Flood Action Plan
FAP 3
North Central Regional Study

Supporting Report VII
Engineering

Earthworks and Embankments VII.1
Flood Control Structures VII.2
Topographic Survey VII.3
Engineering Costs VII.4

February 1993

Financed by:

Commission of the European Communities and
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Project ALA/90/03

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BCEOM, Compagnie Nationale du Rhone
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VII.1 Earthworks and Embankments

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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AEZ	Agro-Ecological Zone
BADC	Bangladesh Agricultural Development Corp.
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BB	Bangladesh Bank
BBS	Bangladesh Bureau of Statistics
BCAL	Bangl.Census of Agricultural Livestock
BCAS	Bangladesh Centre for Advanced Studies
FDC	Bangladesh Fisheries Development Corp.
BIDS	Bangladesh Institute of Development Studies
BIWTA	Bangladesh Inland Water Transport Auth.
BJRI	Bangladesh Jute Research Institute
BKB	Bangladesh Krishi Bank
BNPP	Bangladesh National Physical Plan. Board
BRAC	Bangladesh Rural Advancement Committee
BRDB	Bangladesh Rural Development Board
BRRI	Bangladesh Rice Research Institute
BUET	Bangladesh University of Engg.Technology
BWDB	Bangladesh Water Development Board
CA	Catchment Area
CAS	Catch Assessment Survey
CAT	Coordination Advisory Team
CCCE	Caisse Centrale de Coopération Economique
CEC	Commission of European Communities
CPM	Coarse Pilot Model
CS	Consultants' Studies
DA	Development Area
DAE	Department of Agricultural Extension
DAE	Department of Agricultural Extension
DANIDA	Danish International Development Agency
DDT	Dichlorodiphenyl-trichloroethane
DHI	Danish Hydraulics Institute
DOE	Department of Environment
DOF	Department of Fisheries
DOS	Disk Operating System
DSSTW	Deep Set Shallow Tubewell
DTW	Deep Tubewell
DUL	Desh Upodesh Ltd.
EEC	European Economic Community
EIA	Environmental Impact Assessment
EIP	Early Implementation Programme
FAO	Food & Agricul.Organ.of the United Nations
FAP	Flood Action Plan
FCD	Flood Control and Drainage
FCDI	Flood Control,Drainage & Irrigation Project
FFYP	Fourth Five Year Plan
FHS	Flood Hydrology Study
FMM	Flood Management Modelling
FPCO	Flood Plan Co-ordination Organisation
FRI	Fisheries Research Institute
FRSS	Fisheries Resources Survey System
FSR	Farming Research System
FWP	Food for Work Programme
FY	Financial Year
GOB	Government of Bangladesh
GW	Groundwater
HTW	Hand Tubewell
HYV	High Yielding Variety
IDA	International Development Agency
IPM	Integrated Pest Management Programme
IRRI	International Rice Research Institute
JFP	Jamuna Flood Plain
JPPS	Jamalpur Priority Project Study
LGED	Local Government Engineering Department
ME	Ministry of Education
MF	Ministry of Finance
MIWDFC	Minist.of Irrig., Water Dev.& Flood Control
ML	Ministry of Land
MLGRDC	Minist.of Local Govt.,Rural Dev.& Coop.
MOA	Ministry of Agriculture
MOEF	Ministry of Environment and Forestry
MOFL	Ministry of Fisheries & Livestock
MOSTI	Manually Operated Shallow T/W for Irrig.
MP	Ministry of Planning
MPO	Master Plan Organisation
MTN	Madhupur Tract North
MTS	Madhupur Tract South
NCA	Net Cultivable Area
NCR	North Central Region
NCRM	North Central Regional Model
NCRMG	North Central Regional Model Group
NCRS	North Central Regional Study
NFMP	New Fisheries Management Policy
NGO	Non Government Organisation
NGR	Natural Growth Rate
NWP	National Water Plan
OBFP	Old Brahmaputra Flood Plain
O&M	Operation and Maintenance
ODA	Overseas Development Administration (UK)
PA	Planning Area
PFDS	Public Foodgrain Distribution System
POE	Panel of Experts
PSR	Preliminary Supporting Report
PU	Planning Unit
PWD	Public Works Datum
RARS	Regional Agricultural Research Station
RHD	Roads and Highways Department
RS	Regional Scheme
SES	Socio-Economic Survey
SOB	Survey of Bangladesh
SPARRSO	Space Research & Remote Sensing Organ.
SRP	Systems Rehabilitation Project
SRTI	Sugarcane Research and Training Institute
STW	Shallow Tube Well
SWMC	Surface Water Modelling Centre
TOR	Terms of Reference
Tk	Taka
UNDP	United Nations Development Programme
UNHCR	United Nations H.Commission for Refugees
WFP	World Food Programme

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SR VII.1 - EARTHWORKS AND EMBANKMENTS
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CHAPTER 1
INTRODUCTION

1.1 General

The hydrophysical environment of the North Central Region has been significantly altered during time both by nature and mankind. Every year there are major natural changes to the river morphology with significant movements in river beds and silt load (see SR II.4). There are also significant human interventions made with the construction of embankment, cards and the digging out of drainage channels.

An inventory of the existing infrastructure including flood embankments is given in SR VI. This report (SR VII.1) describes the embankments in detail and sets out the design criteria and costing required at pre-feasibility level of analysis.

1.2 Mapping

The earthworks analysis was carried out during 1991 and the 1:50,000 mapping available was found to be inadequate for determining existing embankments. Although FAP-18 are currently preparing updated maps for part of the region, that information was not available in time for the study and the NCRS undertook an exercise of determining existing embankment and other hydrophysical features by drawing maps from the spot imagery of 1989 at the scale of 1:50.000. These were then matched with survey of Bangladesh map at the same scale. Twenty four sheets were used for the alignment of the proposed embankment along the main rivers.

The aerial photographs of 1983 were used to help identify some of the main features. 1990 aerial photographs, were also used to identify modifications of the river banks, and to assess the bank shifting, of the Jamuna during the last few years.

The bank lines have been traced for 1983, 1989 and 1990. The former positions of the bank line is known from drawings and this gives an indication of the reaches where erosion is currently the most active. Though it is difficult to anticipate the importance of erosion for future years, it appears necessary in some places to keep a reasonable set-back distance. (see Section 3.5).

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CHAPTER 2
EXISTING EMBANKMENTS

2. Existing Embankments

Flood embankments can be considered to include any earthworks which have been constructed that exhibit some influence on flooding patterns. This broad definition includes embankments that have been built either to protect lands from flood damages or to remain above flood levels, like roads or railways.

2.1 Embankments

Embankments have been constructed by many organisation including the BWDB, RHD, Railway Department, LGEB or by local bodies under the management of thanas. Many of these existing embankments are not recorded on any accurate maps, however:-

- BWDB record its embankments on maps, but many of these are obsolete and are difficult to relate to recent maps. The exact locations of embankment is not accurately shown and the locations are complicated by the shifting nature of the river bank.

- Embankments from local bodies are not generally recorded on maps or in any other report, except for these detailed by the LGEB. They have to be identified on the field or on the aerial photographs when they are available. Field reconnaissance was not possible everywhere at this pre-feasibility level of analysis but detailed topographic survey and field checks are required at future feasibility level.

In that respect the inventory Table VII.2.1 and VII.2.2 sets out the information/data available from BWDB, RHD, LGEB, Railway Department etc. Also see Figure VI.5.1.

The main sources of information have been Tangail Division (in charge of Tangail and Jamalpur Districts) who gave all details on existing embankments along the Jamuna left bank as well as inside NCRS area. Dhaka O&M Division-I has similarly supplied data & information of existing embankments in the Districts of Dhaka, Munshiganj, Narayanganj, Manikganj & Gazipur. The Superintending Engineer, Mymensingh O&M circle has also given data accordingly for the district of Mymensingh.

2.1.1 Embankments in Planning Unit I

A flood embankment of a total length of about 80 km. was constructed in the 1960s and early 1970s along the left bank of the Jamuna from Kulkandi in Dewanganj thana to Jagannathganj in Sharisabari thana, by Thana Parishad (local body) and BWDB. This embankment provided some degree of protection to the area in the four thanas of Dewanganj, Islampur, Madarganj and Sharisabari, but river bank erosion is a problem in Bahadurabad & Jagannathganj, where the embankment has shifted in several places.

River training work had to be completed for protection of Dewanganj town, whereas at Sharisabari the Jamuna has been silting up for the last few years. During 1991 river bank erosion was severe in the reach from Bahadurabad to Madarganj.

TABLE VII.2.1
Inventory of Embankments

DISTRICT : TANGAIL

Sl. No.	Name of the Project/Scheme	Embankment Catchment Area (Sq.km)	Length (Km)	Crest Level (m.PWD)	Height (Average) (m)	Top width (m)	Remarks
01.	Pinga-Jokerchar Flood Embankment Project	84.00	37.00	From : 16.00 To : 14.60	From : 3.50 To : 3.00	4.25	
02.	Karatia-Silimpur Flood Embankment Project	40.00	40.00	From : 16.30 To : 13.40	: 3.00 (Average)	4.30	SSFCDI
03.	Kamarnaogaon Sub-Project	--	23.00	From : 10.70 To : 9.70	From : 2.50 To : 1.50	4.30	
04.	Babupur-Lauhati Flood Control & Drainage Scheme in Upazila Delduar	41.00	20.00	From : 14.30 To : 12.70	From : 3.20 To : 0.00	4.30	under F/S
05.	Pathakhali-Konaibeel Sub-Project in Upazila Mirzapur	25.00	15.00	From : 00.00 To : 11.40	From : 2.50 To : 0.00	4.30	(EIP) completed in 1978-79 Total Exp. = Tk. 40.26 lacs Benefitted area =3405 acres
06.	Improvement of Charan & Lakshmi-basha beel in Upazila Kalihati	65.00	42.00	From : 00.00 To : 13.10	From : 0.00 To : 2.70	4.30	SSFCDI Completed in 1983-1984 Cost Tk. 63.58 lacs Benefitted area = 2500 acres
DISTRICT : JAMALPUR							
07.	Kabariabari Khal Sub-Project in Upazila Sharisabari	63.00	37.00	From : 19.00 To : 16.30	From : 3.50 To : 4.00	3.7-4.3	SSFCDI Embankment under resectioning
08.	Katakhali Khal Sub-Project in Upzila Sharisabari	40.00	13.00	From : 19.50 To : 00.00	4.5 4.50	4.30	R/S. Essential
09.	Mahmudpur-Delalerpara Sub-Project in Upazila Melandah	60.70	14.30	From : 19.50 To : 00.00	From : 4.50 To : 0.00	4.30	
10.	Bahadurabad Embankment Sub-Project		7.50		3.50		These embankments are remaining parts of embankments taken away by shifting of Jamuna
11.	Dewanganj Sub-Project (T/P)		13.50		3.50		Probably parts of Dewanganj T/P
DISTRICT : MUNSHIGANJ							
12.	Sreenagar-Mawa-Bhagyakul Sub-Project in Upazila Sreenagar & Lohajang	22.95	30.00	7.30	3.50	4.28	55 % complete SSFCDI
13.	Dhaka South West Project in Munshiganj, Manikganj & Dhaka District Polder 1-4 (Tract 2,3)	971.66	178.00	Variable	Variable	Variable sections	Completed embk 72 km Reg = 2 Nos. Pipe = 9 Sluices
14.	Munshiganj - Tongibair Flood Control and Irrigation Project in Upazila Munshiganj, Tongabari.	Feasibility study has been made & the F/report has been sent to SE/PIU for examining the feasibility after which PP will be prepared. If approved, Tk. 540 lacs may be reqd. for starting work in 91-92					
15.	Munshiganj - T/P Project in Upazila Munshiganj.	PP has been submitted to planning commission, tenders were invited for taking of the work in 1990-1991 but due to financial stringencies works could not be started.					
16.	Protection of Dighirpar Market from river-erosion in Upazila Tongabari	Preliminary Survey has been done Processing is done for allotment of Tk. 350 lacs in 1991-92					
17.	Re-excavation of Rajatrekha khal from Munshirhat to Katakhali & via Masuhati upto Dighirpar in Upazila Munshiganj	Survey will be done for preparation of scheme.					
18.	Re-excavation of Chitalia khal from Munshirhat to Chitalia via. Bagerhat in Upazila Munshiganj	Same as abov					
19.	Construction of flood embankment from Baterchar Market in Tangerchar union to Imampur, Rasulpur & Bhaberchar in Upazila Gazaria.	Same as abov					
DISTRICT : GAZIPUR							
20.	Re-excavation of Dardaria khal in Upazila Kapasia		17.82				
DISTRICT : NARSHINGDI							
21.	Balushair Embankment Project		12.87		4.50	4.27	
22.	Aglarchawk Irrigation Project in Upazila Nawabganj						
23.	Keraniganj Irrigation Project in Upazila Keraniganj.		3.38		2.00	2.45	

TABLE VII.2.2
Inventory of Structures

DISTRICT : TANGAIL.

Sl. No.	Name of Project	Sluice No.	Sluice Draining Area(Sq.m)	No.of vent	Vent size (witdh & Height)	Sill Level m.PWD	Operational Condition
01	02	03	04	05	06	07	08
01.	Pigna-Jokerchar Project	Shakharia Regulator-1		2 Vent	5' x 6'	35m	Good
		Bahadipur Pipe Outlet-2		3' dia	1 layer	32m	without gate
		Bhuapur Regulator-3		10 Vent	10=5'x6'	32m	Good
		Taghari Regulator-4		1 Vent	5'x 6'	-	Good
		Gobindashai Regulator-5		1 Vent	5'x 6'	-	Good
		Nikrail Regulator-6		1 Vent	5'x 6'		Good
		Goaliabari Pipe Outlet-7		3 feet dia	1-layer	35m	without gate
02.	Shankibhanga Sub-Project	Shankibhanga W/C. structure		6 Vent	4=5'x 8 2=2/0+5'x8'		without fall board
03.	Bailjana Sub-Project	Bailjana Regulator		2 Vent	5'x 6'		
04.	Futa Nadi Sub-Project	Futa Nadi W/C.Structure		6 Vent	4=5'x 7' 2=2/0+5'x7'		without fall board
05.	Khirai Sub-Project	Shirai W.C. Structure		6 Vent	4=5'x 7' 2=(0+5')x7'		Good
06.	Noakhali Sub-Project	Noakhali Regulator		1 Vent	4'x 5'		Good
07.	Satbeela Sub-Project	Satbeela Regulator		3 Vent	5'x 6'		Good
08.	Karatia - Silimpur	Bannafair Regulator-1		1 Vent	5'x 6'		Good
		Fatopur Regulator-2		1 Vent	5'x 6'		Good
		Indro-Belta Regulator-3		1 Vent	5'x 6'		Good
		Belta Regulator-4		1 Vent	5'x 6'		Good
09.	Kamarnaogaon Sub-Project	Pipe Outlet-1				8.20m	Good
		....				5.00km	Good
		Baroakhia Regulator		1 Vent	2' dia	5.00m	Good
		Pipe Outlet-1		1 Vent	1.83 x 1.52m	6.00m	Good
		Pipe Outlet-4		1 Vent	1.83x1.52m	6.20m	Good
		Pipe Outlet-5			2'dia	7.30m	Good
		Pipe Outlet-6			2'dia	7.30m	Good
		Kamargaon Regulator			2'dia	5.00m	Good
		Pipe Outlet-8			2'dia	7.30m	Good
		Pipe Outlet-9			1.83x1.75m	7.50m	Good
		Pipe Outlet-2		3 Vent	3'dia	7.30m	Good
		Pipe Outlet-3			2'dia	7.70	Good
		Pipe Outlet-7				6.70	Good
		Kalki Box culvert			5.25x4.60m	58.8m	Good
		Gharpara Box culvert		2 Vent	4.60x4.60m	5.78m	Good
		Tuknikhola Box culvert		2 Vent	4.60m4.60m	5.57m	Good
		Kamargaon Box culvert		1 Vent	4.05x3.05m	5.80m	Good
10.	Pathakhali Konai Beel Project	Konai Regulator		2 Vent	5'x6'	3.05m	Good
		Bardam Regulator					
		Pabdakhali Water Cont.struct		1 Vent	5'x6'	4.42m	Good
11.	Barkati Beel Sub-Project	Barkati Regulator		1 Vent	5'x6'	4.42m	Good
12.a)	Moshajan-Lauhajong Scheme	Bhorah Regulator		2 Vent open	10'-0"	3.81m	Good
b)	Moshajan-Lauhajong Scheme	Nordona Regulator		2 Vent	5'x6'	3.66m	Good
13.	Kabariabari khal Sub-Project in Upazila Sharisabari	1 No.	63.42	6 Vent	1.52mx1.83m	9.91m	The Structure is under construction
14.	Katakhali khal Sub-Project in Upazila Sharisabari	2 Nos.	40.48	3 Vent 1 Vent	1.52mx1.83m 1.52mx1.83m	11.128m 12.195m	In operation In operation
15.	Rouha khal Regulator in Upazila Melandah	1 No.	28.34	3 Vent	1.52mx1.83m	12.195m	Gates need repair
16.	Rouha Bakchari khal Sub-Project in Upazila Jamalpur	1 No.	57.00	2 Vent	1.52mx1.83m	10.11m	In operation
17.	Gobakhali Regulator Sub-Project	1 No.	48.48	2 Vent	1.52mx1.83m	14.024m	In operation

Most of these embankments were overtopped in 1988 and damaged. Around Bahadurabad, a total length of about 14.5 km. of embankments remains out of 80 km.(9.5 km. North of Bahadurabad in Dewanganj thana, in the Northern part of North Central Region, and 5 km. south of Bahadurabad). These embankments were built to a lower specification than BWDB's, being mostly constructed under Food for Work Programme (FWP). They are not recorded on the list of schemes submitted by Tangail O&M Division, who mention them as existing embankments constructed by local bodies in the late seventies.

Flood protection embankments have been constructed in the area around Bahadurabad ghat. These have been constructed according to the nature of shifting of the river bank and the track of the railway. However there has been significant erosion in this area and the ghat location has been changed several times with the embankments following that movement.

The average setback distance is about two to three hundred meters with a maximum at one point of seven hundred meters. The setback distance in some places has been reduced to zero due to river bank erosion.

The erosion of the river bank by Jamuna has been 1.2 Km between 1983 and 1989 in places and even 0.6 km in one year between 1989 and 1990. Without any training works these embankments will not stand for long in their present position. These embankments were not overtopped in 1988, the breaches being due only to bank erosion. The location of these embankments are shown on Figure VI.2.1. The area from Katma to Jagannathganj Ghat (about 56 km.) along the River Jamuna remains unprotected with no existing embankments.

In Madarganj the situation is serious since the erosion has shifted the bank more than two kilometres in one year. There is no embankment to protect the Thana Headquarters and the destruction of this town is threatened. During 1991 floods (July-Aug) many villages of Madarganj Thana were engulfed by the Jamuna.

On the left bank of the Chatal river, between the road to Melandaha and the road to Madarganj, there are 14 km. of embankment which were not overtopped in 1988 but which are located more than 12 km. away from the Jamuna. These were constructed under FFW Programmes and are not maintained by BWDB. They should be considered as protection against flood over spilling from Jamuna.

In the south western part of this area there is a polder project by BWDB between the Jhenai river and the present course of Jamuna (Chatal) enclosing Karbariabari khal. Portions of embankment are now completed on the right bank of Jhenai from north of Pigna to Sharisabari and from Pigna to Jagannathganj ghat and the fertilizer factory. This polder should be closed by an embankment between the fertilizer factory and Sharisabari thana headquarters to protect the area of Sharisabari which is partially unprotected.

2.1.2 Jamalpur - Jagannathganj Railway Embankment

There is a railway from Jamalpur to Jagannathganj (See Figure VI.2.3). The north eastern section is generally in good condition and above even the peak flood levels, but the section from Baushi Bridge to Jagannathganj is more prone to flooding. The total length of the existing improved embankment from Baushi Railway Bridge to Pigna is 26 Km. The 12 Km existing embankment from Jagannathganj Ghat to Sharisabari R.S should be improved to protect the Thana Head Quarters.

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2.1.3 Pigna - Jokerchar Embankment

Just to the south of Jagannathganj there is an embankment known as the "Pigna-Jokerchar" flood embankment. This embankment was constructed in the late seventies by local bodies and is currently being re-sectioned and upgraded by BWDB (from 1986). The total length is some 36 km and it stretches from Pigna to Jokerchar on the northern embankment of the Pungli river.

These embankments were not overtopped in 1988, but suffered several breaches due to:

- Cuts by local people who wanted to decrease the flood level on the Jamuna side. This was done one kilometre upstream of the regulator of Bhuapur on the Fatikjani river during 1988 Flood. Even during floods in July 1991 a public cut was made just north of the Bhuapur (10 vent) Regulator. As a result the BWDB executive engineer has proposed to straighten the embankment by diverting the alignment towards the river-side of Jamuna.

- Erosion at sluice-pipe locations (installed at the base of the embankments for drainage). These outlets were not protected and, the high velocity has eroded the embankment around the pipe.

The width of this embankment is around 3m in its initial condition. BWDB after re-sectioning have, widened the top up to 6.0m. This embankment (crest R.L. being 14.73. PWD) is in good condition and apparently resisted well to the 1988 flood (HFL = 13.80m PWD).

The embankment is well suited for improvement to form part of a controlled flooding scheme, except in the reach between Bhuapur thana headquarters and the bank of Jamuna (at the extremity of the paved road near Bhuapur ghat), where the embankment has had encroachment by people. The settlement of population along that reach of about 6 Km is significant and may result in problems for re-sectioning it. The top width is very narrow in some place (no more than 2.5m) and houses are constructed on both sides of the slopes.

But it will be probably very difficult to settle around the embankment those who have lost their land. Plantation programmes in front of the embankment to reduce wave erosion and to create a source of income for those who lost their lands can be envisaged and should be promoted.

South of the road of Bhuapur, the Jamuna Bridge Authority (JMBA) is constructing (1992) an embankment going from the Bhuapur Ghat point on the Jamuna left bank to the future Bridge site. This embankment is approximately eight kilometres and crosses the existing embankment. Its main purpose is to safeguard the bridge; the width is 7.5 meters and its top elevation is 15.2m PWD. The JMBA plan to close the off-take of old Dhaleswari and Pungli river, see SR VI.

The Pigna-Jokerchar flood embankment ends at Jokerchar near Pungli river offtake. After Jokerchar to the South-West of Pungli off-take, the embankment alignment is less consistent. It runs through plain land up to Ramdevpur (9.0km) except for 3.0.km at two different points along the left bank of 1st offtake of Dhaleswari from North (1.0 Km & 2.0Km).

From Ramdevpur there is an existing embankment (named as Karatia-Silimpur Project in Tangail) for a length of about 16 Km. which runs via Porabari to the crossing of Elangjani river (the Elangjani takes off from Dhaleswari) After crossing the Elangjani river, the same existing embankment (Silimpur-Karatia) takes U-turn & runs along the left bank of Dhaleswari river for a length of about 23km. upto Jaktala village.

2.1.4 Other Existing Embankments

Some other smaller projects components of Pigna-Jokerchar Project are recorded on the NCRS 1:50,000 sheets kept on project files and are also shown on Map VI.I listed in Table VII.2.3.

2.1.5 Dhaka South - West Project

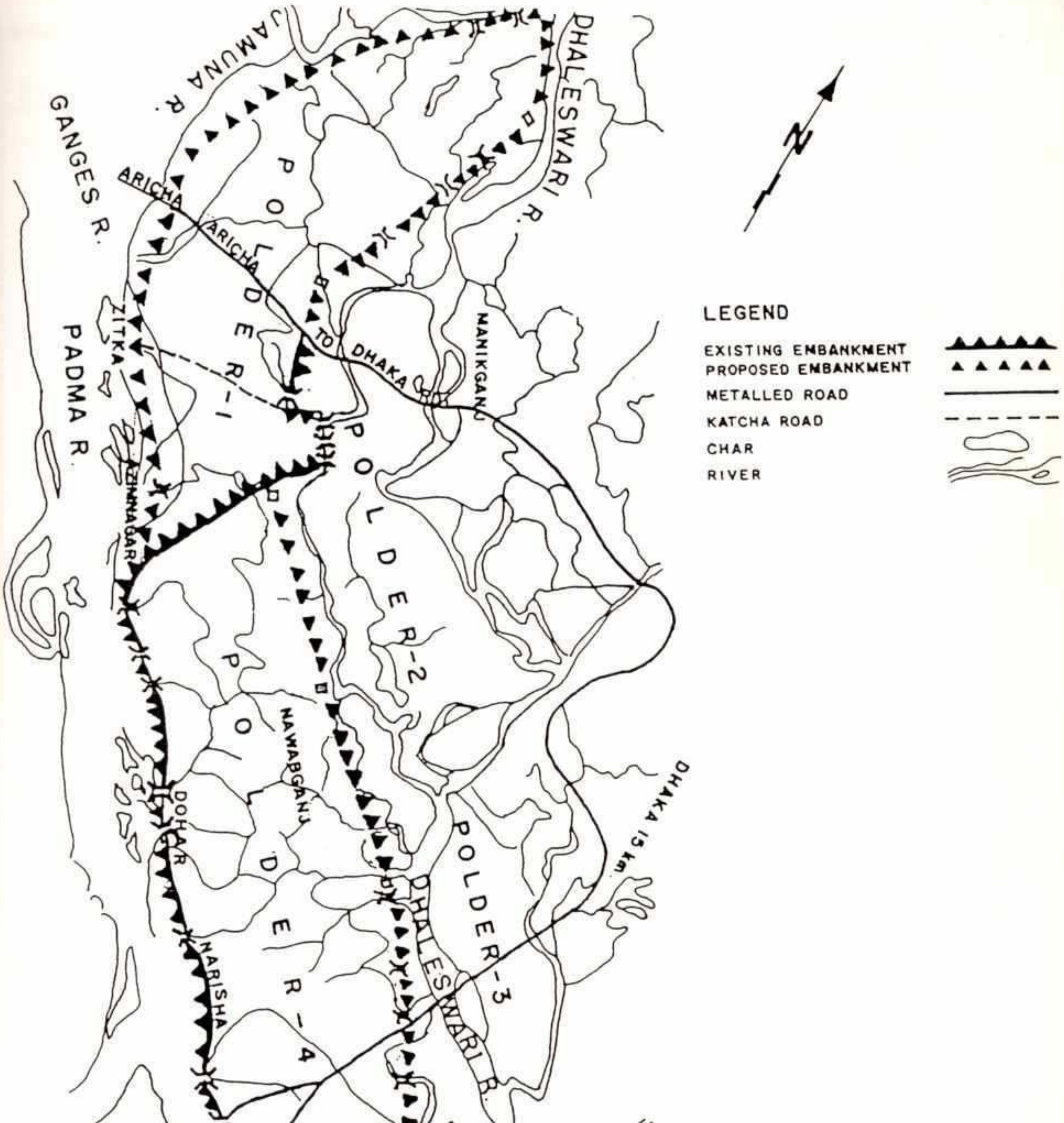
The original Dhaka South-West Project (DSW) Feasibility Study Report was issued in August, 1969. Some work was carried out in 1967 and 1968, financed by Loan No.AID 391-H-059 by the Govt. of Bangladesh (formerly East Pakistan). This report presented a plan of development for the DSW Project, supported by preliminary designs and cost estimates. Conditions & problems within the project area were studied, alternative plans were evaluated, and a recommended plan was proposed.

