4.9 Overall Evaluation of Master Plan

4.9.1 Economic Evaluation

The cost-benefit analysis for the master plan is conducted in compliance with annual disbursement of the project cost, annual operation and maintenance cost, and annual flood damage reduction benefit. Annual flood damage reduction benefit is obtained from flood damages caused by floods with various probabilities of occurrence (See Figure 12). These are obtained year by year from those for the respective river systems to be implemented according to the aforementioned priority order. The term of the cost-benefit analysis is set at 50 years that is regarded as project life.

As a result of the cost-benefit analysis for the flood control master plan, EIRR is obtained at 10.8%. B/C and NPV are 1.08 and 9,315 million under the discount rate of 10%, respectively.

4.9.2 Initial Environmental Examination

The main objectives of the Initial Environmental Examination (IEE) are to clarify environmental issues related to the flood control master plan, and to provide information to guide Environmental Impact Assessment (EIA) in the feasibility study.

The results of IEE are shown in Table 11. The results of IEE indicate that most of the items examined by IEE result in minor or no environmental impact, and that significant impact may be anticipated on noise and vibration during construction. It is therefore concluded that environmental impact is not significant in general and regarded as acceptable.

Table 11 Results of Initial Environmental Examination

Structural Measures	Enrironmental Item													
	Social Environment						Nature Environment					Pollution		
	Resettlement	Transportation system	Communities	Historical assets	Water rights	Solid waste	Topography and geology	Ground water	River flow regime	Flaura and fauna	Aethetics and landscape	Air pollution	Water quality deterioration	Noise and vibration
Bantyiketu River System														
- Weir	C	D	D	D	D	D	C	C	C	D	C	C	D	B
- Regulationg pond	D	D	D	D	D	D	D	D	D	D	C	D	D	C
- Channel improvement	C	D	C	D	D	D	D	D	D	D	C	C	C	C
Kebena River System														
- Weir	C	D	D	D	D	D	C	C	C	D	C	C	D	B
- Channel improvement	C	D	C	D	D	D	D	D	D	D	C	C	C	C
Little Akaki River System														
- Diversion tunnel	C	C	C	D	D	D	C	C	C	D	C	C	D	C
- Regulating pond	D	D	D	D	D	D	D	D	D	D	C	D	D	C
- Channel improvement	C	D	C	D	D	D	D	D	D	D	C	C	C	C
Hanku River System														
- Culvert	D	D	C	D	D	D	D	D	D	D	C	C	C	C

A : very significant B : significant C : significant but relatively minor D : not significant

4.9.3 Overall Evaluation

From financial view, the required annual disbursement is rather large and much higher than the present budget of AFCPO. However, Addis Ababa is the capital city of Ethiopia and has been threatened by serious flooding, especially in 1978 and 1994. Such social disturbance by disaster in the capital city causes significant impediment to economic development not only for Addis Ababa but also the whole country. It is therefore recommended that master plan is to be implemented as basic infrastructures of the capital city, and that the Federal Government and the Region 14 Administration are requested to make necessary efforts of financial arrangement for the implementation.

From economical view, EIRR of 10.8% is a reasonable rate. Moreover, the implementation of mater plan will also create intangible benefits that are not counted into the flood damage reduction benefits as monetary value. Most important one is social stability in line with reduction of threat by disaster. This will contribute to sustainable economic growth of the country. In addition, the implementation of the structural measures will create a lot of employment opportunities during design and

construction stages. When such intangible benefits are taken into account, it is concluded that the implementation of the flood control master plan provides sufficient economic viability.

As a conclusion of overall evaluation, the flood control master plan indicates sufficient viability from the viewpoints discussed above.

Table 12 Overall Evaluation of Flood Control Master Plan

Features	River System				Overall
	Bantyiketu	Kebena	Little Akaki	Hanku	
Outline of Project	- 1 Weir - 6 Regulating Pond - River Channel Improvement - Drainage Improvement	- 2 Weirs - River Channel Improvement	- 1 Flood Diversion - 1 Regulating Pond - River Channel Improvement	- 2 Culverts	
Project Cost (million Birr)					
Structural Measures	148.6	392.1	208.0	2.5	751.2
Non-Structural Measures	6.0	2.4	3.2	0.3	11.9
Total	154.6	394.5	211.2	2.8	763.1
EIRR (%)	11.7	3.5	10.6	7.2	10.8
B/C	1.17	0.42	1.07	0.72	1.08
NPV (million Birr)	11.4	-38.9	4.8	-0.3	9,315
Beneficial Population (person)	610,000	280,000	420,000	35,000	1,345,000
Beneficial Area (km^2)	51	40	33	9	105
Resettlement	small	small	small	small	small
Land Use	Class-B	Class-D	Class-C	Class-D	
Environmental Impact	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant

Note: EIRR : Economic Internal Rate of Return
B/C : Benefit/Cost Ratio
NPV : Net Present Value
Class-A : Mainly Government Agencies
Class-B : Mainly Government Agencies, Commercial Area and Residential Area
Class-C : Mainly Densely Built-up Residential Area
Class-D : Mainly Residential Area

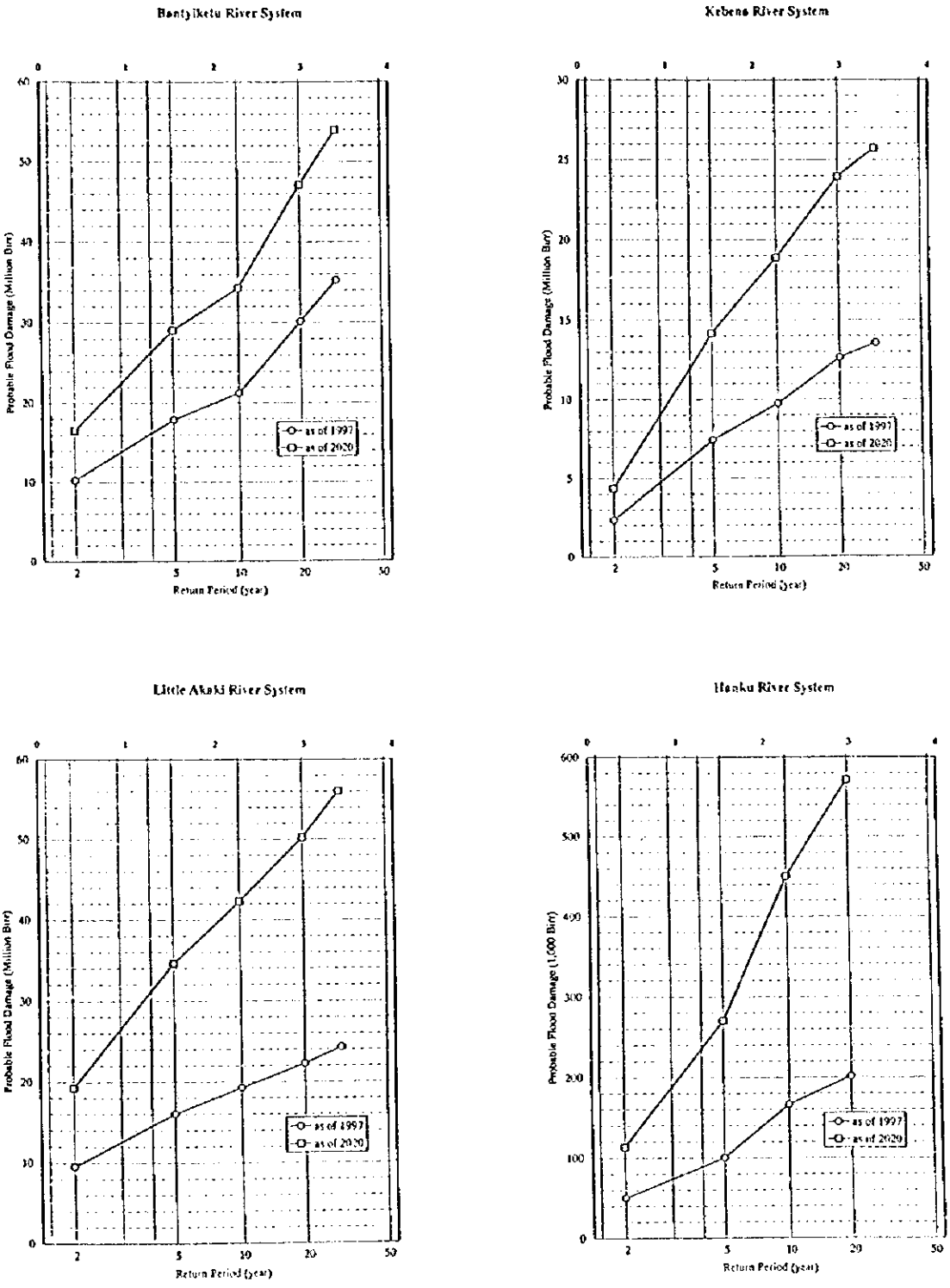


Figure 12 Probable Flood Damages

4.10 Implementation Plan

4.10.1 Structural Measures

The implementation plan of the structural measures are formulated in compliance with priority order by river system, periods of pre-construction and construction stages and disbursement schedule of project cost.

As discussed in the succeeding section, the priority order of river systems are: 1) Bantyketu river system including Kechene and Kurtume rivers, 2) Little Akaki river system, 3) Hanku river system, and 4) Kebena river system. The structural measures will therefore be implemented according to this priority order.

For ease of financial arrangement and avoiding a huge disbursement concentration in a short period, stage wise implementation is applied. The implementation of the structural measures for each river system is divided into two stages except the Hanku river system that is of small scale projects compared with the others. The stage wise implementation plan for each river system is prepared on the basis of engineering viewpoints of flood control effectiveness by structures. In general, flood regulating structure will be constructed in advance and river channel improvement will be implemented later. Construction period is dependent on the scale of structures to be constructed in a stage. Stage wise implementation for each river system is shown below.

Table 13 Stage Wise Implementation Plan

Priority Order	River System	Stage	Structural Measures	Implementation Period
1	Bantyiketu	1	- Kechene Weir	1998 - 2002
			- Kostre Regulating Pond	
			- Bantyiketu Regulating Pond	
			- River Channel Improvement of Bantyiketu river	
			- River Channel Improvement of Kechene river	
			- Drainage Improvement	
		2	- Kurtume No.1 Regulating Pond	2000 - 2004
			- Kurtume No.2 Regulating Pond	
			- Kurtume No.3 Regulating Pond	
			- Kurtume No.4 Regulating Pond	
			- River Channel Improvement of Kurtume river	
2	Little Akaki	1	- Little Akaki Regulating Pond	2003 - 2010
			- Flood Diversion	
		2	- River Channel Improvement of Little Akaki river	2008 - 2011
3	Hanku		- 2 Culverts	2010 - 2013
4	Kebeba	1	- Kebena Weir	2012 - 2018
			- Abo Weir	
		2	- River Channel Improvement of Kebena River	2016 - 2020

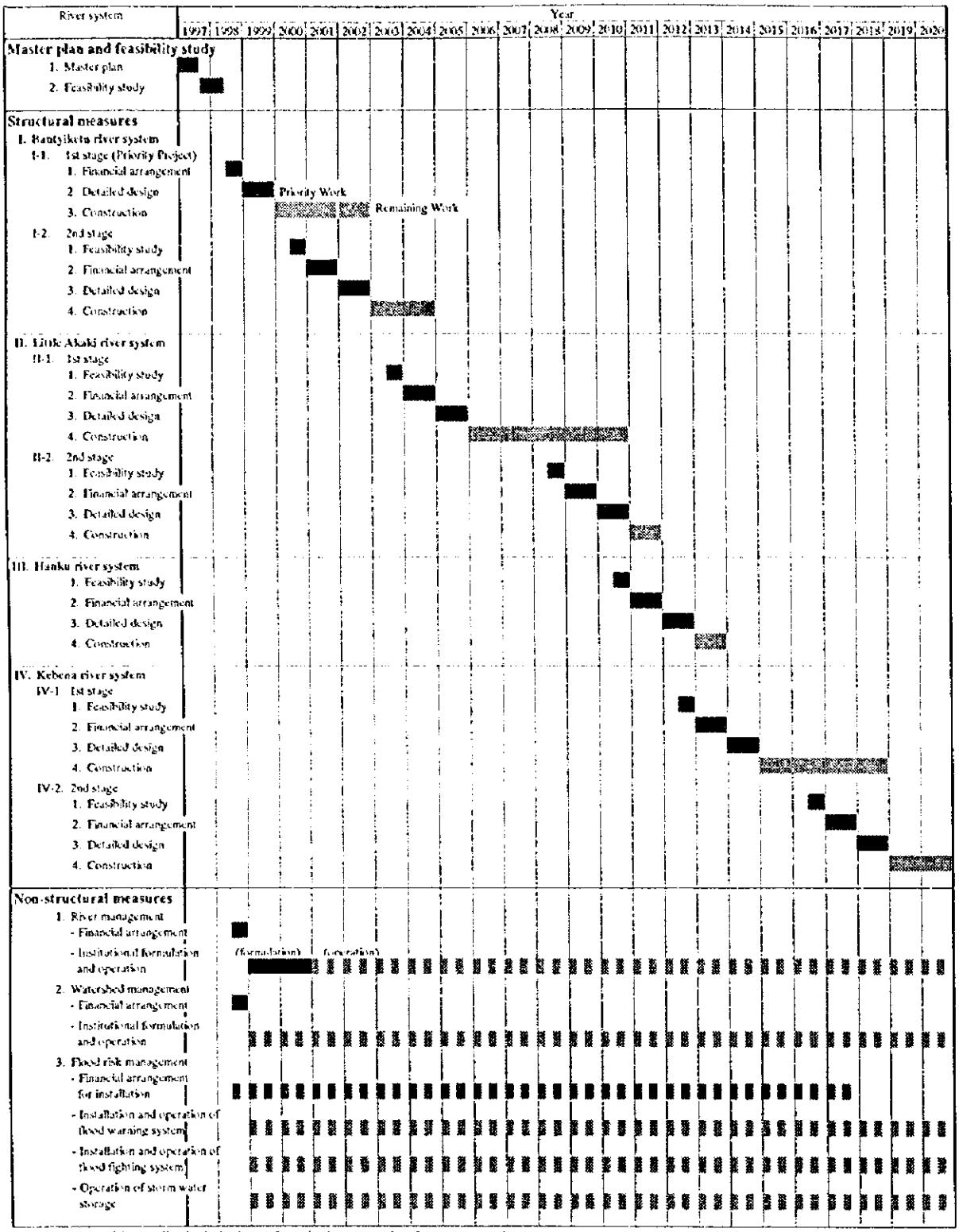
Note: Implementation period consists of feasibility study, financial arrangement, detailed design and construction.

The proposed implementation plan is shown in Figure 13. It is expected that the construction works of the structural measures will commence in the year 2000 at the earliest. All the construction works will be completed in the end of 2020.

4.10.2 Non-structural Measures

The non-structural measures will be implemented along with the structural measures until the year 2020. The proposed implementation plan is shown in Figure 13.

Among the non-structural measures, authorization of river zone and establishment of regulation to prohibit illegal activities in river zone need to be realized as soon as possible. It is proposed that preparatory works including financial arrangement and institutional formulation for these two items of the non-structural measures will be initiated immediately after completion of this Study.



Note: - Feasibility studies include the study on both structural and non-structural measures.
- All the master plan projects will be implemented river by river in order of priority. Each river system will be implemented being divided into two stages, except for the Hanku river system, i.e. 1st stage and 2nd stage.
- Construction period of each stage is scheduled so that the yearly disbursement amount of construction cost should not exceed 500 million Japanese yen (equivalent 30 million Birr).

Figure 13 Proposed Implementation Plan of Master Plan Projects

CHAPTER 5 SELECTION OF PRIORITY PROJECTS FOR FEASIBILITY STUDY

5.1 Priority by River System

The evaluation is made in order to determine the project implementation priority and select a river system to be taken up for selection of the priority projects. Criteria for the evaluation are followings:

a) Technical Aspects
Project is technically viable with a moderate scale of construction work.

b) Financial Aspects
Project cost is within a moderate amount.

c) Economic Aspects
Economic Internal Rate of Return (EIRR) is high rate.

d) Social Impact
Beneficiaries are many in terms of number of population and socio-economic activities. Number of houses subject to resettlement is small.

e) Environmental Impact
Negative environmental impact is not significant and acceptable.

For the purpose of the evaluation, evaluation points are given to each river system according to the items of the evaluation criteria. Priority of river system is concluded on the basis of the total of the evaluation points for all the items of the evaluation criteria. A river system indicating highest score is taken up as the highest priority river system. The items of evaluation criteria and evaluation points are summarized in Table 14.

Priority of river systems is studied for the four river systems, namely, the Bantyiketu river system including the Kechene and Kurtume rivers, the Kebena river system, the Little Akaki river system and the Hanku river system. The priority order of river systems is evaluated as shown in Table 15. The Bantyiketu river system including the Kechene and Kurtume rivers indicates the highest score of the total evaluation points. The priority order of the river systems is concluded as follows:

a) 1st : Bantyiketu river system including Kechene and Kurtume rivers,
b) 2nd : Little Akaki river system,
c) 3rd : Hanku river system, and
d) 4th : Kebena river system.

Table 14 Evaluation Criteria for Priority by River System

Item	Criteria	Point
Financial Aspect		
Cost per Beneficiary (C/B)	C/B < 190 Birr	10
	190 Birr < C/B < 290 Birr	7
	290 Birr < C/B < 390 Birr	5
	C/B > 390 Birr	3
Economic Aspect		
EIRR	EIRR > 13%	10
	13% > EIRR > 10%	7
	10% > EIRR > 5%	5
	EIRR < 5%	3
Social Impact		
Beneficial Population	Population > 450,000	10
	450,000 > Population > 350,000	7
	350,000 > Population > 250,000	5
	Population < 250,000	3
Resettlement	Number of houses subject to resettlement is small (< 30)	10
	Number of houses subject to resettlement is large (> 30)	0
Characteristics of Land Use	Class-A : Mainly government agencies	10
	Class-B : Mainly government agencies, commercial area and residential area	7
	Class-C : Mainly densely built-up residential area	5
	Class-D : Mainly residential area	3
Environmental Impact by IEE	Not significant	10
	Significant	0

Note: 1) In Cost per Beneficiary (C/B), 290 Birr is average cost per beneficiary for all the river systems, derived by rounding (122 + 138 + 130 + 1.4) x 10^6/((610 + 280 + 420 + 35) x 10^3), 190 Birr is defined as the average of cost per beneficiary for all the alternatives of the priority river system derived by rounding (200 + 198 + 211 + 185 + 179)/5.

2) In Beneficial Population, 350,000 is the average beneficial population of the four river systems (Bantyiketu, Kebena, Little Akaki, Hanku), derived by rounding (610,000 + 280,000 + 420,000 + 35,000)/4.

3) In Resettlement, 30 is defined as a maximum number of houses resettled by a project undertaken by Addis Ababa Flood Control Project Office (AFCPO) until now.

Table 15 Summary of Evaluation of Priority by River System

Item	River System			
	Bantyiketu	Kebena	Little Akaki	Hanku
Outline of the Project				
Improvement Works	-1 Weir -6 Regulating Ponds -Channel Improvement	-2 Weirs -Channel Improvement	-Flood Diversion -1 Regulating Pond -Channel Improvement	-2 Culverts
Financial Aspects				
Cost (million Birr)	122	138	130	1.4
Cost per Beneficiary (Birr)	198	493	310	40
(Point)	(7)	(3)	(5)	(10)
Economic Aspects				
EIRR (%)	11.7	3.5	10.6	7.2
(Point)	(7)	(3)	(7)	(5)
B/C	1.17	0.42	1.07	0.72
NPV (million Birr)	11.4	-38.9	4.8	-0.3
Social Impact				
Beneficial Population	610,000	280,000	420,000	35,000
(Point)	(10)	(5)	(7)	(3)
Resettlement	Small	Small	Small	Small
(Point)	(10)	(10)	(10)	(10)
Characteristic of Land Use	Class-B	Class-D	Class-C	Class-D
(Point)	(7)	(3)	(5)	(3)
Environmental Impact by IEE	Not significant	Not significant	Not significant	Not significant
(Point)	(10)	(10)	(10)	(10)
Total of Evaluation Point	(51)	(34)	(44)	(41)
Priority Order	1	4	2	3

Note: Cost consists of construction cost, resettlement cost, engineering service cost, administration cost and physical contingency for both structural and non-structural measures.

5.2 Selection of Structural Measures

5.2.1 Alternative Plans

The implementation of the structural measures for the Bantyiketu river system will require rather large financial sources, compared with the present budgeting situations of

AFCPO to be designated as implementing organization. This will be a first experience for AFCPO to implement flood control project with a comparatively large scale. In consideration of these aspects, a stage wise implementation is proposed as indicated in the implementation plan. Namely, some of the structural measures in the Bantyiketu river system are selected as priority projects that are to be implemented at the earliest.

The structural measures in the Bantyiketu river system consist of several measures of a reservoir by weir, regulating ponds, river channel improvement and drainage improvement. The alternative plans for selection of priority projects are therefore formulated by means of the primary evaluation mainly from technical viewpoints. The drainage improvement is incorporated into all the alternative plans above with due considerations of its urgent necessity for the center of the capital city. The alternative plans are summarized in Table 16.

Table 16 Alternative Plans for Selection of Priority Projects

Structural Measures	Alternative				
	1	2	3	4	5
Kurturne River					
- 4 Regulating Ponds	O	-	O	-	-
- River Channel Improvement	O	-	O	-	-
Kechene River					
- 1 Reservoir by Weir	O	O	-	O	O
- 1 Regulating Pond	O	O	-	O	O
- River Channel Improvement	O	O	-	-	-
Bantyiketu River					
- 1 Regulating Pond	O	O	O	O	O
- River Channel Improvement	O	O	O	O	-
- Drainage Improvement	O	O	O	O	O

Note: The alternative 1 to 5 above consist of structural measures marked 'O', respectively.

