 m and joins the WBC at the upstream of the Karet barrage on the WBC. It has a catchment area of 84 km^2 and a length of about 34 km at the confluence with the WBC. In the upper reaches of the confluence with the WBC, the Krukut river has formed dissected valley and has almost no floodplain. Downstream reaches of the WBC, the river is treated as an urban drainage channel under the control of DKI Jakarta. Upper and middle reaches will be completely urbanized in the near future.

3.6.7 Eastern Banjir Canal System

The construction of the Eastern Banjir Canal (EBC) was proposed by "Masterplan for Drainage and Flood Control of Jakarta" (NEDECO, 1973). The purpose of this plan is to collect the floods of the rivers coming down from the hilly areas such as the Cipinang, Sunter, Buaran, Jatikramat and Cakung rivers and to divert them around the low-lying city towards the Java Sea. At that time, the alignment of the proposed EBC was determined by long-range expectations concerning the extension of the city eastwards. However, the construction of EBC has not been carried out yet due to budgetary limitation for land acquisition.

Proposed Eastern Banjir Canal System consists of the proposed EBC, and those rivers mentioned above, which will be treated as tributaries of the proposed EBC.

Those rivers originate in the hilly area, the suburbs of DKI Jakarta, with elevation from 30 to 120 m and are planned to join the proposed EBC. The catchment areas of those rivers upstream of the proposed EBC are ranging from 13 km^2 to 73 km2; total catchment area of the system is 207 km^2.

In the upper reaches of the proposed EBC, those rivers have formed shallow dissected valley and have almost no floodplain. Upper and middle basins of those rivers will be completely urbanized in the near future. Those rivers go under the West Tarum Canal through siphon.

In the lower reaches of the proposed EBC, those rivers will not receive floods from the upper catchment of the EBC but collect only local rainfall in the urban area. The downstream reaches of the rivers will be treated as urban drainage channels.

3.6.8 CBL Floodway System

The CBL Floodway System consists of the CBL Floodway, and the Bekasi, Cisadang, Cikarang and Cilemahabang rivers which should be treated as tributaries of the floodway.

(1) CBL Floodway

In 1985, the CBL Floodway (Cikarang-Bekasi-Laut Floodway) was constructed by Jatiluhur Irrigation Extension Project to divert flood of the Bekasi, Cisadang, and Cikarang rivers. The floodway has a catchment area of 915 km^2 and a length of about 29 km. Incidentally, the floodway was used to be called T.B.S Floodway (Tjikarang-Bekasi-Sea Floodway).

(2) Bekasi River

The Cikeas and Cileungsi rivers originate in the mountains with an elevation of about 1500 m. Those 2 rivers join each other in the south of Bekasi city. The downstream of the confluence, the river name becomes the Bekasi river. The Bekasi river flows through the city of Bekasi and joins CBL floodway. The Bekasi river, downstream of the floodway, has been abandoned and the former river course has partly been utilized as agricultural area.

The Bekasi river has a catchment area of 403 km^2 and a length of about 116 km at the confluence with the CBL Floodway.

In the upper and middle reaches, the Bekasi river has formed dissected valley. On the other hand, it flows through alluvial coastal plain in the lower reaches; natural levees have been distributed along the river course, on which partial embankments have been constructed.

The fluvial terrace with elevation above 12.5 m has been utilized for the city of Bekasi ,on which urban developments are now extending. The coastal floodplain has been utilized for agricultural land mainly composed of paddy field.

Overall river improvement works have not been carried out yet; only local portion works such as rehabilitation of embankments and protection works have been executed.

The Bekasi barrage, which was constructed in 1958, is always damming up the water level of the Bekasi river by about 8 m, to convey the water of West Tarum Canal from east to west. Therefore, in the city of Bekasi, upstream of the barrage, water level of the Bekasi river is considerably high. According to the Perum Otorita Jatiluhur office, the gates are kept closed even in flooding time. It is supposed that the gate closure in flood time may be one of the causes of inundation in upstream area of the barrage.

(3) Cisadang River

The Cisadang river originates in the hilly area with elevation of about 90 m and joins the CBL Floodway. As a result of construction of the floodway, the downstream reaches of the floodway remains only as a local drainage channel. The Cisadang river has a catchment area of 135 km^2 and a length of about 37 km at the confluence with the floodway.

The Cisadang river and its tributary go under the West Tarum Canal through culverts. Some portion of culverts has now been clogged by sedimentation. The vast, swampy area located just downstream of the Canal, which was suitable for retarding basin, was already reclaimed for factory construction.

(4) Cikarang River

The Cikarang river originates in the hilly area with an elevation of about 300 m and is diverted to the CBL Floodway by the gate at the city of Cikarang. As a result of construction of the floodway, the Cikarang river, downstream of the floodway, has remained as a drainage channel which collects only local rainfall. The Cikarang river has a catchment area of 230 km^2 and a length of about 66 km at the bifurcation with the floodway.

In the upper reaches of the city of Cikarang, it has formed dissected valley. The fluvial terrace with an elevation above 12.5 m has been utilized for the city of Cikarang, and on which urban developments are now extending.

Overall river improvement works have not been carried out yet; only local portion works such as rehabilitation of embankments and protection works have been implemented.

The Cikarang barrage, which was constructed in 1965, is always damming up the water level of the Cikarang river by about 6 m, to convey the water of the West Tarum Canal from east to west. According to Perum Otorita Jatiluhur office in the city of Bekasi, the gates are kept closed even in flooding time. It is supposed that the gates closure in flood time may cause the inundation in upstream area of the barrage.

(5) Cilemahabang River

The Cilemahabang river is located in the easternmost of the Study Area. The Cilemahabang river originates in the low hilly area with an elevation of only 50 m. The river course near the river mouth is unclear; the main stream joins the Java Sea and a branch is diverted to the Cikarang river. The river course in the lower reaches are very small and accordingly it is difficult to distinguish the river from other drainage channels. The Cilemahabang river has a catchment area of 220 km² and a length of about 63 km at the river mouth.

3.7 Ponds and Reservoirs

There are 193 ponds and reservoirs, better known as Situ-situ in local name, in the Study Area. The areas of them range from 0.001 to 3.5 km²; the water depth of them is generally very shallow ranging about 1 to 2 m. Large Situ-situ are concentrated in Kab. Tangerang; Situ Patrasana (3.5 km²) and Situ Garugak (1.8 km²) are located near the Cidurian river, and Situ Cipondoh (1.2 km²) is located near the city of Tangerang. It is supposed that original area of Situ-situ were mostly widened by the embankment for irrigation purpose.

According to "Project Aid Proposal for Conservation Works of Situ-situ in the Jabotabek Area" (DGWRD, August 1994), total existing area of Situ-situ is 21.25 km²; it accounts for 0.35 % of total Study Area (6,070 km²). The areas of Situ-situ by districts are summarized as follows:

- DKI Jakarta (1.68 km²)
- Kab. Bogor (5.15 km²)
- Kab. Tangerang (13.06 km²)
- Kab. Bekasi (1.36 km²)

Total (21.25 km²)

Geomorphologically, Situ-situ are generally located in shallow valley plain which are less dissected than those along big rivers. Few Situ-situ are countable in alluvial coastal plain. Many small Situ-situ are located at the upper end of valley plains where probably ground water springs out.

Some of Situ-situ are filled with water only in rainy season; some of them have been integrated into irrigation system, equipped with gates for supplying water.

As is represented by Situ Cipondoh, large Situ-situ near the city of Tangerang, the pond area is a treasure house of wild plants and animals. However, the number and area of Situ-situ have remarkably decreased, especially in recent years, by land reclamation accompanied by urbanization.

3.8 Flooding Conditions

3.8.1 Flooding Condition in DKI Jakarta

Past flooding condition in Tangerang area is compiled as shown in Figure 3.6. Detailed condition is described in ANNEX 7 (Urban Flooding and Drainage).

3.8.2 Flooding Condition in Tangerang, Bekasi and Bogor Area

In the Study Area, the causes of flooding are classified into several kinds as follows:

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

Some flooding occurs not only by one cause but also by combination of plural causes mentioned above.