Subsequently another Feasibility Report (DSW 1970) put forward the concept of staged implementation in Tracts 1,2,3 (polder 1 & 4) (Figure VII.2.1). The Tract areas & miles of embankment for each are shown in Table VII.2.4.

The concept was formulated jointly by the IDA & ECI/ACE, when it became apparent that some questions concerning water supply and fisheries would need to be resolved before full development of Tracts 1,2, & 3 (polder 1 & 4) could take place. The ECI/ACE worked very closely with the IDA Team to develop a plan for staged implementation that would permit significant flood control and irrigation development to proceed as per project financing, thereby allowing sufficient time for the questions on water supply and fisheries to be resolved.

Figure : VII.2.1

DHAKA SOUTH WEST PROJECT



SOURCE: BWDB 1991

TABLE VII.2.3
List of Smaller Embankments

NCR Embankment Nr.	Description	Map sheet (Nr.)	Length (Km)
2	Islampur - Dewanganj	78/G/16	9.1
4	Nandina-Jhenai River	78/H/13	2+14+1
6 & 7	Natkhani-Jugini	78/H/16-15	15
7	Saranpin-Katimkagra	78/H/16	13.2
	Pakutia-Saranpin	78/H/16	
	Bethida Ghat	79/E/13	4.3+23
8	Kadimkagra-Kalikapur	79/E/13	17.2
	Dhaka Road - Pakutia	74/E/13	4.5+7+16
9	Bandgaon-Kaliakair	78/L/4	11+40
	Manikganj-Jagannathpur	79/I/1	16.2
10	Kalatia-Bandgaon	79/I/1	9.6+10
	Kaliganga R.B.	79/I/1	6.5
12	Kalikapur-Mirzanagar	79/E/14	17
13	Mirganagar-Kamargaon	79/I/2	36.3
	Kalatia-Kaliganga R.B.	79/I/2	23.7
14	Dhaleswari-Kalatia	79/I/6	34.1
15	Kamargaon-Chitrahara	79/I/7	29.5
16	Meghna L.B-Dhaleswari R.B	79/I/10	11.7
17	Meghna L.B.	79/I/11	10.5
18	Demra-Nalkurbil	79/I/10	38.8
19	Railway, Nandina-Narundia	78/L/10	30
20	Mymensingh Railway to Muktagacha Road	78/L/5	19.1
21	Mymensingh Railway	78/L/6	20.4
22	Gobindapur	78/L/10	11.5
23	Toke - Goffargaon	78/L/11	25.5
24	Naga-Sangam to Nalkurbil	78/L/12	33.5

Source : CS 1991

TABLE VII.2.4
Embankments Planned in the Dhaka South West Project

	Acres	Percent	Embankment (miles)
Tract-1	80,800	24.2	41
Tract-2	94,200	28.2	47
Tract-3	159,100	47.6	67
Total	**334,100 = (135,263 Ha)**	**100.0**	**155**

i) **Dhaka South West Plan**

The implementation plan, worked out jointly by the IDA & ECI/ACE, composed of two phases :

Phase-I : consisted of full flood control irrigation and agricultural development for 92000 acres & dry-season irrigation for an additional 46000 acres. Phase-I also included the studies to resolve the questions concerning development in the remaining area of the project. The poldered area of 92000 acres is in the lower end of Tract-I and upper end of Tract-2 and is bisected by the Dhaka-Aricha Road. It was selected as the first area because of its location, water supply and large preparation of easily irrigation land.

About 57 miles of embankment, 2 primary pumping plants & 1400 portable pumps were required. In addition, 46000 more acres, outside the polder, were to receive dry irrigation.

Phase-II : consisted of the development of the remaining area and would be based on the results of the studies conducted in Phase-I.

ii) **Dhaka South West Progress**

Physical works of DSW Phase-I upto June 30, 1991 was as follows :

- **Embankment:** About 43 miles (71.55km) has been completed (Mawa to Baniajuri) against 57 miles as planned See Figure VII.1.2.
- **Regulators:** 2 Nos. R.C.C. Regulator have been completed against 16 Nos. as planned.
- **Pumping station**: Nil
- **Pipe-Sluice**: 9 Nos. completed and 1 No. scheduled to be completed during 1991-1992 under F.D.R. against 7 Nos. as planned.

iii) **Future of the DSW Project**

The DSW Project did not receive further backing from donor agencies, apparently because of the following:

- shortage of water (for pumping) in the Kaliganga river during the dry season.
- unstable banks of the Padma complicating the installation requirements pumping plant on that river.
- difficulties with land acquisition.

Despite there problems, the GOB have completed some 43 miles of embankments, 2 regulators and 9 pipe sluices. The completed section along the Padma from Dhaleswari to Mawa is reported to have facilitated a water level difference of nearly 2 m during the 1987 and 1988 floods and the public demand for the project is still present. However it should be pointed out that for the project to be effective, drainage would have to be assisted by pumping and this option has been shown to be expensive elsewhere in Bangladesh.

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2.2 Railway Embankments

The railway lines crossing the North Central Region are the Dhaka-Mymensingh-Jamalpur-Bahadurabad line and the railway line from Jamalpur to Jagannathganj-ghat.

The railway tracks are placed on embankments which in most places were not overtopped by the 1987/1988 floods. The railway embankments between Dhaka-Narayanganj, Dhaka-Tongi, Tongi-Mymensingh, Mymensingh-Jamalpur, Jamalpur-Dewanganj Bazar, Dewanganj Bazar-Bahadurabad, Dewanganj-Bazar-Kulkandi, Jamalpur-Sarishabari & Sarishabari-Jagannathganj were however over-topped by av. 2 ft. during 1987/1988 Floods for a total length of about 130 km. See also SR VI.2.2 and Figure VI.2.3.

During the 1988 flood three railway bridges (one between Tongi & Dhaka Cantonment and two others between Sharisabari & Bhaira) were destroyed. Almost the entire Railway lines from Jamalpur to Bahadurabad (Kulkandi) & from Jamalpur to Jagannathganj were over-topped by av. 2 ft. during 1988 flood, which also caused 28 Nos. breaches between Jamalpur to Jagannathganj as well as 9 (nine) Nos. breaches between Jamalpur-Bahadurabad.

The embankment was safe from Chasara (in Narayanganj) to Fatullah, Dhaka to Banani, Tongi to Kawraid & Gaffargaon to Nandina. This last portion is from approximately 3km after Jamalpur all along the old Brahmaputra on the direction to Dhaka, and the embankment can be considered to afford protection on eighty kilometres on the right bank of old Brahmaputra.

2.3 Roads and Highways Department

The Roads & Highways Department (RHD) is responsible for construction and maintenance of Primary and most of the Secondary roads in Bangladesh, see SR VI.2.1 and Figure VI.2.1.

Under the new classification of the network, there are four categories of road namely;

- National Highway
- Regional Highway
- Feeder Roads (Type-A)
- Thana connecting Road (Type-A)

The "paved road length" under RHD (as on June 30, 1989) for districts within NCRS is given in Table VII.2.5.

The levels of the road were difficult to define since the long profiles were not (September 1989) available in Dhaka except in some portions under maintenance. However the roads are generally much lower than the major floods and although the embankments of the roads can probably be used in some places to delineate compartments, most of these road embankments should not be considered as providing major flood protection.

TABLE VII.2.5
Paved Road Length in the NCRS Area (as on June 30, 1989)

		National Highway		Regional Highway		Feeder Road Type-A		Thana Road Type-A			
Sl. No.	Name of District	Total	Pucca	Total	Pucca	Total	Pucca	Total	Pucca	Total Road	Total Pucca Road
01.	Dhaka	313	308	14	14	207	102	448	176	982	600
02.	Mymensingh	92	92	155	121	181	74	376	94	804	281
03.	Tangail	121	121	23	23	72	32	85	38	301	214
04	Jamalpur	18	18	16	16	131	37	145	44	310	115
	Total	**544**	**539**	**208**	**174**	**591**	**245**	**1054**	**352**	**2397**	**1310**

Source : Inventory of Roads under RHD as on 30 June 1989 Published by Roads and Highway Department-Sarak Bhaban, Ramna, Dhaka.

CHAPTER 3
FUTURE EMBANKMENTS

3.1 Role of Embankments

The various development options being considered for the NCR water resources development plan are described fully in SR VIII. These options include the need for various types of embankment appropriate to the particular proposed development.

For a full flood embankment located adjacent to the main rivers these may be justification for construction of a larger embankment built to a tighter specification (Interior embankment Class A , see Section 3.2) than for a secondary (marginal) embankment (Class B) located within a flood protected area whose function will be to control local flooding emanating from local rainfall or from regional rivers, see Section 4.

Apart from the embankments built specifically for flood control purposes, there are also road, railway and other embankments that impose some effect on flooding patterns. Similarly flood embankment can also provide additional benefits such as through the provision of road access, and settlements (particularly in severe flood situations).

BWDB and many other embankments have been built with a specific intention in mind and fit into a specific plan. Many such embankments, however, have not been completed and thus the originally planned benefits not obtained. There are many other embankment that have been built without specific plans (e.g. some FFW and locally supervised schemes). Such embankments cause significant impedance to drainage flows and may make the flooding situations worse rather than better.

Every development project should be self-finances for at least operation and maintenance. It is advised that some form of cost recovery should be realised from beneficiaries, see Section 3.6. Other aspects of detailed embankment design should be looked at during Feasibility Level of study. Such aspects include the possible protection of embankments from wave action with the use of suitable tree planting programs.

3.2 Embankment Classes

For pre-feasibility level of planning two classes of embankment are proposed. The precise design of embankments should be the subject of detailed engineering and economic analysis at feasibility level. Design criteria are discussed further in Appendix I.

3.2.1 Class A Embankments

Class A embankments (interior embankments with wider crest) are proposed where they are located on the main river banks and are constructed to withstand the major (more than 1 in 20 year floods).

The design is for a 4.5 m crest width as shown in Figure VII.3.1 and VII.3.2. There are 3 variations:

- new embankment
- improvements to existing embankment
- addition to existing railway embankment

Figure : VII.3.1

EMBANKMENT CLASS — A TYPICAL CROSS SECTIONS

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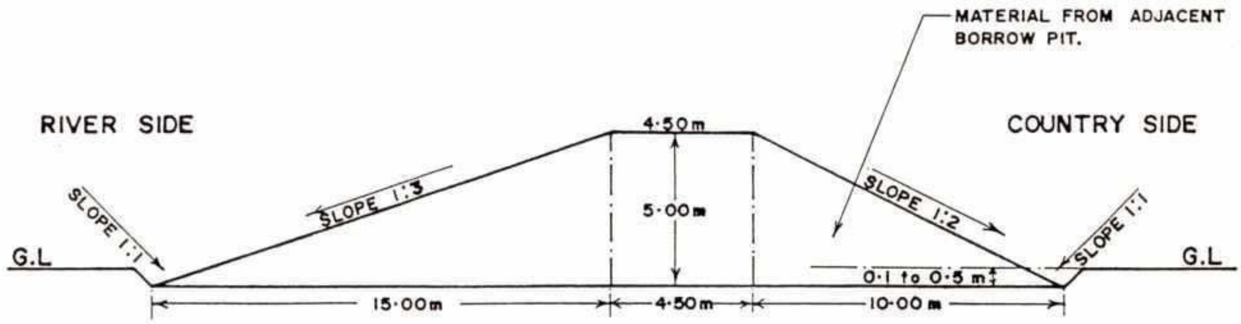
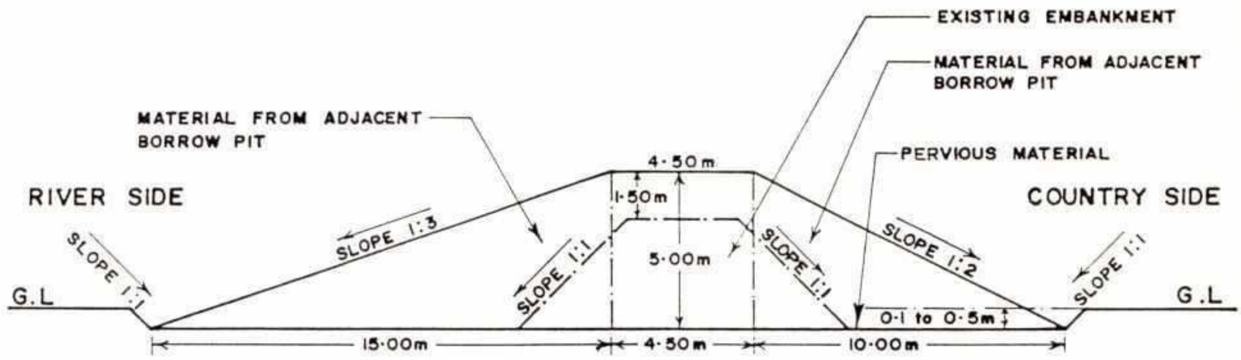
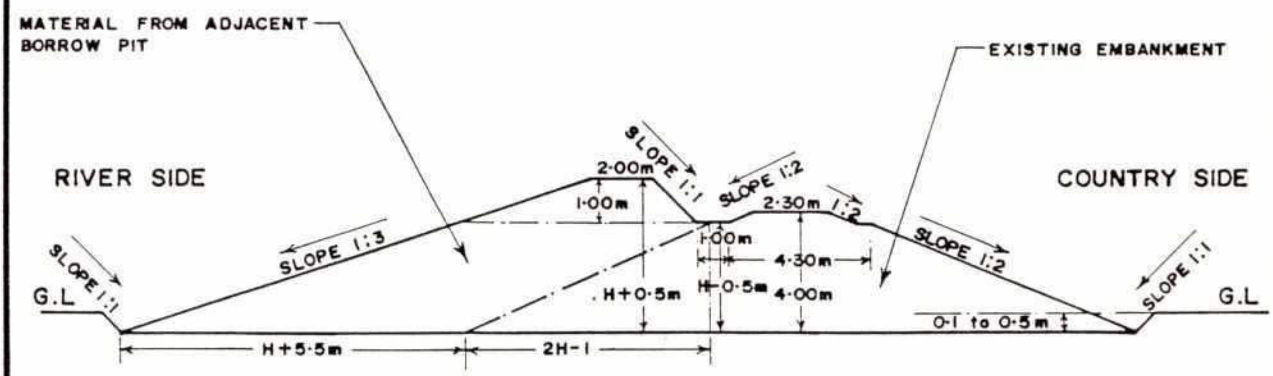


PROPOSED EMBANKMENT



IMPROVEMENT TO EXISTING EMBANKMENT



POSSIBLE ADDITION TO EXISTING RAILWAY EMBANKMENT

(SEE SECTION VII, 5·6)

Figure : VII.3.2
CLASS A EMBANKMENT
PLAN AND PROFILE

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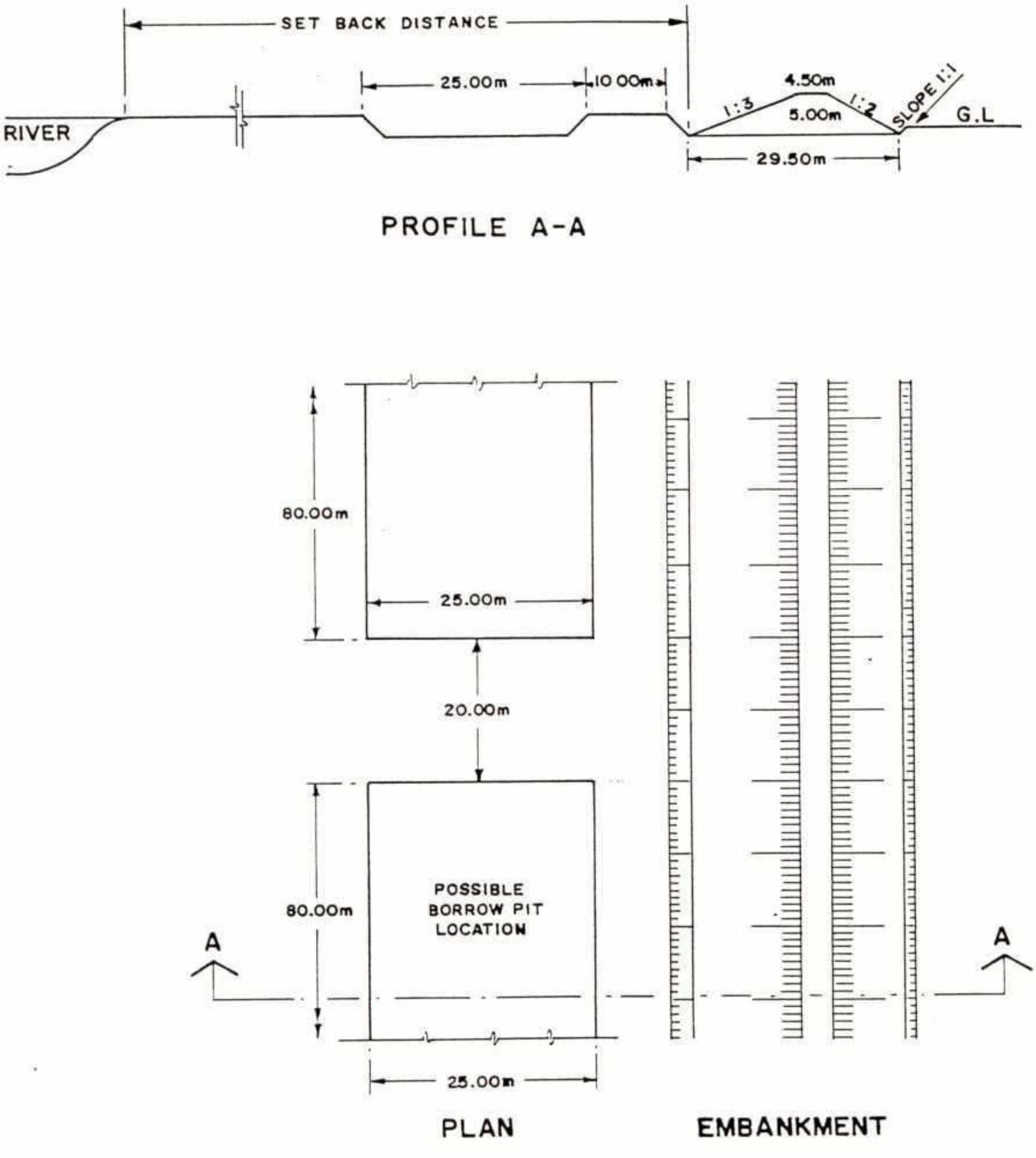

SOURCE: CS 1992

3.2.2 Class B Embankments

Class B embankments (marginal embankments) are proposed for interior embankments along the regional rivers and may also be used in compartmentalisation. They would be designed to withstand lower return period floods (less than 20 years, depending on the specific application).

The design is for a 2.5 m crest width, as shown in Figure VII.3.3

3.2.3 Design Criteria

The embankment design proposed, broadly follows the BWDB standards and the main criteria are summarised in Table VII.3.1.

TABLE VII.3.1

Main Design Criteria[1]

Characteristic	Design Criteria
1. Embankment Slopes (a) "Interior" (b) "Marginal"	 1:3/1:2 1:2/1:2
2. Embankment Crest width (a1) with road (a2) without road (b) without road	 7m 4.5m 2.4m
3. Embankment Foundation	0.1m stripping,limited requirement for toe drain
4. Compaction	85%
5. Return Period	Use 40 years but review at Feasibility Level
6. Freeboard	1.2m
7. Basic costs Unit rates O&M costs - embankment - structures	 BWDB 1991 rates 6% 3%

Note : 1. GPA (FPCO 1992) has been followed with outline designs prepared as necessary, see SR VII.
Source: CS 1992

Other alternative design have been considered and costed for comparative purposes these include:-

- using a wider crest width of 7m and road on top of the embankment
- with a local road on a berm 1.5 m lower than the top crest on the country side
- with crest levels (higher and lower) as applicable to different return periods

The BWDB standard of placing borrow-pits on the river side 10m from the toe of the embankment has been adopted for costing purposes. However it is recommended that this practice is reviewed at feasibility study stage, and modifications made where the ground conditions are of poor quality.

EMBANKMENT CLASS — B
TYPICAL CROSS SECTIONS

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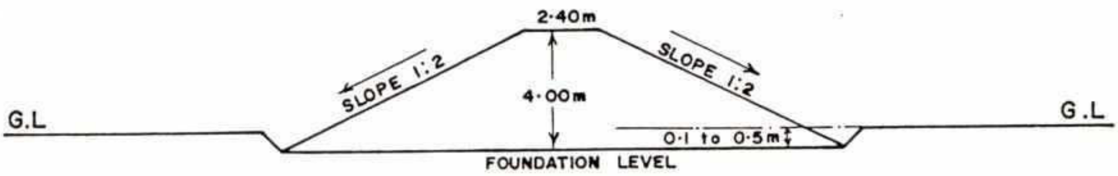
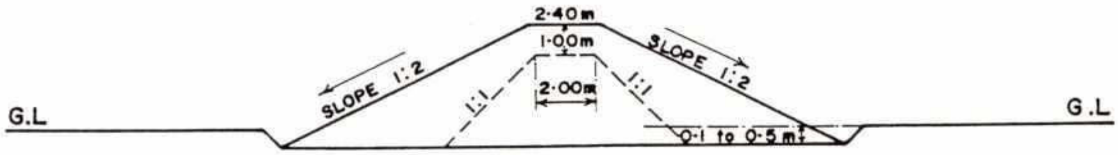


PROPOSED EMBANKMENT



IMPROVEMENT TO EXISTING EMBANKMENT

3.2.4 Design Water Level and Freeboard

If the question of the optimum flood return period to be used in design is considered, it becomes apparent that there is not one generalised answer. The optimum return period is dependent on several factors which vary between the type, location, construction techniques and maintenance of the scheme.

Some of these factors are described below:-

Flood level characteristics

The water levels predicted along rivers for different return periods are unique to the particular location and river. For example FAP 25 analysis of the Jamuna river shows water levels as given in Table VII.3.2. Note that the difference for the with project situation in peak water level from the 1:50 to 1:100 year case is 17 cm at Bahadurabad and 16 cm at Porabari, whereas at Baruria (on the Padma), the water level difference is 24 cm. Similarly the impact of embankments on river water levels varies depending on the location and type of river (FAP 25 estimates show an increase of water levels at 1:50 year return period from the NCRS medium term plan in the order of 8 cm at Bhadurabad but in the order of 54 cm at Porabari).

Damages in area to be protected

The benefits from protecting against flood damage depends on the level of production and value of assets that are vulnerable to flood damage in the area to be protected. There is generally a higher value placed on avoiding damage in urban and industrialised areas, than in agricultural areas.

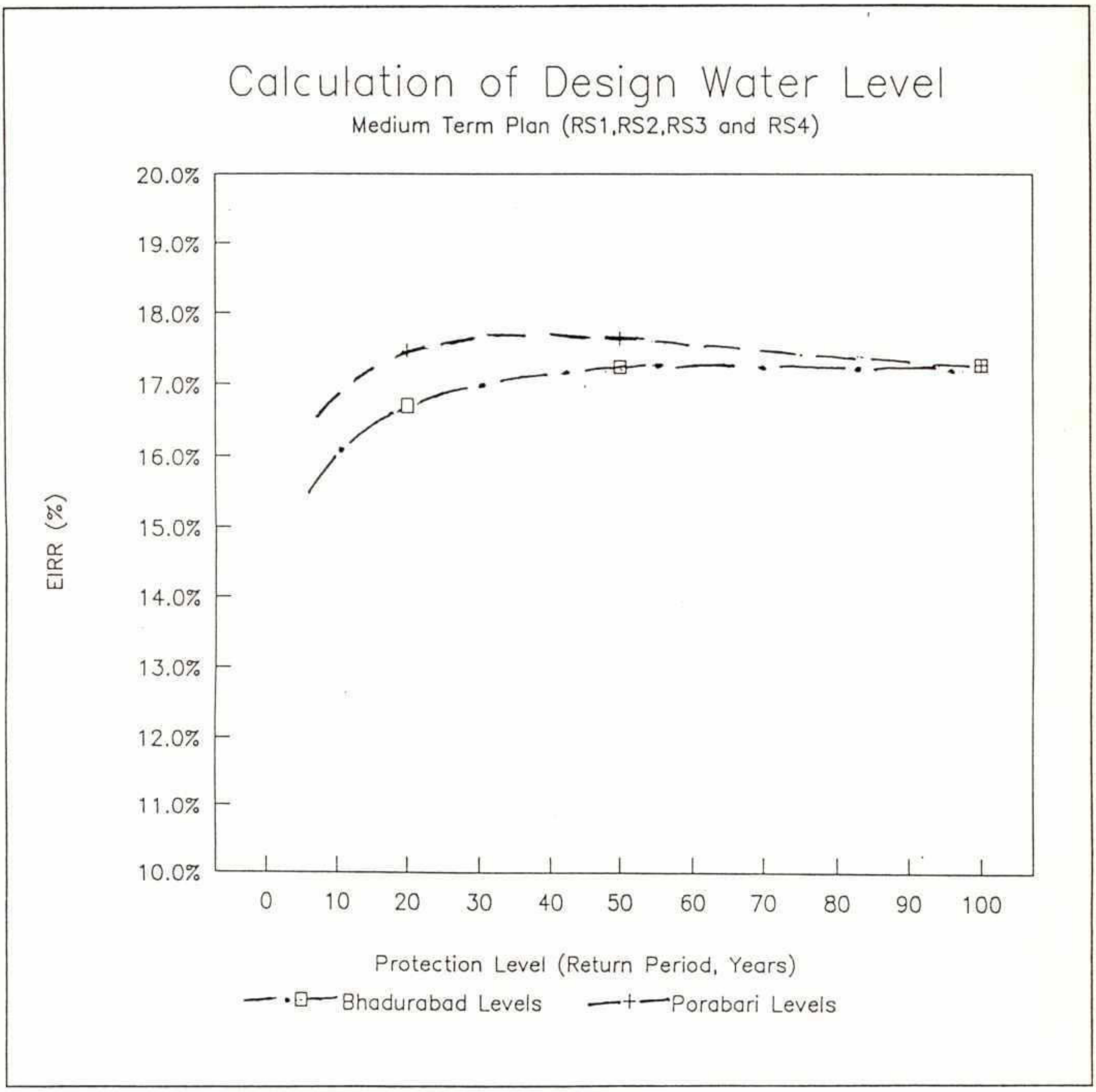
Construction Specification and Freeboard

The standard of construction is related to the allowance made in the tender design documents for such factors as compaction, foundations and level tolerances (these will be related to the cost levels and degree of contractor supervision during construction). The freeboard allowance, which is added on to the design water level should take account of several more factors, including:-

- wave height (dependent on wind speeds, direction, length of reach and cultivation in front of the embankment)
- wave uprush (depending on wind direction and slope)
- maintenance (weak sections or erosion of bank top levels)
- shrinkage and subsidence
- inaccurate hydrological analysis
- inaccurate topographic data

All of the above factors play a part in the optimization of return periods and freeboard allowances for embankment design. The NCRS recommends that the return period for deciding on design water level should be decided at Feasibility Level and may well vary depending on the location of the project and of the location and type of the particular embankment (as described above). For general analysis the NCRS have carried out calculations using the damage estimates given in PSR X.3 and embankment cost estimates. This analysis results in the calculation presented as Table VII.3.3 and Figure VII.3.4.

