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REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF HOUSING BUILDING
PLANNING AND URBAN DEVELOPMENT (CIPTA KARYA)

MEDAN URBAN DEVELOPMENT, HOUSING, WATER SUPPLY AND SANITATION PROJECT

TECHNICAL MEMORANDUM NO. 23

RECOMMENDED DRAINAGE MANAGEMENT SYSTEM

This is a draft of Sections 8 and 12 of the Master Plan Report for Water Supply and Sanitation

OCTOBER 1979

ENGINEERING - SCIENCE, INC. • SINOTECH ENGINEERING CONSULTANTS, INC
A JOINT VENTURE
in association with
PADCO and P.T. DACREA

MEDAN URBAN DEVELOPMENT, HOUSING, WATER SUPPLY AND SANITATION PROJECT

Jln. Singamangaraja 1-3, P. O. Box 26, Phone 20716, Medan-Sumatra, Indonesia

Our ref.: 79/1190/MUDS/313 30 October 1979

Director General Cipta Karya
Ministry of Public Works
Jalan Pattimura 20
Kebayoran Baru
Jakarta Selatan

Subject: Technical Memorandum No. 23, Recommended Drainage Management System

Dear Si

Attached are 20 copies of the subject Technical Memorandum for your information and review. The material contained in this memorandum constitutes submission of Sections 8 and 12 of the draft Master Plan for Water Supply and Sanitation Report.

Yours faithfully,

ENGINEERING SCIENCE INC. MEDAN URBAN PROJECT INDONESIA

John M. McGill
Project Representative

C.C.: Ir. Ruslan Diwiryo, Director of City & Regional Planning
Ir. Susanto Mertodiningrat, Director of Sanitary Engineering
Ir. Sunaryo, Head Sub-Directorate Town Planning
Ir. K. Pohan, Project Manager, MUDS
AID - Jakarta, attn. P. Thorn, Project Officer
ES - Arcadia
SINOTECH - Taipei
DACREA - Jakarta

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1.	Preliminary Site Selection Criteria for Perumnas Medan III, SSCH/LCH Project	March, 1979
2.	Work Plan for Water Supply and Sanitation Master Plans and Feasibility Studies	April, 1979
3.	Policy Issues for Project Guidance	March, 1979
4.	Drainage - Principal Rivers and Rainfall Analysis	May, 1979
5.	Preliminary Evaluation of Sunggal Water Treatment Plant	May, 1979
6.	Public Health Considerations	July, 1979
7.	The Present Drainage System	August, 1979
8.	Recommended Drilling Program	August, 1979
9.	Medan Household Income/Expenditures	August, 1979
10.	Existing Land Use in Medan	August, 1979
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SECTION 8

ALTERNATIVE DRAINAGE MANAGEMENT SYSTEMS

8.1 INTRODUCTION

In section 2.6 the characteristics of the existing drainage system including flooding problems have been described. In section 3.6 the present and projected capacity requirements of the drainage system have been estimated.

In this section alternative levels of service which may be provided for flood control are reviewed and alternative methods for achieving the various service levels are screened for possible application in Medan.

Alternative staged programs for implementing drainage improvements are also developed and evaluated in relationship with local capabilities and ultimate system needs.

8.2 ALTERNATIVE SERVICE AREAS AND SERVICE LEVELS

The following three service areas have been identified for purposes of evaluating alternative drainage systems as shown in Figure 8.1:

1. Present high density, high value urban area (priority 1).
2. Present medium density high value urban area (priority 2).
3. Present low density areas which will become more fully development by year 2000 (priority 3).

These service areas provide a basis for the spatial development of staged alternatives.

The quality of service provided by a drainage system is most frequently described by the level of flood protection that it affords. Other features of the drainage system can also directly and indirectly contribute to the quality of service. These include the degree of isolation between drains and their contents and the environment. Open channels are less isolated than underground closed conduits and therefore present a higher degree of potential health hazard and danger to children playing near them. Nuisance and inconvenience frequently associated with open channels in business areas can make access to shops and other

p. 2a

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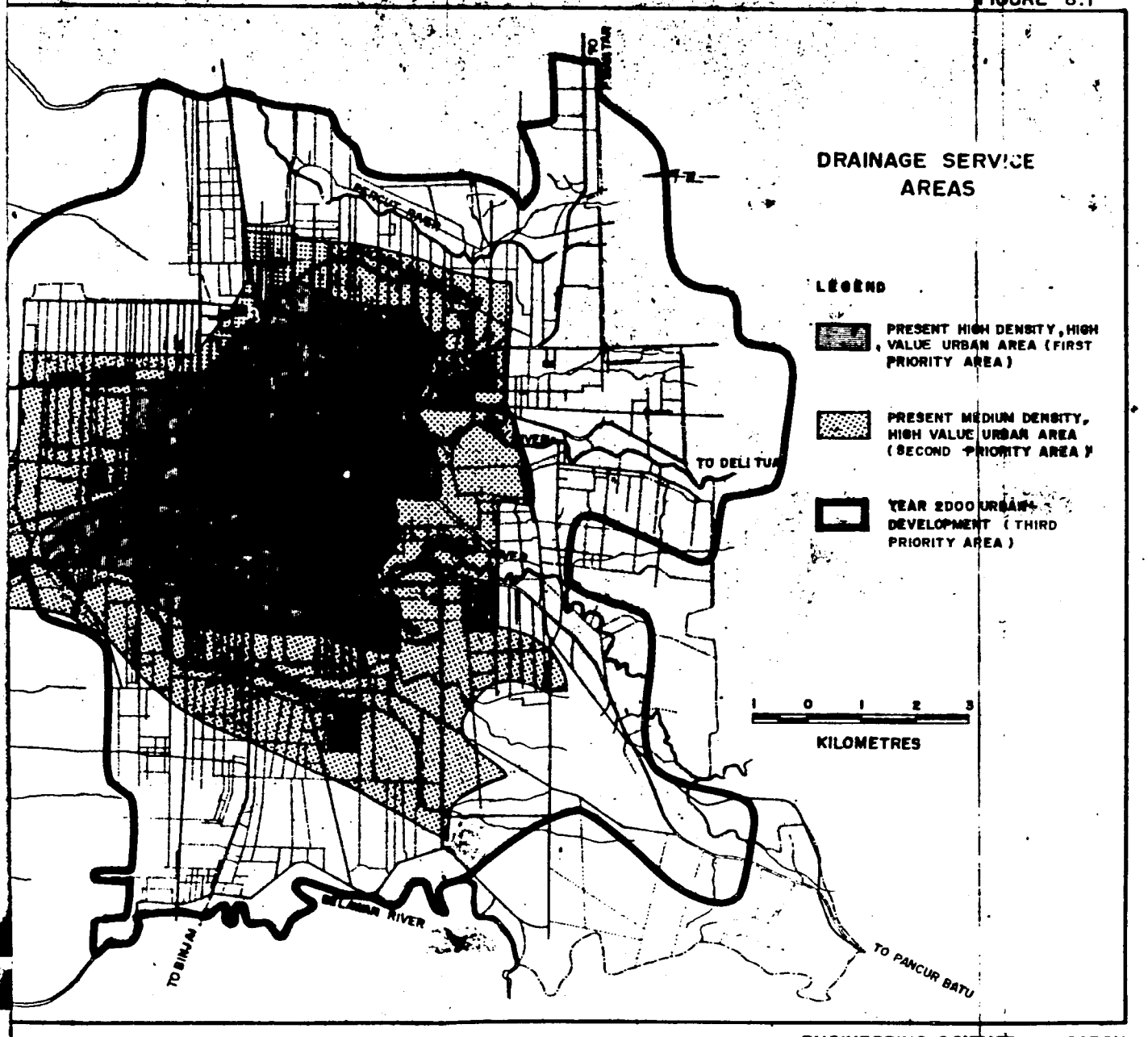
p. 2b

FIGURE 8.1



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places of business inconvenient and unpleasant. Stream bank and roadside erosion also can result in property damage and increased maintenance cost.

Service levels for flood control are typically stated in terms of the capacity of a drain to carry flows which could be expected to be equalled or exceeded once, on average, over a specified time interval, usually expressed in years as the recurrence interval.

The level of protection frequently selected for various elements of drainage systems in urban areas varies from recurrence intervals of two years in residential areas to in excess of 100 years in urban areas where the potential for property drainage and loss of life is high. Specific values used for system evaluation are determined by economic analysis and by engineering judgement.

The level of service stated in terms of the physical quality of the drainage system can be classified as follows:

- Open channels
  - earth improved
  - lined
- Underground closed conduits
  - with local open channels
  - with roadway gutters and inlets and building connections

In Medan where the surface drainage system carries wastewater flow and receives substantial quantities of solid wastes, open channels present a potential threat to the health of citizens and detract from the aesthetic quality of the city because of odors and unsightlines.

8.3 ALTERNATIVE FORMS OF FLOOD CONTROL

8.3.1 Reduction of Flood Runoff

The reduction of flood runoff can be accomplished by:

1. The control of land use and building construction
2. Land treatment methods
3. In channel and off channel storage and flood routing.

The application of these methods of flood control is becoming more prevalent in urban drainage systems because of the savings that can be realized in storm sewer construction and in some cases environmental benefits that can be achieved by the preservation of natural watercourses.

In Medan the control of land use and building construction can not yet be exercised to the extent necessary to accomplish significant reductions of flood runoff by regulation of land use and building construction. In areas which are presently undeveloped the application of off channel storage can be considered as well as flood routing alternatives in specific situations.

Controlling flood flows resulting from intense rainfall is a prime concern in flood control management. One way of controlling such flow is by impounding excess flow and releasing it once the peak flow has passed. The siting of impoundment reservoirs may be considered to reduce downstream flood flow on the Deli River. Appropriate sites do not appear to be abundant to the south of Medan and this fact affects the feasibility of such alternatives.

8.3.2 Improved Inlet

In Medan many of the inlets to local drains and from local drains to major drains are blocked, partially or completely restricting the flow of water from residential and commercial areas and creating upstream ponding.

Clearing existing inlets from local drains to major drains will diminish the amount of ponding and can dramatically improve flooding conditions in some areas.

Inlet conditions can also be improved by providing enclosed building connections connecting building drainage systems and yard drains to the local surface drains. Such inlets should be properly constructed to prevent debris and sediment from entering the drainage system.

8.3.3 Increased Channel Capacity

Increased channel capacity will undoubtedly continue to be the flood control measure having most widespread application in Medan. Such

measures include channel clearing, cleaning and dredging, channel straightening, enlargement and lining.