Outside of DKI Jakarta area, availability of past flooding records is limited compared with those in DKI Jakarta. Accordingly, field reconnaissance and interview survey in the field have been carried out carefully to supplement the information. It is especially important to distinguish the cause of flooding between overflow from the rivers and others. Because the former is the target flooding which should be mitigated by the Flood Control Master Plan. On the other hand, the latter should be treated as a local drainage problem.

(1) Flooding Condition in Tangerang Area

Past flooding condition in Tangerang area is compiled as shown in Figure 3.7, by using available past flood area maps prepared by PU Pengairan Tangerang and previous study reports, by supplementing the information through interview survey in the field. Concerning the Cidurian and Cisadane rivers, detailed study on past floodings has been carried out by "Cisadane River Basin Development Feasibility Study" (DGWRD, August 1986).

(a) Cidurian River

Flooding has occurred along the embanked reaches in coastal plain, downstream of the toll road from DKI Jakarta to Merak, due to mainly dike breach and overflow. Flooding in December 1981, February 1985 and December 1993 were the big floodings in these decades.

Dike breach occurred on the right bank in Desa Kandawati in 1981 flood. According to the previous report above mentioned, since 1982, the broken points have been improved twice by the government and then twice by the public. However, the embankment is keeping broken shape still now because of the subsequent repeated flood. Consequently, overflow from the broken point occurs almost every year. In 1993 flood, an army was sent out to rescue the inhabitants in Kec. Kresek.

Flooding also occurred due to operation and maintenance of irrigation facilities such as intake weir, gate and irrigation canal.

(b) Cimanceuri River

Flooding in December 1981 were the big floodings in these decades. Flooding has occurred along the embanked reaches in coastal plain due to mainly dike breach and overflow. Dike breaches have occurred at Desa Rancalabuh on the right bank and Desa Cirumpak on the left bank. The embankments are left without rehabilitation works still now. Consequently, overflow from those broken points occur almost every year and flood water flows down to the villages located downstream.

In Kota Tigaraksa upstream of the toll road from DKI Jakarta to Merak, flooding has also occurred in the dissected narrow valley plain.

(c) Cisadane River

Flooding has occurred along the embanked reaches in coastal plain, downstream of the toll road from DKI Jakarta to Merak, and the city of Tangerang mainly by dike breach and overflow. Flooding in December 1981 and February 1985 were the big floodings in these decades. The dike breach occurred at Desa Kedaung Wetan in 1981 and 1985 repeatedly.

The Cisadane river has overflowed in the city of Tangerang in 1981 and 1985. One of the reasons of flooding is supposed to be prolonging backwater effect of the Pasar Baru barrage located downstream; dam up of water level reaches by about 10 m. Judging from the maintenance condition at present, it is supposed that the gates could not be operated appropriately in flooding time.

(2) Flooding Condition in Bekasi Area

Information about the past floodings in Bekasi area is limited compared with those in Tangerang area. Past flooding condition in Bekasi area is compiled as shown in Figure 3.8, by using available past flood area maps prepared by Perum Otorita Jatiluhur and by supplementing the information through interview survey in the field.

In the downstream areas of the Bekasi, Cisadang and Cikarang rivers, PROSIJAT irrigation area, the flooding is remarkably decreased by the CBL Floodway constructed in 1985. It is said that 70 % of habitual inundation in the downstream areas is relieved from flooding at present, but remaining 30 % of the area has still been suffering from flooding. In this area, flooding is not caused by the overflow from the mainstream, but by the landside water inundation or the overflow of local drainage channels due to the insufficient capacities.

The Bekasi river has overflowed in the newly developed residential area, which is located in the downstream reaches of confluence of the Cikeas and Cileungsi rivers. In rainy season of 1993 and 1994, flooding occurred in this area; depth of inundation water reached about 1 m.

It is supposed that one of the reasons of flooding is prolonging backwater effect of the Bekasi barrage located downstream, because the gates are kept closed even in flooding time and the dam up of water level reaches up to about 8 m.

(3) Flooding Condition in Bogor Area

As a result of the review of previous studies as well as the interview survey in the field, it was confirmed that few floodings have occurred as shown in Figure 3.9.

The reasons above are that the Cisadane river flows along the west margin of the city of Bogor having deeply dissected valley; the Ciliwung river also flows through the center of the city forming dissected valley; whereas, the city of Bogor is located on the considerably high hilly area high above the rivers.

(4) Flooding Condition of Year 1995 - 1996 Flood

The records on flooding in the Study Area which occurred in the 1996 rainy season in rather big scale will be prepared in the succeeding stage.

3.9 Carrying Capacities of River Channels

Carrying capacities of the existing river channels are estimated by using the non-uniform flow formula based on the results of river survey conducted in the period of August to October 1995 by the Study Team. The conditions for the calculation are shown below.

Calculation method

The fundamental formula of non-uniform flow formula is given as follows.

$$H_i = H_{i-1} + \frac{\alpha Q^2}{2g}\left(\frac{1}{A_{i-1}^2} - \frac{1}{A_i^2}\right) + \frac{Q^2}{2}\left(\frac{n_{i-1}^2}{R_{i-1}^{4/3} \cdot A_{i-1}^2} + \frac{n_i^2}{R_i^{4/3} \cdot A_i^2}\right) \cdot \Delta X$$

where,

- H : Elevation of water level (m)
- g : Acceleration of gravity (m^3/sec^2)
- Q : Discharge (m^3/sec)
- A : Water area (m^2)
- ΔX: Distance between two cross-sections (m)
- n : Manning's coefficient of roughness
- R : Hydraulic radius (m)
- α : Correction coefficient for vertical distribution of velocity

Suffix denotes number of a cross-section, from downstream to upstream.

Tide level

Spring tide (H.H.W.) of PP +1.15 m (approximately TTG +0.55 m) is adopted for the lower-end water level.

Manning's roughness coefficient

n=0.030 : single cross section
n=0.035 : compound cross section

Freeboard

The freeboard is decided according to the design discharge for the Master Plan (See Chapter 4).

The estimated bankfull and freeboard capacities are shown in Table 3.3 and Figure 3.10. The carrying capacities in the Proposed Eastern Banjir Canal are quoted from the study result of "East Jakarta Flood Control Project".

4 FLOOD CONTROL MASTER PLAN

4.1 Basic Concepts of Plan Formulation

4.1.1 Planning Conditions

(1) Target Year

Flood Control Master Plan is formulated on the basis of the target year of 2025 which corresponds with the target year of "Jabotabek Water Resources Management Study (JWRMS)" assisted by World Bank.

(2) Objective Rivers

Objective rivers for the Flood Control Master Plan in Jabotabek, after the field reconnaissance for the present situation on flooding, land use, socio-economic activities, and estimate of future land use and socio-economic development in the future in the target year of 2025, have been selected on the following criteria :

- flooding is a serious problem for the regional socio-economy with the present socio-economic conditions and land use conditions in the river basin; and
- flooding will have a serious impact on the regional socio-economy with the future socio-economic conditions and land use conditions in the river basin.

The Flood Control Master Plan covers 8 river systems which consist of 23 main rivers in the Study Area (refer to Table 3.2).

In DKI Jakarta area, objective rivers for the Flood Control Master Plan are limited to the rivers which are under the control of DGWRD.

In case of the rivers such as the Cipinang, Sunter, Buaran, Jatikramat and Cakung rivers, the objective river reaches are the upstream reaches of the proposed EBC. The downstream reaches of the proposed EBC are treated as a urban drainage channel, since the downstream reaches will not receive floods from the upper catchment of the EBC, but collect only local rainfall in the urban area.

(3) Design Scale

The design scales of the Flood Control Master Plan are basically proposed in accordance with the criteria on design scale in "Flood Control Manual, Volume II Guidelines for Planning and Survey", which was prepared by DGWRD in collaboration with Canadian International Development Agency in 1993. (refer to Table 4.1)

To supplement the original criteria mentioned above, some additional criteria are proposed by the Study Team as shown in Table 4.2, taking into account characteristics of rivers in

Jabotabek area. The design scales proposed by the Study Team are shown in Table 4.2 and Figure 4.1. Design scales of other rivers in Indonesia are shown in Table 4.3 for reference.