Figure VII.3.4



Although the calculation should be regarded as preliminary due to the imprecise data relating to the factors concerned, certain observations can be made. It can be seen that the optimal return period for design depends on location and on cost and implementation period assumptions. Generally the optimal answer lies between 20 and 100 years. Above a return period of 40 years, the IRR is not very sensitive to the return period of design level chosen (this is due to the small difference in water levels between a 40 year and 100 year flood). At prefeasibility level the NCRS has recommend the use of a 40 year return period with a 1.2 m freeboard (this is almost the same as using the BWDB practice of a 1:100 year flood and a 0.9 m freeboard as used for embankments along medium and main size rivers, protecting large areas), but this recommendation should be modified at the more detailed feasibility level using more accurate flood damage estimates and the flood level characteristics relevant to the sub-region concerned.

TABLE VII.3.2

Peak Design Water Levels

	Peak Water Levels (m)[1]		
Station	25	50	100
Bahadurabad	20.60	20.77	20.94
Porabari	12.91	13.08	13.24
Baruria	9.16	9.39	9.63

Note: [1] From FAP 25 model analysis, Main Report, Table 7.3

TABLE VII.3.3

Optimization of Return Period for Embankment Level Design
(Medium Term Plan)

	Using Bhadurabad Level Data			Using Porabari Level Data		
	Return Period(Years)			Return Period(Years)		
Implementation Assumption	20	50	100	20	50	100
Base case (3yr construction, BWDB rates)	Economic Rate of Return (EIRR %)					
	16.70%	17.25%	17.28%	17.47%	17.65%	17.28%
Construction over 6 years	13.66%	14.10%	14.14%	14.26%	14.42%	14.14%
Doubled Cost	7.67%	8.06%	8.05%	8.31%	8.38%	8.05%
Cost increased by 40%	11.99%	12.43%	12.44%	12.68%	12.79%	12.44%

Source: CS 1992

3.3 Flood Level

It has been necessary to calculate flood levels along the river for different return periods to allow for embankment heights to be ascertained. Use has been made of analyses from FAP-1 and in particular FAP-25 for these calculations:-

The Brahmaputra-Jamuna water level for the flood of 100 year return period are given in the First Interim Report of FAP-1, Technical Annex 2, page 20, table 5.5. FAP-25 have recently published their main report (FAP-25 1992) and their return periods for 1:50 and 1:100 are given in Table VII.3.4. These levels are estimated in the natural conditions (without confinement). The chainage (in kilometers) of the gauging stations are based on the schematization of the BRTS 1-D model (FAP-1 1991). Flood levels at different return periods are also given for other rivers in the NCR in Table VII.3.4.

TABLE VII.3.4
Peak Water Levels on the Jamuna at 1:100 and 1:50 Return Period

Station	Chainage (Km)	FAP-1 (m.PWD)	FAP-25[1] (m.PWD	1:50 FAP-25[1] (m.PWD)	1988 Flood Level (Natural Condition) (m.PWD)
a) Jamuna					
Kholabarichar	68.7	22.05	--	--	20.62
Bahadurabad	76.6	20.91	20.73	20.57	16.77
Kazipur	135.0	16.89	16.77	16.60	16.14
Jagannathganj	139.0	16.53	--	--	15.12
Sirajganj	155.8	15.15	15.36	15.10	13.15
Porabari	188.2	13.70	13.26	13.14	11.35
Mathura	--	11.75	11.69	11.42	10.58
Aricha	--	10.94	--	--	Average Water slope (cm/km)
b) Padma					4.6
Baruria	--	--	9.57	9.32	--
Mawa	--	--	7.27	7.01	--
c) Old Brahmaputra					6.53
Jamalpur	--	--	18.00	17.89	--
Nilukhirchar	--	--	13.79	13.39	--

3.4 Embankment Alignment

The NCR investigations have revealed that significant lengths of embankment already exist along the main rivers in the region (see Figure VII.2.X) Future alignments should take into account both the existing embankments (thereby minimizing land acquisition problems), and also the risk of erosion.

There has been much discussion in Bangladesh as to the optimum set back distance to be adopted for the alignment of embankments. Given the availability of required information a calculation can be made relating the cost of construction against the benefits gained from the embankment construction. Such a calculation will give a different optimum set back distance depending on the parameters assumed (see Appendix II).

In practice in the NCR the morphological observations (see SR II.3) show that there are only a few limited places where erosion occurs on the left bank, of the Jamuna.

3.5 Construction Works

Hand labour is widely used in Bangladesh and virtually all the embankments have been constructed that way. The output of manual labour is however low, particularly where the material has to be carried long distances.

Average output is considered to be 2.8 cu.m/manday. This figure has been observed to be applicable in the NCR but work rates should be checked at the feasibility study stage.

It is essential that earth should be homogenized for its quality and texture:-

- First regarding the earth quality: the earth has to be mixed in the borrow-pit to avoid layers which could have more sand or more clay and generally this can be obtained only by mechanized equipment. This point has to be emphasized: for a dyke construction, the work done by the bulldozers at the borrow-pit to get an homogeneous material is very important.

- Second regarding the moisture content: the material in the borrow-pit will not, generally, be at the optimum moisture content. The adjustment in most countries is done in the borrow-pit with mixing by mechanical equipment. Such control is generally not achieved with handwork construction, and any moisture content adjustment is performed on the layer of the dyke. This is not the best way to do it and for dyke construction such a method should be avoided, except for very small adjustment. If it is not possible to reach the right and an homogeneous moisture content, the dyke will face serious problem regarding stability.

To minimize those two problems it has been suggested to strip the ground up to 0.50m deep to get more homogeneous material. Although such a practice is to be recommended it has not been possible to implement such a measure in Bangladesh in the past ,except in particular problem soils areas. Accordingly it is to be recommended in the design only fro problem soils areas and an allowance has been made in the costings for 10% of the embankments to have 0.5m ground stripping, an allowance of 0.1 m has been made elsewhere.

It has been assumed that the average quality of the material from the borrow-pit would be sufficiently impervious or with a K co-efficient which would be proper for a dyke construction. If the material were pure sand it might be necessary to get clay from a far away borrow-pit. As it is not possible to have a good estimation of earth quality along the embankment no allowance has been taken for that.

Compaction is supposed to be performed by equipment according to the usual technical rules. The materials to be tested and brought to its optimum moisture content and compacted.

3.6 Operation and Maintenance

Operation and maintenance is under funded within the BWDB and preventive maintenance almost absent. This is a common problem with water resource projects the world over and studies have been set up within Bangladesh to try and address this problem.

However FAP-13 (Operation and Maintenance Supporting Study of the FAP) and other studies such as the Systems Rehabilitation Project are at an early stage and have yet to propose firm recommendations. The O&M model proposed for SRP includes:-

- incorporating preventive maintenance for earthwork and structures in planning and budgeting of O&M in addition to periodic maintenance work;
- creating arrangements for an NGO or another competent organization (i.e. BRDB) to negotiate employment on behalf of their target group with the BWDB;
- creation of embankment and structure maintenance groups who will be deployed in maintenance work;
- studying the scope for the cultivation of useful crops on embankments;
- finding and testing of formulas for destitute women to obtain user-rights over stretches of embankment in exchange for preventive maintenance work.

SRP are to propose a number of structural changes to improve the managerial set-up related to O&M and proposed the reformulation of responsibilities. The SRP aims to determine the O&M strategies to be adopted eventually throughout BWDB. Their final advise on structuring preventive and periodic maintenance will thus be important for the recommendations under the NCRS.

For the embankment the required operations would be:

- Regular topographical survey to detect any abnormal settlement of the foundations or any abnormal deformations.
- Regular visits to maintain the dyke and repair damages from
  - erosion
  - rat holes and roots of big trees
- Control of vegetation growth has to be carefully surveyed and maintained.
- In rainy season, systematic inspection should be envisaged and the means of action to face a flood period have to be prepared.

APPENDIX I
DESIGN OF EMBANKMENT

I.1 Design Conditions

The embankment can be considered as a dyke, operating as a control structure with the following conditions:

- Water head on its upstream side equal to the maximum water level
- No water on the downstream side.
- The water head is applied long enough for the definitive water seepage line in the dyke section.
- The foundations may be under water pressure (at different level) at least six months per year.

Such a hypothesis induces a conservative design, particularly in the foundation, since it is the most vulnerable part of the construction. The consequence might be heavy cost of foundation treatment whenever detailed investigations show bad conditions to enforce special measures. However, the embankment cost has been calculated assuming that the operating condition of the dyke (mainly in the downstream level, and the duration of the upstream water load) would allow to avoid any treatment for the foundations, and permit a nearer location for the borrow-pits.

If the investigation enables a better appraisal of the geotechnic condition in large areas this would be taken into account in design of the embankment.

I.2 Foundations

The above criteria and the geotechnical data are the basic considerations that have been taken into account to design an embankment.

It has also been considered how long the water load is applied and in which conditions.
From the previous considerations we can deduct that:

- the full load would be applied no more than fifteen days consecutive, in the case of occurrence of a major event,

- in that case, the drawdown would be realised with a rate which can be estimated at 10 cm or 20 cm/day. This is not a rapid drawdown and would not result in severe conditions with the slope stability.

Various kinds of incident have been reported, such as cuts by local people and holes by rats. These are important causes of breaches, but are not due to faults in construction. However poor construction design is at fault where:-

- overtopping and destruction of embankment occurs;
- erosion due to seepage.
- erosion due to default in sluice pipe-line construction;
- erosion and destruction of the embankment when the river bank is scoured at the foot of the dyke.

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Such problems do not seem to have occurred very often according to the results of our inquiry. (On the embankments of the left side of the Jamuna and of the North Central Region for which information was provided from the concerned local circles of the BWDB and on the right side of the Jamuna which were discussed with the BWDB and FAP-1 engineers).

A typical incident in Bangladesh has been the piping in the silty foundations of the Meghna Dhonagoda Irrigation Project, but in the NCR region such case of breaches have not been reported. The case of Meghna left bank project is often quoted where sliding of sandy slopes occurred and resulted in a total breach of the embankment.

- the water load generally applied on the river side slope of the embankment would be;

  50% 1000 days in fifty years or during a continuous period of 80 days in a twenty event
  80% in a continuous period of 80 days in a fifty years.

Those figures result from the flood during time analysis in Bahadurabad and are only indicative.
In general, due to the short time of water load application and its relative total small importance it is possible to avoid and treatment of the foundations, in most part of the alignment. However, in special areas where ground conditions are poor then special foundation treatment is required.

With a set back distance of 500m or more the protection with clay and turfing already experienced has proved efficient, however in places where a set back distance of the embankment less than five hundred entre is necessary, then the concept of the cross-section and the foundation should be revised, specially regarding the problem of pore pressure and piping.

Investigations show that at a greater depth, generally between 10 and 15 meters the material is sand in a proportion over 85%. Clay is less that 5% in all the area which has been investigated, at those levels.

I.3 Existing Practices

The existing embankments in the NCR have generally been constructed in a traditional way:

- The procedures adopted are sound and the detailed engineering documents, where unavoidable are prepared from the BWDB design manual. However, often the embankments are designed on assumed characteristics of the soil rather than actual soil data collected by drilling all along the alignment.

- The construction is often carried out without compaction or compacted only by the feet of the workmen. This results is dykes which sometimes are in poor condition with steep slopes of 1/1 and without protection.

The average height of the class A embankments ranges from 3m to 7m, mostly about 4 to 6m. But in several points, mainly in the South West Dhaka region the height may reach 6.5 m. and 7.0m. Such high dykes may need special consideration as any breach might result in heavy damages.

I.4 Design Factors

For a more comprehensive design the following should be known :

- The hydrograph of the flood from the moment water is spilling on the flood plain to the moment it is down to the river bed level. This flooded period may last one to several months;
- The foundation permeability: packer test or better logan tests should be performed at several depths from top to 10m. It is the best indication to be drawn, from the different investigations, of the quality of the foundations, and one of the most useful.
- The weakness to SPT which is revealed by the geotechnical test on Jamalpur area, needs to be studied in more detail;
- Soil identification;
- Clay identification, nature of despersive soils and control of dispersion;
- Liquefaction proneness of the material;
- Experience on embankment construction in the past

I.5 Stability

Typical cross-sections used by BWDB, recommended in its design standards, have been adopted by other FAP and also by the Jamuna Bridge Authority.

The slopes used are 1:3 on the river side, 1:2 on the country side

The minimum crest width is 4.50m.

It has been checked that the slope of the preatic line is between 1:4 and 1:5.

It has been assumed that the dyke would be homogeneous and of material of the proper quality. It can be recommended to zone the dyke with clayish material on the river side slope and pervious material at the toe of the country side slope. This recommendation at this stage of the study does not look very realistic. It can only be assumed that the homogeneous cross section will fit all the required quality. This point should be studied in detail at the feasibility level.

Although a small height embankment does not require special foundation attention, where the embankment height exceeds 5 metres foundation design should be looked at carefully. It has to be reminded that failures, due to weak foundations, certainly occurred (a good example is Meghna Dhonagoda embankment). A comprehensive inventory of those failures is difficult because of lack of maintenance and because the origins of failure as reported are rather dubious. Such failure will occur again and the damages and consequences may be more important.

For the future embankment it is essential to draw attention on the important risks of such dyke constructions without a thorough analysis of the foundations problems which could be looked at the feasibility stage. This might result in a cost increase for problem areas and could result in a doubling of construction cost for those sections.

I.5.1 Foundations

Foundations are the most significant problem to be resolved in embankment's stability. Although general guidelines can be given at the regional planning level based on the general data which have been collected (and on the investigation performed in the Jamalpur area), further detailed analysis is required at feasibility study level. There are essentially three main problems : the erodability; the shear strength; the sand liquefaction.

Erodability

Possible erosion related to the dispersive soil is a problem that may be encountered with the silt and the clay of the Region, mainly due to the looseness of those materials. For an average gradient of 0.3 to 0.4 the risk of seepage is considerably reduced if permeability after compaction is less than 10^{-7}m/s, this condition being more easily satisfied when compaction is realised at a moisture content slightly superior to the optimum Proctor. There are interactions of compaction permeability and defloculation which affects the probability of piping failure. This may not apply to Bangladesh but it is a risk which is worth evaluating since defloculation appears to be the main cause of piping in such kind of soils and have originated most of dam failures recorded for structures constructed in similar conditions (6 to 10 meters high and loose silty material).

The special character of the dispersive clay may be so dangerous for a dyke this point should be clarified. The identification of dispersive clay is easy and apparently, those problems have not been considered up to now in Bangladesh. In the perspective of different scale project and with higher embankments, this question will naturally become important.

Liquefaction

A special problem may exist in foundations in the NCR because they are made in various places of saturated sand of very low density, which have been encountered in upper layer. The instability is caused by the loose structure of the sand which can collapse under the action of a dynamic load. The loose sand is supporting the static loads due to the dyke, but vibration may cause readjustment of the grains into a more dense structure with a squeezing out of water. Since drainage cannot take place immediately and since the material may not be perfectly pervious, part of the static load is transferred to the water and the foundation behaves as a liquid.

It is well known that foundations consisting of low density and cohesionless sand are suspect and that special investigations have to be made. The criteria generally admitted is the relative density which has to be more than 0.5 and is related to SPT test. It is generally on sand in the range 0.1 - 0.2mm with a steep grain seize curve analysis that this liquefaction with appear.

This foundation can settle with the load of the dyke and as the liquefaction problem is concentrated in the first meters (2 to 3m) of the foundations, the settlement or consolidation has to be checked with laboratory test. Special studies in triaxial shear or undisturbed sample will also be required.

The high percentage of silts in NCR soils may cause a lot of trouble. These silts are of the non plastic fines, are unstable with water and have a tendency to become "quick" when saturated. They are fairly impervious and difficult to compact: this property varies with the size and shape of grains and is generally reflected in the liquid limit. The higher the liquid limit the more compressible it is.

An earthquake may be a case for liquefaction of the sand which are in the dyke foundation.

Shear Strength

During the Phase-I of the Pre-feasibility study (NCR 1990), investigations have been performed in the Jamalpur area. Bore holes have been drilled and laboratory tests have been made on soil samples, see Figure VII.1.1. This data is detailed in the report on geotechnical investigation (NCRS 1990b).

It is well known that the definitions of a soil characteristics (such as Cu) are difficult and may not be representative of the material as it is in the soil. This can be seen in the dispersion of the results of the investigations. However, it is not usual that the unconfined compression tests give a cohesion value over the shear test cohesion value. This can probably be related to the difference of density that appears in the tested material. And also it has to be pointed that the cohesion value deducted from the unconfined compression test is more significant with a saturated material.

But nevertheless the dispersion of the results is rather usual and from that it induces the problems of the variability inside a layer, of those parameters. The difficulty which results is the resistance evaluation and the consequences that it may have on the stability.

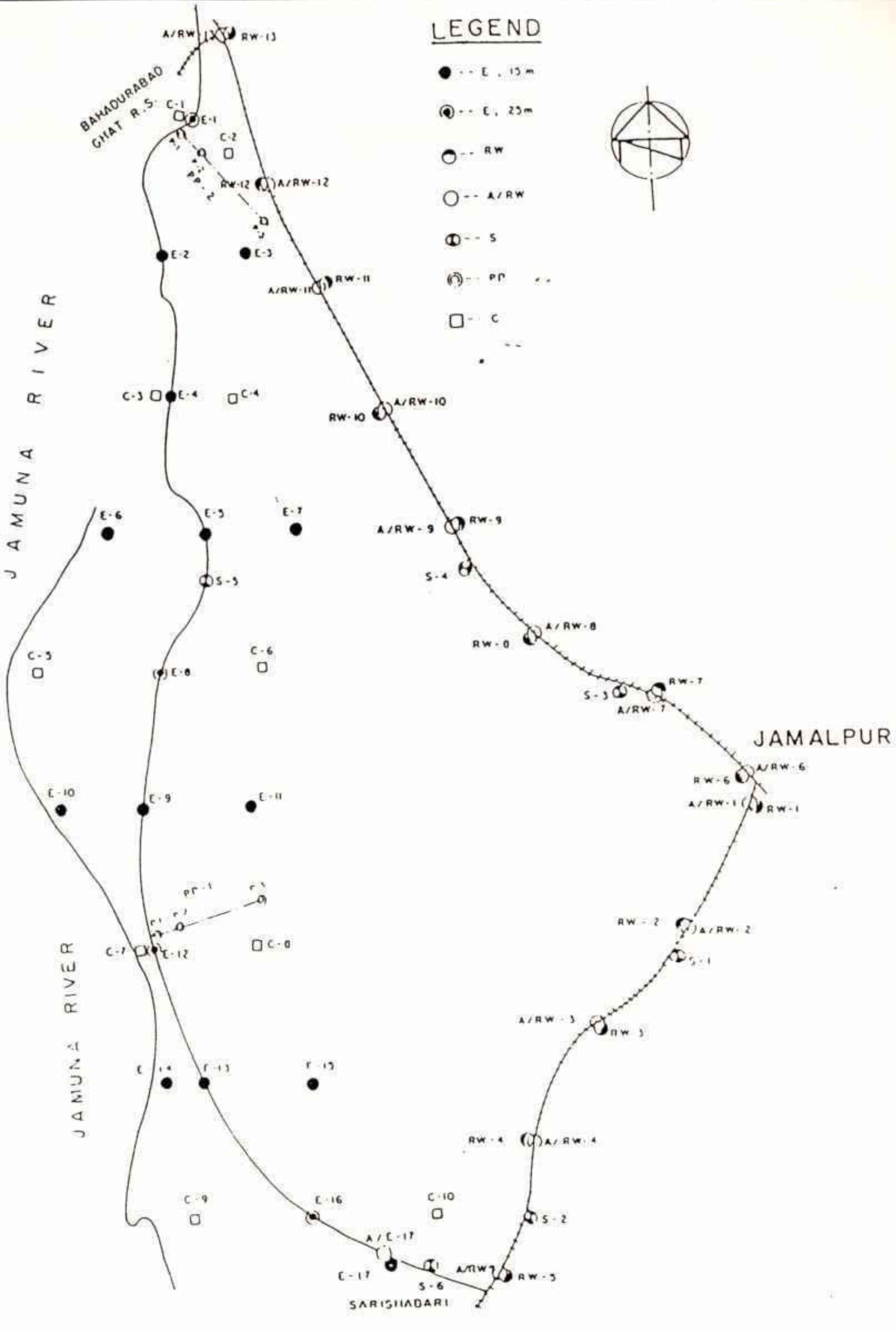
It is also well known that one has to be way on the laboratory tests as long as they cannot be considered as giving information on the real material as it is in its real condition. This is a reminder that it is in the choice of the soil parameters and characteristics that the most important mistakes can be made. The moisture content, is also important and the soil property and reaction is first of all, linked to its water content. No permeability tests have been performed. It is most probable that they should be considered as saturated (in most stability cases).

As it can be seen on several recent failure examples it is important to have a reliable knowledge of the pore pressure and the heterogeneity of the material.

Also it has to be pointed out that existing soft clay layer or zones of weaker strength have consequences on the definition of failure line. Loads may concentrate on those weak layer with an increase of pore pressure. Those "load transfer" increase the stress and pore pressure in the soft layer and accelerate the movements into failure.

Figure VII.1.1

Location of Boreholes



Souece:- NCRS 1990 b

TABLE VII.I.1
Geotechnical Tests

a) SPT Tests and Limits

The data are given at 3m depth and 5m depth

Bore hole No.	Moisture content %	SPT test	LW	Tp	Dry density	Silt %	Clay %
RW1		2	50	30		55	30
	24	20	70	40	1.6	40	45
RW2		4	30	15		50	15
	50	8	45	20	1.1	70	25
RW3		6	45	20		65	30
	32	10			1.4	20	5
RW4		5	40	20		70	20
	28	8			1.5		
RW5		5	40	20		70	15
	27	4			1.4	70	15
RW6		5	40	20		60	30
	30	10			1.5		
RW7		6	30	20		70	30
	27	10	50	25	1.5	45	45
RW8		7	50	20		65	20
	33	6	40	15		70	15
RW9		6				30	6
	31	10	45	20	1.5	65	30
RW10		4	40	20		70	25
	29	5			1.5		
RW11		6	40	20		75	15
	28	10	50	25	1.5	60	35
RW12		4	50	25		60	35
	30	4			1.5		
E1		4	40	20		75	20
	31	10			1.4		
E2		3				65	10
	30	7			1.4	45	10
E3		6	40	20		80	10
	30	5			1.4	75	20
E4		5	35	20		60	15
	30	7					
E5		12				12	2
		5					
E7		7	35	20		70	15
	33	2	40	20	1.4	60	20
E8		2				65	15
	33	10			1.4		
E9		5				75	10
	29	3			1.4	65	10
E10		3				15	2
		4				13	2
E11		3				70	15
		10			1.4	35	10
E12		3				65	10
		7			1.5		
E13		3				80	15
		3			1.4	55	5
E14		3				85	10
		8				7	2
E15		2				75	15
	30	15			1.4		
E16		4				80	10
		15				20	2
E17		7				60	5
		8				60	5
S1		5				10	2
		5				10	2
S2		7				15	2
		4				10	1
S3		1				65	4
		1				70	5
S4		7				25	3
		4					
S5		2				80	15
		3				70	10
S6		4				10	2
		10					

C:\123\CENG\TABLEGLO.WK1

TABLE VII.I.1 (Contd)

b. Consolidation Tests

Bore hole No.	C (10-3)	Cc	df			Wo	W
RW1	2.00	0.14	1.79	0.66	0.50	24.40	18.60
RW2	2.20	0.36	1.40	1.32	0.87	50.40	33.10
RW3	2.80	0.17	1.57	0.84	0.69	35.70	25.40
RW7	2.70	0.14	1.69	0.72	0.59	26.60	21.80
RW8	4.90	0.16	1.59	0.88	0.67	33.20	25.20
RW9	3.20	0.13	1.69	0.83	0.67	31.00	25.00
RW10	5.00	0.15	1.67	0.76	0.60	28.80	22.20
RW11	6.50	0.12	1.67	0.76	0.59	28.20	22.20
E1	0.82	0.18	1.54	0.88	1.73	31.70	27.40
E2	0.95	0.18	1.54	0.90	0.73	32.60	27.30
E3	0.56	0.15	1.56	0.82	0.71	29.60	26.60
E7	0.60	0.16	1.45	0.92	0.81	33.60	30.90
E9	0.98	0.13	1.48	0.89	0.80	32.60	28.40
E13	0.56	0.19	1.56	0.85	0.70	30.50	26.80
E15	0.65	0.12	1.53	0.83	0.75	29.50	27.50

c. Unconfined Compression Tests

RW1	5.8	1.7	22.0
RW3	4.4	1.4	32.0
RW4	5.8	1.5	27.0
RW5	5.2	1.4	31.0
RW6	4.2	1.6	20.0
RW7	5.8	1.6	27.4
RW8	4.9	1.4	33.0
RW13	7.0	1.5	26.0
E1	1.3	1.4	32.0
E2	1.3	1.4	33.0
E3	4.4	1.5	30.0
S2	2.7	1.5	29.0

d. Direct Shear Tests

RW2	3.60	6	1.13	50.4
RW4	6.00	12	1.52	28.4
RW5	1.30	17	1.43	30.0
RW6	4.60	9	1.46	29.8
RW8	2.10	12	1.47	29.9
RW9	1.20	19	1.42	30.9
RW10	2.40	12	1.51	28.8
RW11	1.25	14	1.51	28.2
RW13	2.20	17	1.44	30.5
E2	1.30	24	1.48	28.4
E7	1.60	9	1.37	33.6
E8	1.40	16	1.41	32.6
E9	2.10	23	1.44	28.5
E11	1.80	14	1.46	29.5
E12	2.80	24	1.49	28.2
E13	0.50	18	1.44	30.5
E15	1.40	21	1.46	29.5
S5	1.40	19	1.43	31.5

[Explanation of the term "load transfer" :usually the forces (pore pressure, weight of earth, earth pressure etc.) are considered as distributed according to the geometry of the section for an homogeneous section. In the case of a weak zone, that distribution will be modified and forces will concentrate on that weak zone as the consequence of the development of a plastic zone; that is called "load transfer".]

In that case the decrease of the different characteristic values has to be considered and the laboratory tests should be performed in that respect.

Cross-Section Stability

The characteristics of materials are not well enough known to achieve a stability computation in a general case. The laboratory tests have to be conducted in the required way which enable to get a good knowledge of the behaviour of the material.

The traditional way to evaluate a slope stability such as the Swedish failure circle with slices, total stresses, and one security co-efficient in every point is certainly not perfect in the case when non-homogeneous strength of the material may lead to load transfer. Failures have been experienced, in soft clay or saturated sand foundation with security co-efficient superior to one.

A conservative solution is to suppose cohesion equal to zero.

A stability evaluation with the Swedish failure circle with

$Cu = 30$ kpa and $\phi = 25°$.

gives a stability co-efficient of 1.55 for the cross-section envisaged in the BWDB standards. But this is not very significant since it is possible to have Cu = o and ϕ less than 10° in saturated material.