Many of the drainage channels in the study area are severely constricted by vegetative growth and by solid wastes. In addition, erosion caused by rainfall in southern rural areas has created sedimentation problems in the lower reaches of the major rivers.

Clearing, cleaning and dredging will significantly increase channel capacity. Field inspections carried out as part of this study suggest that an increase in channel capacity of much as 50 to 100 percent could reasonably be expected by channel clearing, cleaning and dredging alone. Channel straightening and enlarging in the densely developed urban areas of the city is made difficult because of residential development near the streams which in some instances has been observed to encroach upon the flood waterway.

In the lower reaches of the major rivers extensive widening of the waterway will create unstable stream bed conditions that will require extensive maintenance to retain capacity.

In the densely developed areas of the city diking existing channels would necessitate pumping to ensure drainage of low lying areas, when the major river channels are carrying flood flows. Deepening channels can be considered in some areas. In the lower reaches of the major rivers outlet is controlled by sea level and sediments deposited at the mouths of the rivers.

Channel lining to reduce flow resistance must therefore be considered for drains within the densely developed urban area.

8.3.4 Avoidance and Mitigation of Flood Damage

Flood protection measures in addition to these provided by the control of runoff and increased drainage system capacity can be accomplished by both the public and private sectors to avoid flood damage such as:

- Land use control, regulating development in areas subject to flooding.

- Site development, such as filling areas on which development is to occur.

- Constructing private diking systems.

In areas where measures are not taken to avoid flooding damage precautions can be taken to ensure that damage is minimized and other effects of flooding are mitigated. These include:

- A stream flow monitoring and warning system
- Assistance with evacuation
- Emergency health care, food and accomodation for flood victims
- Assistance with clean up operations

8.3.5 Control of Other Features

In areas where access and aesthetics play an important role in the operation of the drainage system detrimental effects can be avoided by enclosing drains beneath the street surface and by providing curbs and gutters, inlets and catch basins. When such system are installed careful attention must be given to final road elevations, grades and street cross sections to ensure satisfactory outlet for drainage from adjacent properties including requirements for the installation of building connections.

Public health and aesthetic problems will also be reduced with the long term provision of sanitary sewers. Building plumbing systems should provide for the separation of surface water and wastewater flows during initial construction to avoid costly separation work at some future time.

8.4 EVALUATION OF ALTERNATIVE DRAINAGE SYSTEM IMPROVEMENTS

In the following subsection the application of the foregoing service levels and control elements to the various physical components of drainage system, service areas and service groups are examined and those alternatives having particular application in Medan are selected.

8.4.1 Major River Channels

8.4.1.1 Lower Deli River

The existing capacity of the lower Deli River below its confluence with the Babura and the estimated capacity requirements are illustrated in Figure 8.2.

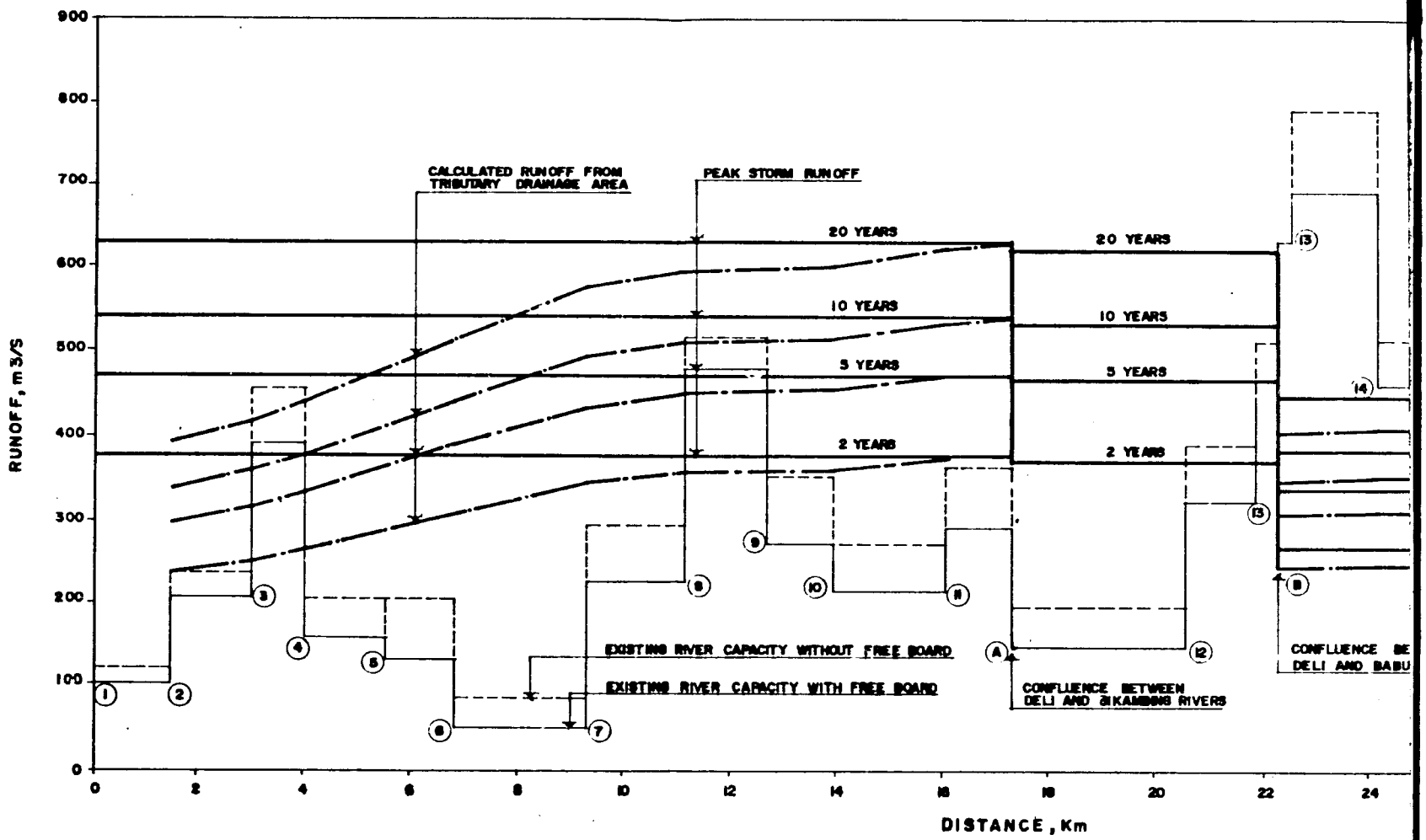
Although this analysis is approximate only, because of the limited streamflow data available, it can generally be concluded that over bank flooding of the Deli River can be expected to occur frequently.

The tributary area of the lower Deli River is bisected by two potential obstructions, the railway and roadway embankment immediately to the east of the river. Although flooding is certainly caused by overbank flow some local ponding may be attributed to restrictions to flow through these embankments.

The area subject to flooding within the tributary area of the lower Deli is agricultural with the exception of a strip of land between the river and railway in which there is significant industrial development and a small relatively densely populated urban area above the confluence of the Sikambing River.

Current preliminary plans for enlarging the channel of the lower Deli have been based on a flow capacity of 800 m^3/s, a relatively large flood flow.

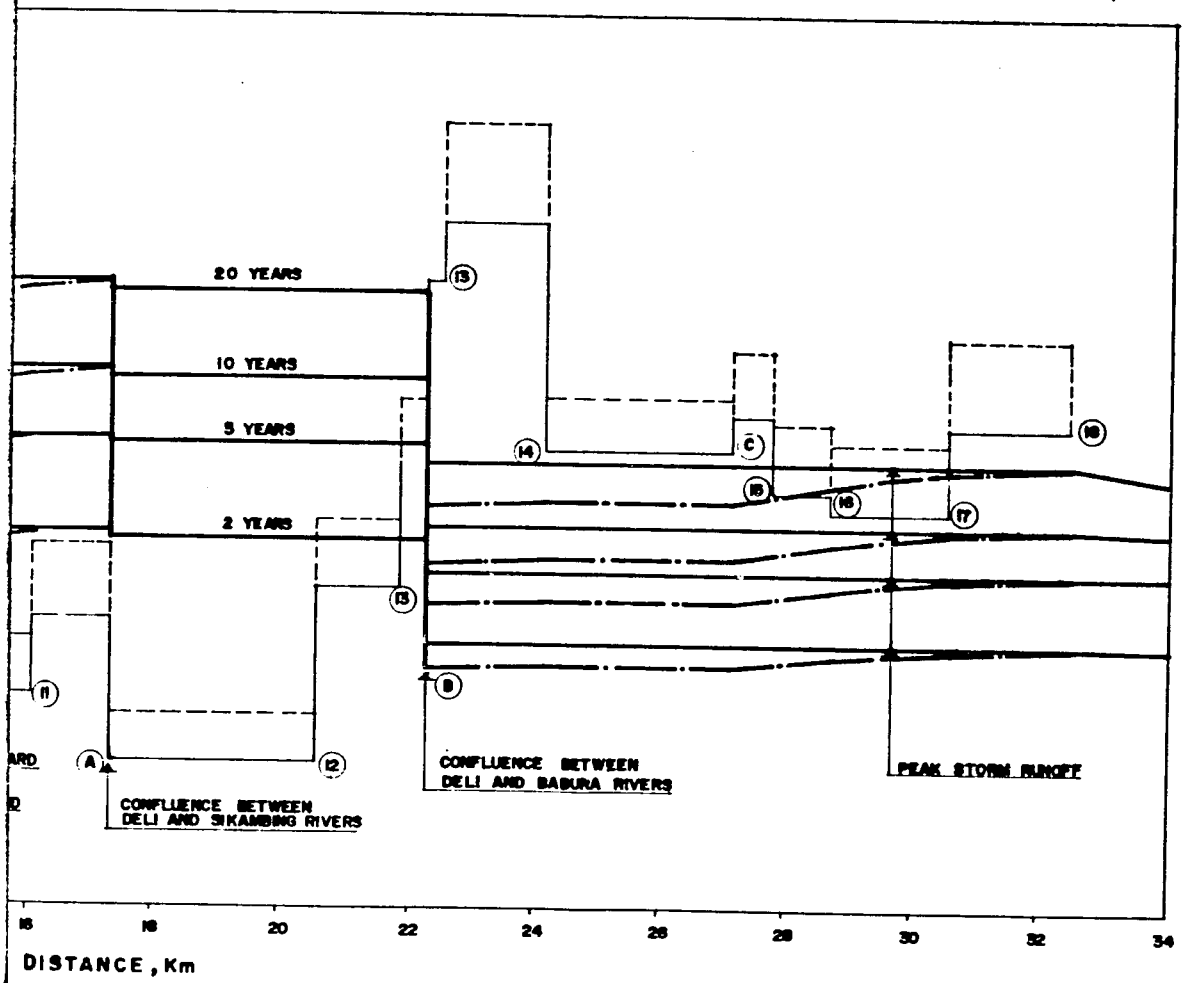
Impoundments at locations upstream of Medan can be constructed to reduce the magnitude of flood flows. Multiple use of such impoundments for irrigation and water supply could be considered. The degree of flood protection that can be provided and the cost is a matter for detailed specific investigation. Optimum reservoir systems would undoubtedly involve a combination of channel improvements and reservoir storage. Reductions in flood flows of possibly 25 to 50 percent could be expected at a cost comparable to the program of channel improvements which provide a moderate level of flood protection. This option should be studied further at the time reservoirs may be considered for water supply or irrigation purposes and when further major channel improvements are considered in the lower Deli.