The design scales of Western and proposed Eastern Banjir Canals, Cengkareng Floodway are set at a 100-year return period to protect the center of DKI Jakarta. The design scales of the Angke, Pesanggrahan and Ciliwung rivers which have relatively large catchment areas of over 100 km^2 and joins those floodways are also set at a 100-year return period taking into account of the previous design scale. The design scale of a 25-year return period is proposed for the rivers which also join those 3 floodways but have comparatively small catchment area of less than 100 km^2.

The design scales of the Cisadane and Bekasi rivers are set at a 50-year return period taking into account the importance of Tangerang and Bekasi city areas and those large-scale river basins. The design scale of a 50-year return period is also proposed for the CBL Floodway considering previous design scale. The rivers located far further in the Study Area are planned to be protected against a 25-year flood.

(4) Target Flooding Type

In principle, the Flood Control Master Plan is formulated to mitigate the flooding from the rivers caused by the rainfall in upper mountainous or hilly areas. Flooding of drainage channel, landside water and urban drainage problem caused by local rainfall are treated as the related part of the said flood control. However, as a matter of course, especially in DKI Jakarta area, special attention should be paid to coordination and integration of flood control and drainage.

4.1.2 Basic Planning

(1) Comprehensive Flood Control

The Study Area has been being urbanized very rapidly in recent years due to the rapid growth of the economy in the area. The situation is so serious in the view point of flood control that it no longer seems to be possible to expect the level of flood control to desired extent only by structural measures.

In order to keep the function of the said area as the mainstay of national socio-economy, it is necessary to introduce 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 measures other than the structural measures. The concept of comprehensive flood control is schematically shown in Figure 4.2.

In the formulation of the Flood Control Master Plan, this concept of comprehensive flood control is applied in due consideration of the area in the present and estimated future conditions.

(2) Zoning of Basin by Flood Control Function

Principally the Study Area is zoned by flood control function as shown in Figure 4.3.

(a) Water Retention Zone

The function of the area is the infiltration or detention of rain water in the area mainly as the area of headwaters. This function should be kept or increased from the viewpoint of flood control.

In the Study Area, geomorphologically, mountainous and hilly areas in the upper and middle reaches are zoned as water retention zone.

(b) Retarding Zone

The area is mainly located along rivers in the upper/middle reach and the function of the area is the retarding function of rain water and or river water. The function should be kept or increased from the viewpoint of flood control.

In the Study Area, geomorphologically, alluvial valley plain area along the river course in the middle and upper reaches is zoned as retarding zone.

(c) Low-lying Zone

The area is where rain water is detained, gravity drainage can not be expected, and or flood water of river may flow into. And the area is where it is necessary to protect from inundation.

In the Study Area, geomorphologically, alluvial coastal plain area in the lower reaches is zoned as low-lying zone.

(3) Objective Area and Stretches of Master Plan

In principle, the target area which should be protected from the flooding by structural measures is the low-lying coastal floodplain in the embanked downstream reaches.

The valley plain of hilly area in the middle reaches is not treated as the target area of flood control in due consideration that the rivers flow in deeply dissected valley. From the viewpoint of Comprehensive Flood Control, in the narrow valley plain along the middle reaches, it will be desired that the inundation should be left in the present situation as much as possible by flood plain zoning and land use regulation. The reasons are as follows:

- scale of river improvement in the lower reaches is mitigated by the storage function in the valley plain in hilly area as natural retarding basin ;
- the economic benefit of the river improvement in the valley plain area is limited because of its narrow flood plain.

The flood plain zoning area here is defined as the area where the river area is defined and the delineation is announced to the public, and the food risk map is prepared in future.

The area to be protected by structural measures and the area of flood plain zoning are shown in Table 4.4 and Figure 4.4.

(4) Basic Consideration by Areas

The Study Area is classified into 2 areas from the viewpoint of development progress as below:

- central river basins of such as the Cengkareng Floodway System, the Western Banjir Canal System and Proposed Eastern Banjir Canal System which flow through DKI Jakarta;
- western river basins of the Cidurian, Cirarab, Cimanceuri and Cisadane rivers, and eastern river basin of the CBL Floodway System.

The following consideration is given in the study on the Flood Control Master Plan of the above river basins respectively:

(a) Central River Basins

In this area, on account of the high urbanization, land acquisition has become so difficult that it is considered that part of the "Masterplan for Drainage and Flood Control of Jakarta" (NEDECO, 1973) may not be implemented without modification. But many flood control and drainage projects are existing or on-going in accordance with the existing Master Plan. Yet these projects should be introduced as much as possible depending on the present new situation in the area. In the planning, as a matter of fact, consideration is given to the issue of people's relocation.

It is supposed that the comprehensive flood control including non-structural measures is effective for the relatively big, hilly rivers in DKI Jakarta such as the Angke and Pesanggrahan rivers. Those rivers have no mountainous area in the upper basins, originate in hilly area and have densely populated low-lying area along the lower reaches in coastal plain. The upper river basins, where the area should function as runoff retention area, will be completely urbanized in the near future. In such a case, it may be difficult to cope with only by structural measures, on account of the big increase of flood discharge caused by the loss of flood retention function in upper basins and the difficulties of land acquisition in the lower reaches.

In this area, however, structural measures are inevitably required in due consideration of the following issues, even though non-structural measures should be introduced:

- seriousness of flooding;
- largeness of flood damage due to the accumulation of property accompanied by rapid

- growth of the economy;
- remarkable progress of urbanization in recent years; and
- difficulties and uncertainness of land use regulation.

Accordingly, the possibility of structural measures such as flood way or dam is also studied.

(b) Western and Eastern River Basins

Urbanization is intensively going on in the objective river basins, especially in the hilly middle reaches. Accordingly the mechanism of run-off in the basins has been changing. The Master Plan should be formulated in consideration of these changes in the basin and future program of rural development in the basin. Water retention function in the basin is considered as is planned in the Situ-situ project in each river basin.

In the lower reaches on coastal floodplain, it is estimated that the area will be mainly utilized as agricultural land even in 2025, the target year of the Master Plan. The land acquisition for river improvement is not expected so difficult as compared with that in urban area. Therefore, structural measures as well as non-structural measures are introduced.

(5) Basic Design Discharge

As discussed in previous chapters, the rivers in the Study Area are classified into 8 river systems (refer to Figure 4.1):

(1) Cidurian river system
(2) Cimanceuri river system
(3) Cirarab river system
(4) Cisadane river system
(5) Cengkareng Floodway system
(6) Western Banjir Canal system
(7) Proposed Eastern Banjir Canal system
(8) CBL Floodway system

Alternatives of flood control master plan are discussed below for those river systems.

The basic design discharges before regulation by flood control facilities are shown in Figure 4.5 (details of run-off analysis are described in ANNEX 5 (Hydrology)).

4.2 Comparison of Alternative Plans

4.2.1 General

The comparison of flood control alternative plans here discussed is focused on the structural measures. Non-structural measures are discussed in the sub-section 4.4.

Alternatives of flood control master plan have been prepared in consideration of previous studies and plans related to flood control in Jabotabek, the present situation of rivers, flooding, land use, socio-economic activities, and the future situation of those aspects in the target year of 2025.

Although the concept of comprehensive flood control, as discussed in the Inception Report, which aims at flood control not only by structural measures but also by non-structural measures, is introduced in this Study, structural measures for flood control are discussed here as alternatives of flood control master plan for Jabotabek. Non-structural measures will be discussed later.

The conceivable alternatives proposed and design discharge distributions of the alternatives are schematically shown in Figure 4.6. As shown in the figure, river systems which are given more than one alternative are the Cengkareng Floodway, Western Banjir Canal and Proposed Eastern Banjir Canal systems. Accordingly the comparison of alternatives of flood control schemes are discussed for these river systems. The study result on floodways and flood control dam are described in ANNEX 8 (Design and Cost Estimate).

For the river system which are given just one flood control scheme are the Cidurian, Cimanceuri, Cirarab, Cisadane, and CBL Floodway systems.

The financial project cost including the direct construction cost, land acquisition and house compensation cost for all the alternative plans are shown in Figure 4.9.

4.2.2 Methodology of River Planning

River plannings of the objective rivers are performed basically based on the results of river survey conducted in the period of August to October 1995 by the Study Team and the design discharges calculated by the Study Team.

(1) Calculation Method

Uniform flow calculation is applied for the river planning of Master Plan.