5.2.2 Evaluation and Selection of Priority Projects

The evaluation of the alternative plans and the selection of priority projects are conducted applying the same manner as that of the evaluation of priority by river system discussed in the previous section. The selection of priority projects is concluded on the basis of the total of the evaluation points for all the items of the evaluation criteria. An alternative plan indicating highest score is taken up as priority projects. The items of evaluation criteria and evaluation points are also the same as those of the evaluation of priority by river system.

The alternative plans are evaluated as shown in Table 17. The Alternative 4 indicates the highest score of the total evaluation points. The selection of priority projects is summarized as follows.

Table 17 Summary of Selection of Priority Projects

Item	Alternative				
	1	2	3	4	5
Financial Aspects					
Cost (million Birr)	122	93	80	87	75
Cost per Beneficiary (Birr)	200	198	211	185	179
(Point)	(7)	(7)	(7)	(10)	(10)
Economic Aspects					
EIRR (%)	11.7	12.6	12.1	13.3	11.9
(Point)	(7)	(7)	(7)	(10)	(7)
B/C	1.17	1.27	1.22	1.35	1.20
NPV (million Birr)	11.4	15.6	11.0	18.9	9.3
Social Impact					
Beneficial Population	610,000	470,000	380,000	470,000	420,000
(Point)	(10)	(10)	(7)	(10)	(7)
Resettlement	Small	Small	Small	Small	Small
(Point)	(10)	(10)	(10)	(10)	(10)
Characteristic of Land Use	Class-B	Class-B	Class-B	Class-B	Class-B
(Point)	(7)	(7)	(7)	(7)	(7)
Environmental Impact by IEE	Not significant	Not significant	Not significant	Not significant	Not significant
(Point)	(10)	(10)	(10)	(10)	(10)
Overall Evaluation					
(Overall Point)	(51)	(51)	(48)	(57)	(51)
Priority Project				Selected	

Note: Cost consists of construction cost, resettlement cost, engineering service cost, physical contingency and price contingency for both structural and non-structural measures for both structural and non-structural measures.

5.3 Selection of Non-structural Measures

The non-structural measures for priority projects are selected from the viewpoints of urgent necessity, technical and institutional practicability.

Authorization of river zone is an essential matter for the flood control master plan. Necessary legislation for river zone needs to be enforced in the earliest stage of the implementation.

Social education for river and flood helps to enhance effectiveness of the said legislation to prevent illegal activities in the river zone. In addition, it contributes to popularization of flood warning and fighting to be managed by community organizations.

The concept of flood warning and fighting corresponds with the policy of the National Disaster Prevention and Preparedness Management, which is supported by the institutional system covering the community organizations of Zone, Wereda, and Kebele. Therefore, it is a practical and effective way that flood warning and fighting system are established in combination with the said institutional system.

As a conclusion of the considerations above, the following non-structural measures are incorporated into the priority projects for the succeeding feasibility study.

a) River Management

- Authorization of river zone
- Social education for river and flood

b) Flood Risk Management

- Flood warning system
- Flood fighting system

5.4 Priority Projects for Feasibility Study

The selected priority projects are summarized in Table 18 and Figure 14. The features of the priority projects are based on the results of the master plan and are subject to be updated in the succeeding feasibility study.

Table 18 Priority Projects for Feasibility Study

(1) Structural Measures

Objective Rivers	
- Bantyiketu river	• Catchment area = 5.4 km^2
	• Length = 4.5 km
- Kechene river	• Catchment area = 13.6 km^2
	• Length = 11.2 km
Project Features	
- Kechene weir	• Concrete gravity type
	• Height = 20 m
	• Reservoir storage = 115,000
- Kostre regulating pond	• Pond storage = 21,000 m^3
- Bantyiketu regulating pond	• Pond storage = 54,000 m^3
- River channel improvement of Bantyiketu river	• Channel excavation : 33,500 m^3
	• River bank protection : 300 m
	• Flood wall : 1,950 m
- Drainage improvement	• Drainage area = 2.48 km^2
	• Length of road side ditch = 4,000 m
- Associated works	• Repair of bridge abutment : 1 no.
	• Rehabilitation of aqueduct : 1 no.
	• Rehabilitation of irrigation intake : 1 no.

(2) Non-structural Measures

River Management	
- Authorization of river zone	• Delineation of river zone for river management: 5 m width from both river bank
	• Prohibition of illegal activities in river zone
- Social education for river and flood	• Enlightenment of public awareness for river and flood
Flood Risk Management	
- Flood warning system	• Installation of rainfall gauges, communication lines, and sirens
- Flood fighting system	• Involvement of community organizations to flood fighting
	• Construction of storehouses with necessary materials for flood fighting

(3) Project Cost and Benefit

Project Cost	
- Structural measures	99,483 thousand Birr
- Non-structural measures	6,005 thousand Birr
- Total	105,498 thousand Birr
Project Benefit	
- Beneficial population	470,000
- EIRR	13.3%
- B/C	1.35

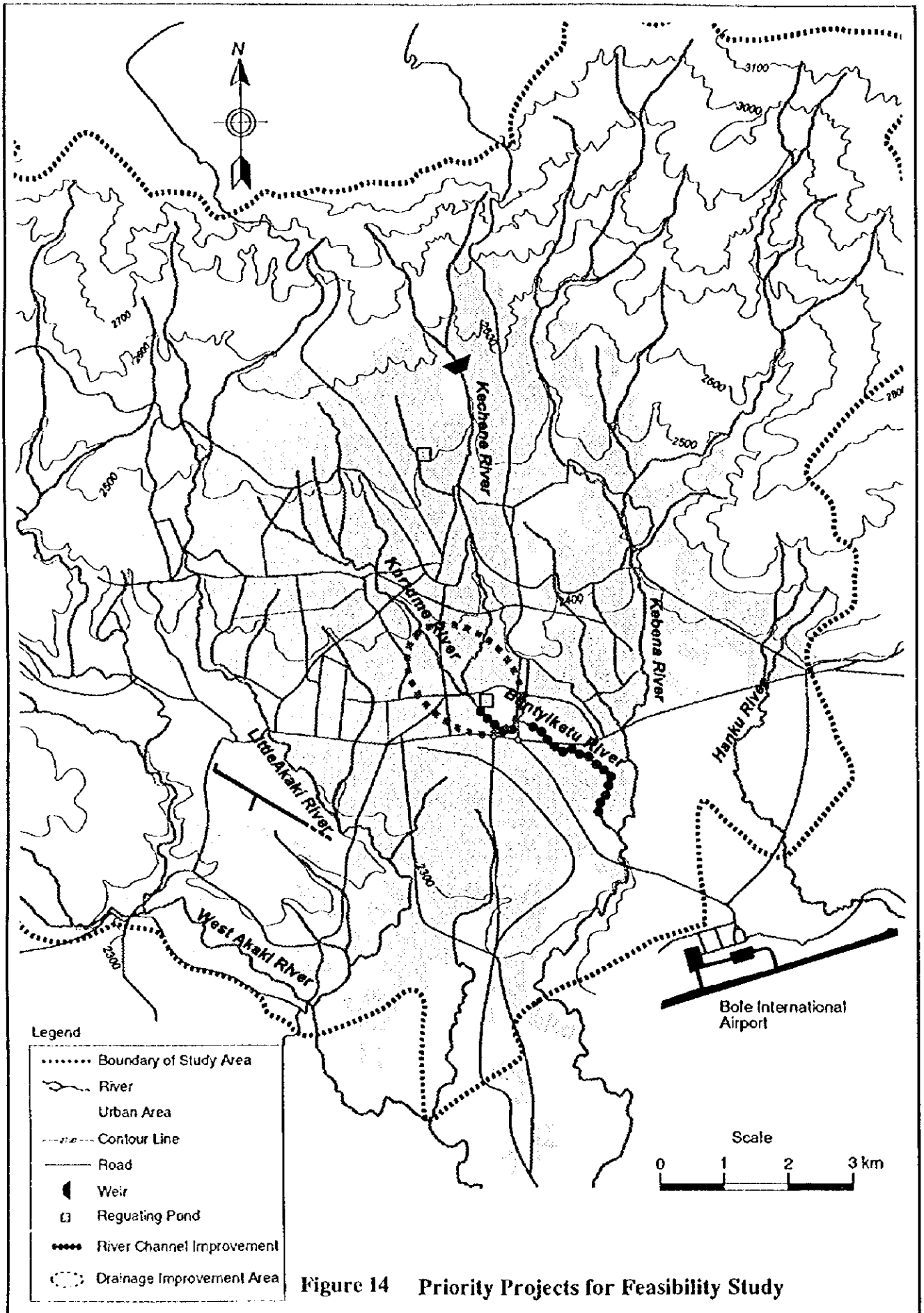


Figure 14 Priority Projects for Feasibility Study

CHAPTER 6 FEASIBILITY STUDY ON PRIORITY PROJECTS

6.1 Basic Planning Conditions of Priority Projects

6.1.1 Flood Control Plan

(1) Objective Rivers and Stretches

Objective rivers of the priority projects are basically the Bantyiketu and the upper Kechene. Stretches of the lower Kebena and the lower Kechene rivers connecting to the Bantyiketu are incorporated into the plan from the viewpoint of transition.

a) Lower Kebena river: just upstream of the Bole road bridge
b) Bantyiketu river: the confluence with the Kebena river - Filwiha bridge
c) Lower Kechene river: just upstream of Kechene 2nd bridge
d) Upper Kechene including Kostre river: respective proposed sites of weir and pond

(2) Design Discharge Distribution

Design discharges of the priority projects have been estimated in the Phase I Study with 30-year probable flood for the Bantyiketu (and Kebena rivers,) and 20-year probable flood for Kechene river.

(3) Non-structural Measures

The non-structural measures proposed in the priority projects are 1) authorization of river zone and 2) social education for river and flood from the viewpoint of river management, and 3) flood warning system, and 4) flood fighting system in the viewpoint of flood risk management.

6.1.2 Urban Drainage Plan

(1) Drainage Areas

The objective area of urban drainage is the run-off basin which drains to the Bantyiketu river in the reaches from the Finfine bridge up to the Filwiha bridge corresponding to the confluence of the Kechene and Kurtume rivers. Based on the field reconnaissance, the outline network of the existing drainage system in the objective area is estimated from the locations of street inlets along the main streets found in the field.

(2) Drainage Problems

The street inlets along the streets in the objective areas are limited in numbers and their sizes are not sufficient. The inlets are clogged with various garbage and soil at places. As a result, greater part of the run-off in the objective areas flows on the streets and is collected into the low-lying area around the Addis Ababa Stadium and Abiot Square. Due to the insufficient conditions of the drainage facilities to the Bantyiketu river the collected water becomes stagnant and blocks the traffic in the center of the Addis Ababa often in rainy seasons.

The collected water becomes stagnant near the Finfine National Restaurant due to the reasons that street inlets with curb opening are insufficient in numbers and size.

(3) Basic Concept

Basic concept on drainage plan prepared here is that the drainage facilities are to be additionally constructed to the existing drainage facilities to decrease the inundation conditions in the objective area due to the insufficient conditions of the existing drainage facilities.

Rehabilitation of the existing drainage facilities may substantially decrease the present inundation conditions in the objective area. However, due to the lack of information of drawings of the present facilities, planning of the rehabilitation of the existing facilities could not be achieved in sufficient level. Besides, the project scale of the rehabilitation of the existing facilities may exceed the limited financial sources because all the existing facilities are constructed underground, and the costs of the inventory works and the demolishing works of present facilities may pile up too much.

The design discharge is to be determined on the condition that the rainfall intensity is 30 mm/hour corresponding to the return period of 1.5 years. Since the drainage improvement is to be achieved with additional drainage facilities, design runoff is to be drained by the existing facilities in combination with the planned additional facilities. Some portion of the runoff is to be drained by the existing facilities and the remaining portion is to be drained by the additional facilities.

6.2 Structural Measures

6.2.1 Flood Control Plan

(1) River Channel Improvement of Bantyiketu River

The design longitudinal profile of the Bantyiketu river is shown in Figure 15. The design riverbed gradient is determined to correspond with the present riverbed gradient as much as possible. The design high water level is obtained on the basis of water level calculation by Manning's formula using the design discharge. In the course of the calculation of the design high water level, standard cross sections are provided by location to make the design high water level adjusted within the average riverbank elevation with necessary free board. In compliance with these studies, the basic features of the river channel improvement are determined and summarized as follows.

Table 19 Basic Features of River Channel Improvement of Bantyiketu River

Reach No.	Distance (km)	Riverbed Gradient	Design Discharge (m^3/sec)	Features of River Channel	
				Width (m)	Depth (m)
1	From 1.42 to 2.06	1/140	170	17 / 25	3.6
2	From 2.06 to 3.34	1/140	170	18	3.6
3	From 3.34 to 3.99	1/125	145	15 / 31	3.6
4	From 3.99 to 5.15	1/140	145	16	4.1
5	From 5.15 to 5.26	1/140	175	17	4.1

Note: Distance is measured from the Bole railway bridge corresponding to the starting section of the river cross section survey.

The alignment of river channel is designed using the topographic maps with a scale of 1:2,000. The design of river channel alignment is carried out on the conditions that the present alignment is not to be modified in general but some heavy bending or eroded locations are to be improved to smooth alignment with floodwall or slope protection as required.

(2) River Channel Improvement of Lower Kebena and Lower Kechene

The bank slopes of the lower Kebena just upstream of Bole bridge are prone to bank erosion. Slope protection works are taken up in the said reach.

Just upstream of the 2nd bridge in the lower Kechene river, both river banks have been eroded and riparian areas are subject to inundation and washing away. Accordingly, this reach is protected by construction of floodwall.

The Lower Kechene river meanders significantly upstream from the 2nd bridge. Generally, at the outermost points of meandering sections, water rise is expected to take

place due to centrifugal force and in the Lower Kechene river, the water rise is estimated at about 1.5 meters for the design discharge ($85m^3/s$). However, the existing flow capacity of the Lower Kechene river far exceeds the design discharge and all houses along this stretch of the Lower Kechene river are built on banks more than 5 meters higher than riverbeds. Therefore, all houses situated at outermost points of meandering sections are considered to be immune from inundation caused by water rise due to centrifugal force, and no structural measures are conceived for such water rise.

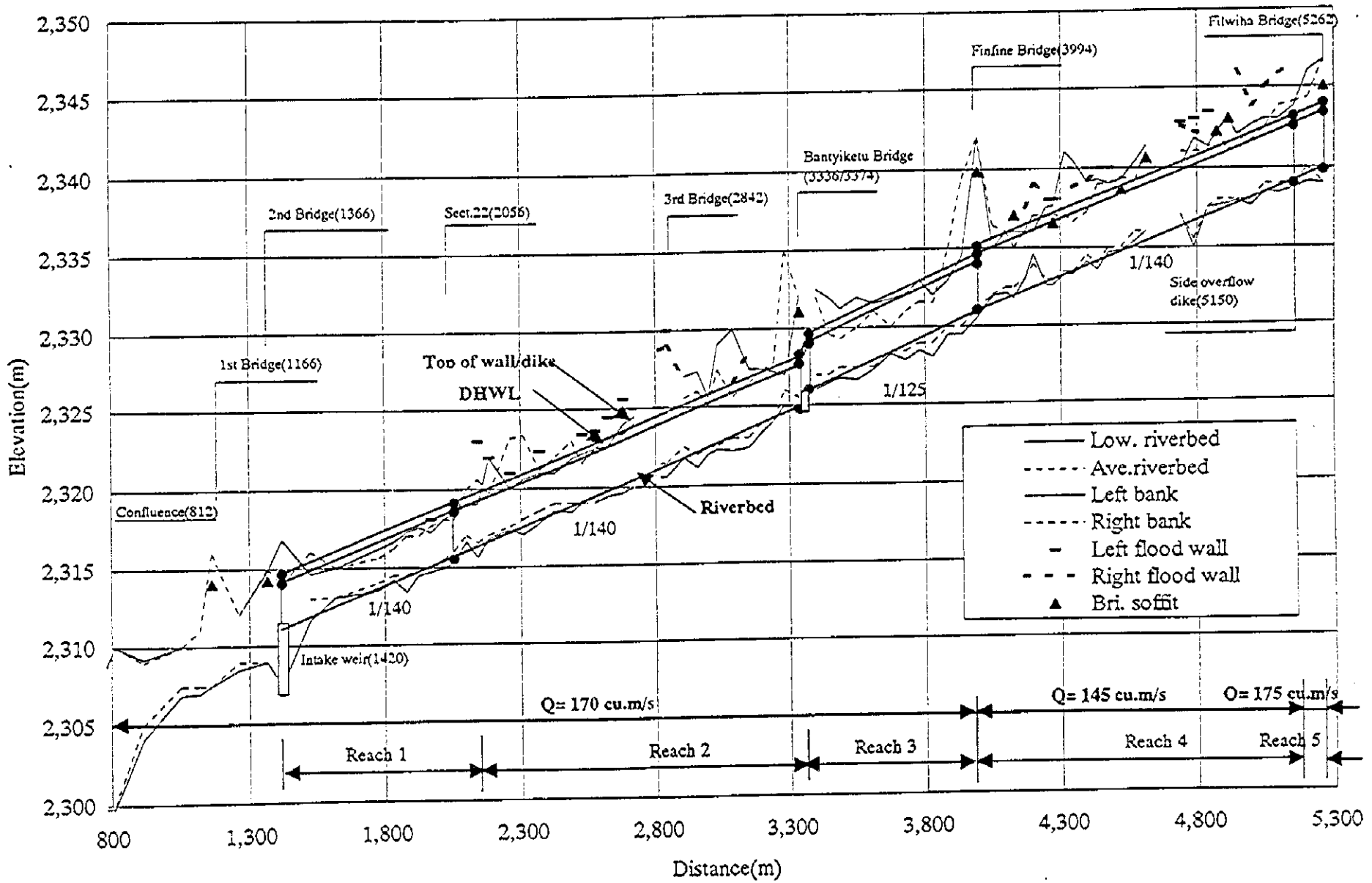


Figure 15 Longitudinal Profile of Bantyiketu River

(3) Bantyiketu and Kostre Regulating Ponds

The analysis is carried out to determine a required storage capacity of pond and dimensions (width and height) of lateral overflow section. Hydraulic calculation is therefore carried out on the basis of design river channel around regulating pond, and design discharges for river channel and lateral overflow section. As a result of hydraulic calculation, the basic design features of regulating pond are obtained as follows.

Table 20 Basic Features of Regulating Pond

Bantyiketu Regulating Pond			
1)	Design Discharge (Peak Discharge)	Probable 30-Year Flood	
		- Upstream River Channel	: 175 m^3/sec
		- Downstream River Channel	: 145 m^3/sec
		- Lateral Overflow	: 30 m^3/sec
2)	Lateral Overflow Section	Length : 50 m Height : 3.3 m	
3)	Required Storage	73,000 m^3	
Kostre Regulating Pond			
1)	Design Discharge (Peak Discharge)	Probable 20-Year Flood	
		- Upstream River Channel	: 28 m^3/sec
		- Downstream River Channel	: 14 m^3/sec
		- Lateral Overflow	: 14 m^3/sec
2)	Lateral Overflow Section	Length : 30 m Height : 4.5 m	
3)	Required Storage	26,000 m^3	