A better approach of that problem has to take into account the possible weakness of the foundation and a larger failure line

In the case as shown in Figure VII.1.2, the dyke can slide on a layer of material with a weak shear strength. The portion of dyke between two vertical plans (see Figure VII.5.5) (Aa and Bb) is under the following forces:

$$P1 = \frac{d.h_{1}^{2}}{2\,\beta} - \frac{2ch_1}{\sqrt{\beta}}$$

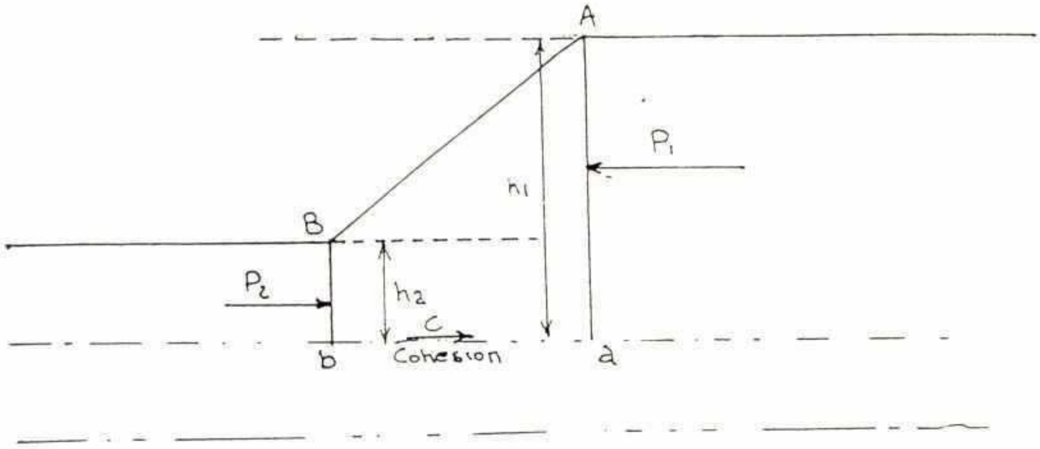
d : density

h1 : distance Aa

$$\beta = tg^2\left(\frac{\pi}{4} + \frac{\phi}{2}\right)$$

and c cohesion

Figure VII.I.2
Cross Section Stability



See Annex I.5.1 for explanation

Source : CS 1992

$P2 = \underline{d}.ß.h_2^2 + 2.c.\sqrt{ß}\,.h_2$

h2 : distance Bb

If the material is saturated clay it can be considered $\phi \approx 0$ or $ß \simeq 1$

$$P_1 = \frac{d}{2}.\, h_1^2 - 2ch_1$$

$$P_2 = \frac{d}{2}.\, h_2^2 + 2ch_2 \quad \text{with } P_1 \leq P_2 + C$$

$$\text{security coefficient } \sigma = \frac{P_2 + C}{P_1}$$

If the cohesion is small,this can be written

$$P_1 \leq P_2 \quad \text{or,}$$

$$\frac{dh_1^2}{2} - 2ch_1 < \frac{dh_2^2}{2} + 2ch_2$$

$$\frac{d}{2}\,(h_1^2 - h_2^2) < 2c\,(h_1+h_2) \quad \text{as } h_1 > h_2$$

$$h_1 - h_2 < \frac{4c}{d}$$

It can be observed;

1. That the ratio c/d with the value deducted from the investigation may be less than one, even it could be zero, if the material is saturated sand or very soft clay.

2. This ratio is the critical height Hc. Since h2 can be very small, (because even top layer can be soft and cohesion-less material) it shows very clearly that the stability problem comes from the foundation and not from the dyke itself. Its height is sufficiently small to avoid any critical problem on the aspect of the slope stability.

APPENDIX II
SET BACK DISTANCE

II.1 General

From a technical point of view the problem of the set back distance is related to the scale of embankment slope protection and bank protection against erosion. These two different problems should be treated separately.

II.2 Slope

Protection of an embankment may be required due to strong currents adjacent to the slope, wave action and lower cohesiveness of the construction material. Certain embankments do not stand without protection (along the Meghna river and in Sylhet) and in most of those cases it is the wave action and the sandy material of the embankment which make slope protection necessary.

Observation in the NCRS area indicates that slope erosion is not a problem. In Bahadurabad some portions of the embankment are damaged, but that is due to bank scouring. The railway line embankment, running for over 100 km (very) close to the Old Brahmaputra does not show any sign of slope damage due to flood current or wave action. Embankments in the NW (PU1) are very sandy and do erode by current erosion (bank scour) of the river but bank protection will not be of any benefit under that condition. The main wind direction during the monsoon (S-SW) prevents the embankments here form severe wave attack as the embankments here are mainly on a N-S alignment.

The conclusions of these observations confirm that slope protection, as presently done by turfing is an adequate and a cheap way to protect the embankment slope. Only at some places (near river closures, where open water is near to the embankment) will some protection (brick block protection on filter or fabrics or sand-cement blocks) be required, but that is only localised.

II.3 Set Back Distance Associated with Bank Protection

Using Manning formula it can be shown that velocity in the flood plain between the embankment and the bank of the river even at high flood flows is less than that which would cause erosion of the embankment.

The main erosion problem relates to the degree of river bank protection.Generally the materials over the river banks are very loose and cannot withstand the action of the current and the outflow & seepage from groundwater. In some places this erosion is very active and needs special attention.

Jamuna

The problem of erosion is most evident at two main points on the left bank of the Jamuna: Bahadurabad and Madarganj. The total distance of river bank concerned is about 20 km. in Bahadurabad and 15 km in Madarganj.

At these points the Jamuna is seriously eroding the left bank and the movement has been:

Period	Total Erosion in the Period	Average Rate per Year
1948 - 1960	3 Km	0.250 Km
1960 - 1983	3 Km	0.130 Km
1983 - 1989	2 Km	0.270 Km
1989 - 1990	1 Km	1.000 Km

which means a total movement of around 9km in about forty years. It is difficult to predict any position of the river bank in the future.

In such a case where the river bank erosion is active, the choice is either to protect the river bank or if not decide on a retired set back distance, often over and again.

River Bank Fixed

If the river bank is fixed, the set back distance may be proposed on:

- Technical requirements, according to the kind of works envisaged for bank stabilization
- Local constraints

In general, the set back made by the BWDB along the Jamuna is 500m to 800m that distance is deemed necessary to have a sufficient retirement from the main flow.

River Bank Eroding

If the river bank is not fixed it is very difficult to estimate the erosion rate and any setback distance may prove insufficient in a few years time. An approach to the estimation of a set-back distance for this case is given in Section II.5.

II.4 River Training Works

To combat bank erosion the river bank can be fixed with River Training works. These can be :

- Bank revetment
- Groynes
- Construction of hard points

II.4.1 Revetment

The river banks at some places are 50m deep. Revetments have to be constructed with slopes less than 1 vertical to 4 horizontal (this being considered as a precaution against instability due to the poor geotechnical conditions of the top layer soils and the risk of liquefaction).

An underlying filter has to protect the revetment against suction of fine particles through the protection blocks. In general, a geotextile fabric will be placed.

Mattresses of block protection are placed on the filter. The falling apron technique is adopted to increase the feasibilities of the revetment.

II.4.2 Groynes

Groynes are designed with a length of, some 1 km and constructed on the flood plain starting at the embankment. The distance between two groyne is generally four times the length of a groynes. The end of the groynes are constructed also with a falling apron (dredged) to combat future scouring at the toe.

II.4.3. Construction of hard points

A tentative plan for large scale stabilization of a river may be the "pinning" of the river at two or more points in order to control the migration of the dominant anabranch wave forms that appear to play an important role in long term bankline movement (FAP-1 1991).

Such hard points have also been considered by the Jamuna Bridge Authority to stabilize the river bank upstream the location of the Bridge. Stabilizing hard points could work, but the relation between the distance of the two points and the erosion have yet to be determined.

So far it seems that protection by revetments is apparently cheaper than by groynes (FAP-1 and Jamuna Bridge studies).

Protecting the Jamuna river bank might cost US $ 5 to 20 million per km. (to this an annual maintenance cost of US $ 0.5 - 1.0 million per km should be added). The construction of hard points might be a good solution but the technique should be proven.

Padma

The river Padma does not seem to have the same erosion problems as the Jamuna. Near Aricha, the Padma river is apparently quite stable. North of Aricha, the Jamuna is eroding.

The only eroding zone of the Padma is in a reach between km 23 and 35 from Aricha, downstream around Harirampur. Embanking this stretch along the river will require special attention.

II.4.4 Tentative Estimation of Set-back Distance Without Bank Protection

The location of embankment along the major rivers (Jamuna and Padma) can be proposed with the following criteria:

When the bank is not eroding or has not been eroded for a long time, or when there is accretion, the dyke is placed taking into account all the parameters:

- Technical constraint
- Topographical situation
- Morphological changes in the past
- Local constraint (as existing embankments)

These considerations lead to a position of dyke which does not take into account other economic constraints as:

- lands use benefit
- damages
- population protection
- socio-economic impact

- When the bank is eroding there are two possibilities :
  a. River Training works are realized and river bank is protected from further erosion.
  b. No River Training works will be envisaged.
     In that case final cost of the embankment will depend upon the set-back distance of the dyke.

Two cases are considered :

a) The erosion is important

The previous movement of the river bank indicates, an average typical probability of destructions of the dyke according to the set-back distance adopted, in the future .

Set Back Distance	Time of 100% probability Destruction
1 km	2 years
2 km	5 years
3 km	10 years
4 km	17 years
5 km	30 years
6 km	50 years

The cost of a dyke constructed at 1 km of the river bank would be the sum of the costs of that dyke constructed at years 0, 2, 5, 10, 17, 30, 50.

If we assume an interest rate of 12% the cost C1 would be :

- $C1 = C+cx0792+cx0.567+cx0.322+cx0.146+cx0.033+cx0.04$
- $C1 = C(1+0.797+0.567+0.322+146+0.33+0.04)$
- $C1 = 2.869C$

The cost of a dyke constructed at 2km of the river bank would be the sum of costs of that dyke constructed at years 0, 5, 17, 50.

- $C2 = C(1+0.567+0.146+0.04)$
- $C2 = 1.717C$

The cost of a dyke constructed at 3km of the river bank would be the sum of the costs of that dyke constructed at years 0, 10, 50

- $C3 = C(1+0.322+0.004)$
- $C3 = 1.326C$

The cost of dyke constructed at 4km of the river bank would be :

- $C4 = 1.270C$
- $C4 = 1.146C$

The cost of dyke at 5 km would be :

- $C5 = 1.004C$

The curve C1 versus set back distance has been traced which gives the cost of the embankment versus the set-back distance.

This cost has to be appreciated with the benefits which can be expected from the different positions of the embankment. This calculation means that the investment for the dyke may vary from one to three times when the dyke is retired from 5 km to 1 km.

b) The erosion is probable but less important

We appreciate the importance of the erosion with the following probability of destructions :

Set-back distance	Time of 100% probably distance
1km	5 years
2km	15 years
3km	30 years

an embankment would cost :

at 1 km :

- C1^ = C(1+0.56+0.183+0.33)
- C1^ = 1.783C

at 2km :

- C2^ = C(1+0.183)
- C2^ = 1.183C

at 3 km :

- C3^ =1.33C

This calculation means that the cost of embankment varies from 1 to 1,8 times according to the set back distance. The first calculations might be applied on 35km of embankment along the Jamuna where the erosion is very active and, the second calculations along 10 kms of embankment along the Padma, where the erosion is not so important.

4.5.4 Morphological Consequences of Embankments

All along the Jamuna left bank the only new positions of embankment which may create some problems is the alignment of the Northern part between Dewanganj and Sarishabari.

We have seen that the total length of that portion of embankment is 64 kms and out of those:

- 15 kms are at an average set back distance of 1.5 kms.
- 20 kms are at an average set back distance of 2.0 kms
- 30 kms are at an average set back distance more than 3.0 kms

It has been estimated in the chapter 3, that from FEC and FAP- 1 studies that the spilling discharge of Jamuna in the North Central Region could have reached the amount of 15 000 m^3/s for a total discharge of about 100 000 m^3/s. The construction of those 64 kms of embankments will, consequently increase the flow in Jamuna of 15 000 m^3/s for 85.000 m^3/s which were remaining in the active river bed downstream Sarishabari. That means an increase of about 17% of the discharge. This can hardly be avoided, since one of the main objectives of our embankments is to reduce to acceptable proportions those devastating floods in the Central Region.

We can say that the morphological changes that may appear in the river bed are the consequences of what is called the dominant discharge flow and which can be defined in that way:

In rivers which experience a highly variable range of flows, the dimensions and geometry of the channel are determined by the flow which performs the most work, where work is defined as sediment transport" (FAP-1 Annex-4 page-2). The analysis defined the dominant discharge to be 38,000 m^3/s in Bahadurabad it shows that it is close but a little less than the bankfull discharge which is estimated at about 45,000 m 3/s.

The dominant discharge is equalled or exceeded approximately 18% of the time.

The flows between 32,000 m^3/s and 50,000 m^3/s are transporting about forty percent of all the sediment moved by the Jamuna, while the flows over 70,000 m^3/s contributes only less than 2%.

Those conclusions are important and emphasizes the importance of flow around 40,000 m^3/s which have the major impact since they carry almost a third of the total load,

They show that for a discharge of 70,000 m^3/s at Bahadurabad (equalled or exceeded 1% of the time) the construction of an embankment along the left bank of the Jamuna should not have much consequences. But the result of the model runs would be appreciated to confirm those results.

We can say that the position of the embankment, for those discharges (up to 70,000 m^3/s) should not have any consequences, considering also the criteria which suggest a limitation of the variation of discharge to 10% :

- The section of the Jamuna at Bhadurabad Transit is approximately 43.000m^2 for 45,000m^3/s at the level 19.00 and average velocity is about 1.20m/s.

- At the level of 19.60 the discharge is about 75,000 m^3/s and the total section about 50,000 m^2.

  In that case, a variation of flood plain of 1 Km gives an additional section of 600m^2 (0.6m x 1,000m) with an average velocity in the plain 0.3% of the average velocity in the river bed, (estimated at maximum 0.5m/s see paragraph 4.5.1.2, for an average 1.5m/s (75.000m^3/s/50.000m^3) which means an equivalent surface of 200m^2 (600m^2x0.3%)or 0.4% (50.000m^2/200m^2) of the total surface.

  So, we see that a reduction of 1km of set-back distance would increase the flow in the river of about 0.4%, which is not very significant.

- For the high flood, the water depth may rise at 1.90 meter and for 1km of flood plain the section is 1900m^2. At the level of 20.90 the section of the Jamuna in the main river bed would be about 62 000 m^2 for 100 000m^3/s. With a velocity of 0.6m/s which can be expected with that water depth (see paragraph 4.5.1.2) the variation of discharge due to 1km of flood plain would be about 1,200 m^3/s or 1.2% of the total discharge.

  This variation for a flood which would occur once in 100 years does not appear also, as in the previous case, to be very significant.

VII.2 Flood Control Structures

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Flood Action Plan
FAP 3
North Central Regional Study

Supporting Report VII.2
Flood Control Structures

February 1993

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SUPPORTING REPORT VII.2-FLOOD CONTROL STRUCTURES

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CHAPTER 1
OUTLINE DESIGNS

1.1 Introduction

At this pre-feasibility level of design the Consultants have prepared outline designs for the required major structures as recommended in the GPA (FPCO 1992). In general BWDB designs are to be used in the preliminary planning and cost estimates, however the NCRS consultants have prepared outline designs for the following particular situations.

1.2 Outline Design Structures

1.2.1 Throttled inlet structure (Figure VII.2.1)

This structure is envisaged in the event that a control is required at the intake of the Dhaleswari offtake confluence to a max. of approx. 4000 m^3/sec. (bankfull flow); although such an intake structure is not at present part of the Regional Water Resources Development Plan

The idea would be to bring the Jamuna embankments at the offtake of the Dhaleswari to such a distance that the intake capacity will be limited and at the same time the water velocity remains acceptable and slope and bottom protection can resist the scour force.

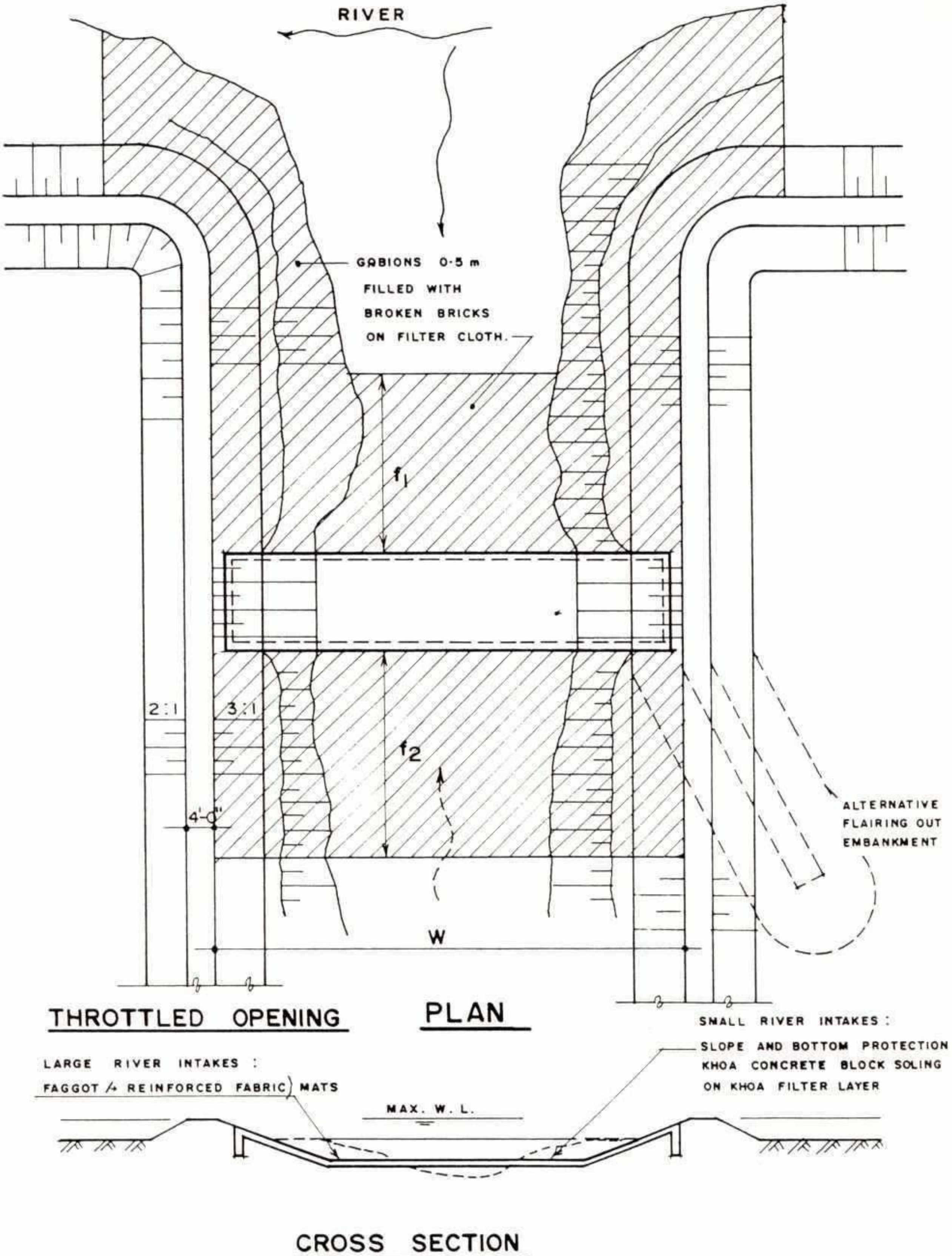
A river works protection consisting of faggot mats(fascine mattresses) constructed of bamboo and two layers of heavy filter cloth and ballasted with a layer of approx. 0.5 m boulders. The upstream and downstream slope and bottom protection is envisaged to be placement of gabions/crates (0.5 m) filled with broken bricks placed on a filter cloth. In the detailed design stage a model test might be required.

1.2.2 Combination of Bridge with Semi-controlled Structure (Figure VII.2.2)

After studying the local conditions of a river branch it might be possible that a combination of regulator and navigation lock can be omitted and a semi-controlled structure type B is feasible.

Part of the river flow can be regulated by gates and part is kept permanently open for the purpose of navigation and fish migration. At high river discharge, the gates have to be up to prevent excessive flow through the navigation opening only and subsequently preventing heavy local scour. This requires an operation warning system and preferably a coupled automatic (electric) operated gate lifting system. A system of 4 gates of 3.35m width or 7 gates of 1.52 m width between bridge piers and abutments leaves the choice of a concrete bridge or steel bridge open. Upstream and downstream of the piers a caisson type cut-off or sheet piles is envisaged which should not interfere with the (batter) pile foundation.

Check Structure Outline Design

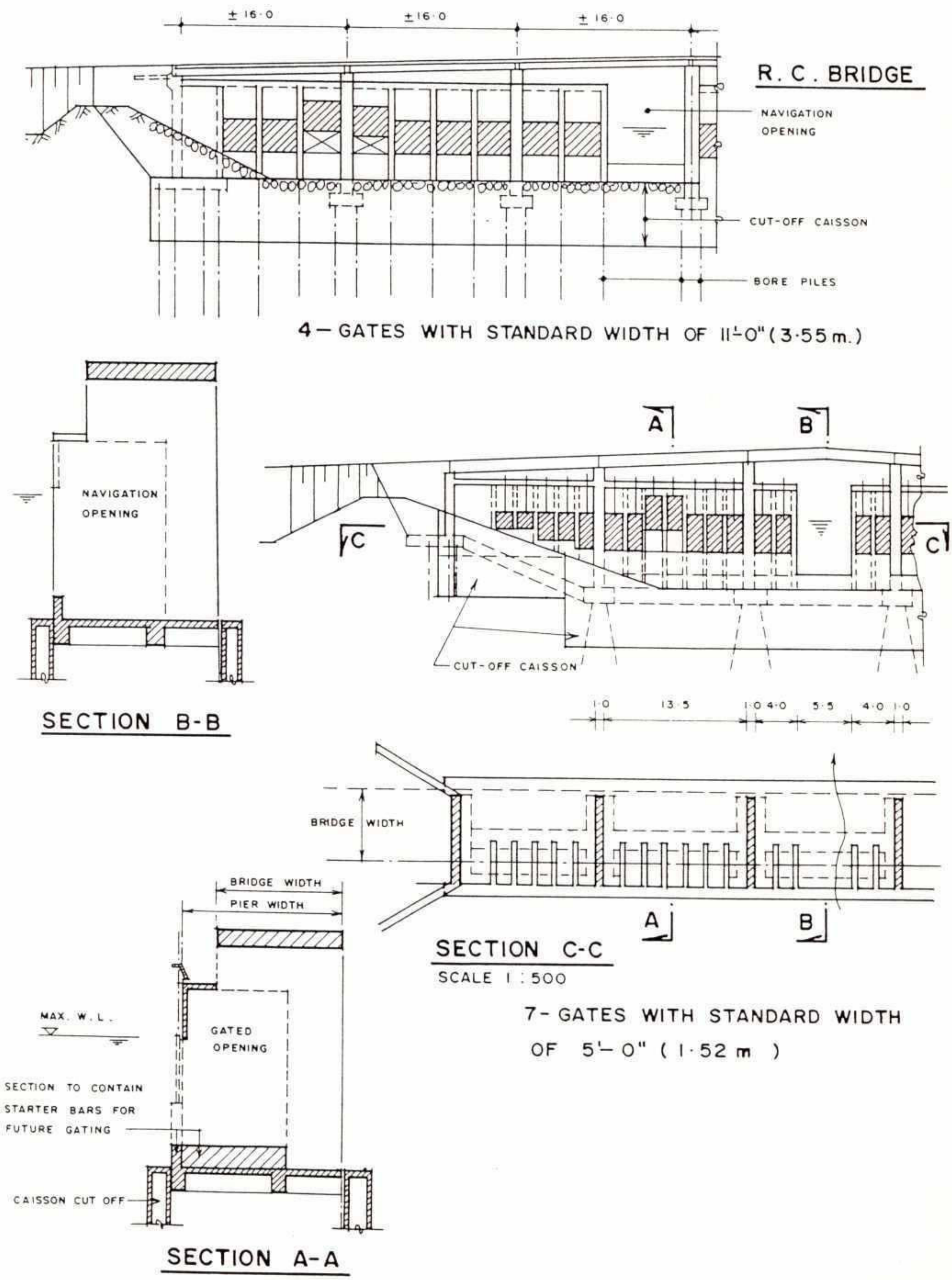


CHECK STRUCTURE

FIXED SECTION DOWNSTREAM AND IN THE KHAL "W" WIDTH TO BE DECIDED, AFTER THE RESULTS OF A HYDRAWLIC CALCULATION OF ALLOWED INTAKE AND DISCARGE, ARE KNOWN.

NOT TO SCALE

Bridge-Cum-Semi-Control Structure Outline Design



The foundation slab can be designed as stilling basin if the gates are placed at the upstream side, but a proper gabion (crates) type bottom protection upstream and downstream is always required. In order to keep a minimum water depth in the upstream river, a fixed sill can be designed in the navigation opening. A river traffic guide structure upstream and downstream of the navigation opening has to be included in the feasibility study. Careful planning the design stage makes it possible to execute the gated sections at a later stage.

1.2.3 Regulator with Vertical Sliding Gates, Combined with Flap Gate(s) (Figure VII.2.3) 2

The estimated capacity per gate is 10 m^3/sec, based on a water level difference of 0.15m and a drainage co-efficient of 0.03. In case one or more gates are (temporarily) not placed the originally fully controlled structure becomes a semi controlled structure. The addition of one or more flap gates leaves the possibility of drainage of the country side (d/s) when all the gates of the fully controlled structures are lowered during low river water level. Since considerable u/s and d/s. water level differences can occur, piping under and around the piled structure can be omitted by a sheet piling screen.

U/s and d/s. slope and bottom protection is envisaged to be carried out by gabions (crates) filled with broken bricks placed on a filter cloth.

At the downstream side the embankment retaining walls are extended beyond the return wall. On the sketch they are marked as stream guide wall and serve the purpose of slope protection.

The 2.44x3.35 m (h x w) sliding gates can be operated from a service bridge or from a special bridge which can also be used to lower stoplogs in case of emergency. This structure can be used as :

- flushing regulator
- intake regulator
- drainage regulator

1.2.4 Navigation Lock (Figure VII.2.4)2

In case a regulator type C or weir type M is required to regulate the water flow, a bypass has to be constructed for the navigation. The sizes of the navigation locks depend on the boats that have to pass. This has to be investigated for each planned location. The set-up of the outline design is based on the standard navigation locks constructed in Bangladesh with plan dimensions 6mx30m(wxl)

Filling/emptying of the lock compartment is envisaged through pipes circumventing the vertical sliding gates. A fixed bridge is preferred, to span the lock compartment. The vertical lifting gates are balanced with counterweights that can sink down in prepared box holes in the walls. A small electrical operated motor is required for operation of the vertical roller gates.