PROJECTED STORM RUNOFF FOR DELI RIVER BASIN

P. 8b

FIGURE 8.2



RM RUNOFF FOR DELI RIVER BASIN

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Channel clearing, cleaning and dredging in the lower Deli is estimated to cost Rp.0.3 x 10^9.

The estimated cost of an enlarged unlined channel for the lower Deli River capable of providing a moderate level of flood protection (roughly a 5 year recurrence interval) is about Rp.3 x 10^9 to Rp.4 x 10^9. The benefits that would be derived from expenditures of these magnitudes would have to be carefully evaluated before implementing such schemes.

The maintenance of an enlarged channel in the lower Deli would also require careful evaluation in relation to sedimentation and vegetative growth to ensure that channel capacity is maintained once initial construction is complete.

Major expenditures in the lower Deli River should not be considered until more reliable flood flow data become available. In the meantime significant benefits could be derived by cleaning clearing and dredging the existing channel. Diking in selected areas could also be considered to provide an additional measure of flood control, however, flooding could continue to occur relatively frequently especially in lower areas.

Controls on land use and site development within the area subject to flooding should also be instituted to avoid flooding damage. This area would also benefit greatly from a program to mitigate the effects of flooding that does occur as previously described.

8.4.1.2 Upper Deli River

Figure 8.2 illustrates that the existing channel capacity of the Deli River upstream of its confluence with the Babura is capable of providing a high degree of protection from overbank flooding (possibly in excess of a 20 year recurrence interval).

The extensive flooding that occurs in part of east Medan is beyond the natural boundary of the upper Deli River catchment area. The tributary area has been extended easterly to Jalan Sutomo where a drain has been constructed diverting flow from the Kera River basin to the Deli River at a junction point downstream of the Babura. The southerly extremity of this drain serves a relatively small part of the Kota Matsum area.

Flooding is not prevalent in the area served by the Jalan Sutomo drain or by the upper Deli River. Such local drainage problems that do exist appear to be attributable to development that has occurred within the flood waterway and flood plain and to local ponding.

It is recommended that only relatively minor channel improvements be carried out in the upper Deli River channel to ensure that the full potential of the existing channel is available for flood protection.

8.4.1.3 Babura River

As illustrated in Figure 8.3, within the present high and medium density urban area, the existing channel, like that of the Deli River, has adequate capacity to provide a high level of flood protection. Flooding problems within its tributary area appear to be attributable to defficiencies in local drains. Like the upper Deli River relatively minor channel improvements are required to ensure that the full potential of the existing channel is realized. In the southerly portion of the study area relatively broad and well defined flood plains exist which are extensively used for agricultural purposes. Urban development in these flood plains should be controlled by appropriate zoning regulations. Some relatively minor channel improvements may be required in the future when development in the general area is considered.

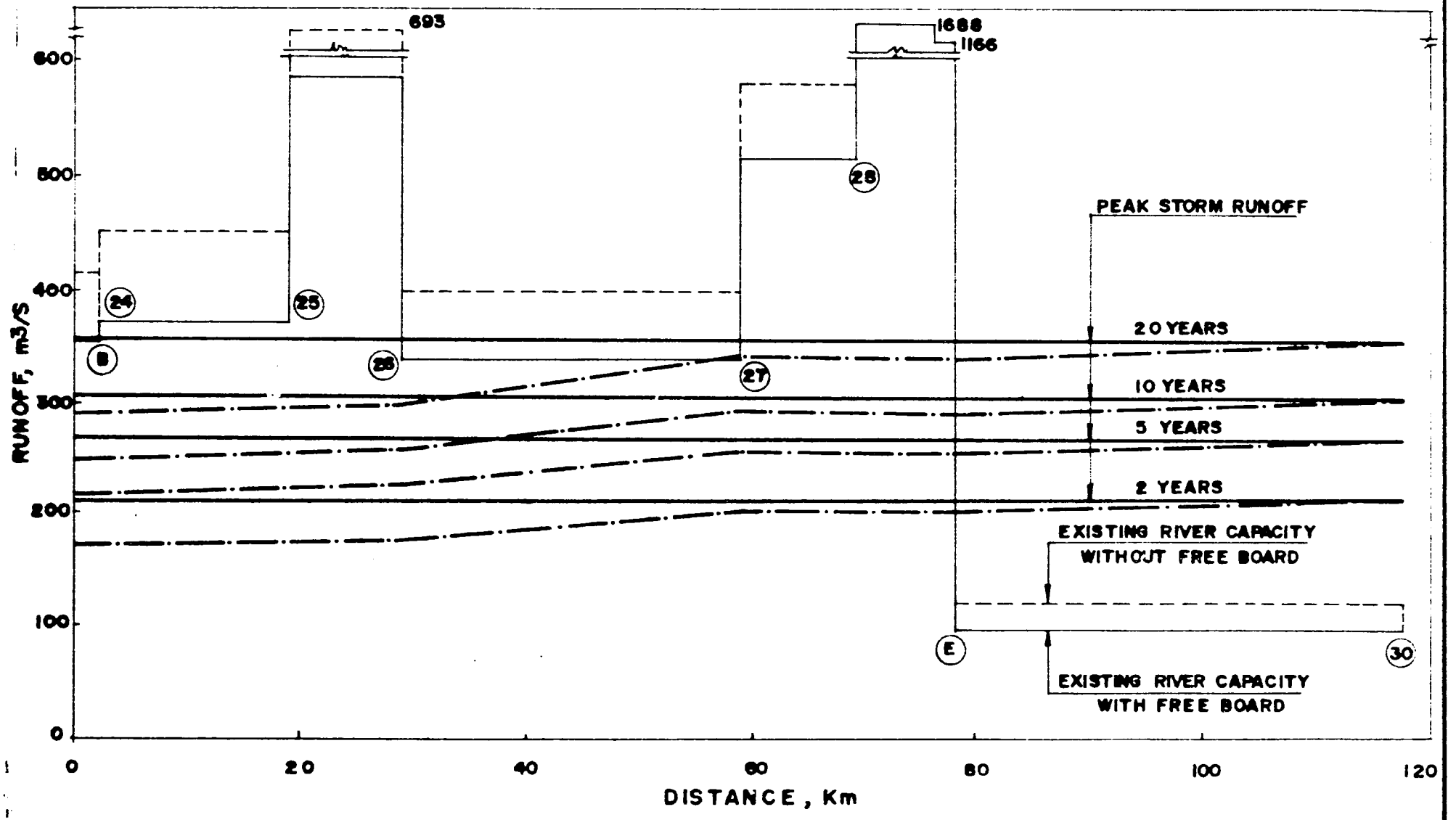
8.4.1.4 Belawan River

Only a relatively small portion of the watershed of the Belawan lies within the study area. Flooding problems within the study area attributable to the overflow of river banks have not been reported. Development within the study area is not likely to contribute significantly to an increase in flooding potential downstream of Medan.

The channels and flood plains of this river through the study area are well defined. The control of flood plain development and adequate routine channel maintenance are considered to be adequate flood control measures in these areas.

8.4.1.5 Percut River

The Percut River, like the Belawan River, has only a small portion of its tributary area within the study area and severe flooding damage



PROJECTED STORM RUNOFF FOR BABURA RIVER BASIN

FIGURE 8.3

has not been reported although most of the reaches within the study area have limited channel capacity as illustrated in Figure 8.4. The flood plains in these areas are well defined and development within areas subject to inundation should be controlled by regulation. The Percut River receives flood flow diverted from the Kera basin and some future channel improvements in the form of channel cleaning, clearing and dredging are proposed.