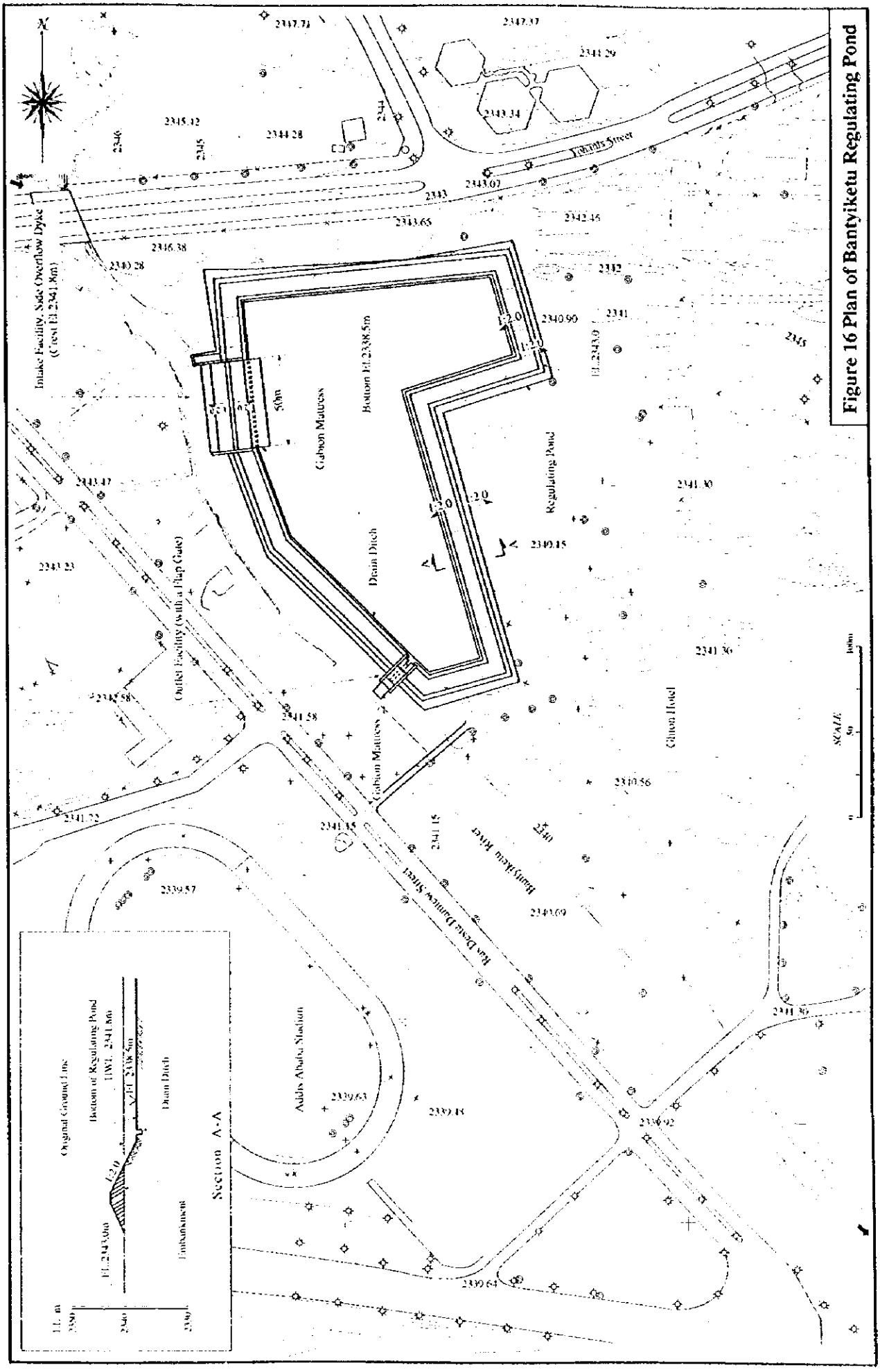


Figure 16 Plan of Bantyiketu Regulating Pond

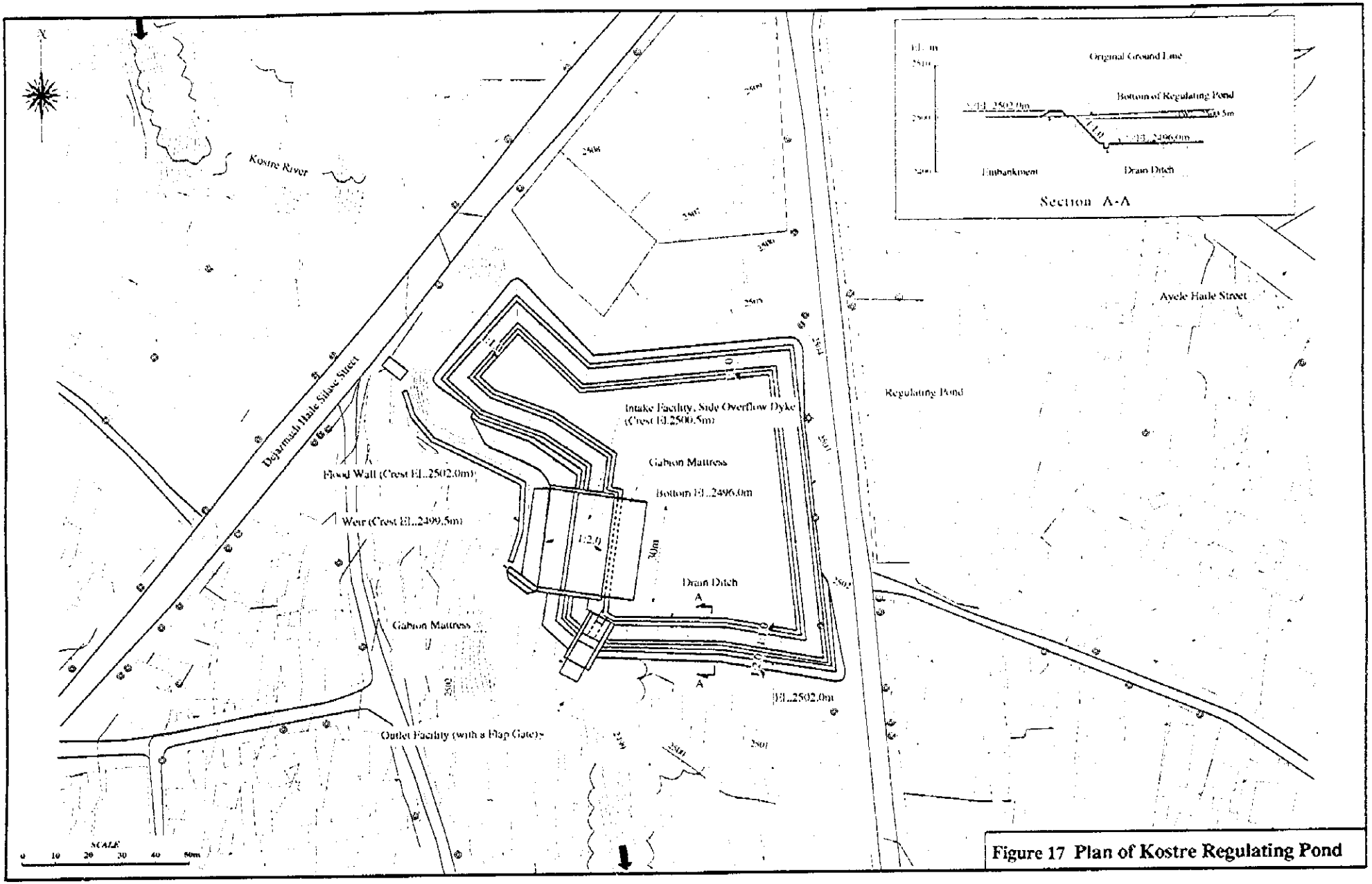


Figure 17 Plan of Kostre Regulating Pond

(4) Kechene Weir

The flood control storage of reservoir is examined by inflow – outflow calculation. The design flood hydrographs of probable 20-year and 30-year flood are applied as reservoir inflow for the calculation. A relationship between reservoir water level and storage is obtained from the topographic maps with a scale of 1/2,000.

For construction of weir, it is necessary to provide an overflow spillway discharging excessive flood from reservoir. The probable 200-year flood is applied as design capacity of overflow spillway. Width and depth of overflow spillway to be provided at the crest of weir are determined from this design discharge.

The results give the basic features of the Kechene weir as follows.

Table 21 Basic Features of Kechene Weir

Reletionship between Water level, Water Surface Area and Reservoir Storage

Water Level (EL. m)	2,495	2,500	2,505	2510	2,515
Surface Area (m^2)	115	4,096	9,331	17,013	31,127
Storage (m^3)	60	10,600	44,200	110,100	230,500

Flood Control Storage by Reservoir
Low Water Level of Reservoir : EL. 2,499 m
Orifice Outlet : 1.2 m×1.2 m, 3 nos., Invert Level EL. 2,499 m

Design Flood	Peak Discharge Inflow (m^3/sec)	Peak Discharge Outflow (m^3/sec)	Design Flood Water Level (EL. m)	Reservoir Storage (m^3)
Probable 20-year Flood	85	49	2,508.3	83,000
Probable 30-year Flood	91	50	2,509.0	96,000

Spillway
Crest of Overflow Spillway : EL. 2,509.0 m
Width of Overflow Spillway : 20 m

Design Flood	Peak Discharge (m^3/sec)	Water Depth of Overflow Discharge	Highest Water Level (EL. m)
Probable 200-year Flood	120	2.5	2,511.5

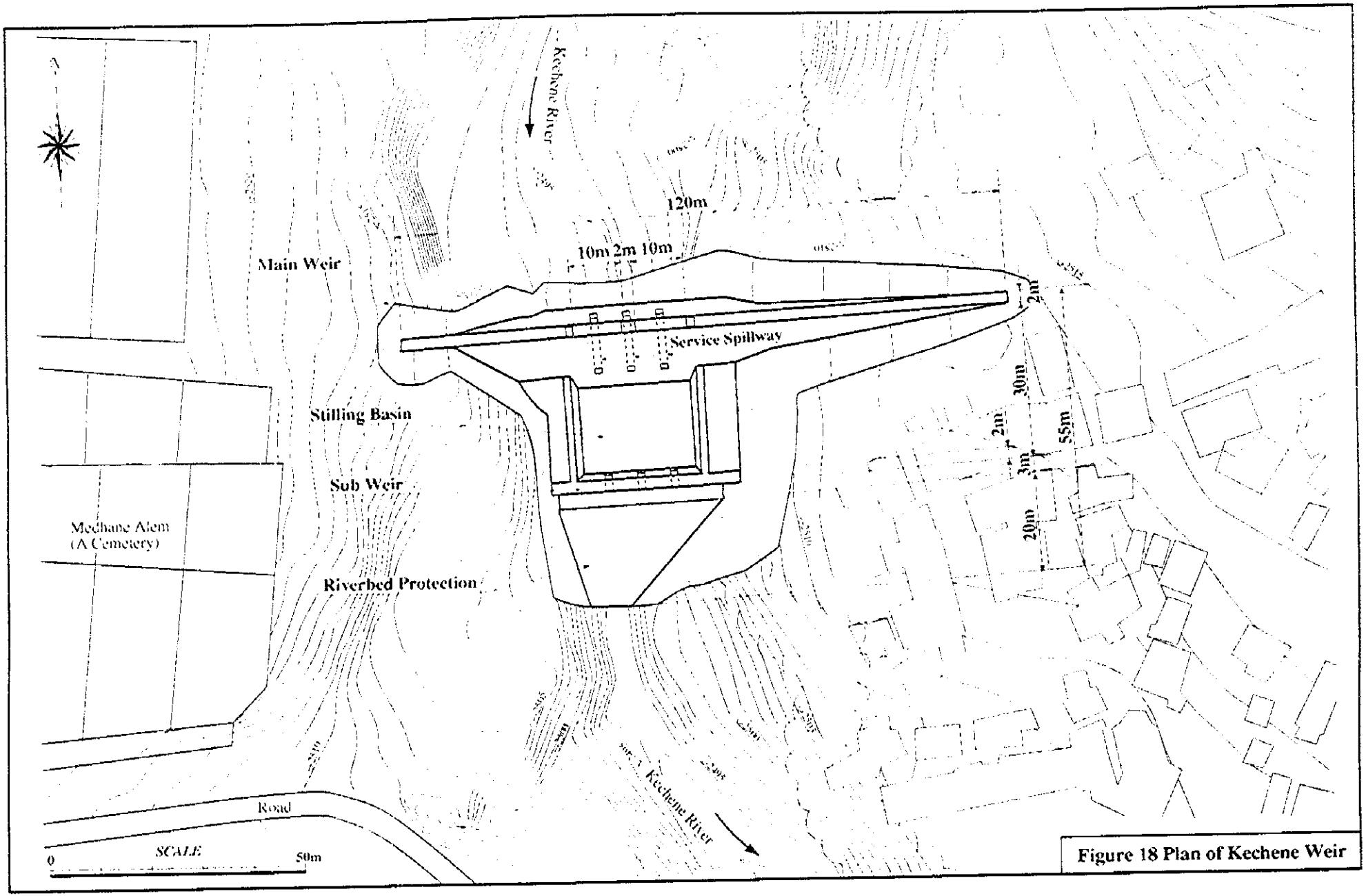
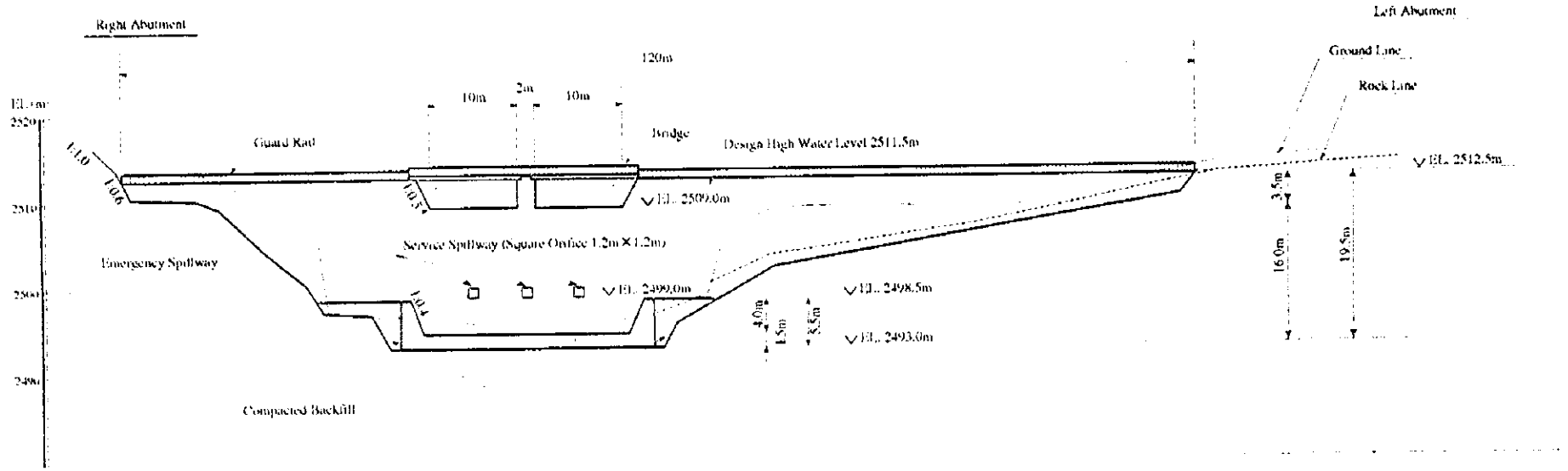
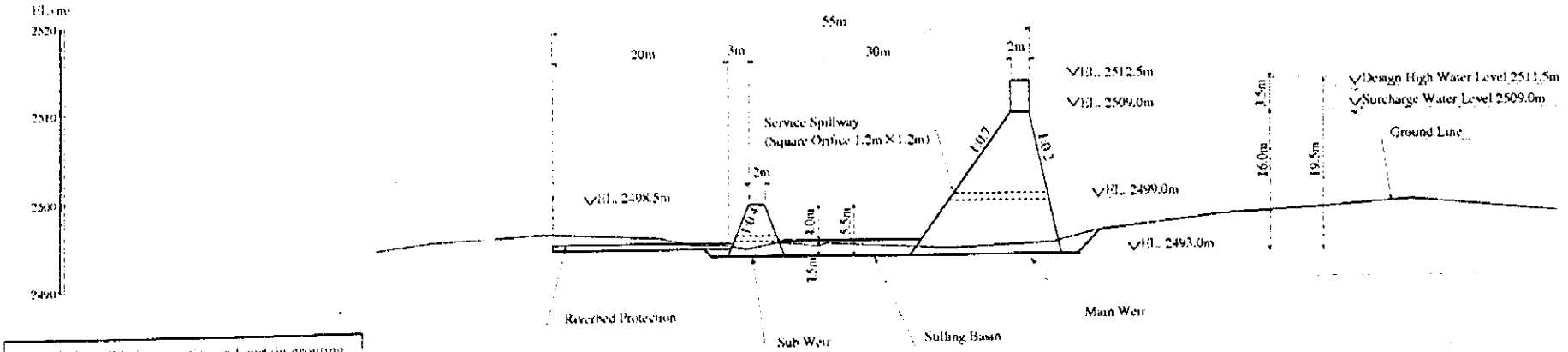


Figure 18 Plan of Kechene Weir

DOWN STREAM VIEW OF MAIN WEIR



LONGITUDINAL PROFILE



Note : Consolidation grouting and curtain grouting are to be applied to foundations if their necessity is substantiated by geological investigations.

Figure 19 Down stream View and Longitudinal Profile of Kechene Weir

6.2.2 Urban Drainage Plan

(1) Northern Basin

A drainage ditch with grating across the Churchil Avenue is planned on the northern side of the Saba Square. Then the trapped road surface water is planned to be leaded to the Kurtume river before flowing into the culvert under the Churchill Avenue. The design discharge for the new facilities is 0.7 m^3/sec.

(2) Eastern Basin

In the sub-basin-E1, a drainage ditch with grating across the Menelik II Avenue is planned on the northern side of the Finfine bridge. Then the trapped road surface water is planned to be leaded to the Bantyiketu river just at the bridge site. The design discharge for the new facilities is 0.7 m^3/sec.

In the sub-basin-E2, a drainage ditch is planned across the Yohanis Street and the road which meets the Yohanis Street in front of the Finfine National Restaurant, and the collected surface water is planned to be leaded to the Bantyketu river along the planned Bantyiketu regulating pond. In consideration of the existing conditions that the existing drainage pipeline is running underneath the planned regulating pond, the existing facilities need to be demolished and replaced with a new facility. Accordingly the design discharge for the new facilities is the design run-off from the objective run-off basin. The design discharge for the new facilities is 1.4 m^3/ssec.

(3) West-southern Basin

In the sub-basin-WS1, a drainage ditch with grating across the Ras Danitew Street is proposed about 125 meters southern side of the crossroads of the Yohanis Street and the Ras Danitew Street. This facility is to drain the run-off water to the Bantyiketu river on the upstream side of the Cottage Restaurant about 60 meters downstream of the confluence of the Kechene and Kurtume rivers. The design discharge for the new facilities is 1.5 m^3/s.

In the sub-basin-WS2, a drainage ditch with grating is planned across the street just northern side of the Addis Ababa Stadium, across the Ras Danitew Street, along the street and along the lane to the Addis Ababa Tennis Club to the Bantyiketu river. The design discharge for the new facilities is 1.5 m^3/s.

In the sub-basin-WS3, two drainage ditches with grating are planned; one across the street that meets the Ras Mekonin Avenue on the western side of the Abiot Square, across the Ras Danitew Street, and to the Bantyiketu river, the other across and along the Ras Mekonin Avenue. The latter ditch is to be connected to the street inlet that is presently located along the Ras Mekonin Avenue just over the drainage culvert

connected to the Bantyiketu river. The design discharges for the new facilities are 1.1 m^3/s for the former and 0.5 m^3/s for the latter.

(4) Summary of Urban Drainage Plan

The basic features of the urban drainage plan are summarized in Table 22. Locations of the proposed drainage facilities are shown in Figure 20.

Table 22 Summary of Urban Drainage Plan

Drainage Basin	Sub-basin	Drainage Area (km^2)	Design Discharge (m^3/sec)	Features
Northern Basin		0.25	0.7	- Drainage Ditch with Grating and Leading Channel to River - Width : 0.8 m - Depth : 0.6 m - Length : 65 m
Eastern Basin	E1	0.23	0.7	- Drainage Ditch with Grating and Leading Channel to River - Replacement of Existing Drainage Pipeline - Width : 0.8 m - Depth : 0.8, 1.0 and 1.2 m - Length : 17 m
	E2	0.25	1.4	- Drainage Ditch with Grating and Leading Channel to River - Width : 0.8 m - Depth : 0.8 m - Length : 452 m
	E3	0.25	-	(Drainage improvement not required)
West-southern Basin	WS1	0.53	1.5	- Drainage Ditch with Grating and Leading Channel to River - Width : 0.8 m - Depth : 0.8 m - Length : 110 m
	WS2	0.54	1.5	- Drainage Ditch with Grating and Leading Channel to River - Width : 0.8 m - Depth : 1.3 and 1.55 m - Length : 187 m
	WS3	0.39 (Western)	1.1	- Drainage Ditch with Grating and Leading Channel to River - Width : 0.8 m - Depth : 0.8, 1.0 and 1.2 m - Length : 138 m
		0.17 (Eastern)	0.5	- Drainage Ditch with Grating Connecting to Existing Culvert - Width : 0.8 m - Depth : 0.5 and 0.75 m - Length : 93 m

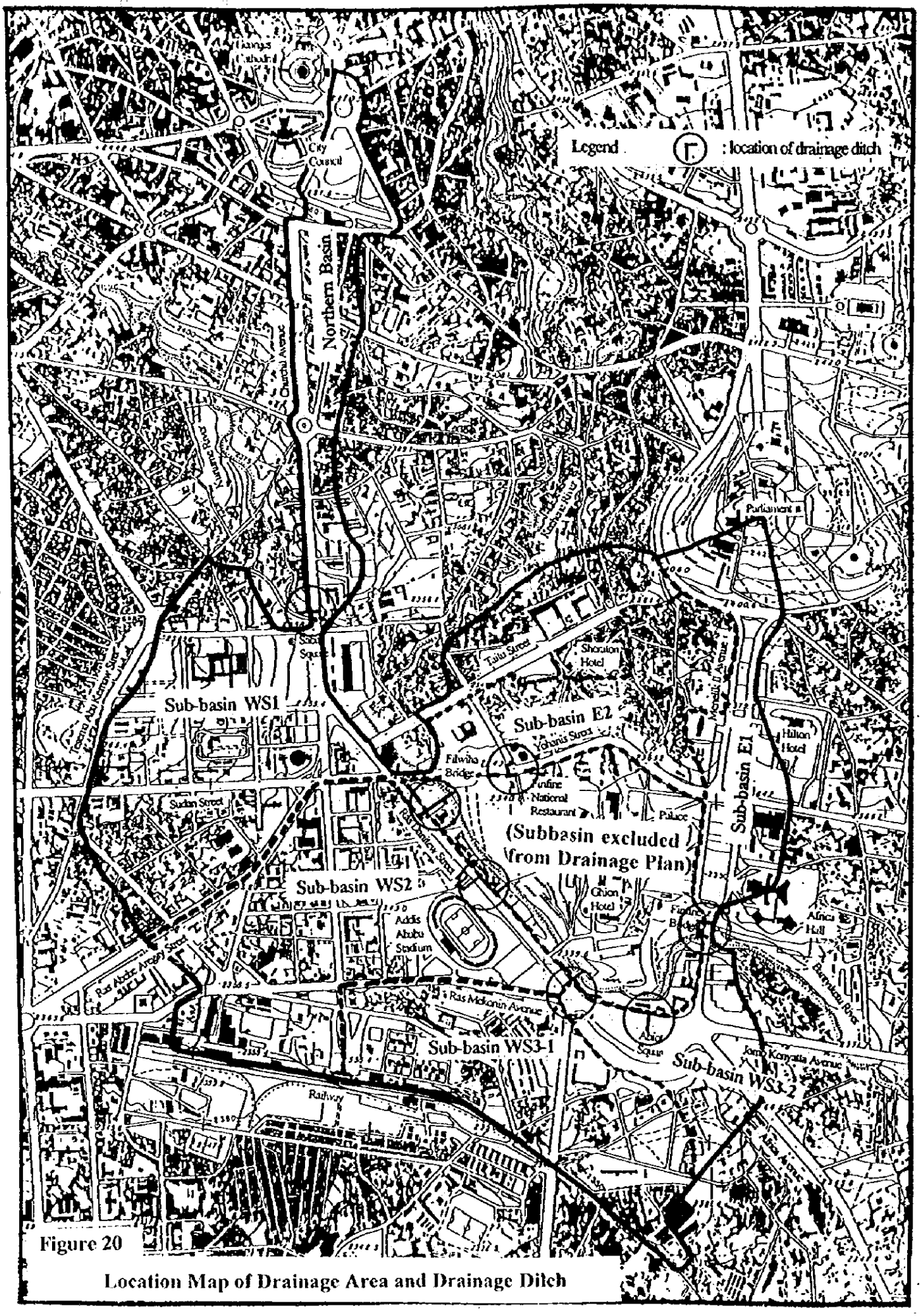


Figure 20

Location Map of Drainage Area and Drainage Ditch

6.3 Non-Structural Measures

The non-structural measures need to be supported by appropriate institutional systems in accordance with the regulations and institutions of the Region 14 Administration, and by wide participation of inhabitants in flood control and prevention activities. Institutional support is to be managed by the proposed Addis Ababa River Board (AARB) and the Addis Ababa River Management Authority (AARMA), discussed in the succeeding section 6.6, Organization and Institution.