The fundamental formula of uniform flow formula is given as follows.

$$Q = \frac{1}{n} \cdot AR^{2/3} I^{1/2}$$

where,

- Q : Discharge (m^3/sec)
- n : Manning's Roughness coefficient
- A : Water area (m^2)
- R : Hydraulic radius (m)
- I : Gradient of river-bed

(2) Roughness Coefficient

Manning's roughness coefficients adopted for the planning are shown below.

Roughness Coefficient	Rivers
0.025 (low-water channel) 0.040 (high-water channel)	Floodways in DKI Jakarta (Cengkareng Floodway, Western Banjir Canal and Proposed Eastern Banjir Canal)
0.030 (low-water channel) 0.050 (high-water channel)	Rivers and floodway excluding above 3 floodways

(3) Datum

The elevation adopted for the planning is the elevation above the mean sea level (Titik Tinggi Geodesi = TTG). The datum of PP, NWP and Walahar Peil are converted into TTG in this study. The adopted datum in the previous studies in the Study Area are as follows:

- Master Plan for Drainage and Flood Control of Jakarta (NEDECO) : PP
- Cengkareng Drain System Study (NEDECO) : PP
- West Jakarta Flood Control System Project : PP
- East Jakarta Flood Control Project : PP
- Jatiluhur Irrigation Extension Project <CBL Floodway> : Walahar Peil

The elevation relation between these 4 datum is approximately as follows:

TTG +0.0 m = NWP -0.975 m = PP +0.6 m = Walahar Peil +0.415 m

It is quite difficult to estimated the correct relation between TTG and PP, since the basic stuff of PP has already been lost and there is no available correct data for the estimation nowadays.

4.2.3 Cidurian River System

(1) Present Situation

The river basin has a mountainous area in the upstream reaches. The present land use in the basin is almost agriculture. Upstream and middle reaches do not have flood embankment but the flooding stays in the narrow valley plain. Downstream reaches have flood embankment but do not have enough carrying capacities and breach of the flood embankment often occurs. And the breaches have been left as they are now for a few years. The Ciujung river, a big river, flows parallel on the west.

(2) Future Situation

The future land use in the basin is estimated basically as still agricultural land. In the upstream basin, Tanjung Dam is proposed as one of the water supply facilities to Jabotabek in

Jabotabek Water Resources Management Studies (JWRMS).

(3) Area and Stretches to be Protected

Accordingly the area to be protected is mainly agricultural land along the downstream embankment reaches from the estuary to the bridge on Jl. Serang Raya in Parigi.

The upstream reaches of the mainstream from Parigi is treated as river area to preserve flood retarding function. On the other hand, it is not necessary to set up river area along the valley plain of the Cibeureum river, the tributary of the Cidurian, since the area is estimated basically as still agricultural land in future.

(4) Conceivable Measures

Conceivable measures for this river are, in consideration of the above, river improvement, construction of flood control dam, and construction of floodway to the Ciujung river.

(5) Consideration

Possibility of Floodway

Floodway is not studied because no serious social problem exists in downstream reaches, and it just requires only additional land acquisition, and besides it discharges flood to outside of Jabotabek area.

Possibility of Flood Control Dam

Single purpose flood control dam is neither studied because it is too much costly compared with river improvement since the downstream reaches are in the agricultural land. Besides, heightening the Tanjung Dam for multipurpose reservoir is practically impossible topographically and geologically. The option of joint operation of the reservoir without heightening of dam is not appropriate in consideration of the present study result of JWRMS that the water balance between the demand and supply in Jabotabek would be very serious in future.

Conclusion

In consideration of the above and the present situation of land use in the downstream reaches, securing land for river improvement works is required now.

(6) Alternatives

Accordingly river improvement option is the only one and the best option for flood control of this river system. Rehabilitation work of existing embankment breach portion is required in early stage.

Near the estuary of about 5 km, the gradient of the river bed is very gentle (approximately I=1/6,000) compared with the upper reach, since this reach is a floodway constructed in the early years in this century. This reach is desired to be deepened as shown in Figure 4.11.

4.2.4 Cimanceuri River System

(1) Present Situation

The river basin does not have a high mountainous area in the upstream reaches. It has just hilly area in the upper basin. Accordingly there is no dam site appropriate. The upstream runoff basin is widely and rapidly urbanized as Tigaraksa New Town. Retarding area is also disappearing due to the urbanization or already bought up by developers. The downstream reaches have flood embankment but do not have enough carrying capacities and once the embankment was breached and flooding often occurs since then. The breaches have been left as they were then.

(2) Future Situation

The future land use in the downstream basin is estimated basically as still agricultural land.

(3) Area and Stretches to be Protected

Accordingly the area to be protected is mainly agricultural land along the downstream reaches from the estuary to the bridge on Jl. Serang Raya in Balaraja.

In the upstream reaches from Balaraja, the mainstream and the Cipaseun river which are flowing along Tigaraksa New Town are treated as river area to preserve flood retarding function.

(4) Conceivable Measures

Conceivable measures for this river are, in consideration of the above, only river improvement works.

(5) Alternatives

Accordingly river improvement option is the only one option for flood control of this river system. Rehabilitation work of existing embankment breach portion is required in early stage.

4.2.5 Cirarab River System

Basically all the situations in the basin are the same as those of Cimanceuri river system. Accordingly the only one option for flood control master plan of this river is river improvement works in the embanked downstream reaches.

Judging from the shape of the cross sections surveyed by the Study Team, river improvement works have been being performed in the downstream reaches (0 - 10 km). Accordingly only small scale of improvement works are required.

4.2.6 Cisadane River System

(1) Present Situation

The river basin has a mountainous area in the upstream reaches. In the middle reaches basin, Tangerang city, now developing as a satellite city of Jakarta, is located. The present land use along the embanked reaches downstream of Tangerang city is agricultural land and Soekarno-Hatta International airport.

Upstream and middle reaches do not have flood embankment but have big carrying capacities. Downstream reaches have flood embankment but carrying capacities decrease gradually from the upstream to the downstream and the river channel do not have enough capacity near the estuary. Breach of the flood embankment has once occurred.

Just on the downstream side of Tangerang city, Pasar Baru barrage across the river with 10 gates, is located. This barrage was constructed for irrigation purpose but due to its deterioration, some gates does not function properly.

(2) Future Situation

The future land use in the basin is estimated to be urbanized very widely in the middle reaches basin. In the downstream basin, the land is estimated to remain as agricultural land. But the seacoast area is planned to be reclaimed for new town extending from around the river-mouth of the Lower Angke to close to the estuary of the Cirarab river.

(3) Area and Stretches to be Protected

Accordingly the area to be protected is mainly agricultural land along the downstream reaches from the estuary to Pasar Baru barrage.

The upstream reaches from the barrage are treated as river area to preserve flood retarding function. The river area is necessary not only for flood plain zoning but also for safety against the urgent discharge from the Angke or Ciliwung Floodways (refer to 4.2.7 and 4.2.8 respectively).

(4) Conceivable Measures

Conceivable measures for this river are, in consideration of the above, river improvement and construction of flood control dam.

(5) Consideration

Possibility of Flood Control Dam

Flood control dam is not studied because it is too much costly compared with river improvement in the downstream reaches since the downstream reaches are in the agricultural land. Besides, Parung Badak Dam was once studied but due to its social issue that about 120,000 people would have to be resettled, the idea was already discarded in JWRMS.

Though Genteng dam is included in the plan as one of the water supply facilities for Jabotabek area by JWRMS, this option is not studied as one of alternatives of flood control in the same consideration with that of Tanjung dam in the basin of the Cidurian river.

Reclamation Plan

The reclamation plan around the estuary of the Cisadane river would be formulated so as not to make any adverse impact to the upstream reaches. At present, the technical situations on the reclamation is not finalized yet.

(6) Alternatives

Accordingly river improvement option is the only one option for flood control of this river system.

From the viewpoint of comprehensive river water management, the rehabilitation of Pasar Baru barrage, such as repair of some gates and the construction of generator for the gate operation, is also necessary to make sure the operation in flooding time. The design discharge can go through the barrage safely if the gates are operated properly.