8.4.2 Major Drains

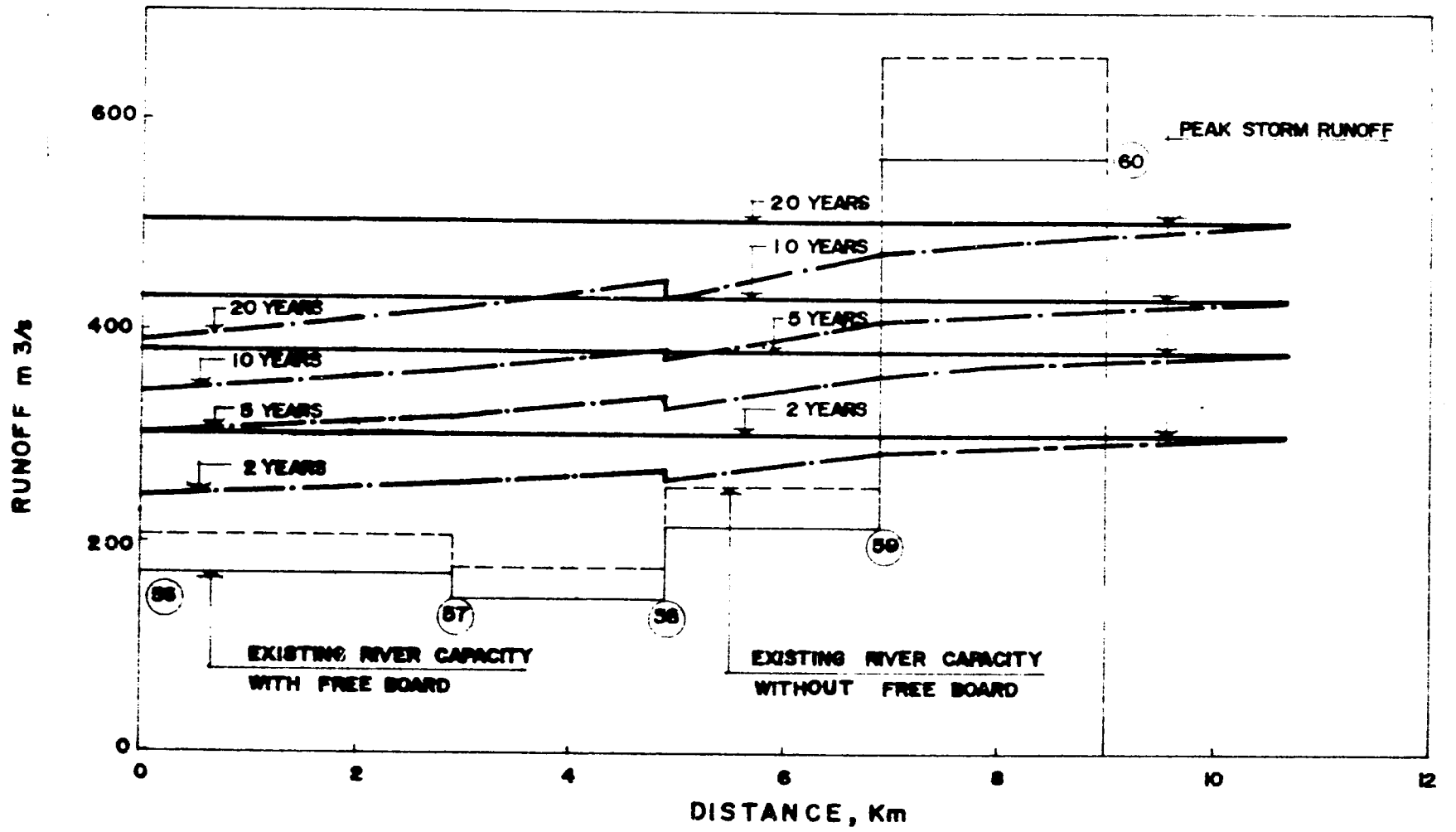
8.4.2.1 Kera River

The capacity of the main channel of the Kera River in relation to flood projected flows is shown in Figure 8.5. Regular flooding occurs extensively throughout the Kera River watershed within the study area. Flooding attributable in part to overbank flow and to local ponding caused by deficiences in local drains. A diversion to the nearby Percut River has been constructed to provide relief to the downstream reaches of the Kera and major channel improvements have been carried out for improved flood control. Present high density high value and medium density high value areas are affected by flooding particularly to the west of the Kera River channel. In the Kera basin there is little option to improve flood control by means other than increasing channel capacity.

Clearing, cleaning and dredging of the existing channel will significantly increase the level of flood protection however a preliminary analysis indicates that frequent flooding could still be experienced. The topography of the area and alignment of the existing channel is such that the construction of a relief channel or channels could be considered as an alternative to increasing the size of the existing channel. The high density high value land use comprising much of the area subject to overbank flooding suggests that at least a moderate level of flood protection should be considered for this area.

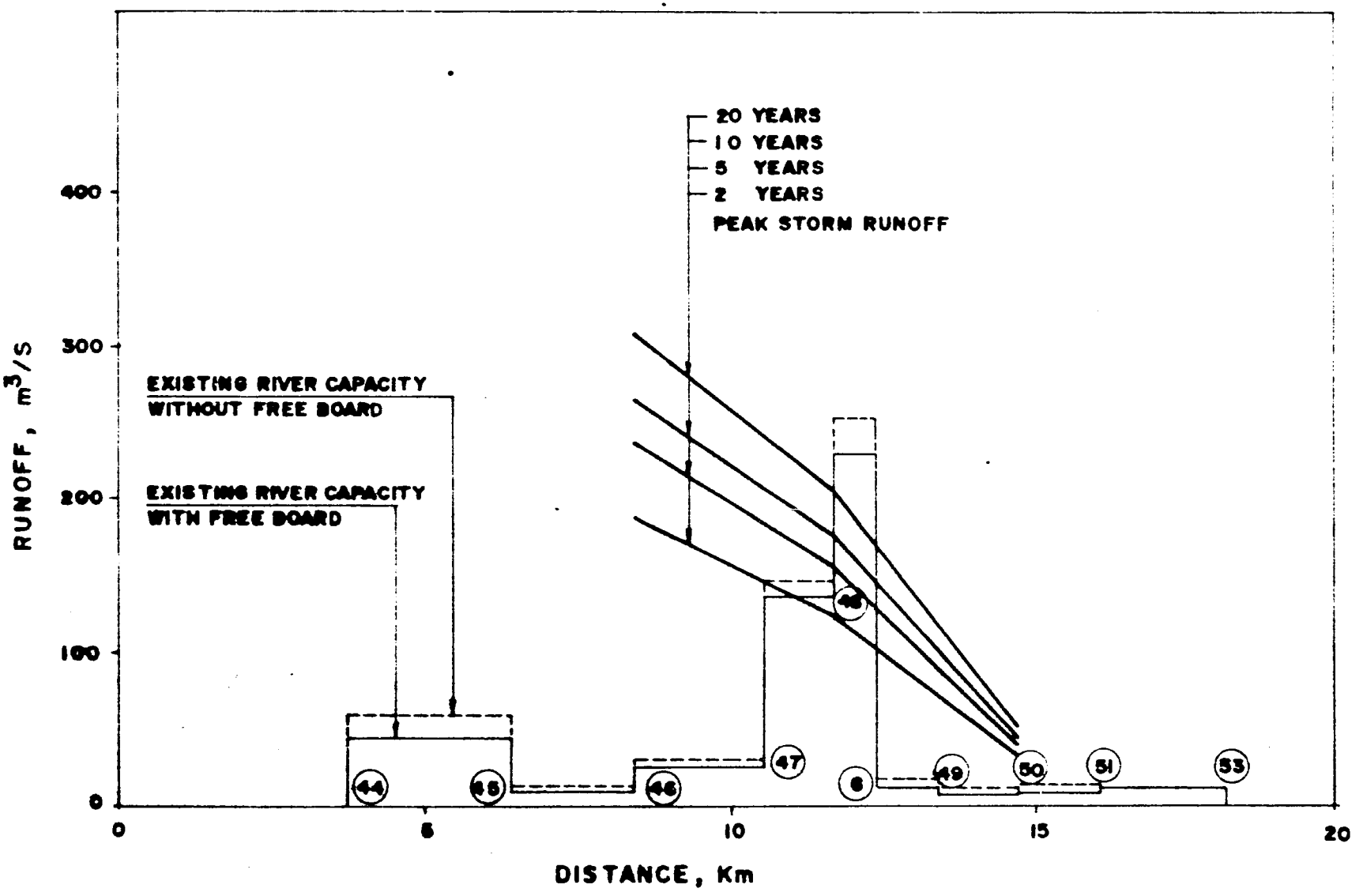
Figure 8.6 illustrates channel costs for main drains of various types of construction and for various degrees of flood protection.

It can be seen from the figure that the construction cost of providing increasing levels of flood protection for channels of similar type is relatively small in comparison with the cost of providing improved channel types.



PROJECTED STORM RUNOFF FOR PERCUT RIVER BASIN

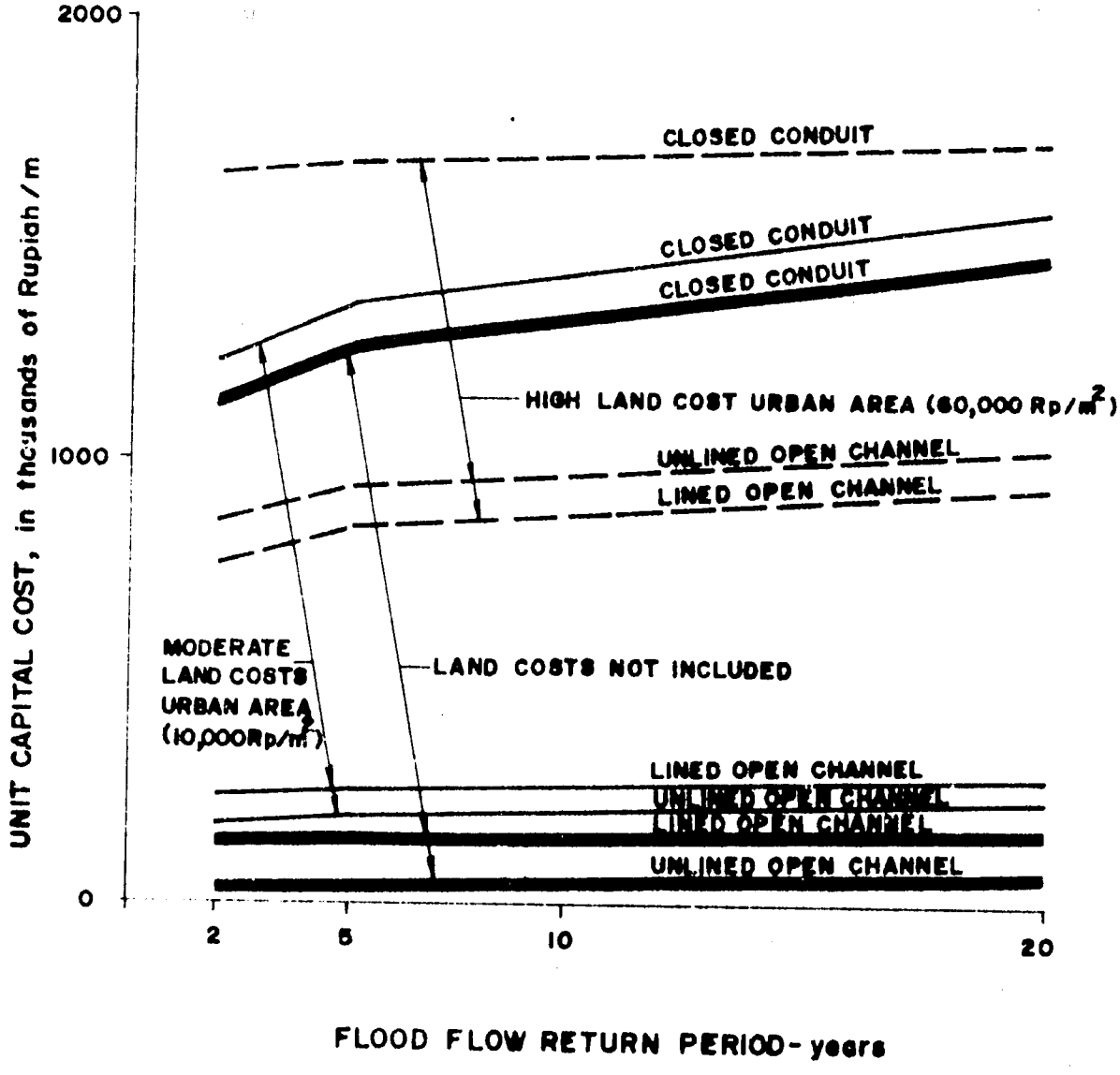
FIGURE : 8.4



PROJECTED STORM RUNOFF FOR KERA RIVER BASIN

FIGURE 8.5

FIGURE 8.6



TYPICAL COMPARATIVE COSTS OF MAIN DRAINS

When land for drain rights-of-way must be acquired land costs are an important factor in the selection of channel type. However figure 8.6 illustrates that enclosing main drains cannot be justified on the basis of construction and land costs alone.