(1) River Zone

The river zone is established to administrate and manage the rivers and river structures in proper conditions. Objective rivers and stretches for the river zone are proposed in compliance with the future expansion of the urban area estimated from the land use plan by the Addis Ababa Master Plan.

1) Objective rivers and stretches

a) Bantyiketu river system : from confluence with Kebena river to head water
b) Kebena river system : from Aba Samuel lake to head water
c) West Akaki river system : from Aba Samuel lake to head water
d) Little Akaki river system : from confluence with West Akaki to head water
e) Hanku river system : from confluence with Kebena river to head water

2) Cross-sectional boundary of river zone

The following are cross-sectional boundary of the river zone and shown in Figure 21.

a) In case without flood protection wall:
5 meters from present or proposed river bank line.

b) In case with flood protection wall:
5 meters from flood protection wall.

For the above purpose, an institutional support with bylaw is required for an overall river management system. River Management and O/M Division of AARMA is in charge of this matter. The following are required institutional support items.

a) Designation of the highest responsible administrator (President) in the river management for rivers and river structures,
b) Rivers, river stretches and river widths to be designated,
c) Regulation of land use in the riverine area,
d) Permission system for utilization and construction of facilities in the river zone, and

e) Regulation and penalty for illegal activities such as utilization of river zone without permission, garbage and soil dumping.

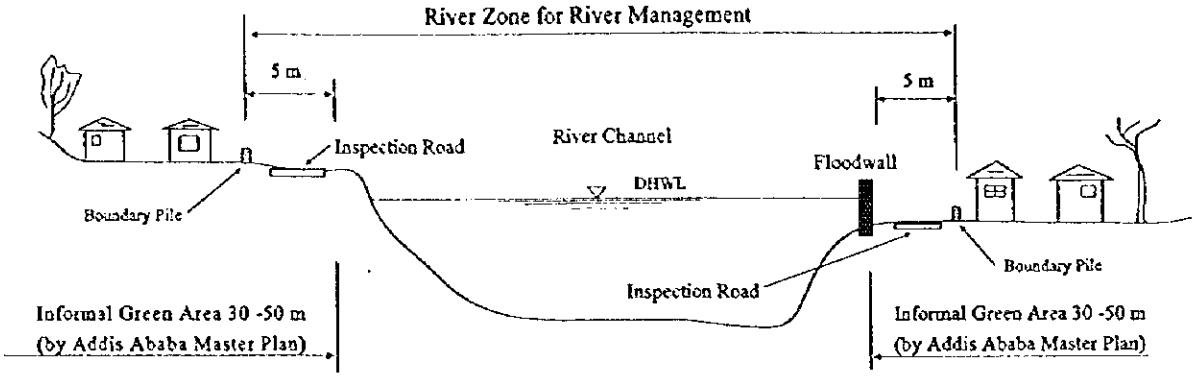


Figure 21 Concept of River Zone

(2) Social Education

At present, many illegal activities have been observed in the river areas. These are dumping garbage and soil to river areas, and utilization of river areas and construction of private facilities without permission. AARMA is newly to manage such illegal ones.

Kebele and each community are principally responsible for the social education that is directed by AARB and AARMA (mainly by Administration Division). The social education is, at all times, programmed with community organizations. The programs are as follows.

a) Seminar for community leaders,
b) Seminar for people in each community,
c) Campaign through TV and radio,
d) Designation of River Day and annual River Festival (Love River),
e) Annual demonstration of flood fighting activity and
f) Commendation system for outstanding community.

(3) Flood Warning System

In order to mitigate the damage due to flooding as much as possible, a simple flood warning system is setup in Survey and Investigation Division of AARMA. AARMA takes charge of issuance of warning under the direction of AARB. The warning system comes into force firstly in the concerned area of the priority projects, as a pilot one. Then, the system is one after another applied to other areas.

Warning is issued based on the rainfall amount observed at the 3 rainfall observatory stations to be newly installed in the mountainous area and information obtained from National Meteorological Services Agency. In addition, 3 staff gauges are installed in the Kechene and Bantyiketu rivers. AARMA (Manager) is to issue warning by siren in accordance with the flowchart as shown in Figure 22.

(4) Flood Fighting System

In order to mitigate the flooding damage during flooding, a flood fighting system is established. The flood fighting system consists of flood prevention works mainly for prevention of the damage due to overtopping by using sandbags and evacuation of the concerned people for emergency case. In the same manner with the flood warning system, the flood fighting system is initiated in the concerned areas of the priority projects.

Each community of Kebele principally operates the system under the direction of AARB and AARMA (mainly by Survey and Investigation Division), as shown in Figure 23.

For this purpose, existing community organizations are assigned to this system as flood fighting teams. These communities actually operate the fighting system on the sites in cooperation with other organizations concerned such as NGO and Wereda Disaster Relief Cell. Participation of inhabitants is an essential requisite for this system and self-defense by communities is a basic factor of this system.

A communication and information system among AARMA (mainly by Survey and Investigation Division), Zone/Wereda, Kebele and each community is established. In order to operate the system effectively, periodical demonstrations (training) of the flood fighting system are required from the viewpoint of popularization and sustainability.

In the riparian areas, 5 storage houses for flood fighting are installed to keep necessary materials and equipment for activity use.

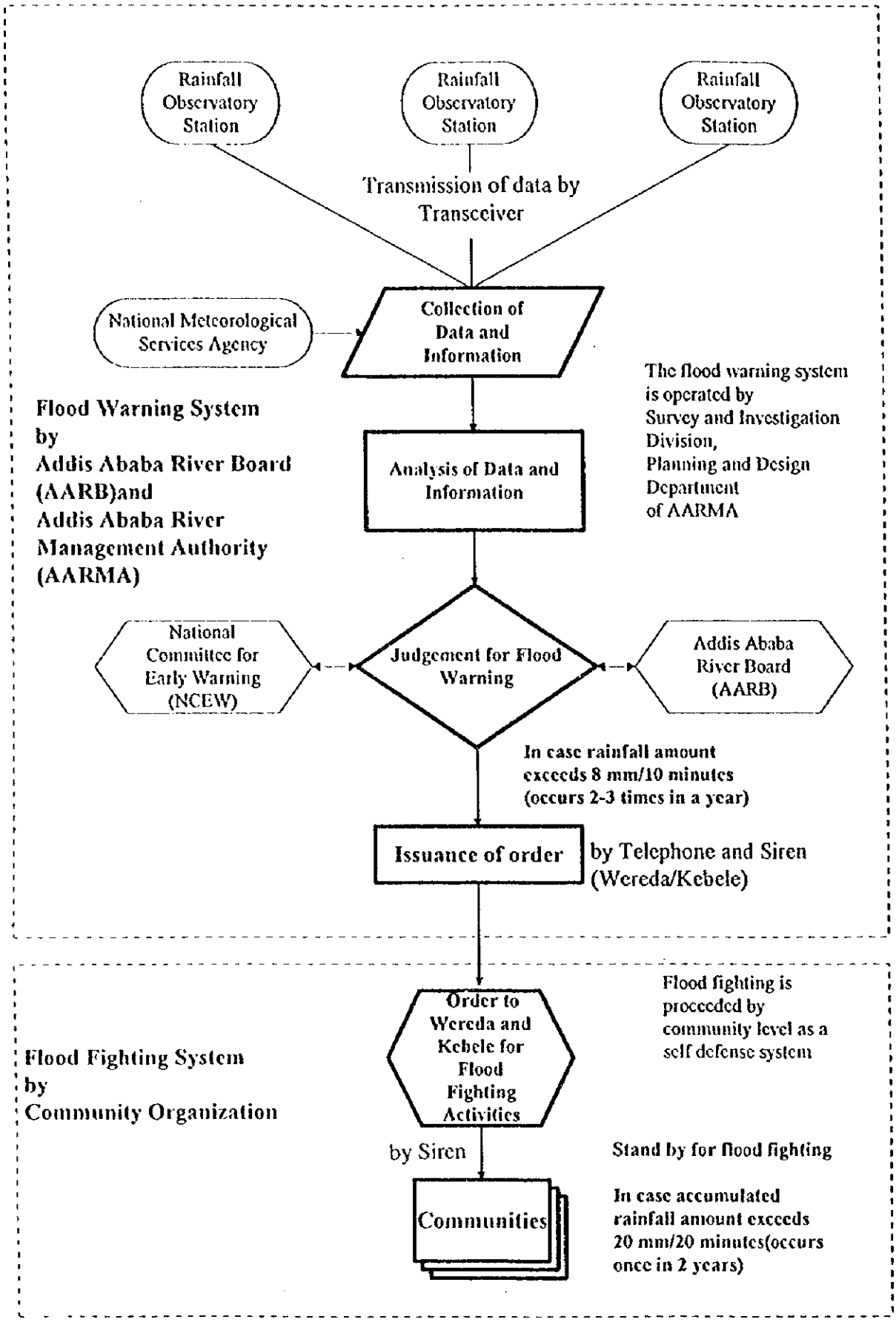


Figure 22 Outline of Flood Warning System

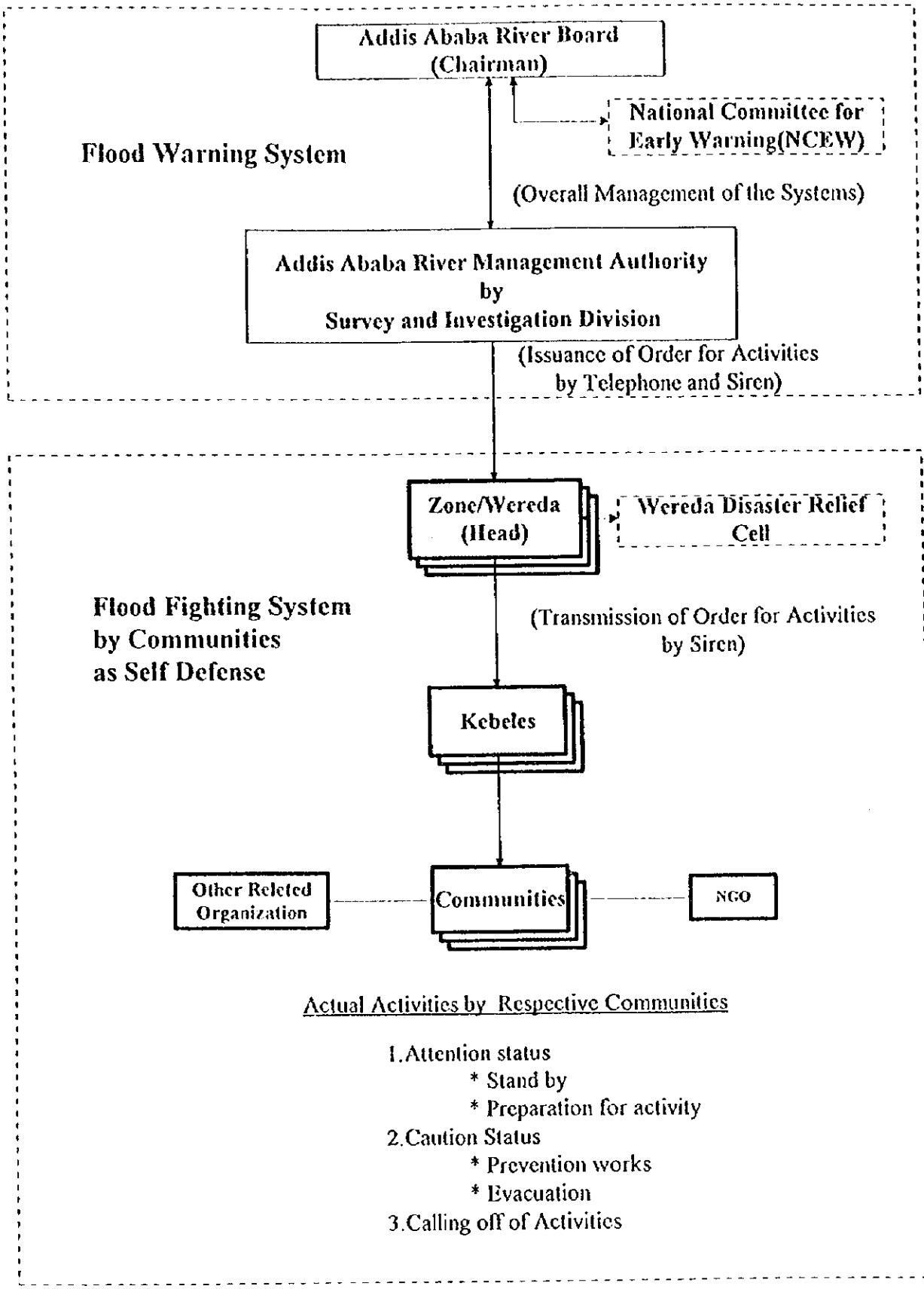


Figure 23 Community Organization and Communication Chart for Flood Fighting

6.4 Project Cost

Initial investment cost for structural measures comprises 1) construction cost, 2) engineering service cost, 3) resettlement cost, 4) administration cost, 5) physical contingency and 6) price contingency. Initial investment cost for non-structural measures comprises 1) installation cost, 2) administration cost, 3) physical contingency and 4) price contingency. Annual operation and maintenance (O&M) cost comprises those of structural measures and non-structural measures.

Project cost is estimated US$ 15,360 thousand (equivalent to Birr 104,448 thousand). The costs for structural measures and for non-structural measures are estimated US$ 14,736 thousand (equivalent to Birr 100,205 thousand) and US$ 624 thousand (equivalent to Birr 4,243 thousand) respectively. Breakdown of the project cost is given in Table 23.

Annual operation and maintenance cost is estimated US$ 69 thousand (equivalent to Birr 469 thousand). The costs for the structural measures and for the non-structural measures are estimated US$ 40 thousand (equivalent to Birr 272 thousand) and US$ 29 thousand (equivalent to Birr 197 thousand) respectively.

Annual disbursement schedule is given in Table 24.

Table 23 Summary of Project Cost

(Unit: US$, thousand)

Item	F.C.	L.C.	Total
Structural measures			
1. Construction cost			
1) Kechene weir	724	1,700	2,424
2) Kostre regulating pond	405	397	802
3) Bantyiketu regulating pond	967	707	1,674
4) Bantyiketu river channel improvement			
- Flood wall	33	548	581
- Slope protection	635	495	1,130
- Channel excavation	224	128	352
- Associated works	0	103	103
Sub-total of 4)	892	1,274	2,166
5) Urban drainage improvement	1,338	321	1,659
Sub-total of 1.	4,326	4,399	8,725
2. Engineering services cost	1,780	61	1,841
3. Resettlement cost	0	30	30
4. Administration cost	269	749	1,018
Sub-total of (1. - 4.)	6,375	5,239	11,614
5. Physical contingency	635	526	1,161
Sub-total of (1. - 5.)	7,010	5,765	12,775
6. Price contingency	718	1,243	1,961
Total of (1. - 6.)	**7,728**	**7,008**	**14,736**
Non-structural measures			
1. Installation cost			
1) River zone	0	189	189
2) Flood warning system	64	92	156
3) Flood fighting system	3	79	82
4) Social education	0	5	5
Sub-total of 1.	67	365	432
2. Administration cost	3	49	52
Sub-total of (1. - 2.)	70	414	484
3. Physical contingency	7	41	48
Sub-total of (1. - 3.)	77	455	532
4. Price contingency	7	85	92
Total of (1. - 4.)	**84**	**540**	**624**
Total of structural and non-structural measures			
Project cost	**7,812**	**7,548**	**15,360**

Note: - Price level; June 1997, US$ 1.0 = Birr 6.8 = J.Yen 114.7
- Tax is included in the cost.

Table 24 Annual Disbursement Schedule

(Unit: US$, thousand)

Item	1998			1999			2000			2001			Total		
	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
Structural measures															
1. Construction cost															
1) Kechene weir	0	0	0	0	0	0	543	1,275	1,818	181	425	606	724	1,700	2,424
2) Kostre regulating pond	0	0	0	0	0	0	405	397	802	0	0	0	405	397	802
3) Bantyiketu regulating pond	0	0	0	0	0	0	484	354	837	484	354	837	967	707	1,674
4) Bantyiketu river channel improvement															
- 1 Flood wall	0	0	0	0	0	0	8	137	145	25	411	436	33	548	581
- 2 Slope protection	0	0	0	0	0	0	159	124	283	476	371	848	635	495	1,130
- 3 River channel excavation	0	0	0	0	0	0	56	32	88	168	96	264	224	128	352
- 4 Associated works	0	0	0	0	0	0	0	26	26	0	77	77	0	103	103
Sub-total of 4)	0	0	0	0	0	0	223	319	542	669	956	1,625	892	1,274	2,166
5) Urban development works	0	0	0	0	0	0	335	80	415	1,004	241	1,244	1,338	321	1,659
Sub-total of 1.	0	0	0	0	0	0	1,989	2,424	4,413	2,337	1,975	4,312	4,326	4,399	8,725
2. Engineering services cost	0	0	0	890	31	921	445	15	460	445	15	460	1,780	61	1,841
3. Resettlement cost	0	0	0	0	30	30	0	0	0	0	0	0	0	30	30
4. Administration cost	27	75	102	81	225	305	81	225	305	81	225	305	269	749	1,018
Sub-total of (1. - 4.)	27	75	102	971	285	1,256	2,515	2,664	5,179	2,863	2,215	5,077	6,375	5,239	11,614
5. Physical contingency	3	7	10	97	29	126	249	269	518	286	221	508	635	526	1,161
Sub-total of (1. - 5.)	30	82	112	1,068	314	1,381	2,764	2,933	5,697	3,149	2,436	5,585	7,010	5,765	12,775
6. Price contingency	1	5	6	65	39	104	256	560	816	395	639	1,035	718	1,243	1,961
Sub-total of (1. - 6.)	**30**	**87**	**118**	**1,133**	**352**	**1,485**	**3,020**	**3,493**	**6,513**	**3,544**	**3,076**	**6,620**	**7,728**	**7,008**	**14,736**
Non-structural measures															
1. Installation cost															
1) River zone	0	0	0	0	0	0	0	189	189	0	0	0	0	189	189
2) Flood warinig system	0	0	0	0	0	0	64	92	156	0	0	0	64	92	156
3) Flood fighting system	0	0	0	0	0	0	3	79	82	0	0	0	3	79	82
4) Social education	0	0	0	0	0	0	0	5	5	0	0	0	0	5	5
Sub-total of 1.	0	0	0	0	0	0	67	365	432	0	0	0	67	365	432
2. Administration cost	1	10	10	1	15	16	2	25	26	0	0	0	3	49	52
Sub-total of (1. - 2.)	1	10	10	1	15	16	69	390	458	0	0	0	70	414	484
3. Physical contingency	0	1	1	0	1	2	7	39	46	0	0	0	7	41	48
Sub-total of (1. - 3.)	1	11	11	1	16	17	75	428	504	0	0	0	77	455	532
4. Price contingency	0	1	1	0	2	2	7	82	89	0	0	0	7	85	92
Sub-total of (1. - 4.)	**1**	**11**	**12**	**1**	**18**	**19**	**82**	**510**	**593**	**0**	**0**	**0**	**84**	**540**	**624**
Total of structural and non-structural measures															
Project cost	**31**	**99**	**130**	**1,134**	**371**	**1,505**	**3,103**	**4,003**	**7,106**	**3,544**	**3,076**	**6,620**	**7,812**	**7,548**	**15,360**

Note: - Price level; June 1997, US$ 1.0 = Bht 6.8 = J.Yen 114.7
- Tax is included in the cost.

6.5 Construction Plan

6.5.1 Major Work Quantities

Major work quantities for structural measures are shown in Table 25.

Table 25 Major Work Quantities

Work Item	Unit	Weir (1 place)	Regulating Pond (2 places)	Flood Wall (1,200m)	Slope Protection (1,100m)	River Channel Excavation (2,000m)	Associated Works	Urban Drainage Improvement	Total
Excavation, soil	m3	6,200	98,600	0	0	10,500	0	7,200	122,500
Excavation, rock	m3	10,200	29,400	0	0	10,000	0	0	49,600
Concrete	m3	10,400	400	800	1,000	0	0	1,400	14,000
Reinforcing bar	kg	27,500	0	0	240,000	0	0	64,500	332,000
Wet masonry	m3	0	8,800	5,800	0	0	300	0	14,900

The following equipment, materials and facilities will be required for the non-structural majors.