Fully Controlled Regulator
Outline Design

Note: Can be used as:
- Flushing Regulator
- Intake Regulator
- Drainage Regulator

See Figure VII.2.4 for Navigation Lock

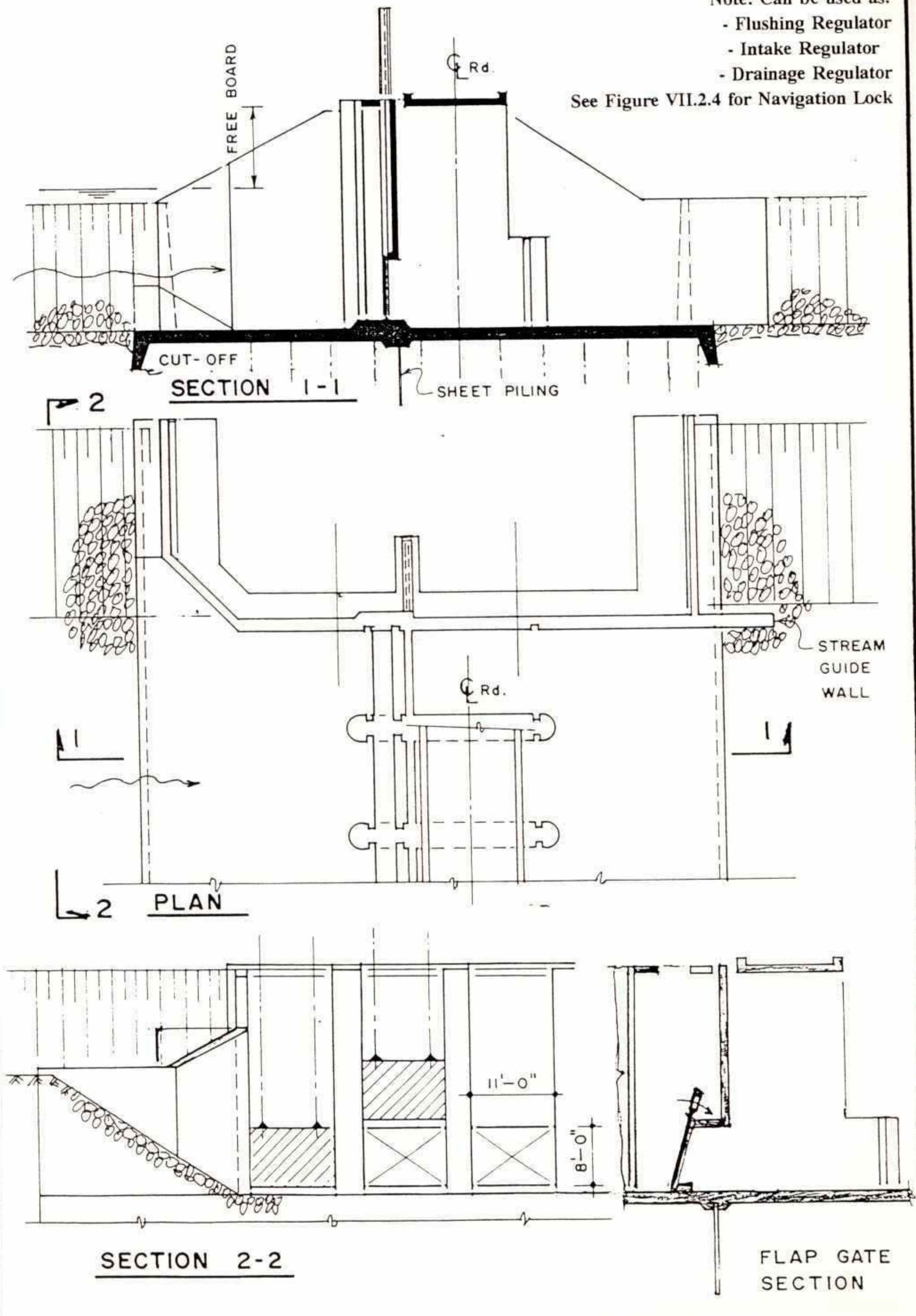
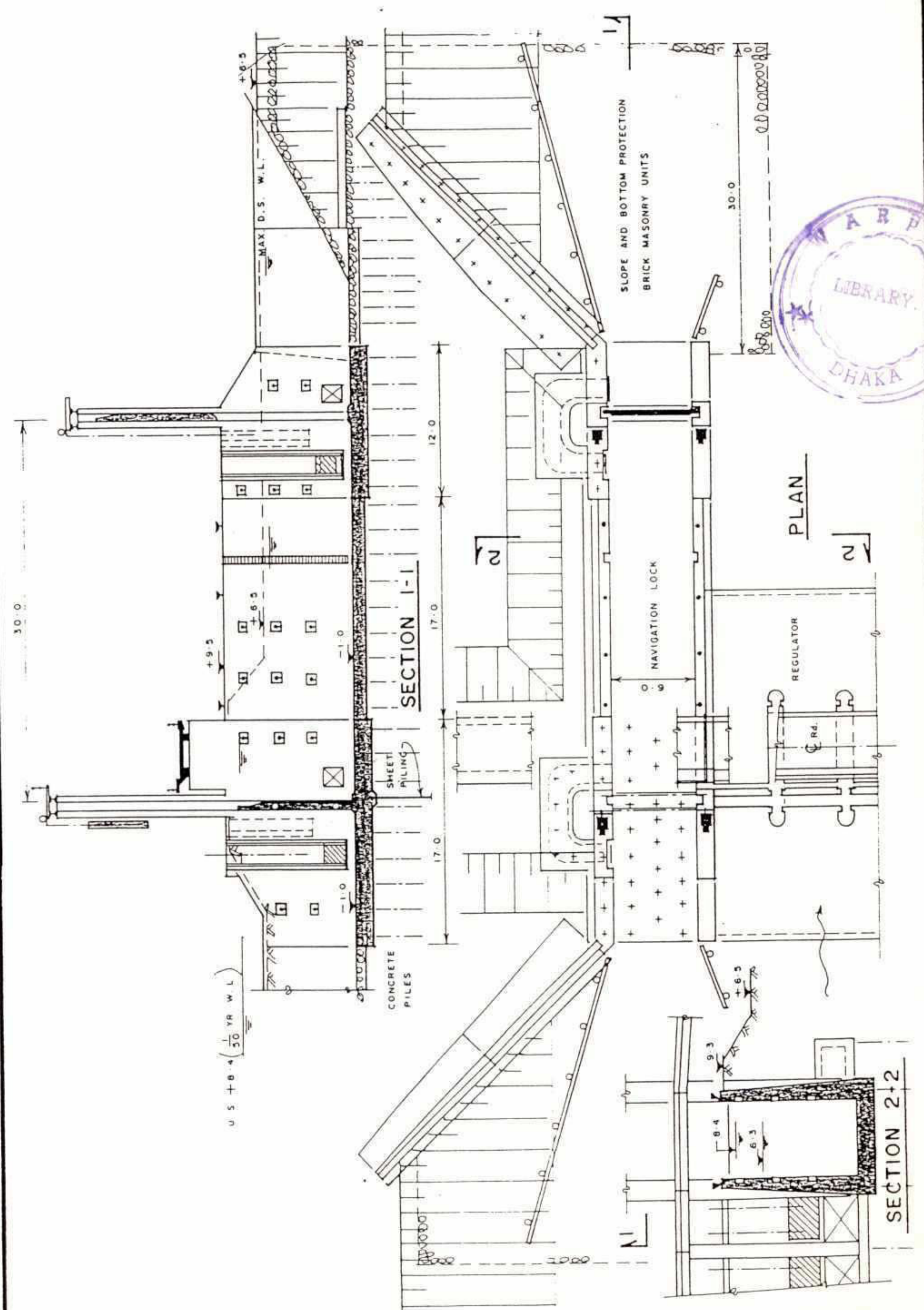


Figure VII.2.4

Regulator with Navigation Lock
Outline Design



The sheet pile screen under the adjacent regulator has to be continued under the pile supported navigation lock. A wooden guide structure consisting of wooden piles and beams with small bollards are required to safely guide the boats into the navigation lock.

A strategic located operator room has to be considered in the detailed design stage.

1.2.5 Controlled Flooding Inlet(CFI) Controlled Drainage Outlet,CDO (Figure VII.2.5)

The C.F.I. is placed across a small river or khal. The gates are opened to let silt loaded water in that will spread over the fields to fertilize and saturate it. To control damage caused by high water velocities an u/s and d/s stilling basin has to be constructed. The structure can be designed for standard gates sizes 6'x 5' or 8' x 11' (h x w) and if required one or more barrels can be furnished with flap gates.

The structure is designed for reverse flow. When the river water level drops the gates can be opened to increase the drainage flow already taking place through the flap gates section (s).

Slope and bottom protection u/s and d/s is envisaged to be constructed in gabions (crates) filled with broken bricks placed on a non woven filter cloth.

The advantage of this system is that in the dry season grass will start to grow in the cages and the grass roots will eventually take over the task of the wire mesh.

Depending on the subsoil conditions a sheet pile screen or concrete cut-offs are required under the raft foundation.

1.2.6 Controlled Drainage Outlet (Figure VII.2.6)

This structure is mainly designed as C.D.O for the Jamuna and Padma embankment. The standard 5'x 6' gate is placed on the main river side and the service platform has to be constructed above max. flood level.

In the upstream and downstream, a set of stoplog grooves are constructed in the walls to lower stoplogs in case the gate is jammed.

Concrete cut-offs if properly executed (no shuttering) are most likely sufficient to stop the piping under the raft foundation.

Slope and bottom protection are gabions (crates), similar to the one as described before.

Upstream the wingwalls are flared out and on the downstream such the barrel walls are extended into the canal to serve as stream guide walls.

Controlled Flooding Inlet (Flushing Sluice) Outline Design

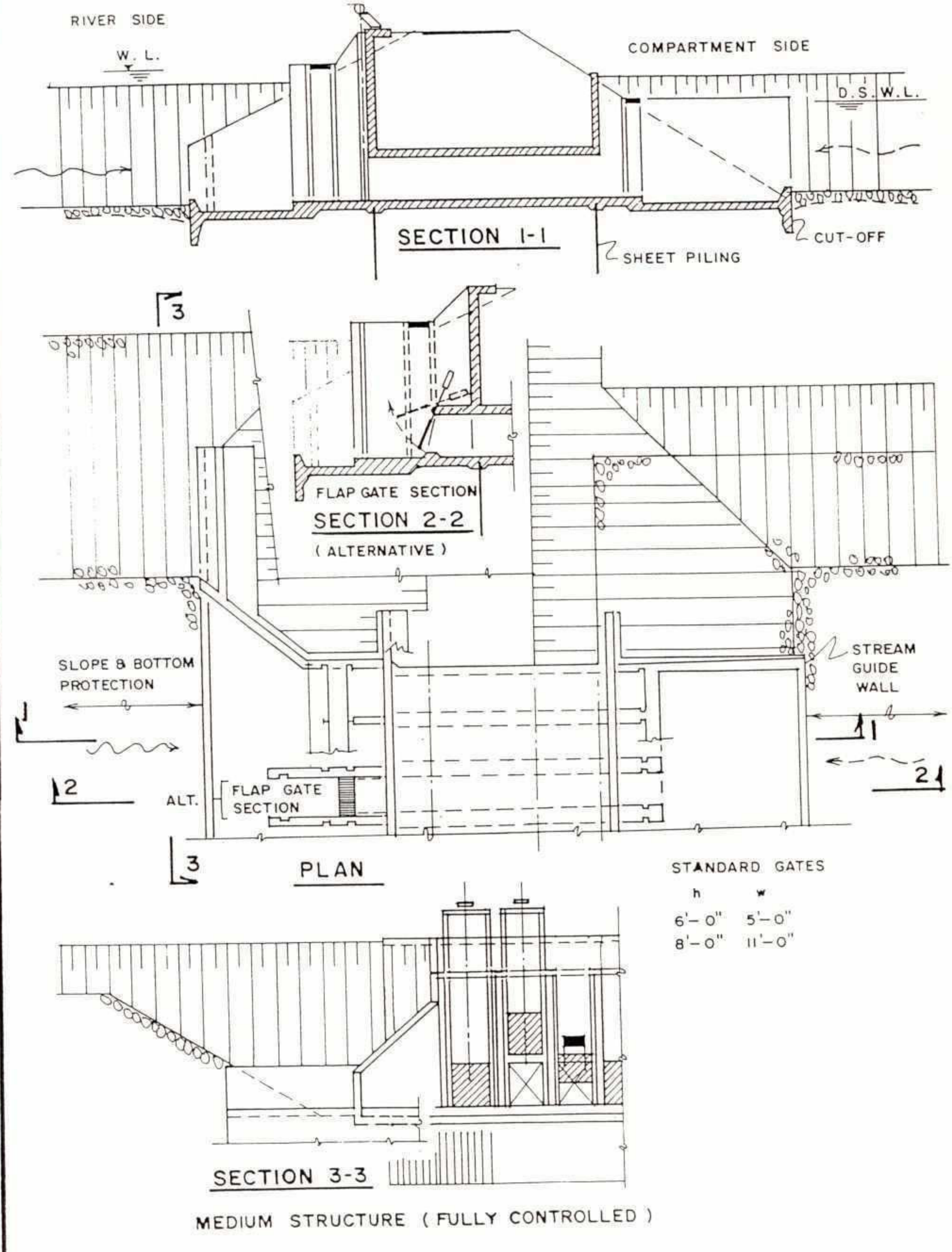
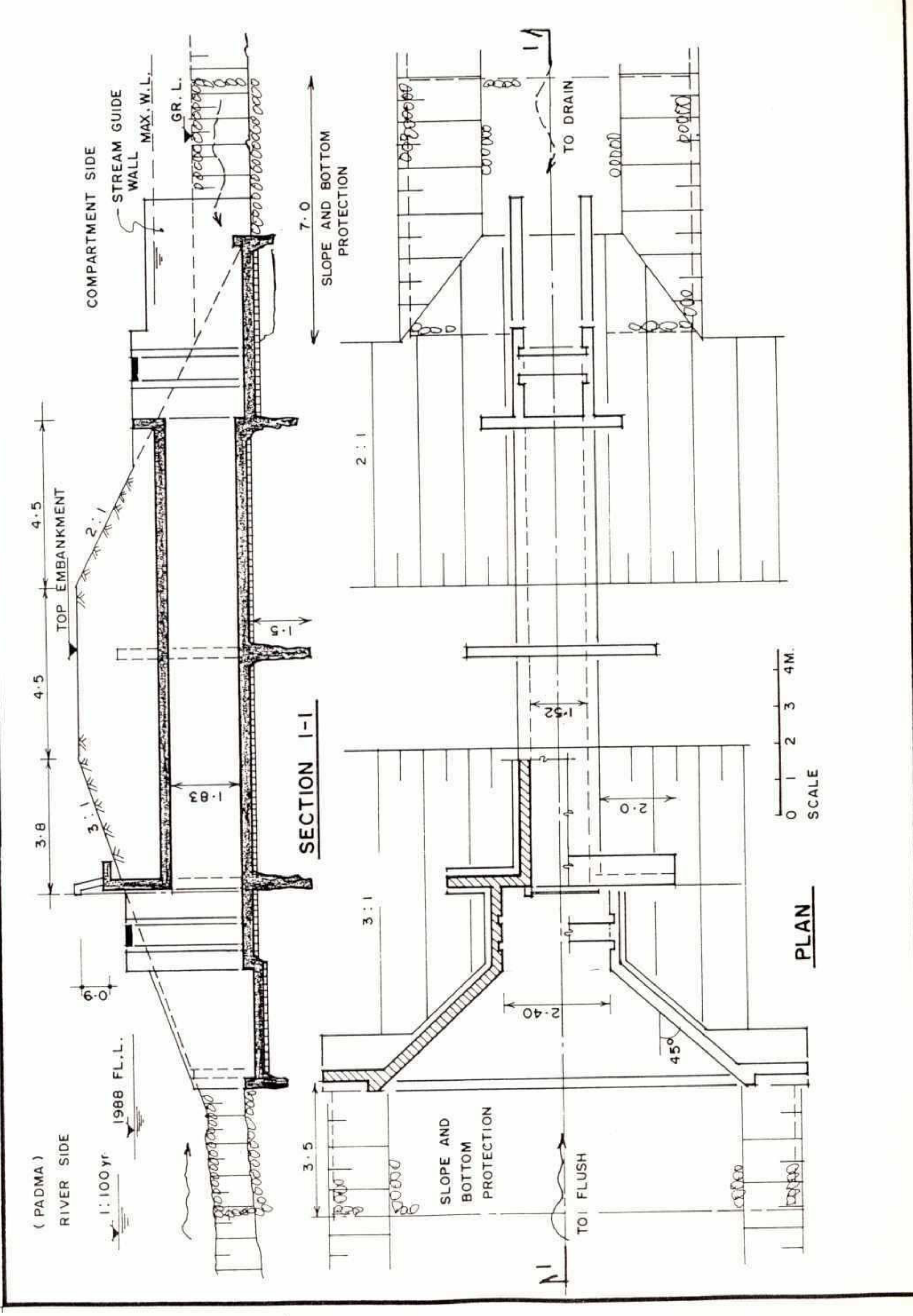


Figure VII.2.6

Controlled Drainage Outlet (C.D.O)
Outline Design



1.2.7 Multiple Barrel Box Culvert (Figure VII.2.7)

For fully controlled drainage, a number of standard barrels 6'x5' or 8'x 11' (h x w) can be constructed at the confluence of drain and main canal. A minimum of 0.6 m soil cover is advised. This structure is proposed for relative large drainage capacities and the number of barrels can be adapted to the design requirements

A major road on top of the embankment can be included in the boundary conditions for the strength calculations of this type of structure.

1.2.8 Road Pipe Culvert (Figure VII.2.8)

The intake structure includes a stoplog groove in the side walls and a gate frame in the front wall. The gate frame will be bolted to an embedded hot dip galvanised frame. In this way the whole set can be removed for maintenance or replacement.

Connected to the front wall is a reinforced concrete pipe founded on a mass concrete foundation.

To quantify the number of these structure it is assumed that at approx. 2 km c.to c. this type is constructed in the new embankments.

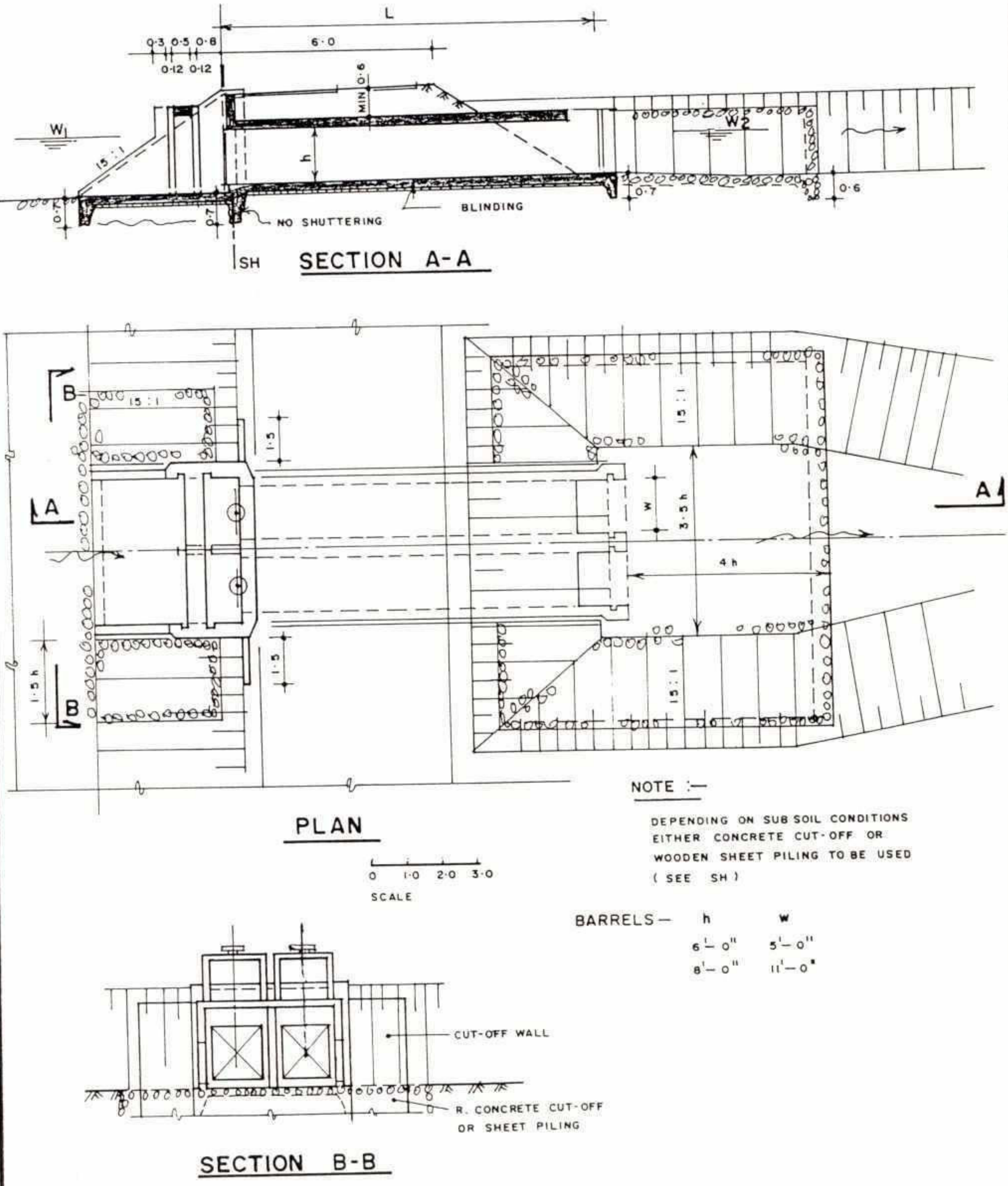
1.2.9 Weir, Stepped Weir, Sluice (Figure VII.2.9)

This semi controlled structure should have a max. capacity of approx. 1000 m 3/ sec. and is considered to be placed in the confluence Turag/Bangshi. The stepped weir allows an increased capacity at different river stages. The gated sections are designed to allow a minimum (bed) flow at all times and one gated section can be constructed in such a way that navigation of country boat can take place at low discharges while at higher discharges the boats can pass over the stepped weir. The gates can be operated from a platform at approx. embankment level. When the weir is submerged the platform can be reached by boat.

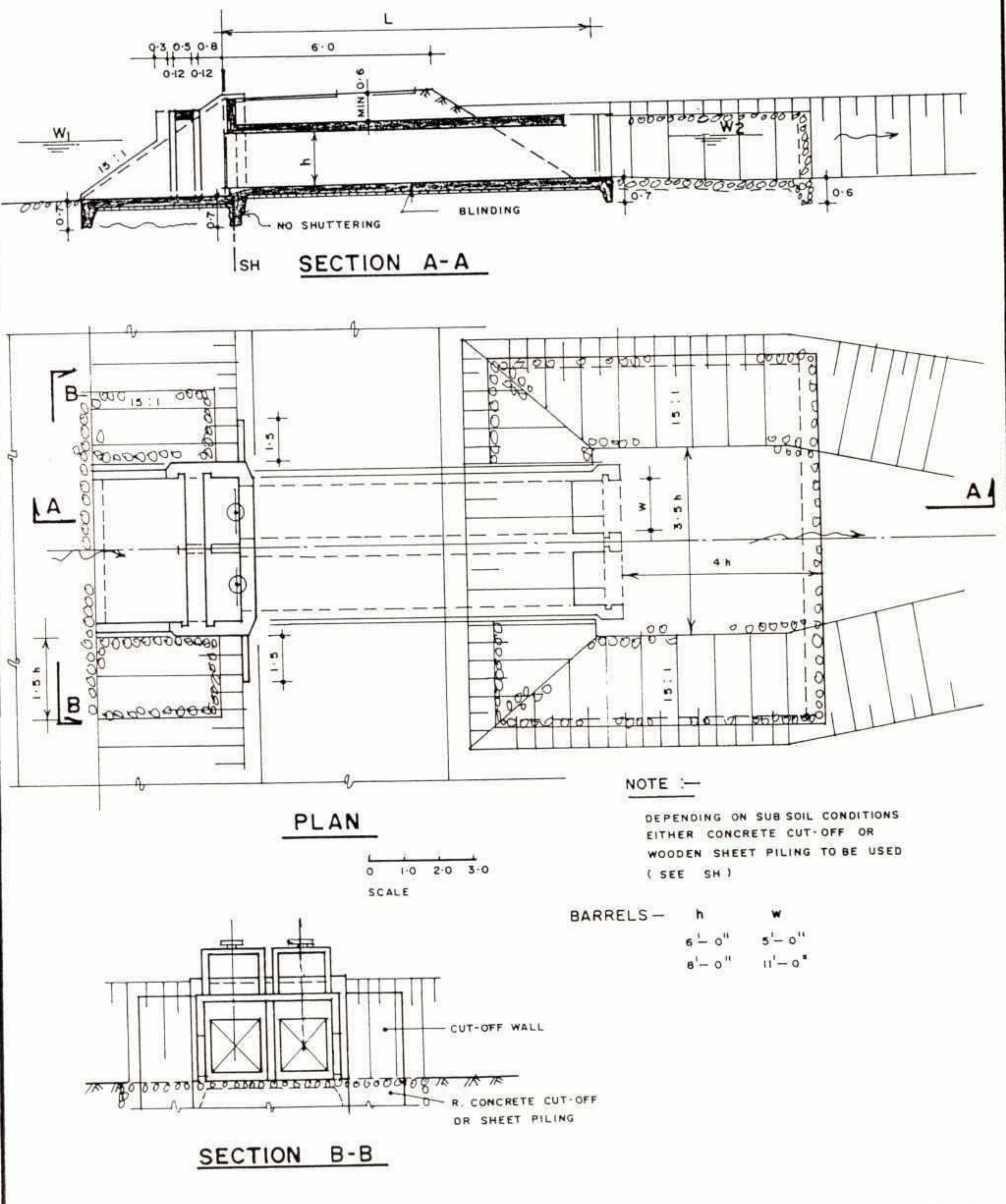
The fixed earth body weir has a protection of concrete blocks on khoa/filter cloth and the bottom protection throughout is gabions (crates) filled with broken bricks placed on filter cloth.

The gated section is piled and jointed to the raft founded stepped weir section. Stepped weir and gated section have a down stream stilling basin.