4.2.7 Cengkareng Floodway System

(1) Present Situation

The Cengkareng floodway system consists of mainly the Mookervaart canal, the Angke, Pesanggrahan and Grogol rivers, and the Cengkareng floodway. These rivers do not have mountainous areas in the upstream reaches. These rivers flow mainly in the presently densely populated area and the flooding problem exists in these urbanized areas. The upstream basins have some hilly areas. In the middle reaches, the Cisadane river flows rather close to the Angke river.

Dam on the Pesanggrahan river in Cinere was once planned in the Cisadane-Jakarta-Cibeet Water Resources Development Plan in 1980. But the reservoir area has been developed as residential area though the area was not estimated to cause major population displacement problem at that time. Geological investigation for dam location in more upstream reaches has been conducted in the present Study.

(2) Future Situation

The basin in future is estimated mainly to be urbanized basin. In addition, the seacoast area is planned to be reclaimed for new town extending from around the river-mouth of Kali Kamal about 3 km west of the river-mouth of the Cengkareng Floodway to close to the river-mouth of the proposed Eastern Banjir Canal.

(3) Area and Stretches to be Protected

Accordingly the area to be protected is mainly urbanized area in the downstream basins.

For the Angke and Pesanggrahan rivers, the river improvement stretches of the existing detailed design of "West Jakarta Flood Control System Project" are adopted for this new Master Plan as well.

River improvement of following river stretches is not considered to be necessary, since the present carrying capacity of those rivers are bigger than the design discharge.

- Grogol river
- The upstream reach of Mookervaart Canal
  (the boundary of DKI Jakarta and Tangerang - Sewan gate at Tangerang)

The upstream reaches of the Angke and Pesanggrahan river are treated as river area to preserve flood retarding function.

(4) Conceivable Measures

Conceivable measures for these rivers are, in consideration of the above, river improvement, construction of flood control dam, and construction of Angke floodway from the Angke river to the Cisadane river.

(5) Consideration

Floodway and Flood Control Dam

Floodway might be one of the solutions because the downstream reaches of the Angke river run in the densely urbanized areas. Single purpose flood control dam might be also one of the solutions with the same reason. For this purpose, geological investigation in the field has been conducted in this Study. But from the geological view point, the multipurpose reservoir is not studied since the foundation condition does not allow the storage type dam.

Reclamation Plan

The reclamation plan around the river-mouth of the Cengkareng Floodway would be formulated so as not to make any adverse impact to the upstream reaches. At present, the technical situations on the reclamation is not finalized yet.

(6) Alternatives

Accordingly options of floodway, flood control dam, and river improvement works and/or the combination of these are studied as alternatives of flood control of this river system.

Following existing plans are introduced as much as possible:

- Cengkareng Drain System Study (NEDECO)
- West Jakarta Flood Control System Project

Following 4 alternatives are studied for flood control of this river system. These alternatives include replacement or rehabilitation of existing barrages such as the Cengkareng barrage and the Koneng barrage.

- River improvement (CKR-1)
- River improvement + Limo Dam (CKR-2)
- River improvement + Angke Floodway (CKR-3)
- River improvement + Limo Dam + Angke Floodway (CKR-4)

As a master plan level, the preliminary design of the Limo dam and the Angke floodway is conducted. The relationship between reservoir water level, area and storage volume of the Limo dam are shown in Figure 4.7. The basic features of the dam and floodway are described in ANNEX 8 (Design and Cost Estimate). The standard river cross sections of alternatives are shown in Figure 4.8.

Among these alternatives, direct construction cost is the minimum for CKR-1 and the second minimum is for CKR-3. CKR-4 needs the maximum construction cost among the other alternatives.

(7) Small Scale Improvement at I.K.P.N. along Pesanggrahan River

Floods have been caused by river water flown into the area over the existing concrete wall along the left bank of the river as well as local rain water on the area. It can be suggested that the following measures be taken for improvement of the present situation:

- Improvement of the existing concrete wall
- Improvement of local drainage channel and replacement of the existing drainage pump.

4.2.8 Western Banjir Canal System

(1) Present Situation

The Western Banjir Canal (WBC) system mainly consists of the Krukut, Ciliwung, and the Western Banjir Canal. The Ciliwung river has a mountainous basin in the upstream of Bogor city. A previous study once made a detailed design of Depok Dam in the area downstream of Bogor City and in the midst of town area of Depok. But the riverine area has been developed as real estate area and there remains no room for construction of the spillway of the dam.

The middle stream basin of the Ciliwung river is already densely populated. The upstream and middle reaches of the river do not have flood embankment but have rather big carrying capacities. The Ciliwung river bifurcates to the WBC and the old Ciliwung river (Ciliwung drain) at Manggarai in the midst of DKI Jakarta. In Bogor city, the Ciliwung and Cisadane river flow rather close to each other.

The upstream reaches of the WBC before joining the Krukut river have relatively large carrying capacity compared with that of the downstream reaches

(2) Future Situation

The upstream basin of the Ciliwung river in mountainous area is estimated to remain mostly as it is now in the target year of 2025. The future land use in the basin other than that is estimated to be mostly urbanized in 2025.

The sea coast area of DKI Jakarta is planned to be reclaimed as urban area of about 2,700ha in near future. The present rivers and drainage channels discharging to the Java sea in the said area would be extended toward the north in the reclaimed area.

(3) Area and Stretches to be Protected

Accordingly the area to be protected by river improvement is mainly urbanized area along the WBC.

Meanwhile, the narrow valley plain along the Ciliwung and Krukut rivers are treated as river area to preserve flood retarding function. Comprehensive Flood Control Measures is necessary to be introduced. As DGWRD is now promoting resettlement program in the valley along the Ciliwung river, many houses and/or squatters are densely located in the valley and accordingly it is practically difficult to implement river improvement against the design discharge in ordinary ways.

(4) Conceivable Measures

Conceivable measures for this river system are, in consideration of the above, river improvement, construction of Ciliwung floodway from the Ciliwung river to the Cisadane river at Bogor city, and construction of flood control dam at Ciawi where the geological investigation has been conducted in the present Study.

(5) Consideration

Depending on the design discharge of the river system, the river improvement is possible just inside the present river area. If additional land acquisition for the river improvement is required, then that may cause serious social problem since the area is already densely populated area in the midst of DKI Jakarta.

The forest reservation area along the left bank of the lowest reaches of the WBC (Muara Angke) is desired to be preserved in the future. Because it proved that the area showed quite effective flood retention function against the past big flooding on Jan. 6 to 8, 1996.

The present design discharge distribution on this river system includes the design discharge distribution of 75 m^3/s to the Ciliwung drain for 100-year flood discharge of the Ciliwung river. Based on this discharge distribution, detailed design of the Ciliwung drain has been completed under JUDP-II Project (Package 4). Accordingly this condition is treated as given condition for study on design discharge distribution in this Study.

The reclamation plan around the estuary of the WBC would be formulated so as not to make any adverse impact to the upstream reaches. At present, the technical situations on the reclamation is not finalized yet.

(6) Alternatives

Accordingly river improvement, construction of Ciliwung floodway from the Ciliwung river to the Cisadane river, and construction of flood control dam at Ciawi on the Ciliwung river are studied as the alternatives of flood control of this river system.

Following 3 alternatives are studied for flood control of this river system. These alternatives includes replacement or rehabilitation of existing barrages such as the Manggarai and the Karet barrages.

- River improvement (WBC-1)
- River improvement + Ciawi Dam (WBC-2)
- River improvement + Ciliwung Floodway (WBC-3)

The alternative WBC-3, since it discharges the flood flow of the Ciliwung river in the upstream reaches, should include the river improvement of the Cisadane river in the downstream reaches between the estuary and Pasar Baru barrage. All alternatives are studied on condition that the flood discharge of 75 m^3/s should be diverted from the Ciliwung river to the Ciliwung drain at the Manggarai barrage site.

The alternative of the Ciawi Dam (WBC-2) is discarded by the result of run-off calculation. The flood control effect of the dam to the downstream reaches is found to be so small as can be seen in Figure 4.6.

As a master plan level, the preliminary design of the Ciliwung floodway is conducted. The relationship between reservoir water level, area and storage volume of the Ciawi dam are shown in Figure 4.7. The basic features of the dam and floodway are described in ANNEX 8 (Design and Cost Estimate). The standard river cross sections of alternatives are shown in Figure 4.8.

Among two alternatives of WBC-1 and 3, direct construction cost is minimum for WBC-1 and the second minimum is for WBC-3.