1) Flood Warning System

a)	Rainfall gauge	:	3 sets
b)	Water level gauge	:	10 sets
c)	Walkie-talkie	:	8 sets
d)	Siren	:	10 sets
e)	Electric Line	:	5,300 m

2) Flood Fighting System

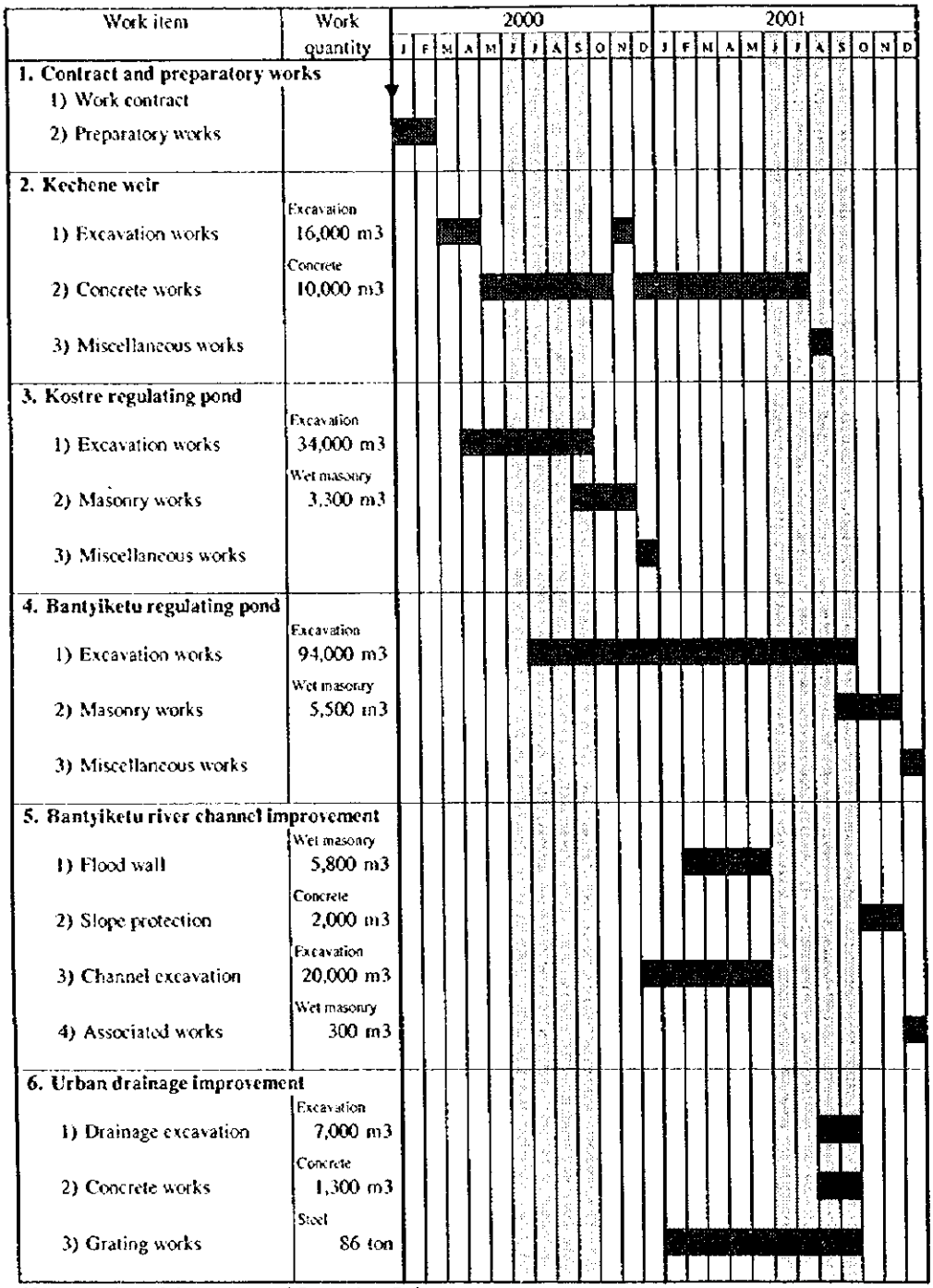
a)	Storage house with materials required for flood fighting	:	5 sets
b)	Walkie-talkie	:	5 sets

6.5.2 Construction Schedule

Construction works are scheduled to be commenced from the upstream site as follows, since upstream structures can eliminate flood damage in the downstream site during the construction and can also bring the project benefit earlier.

a) Construction works of the Kechene weir
b) Construction works of the Kostre regulating pond
c) Construction works of the Bantyiketu regulating pond
d) Channel improvement works of the Bantyiketu River
e) Urban drainage improvement works

It is supposed that construction work contract will be concluded at the beginning of 2000 and the whole of construction works will be completed at the end of 2001. It will take 2 years to complete the construction. Construction schedule is shown in Figure 24.



Note: - June, July, August and September: Rainy season
- Construction of upper facilities will be commenced prior to downstream facilities.

Figure 24 Construction Schedule

6.6 Organization and Institution

6.6.1 Organization for Project Implementation

The priority projects would be a pilot for flood control and damage mitigation measures in not only Addis Ababa but also Ethiopia. It is expected that through implementation of the priority projects, a lot of staff who can apply the basic technologies to the flood control and damage mitigation measures be provided to the country.

Required organizations including community level as a participation of inhabitants need to be established for an implementation of the priority projects and river management, and the subsequent projects in the master plan.

Figure 25 shows the proposed overall organization for project implementation. Figure 26 shows the proposed organization of Addis Ababa River Board and Addis Ababa River Management Authority.

(1) Addis Ababa River Board

Addis Ababa River Board to be newly organized is entirely responsible.

The President of Region 14 Administration designates and authorizes Addis Ababa River Board that is entirely responsible for project implementation of long, medium and short terms structural and non-structural measures on flood prevention, urban drainage, and resettlement in Region 14 Administration.

The President chairs the board that is organized by heads of the concerned Bureaus and Authorities of Region 14 Administration. Addis Ababa River Board takes charge of coordination with all relevant governmental agencies and regional organizations in implementing the project.

(2) Addis Ababa River Management Authority

A new organization of Addis Ababa River Management Authority needs to be established by reorganizing the existing AFCPO and assigning staff required for execution of the project and river management. Under the direction of the Addis Ababa River Board, Addis Ababa River Management Authority functions as the executing body of the project.

Addis Ababa River Management Authority is designated and authorized by Region 14 Administration that is responsible for implementations of river management, flood prevention and urban drainage projects, and resettlement with administrative power.

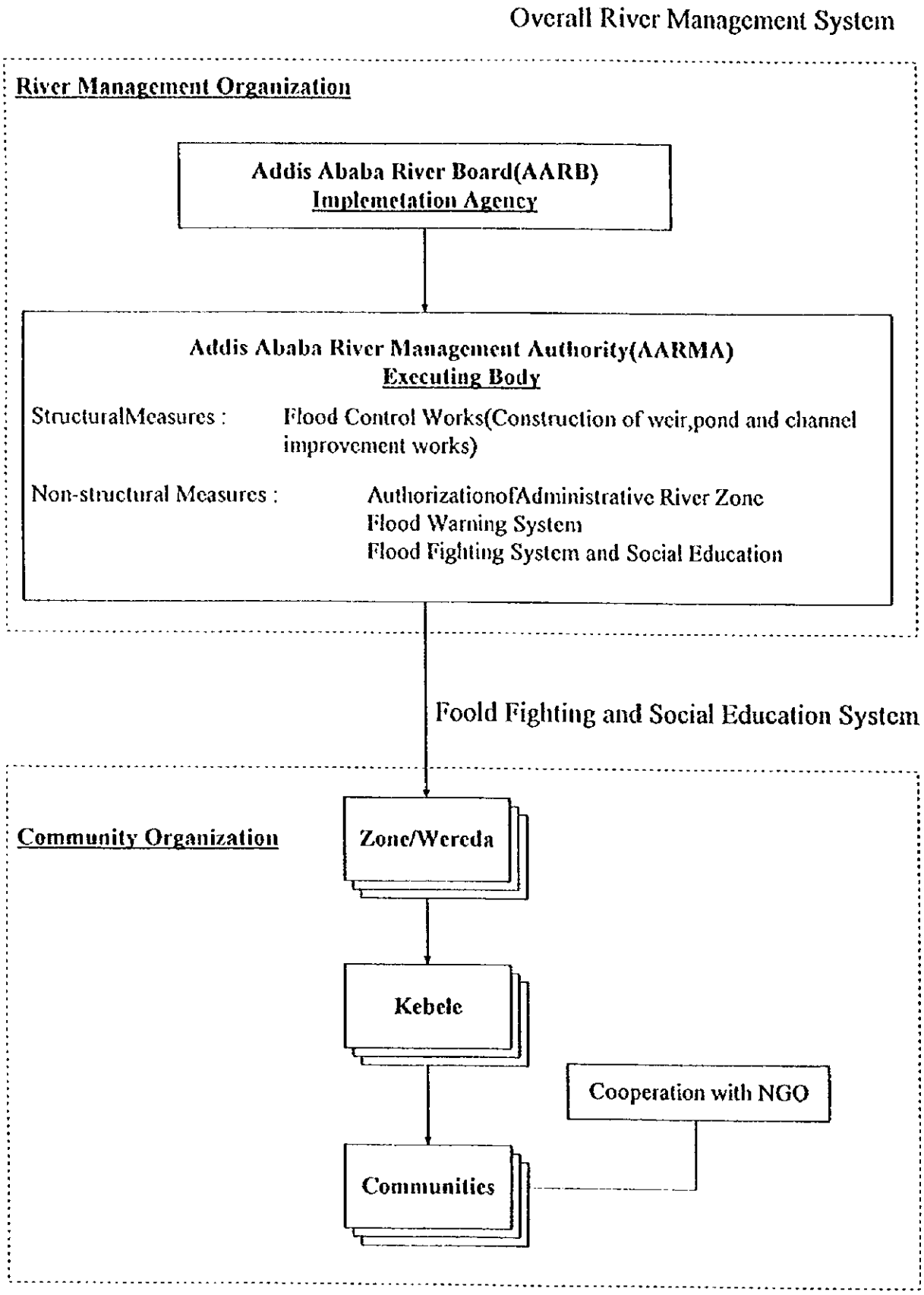
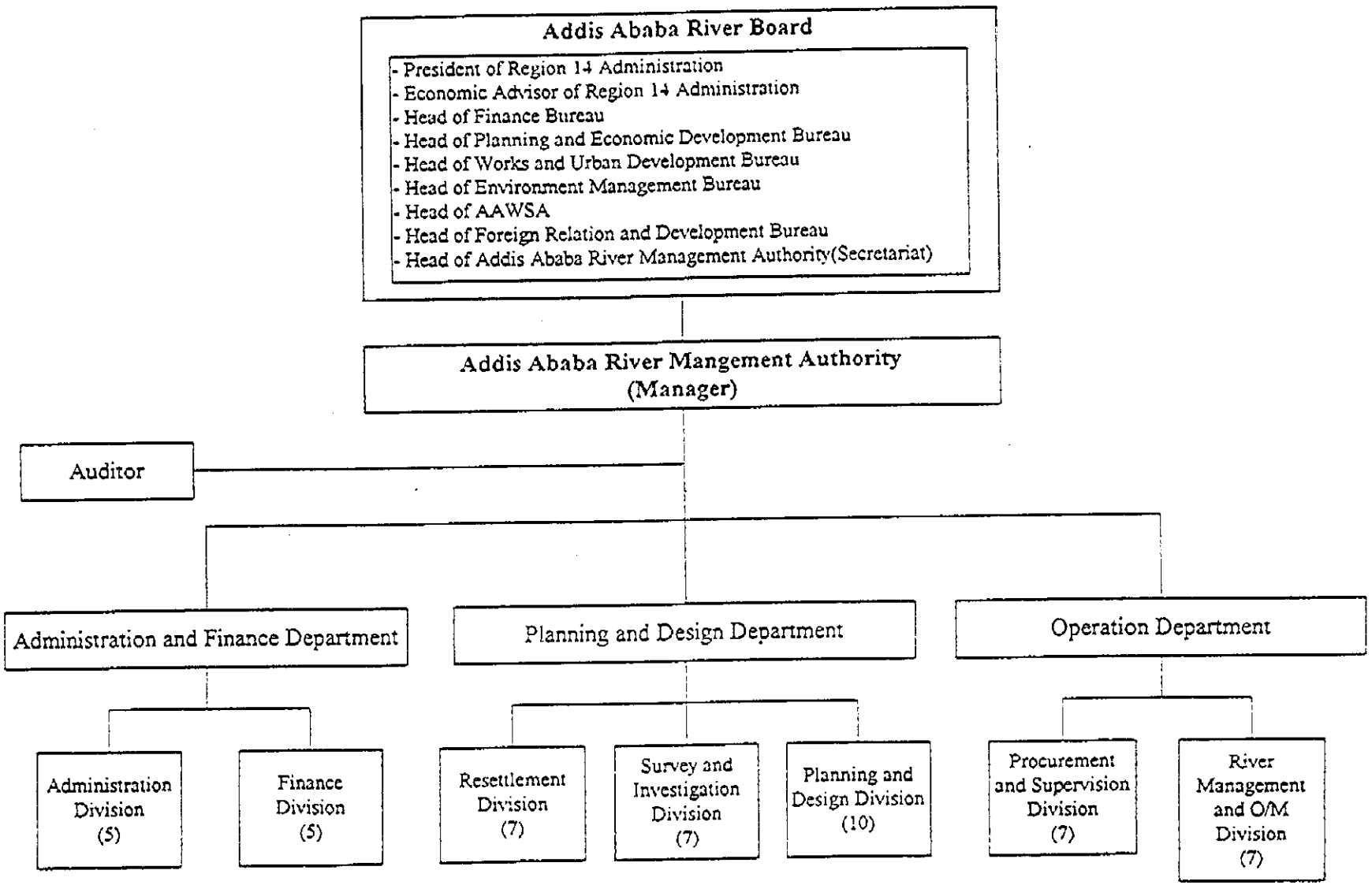


Figure 25 Overall Organization Chart for Project Implementation



Note; ( ) means required persons.

Figure 26 Proposed Organization of Addis Ababa River Board and Management Authority

This Authority is functionally and institutionally same with that of the Addis Ababa Road Authority of the Region 14 Administration. The budget is all covered by Region 14 Administration. Required personnel numbers will be around 50.

(3) Community Organizations

Available each community basically operates the flood fighting and social education systems in the non-structural measures, with guidance by AARB and AARMA. A participation of inhabitants is requisite for the system operations. For this purpose, required institutional support needs to be established in line with the regulations of Region 14 Administration.

6.6.2 Institutions for Non-Structural Measures

In addition to the institutional setup for the respective organizations required for project implementation, the following institutional systems are established for the non-structural measures.

(1) Institutions for River Zone and Social Education

For authorization of the river zone, an institutional support with bylaw is required for an overall river management system. The concerned law-section in the Region 14 Administration and AARMA, as executing body of the project which are directed by AARB, take charge of these institutional matters in accordance with the regulations of Region 14 Administration. The following are the required institutional support items.

a) For River Zone

- Designation of the highest responsible administrator (President) in the river management for rivers and river structures,
- Rivers, river stretches and river widths to be designated,
- Regulation of land use in the riverine area
- Permission system for utilization and construction of facilities in the river zone and
- Regulation of and penalty for illegal activities such as utilization of river zone without permission, garbage and soil dumping.

b) For Social Education

- Seminar for community leaders,
- Seminar for people in each community,
- Campaign through TV and radio,
- Designation of River Day and annual River Festival (Love River),
- Annual demonstration of flood fighting activity and
- Commendation system for outstanding community.

(2) Institutions for Flood Warning and Flood Fighting System

To operating the flood warning system needs required institutional system in relation with flood fighting system that is to be operated by community organizations.

From the above, the following major matters are authorized by the regulations and institutions of the Region 14 Administration.

a) For Flood Warning

- System and flowchart of information and warning
- Relationship with related organizations

b) For Flood Fighting

- Community organization for flood fighting,
- Communication system and flood fighting activities (flood fighting plan),
- Organization and responsibility of community (flood fighting team),
- Responsible administrator of each community (leader of flood fighting team),
- Annual training of flood fighting activities,
- Installation of storage house for flood prevention works,
- Designation of location of safety shelter and evacuation route in emergency case,
- Commendation system for outstanding community,
- Sharing of cost for activities and
- Opening of public hearing.

6.6.3 Operation and Maintenance

As described in the above section 6.6.2, AARMA under the direction of AARB is responsible for overall management for all completed river structures and established non-structural measures in the priority projects. Activity on operation and maintenance starts immediately after the completion of the priority projects. River Management and O/M Division in AARMA takes charge of operation and maintenance for completed works and non-structural measures.

The detail operation and maintenance manual for the priority projects will be prepared in due time of the subsequent detailed design stage.

6.7 Project Evaluation

6.7.1 Environmental Impact Assessment

Environmental impact assessment of the priority projects is prepared on the basis of the draft Environmental Impact Assessment Guideline prepared by the Environmental Protection Authority of the Federal Democratic Republic of Ethiopia and in consideration of the JICA guideline for the environmental impact consideration for development projects.

The project is evaluated that it will not have any negative impacts to natural environment. The project will not cause waste problem. The project will not affect areas with conservation-worthy fauna or flora or other especially vulnerable ecosystems since those are not existing along the objective reaches of the Bantyiketu river. The project will not affect areas with conservation-worthy objects or landscape since those are not existing. The project will not change the people's way of life. The project will not change the local people's use of other natural resources since there exist no natural resources along the river.

6.7.2 Social Impact Assessment

(1) Overall

The project is evaluated to have only positive impacts to the society during the operation stage since the project mitigates the habitual inundation conditions in the objective area reducing the inundation damage and accordingly reducing the possibility of infection to diseases and contributing to the cleanness of the city.

(2) Creation of Job Opportunity

Positive impact is also expected during the construction stage of the project. The project implementation will create job opportunity to local people. The implementation of the project needs more than 60 thousand man-day labors. Since the jobless rate in Addis Ababa is estimated at about 34.7% as of 1994 according to the Population and Housing Census of Ethiopia, this job opportunity has a significant level.

(3) Resettlement

Conceivable negative impact by the projects is resettlement mainly for the construction of the Kechene weir. Four houses are needed to move to other place since those houses area will be submerged during the design flood for retention function of the weir.

The compensation method is established in the Region 14 Administration. The responsible agency for the resettlement is Addis Ababa Flood Control and Prevention Project Office.

(4) Traffic Disturbance

Other negative impact by the projects during the constructions stage will be the disturbance of the traffic. The passage of heavy vehicles between the construction site and disposal area may create the heavy traffic volume along the road. The traffic volume for dumping soil is estimated at about 4,500 car-days. The traffic volume for transporting ready-mixed concrete by mixer car for the construction of Kechene weir is estimated at about 3,100 cars.

Besides, the construction of the drainage ditch across main streets is planned in the projects. The planned streets for the said structures have usually heavy traffic volume. But those streets have more than 4 lanes and it is possible to avoid one way traffic during the construction of the facilities.

Traffic control during the construction stage should be conducted with the cooperation of the traffic police.

(5) Air Pollution

Other conceivable negative impacts are air pollution by the passage of dump trucks. It is expected that the passage of dump trucks for the construction sites will cause a serious cloud of dust especially during the dry season. The mitigation measure will be watering on the road.

6.7.3 Economic Evaluation

(1) Flood Reduction Benefits

Benefits of flood control projects are estimated from difference of the flood damages between those with and without project. In other words, they are flood damage reduction benefits. The annual flood reduction benefits of the priority project have been estimated at 8.43 million Birr/year in 1997 and 13.58 million Birr in 2020, respectively.

(2) Economic Project Costs

The financial project costs have been converted into the economic project costs (accounting price) with the same manner as that applied for the evaluation of the flood control master plan. The economic project costs of both structural and non-structural measures are shown below.

Table 26 Economic Project Cost

Cost Item	Financial Cost (US$ 1,000)	Economic Cost	
		(US$ 1,000)	Equivalent in 1,000 Birr
1. Construction Cost	8,725	7,720	52,496
2. Resettlement Cost	30	26	177
3. Engineering Service Cost	1,841	1,655	11,254
4. Administration Cost	1,018	894	6,079
5. Sub-total of (1 - 4)	11,614	10,295	70,006
6. Physical Contingency	1,161	1,030	7,004
7. Sub-total of (5 - 6)	12,775	11,325	77,010
8. Cost for Non-structural Measures	532	465	3,162
9. Total of (7 - 8)	13,307	11,790	80,172

(3) Annual Operation and Maintenance Cost

Economic annual operation and maintenance costs for both structural and non-structural measures are estimated as shown below.

Table 27 Annual Operation and Maintenance Cost

Cost Item	Financial Cost (US$ 1,000)	Economic Cost	
		(US$ 1,000)	Equivalent in 1,000 Birr
1. Structural Measures	40	35	238
2. Non-structural Measures	29	25	170
3. Sub-total of (1 - 2)	69	60	408

The annual operation and maintenance cost includes annual reserve fund for replacement of mechanical and metal facilities such as gates after their lifetime (assumed 25 years) within the project life (50 years).

(4) Economic Evaluation

The cost-benefit analysis of the priority projects have been made by a cash flow analysis using three types of indicators, i.e. economic internal rate of return (EIRR), benefit cost ratio (B/C ratio), and net present value (NPV). Discount rate of 10% is assumed for calculation of B/C ratio and NPV. .

a) EIRR : 12.8%
b) B/C Ratio : 1.29
c) NPV : 16.43 million Birr

(5) Sensitivity Analysis

Sensitivity of the economic evaluation of the projects has been examined adopting increase in cost and decrease in benefit. The results of the analysis are shown below.