Fully Controlled Drainage Outlet
(Multiple Barrel Box Culvert)
Outline Design



Fully Controlled Drainage Outlet (Multiple Barrel Box Culvert) Outline Design



Fully Controlled Drainage Outlet Road Pipe Culvert Outline Design

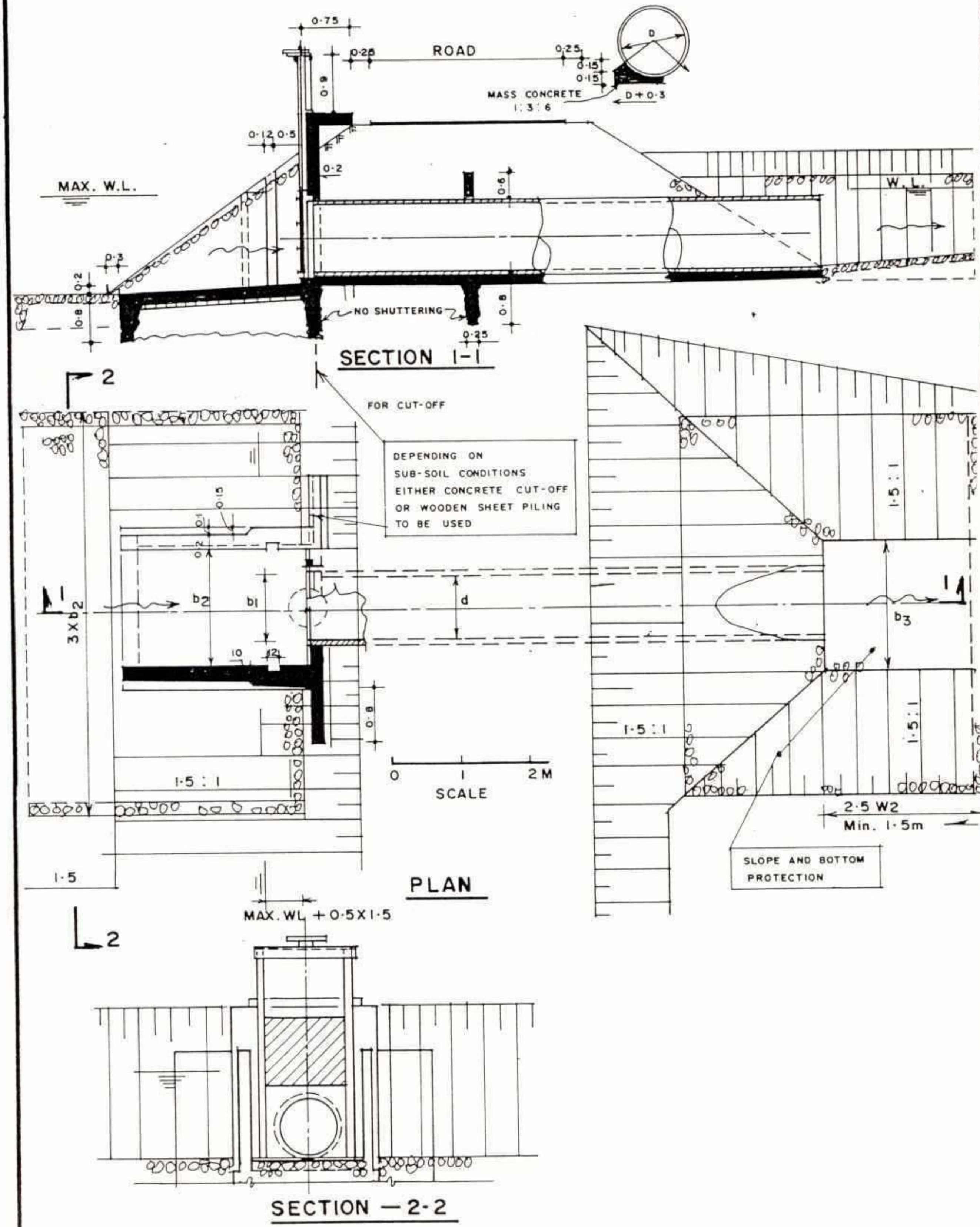
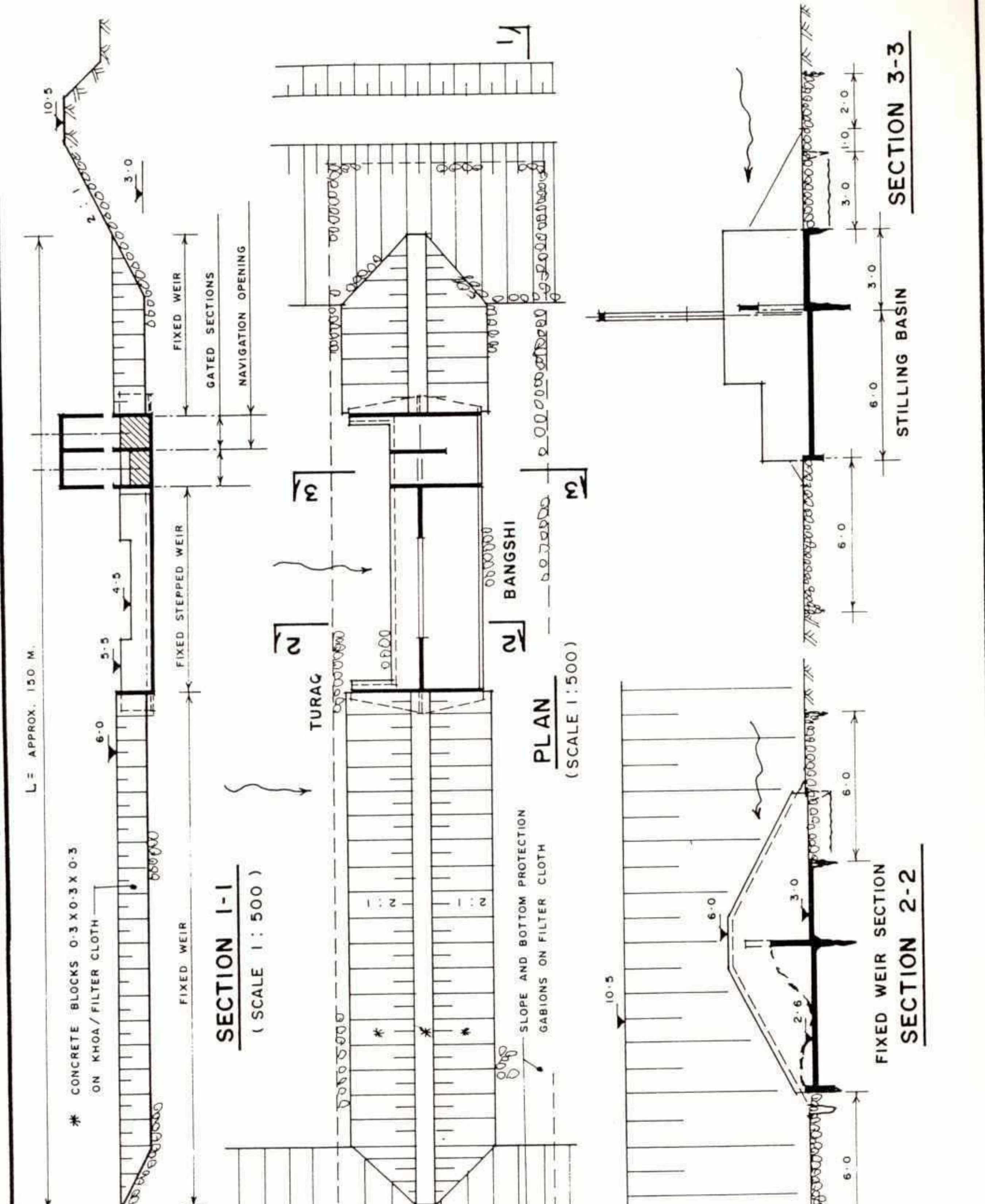


Figure VII.2.9

Weir/Stepped Weir/Sluice Outline Design



1.2.10 Raised Fixed Sill, Weir (Figure VII.2.10)

This semi controlled structure can be executed with a perforation of pipes to allow a bed flow at low discharges.

The weir width and bank slopes can be adapted at the design stage to incorporate a road surface. Country boat can make use of a slipway with bullahs to negotiate the weir at low discharges. The construction of the weir is similar to the type J structure.

1.2.11 Outline Design of a Multiple Span Large Bridge (Figure VII.2.11)

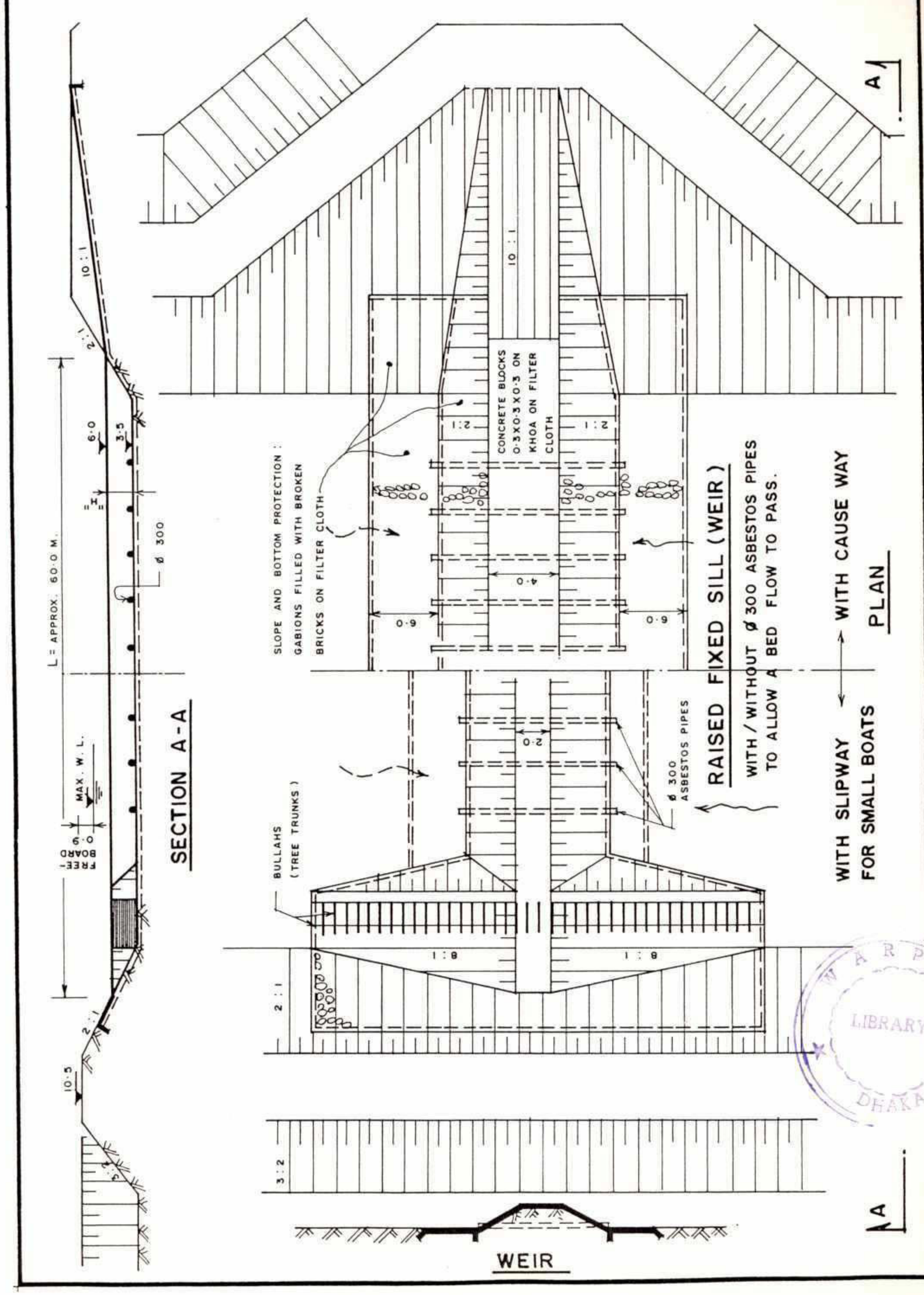
This type of bridge is a standard construction in Bangladesh. The type of piles used are bore piles. The slope and bottom protection are by gabions (crates) filled with broken bricks placed on filter cloth.The piers and abutments can also be designed to carry concrete bridge slabs of smaller spans.

1.3 Additional Outline Designs

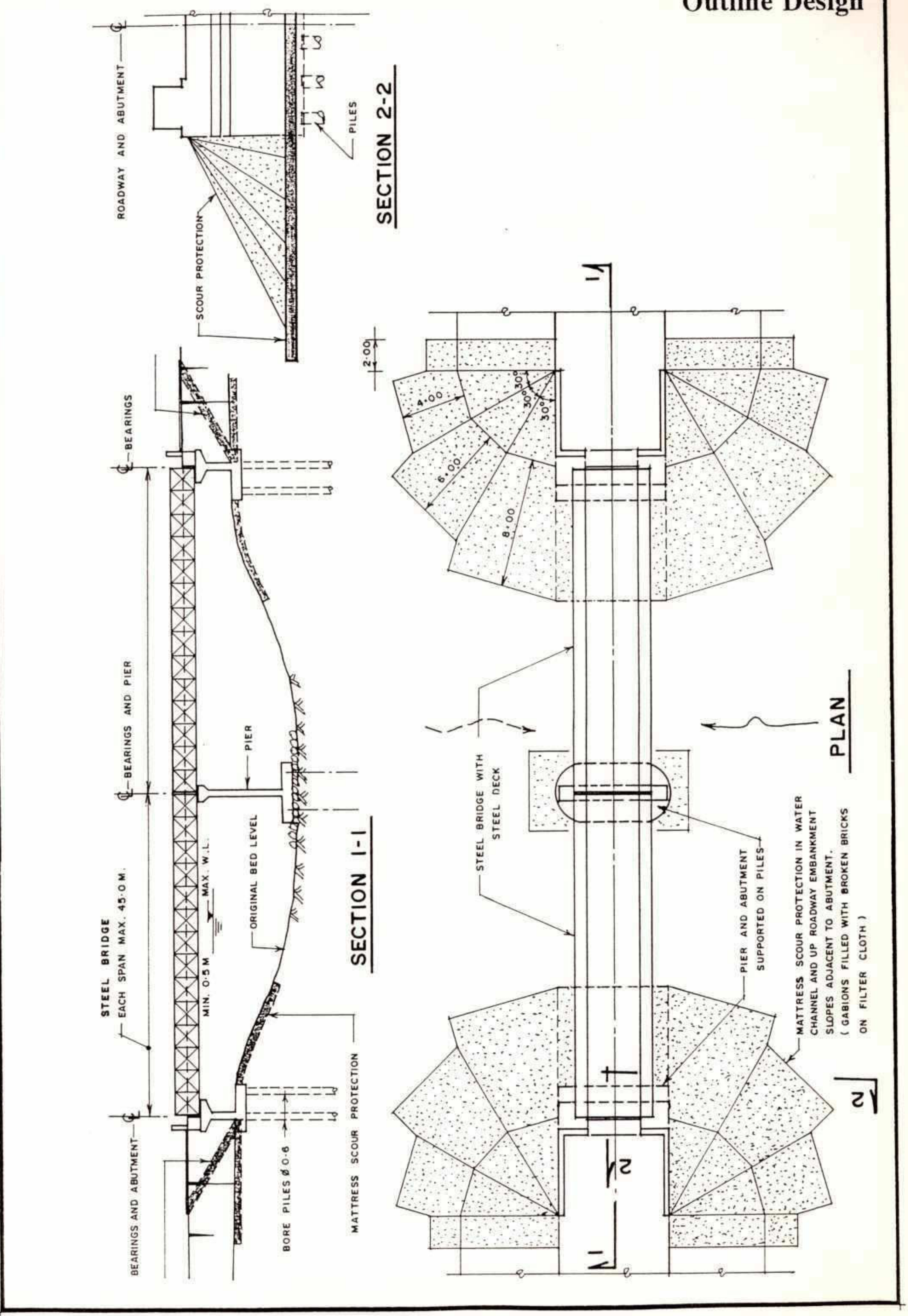
Further outline design have been prepared of structures that may become more appropriate at later stages of the development programme. These include the following and outline designs have been kept on project files for future reference:-

- Weir and navigation lock:
- Discharge Regulator: Maximum capacity $\pm$ 50m^3/sec.
- Road Pipe Culvert
- Road Box Culverts
- Large box culvert with stilling basin
- Reinforced Concrete Bridge for Small Road
- Prepared Breach in Embankments
- Crump weir
- Side escape combined with causeway

Raised Fixed Sill Weir
Outline Design



Multiple Span Large Bridge Outline Design



VII.3 Topographic Survey

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Flood Action Plan
FAP 3
North Central Regional Study

Supporting Report VII.3
Topographic Survey

February 1993

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SUPPORTING REPORT VII.3-TOPOGRAPHIC SURVEY

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CHAPTER 1
MAPPING

1.1 Introduction

The Study has had access to the following maps covering the North Central Region:-

- 1: 50 000 revised topographic maps
- 4" to the mile (1/15 840) water development maps
- 8" to the mile (1/7 920) water development maps

The 1:50 000 map series has been updated in the last few years, whereas the 4":mile and 8":mile maps were produced in the 1960's, see below.

Three sets of aerial photography are available:-

- 1983 at 1:50 000 (most of region)
- 1990 at 1:50 000 (2/3rds of the region)
- 1990 at 1:20 000 (adjacent to Jamuna river only)

Satellite imagery was available at 1:50 000 for February/March 1990 and had previously been used to prepare the land use maps supplied with the Reconnaissance Study Report (NCRS 1991). A computer tape was also available for imagery from October/November 1991 which has been used for the land use mapping given in SR I Annex I.

Other maps and imagery have been observed from different sources, notably SPARRSO, other FAP studies and government departments including BWDB. SPARRSO produce images from the NOAA satellite which give useful general views of the flooding in the Region.

The availability of good accurate topographic mapping is essential for water resources planning. Accurate elevational control is particularly important and care has to be taken to ensure that the available mapping provides accurate data. This aspect is being looked into by FAP 18 and errors have been identified by their survey teams which are presently being resolved. It is important that at the next stage of planning in the NCRS that updated topographic mapping is used resulting from the FAP 18 work.

1.2 Mapping

1.2.1 1:50 000 Topographic Maps

Coloured 1:50 000 topographic maps are available for the whole of the NCR. These maps were first published in 1959 and subsequently revised and reprinted in 1972,1974 and 1991. The precise revisions vary from map to map, but in general revisions have been made using aerial photography at 1:30 000 scale from 1974/75 ground checked in 1978/79 and also in 1984/85 and 1988/89.

The map series is useful for general purposes but has the following limitations:- few spot heights, widely spaced contours, a duplication of place names and a military grid (in yards). The projection type is not indicated on the maps but is assumed to be the Transverse Mercator. The unstable nature of the rivers in the region means that river bank alignments are constantly changing and thus any mapping more than 1 year old should be treated with caution.

1.2.2 Water Development Maps

There are two series of Water Development Maps at 4":mile and 8":mile.

The 4":mile (1:15 840) maps were compiled from aerial photography taken in 1961 verified on the ground during 1962/63 and published from 1964 onwards. The fieldwork was done by various methods. The earlier maps were prepared using plane tabling and later on by chain traversing and levelling. Survey pillars were established on a 80 chains grid (however these survey pillars cannot at present be located). Spot height were run along trace lines at about five chains apart and were tied in to the survey pillars and the benchmarks. The heights given on these maps should be converted to the East Pakistan (PWD) datum by adding 1.5 feet (0.46m).

The 8":mile (1:7 920) maps were compiled from aerial photography during 1961/62 and were published in 1964. The process of compilation was as for the 4" maps except that spot height intervals is at 10 chains (220 yards or approximately 200m).

These two map series are the most accurate available showing the land form in sufficient detail for hydrological and engineering planning. Although adequate at the time produced, they now suffer from being some 30 years old and thus do not show recent changes in land form, which are particularly significant close to the rivers and on the active flood plains.

1.2.3 Satellite Imagery

A large number of satellite images are now available covering Bangladesh. These include Landsat, SPOT and Soyuzkarta scenes. Unfortunately the cloud cover during the period May to October in Bangladesh is such that it is difficult to find satellite scenes that give good coverage during this monsoon season.

Two scenes have been used by the NCRS. These are from the SPOT satellite and are for February 1990 and October/November 1991. These have been used to prepare Land Use mapping (see SR I, Annex I) but have also been used to prepare up to date tracings of the river alignments for use in the engineering planning.

These tracings at 1:50 000 have been kept on project files. They consist of a combination of information from the SPOT images together with topographic data from the 4" and 8" to the mile mapping. They [provide the most upto date information required for study of the drainage and river systems and have been used in estimating the overland flow regime and in identifying water management unit layouts.

They should be supplemented and eventually superseded at feasibility level by mapping to be supplied by the Finnmap program (FAP 18) and by digital elevation mapping being prepared by FAP 19.

1.2.4 Aerial Photography

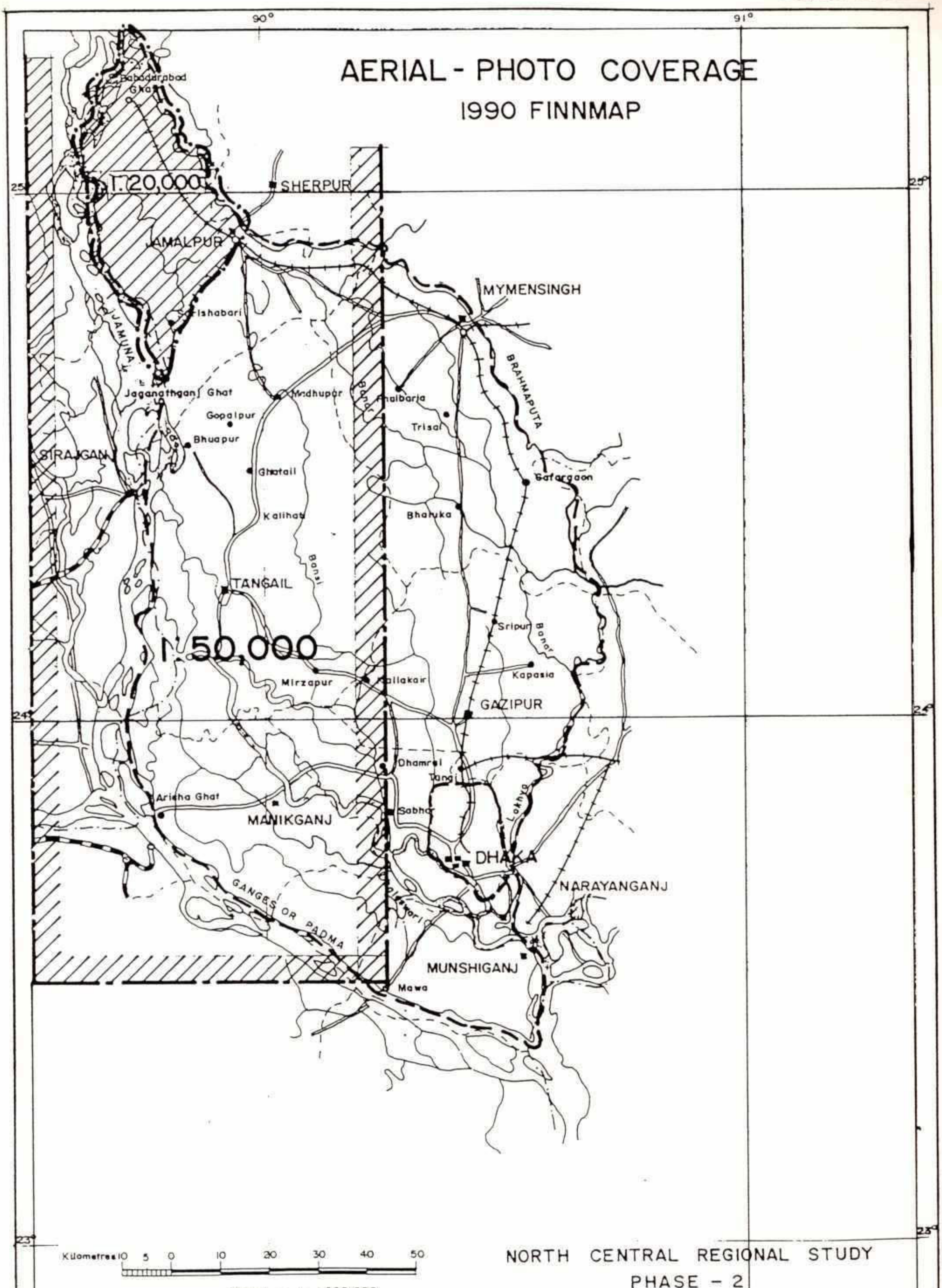
Three sets of aerial photography were supplied to FAP 3:-

1983 1:50 000 covers all of the NCR, but certain scenes were not made available to NCRS due to security reasons. The quality of these scenes is good but they have been largely superseded. They are still useful for observation of changes, particularly in river alignment, through the years.

1990 1:50 000 photography from Finnmap is available for half of the region and 1:20 000 photography for the Jamalpur Priority Project area (see Figure VII.3.1). This photography is of good quality and is being used by Finnmap to produce photomosaics and ortho-corrected mapping with contours for the FAP 3.1 and FAP 20 pilot project areas of Jamalpur and Tangail respectively.

At feasibility study level improved mapping is required at a scale of at least 1:20 000 mapping. These should be prepared as per the program presently being carried out by FAP 18 for FAP 3.1 and FAP 20. It is important that these maps are made available before the feasibility starts. The present FAP 18 program would not allow for such mapping to be available before 1994 and it is important to agree upon a program of mapping for future feasibility studies.

Figure : VII.3.1



CHAPTER 2
TOPOGRAPHICAL SURVEY

2.1 Topographic Survey Program

Under the Study, a separate programme of topographic survey work has been undertaken to supplement data. This programme primarily focused on the survey of the existing embankment alignments.

The survey work included the following:-

: From Sarishabari to the district boundary between Tangail and Manikganj (approx. 80km)

: From Badhurabad Ghat to Sarishabari (part survey) (approx. 60km)

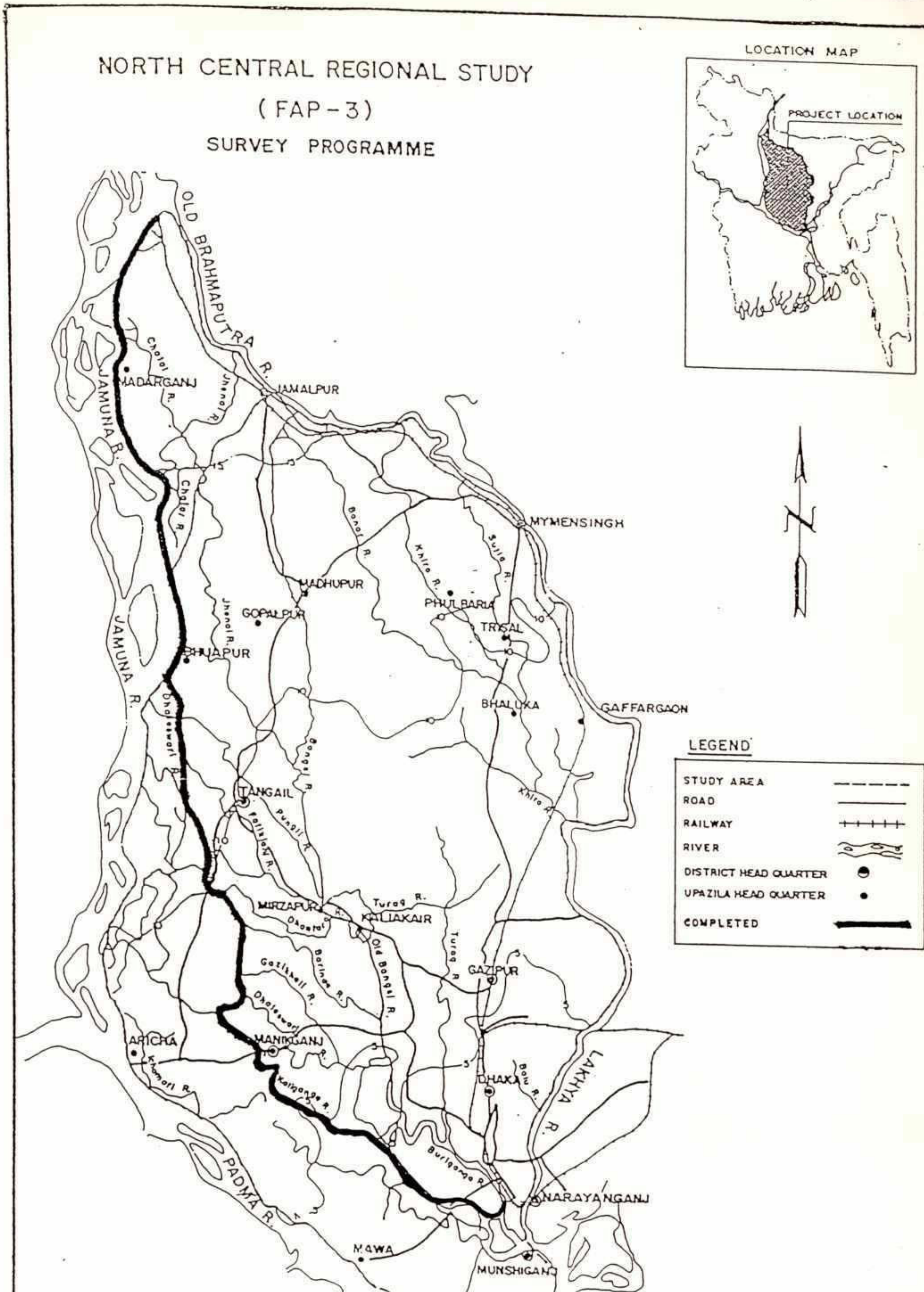
: From district boundary between Tangail and Manikganj to the River Buriganga (part survey) (approx. 80Km)

The topographic survey comprised surveying of longitudinal profile of the embankments as well as survey of embankment cross-sections (50 to 100m) at 500m intervals and a transect of 1km (inland) at 10 km intervals along the left bank of the Jamuna and Dhaleswari for a length of 220 km (see Figure VII.3.2). Additional lengths of 10 km (along an old embankment from Manikpotol to Kulpal) and 28.9km from Kalatia to Kaotail were completed.