Though WBC-3 needs much more direct construction cost compared with WBC-1, these two alternatives are taken up for economic evaluation in due consideration that WBC-1 needs more land acquisition and house compensation cost than those of WBC-3.

4.2.9 Proposed Eastern Banjir Canal System

(1) Present Situation

The proposed Eastern Banjir Canal system consists of the Cipinang, Sunter, Buaran, Jatikramat, Cakung rivers, and the Eastern Banjir Canal itself to divert the flood discharges of these rivers to the Java sea through the eastern periphery of DKI Jakarta that was proposed in the existing Master Plan for DKI Jakarta in 1973. The basins of these rivers are already mostly urbanized.

Eastern Banjir Canal has not been constructed yet since it was proposed in 1973. In the meanwhile, the area for the Eastern Banjir Canal that was formerly almost agricultural land, is now half urbanized and is estimated to be totally urbanized in the near future even though house construction in the area has been restricted. Accordingly the land acquisition for construction of the Banjir Canal now seems to be very difficult.

But construction works of flood control and drainage facilities in DKI Jakarta in line with the present flood control and drainage master plan, have been implemented under the West Jakarta Flood Control, East Jakarta Flood Control, and the other flood control and drainage projects. Those include the works in the downstream reaches of the rivers of the Eastern Banjir Canal system above-mentioned on the condition that the Eastern Banjir Canal would be constructed as planned and designed.

The detailed design for the improvement works of those rivers in the upstream reaches of the proposed Eastern Banjir Canal has been also finished.

(2) Future Situation

The basin of this river system is estimated to be totally urbanized in the target year of 2025.

(3) Area and Stretches to be Protected

Area to be protected is, accordingly, the fully urbanized area of DKI Jakarta and the suburbs.

(4) Conceivable Measures

Conceivable measures for this river system are, in consideration of the above, construction of the said Eastern Banjir Canal with the design by the on-going "East Jakarta Flood Control

Project", or with somewhat modified plan and design, since the target year of the present master plan is the year of 2025, and then the design discharge is a different one. The hydrological analysis on the design storm is conducted in the present Study in consideration of the future land use in the basin. Other measure may be the river improvement of the existing rivers without construction of EBC.

(5) Consideration

As discussed in Chapter 2, some alternative study on the Eastern Banjir Canal was conducted in 1993. The alternative study included the alternatives on the alterations of the alignment and the cross-sections of the Canal. The alteration of the alignment to upstream and downstream in the basin was not proved to be less in the cost compared with the original alignment.

But it did not include the alignment alteration just to the alignment of the present West Tarum Canal. The concept of this option is that floods of the objective rivers of this river system should be discharged to the present Cakung river on the present right of way of West Tarum Canal and then to the Java sea along the present alignment of the Cakung river and the downstream reaches of the original alignment of the Eastern Banjir Canal.

This option might avoid much land acquisition problem even though this still needs some land acquisition along the present Cakung river and further study to examine if this right of way would be enough for the design discharge. An option to divert the flood to Bekasi river is not studied because the flood in DKI Jakarta would be shifted to the also densely populated city of Bekasi.

If the alignment of the Eastern Banjir Canal would be shifted to the alignment of the Outer Ring Road, then the catchment area of the floodway would be about the half of the present one of the master plan. Then the design discharge of the remaining basin should be treated by the downstream reaches of the rivers or by the Eastern Banjir Canal with a smaller scale. Treatment by the downstream reaches is not practically possible because improvement works of the downstream reaches are already designed and partly improved by the present on-going project. The treatment by the Eastern Banjir Canal with a smaller scale means that two floodways would be constructed and that means too much cost would be needed in comparison with one floodway.

Since the design discharges of the Eastern Banjir Canal is changed from that of the present ones as previously mentioned as the result of hydrological analysis in the present Study, the alteration of the cross-section of the Canal is studied along the original alignment.

(6) Alternatives

Accordingly the alteration of the alignment and the cross-sections of the original design of the Eastern Banjir Canal is studied as the alternatives of flood control of this river system.

Following 4 alternatives are discussed here for flood control of this river system:

- Construction of EBC with open channel and box culvert (EBC-1-1)
- Construction of EBC with open channel with PC-sheet pile revetment (EBC-1-2)
- Construction of EBC with open channel with compounded double cross-section (EBC 1-3)
- River Improvement of Existing Rivers without Construction of EBC (EBC-2)

For all the alternatives, the concept of utilization of existing river as much as possible is considered. Accordingly for the alternatives of EBC-1-1, 1-2 and 1-3, the existing alignment which, after joining the Cakung river, flows straightforward to the north is modified in the present study by using the downstream reaches of Cakung drain and the Marunda drain as much as possible.

As for the alternative to utilize the West Tarum Canal which corresponds to the alternative of EBC-1-1, it has proved that the alternative of EBC-1-1 is much more costly than the other alternatives of EBC-1-2 and 1-3 as discussed below. Accordingly the alternative to utilize the West Tarum Canal has been abandoned before proceeding to more detail study.

EBC-1-1

This option aims to minimize the construction cost as much as possible but needs the maximum land acquisition cost.

EBC-1-2

This option needs the second minimum construction cost and the second minimum land acquisition cost.

EBC-1-3

This option needs the maximum construction cost but the minimum land acquisition cost.

EBC-2

This scheme includes the option to construct a floodway from the Sunter river to the Buaran river in the reaches upstream of the original alignment of EBC. This option of construction of floodway from the Sunter to Buaran aims to avoid the much discharge load in the downstream reaches of the Sunter river where the area is densely populated and land acquisition should be so difficult.

But the longitudinal profile of the both rivers show that the Sunter river flows in a very deep valley whereas the Buaran river flows in a rather flat plain. The elevations of the river-bed at the proposed alignment crossing the national road of Jakarta - Cikampek are as follows:

El. 13.36 m P.P.	Buaran river
El. 10.47 m P.P.	Sunter river

Accordingly only the option of river improvement of existing rivers without floodway is discussed here.

This option needs the maximum volume of excavation and embankment, and maximum land acquisition area compared with the other alternatives, since the necessary river improvement length is about 48 km while the other alternative needs the length of about 23.4 km and existing channels to be incorporated for this option are small ones with the river width of about 10 m or so.

Accordingly the alternatives of EBC-1-1, 1-2, and 1-3 are taken up for the economic evaluation.

4.2.10 CBL Floodway System

(1) Present Situation

This river system includes the CBL Floodway, the Bekasi, Cikarang, Cisadang, and Cilemahabang rivers. This river system does not have a high mountainous area in the upstream basin. Bekasi city, in the same way with Tangerang city, now developing as a satellite city of Jakarta, is located in the middle reaches basin of the Bekasi river. The land use along the upstream and downstream reaches of these rivers are agriculture at present. In the middle reaches basin, due to the urbanization of the area, retarding area is also disappearing in the same manner with that in Tangerang.

The Bekasi river does not have flood embankment in the upstream reaches but has flood embankment in the downstream reaches.

Just in the midst of Bekasi city, Bekasi barrage on the Bekasi river is located for irrigation and municipal water supply purpose. This barrage was constructed to convey water from Jatiluhur reservoir further to the west through the Bekasi river. The design discharge of 590 m^3/s can go through the barrage safely. Due to its operation, some flooding problems in the upstream reaches might have occurred.

CBL floodway was constructed in 1985 to protect the downstream area of these rivers.

(2) Future Situation

Except the downstream basin, the wide area of the basin is estimated to be urbanized in future. This includes the urban development of Jonggol area with the scale of roughly about the half of present DKI Jakarta on the west of Bogor city. But more than half of the area will be located outside of Jabotabek area.

(3) Area and Stretches to be Protected

Area to be protected is along the following stretches which will partly be urban area and partly the agricultural land.

- CBL Floodway (estuary - confluence with Cisadang river)
- Bekasi river (confluence with CBL - cross section No. BKS-18)
- Cisadang river (confluence with CBL - Jl. Jakarta-Cikarang)

River improvement of following river stretches is not considered to be necessary, since the present carrying capacity of those rivers are bigger than the design discharge.