Table 28 Sensitivity Analysis

Sensitivity	EIRR (%)	B/C Ratio	NPV (1,000 Birr)
a) Base Estimate	12.8	1.29	16,434
b) Project Cost Increase of 15%	11.2	1.12	8,024
c) Benefit Decrease of 15%	11.0	1.10	5,559
d) Combination of b) and c) above	9.6	0.96	-2,852

(6) Results of Economic Evaluation

As a result of the economic evaluation including sensitivity analysis, the priority project has sufficient EIRR (12.8%), and its B/C ratio and NPV are also high. The projects can be judged economically feasible from the results.

6.7.4 Conclusions of Project Evaluation

It is concluded that the priority projects indicate sufficient viability for their implementation. With due consideration of the previous flood damages as experienced in 1978 and 1994, flood control projects are one of the urgent requirements for Addis Ababa. It is therefore recommended that the priority projects be realized at the earliest as a part of infrastructure development in Addis Ababa.

The projects show a fairly good economic feasibility with the economic internal rate of return (EIRR) of 12.8%. The beneficial population will be 470,000 people in the year of 2020, which is equivalent to 35% of the beneficiaries expected by the implementation of the flood control master plan. The beneficial area is also extensive at 43 km^2 covering the city center of Addis Ababa in terms of public services, commercial activities and transportation.

It is therefore foreseeable that these benefits will greatly outweigh potential negative impacts including a limited number of resettlement and some aspects during construction.

The annual disbursement of the project cost is estimated at 130, 1505, 7106, and 6620 thousand US$/year during the implementation period of 4 years. It appears to be acceptable for further budget allocation to flood control projects by the Region 14 Administration.

6.8 Implementation Plan

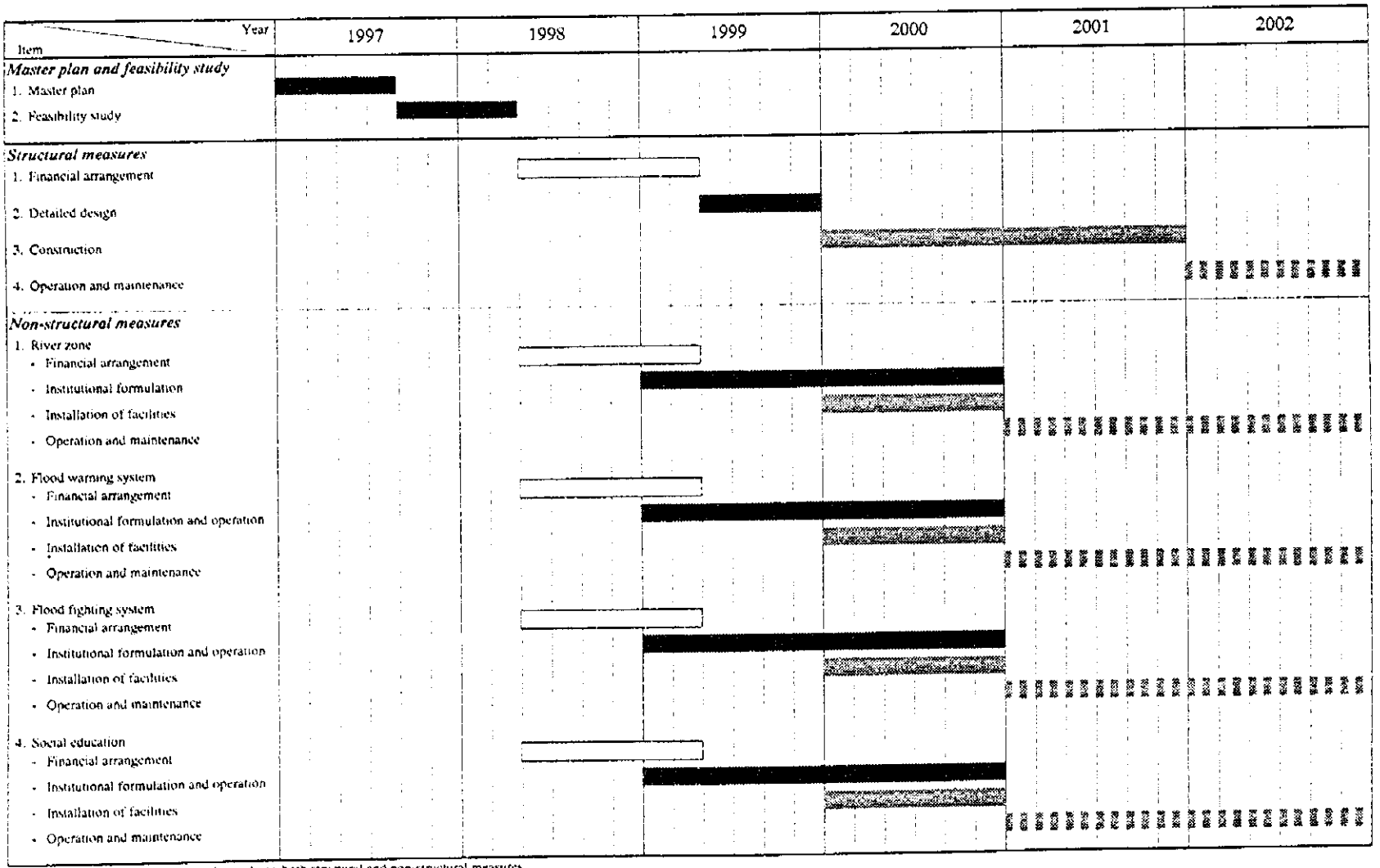
The implementation plan of priority project is formulated respecting that of master plan study.

Supposed that it is decided to implement the project just after this feasibility study, the implementation will be commenced from the year of 1999 after some period of financial arrangement.

Structural measures will be commenced with detailed design in the middle of 1999. The detailed design including tender for construction will be conducted for eight months. EIA (Environmental Impact Assessment), if required, and resettlement for construction works will be executed simultaneously with the detailed design. The detailed design including tender for construction will be finished end of 1999. After the detailed design, the construction works will be executed for two years. It will be commenced in the beginning of 2000 and will be completed end of 2001. Operation and maintenance will be carried out successively after the completion of the construction works from 2002.

Non-structural measures of river zone, flood warning system, flood fighting system and social education will be implemented simultaneously. The non-structural measures will be commenced with the formulation of institution in the middle of financial arrangement, under the yearly budget of present AFCPO, from the beginning of 1999. The institution will be formulated for two years from 1999. The facilities of non-structural measures will be installed within a year of 2000. The institutional formulation and the installation of facilities will be completed in the end of 2000. Operation and maintenance will be carried out successively from 2001.

Proposed implementation plan of priority project is shown in Figure 27.



Note: - Feasibility study includes the study on both structural and non-structural measures.
- EIA and resettlement are conducted simultaneously with the detailed design.
- Detailed design includes tender for construction.

Figure 27 Proposed Implementation Plan of Priority Project

6.9 Conclusions of Priority Projects

6.9.1 Structural Measures

(1) River Channel Improvement

• Bantyiketu River		
- Channel Excavation	20,500	m^3
- Embankment	400	m^3
- Floodwall	3,010	m^2
- Slope Protection	5,010	m^2
- Repair of Intake Weir	1	
- Improvement of Aqueduct	1	
- Protection of Sewerage Pipes	2	
• Lower Kebena River		
- Slope Protection	4,830	m^2
• Lower Kechene River		
- Floodwall	540	m^2
• Urban Drainage Improvement		
- Drainage Area	2.61	km^2
- Drainage Ditch	1,060	m

(2) Construction of Bantyiketu and Kostre Regulating Ponds

• Bantyiketu Regulating Pond		
- Reservoir Area	29,900	m^2
- Reservoir Volume	73,000	m^3
- Length of Lateral Overflow Dike	50	m
- Design Discharge of Lateral Overflow Dike	30	m^3/sec
• Kostre Regulating Pond		
- Reservoir Area	6,500	m^2
- Reservoir Volume	26,000	m^3
- Length of Lateral Overflow Dike	30	m
- Design Discharge of Lateral Overflow Dike	14	m^3/sec

(3) Construction of Kechene Weir

- Reservoir Area	20,000	m^2
- Reservoir Volume	88,000	m^3
- Weir Height : Non-overflow section	19.5	m
- Weir Height : Overflow section	16.0	m
- Crest Length	120	m
- Design Discharge of Orifice Outlet (1.2 m × 1.2 m, 3 nos.)	50	m^3/sec
- Design Discharge of Overflow Spillway (Width = 20 m)	120	m^3/sec

6.9.2 Non-structural Measures

(1) Authorization of River Zone

- Delineation of river zone covering river channel and extent of 5 meters from both river banks
- Legal arrangement for river management

(2) Social Education for River and Flood

- Enlightenment of public awareness for river and flood
- Popularization of flood warning and fighting to communities

(3) Flood Warning System

- Installation of rainfall gauges, water level gauges, electric lines and sirens
- Establishment of communication and information system for operation

(4) Flood Fighting System

- Institutional set-up self-defense activities by community organizations
- Establishment of communication and information system for operation
- Installation of 5 storage houses with materials required for flood fighting activities

6.9.3 Project Cost and Benefit

(1) Project Cost

- Structural Measures : 100.2 million Birr
- Non-structural Measures : 4.2 million Birr
- Total : 104.4 million Birr

(2) Benefit

- Beneficial Population : 470,000 people
- Beneficial Area : 43 km^2
- EIRR : 12.8 %
- B/C : 1.29

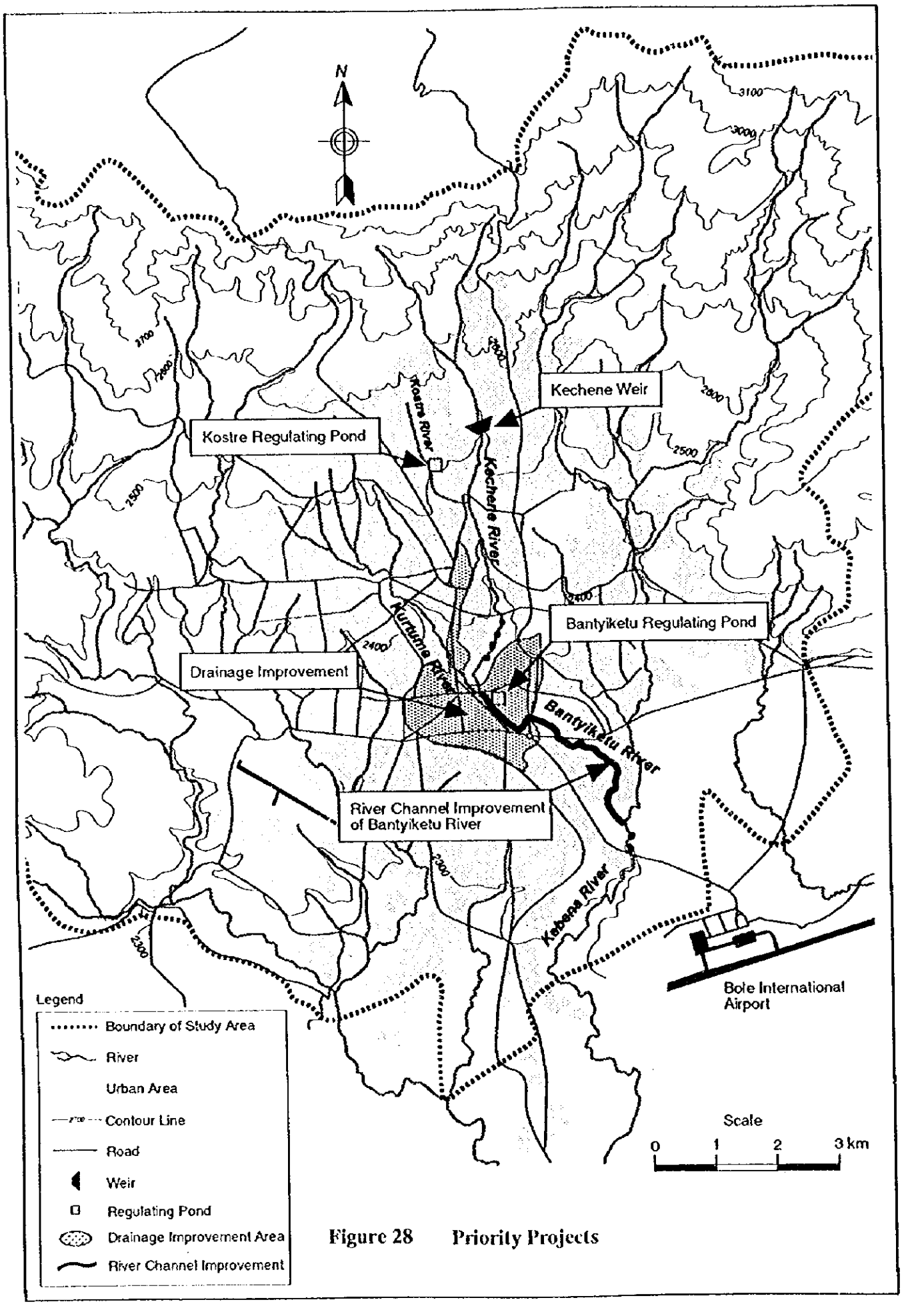


Figure 28 Priority Projects

CHPAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

(1) Advance toward Implementation of Structural and Non-structural Measures Contemplated by Master Plan

The amount of flood damages in the Region 14 Administration is soaring year by year with the drastic increase of population and infrastructures. It is recommended that the priority projects be first launched among projects proposed by the master plan, and that the rest of the master plan projects be continuously implemented according to the implementation plan of the master plan projects from the view point of local economic conditions and social welfare.

The master plan presumes 22 years as implementation period of the master plan projects from modest financial situation in Ethiopia. It is recommended that, with more ample budget appropriated for flood control projects, the implementation of the master plan projects be accelerated, keeping up with more rapid economic growth and improvement of infrastructures in Ethiopia.

(2) Early Implementation of Priority Projects

Flood control measures of the Bantyiketu river and the upper Kechene river are chosen for the priority projects. 11 % of total population of the Region 14 administration enjoy direct or indirect benefits created by the priority projects, and more intangible and unquantifiable benefits are expected. The priority projects indicate high economic viability with Economic Internal Rate of Return (EIRR) of 12.8 % and Benefit-Cost ratio of 1.29 and their early implementation is strongly recommended.

It is inevitable and almost compulsory that all structural measures contemplated by the priority projects are implemented as an integrated package, not stage-wise, in order to attain the anticipated goal of flood damage reduction.

(3) Early Establishment of Addis Ababa River Board (AARB) and Addis Ababa River Management Authority (AARMA) and Legislation for River Management

For the implementation of both structural and non-structural measures proposed by the priority projects, Addis Ababa River Board (AARB) and Addis Ababa River Management Authority (AARMA) are to be established as soon as possible.

Early legislation is also strongly emphasized as well as establishment of the two organizations. Especially, in connection with river management, flood warning and flood fighting, legislation has to cover various items such as 1) the status and responsibilities of and the rights entrusted to AARB and AARMA, 2) the duties,

responsibilities of and the rights entrusted to local organizations (Zone, Wereda, Kebele, communities etc.) and local people, 3) punitive measures.

(4) Reinforcement of Organizations by of Foreign Experts

Not only structural measures such as construction of a weir and regulating ponds, but also non-structural measures such as river management and flood risk management contemplated by the priority projects are quite new and challenging subjects to the Region 14 Administration.

Hence, it is recommended that foreign experts be assigned to provide AARB and AARMA with fundamental know-how required for construction supervision of the proposed structural measures and efficient implementation of the non-structural measures on a long-term basis.

(5) Restriction of Land Use along the West Akaki and the Kebena rivers in Southern Part of Study Area

According to the Addis Ababa Master Plan, urban areas of Addis Ababa are expanding toward the southern border zones of the Study Area where the West Akaki and the Kebena rivers penetrate. Hence, land use and development along the two rivers have to be strictly restricted to avert impending increase of flood damages.

(4) Collection of Climatological and Hydrological Data

At present, river channel improvement such as the construction of flood walls is often launched without support of proper hydrological analyses because of the lack of hydrological data. To enforce river management, flood warning and other non-structural measures contemplated by the priority projects in an effective manner, climatological and hydrological data such as rainfall, river discharges are essential. Hence, collection of these data is extensively stressed, with budget appropriation required.

ANNEXES

ANNEX-1 Gross Domestic Product

Year	At Current Market Price				At 1980/81 Constant Factor Cost			
	GDP		GDP Per Capita		GDP		GDP Per Capita	
	Amount (Million Birr)	Growth Rate	Amount (Birr)	Growth Rate	Amount (Million Birr)	Growth Rate	Amount (Birr)	Growth Rate
1980/81	10,079	-	278	-	9,325	-	258	-
1981/82	10,636	5.5%	285	2.4%	9,374	0.5%	251	-2.4%
1982/83	11,775	10.7%	307	7.5%	10,327	10.2%	269	7.0%
1983/84	10,988	-6.7%	278	-9.3%	9,676	-6.3%	245	-8.9%
1984/85	13,027	18.6%	320	15.1%	8,735	-9.7%	215	-12.4%
1985/86	13,575	4.2%	322	0.7%	9,597	9.9%	228	6.2%
1986/87	14,391	6.0%	331	2.6%	10,949	14.1%	252	10.4%
1987/88	14,971	4.0%	334	1.0%	10,948	0.0%	244	-2.9%
1988/89	15,742	5.2%	341	2.0%	10,986	0.4%	238	-2.7%
1989/90	16,826	6.9%	353	3.7%	11,433	4.1%	240	1.0%
1990/91	19,195	14.1%	390	10.4%	10,938	-4.3%	222	-7.4%
1991/92	20,792	8.3%	409	4.9%	10,535	-3.7%	207	-6.7%
1992/93	26,690	28.4%	509	24.4%	11,799	12.0%	225	8.6%
1993/94	28,355	6.2%	524	2.9%	11,999	1.7%	222	-1.5%
1994/95	34,063	20.1%	609	16.3%	12,644	5.4%	226	2.0%
Average Annual Growth Rate								
1984/85-1994/95 (last 10 years)	10.1%		6.7%		3.8%		0.5%	
1989/90-1994/95 (last 5 years)	15.1%		11.5%		2.0%		-1.2%	

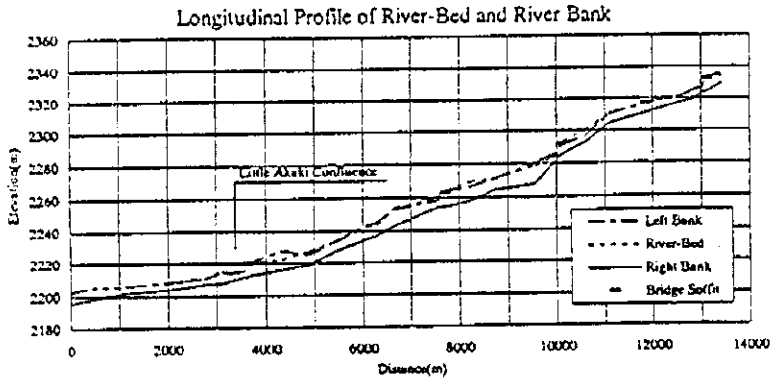
Source: National Account of Ethiopia, Revised Series, 1980/81 - 1994/95, MEDAC

ANNEX-2 Population in Urban and Rural Areas of Ethiopia and Addis Ababa

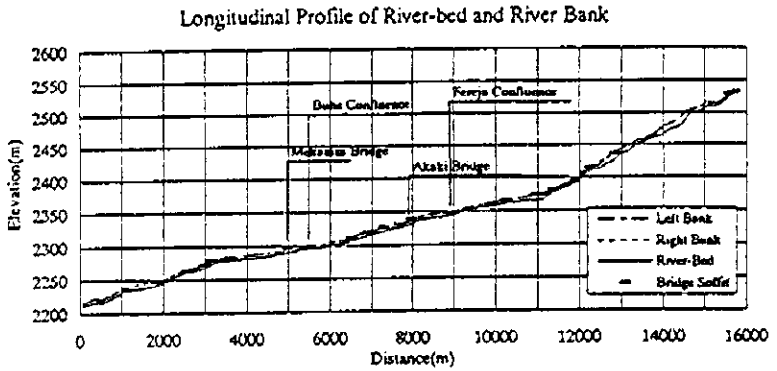
	Population (1,000 persons)			Growth Rate (%)	
	1978	1984	1994	78 - 84	84 - 94
Ethiopia					
Urban					
Male	1,761	2,282	3,985	4.4%	5.7%
Female	1,959	2,587	4,234	4.7%	5.0%
Total	3,720	4,869	8,219	4.6%	5.4%
Rural					
Male	13,123	19,155	23,593	6.5%	2.1%
Female	12,566	18,592	23,127	6.7%	2.2%
Total	25,689	37,747	46,720	6.6%	2.2%
Total					
Male	14,884	21,437	27,578	6.3%	2.6%
Female	14,525	21,179	27,361	6.5%	2.6%
Total	29,409	42,616	54,939	6.4%	2.6%
Addis Ababa					
Urban					
Male	554	685	1,009	3.6%	3.9%
Female	614	738	1,076	3.1%	3.8%
Total	1,168	1,423	2,085	3.3%	3.9%
Rural					
Male	-	-	14	-	-
Female	-	-	14	-	-
Total	-	-	28	-	-
Total					
Male	554	685	1,023	3.6%	4.1%
Female	614	738	1,090	3.1%	4.0%
Total	1,168	1,423	2,113	3.3%	4.0%

Source 1. Ethiopia Statistical Abstract 1978, 1995, CSA.
2. Population and Housing Census of Ethiopia, 1984, 1994, CSA.
3. Report on the Analysis of the Addis Ababa Demographic Survey, September 1978, Central Statistic Office