All the above survey has been drawn up and is kept on project files. The profiles have been used in estimating the earthwork requirements for the various Regional Schemes as detailed in SR VII.4.

2.2 Topographic Contract

After discussions with the FPCO, CEC and CCCE in early 1992 it was decided that further long sections and cross sections as originally set out in the Contract were no longer of a high priority. The remaining allocation of topographic survey work was reallocated through Rider Nr.2 to be used as part of the budget for hydrological investigations during the 1992 monsoon season.


NORTH CENTRAL REGIONAL STUDY
(FAP-3)
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LOCATION MAP
PROJECT LOCATION
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JAMUNA R.
MADARGANJ
JAMALPUR
MYMENSINGH
MADHUPUR
GOPALPUR
PHULBARIA
TRISAL
BHALUKA
GAFFARGAON
TANGAIL
MIRZAPUR
KALIAKAIR
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MAWA
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Old Bangsi R.
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Kaliganga R.
Burigange R.
Khiro R.
Banar R.
Pungli R.
LEGEND
STUDY AREA
ROAD
RAILWAY
RIVER
DISTRICT HEAD QUARTER
UPAZILA HEAD QUARTER
COMPLETED

VII.4 Engineering Costs

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Flood Action Plan
FAP 3
North Central Regional Study

Supporting Report VII.4
Engineering Costs

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SUPPORTING REPORT VII.4 - ENGINEERING COSTS

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CHAPTER 1
INTRODUCTION

1.1 General

The cost estimates have been prepared in such a way as to allow for future changes in costs and specifications. The approach has been to use the FPCO guidelines for project assessment (GPA) as the baseline and then to carry out sensitivity tests for various possible alternative costings. These sensitivity analyses have been carried out in the economic analysis (see SR X).

1.2 Unit Rates

The GPA (FPCO 1992) states that the cost estimate of structures and embankments should be prepared with rates from BWDB's schedule of rates of May 1991 (to be updated to mid June if necessary). However the latest schedule of rates available at the time of preparation of this report (early 1992) with the BWDB's Design and Divisional Office for the Mymensingh and Dhaka Circles was September 1988.

These rates have been updated by the NCRS, see Tables VII.4.1,and VII.4.2. The rates of Mymensingh and Dhaka circles are different with the Dhaka circle generally having higher rates, see Table VII.4.3.

As an illustration of the effect of these unit rate differences on costing of works comparative calculations have been made of a standard 2-vent sluice and of a 4m high interior embankment. For the sluice the total Dhaka cost is 1.6% higher than under the Mymensingh Circle and for the embankment the cost is 29.8% higher.

The Consultants are concerned that the BWDB rates may not reflect the rates that will be encountered at tendering stage for construction of proposed works. A discussion on the basis of cost calculations is given as Annex VII.I.

CHAPTER 2
COSTS

2.1 Earthworks

The embankment types costed are given in Table VII.2.1. The option of a 7m road however has not been included in the costings for the Regional Schemes. The cost and benefits of providing a rural road should be looked at as a separate economic analysis at feasibility level. Thus the main embankment options is for either an "interior" embankment with a 4.5m crest width or a "marginal" embankment with 2.4m crest width.

At this pre-feasibility level of planning the costing has assumed that "interior" embankments will be required on the major rivers (Jamuna and Padma) and that "marginal" embankments will be adequate on the regional rivers.

A return period of 40 years with a freeboard of 1.2m has been used as the base case, but sensitivity analyses have been carried out to see the effect on costs of increasing both of these factors. Costings are given in Tables VII.2.2 to VII.2.8.

Operation and Maintenance costs have been taken as 6% of the construction cost in the base case but further discussion is given on this aspect in Annex I.

TABLE VII.2.1
Main Design Criteria[1]

Characteristic	Design Criteria
1. Embankment Slopes (a) "Interior" (b) "Marginal"	 1:3/1:2 1:2/1:2
2. Embankment Crest width (a1) with road (a2) without road (b) without road	 7m 4.5m 2.4m
3. Embankment Foundation	0.1m stripping,limited requirement for toe drain
4. Compaction	85%
5. Return Period	Use 40 years but review at Feasibility Level
6. Freeboard	1.2m
7. Basic costs Unit rates O&M costs - embankment - structures	 BWDB 1991 rates 6% 3%

Note: 1. GPA (FPCO 1992) has been followed with outline designs prepared as necessary, see SR II.2
Source: CS 1992

TABLE VII.2.2

UNIT RATE OF MYMENSINGH CIRCLE UPDATED TO JUNE 1991

Table VII 5.1(a)

Sl. No.	Item of Work	Unit	BWDB Schedule Rate of Sept. '88 (Tk)	Updated Rate of Jan 1991 As Calculated (Tk)	Inflation From Sept 88 To Jan 91 (Annual) (%)	Inflation From Jan 91 To June 91 (50%) Half year	Updated Rate of June 1991 (Tk)
01.	Earthwork in flood Embankment						
1a.	From borrow pit	100 Cu.M	1276	1449	6.6	3.3	1496
1b.	With royalty	100 Cu.M	2100	2357	5.9	2.95	2426
02.	Earthwork in channel excavation						
2a	Main channels	100 Cu.M	1800	1906	2.9	1.45	1961
2b.	Secondary channel	100 Cu.M	1601	1668	2.1	1.05	1685
03.	Earthwork in Diversion Channel	100 Cu.M	1601	1668	2.1	1.05	1685
04.	Fine dressing & close turfing	100 Sq.M	200	200	0.0	1.0	220
05.	Earthwork in foundation Excavation						
5a.	Regulators	100 Cu.M	2076	2149	1.8	0.90	2187
5b.	Others	100 Cu.M	1851	1970	3.1	1.55	2000
06.	Compacted backfill around structure						
6a.	By sand	Cu.M	160	172	3.7	1.85	175
6b.	By Excavated Material	100 Cu.M	1326	1494	6.2	3.1	1540
7a.	C.C (1:4:8)	Cu.M	1544	1881	10.4	5.2	1624
7b.	C.C.(1:3:6)	Cu.M	1765	2090	8.8	4.4	2182
7c.	C.C.(1:2:4:)	Cu.M	2418	2626	4.2	2.1	2681
08.	R.C.C.including shuttering						
8a.	In foundation and base slab	Cu.M	2683	2965	5.1	2.55	3040
8b.	Above base slab	Cu.M	3036	3495	7.3	3.65	3622
8c.	Average	Cu.M	2824	3248	7.2	3.6	3364
09.	MS Reinforcement	M.Ton	22500	23000	1.1	0.55	23126
10.	Brickwork (1:4)	Cu.M	1359	1619	9.1	4.55	1692
11.	Brick Block protection	Cu.M	1363	1412	1.8	0.9	1424
12.	3" flat brick soling	Sq.M	70	92	14.6	7.3	99
13.	R.C.C.pipes						
13a.	Dia = 45 cm (5 cm thickness)	RM	623	748	9.5	4.75	784
13b.	Dia = 60 cm (7.5 cm thickness)	RM	1614	1935	9.5	4.75	2026
13c.	Dia = 90 Cm (7.5 cm thickness)	RM	1994	2394	9.6	4.8	3074
14a.	Steel Flap Gates (1.5 M x 1.8 M)	Nr.	70000	70000	0.0	1.0	70700
14b.	Steel Slide Gates (1.5 M x1.8 M)	Nr.	80000	85000	3.1	1.55	86318
14c.	Steel Slide Gates (0.9 M x 0.9 M)	Nr.	30000	35000	8	4.0	36400
14d.	Steel Slide Gates (0.45M x 0.45 M)	Nr.	20000	22000	4.9	2.45	22539
15.	PVC water stop (23 cm)	Rm	761	838	4.9	2.45	856
16.	Wooden stoplog	Cu.M	19768	21745	4.9	2.45	22277
17.	Land Acquisition	Ha	222390	259455	8.0	4.0	269833
18.	Clearing site	100 Sq.M	45	55	11.11	5.55	58
19.	Earthwork in construction of approach embnk	100 Cu.M	1475	1675	6.7	3.35	1731
20.	Khoa (Brick chip) bed	Cu.M	737	774	2.5	0.62	778
21.	Sand Filter (FM 71)	Cu.M	160	172	3.7	1.85	175
22.	C.C.Block (1:3:6) of size 40cmx40cmx30cm	Nr.	121	125	1.65	0.82	126
23.	Caission sinking	Sq.M	356	374	2.5	1.25	378
24.	Project Building	Sq.M	4950	5445	4.9	2.45	5578
25.	Extra over earthwork	100 Cu.M	100	100	0.0	1.0	101

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TABLE VII.2.3

UNIT RATE OF DHAKA CIRCLE UPDATED TO JUNE 1991

Table VIII.5.1(b)

Sl. No.	Item of Work	Unit	BWDB Schedule Rate of Sept. '88 (Tk)	Updated Rate of Jan 1991 As Calculated (Tk)	Inflation From Sept 88 To Jan 91 (Annual) (%)	Inflation From Jan 91 To June 91 (50%) Half year	Updated Rate of June 1991 (Tk)
01.	Earthwork in flood Embankment						
1a.	From borrow pit	100 Cu.M	3600	3338	6.6	3.3	3965
1b.	With royalty	100 Cu.M	5400	5719	5.9	3.0	5891
02.	Earthwork in channel excavation/ re-excavation & spread soil for embankment						
2a	Main channel	100 Cu.M	1600	1646	2.9	1.5	1671
2b.	Secondary channel	100 Cu.M	1600	1634	2.1	1.0	1650
03.	Earthwork in Diversion Channel	100 Cu.M	1600	1634	2.1	1.0	1650
04.	Fine dressing & close turfing	100 Sq.M	260	260	0.0	0.0	260
05.	Earthwork in foundation Excavation	100 Cu.M					
5a.	Regulators	100 Cu.M	2300	2341	1.8	0.0	2362
5b.	Others	100 Cu.M	2300	2341	3.1	1.6	2409
06.	Compacted backfill around structure						
6a.	By sand	Cu.M	2600	2696	3.7	1.9	2747
6b.	By Excavated Material	100 Cu.M	1500	1593	6.2	3.1	1642
7a.	C.C (1:4:8)	Cu.M	1468	1621	10.4	5.2	1705
7b.	C.C.(1:3:6)	Cu.M	1578	1717	8.8	4.4	1793
7c.	C.C.(1:2:4:)	Cu.M	1887	1966	4.2	2.1	2007
08.	R.C.C.including shuttering						
8a.	In foundation and base slab	Cu.M	2230	2344	5.1	2.6	2405
8b.	Above base slab	Cu.M	2230	2393	7.3	3.7	2482
8c.	Average	Cu.M	2230	2391	7.2	3.6	2477
09.	MS Reinforcement	M.Ton	25000	25275	1.1	0.6	25423
10.	Brickwork (1:4)	Cu.M	1269	1385	9.1	4.6	1449
11.	Brick Block protection	Cu.M	1275	1298	1.8	1.4	1316
12.	3" flat brick soling	Sq.M	73	84	14.6	7.3	90
13.	R.C.C.pipes						
13a.	Dia = 45 cm (5 cm thickness)	RM					675
13b.	Dia = 60 cm (7.5 cm thickness)	RM					900
13c.	Dia = 90 Cm (7.5 cm thickness)	RM					1350
14a.	Steel Flap Gates (1.5 M x 1.8 M)	Nr.	35000	35000	0.0	0.0	35000
14b.	Steel Slide Gates (1.5 M x1.8 M)	Nr.	69000	71139	3.1	1.6	72277
14c.	Steel Slide Gates (0.9 M x 0.9 M)	Nr.	43289	46752	8.0	4.0	48622
14d.	Steel Slide Gates (0.45M x 0.45 M)	Nr.	22000	23078	4.9	2.5	23655
15.	PVC water stop (23 cm)	Rm	310	325	4.9	2.5	333
16.	Wooden stoplog	Cu.M	20370	21368	4.9	2.5	21902
17.	Land Acquisition	Ha		270000	8.0	4.0	280800
18.	Clearing site	100 Sq.M	56	62	8.0	5.6	65
19.	Earthwork in construction of approach embnk	00 Cu.M	3600	3841	6.7	3.4	3972
20.	Khoa (Brick chip) bed	Cu.M	657	673	2.5	1.3	682
21.	Sand Filter (FM >1)	Cu.M		180	3.7	1.9	183
22.	C.C.Block (1:3:6) of size 40cmx40cmx30cm						
23.	Caission sinking						
24.	Project Building						
25.	Extra over earthwork						

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TABLE VII.2.4

COMPARISON OF DHAKA AND MYMENSINGH CIRCLE

Table VIII.5.2

Sl. No.	Item of Work	Rate of Dhaka Circle A	Rate of Mym. Circle B	Compare of Rate by % B/Ax100
1.	Earthwork in flood Embankment			
1a.	From borrow pit	3965	1496	(-) 38%
1b.	With royalty	5891	2426	(-) 41%
2.	Earthwork in channel excavation/ re-excavation and spread spoil for embankment			
2a	Main channels	1671	1961	(+) 117%
2b.	Secondary channels	1650	1685	(+) 102%
3.	Earthwork in Diversion Channels	1650	1685	(+) 102%
4.	Fine dressing & close turfing	260	220	(-) 84%
5.	Earthwork in foundation Excavation			
5a.	Regulators	2362	2187	(-) 93%
5b.	Others	2409	2000	(-) 83%
6.	Compacted backfill around structure			
6a.	By sand	275	175	(-) 64%
6b.	By Excavated Material terials	1642	1540	(-) 94%
7a.	C.C (1:4:8)	1705	1624	(-) 95%
7b.	C.C.(1:3:6)	1793	2182	(+)122%
7c.	C.C.(1:2:4:)	2007	2681	(+)134%
8.	R.C.C.including shuttering			
8a.	In foundation and base slab	2405	3040	(+)126%
8b.	Above base slab	2482	3622	(+)146%
8c.	Average	2477	3364	(+)136%
9.	MS reinforcement	25423	23126	(-) 91%
10.	Brickwork (1:4)	1449	1692	(+)117%
11.	Brick Block protection	1316	1424	(+)108%
12.	3" flat brick soling	90	99	(+)110%
13.	R.C.C.pipes			
13a.	Dia = 45 cm (5 cm thickness)	675	784	(+)116%
13b.	Dia = 60 cm (7.5 cm thickness)	900	2026	(+)225%
3c.	Dia = 90 Cm (7.5 cm thickness)	1350	3074	(+)228%
14a.	Steel Flap Gates (1.5 M x 1.8 M)	35000	70700	(+)202%
14b.	Steel Slide Gate(1.5 M x1.8 M)	72277	86318	(+)119%
14c.	Steel Slide Gate(0.9 M x 0.9 M)	48622	36400	(-) 75%
14d.	Steel Slide Gate (0.45M x 0.45 M)	23655	22539	(-) 95%
15.	PVC water stop (23 cm)	333	856	(+)257%
16.	Wooden stoplog	21902	22277	(+)102%
17.	Land Acquisition	280800	269833	(-) 96%
18.	Clearing site	65	58	(-) 89%
19.	Earthwork in construction of approach embnk	3972	1731	(-) 44%
20.	Khoa (Brick chip) bed	682	778	(+)114%
21.	Sand Filter (F.M.71)	183	175	(-) 96%
22.	C.C.Block (1:3:6) of size 40cmx40cmx30cm	131	126	(-) 96%
23.	Caission sinking	629	378	(-) 60%
24.	Project Building	6150	5578	(-) 90%
25.	Extra over earthwork	110	101	(-) 91%

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TABLE VII.2.5
BWDB Schedule of Rates for Earthwork

Sl. No.	Description of items	Unit	Rate in Tk.	Rate updated June 1991
	1. Mumensingh Circle (oct. 89) (Unit Prices used for FAP-3 evaluation)			
1a	Earthwork to design section by manual labour within leads of 30m	cum	13.75	15.40
2a	Earthwork to design section by manual labour including royalty within all leads	cum	22.00	24.40
3a	Earthwork in channel excavation & spread spoil.	cum	16.00	16.85
4a	Fine dressing and close turfing	m2	2.00	2.20
	2. Dhaka Circle (sept.88)			
1b	Earthwork to design section by manual labour within leads of 30m	cum	19.70	23.60
2b	Royalty for taking earth from private land	cum	18.00	21.20
3b	Earthwork to design section including compaction to 85%	cum	35.00	41.30
4b	Earthwork in excavation and spread spoil	cum	16.00	16.50
5b	Fine dressing and close turfing	m2	2.60	2.60

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TABLE VII.2.6

Standard Rate use for estimating Embankment Costs

Sl. No.	Short Description of items	Unit	Rate (Tk)
01.	Pre-requisite before commencement of Embankment like clering vegetation & all roots, water hyacinth, trres with stumps etc. from the base of the embankment.	sq.m	0.84
02.	Removal of earth to a depth of 0.5m from the base of embankment.	cu.m	16.85
03.	Royalty for taking earth from land to be arranged by the contractor.	cu.m	9.30
04.	Earthwork by Manual labour in construction of new, compacted embankemtn to design section with 15cm cambering in all kinds of soil free peats and other impurities like grass, roots, from stumps etc. and throwing the earth in layers not exceeding 20cm with all leads and lifts. Earth to be arranged by the contractor Minimum compaction obtained has to be 85% (Excluding the charge for compaction)	cu.m	20.15
05.	Machinery hire, fuel and lubricant cost & all other expenses for compacting the embankment to 85% minimum compaction with reference laboratory density test. Machine to be arranged by the contractor. Payment will be made on compacted volume of earth.	cu.m	15.00
06.	Fine dressing and close turfing the crest and slopes of the embankemnt with good quality sods with all leads and lifts including ramming, watering etc. complete. Payment to be made on grown up grass area only.	sq.m	2.20

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TABLE VII.2.7
Construction Cost of Embankments without Roads (40 year Return Period)[1]

Planning Unit	Embankment No	Length KM	Break up of total cost in ,000 Taka				Total cost in ,000 Taka
			Land Acq. cost 21%	Royalty for purchased Earth 12%	Machinery cost compaction 25%	Cost of labour 42%	
1	1/E1	67	84494.97	48282.84	100589.25	168989.94	402357.00
	1/E2	42	53649.12	30656.64	63868.00	107298.24	255472.00
2/4	2-4/E3	37.5	22225.14	12700.08	26458.50	44450.28	105834.00
	2-4/E1	40	48446.79	27683.88	57674.75	96893.58	230699.00
	2-4/E2	6	7901.67	4515.24	9406.75	15803.34	37627.00
3	3/E1	119	147817.74	84467.28	175973.50	295635.48	703894.00
5	5/E1	25	17459.19	9976.68	20784.75	34918.38	83139.00
	5/E2	30	29850.03	17057.16	35535.75	59700.06	142143.00
	5/E3	12	15328.32	8759.04	18248.00	30656.64	72992.00
6	6/E1	75	63763.14	36436.08	75908.50	127526.28	303634.00
	6/E2	27	34149.15	19513.80	40653.75	68298.30	162615.00
	6/E3	15	20087.76	11478.72	23914.00	40175.52	95656.00
	6/E4	26	32292.33	18452.76	38443.25	64584.66	153773.00
	6/E5	42	69046.11	39454.92	82197.75	138092.22	328791.00
7	7/E1	14.5	22461.39	12835.08	26739.75	44922.78	106959.00
	7/E2	50.5	74364.36	42493.92	88529.00	148728.72	354116.00
	7/E3	11	8535.66	4877.52	10161.50	17071.32	40646.00
	7/E4	8	6625.50	3786.00	7887.50	13251.00	31550.00
8	8/E1	74.5	58936.92	33678.24	70163.00	117873.84	280652.00
	8/E2	23	18195.24	10397.28	21661.00	36390.48	86644.00
9/12	9-12/E1	61	140081.34	80046.48	166763.50	280162.68	667054.00
10/13	10-13/E1	73.5	120690.15	68965.80	143678.75	241380.30	574715.00
	10-13/E2	76	112956.06	64546.32	134471.50	225912.12	537886.00
	10-13/E3	112.5	145960.50	83406.00	173762.50	291921.00	695050.00
	TOTAL	1068.00	1355318.58	774467.76	1613474.50	2710637.16	6453898.00

Notes:- [1] These costs have been used to give indicative costs for flood control embankment schemes for initial planning purposes. The costs given in SR X, Table X.4.2 are estimates for specific Regional Schemes and the cost estimates given therein have been revised as appropriate for the particular scheme. The costs given in SR X will thus, in most cases, be different from the indicative costs quoted above. **e.g.** embankment 1/E2 is costed above as a Class A embankment (4.5m width) but is reduced to a Class B embankment (2.4m width) in the Regional Schemes

TABLE VII.2.8
Construction Cost of Embankments with Roads (40 year Return Period)[1]

Planning Unit	Embankment No	Length KM	Break up of total cost in ,000 Taka: Land Acq. cost 21%	Royalty for purchased Earth 12%	Machinery cost compaction 25%	Cost of labour 42%	Total cost in ,000 Taka
1	1/E1	67	96185.46	54963.12	114506.50	192370.92	458026.00
	1/E2	42	61027.47	34872.84	72651.75	122054.94	290607.00
2/4	2-4/E3	37.5	27015.87	15437.64	32161.75	54031.74	128647.00
	2-4/E1	40	56493.57	32282.04	67254.25	112987.14	269017.00
	2-4/E2	6	9109.17	5205.24	10844.25	18218.34	43377.00
3	3/E1	119	172274.97	98442.84	205089.25	344549.94	820357.00
5	5/E1	25	20954.85	11974.20	24946.25	41909.70	99785.00
	5/E2	30	35089.74	20051.28	41773.50	70179.48	167094.00
	5/E3	12	17436.51	9963.72	20757.75	34873.02	83031.00
6	6/E1	75	74982.81	42847.32	89265.25	149965.62	357061.00
	6/E2	27	38862.60	22207.20	46265.00	77725.20	185060.00
	6/E3	15	23316.09	13323.48	27757.25	46632.18	111029.00
	6/E4	26	37408.77	21376.44	44534.25	74817.54	178137.00
	6/E5	42	77629.23	44359.56	92415.75	155258.46	369663.00
7	7/E1	14.5	25361.91	14492.52	30192.75	50723.82	120771.00
	7/E2	50.5	84030.87	48017.64	100036.75	168061.74	400147.00
	7/E3	11	10142.58	5795.76	12074.50	20285.16	48298.00
	7/E4	8	7903.77	4516.44	9409.25	15807.54	37637.00
8	8/E1	74.5	70092.54	40052.88	83443.50	140185.08	333774.00
	8/E2	23	21639.24	12365.28	25761.00	43278.48	103044.00
9/12	9-12/E1	61	144777.99	82730.28	172354.75	289555.98	689419.00
10/13	10-13/E1	73.5	135632.91	77504.52	161467.75	271265.82	645871.00
	10-13/E2	76	127401.54	72800.88	151668.50	254803.08	606674.00
	10-13/E3	112.5	165986.73	94849.56	197603.25	331973.46	790413.00
	TOTAL	1068.00	1540757.19	880432.68	1834234.75	3081514.38	7336939.00

Notes:- [1] These costs have been used to give indicative costs for flood control embankment schemes for initial planning purposes. The costs given in SR X, Table X.4.2 are estimates for specific Regional Schemes and the cost estimates given therein have been revised as appropriate for the particular scheme. The costs given in SR X will thus, in most cases, be different from the indicative costs quoted above.

TABLE VII.2.9
Construction Cost of Embankments with Roads at Lower Level (40 year Return Period)[1]

Planning Unit	Embankment No	Length KM	Break up of total cost in ,000 Taka: Land Acq. cost 21%	Royalty for purchased Earth 12%	Machinery cost compaction 25%	Cost of labour 42%	Total cost in ,000 Taka
1	1/E1	67	92813.70	53036.40	110492.50	185627.40	441970.00
	1/E2	42	58888.62	33650.64	70105.50	117777.24	280422.00
2/4	2-4/E3	37.5	25066.65	14323.80	29841.25	50133.30	119365.00
	2-4/E1	40	55134.66	31505.52	65636.50	110269.32	262546.00
	2-4/E2	6	8882.58	5075.76	10574.50	17765.16	42298.00
3	3/E1	119	170538.69	97450.68	203022.25	341077.38	812089.00
5	5/E1	25	19659.15	11233.80	23403.75	39318.30	93615.00
	5/E2	30	33538.89	19165.08	39927.25	67077.78	159709.00
	5/E3	12	16825.41	9614.52	20030.25	33650.82	80121.00
6	6/E1	75	71165.85	40666.20	84721.25	142331.70	338885.00
	6/E2	27	37503.69	21430.68	44647.25	75007.38	178589.00
	6/E3	15	22787.73	13021.56	27128.25	45575.46	108513.00
	6/E4	26	36452.64	20830.08	43396.00	72905.28	173584.00
	6/E5	42	75490.38	43137.36	89869.50	150980.76	359478.00
7	7/E1	14.5	24607.17	14061.24	29294.25	49214.34	117177.00
	7/E2	50.5	81464.25	46551.00	96981.25	162928.50	387925.00
	7/E3	11	9564.03	5465.16	11385.75	19128.06	45543.00
	7/E4	8	7476.21	4272.12	8900.25	14952.42	35601.00
8	8/E1	74.5	66275.58	37871.76	78899.50	132551.16	315598.00
	8/E2	23	20460.93	11691.96	24358.25	40921.86	97433.00
9/12	9-12/E1	61	141683.01	80961.72	168670.25	283366.02	674681.00
10/13	10-13/E1	73.5	131974.71	75414.12	157112.75	263949.42	628451.00
	10-13/E2	76	123497.22	70569.84	147020.50	246994.44	588082.00
	10-13/E3	112.5	162916.11	93094.92	193947.75	325832.22	775791.00
	TOTAL	1068.00	1494667.86	854095.92	1779366.50	2989335.72	7117466.00

Notes:- [1] These costs have been used to give indicative costs for flood control embankment schemes for initial planning purposes. The costs given in SR X, Table X.4.2 are estimates for specific Regional Schemes and the cost estimates given therein have been revised as appropriate for the particular scheme. The costs given in SR X will thus, in most cases, be different from the indicative costs quoted above.