The potential for damage caused by the erosion of channel banks and over bank flooding is higher than for local drains by virtue of the greater quantities of flow conveyed. This requirement for a greater overall reliability of service can be satisfied by providing a higher degree of channel capacity and by providing features which will minimize maintenance needs.

It is recommended therefore that all main channels be constructed to provide relief from flood flows with a 5-year recurrence interval and that the channels be lined in all high and medium density areas.

8.4.2.2 Sikambing River

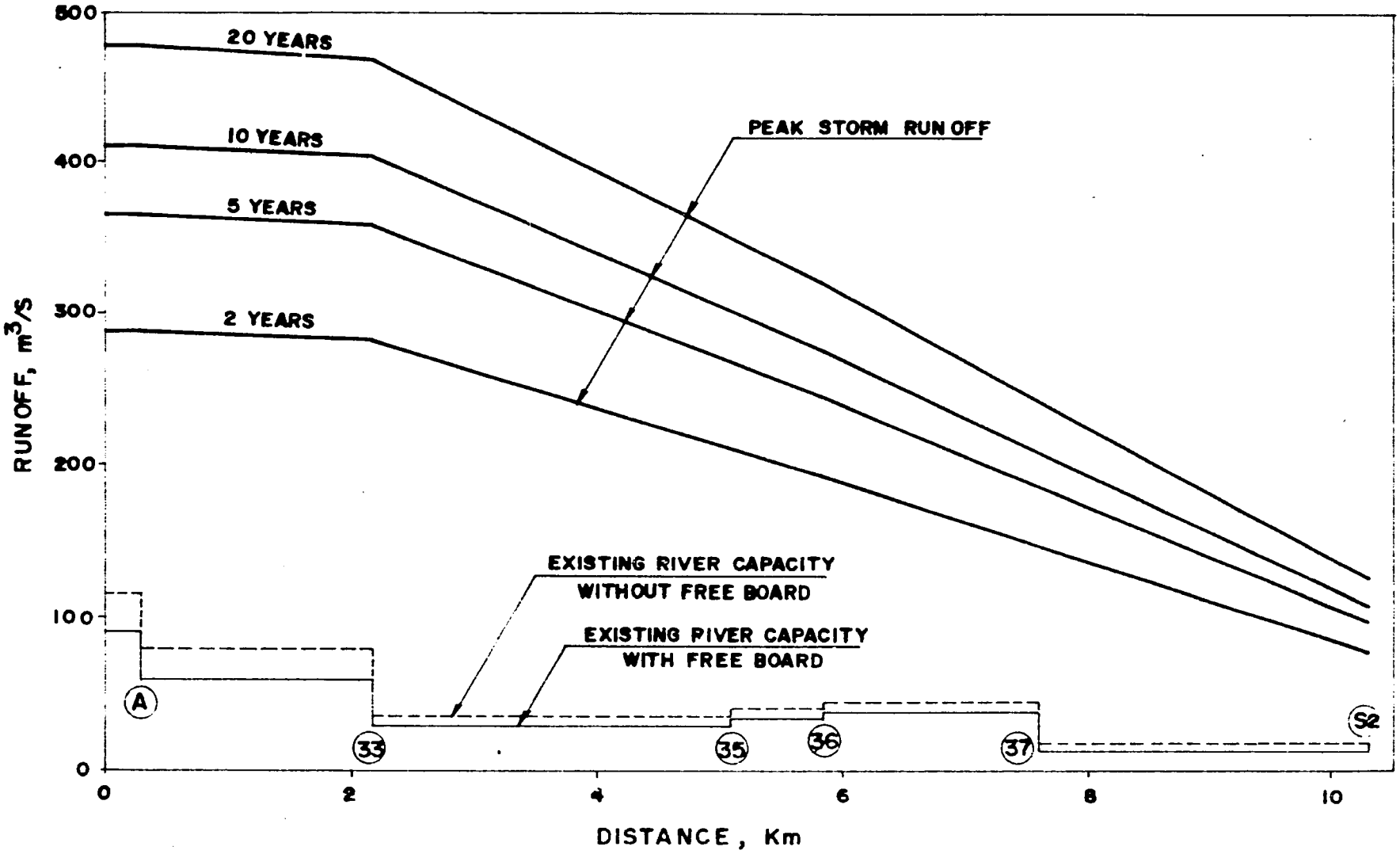
Figure 8.7 illustrates that the capacity of the present Sikambing channel can be expected to be exceeded frequently. Overbank flooding problems have been reported in the vicinity of Jalan Binjai. The absence of problems in other areas is due in part no doubt, to the lower density of development in areas which may be inundated.

At the present time the provision a high level of flood protection need not be considered. In the short term, channel clearing, cleaning and dredging will substantially increase channel capacity and channel improvements to provide moderate levels of flood protection can be considered when future conditions indicate a requirement.

The area subject to flooding adjacent the Sikambing appears well defined and land use controls should be instituted to control development in areas subject to inundation.

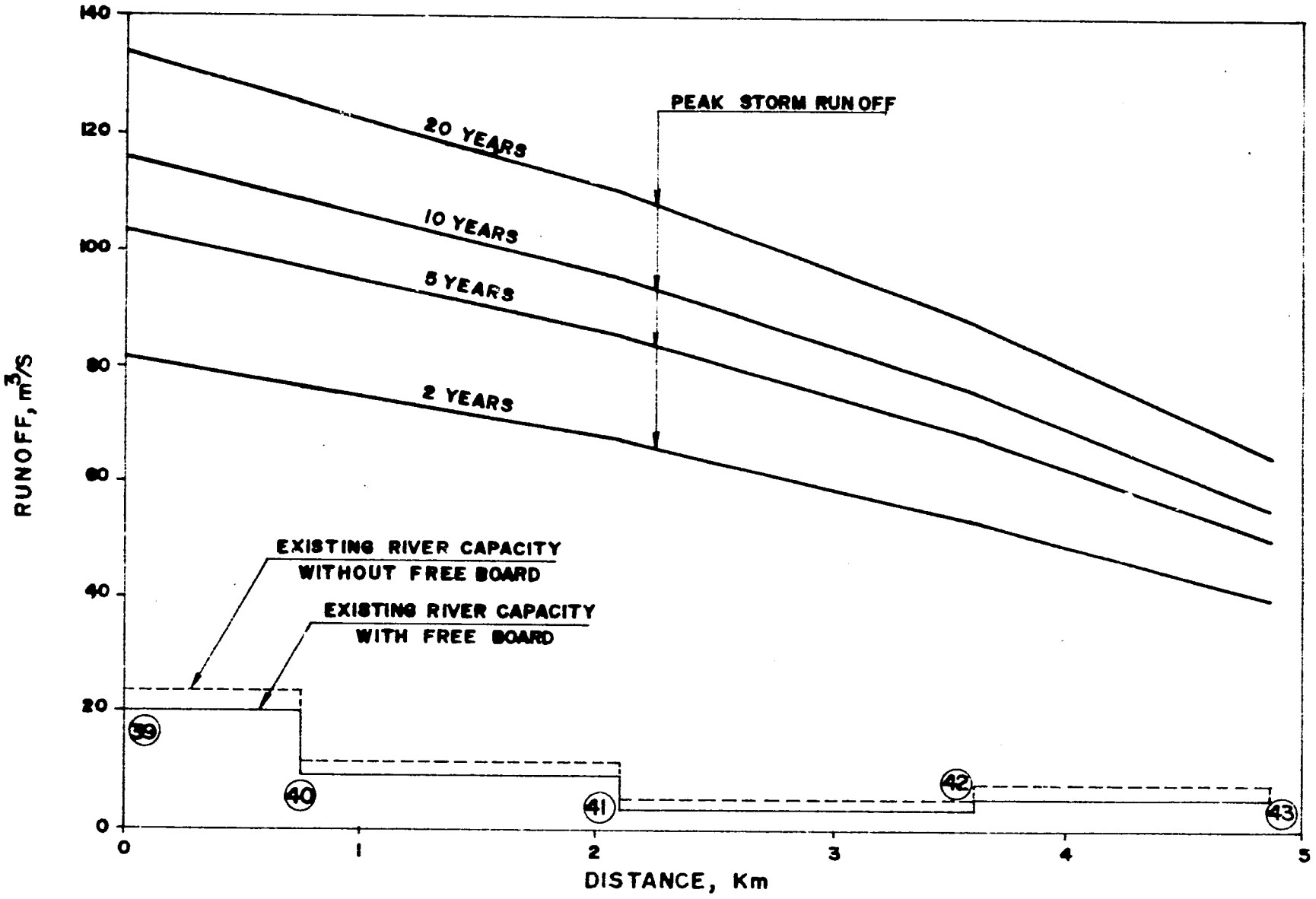
8.4.2.3 Putih River

The watershed of the Putih lies almost entirely within the existing high density high value urban area. Some channel improvements have been carried out, but extensive blockage by solid waste has occurred in the improved reaches. Although the analysis of channel adequacy illustrated in Figure 8.5 indicates that frequent overbank flooding might be expected extensive flooding problems have not been reported. Flooding due to local



PROJECTED STORM RUNOFF FOR SIKAMBING RIVER BASIN

FIGURE 8.7



PROJECTED STORM RUNOFF FOR PUTIH RIVER BASIN

FIGURE 8.8

ponding occurs frequently and is considered to be attributable to deficiencies of local drains.

Channel clearing and cleaning and dredging in improved sections of the stream should be undertaken to ensure that the maximum potential of the improved drain is realized. Future operation of the drain should be monitored before implementing additional improvements.

8.4.2.4 Badra River

Within the study area extensive flooding occurs in the upper reaches of the Badra watershed which appears to result from ponding caused by restrictions to flow at the Jalan Binjai and railway embankments. A similar condition exists to the north which affects the Medan I housing development.

Flooding in both of these areas is attributable to deficiencies in local drains which are discussed in the following subsection.

8.4.3 Local Drainage Works

8.4.3.1 Local Drains

Local drains may be classified as street drains, which provide for the drainage of individual streets and adjacent properties; and submain drains which receive flow from a relatively small number of street drains and carry the flow to the main drains and major rivers discussed previously.