- CBL Floodway (the upstream reaches before joining of the Cisadang river)
- Bekasi river (cross section No. BKS-18 - Bekasi barrage)
- Cikarang river
- Cilemahabang river

The Cilemahabang river has been being improved by Jatiluhur Irrigation Extension Project as one of the drainage channels of the overall irrigation system in this area.

Along the Bekasi river, the upstream reaches from Bekasi barrage is treated as river area to preserve flood retarding function. In this area, local inundation along the narrow valley plain will be greatly diminished after the barrage is replaced with siphon and accordingly the backwater problem is solved; the replacement is proposed by JWRMS.

(4) Conceivable Measures

There is no appropriate dam site and existing retarding area is disappearing due to the present urbanization. Accordingly the conceivable measures are the river improvement works.

(5) Alternatives

Accordingly river improvement is the only one option for flood control of this river system.

As to the river planning of the CBL Floodway, the existing plan of the by Jatiluhur Irrigation Extension Project is introduced as much as possible.

Excavation work is required in large quantities in the downstream reaches of CBL Floodway after joining of the Bekasi river as shown in Figure 4.11, even though the design river bed is set 1 m higher than that of the existing original plan.

4.3 Evaluation of Alternatives

4.3.1 Criteria

Economic evaluation of selected alternatives is conducted in ANNEX 1 (Socio-economy and Economic Evaluation). Here the overall evaluation of the selected alternatives is conducted in this sub-section. The view points for overall evaluation here considered are the following:

1) economic internal rate of return (EIRR)
2) project cost
3) city and rural development plans
4) land acquisition and house compensation
5) water resources development plans
6) environmental aspects
7) socio-economic aspects

4.3.2 Evaluation

In consideration of the above criteria, overall evaluation among the alternatives is conducted as shown in Table 4.5.

For the river systems of the Cidurian, Cimanceuri, Cirarab, Cisadane, and CBL, the studied alternative of each system is river improvement scheme in due consideration of the situation of each river. Accordingly the evaluation of the alternatives of the following river systems are discussed here.

1) Cengkareng Floodway system
2) Western Banjir Canal system
3) Eastern Banjir Canal system

(1) Cengkareng Floodway system

As discussed in the sub-section of 4.2, the following alternatives are selected for economic evaluation :

1) CKR-1 : river improvement only
2) CKR-3 : river improvement + Angke floodway to the Cisadane

The EIRRs of the these alternatives of CKR-1 and CKR-3 are as follows:

CKR-1 42.9 %
CKR-3 13.7 %

(2) Western Banjir Canal system

As discussed in the sub-section of 4.2, the following alternatives are selected for economic evaluation :

1) WBC-1 : river improvement only
2) WBC-3 : river improvement + Ciliwung floodway to the Cisadane

Since the WBC-3 should include the river improvement (CSD-1') of the downstream reaches of the Cisadane river so as to convey not only the design discharge of the Cisadane river but also that of Ciliwung Floodway safely, the comparison of the EIRRs of the alternatives of WBC-1 and WBC-3 are conducted with the cost and benefit of the river improvement of the Cisadane river as follows:

WBC-1 + CSD-1	22.5 %
WBC-3 + CSD-1'	15.4 %

Though WBC-1 + CSD-1 has a high EIRR, the land acquisition and house compensation cost of the alternative is about 1.4 times of that of WBC-3 + CSD-1'. This means that so many people should be relocated for the project since the area is located in the so densely populated area. This leads to the practical difficulties of project implementation.

On the other hand, WBC-3 + CSD-1' does not need so much land acquisition compared with WBC-1 + CSD-1 even it still needs substantial land acquisition. In addition, the EIRR of WBC-3 + CSD-1' still has a rather high EIRR.

Accordingly the WBC-3 + CSD-1' should be adopted as the flood control master plan of the river system.

(3) Eastern Banjir Canal system

As discussed in the sub-section of 4.2, the following alternatives are selected for economic evaluation :

1) EBC-1-1 : box culvert scheme
2) EBC-1-2 : PC-sheet pile revetment scheme
3) EBC-1-3 : open channel scheme

The EIRRs of these schemes are as follows:

EBC-1-1	7.9 %
EBC-1-2	18.6 %
EBC-1-3	27.4 %

The EBC-1-3 needs the least cost compared with others, and has a high EIRR, but needs the highest land acquisition and house compensation cost.

On the other hand, EBC-1-2 has less land acquisition and house compensation cost. And the scheme has rather high EIRR. The total cost of civil works and land acquisition and house compensation cost is nearly the same with that of the EBC-1-1.

The EBC-1-3 needs a very high civil works cost and then has the very low EIRR, though the land acquisition and house compensation cost is the minimum.

In consideration of these, the EBC-1-2 should be adopted as the optimum plan of flood control master plan for this river system.

4.4 Proposed Master Plan

As the flood control master plan in Jabotabek area, for the target year of 2025, the features of proposed stretch of flood control master plan is shown in Table 4.6.

The design discharge distribution of the proposed flood control master plan is shown in Figure 4.10.

The proposed design discharge distribution is somewhat different from that of the existing one in some river systems because of the difference of the methodology of rainfall and run off analyses and the difference of the assumption of future land use condition and so on.

According to the result of the initial environmental examination (IEE), 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.

4.4.1 Structural Measures

The incorporated structural measures in the flood control master plan for Jabotabek area are also schematically shown together with the design discharge distribution in Figure 4.10.

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 4.11 Dimension of longitudinal profiles and standard cross sections are shown in Tables 4.7 and 4.8.

Other than the conventional river channel improvement works, the following works are incorporated.

Cengkareng Floodway System

Angke floodway
about 4 km long at around the boundary of Tangerang and Serpong

Western Banjir Canal System

Ciliwung floodway
about 1 km long at the upstream side of Bogor city

4.4.2 Non-Structural Measures

(1) Watershed Management

Flood control can not be achieved only by the structural method. The basic point of non-structural method for flood control should be the watershed management.

The river consists of water and soil. Both are supplied from the watershed of the river. Countermeasures in only the downstream reaches, therefore, are not enough for flood control. If the watersheds are indiscriminately developed in different to the situation in the downstream area, then the flood peak will increase unexpectedly and the sediment supply to the river will increase so much and then the river-bed will be elevated so much. The both will surely result in a serious flooding in the downstream basin and then serious flood damage maybe including the loss of human lives.

Accordingly the preservation of the soil conservation and flood retention functions in upper watershed is the essential part of the non-structural flood control. Like in the medical field, prevention against becoming sick is much more important than curing after becoming sick.

The runoff analysis in the basin is conducted in the present study. Even the data utilized for the runoff analysis in the present study is very much limited, future runoff in the basin is estimated to increase so much due to its urbanization in the upstream basins. For example, the basin of the Cengkareng Floodway system is estimated to have been urbanized by 28 % of the whole basin at present. But future urbanization in 2025 is estimated to be about 88 % of the whole basin. Accordingly the flood peak is estimated to increase from 240 m^3/s from the present stage to 620 m^3/s in future stage due to its urbanization.

This includes the preservation of forest, paddy field, lake and pond (Situ-situ), and then regulation of land development in the basin. All these will contribute to the preservation of the flood retention function in the basin and soil conservation.

As a matter of fact, sabo works as structural method in the basin is also an important aspect of watershed management from the view point of flood control.

(2) Flood Plain Management

Flood plain management here comprises that in the middle reaches and the low-lying area in the downstream basin.

Middle Reaches

In the middle reaches, an important aspect is land regulation to preserve the flood retarding function in the basin. Not only the valley plain in middle hilly reaches of rivers in Jabotabek area, but also the lakes and ponds (Situ-situ) scattered in the area play an important role for flood retarding function. This also contributes so much to suppress the increase of flood peak in the downstream reaches.

The area that is presently functioning as the retarding basin of rivers should not be developed as residential or commercial area. The authorities responsible to flood control should define the flood retarding area for each river and with the coordination with the local government, land use development should de regulated.

This management also includes the regulation of land filling in the basin. This land filling activity can be found everywhere in Jabotabek area. This also gradually diminishes the retarding function in the basin.

Low-lying Area

In the low-lying area, flood forecasting and flood proofing are the major non-structural method for flood control.