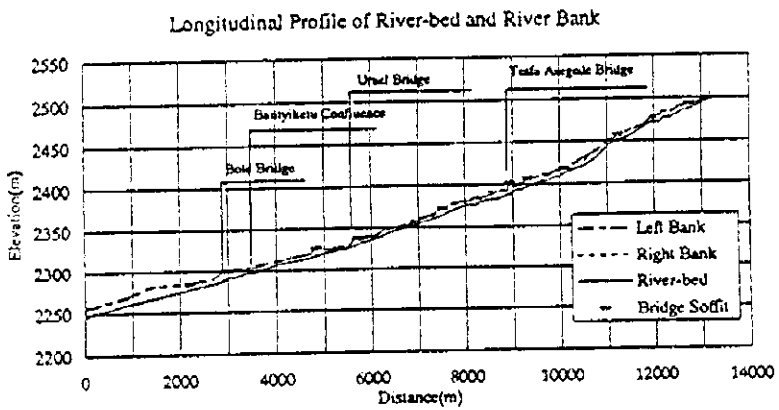
Note: Numbers of population of Ethiopia and Addis Ababa in 1978 are estimated figures based on mainly on the National Sample Survey Second Round (N.S.S.II 1969 - 1977)



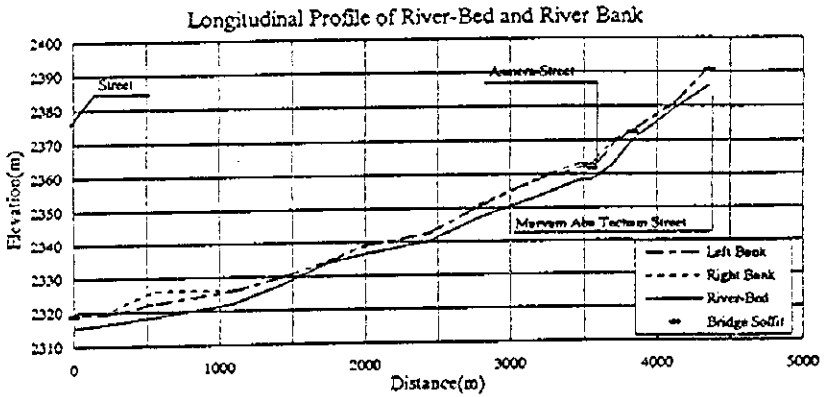
West Akaki River



Little Akaki River

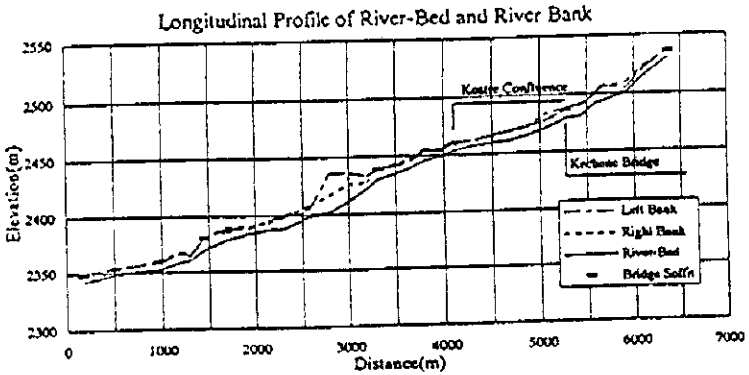


Kebena River

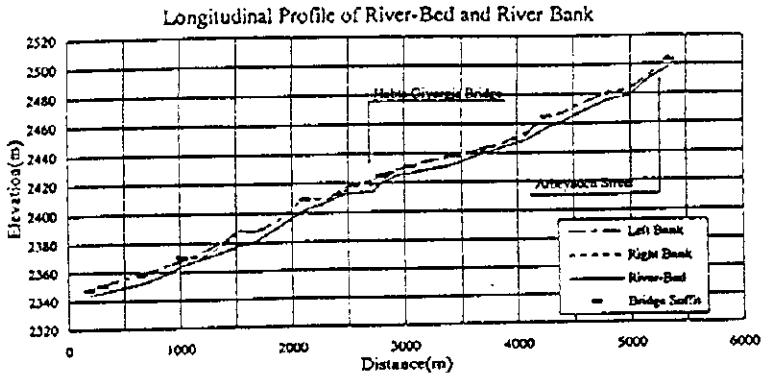


Hanku River

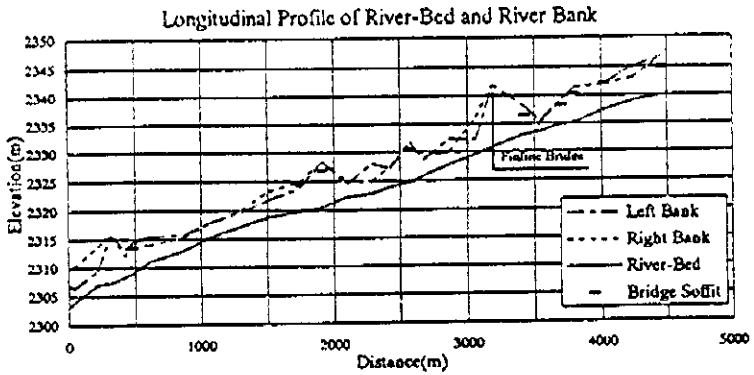
ANNEX-3 Longitudinal Profile of Rivers (1/2)



Kechene River

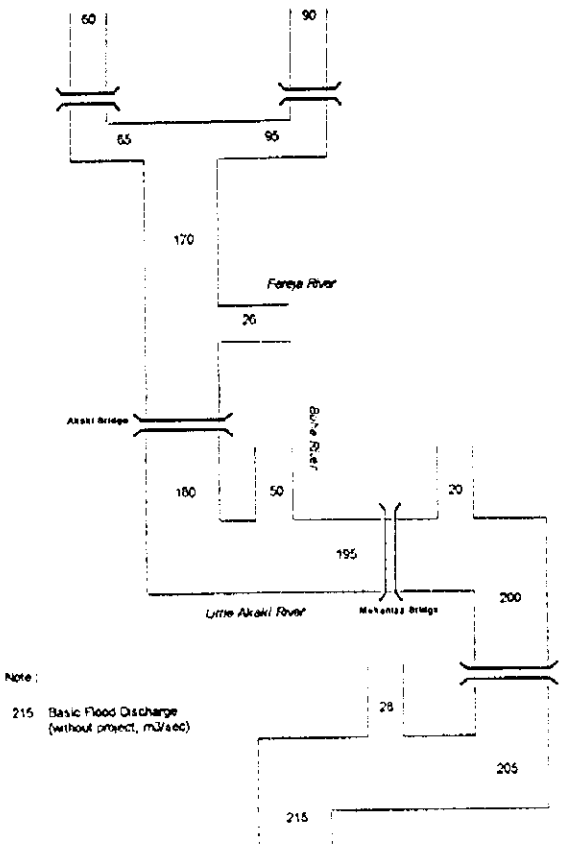


Kurtume River

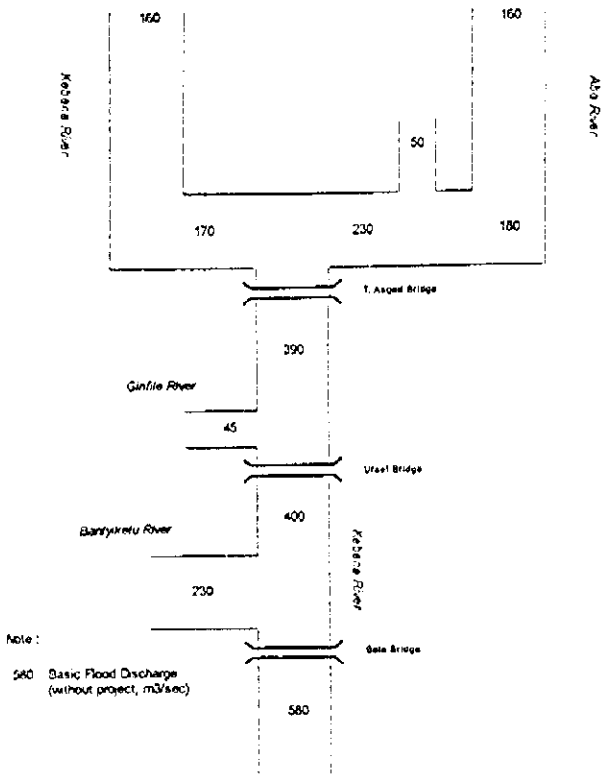


Bantyiketu River

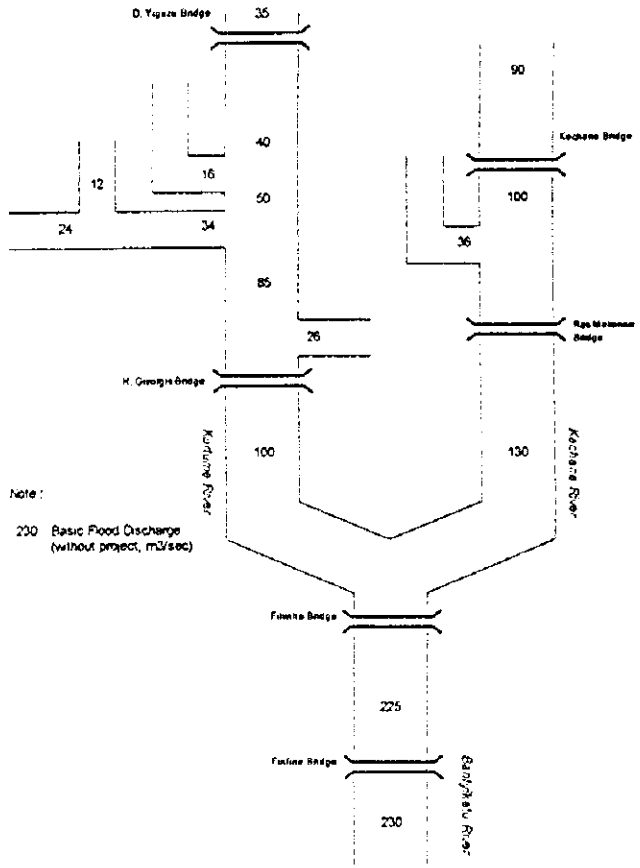
ANNEX-4 Longitudinal Profile of Rivers (2/2)



Basic Flood Discharge for Little Akaki River
(Return Period 30-year)

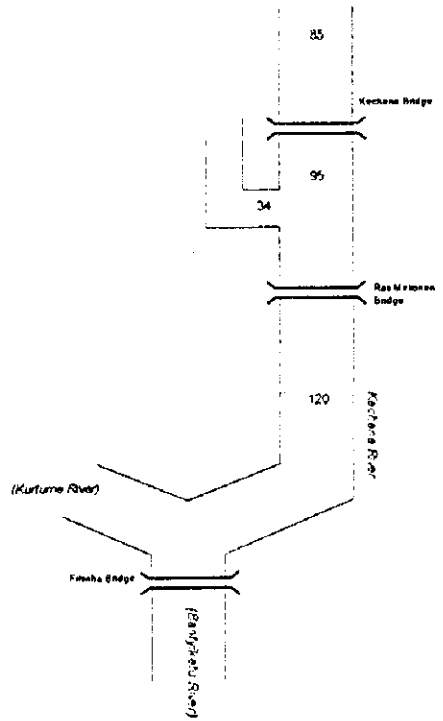


Basic Flood Discharge for Kebena River System
(Return Period 30-year)

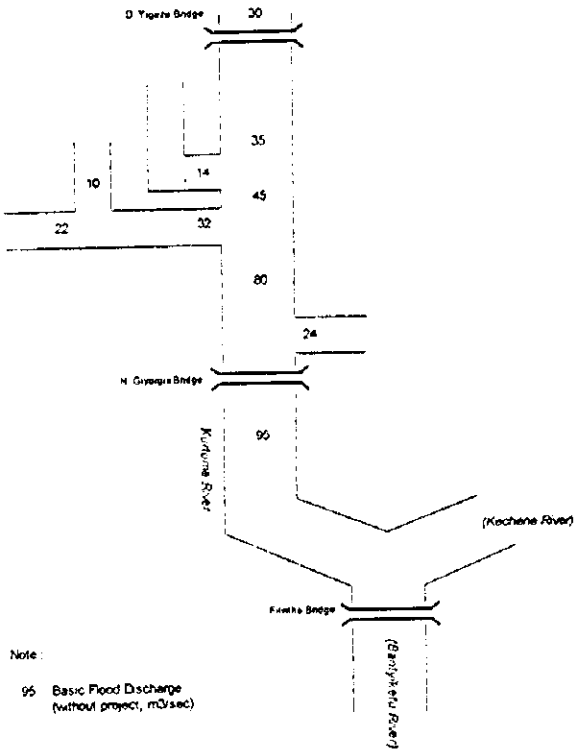


Basic Flood Discharge for Bantyiketu River System
(Return Period 30-year)

ANNEX-5 Basic Flood Discharge (1/2)

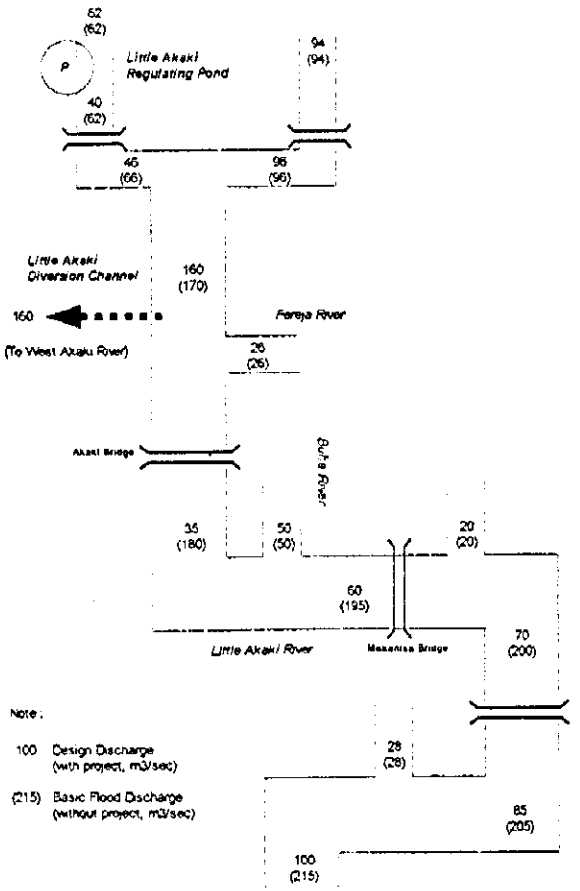


Basic Flood Discharge for Kechene River
(Return Period 20-year)

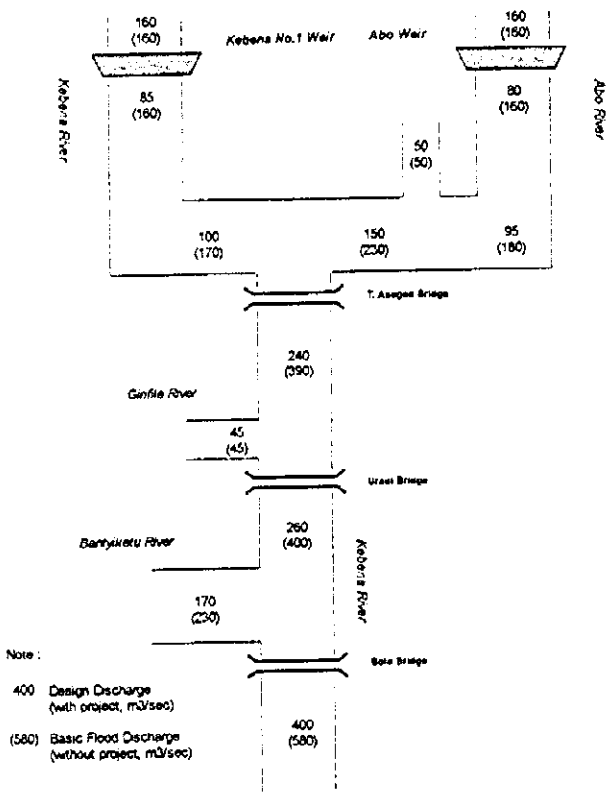


Basic Flood Discharge for Kurfume River
(Return Period 20-year)

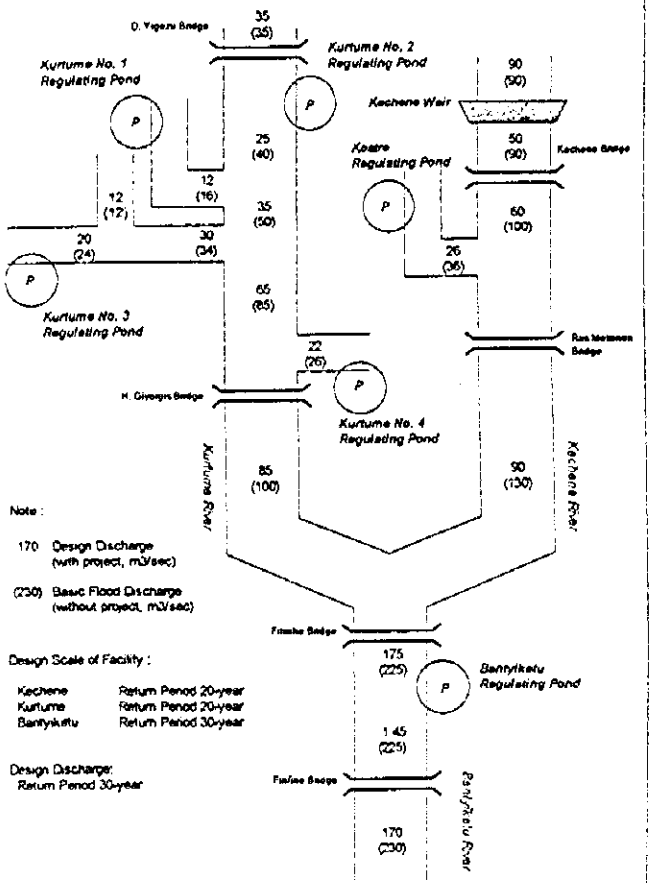
ANNEX-6 Basic Flood Discharge (2/2)



Design Discharge Distribution for Little Akaki River (Return Period 30-year)

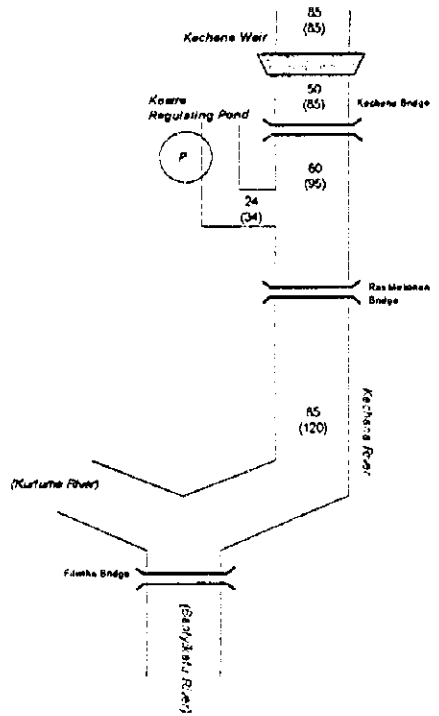


Design Discharge Distribution for Kebena River System (Return Period 30-year)



Design Discharge Distribution for Bantyiketu River System (Return Period 30-year)

ANNEX-7 Design Discharge Distribution (1/2)

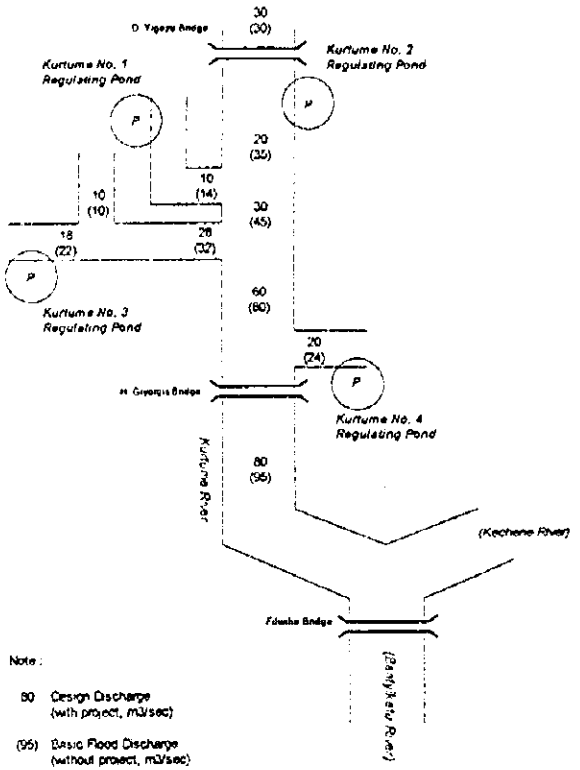


Note :

85 Design Discharge (with project, m3/sec)

(120) Basic Flood Discharge (without project, m3/sec)

Design Discharge Distribution for Kechene River (Return Period 20-year)