The improvement of local submains has been reviewed throughout the study area as illustrated in Figure 8.9.

Alternatives for local drainage can be considered in terms of the degree of flood protection afforded and the degree of isolation from the urban environment. Open improved earth channels, open concrete lined channels, and enclosed buried conduits have been applied in Medan in the past. Typical characteristics and unit costs of conduits having similar carrying capacities are illustrated in Figure 8.10. Drain costs increase dramatically with improved channel type. The relative increase in unit costs of providing increased flood protection is less dramatic.

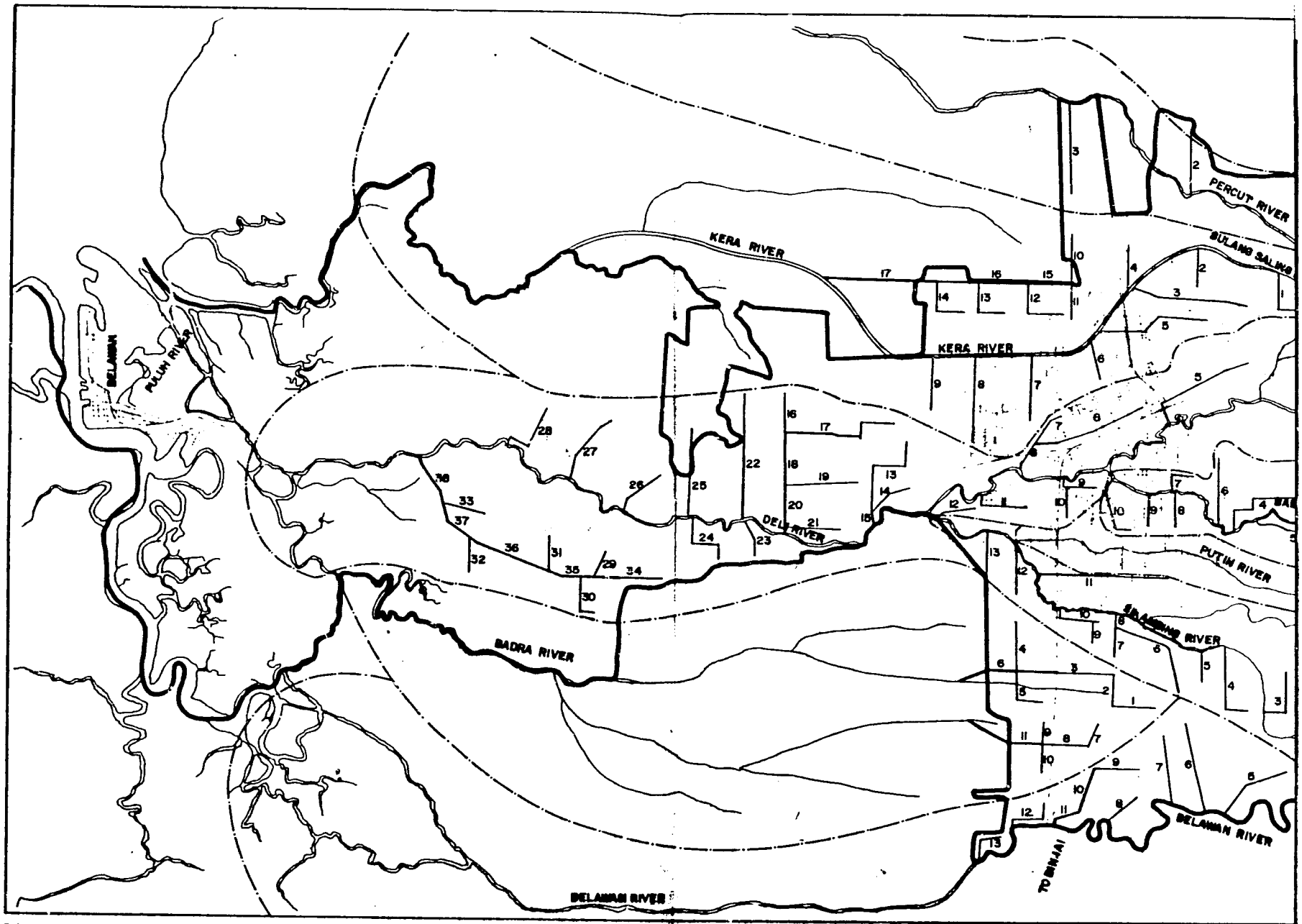


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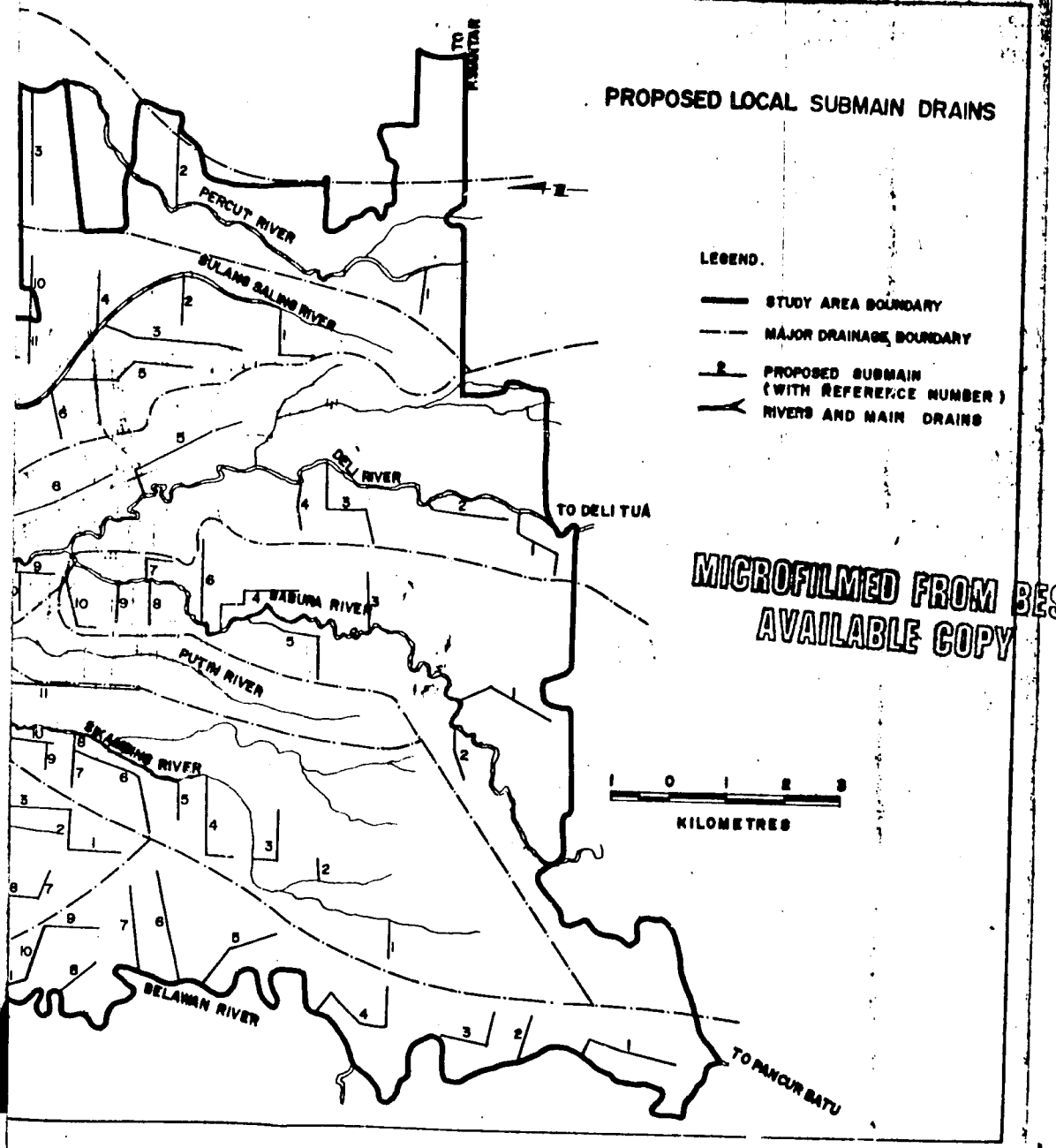
FIGURE 8.9



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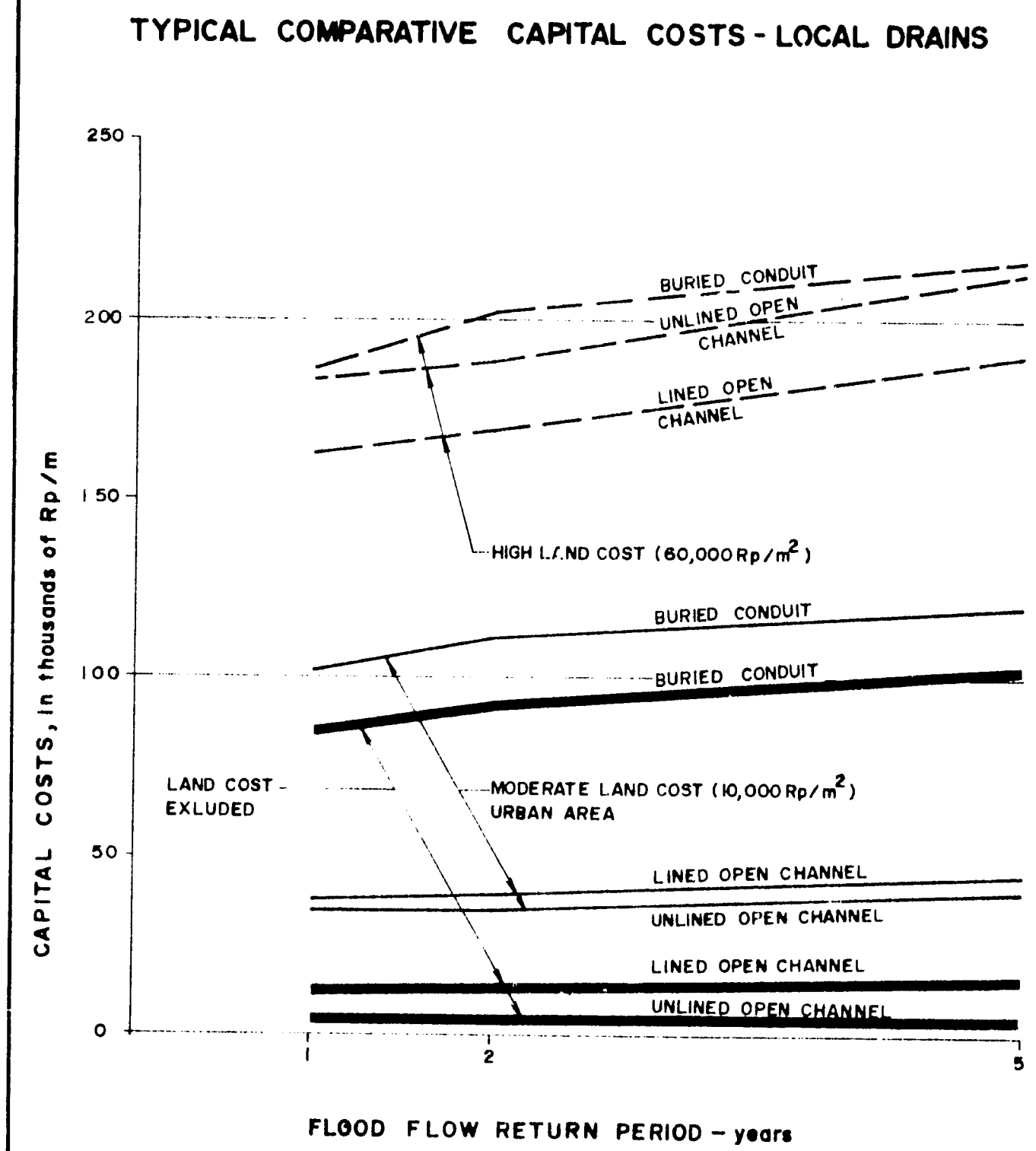
TYPICAL COMPARATIVE CAPITAL COSTS - LOCAL DRAINS
250
200
150
100
50
0
CAPITAL COSTS, in thousands of Rp/m
BURIED CONDUIT
UNLINED OPEN CHANNEL
LINED OPEN CHANNEL
HIGH LAND COST (60,000 Rp/m²)
BURIED CONDUIT
BURIED CONDUIT
LAND COST - EXLUDED
MODERATE LAND COST (10,000 Rp/m²) URBAN AREA
LINED OPEN CHANNEL
UNLINED OPEN CHANNEL
LINED OPEN CHANNEL
UNLINED OPEN CHANNEL
1
2
5
FLOOD FLOW RETURN PERIOD - years