(3) Public Information and Education

Public information and education comprises the aspects of flood prevention and that of flood damage mitigation

Flood Prevention

Activity of public information and education for people not to construct illegal facilities inside the river area, and not to dump garbage to the river area. This should be conducted by the following methods:

- to hold forum
- to hold ceremony or concert to love rivers
- to make campaign through mass-media especially by popular people like a film star or singers

Flood Damage Mitigation

Activity of public information and education to mitigate the flood damage as much as possible since the flood of rivers as natural phenomena may sometimes exceeds the design discharge that is always limited to certain scale due to socio-economic situation of the area, and because the flood control facilities planned can not be constructed all at once due to the limitation of the government budget. Usually completion of the flood control facilities needs a long time.

This comprises the following:

- preparation of flood risk map
- establishment of flood warning board to show the past maximum inundation water level in the area

(4) Related Agencies

There are many related agencies to non-structural measures such as ministry of public works, ministry of forest, ministry of industry, ministry of agriculture, ministry of education and culture and ministry of people's welfare.

4.5 Selection of Priority Projects

4.5.1 Criteria

Criteria to select priority projects which are to be taken up for the feasibility study are as follows:

1) Economic internal rate of return (EIRR) is high.
2) Project cost is within the moderate amount.
3) Beneficiaries are many.
4) The project is urgently needed technically and socially.
5) Implementation of the project is easy with less social and environmental issues.

4.5.2 Overall Evaluation

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 as shown in Table 4.9. Accordingly, the following projects are selected as the priority projects for the feasibility study.

1. Improvement of the Western Banjir Canal (Estuary - Manggarai Barrage, l=17 km)
2. Improvement of the Cisadane River (Estuary - Pasar Baru Barrage, l=21 km)
3. Construction of the Ciliwung Floodway

The economic viability (EIRR) of the project is estimated to be 15.4 %. This value of EIRR is not the highest one among those of the other schemes of proposed flood control master plan in Jabotabek area. But the project area is located in the center of DKI Jakarta where the political and economic centers of Indonesia are located. The project benefits not counted in monetary term should be so high.

Besides this scheme is socially urgently needed since the flooding in January 6 to 8, 1996 brought about a serious flood damage to the central part of DKI Jakarta even though the flood embankment of the Western Banjir Canal did not totally collapsed.

Since this scheme includes the floodway from the Ciliwung to Cisadane rivers, the river improvement of the downstream reaches of the Cisadane river should be included.

This will be also highly beneficial to surroundings of the north-western area of the Soekarno-Hatta International Airport. Since the benefits counted in monetary term do not include the enhancement benefit due to the development of coastal area between the estuary of the Cisadane and the river-mouth of the Lower Angke by KAPUKNAGA Project.

Following the selected 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.

4.6 Review of Design Discharge Distribution

4.6.1 Western Banjir Canal

Design discharge distribution of the Western Banjir Canal is proposed based on the design discharge distribution between the Ciliwung river and the Ciliwung drain (old Ciliwung river) as shown in Figure 4.10. The design discharge distribution from the Ciliwung river to the Ciliwung drain was once determined to be 75 m^3/s in the master plan formulated in 1973.

This design discharge distribution to the Ciliwung drain was once succeeded in the present study on the flood control master plan in JABOTABEK.

But in consideration of the surrounding situation of the Ciliwung drain, review of this design discharge to the Ciliwung drain has been conducted aiming at decreasing the discharge to the Ciliwung drain.

Decreasing the design discharge to the Ciliwung drain directly leads to the increase of design discharge to the Western Banjir Canal. But since the Western Banjir Canal is located in the very densely populated area of DKI Jakarta, widening of the river for increasing the carrying capacity of the river should be avoided as much as possible. The river improvement of the Western Banjir Canal should be planned in the present right of way in principle.

In consideration of the above, the review of design discharge distribution of the Ciliwung drain has been conducted. The conclusion is that the design discharge distribution of the Ciliwung drain from the Ciliwung river can be decreased from 75 m^3/s to 50 m^3/s. On this condition, new design discharge distribution of the Western Banjir Canal is calculated and is shown in Figure 4.12.

The concept of the design discharge distribution under 100-year flood events can be modified as shown in Table 4.10.

4.6.2 Cisadane River

In the flood control master plan of the Cisadane river, the design discharge of the Cisadane river in the downstream reaches is proposed to be 1900 m^3/s. This is calculated based on the concept that the flood diversion (600 m^3/s, return period of 100 years) from the Ciliwung river to the Cisadane river and flood diversion (115 m^3/s, return period of 50 years) from the Angke river to the Cisadane river occur simultaneously with the flood occurrence in the Cisadane river with the return period of 50 years (refer to Figure 4.13).

The occurrence probability of this situation might be very small. If the probability could be estimated to be very small, the design discharge distribution of the Cisadane river may be decreased to certain extent. But the shortage of available data on rainfall in the basin would not allow the hydrological analysis on the occurrence probability of this situation.

After discussion on this issue with authorities concerned, it is concluded that this design discharge of 1,900 m^3/s should be adopted in order to ensure the maximum safety level of the Cisadane river against the artificial flood diversion from the Ciliwung and the Angke floodways.

4.7 Channel Conditions for Reclamation

4.7.1 Introduction

Sea coast reclamation plans are now underway. One is a reclamation plan along the sea coast of DKI Jakarta, so called PANTURA. The other is a reclamation plan along the sea coast of the western part of DKI Jakarta and some part of the West Java Province, so called KAPUKNAGA. The objective reach is 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 Western Banjir Canal, the Cengkareng Floodway, and the Cisadane river, so that they would not cause any raise of the design high water level in the flood control master plan in JABOTABEK.

4.7.2 The Cisadane River

Though the mangrove forest around the estuary of the Cisadane river will be kept as it is now by the plan, the necessary conditions of the channel as the extension of the Cisadane river to be prepared in the reclamation area are discussed here.

(1) Basic Features of the Cisadane River at the Estuary in the Master Plan

Since the Cisadane river is planned to be improved in the reaches starting from the point 1.8 km upstream from the present estuary, the following channel conditions of the Cisadane river at that starting point in the Master Plan are taken into consideration (refer to succeeding Section 5.4):

1) Design Scale	: 50-year return period
2) Design Discharge	: 1900 m^3/s
3) High water level	: 3.71 m
4) River-bed elevation	: -4.93 m
5) Width of low-water channel	: 94 m

(2) Basic Assumptions of the Channel in the Reclaimed Area

Channel conditions in the reclaimed area are studied by using non-uniform formula on the following assumptions:

1) The channel-bed elevation would be maintained as high as the design river-bed elevation at the downstream end of the master plan.
2) The width of low water channel should gradually increase towards the new estuary.
3) The width of high water channel should be the same as that at the downstream end of the master plan.

(3) Result of Calculation

The channel in the reclaimed area as the extension of the Cisadane river, should have the width of at least 248 m at the new estuary against the width of 192 m in the master plan to avoid the raise of design high water level in the master plan.

4.7.3 The Cengkareng Floodway

(1) Basic Features of the Cengkareng Floodway at the Estuary in the Master Plan

The following channel conditions of the Cengkareng Floodway at the estuary in the Master Plan are taken into consideration:

1) Design Scale	: 100-year return period
2) Design Discharge	: 510 m^3/s
3) High water level	: 1.20 m
4) River-bed elevation	: -4.55 m
5) Width of low-water channel	: 57 m

(2) Basic Assumptions of the Channel in the Reclaimed Area

The same assumptions with those of the case of the Cisadane river are utilized here.

(3) Result of Calculation

The channel in the reclaimed area as the extension of the Cengkareng Floodway should have the width of at least 133 m at the new estuary against the width of 120 m in the master plan to avoid the raise of design high water level in the master plan.

4.7.4 The Western Banjir Canal

(1) Basic Features of the Western Banjir Canal at the Estuary in the Master Plan

The following channel conditions of the Western Banjir Canal at the estuary in the Master Plan are taken into consideration (refer to succeeding Section 5.3):

1) Design Scale : 100-year return period
2) Design Discharge : 500 m^3/s
3) High water level : 0.85 m
4) River-bed elevation : -4.75 m
5) Width of low-water channel : 53 m

(2) Basic Assumptions of the Channel in the Reclaimed Area

The same assumptions with those of the case of the Cisadane river are utilized here.

(3) Result of Calculation

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 147 m at the new estuary against the width of 100 m in the master plan to avoid the raise of the design high water level in the master plan.