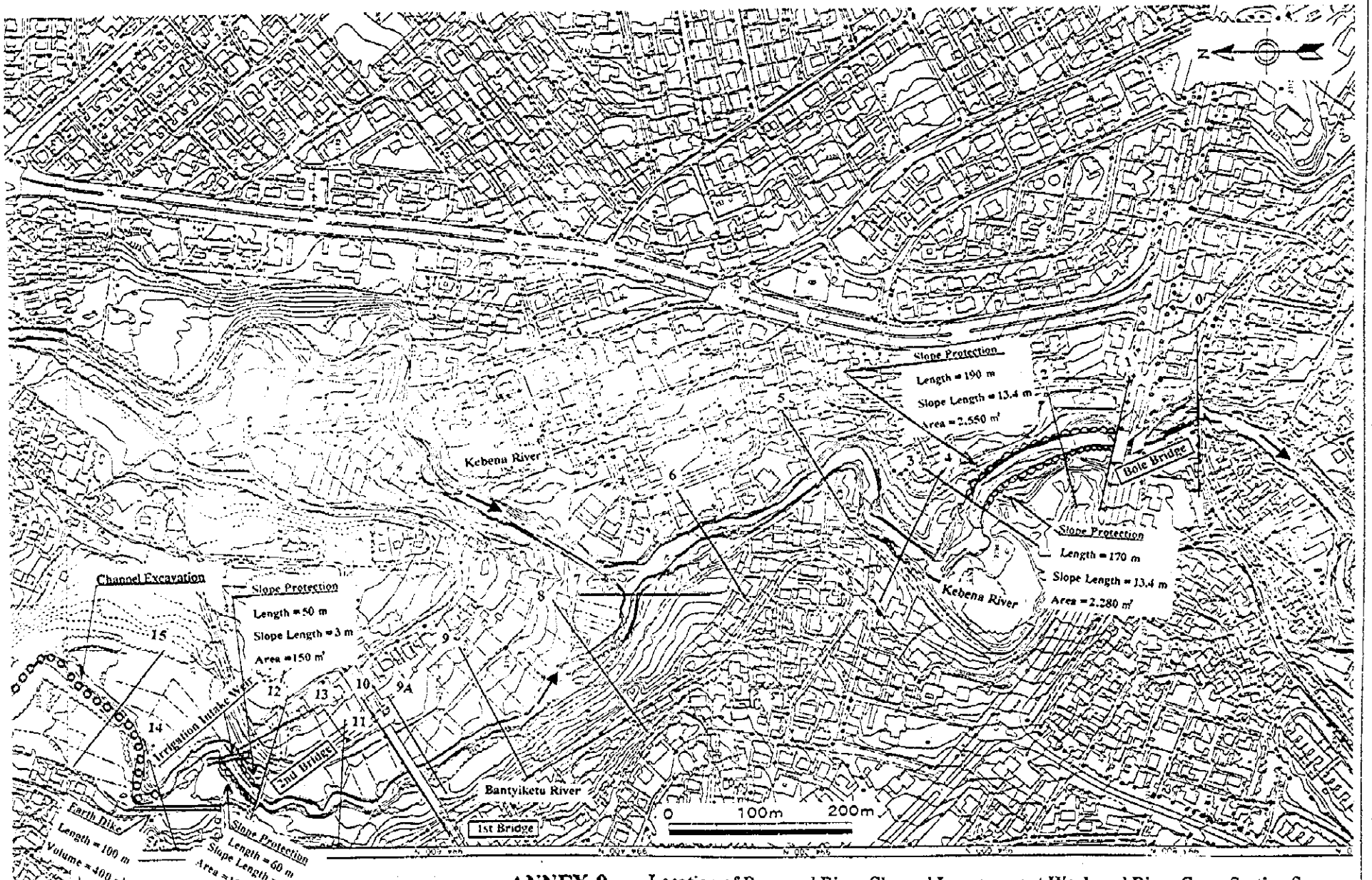
Note :

80 Design Discharge (with project, m3/sec)

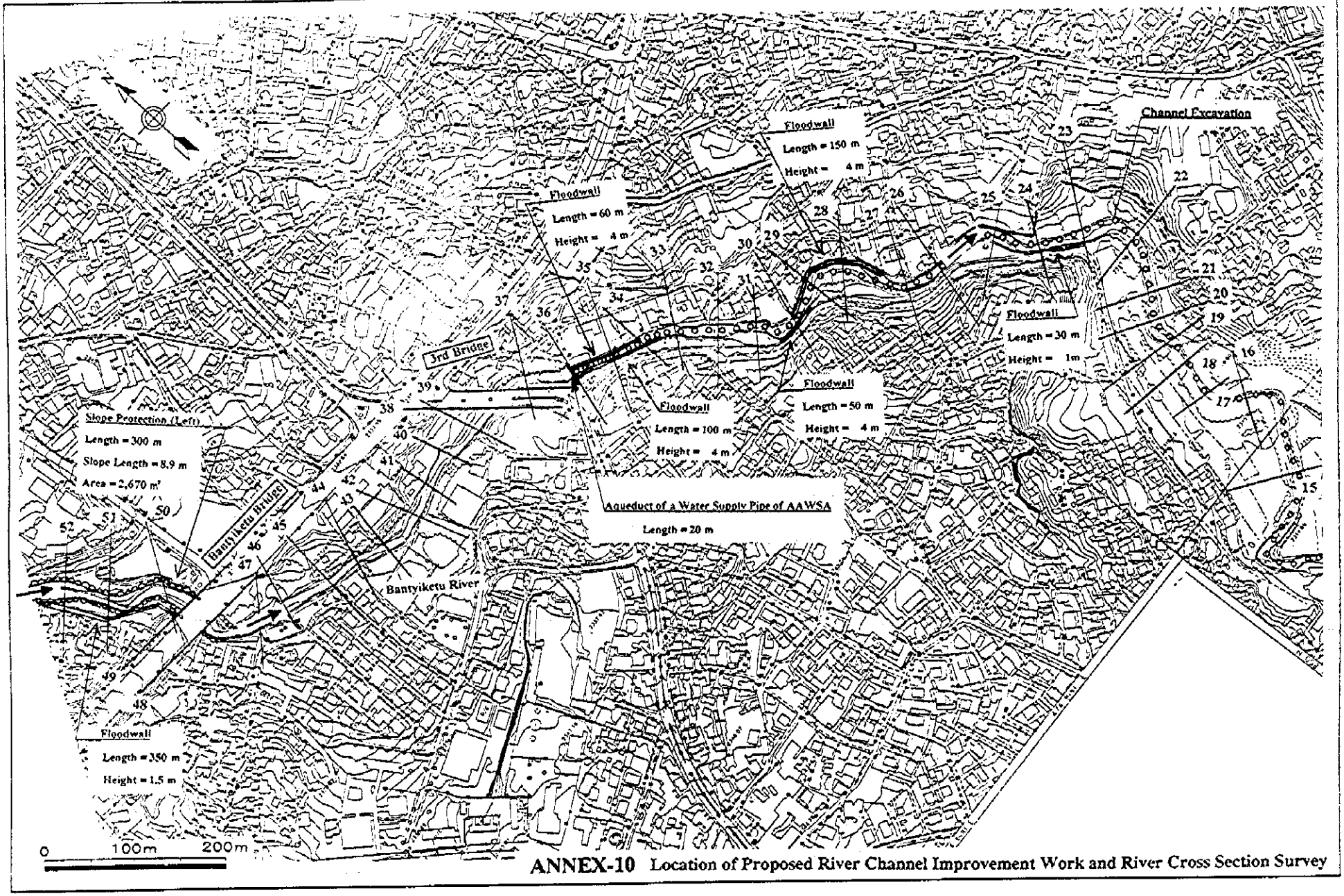
(95) Basic Flood Discharge (without project, m3/sec)

Design Discharge Distribution for Kurfume River (Return Period 20-year)

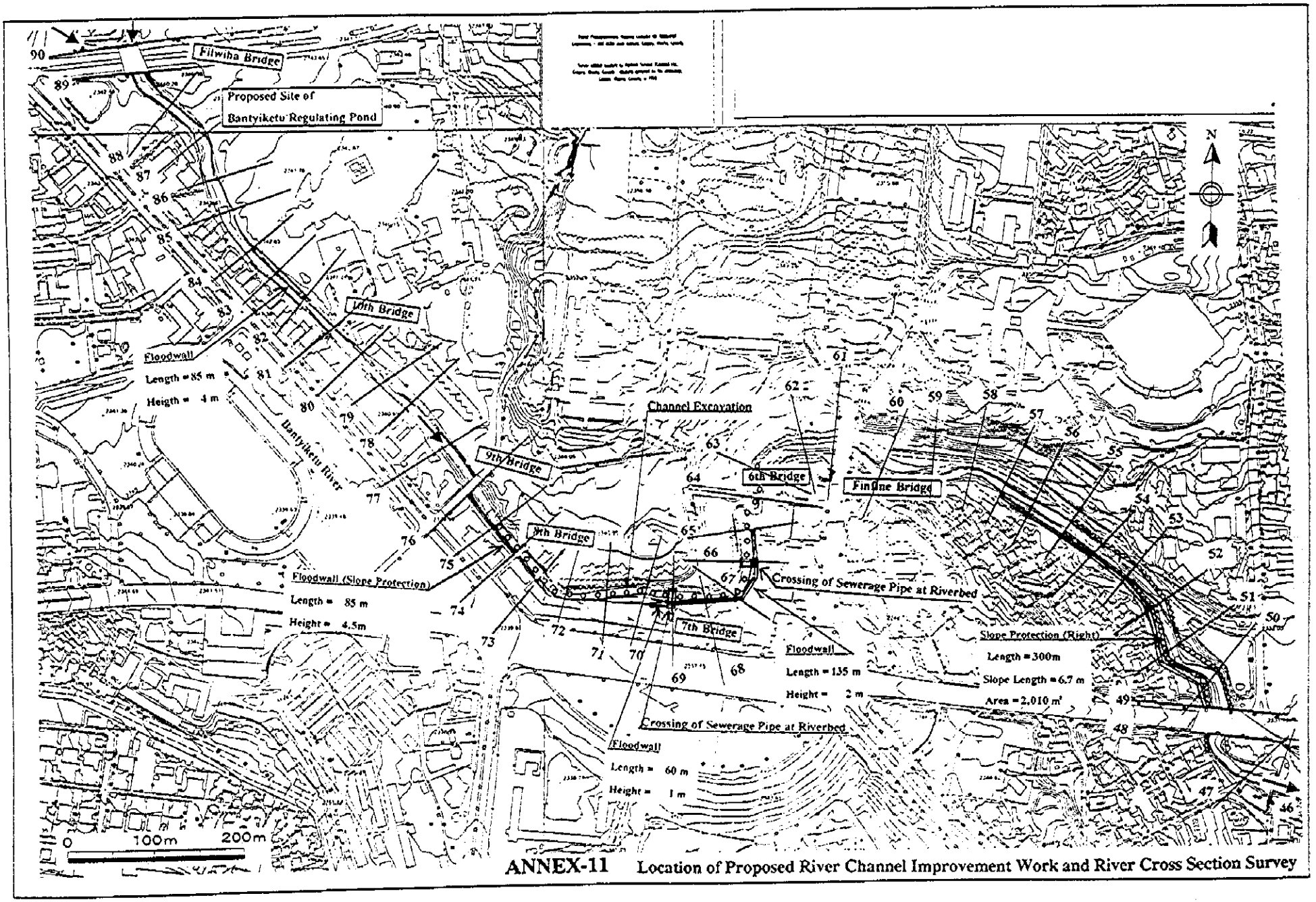
ANNEX-8 Design Discharge Distribution (2/2)



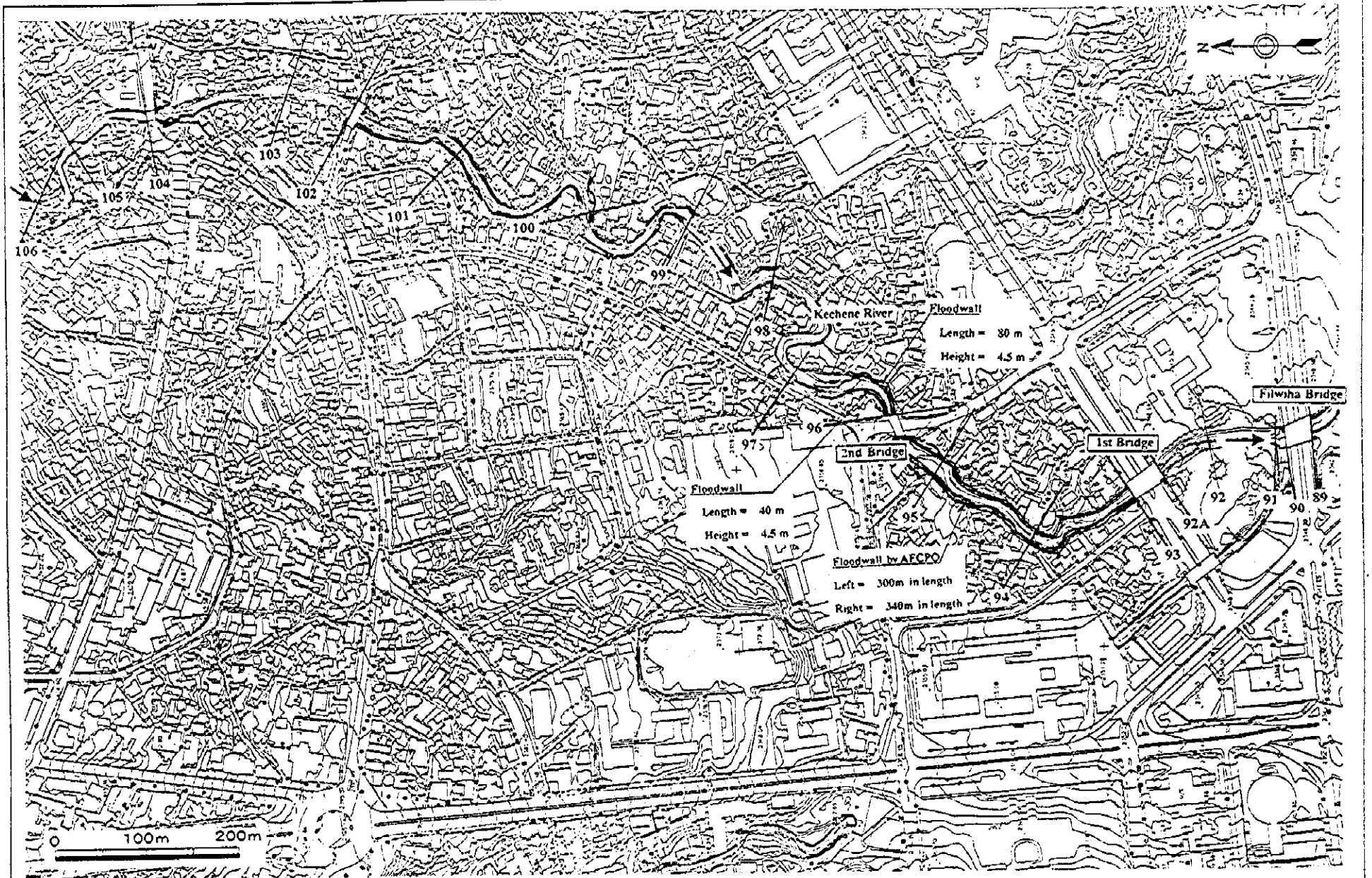
ANNEX-9 Location of Proposed River Channel Improvement Work and River Cross Section Survey



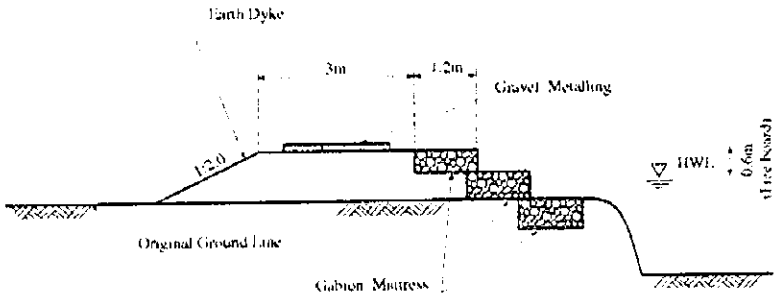
ANNEX-10 Location of Proposed River Channel Improvement Work and River Cross Section Survey



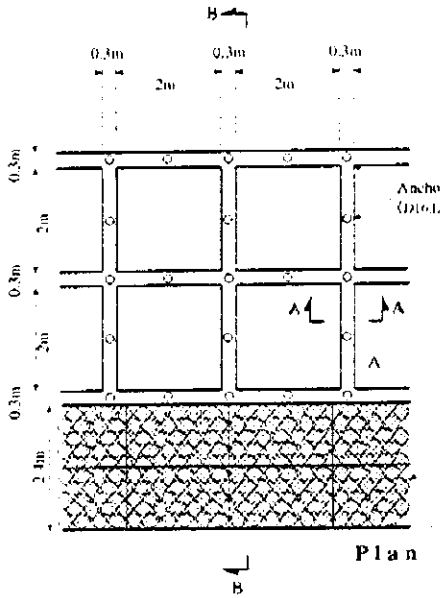
ANNEX-11 Location of Proposed River Channel Improvement Work and River Cross Section Survey



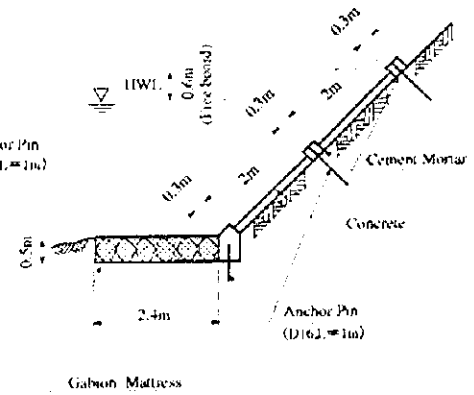
ANNEX-12 Location of Proposed River Channel Improvement Work and River Cross Section Survey



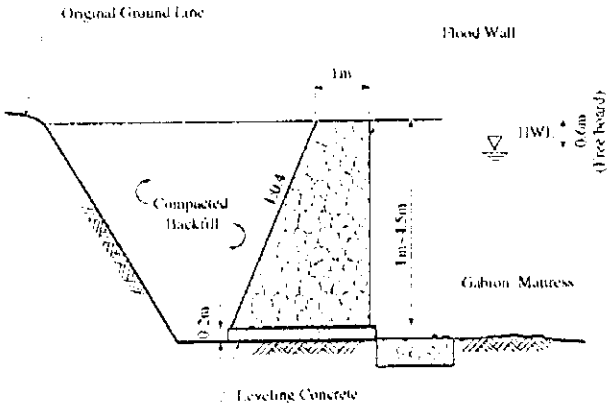
Typical Cross Section of Earth Dyke



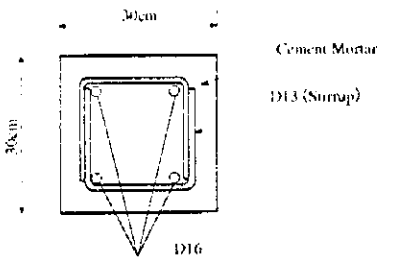
Plan



Cross Section
(Section B—B)



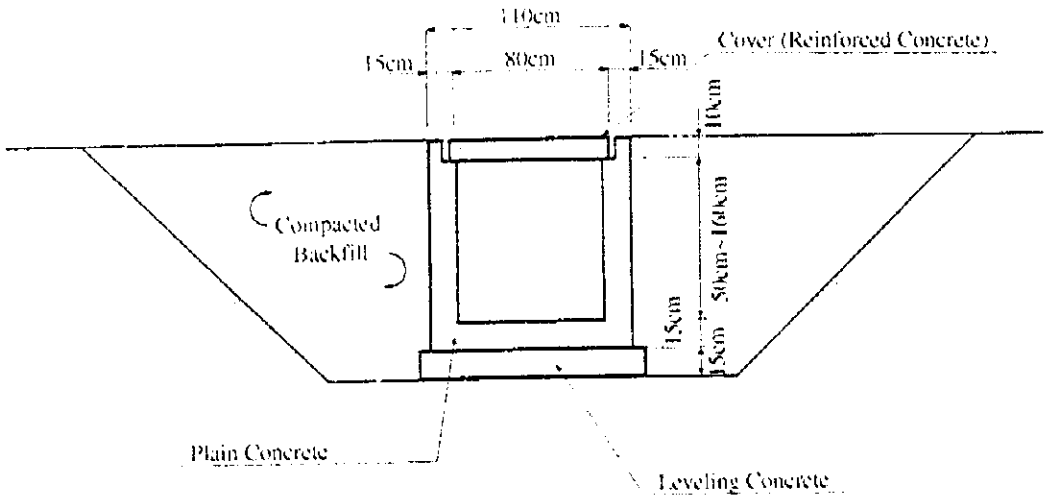
Typical Cross Section of Flood Wall



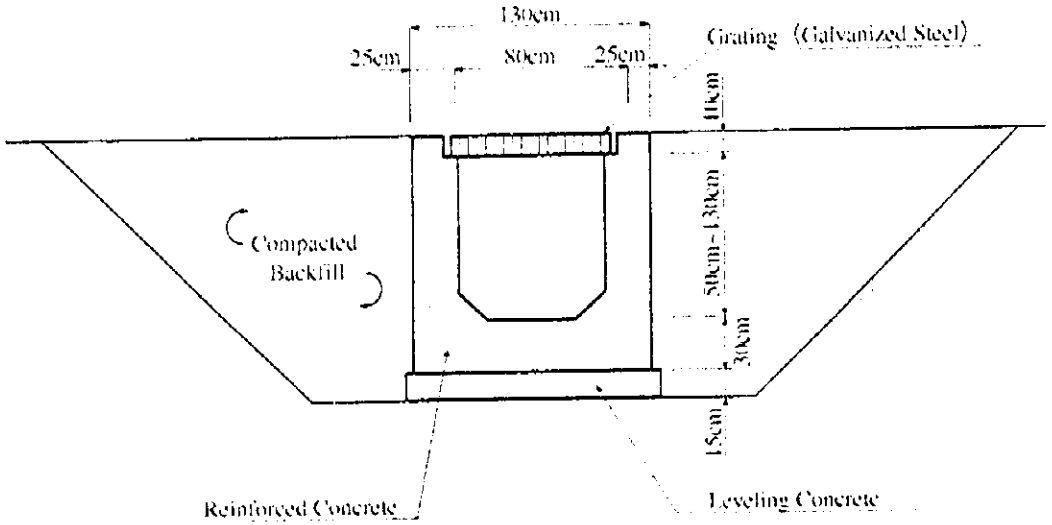
Detail Cross Section of Frame
(Section A—A)

Typical Plan and Cross Section of Slope Protection Work

ANNEX-13 Typical Features of River Channel Improvement Work



Standard Drain Ditch



Drain Ditch at Road Crossing

ANNEX-14 Typical Cross Sections of Drain Ditches