In very high density high value areas, traffic conditions, land values, and physical constraints of existing development may require the consideration of lining and enclosing drains. In other areas channel lining should primarily be considered when justified in the basis of reduced maintenance costs, access and land values.

Careful attention must also be paid to the appurtenances of local drainage works. In the case of open drains access culverts and culverts at street intersections must be adequately sized. Where closed conduits are provided sufficient inlets must be installed and measures taken to avoid erosion of street and roadside surfaces by the provision of curbs and gutters. Catch basins should also be provided at inlets to control the entry of sediment into the underground conduits which may obstruct flow.

Connections from adjacent properties may also be necessary because of drainage conditions on properties adjacent to the street. These may take the form of building connections, connecting stormwater drains in buildings directly to the street drains, and yard drains connecting low lying areas to the underground street drains with elevations selected to provide for gravity outlet.

When storm drains are constructed under city streets attention must be given to the relative elevations of other utilities to avoid interference. New local street drains are typically constructed in conjunction with new roads or with major road and street redevelopment projects. It is assumed that this practice will continue with funds for such drains provided in road development budgets. However, such drains should be designed and constructed to conform with the requirements of the drainage program. Drainage capital cost estimates do not include local street drains on new or redeveloped streets.

8.4.4 Summary

In the foregoing sections considerations relating to the alternative service objectives, service areas, and drainage areas have been discussed.

Service objectives selected for application in Medan for purposes of Master Plan Development are summarized in Table 8.1.

TABLE 8.1

DRAINAGE MANAGEMENT SYSTEM - SERVICE OBJECTIVES

	Service Level	Description: Facilities	Description: Flood Flow Return Interval - years	Application
1.	a	Enclosed channel with full street improvements	5	Local street drains and submains in high density high value commercial districts
	b	Enclosed channel with full street improvements	2	Local street drains and submains in high density lower value commercial districts
2.	a	Enclosed channel	5	Local submains in medium and low density high value commercial districts
	b	Enclosed channel	2	Local submains in medium and low density lower value commercial districts
3.	a	Lined open channels	5	Main drains and other local submains in high density and medium density areas
	b	Lined open channels	2	Other local submains in low density areas Local street drains in high and medium density areas
4.	a	Improved earth open channels	5*	Major river waterways
	b	Improved earth open channels	2	Local street drains in low density areas

* The objective for the lower Deli is tentative and is subject to review and revision based on monitoring data.

SECTION 12

RECOMMENDED DRAINAGE MANAGEMENT SYSTEM

In Section 8 alternative systems for the improvement of drainage and the control of flooding were evaluated and a recommended staged program was selected for further development.

Further details fo the recommended system are presented in this section including requirements for organization administration operations and maintenance as well as system monitoring and performance evaluation.

An implementation schedule and cost estimates are provided for use in subsequent feasibility studies.

12.1 DESCRIPTION OF RECOMMENDED SYSTEM

12.1.1 General

The major elements of the recommended drainage management system are as follows:

1. Kera Basin: Staged implementation of major improvements in the Kera Basin which are to be initiated immediately and are to be completed by 1990 with the objective of providing a moderate level of flood protection. Figure 8.9 shows the tributary area boundary, main drains and submain drains in the Kera Basin.

2. Urban area: Throughout the program period to year 2000 carry out a continuous program of channel clearing, cleaning, and dredging in the urban area and other areas subject to flooding with the objective of ensuring that the flood control potential of existing channels is realized. Figure 8.1 shows the boundary of the urban area.

3. Monitoring: Monitor drainage system operation after initial channel cleaning and throughout the program period to provide basic design and performance evaluation data and to establish priorities for future channel improvements.

4. Downstream Channel Clearing, Cleaning, and Dredging: After initial monitoring data has been evaluated initiate long term

program for drainage in downstream reaches of major rivers and drains, primarily the lower Deli River and Kera River.

5. Channel Improvements: Immediately initiate and continuously execute a channel improvement and new channel construction program.

   The program to be coordinated with:

   - the flood monitoring program
   - road improvement and construction program
   - implementation of the sanitary sewerage program and other utility programs

6. A program for providing flood warning and emergency assistance and relief for flood victims.

7. Control of urban development (land use, site development and building construction).

8. Training and technical assistance.

12.1.2 Description of Recommended System

The physical works proposed for each stage of the program in each of the service and drainage areas is summarized in Table 12.1.

12.2 OPERATIONS AND MAINTENANCE

12.2.1 System Operation

Operation and maintenance work will consist primarily of drain and catch basin clearing and cleaning. These operations can be most economically carried out by current labour intensive methods.

12.2.2 Monitoring

12.2.2.1 Flow Recording and Inundation Records

Futher basic flood flow data is required to complete the evaluation of flooding problems especially for the lower Deli River.

TABLE 12.1

APPLICATION OF SERVICE OBJECTIVES [a]

Drainage Basin	Staged Alternative: Stage I Service Area [b] 1	2	3	Stage II Service Area 1	2	3	Stage III Service Area 1	2	3
Lower Deli									
Main channel [d]	CCD [c]	CCD	-	-	-	CCD	4a	4a	4a
Local drains									
Submains	CCD	CCD	CCD	3a	3a	CCD	3a	3a	3b
Street [e]									
Res High Value	CCD	CCD	-	CCD	CCD	CCD	3b	3b	3b
Res Low Value	CCD	CCD	-	CCD	CCD	CCD	3b	3b	4b
Com High Value	CCD	CCD	-	1a	2a	CCD	1a	2a	2a
Com Low Value	CCD	CCD	-	1b	2b	CCD	1b	2b	2b
Upper Deli									
Main channel [f]	CCD	CCD	-	CCD	CCD	CCD	CCD	CCD	CCD
Local drains									
Submains [d]	3a	3a	CCD	3a	3a	3b	3a	3a	3b
Street									
Res High Value	CCD	CCD	-	CCD	CCD	CCD	3b	3b	4b
Res Low Value	CCD	CCD	-	CCD	CCD	CCD	3b	3b	4b
Com High Value	CCD	CCD	-	1a	2a	CCD	1a	2a	2a
Com Low Value	CCD	CCD	-	1b	2b	CCD	1b	2b	2b
Babura									
Main channel	CCD	CCD	-	CCD	CCD	CCD	CCD	CCD	CCD [h]
Local drains									
Submains [g]	3a	3a	CCD	3a	3a	3b	3a	3a	3b
Street									
Res High Value	CCD	CCD	-	CCD	CCD	CCD	3b	3b	4b
Res Low Value	CCD	CCD	-	CCD	CCD	CCD	3b	3b	4b
Com High Value	CCD	CCD	-	1a	2a	CCD	1a	2a	2a
Com Low Value	CCD	CCD	-	1b	2b	CCD	1b	2b	2b

Notes:
a. See Table 8.1 for definition of service objectives.
b. Refer to Figure 8.1 for service area boundaries.
c. CCD means clear clean and dredge existing channels.
d. The improvement objective suggested for the lower Deli is tentative and is subject to review and revision based upon monitoring data.
e. Street drains includes submains on streets in commercial areas.
f. Clearing, cleaning and dredging of the upper Deli channel will ensure that a high level of flood protection is maintained.
g. Submain improvements to be selectively initiated in Stage I to correct specific problem situations.
h. In the upper reaches of the Babura provision is made for some channel improvements.

TABLE 12.1 (Continued)

Drainage Basin	Staged Alternative								
	Stage I Service Area			Stage II Service Area			Stage III Service Area		
	1	2	3	1	2	3	1	2	3
Percut									
Main channel	N/A	N/A	-	N/A	N/A	CCD	N/A	N/A	4a
Local drains									
Submains	N/A	N/A	-	N/A	N/A	CCD	N/A	N/A	3b
Street									
Res High Value	N/A	N/A	-	N/A	N/A	CCD	N/A	N/A	4b
Res Low Value	N/A	N/A	-	N/A	N/A	CCD	N/A	N/A	4b
Com High Value	N/A	N/A	-	N/A	N/A	CCD	N/A	N/A	2a
Com Low Value	N/A	N/A	-	N/A	N/A	CCD	N/A	N/A	2b
Belawan									
Main channel	N/A	N/A	-	N/A	N/A	CCD	N/A	N/A	CCD[i]
Local drains									
Submains	N/A	N/A	-	N/A	N/A	CCD	N/A	N/A	3b
Street									
Res High Value	N/A	N/A	-	N/A	N/A	CCD	N/A	N/A	4b
Res Low Value	N/A	N/A	-	N/A	N/A	CCD	N/A	N/A	4b
Com High Value	N/A	N/A	-	N/A	N/A	CCD	N/A	N/A	2a
Com Low Value	N/A	N/A	-	N/A	N/A	CCD	N/A	N/A	2b
Kera[j]									
Main channel	3a	3a	3b	3a	3a	3b	-	-	-
Local drains									
Submains	3a	3a	3b	3a	3a	3b	-	-	-
Street									
Res High Value	3b	3b	4b	3b	3b	4b	-	-	-
Res Low Value	3b	3b	4b	3b	3b	4b	-	-	-
Com High Value	1a	2a	2a	1a	2a	2a	-	-	-
Com Low Value	1b	2b	2b	1b	2b	2b	-	-	-
Sikambing									
Main channel	N/A	CCD	-	N/A	4a	CCD	N/A	4a	4a
Local drains									
Submains	N/A	CCD	-	N/A	3a	CCD	N/A	3a	3b
Street									
Res High Value	N/A	CCD	-	N/A	CCD	CCD	N/A	3b	4b
Res Low Value	N/A	CCD	-	N/A	CCD	CCD	N/A	3b	4b
Com High Value	N/A	CCD	-	N/A	CCD	CCD	N/A	2a	2a
Com Low Value	N/A	CCD	-	N/A	CCD	CCD	N/A	2b	2b

i. Channel clearing, cleaning and dredging will ensure that a high level of flood protection is maintained.

j. Program of works in the Kera basin to be completed by 1990.

TABLE 12.1 (Continued)

Drainage Basin	Staged Alternative								
	Stage I Service Area			Stage II Service Area			Stage III Service Area		
	1	2	3	1	2	3	1	2	3
Putih									
Main channel	CCD	CCD	N/A	3a	CCD	N/A	3a	3a	N/A
Local drains									
Submains	CCD	CCD	N/A	3a	CCD	N/A	3a	3a	N/A
Street									
Res High Value	CCD	CCD	N/A	3b	CCD	N/A	3b	3b	N/A
Res Low Value	CCD	CCD	N/A	3b	CCD	N/A	3b	3b	N/A
Com High Value	CCD	CCD	N/A	1a	CCD	N/A	1a	2a	N/A
Com Low Value	CCD	CCD	N/A	1b	CCD	N/A	1b	2b	N/A
Badra									
Main channel	N/A	N/A	N/A	N/A	N/A	4a	N/A	N/A	4a
Local drains									
Submains	N/A	N/A	CCD	N/A	N/A	3a	N/A	N/A	3a
Street									
Res High Value	N/A	N/A	CCD	N/A	N/A	CCD	N/A	N/A	4b
Res Low Value	N/A	N/A	CCD	N/A	N/A	CCD	N/A	N/A	4b
Com High Value	N/A	N/A	CCD	N/A	N/A	CCD	N/A	N/A	2a
Com Low Value	N/A	N/A	CCD	N/A	N/A	CCD	N/A	N/A	2b

The recommended monitoring program should be developed giving consideration to the following items:

1. Parameters:
   - flood flow rates
   - water quality
   - areas inundated
   - flood damage
2. Locations:
   - Primarily in major rivers and main drains
3. Methodology:
   - equipment and field installation
   - sampling procedures and equipment
   - frequency of observations

12.2.2.2 Channel and Drain Maintenance

Monitoring of operations and maintenance will continue to be an important element of drainage system management to ensure the fulfillment of drainage program objectives.

Work schedules and staffing requirements for the maintenance program will have to be continuously reviewed on the basis of the monitoring results and adjustments made as required to ensure that reasonable production standards are applied and met.

The organizational elements necessary to carry out this function are described in Section 15.

12.3 PHASED IMPLEMENTATION PROGRAM

Figure 12.1 illustrates the phased implementation program for drainage and flood control.

Critical items which can be initiated prior to mid-1981 when conventional international funding will become available have been identified as an immediate action program.

12.4 COSTS

The estimated capital and operation and maintenance costs of the foregoing program of works for the drainage system is summarized in Table 12.2 and 12.3.

DRAINAGE IMPLEMENTATION SCHEDULE

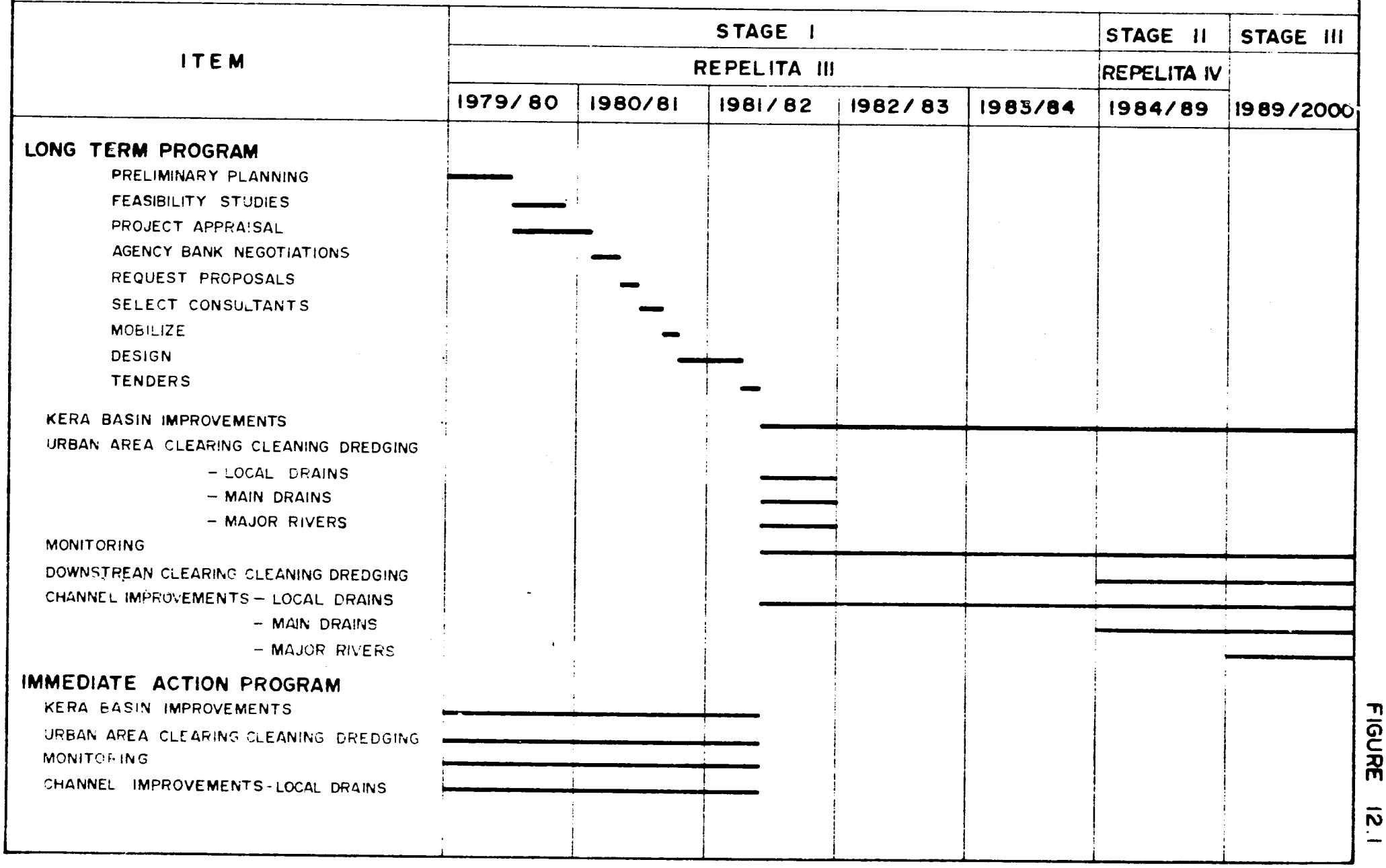

FIGURE 12.1

TABLE 12.2

ESTIMATED CAPITAL COSTS FOR RECOMMENDED DRAINAGE SYSTEM

Item	Estimated Capital Cost in Thousands of Rupiah						
	1979/80	1980/81	1981/82	1982/83	1983/84	1984/89	1989/2000
Kera basin improvements	-	(570,000)	290,000 (280,000)	720,000	870,000	4,470,000	-
Urban area clearing, cleaning, dredging							
Local drains	(121,000)	(121,000)	61,000 (60,000)	121,000	121,000		
Main drains	(190,000)	(190,000)	95,000 (95,000)	191,000 (95,000)	190,000		
Monitoring	(75,000)	(12,000)	6,000 (6,000)	12,000	12,000	-	-
Downstream clearing, cleaning, dredging						270,000	-
Channel improvements: - Local drains	(312,000)	(253,000)	184,000 (194,000)	607,000	647,000	3,589,000	10,885,000
- Main drains						1,100,000	2,200,000
- Major rivers							4,136,000
Sub Total	(698,000)	(1,146,000)	635,000 (636,000)	1,650,000	1,840,000	9,429,000	17,221,000
Training Engineering & Technical Assistance	(70,000)	(115,000)	63,000 (64,000)	165,000	184,000	943,000	1,722,000
Land	(1,000)	(1,000)	500 (500)	1,000	1,000	5,000	11,000
Contingencies	(115,000)	(189,000)	105,000 (105,000)	272,000	304,000	1,557,000	2,843,000
Total	(884,000)	(1,451,000)	803,500 (805,500)	2,088,000	2,329,000	11,934,000	21,797,000

Note: - Costs at 1979 prices.
- ( ) indicates immediate action program expenditures.

TABLE 12.3

ESTIMATED OPERATION AND MAINTENANCE COSTS FOR RECOMMENDED DRAINAGE MANAGEMENT SYSTEM

Item	Estimated Annual Operation and Maintenance Cost in Thousands of Rupiah						
	1979/80	1980/81	1981/82	1982/83	1983/84	1984/89	1989/2000
Proposed Improvements							
Kera Basin			1,000	2,000	4,000	10,000	10,000
Local Drains	36,000	25,000	23,000	22,000	20,000	18,000	16,000
Urban Area:							
Main Drains	20,000	14,000	13,000	11,000	10,000	9,000	8,000
Rivers		10,000	25,000	24,000	23,000	20,000	20,000
Downstream channels				25,000	17,000	15,000	13,000
Monitoring						12,000	12,000
Total	56,000	49,000	62,000	84,000	74,000	84,000	79,000

Note: - Costs at 1979 prices.