TABLE VII.2.10
Construction Cost of Embankments without Roads (1:5 year Return Period)[1]

Planning Unit	Embankment No	Length KM	Break up of total cost in ,000 Taka: Land Acq. cost 21%	Royalty for purchased Earth 12%	Machinery cost compaction 25%	Cost of labour 42%	Total cost in ,000 Taka
1	1/E1	67	71333.43	40761.96	84920.75	142666.86	339683.00
	1/E2	42	45336.06	25906.32	53971.50	90672.12	215886.00
2/4	2-4/E3	37.5	17812.83	10178.76	21205.75	35625.66	84823.00
	2-4/E1	40	42454.02	24259.44	50540.50	84908.04	202162.00
	2-4/E2	6	6789.09	3879.48	8082.25	13578.18	32329.00
3	3/E1	119	131208.21	74976.12	156200.25	262416.42	624801.00
5	5/E1	25	14277.27	8158.44	16996.75	28554.54	67987.00
	5/E2	30	25196.85	14398.20	29996.25	50393.70	119985.00
	5/E3	12	12953.22	7401.84	15420.50	25906.44	61682.00
6	6/E1	75	53649.33	30656.76	63868.25	107298.66	255473.00
	6/E2	27	28895.79	16511.88	34399.75	57791.58	137599.00
	6/E3	15	14245.14	8140.08	16958.50	28490.28	67834.00
	6/E4	26	28127.61	16072.92	33485.25	56255.22	133941.00
	6b/E1	42	60020.10	34297.20	71452.50	120040.20	285810.00
7	7/E1	14.5	19231.38	10989.36	22894.50	38462.76	91578.00
	7/E2	50.5	63631.89	36361.08	75752.25	127263.78	303009.00
	7/E3	11	8998.08	5141.76	10712.00	17996.16	42848.00
	7/E4	8	5475.75	3129.00	6518.75	10951.50	26075.00
8	8/E1	74.5	54643.89	31225.08	65052.25	109287.78	260209.00
	8/E2	23	16869.93	9639.96	20083.25	33739.86	80333.00
9/12	9-12/E1	61	114783.69	65590.68	136647.25	229567.38	546589.00
10/13	10-13/E1	73.5	104926.71	59958.12	124912.75	209853.42	499651.00
	10-13/E2	76	97665.12	55808.64	116268.00	195330.24	465072.00
	10-13/E3	112.5	124272.96	71013.12	147944.00	248545.92	591776.00
	TOTAL	1068.00	1162798.35	664456.20	1384283.75	2325596.70	5537135.00

Notes:- [1] These costs have been used to give indicative costs for flood control embankment schemes for initial planning purposes. The costs given in SR X, Table X.4.2 are estimates for specific Regional Schemes and the cost estimates given therein have been revised as appropriate for the particular scheme. The costs given in SR X will thus, in most cases, be different from the indicative costs quoted above.

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2.2 Structures

BWDB standard structure designs have been used where appropriate but alternative designs have been prepared (see SR VII.2) for specific applications and for controlled regulators. Costings for specific structures are given in Tables VII.2.8 to VII.2.37.

TABLE VII.2.11
Summary of Structure Costs

INCLUSIVE GATES

Plan. unit	Structure	Part of flood embank.	Part of drainage	Number	Factor	Unit cost (M Tk)	Total cost (M Tk)	Total per planning unit	Conversion rate	Total cost per planning unit (incl. Dhaka rates)	Foreign comp %	Foreign comp. amount
1	C10+D	1		1	1	64.860	64.860					
								64.860	1	64.860	68	44.105
2	C5		1	1	1	19.944	19.944					
	B8	1		1	1	15.950	15.950					
								35.894	1	35.894	68	24.408
3								0		0		0
4	C5		1	1	0.5	19.944	9.972					
	Excav(km)		1	27	0.5	6.708	90.558					
								100.530	1	100.530	10	10.053
5	E2		1	4	1	1.308	5.232					
	H		1	14	1	0.142	1.988		(1 for			
	Excav(km)		1	27	0.5	6.708	90.558		excav)			
								97.778	1.0163	97.896	5	4.895
6A	C5		1	1	0.5	19.944	9.972					
	C20		1	1	0.5	65.032	32.516					
	A	0.5	0.5	1	1	116.700	116.700					
	E		1	1	1	1.542	1.542					
	E1		1	1	1	0.920	0.920					
	H		1	10	1	0.142	1.420					
								163.070	1.0163	165.728	62	102.751
6B	E1		1	1	1	0.920	0.920					
	E1		1	1	0.5	0.920	0.460					
	H		1	22	1	0.142	3.124					
								4.504	1.0163	4.577	65	2.975
7	C1/1		1	1	0.5	10.944	5.472					
	C14		1	1	1	47.010	47.010					
	C20		1	1	0.5	65.032	32.516					
	C25/5		1	1	1	95.091	95.091					
	E1		1	5	1	0.920	4.600					
	C3		1	2	1	1.017	2.034					
	G2'		1	3	1	1.438	4.314					
	B8		1	1	1	15.950	15.950					
	H		1	55	1	0.142	7.810					
								214.797	1.0163	218.298	53	145.443
8	C4		1	1	0.5	16.952	8.476					
	C20+D		1	1	0.5	94.919	47.460					
	E1		1	1	1	0.920	0.920					
	E2		1	2	1	1.308	2.616					
	G1		1	3	1	0.469	1.407					
	J		1	1	1	6.048	6.048					
	H		1	58	1	0.142	8.236					
								75.163	1.0163	76.388	66	50.416
10	C4/1		1	1	1	19.944	19.944					
	C14		1	1	1	47.010	47.010					
	C20		1	1	1	65.032	65.032					
	E1		1	1	0.5	0.920	0.460					
	E1		1	7	1	0.920	6.440					
	F1	1		2	1	0.714	1.428					
	H		1	73	1	0.142	10.366					
								150.680	1.0163	153.136	66	101.070
11	C1/1		1	1	0.5	10.944	5.472					
	C20+D		1	1	0.5	94.919	47.460					
	E1		1	4	1	0.920	3.680					
	E3/1		1	1	1	2.089	2.089					
	H		1	33	1	0.142	4.686					
	Excav(km)		1	22	1	8.136	178.992					
	Excav(km)		1	26	0.5	18.173	236.249					
								478.627	1.0163	486.429	8	38.914
12	C4		1	1	0.5	16.952	8.476					
	E1		1	1	1	0.920	0.920					
								9.396	1.0163	9.549	68	6.493
13	C10	1		1	1	31.173	31.173					
	E1		1	2	1	0.920	1.840					
	F1	1		11	1	0.714	7.854					
	G2		1	2	1	0.743	1.486					
	G3		1	1	1	1.017	1.017					
	L2		1	1	1	11.000	11.000					
	H		1	60	1	0.142	8.520					
	Excav(km)		1	26	0.5	18.173	236.249					
								299.139	1.0163	304.015	14	42.562
							TOTALS : (struct)	832.505		843.225		
							(excav)	861.932		874.075		
								1694.433		1717.300		577.085

TABLE VII.2.12
Cost of Combined Bridge and Regulator (see Figure VII.2.2)

COMBINED BRIDGE-REGULATOR MAP 79 I/1 Structure n 7 (inclusive navigation opening)	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks									
-excavation	1200	m3	22	0.026	0.17	100	0.17		0.00
-backfill+compaction		m3	15.4	0.000	0.00	100	0.00		0.00
Piles D=.06 l=15m	68	nos	75000	5.100	31.97	30	9.59	70	22.38
Slope & bottom protection									
-filtercloth Terram 2000	1400	m2	150	0.210	1.32	20	0.26	80	1.05
-gabions filled with broken bricks (h=.3m)	1400	m2	480	0.672	4.21	60	2.53	40	1.69
Blinding									
-mass concrete .075m	400	m2 (*.075 =m3)	2182	0.065	0.41	60	0.25	40	0.16
-khoa .12m	400	m2 (*.12 =m3)	778	0.037	0.23	100	0.23		
-sand .12m	400	m2 (*.12 =m3)	175	0.008	0.05	100	0.05		
R concrete (incl. shuttering)	800	m3	3364	2.691	16.87	40	6.75	60	10.12
+reinforcement	96	ton	23126	2.220	13.92	20	2.78	80	11.13
Sheetpiling (800 m2)	57600	kg	36	2.074	13.00	20	2.60	80	10.40
Construction steel	3000	kg	50	0.150	0.94	20	0.19	80	0.75
Bituminous wearing coarse	300	m2	110	0.033	0.21	40	0.08	60	0.12
Neoprene pads	12	nos	2000	0.024	0.15	20	0.03	80	0.12
Gates+frames+lift devices (2.44m * 3.35m)	8	nos	330000	2.640	16.55	20	3.31	80	13.24
				15.952	100.000		28.824		71.176

COMBINED BRIDGE-REGULATOR MAP 78 H/13 Structure Jamalpur FAP (incl. navigation opening)	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks									
-excavation	1200	m3	22	0.026	0.17	100	0.17		0.00
-backfill+compaction		m3	15.4	0.000	0.00	100	0.00		0.00
Piles D=.06 l=15m	68	nos	75000	5.100	31.97	30	9.59	70	22.38
Slope & bottom protection									
-filtercloth Terram 2000	1400	m2	150	0.210	1.32	20	0.26	80	1.05
-gabions filled with broken bricks (h=.3m)	1400	m2	480	0.672	4.21	60	2.53	40	1.69
Blinding									
-mass concrete .075m	400	m2 (*.075 =m3)	2182	0.065	0.41	60	0.25	40	0.16
-khoa .12m	400	m2 (*.12 =m3)	778	0.037	0.23	100	0.23		
-sand .12m	400	m2 (*.12 =m3)	175	0.008	0.05	100	0.05		
R concrete (incl. shuttering)	800	m3	3364	2.691	16.87	40	6.75	60	10.12
+reinforcement	96	ton	23126	2.220	13.92	20	2.78	80	11.13
Sheetpiling (800 m2)	57600	kg	36	2.074	13.00	20	2.60	80	10.40
Construction steel	3000	kg	50	0.150	0.94	20	0.19	80	0.75
Bituminous wearing coarse	300	m2	110	0.033	0.21	40	0.08	60	0.12
Neoprene pads	12	nos	2000	0.024	0.15	20	0.03	80	0.12
Gates+frames+lift devices (2.44m * 3.35m)	8	nos	330000	2.640	16.55	20	3.31	80	13.24
				15.952	100.000		28.824		71.176

TABLE VII.2.13
Cost of Regulator with Navigation Lock (see Figure VII.2.4)

REGULATOR C MAP 79 I/5 Structure n 2 (to be combined with nav. lock)	Bank sections 1	Middle sections 19	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	2100	24700	26800	m3	22	0.590	0.96	100	0.96		0.00
-backfill+compaction	500		500	m3	15.4	0.008	0.01	100	0.01		0.00
Piles D=.06 l=15m	28	323	351	nos	75000	26.325	42.99	30	12.90	70	30.09
Slope & bottom protection											
-concrete blocks .4*.4*.3	250	2470	2720	m2 (*.3 =m3)	2182	1.781	2.91	60	1.74	40	1.16
-khoa .12m	250	2470	2720	m2 (*.12 =m3)	778	0.254	0.41	100	0.41		0.00
-sand .12m	250	2470	2720	m2 (*.12 =m3)	175	0.057	0.09	100	0.09		0.00
Blinding											
-mass concrete .075m	350	1900	2250	m2 (*.075 =m3)	2182	0.368	0.60	60	0.36	40	0.24
-khoa .12m	350	1900	2250	m2 (*.12 =m3)	778	0.210	0.34	100	0.34		0.00
-sand .12m	350	1900	2250	m2 (*.12 =m3)	175	0.047	0.08	100	0.08		0.00
R concrete (incl. shuttering)	200	3420	3620	m3	3364	12.178	19.89	40	7.96	60	11.93
+reinforcement	24	410	434	ton	23126	10.037	16.39	20	3.28	80	13.11
Sheetpiling	1800	23750	25550	kg	36	0.920	1.50	20	0.30	80	1.20
Construction steel	1250	35150	36400	kg	50	1.820	2.97	20	0.59	80	2.38
Bituminous wearing coarse	10	342	352	m2	110	0.039	0.06	40	0.03	60	0.04
Gates+Frames+Lifting devices			20	nos	330000	6.600	10.78	20	2.16	80	8.62
						61.232	100.00		31.22		68.78

TABLE VII.2.14
Cost of Fully Controlled Regulator (see Figure VII.2.3)

REGULATOR C MAP 79 I/5 Structure n 3A	Bank sections 2	Middle sections 1	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	4200	1300	5500	m3	22	0.121	1.11	100	1.11		0.00
-backfill+compaction	1000		1000	m3	15.4	0.015	0.14	100	0.14		0.00
Piles D=.06 l=15m	56	17	73	nos	75000	5.475	50.03	30	15.01	70	35.02
Slope & bottom protection											
-concrete blocks .4*.4*.3	500	130	630	m2 (*.3 =m3)	2182	0.412	3.77	60	2.26	40	1.51
-khoa .12m	500	130	630	m2 (*.12 =m3)	778	0.059	0.54	100	0.54		0.00
-sand .12m	500	130	630	m2 (*.12 =m3)	175	0.013	0.12	100	0.12		0.00
Blinding											
-mass concrete .075m	700	100	800	m2 (*.075 =m3)	2182	0.131	1.20	60	0.72	40	0.48
-khoa .12m	700	100	800	m2 (*.12 =m3)	778	0.075	0.68	100	0.68		0.00
-sand .12m	700	100	800	m2 (*.12 =m3)	175	0.017	0.15	100	0.15		0.00
R concrete (incl. shuttering)	400	180	580	m3	3364	1.951	17.83	40	7.13	60	10.70
+reinforcement	48	22	70	ton	23126	1.619	14.79	20	2.96	80	11.83
Sheetpiling	3600	1250	4850	kg	36	0.175	1.60	20	0.32	80	1.28
Construction steel	2500	1850	4350	kg	50	0.218	1.99	20	0.40	80	1.59
Bituminous wearing coarse	20	18	38	m2	110	0.004	0.04	40	0.02	60	0.02
Gates+Frames+Lifting devices			2	nos (1+1)	330000	0.660	6.03	20	1.21	80	4.82
						10.944	100.00		32.75		67.25

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TABLE VII.2.15
Cost of Fully Controlled Regulator (see Figure VII.2.3)

REGULATOR C MAP 78 L/4 Structure n 3	Bank sections 2	Middle sections 29	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	4200	37700	41900	m3	22	0.922	0.97	100	0.97		0.00
-backfill+compaction	1000		1000	m3	15.4	0.015	0.02	100	0.02		0.00
Piles D=.06 l=15m	56	493	549	nos	75000	41.175	43.30	30	12.99	70	30.31
Slope & bottom protection											
-concrete blocks .4*.4*.3	500	3770	4270	m2 (*.3 =m3)	2182	2.795	2.94	60	1.76	40	1.18
-khoa .12m	500	3770	4270	m2 (*.12 =m3)	778	0.399	0.42	100	0.42		0.00
-sand .12m	500	3770	4270	m2 (*.12 =m3)	175	0.090	0.09	100	0.09		0.00
Blinding											
-mass concrete .075m	700	2900	3600	m2 (*.075 =m3)	2182	0.589	0.62	60	0.37	40	0.25
-khoa .12m	700	2900	3600	m2 (*.12 =m3)	778	0.336	0.35	100	0.35		0.00
-sand .12m	700	2900	3600	m2 (*.12 =m3)	175	0.076	0.08	100	0.08		0.00
R concrete (incl. shuttering)	400	5220	5620	m3	3364	18.906	19.88	40	7.95	60	11.93
+reinforcement	48	626	674	ton	23126	15.587	16.39	20	3.28	80	13.11
Sheetpiling	3600	36250	39850	kg	36	1.435	1.51	20	0.30	80	1.21
Construction steel	2500	53650	56150	kg	50	2.808	2.95	20	0.59	80	2.36
Bituminous wearing coarse	20	522	542	m2	110	0.060	0.06	40	0.03	60	0.04
Gates+Frames+Lifting devices			30	nos (5+25)	330000	9.900	10.41	20	2.08	80	8.33
						95.091	100.00		31.29		68.71

TABLE VII.2.16
Cost of Fully Controlled Regulator (see Figure VII.2.3)

REGULATOR C MAP 78 H/14 Structure Chatal River (to be combined with nav. lock)	Bank sections 1	Middle sections 9	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	2100	11700	13800	m3	22	0.304	0.97	100	0.97		0.00
-backfill+compaction	500		500	m3	15.4	0.008	0.02	100	0.02		0.00
Piles D=.06 l=15m	28	153	181	nos	75000	13.575	43.55	30	13.06	70	30.48
Slope & bottom protection											
-concrete blocks .4*.4*.3	250	1170	1420	m2 (*.3 =m3)	2182	0.930	2.98	60	1.79	40	1.19
-khoa .12m	250	1170	1420	m2 (*.12 =m3)	778	0.133	0.43	100	0.43		0.00
-sand .12m	250	1170	1420	m2 (*.12 =m3)	175	0.030	0.10	100	0.10		0.00
Blinding											
-mass concrete .075m	350	900	1250	m2 (*.075 =m3)	2182	0.205	0.66	60	0.39	40	0.26
-khoa .12m	350	900	1250	m2 (*.12 =m3)	778	0.117	0.37	100	0.37		0.00
-sand .12m	350	900	1250	m2 (*.12 =m3)	175	0.026	0.08	100	0.08		0.00
R concrete (incl. shuttering)	200	1620	1820	m3	3364	6.122	19.64	40	7.86	60	11.78
+reinforcement	24	194	218	ton	23126	5.041	16.17	20	3.23	80	12.94
Sheetpiling	1800	11250	13050	kg	36	0.470	1.51	20	0.30	80	1.21
Construction steel	1250	16650	17900	kg	50	0.895	2.87	20	0.57	80	2.30
Bituminous wearing coarse	10	162	172	m2	110	0.019	0.06	40	0.02	60	0.04
Gates+Frames+Lifting devices			10	nos	330000	3.300	10.59	20	2.12	80	8.47
						31.173	100.00		31.33		68.67

TABLE VII.2.17
Cost of Fully Controlled Regulator (see Figure VII.2.3)

REGULATOR C MAP 78 H/16 Structure n 4	Bank sections 2	Middle sections 19	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	4200	24700	28900	m3	22	0.636	0.98	100	0.98		0.00
-backfill+compaction	1000		1000	m3	15.4	0.015	0.02	100	0.02		0.00
Piles D=.06 l=15m	56	323	379	nos	75000	28.425	43.71	30	13.11	70	30.60
Slope & bottom protection											
-concrete blocks .4*.4*.3	500	2470	2970	m2 (*.3 =m3)	2182	1.944	2.99	60	1.79	40	1.20
-khoa .12m	500	2470	2970	m2 (*.12 =m3)	778	0.277	0.43	100	0.43		0.00
-sand .12m	500	2470	2970	m2 (*.12 =m3)	175	0.062	0.10	100	0.10		0.00
Blinding											
-mass concrete .075m	700	1900	2600	m2 (*.075 =m3)	2182	0.425	0.65	60	0.39	40	0.26
-khoa .12m	700	1900	2600	m2 (*.12 =m3)	778	0.243	0.37	100	0.37		0.00
-sand .12m	700	1900	2600	m2 (*.12 =m3)	175	0.055	0.08	100	0.08		0.00
R concrete (incl. shuttering)	400	3420	3820	m3	3364	12.850	19.76	40	7.90	60	11.86
+reinforcement	48	410	458	ton	23126	10.592	16.29	20	3.26	80	13.03
Sheetpiling	3600	23750	27350	kg	36	0.985	1.51	20	0.30	80	1.21
Construction steel	2500	35150	37650	kg	50	1.883	2.89	20	0.58	80	2.32
Bituminous wearing coarse	20	342	362	m2	110	0.040	0.06	40	0.02	60	0.04
Gates+Frames+Lifting devices			20	nos	330000	6.600	10.15	20	2.03	80	8.12
						65.032	100.00		31.38		68.62

TABLE VII.2.18
Cost of Fully Controlled Regulator (see Figure VII.2.3)

REGULATOR C MAP 79 I/5 Structure n 14	Bank sections 2	Middle sections 4	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	4200	5200	9400	m3	22	0.207	1.04	100	1.04		0.00
-backfill+compaction	1000		1000	m3	15.4	0.015	0.08	100	0.08		0.00
Piles D=.06 l=15m	56	68	124	nos	75000	9.300	46.63	30	13.99	70	32.64
Slope & bottom protection											
-concrete blocks .4*.4*.3	500	520	1020	m2 (*.3 =m3)	2182	0.668	3.35	60	2.01	40	1.34
-khoa .12m	500	520	1020	m2 (*.12 =m3)	778	0.095	0.48	100	0.48		0.00
-sand .12m	500	520	1020	m2 (*.12 =m3)	175	0.021	0.11	100	0.11		0.00
Blinding											
-mass concrete .075m	700	400	1100	m2 (*.075 =m3)	2182	0.180	0.90	60	0.54	40	0.36
-khoa .12m	700	400	1100	m2 (*.12 =m3)	778	0.103	0.51	100	0.51		0.00
-sand .12m	700	400	1100	m2 (*.12 =m3)	175	0.023	0.12	100	0.12		0.00
R concrete (incl. shuttering)	400	720	1120	m3	3364	3.768	18.89	40	7.56	60	11.33
+reinforcement	48	86	134	ton	23126	3.099	15.54	20	3.11	80	12.43
Sheetpiling	3600	5000	8600	kg	36	0.310	1.55	20	0.31	80	1.24
Construction steel	2500	7400	9900	kg	50	0.495	2.48	20	0.50	80	1.99
Bituminous wearing coarse	20	72	92	m2	110	0.010	0.05	40	0.02	60	0.03
Gates+Frames+Lifting devices			5	nos (1+4)	330000	1.650	8.27	20	1.65	80	6.62
						19.944	100.00		32.02		67.98

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TABLE VII.2.19
Cost of Fully Controlled Regulator (see Figure VII.2.3)

REGULATOR C MAP 79 I/6 Structure n 2	Bank sections 2	Middle sections 9	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	4200	11700	15900	m3	22	0.350	1.00	100	1.00		0.00
-backfill+compaction	1000		1000	m3	15.4	0.015	0.04	100	0.04		0.00
Piles D=.06 l=15m	56	153	209	nos	75000	15.675	44.82	30	13.45	70	31.37
Slope & bottom protection											
-concrete blocks .4*.4*.3	500	1170	1670	m2 (*.3 =m3)	2182	1.093	3.13	60	1.88	40	1.25
-khoa .12m	500	1170	1670	m2 (*.12 =m3)	778	0.156	0.45	100	0.45		0.00
-sand .12m	500	1170	1670	m2 (*.12 =m3)	175	0.035	0.10	100	0.10		0.00
Blinding											
-mass concrete .075m	700	900	1600	m2 (*.075 =m3)	2182	0.262	0.75	60	0.45	40	0.30
-khoa .12m	700	900	1600	m2 (*.12 =m3)	778	0.149	0.43	100	0.43		0.00
-sand .12m	700	900	1600	m2 (*.12 =m3)	175	0.034	0.10	100	0.10		0.00
R concrete (incl. shuttering)	400	1620	2020	m3	3364	6.795	19.43	40	7.77	60	11.66
+reinforcement	48	194	242	ton	23126	5.596	16.00	20	3.20	80	12.80
Sheetpiling	3600	11250	14850	kg	36	0.535	1.53	20	0.31	80	1.22
Construction steel	2500	16650	19150	kg	50	0.958	2.74	20	0.55	80	2.19
Bituminous wearing coarse	20	162	182	m2	110	0.020	0.06	40	0.02	60	0.03
Gates+Frames+Lifting devices			10	nos	330000	3.300	9.44	20	1.89	80	7.55
						34.973	100.00		31.62		68.38

TABLE VII.2.20
Cost of Fully Controlled Regulator (see Figure VII.2.3)

REGULATOR C MAP 78 H/15 Structure n 8	Bank sections 2	Middle sections 4	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	4200	5200	9400	m3	22	0.207	1.04	100	1.04		0.00
-backfill+compaction	1000		1000	m3	15.4	0.015	0.08	100	0.08		0.00
Piles D=.06 l=15m	56	68	124	nos	75000	9.300	46.63	30	13.99	70	32.64
Slope & bottom protection											
-concrete blocks .4*.4*.3	500	520	1020	m2 (*.3 =m3)	2182	0.668	3.35	60	2.01	40	1.34
-khoa .12m	500	520	1020	m2 (*.12 =m3)	778	0.095	0.48	100	0.48		0.00
-sand .12m	500	520	1020	m2 (*.12 =m3)	175	0.021	0.11	100	0.11		0.00
Blinding											
-mass concrete .075m	700	400	1100	m2 (*.075 =m3)	2182	0.180	0.90	60	0.54	40	0.36
-khoa .12m	700	400	1100	m2 (*.12 =m3)	778	0.103	0.51	100	0.51		0.00
-sand .12m	700	400	1100	m2 (*.12 =m3)	175	0.023	0.12	100	0.12		0.00
R concrete (incl. shuttering)	400	720	1120	m3	3364	3.768	18.89	40	7.56	60	11.33
+reinforcement	48	86	134	ton	23126	3.099	15.54	20	3.11	80	12.43
Sheetpiling	3600	5000	8600	kg	36	0.310	1.55	20	0.31	80	1.24
Construction steel	2500	7400	9900	kg	50	0.495	2.48	20	0.50	80	1.99
Bituminous wearing coarse	20	72	92	m2	110	0.010	0.05	40	0.02	60	0.03
Gates+Frames+Lifting devices			5	nos	330000	1.650	8.27	20	1.65	80	6.62
						19.944	100.00		32.02		67.98

TABLE VII.2.21
Cost of Fully Controlled Regulator (see Figure VII.2.3)

REGULATOR C MAP 79 E/13 Structure n 3	Bank sections 2	Middle sections 13	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	4200	16900	21100	m3	22	0.464	0.99	100	0.99		0.00
-backfill+compaction	1000		1000	m3	15.4	0.015	0.03	100	0.03		0.00
Piles D=.06 l=15m	56	221	277	nos	75000	20.775	44.19	30	13.26	70	30.93
Slope & bottom protection											
-concrete blocks .4*.4*.3	500	1690	2190	m2 (*.3 =m3)	2182	1.434	3.05	60	1.83	40	1.22
-khoa .12m	500	1690	2190	m2 (*.12 =m3)	778	0.204	0.43	100	0.43		0.00
-sand .12m	500	1690	2190	m2 (*.12 =m3)	175	0.046	0.10	100	0.10		0.00
Blinding											
-mass concrete .075m	700	1300	2000	m2 (*.075 =m3)	2182	0.327	0.70	60	0.42	40	0.28
-khoa .12m	700	1300	2000	m2 (*.12 =m3)	778	0.187	0.40	100	0.40		0.00
-sand .12m	700	1300	2000	m2 (*.12 =m3)	175	0.042	0.09	100	0.09		0.00
R concrete (incl. shuttering)	400	2340	2740	m3	3364	9.217	19.61	40	7.84	60	11.76
+reinforcement	48	281	329	ton	23126	7.608	16.18	20	3.24	80	12.95
Sheetpiling	3600	16250	19850	kg	36	0.715	1.52	20	0.30	80	1.22
Construction steel	2500	24050	26550	kg	50	1.328	2.82	20	0.56	80	2.26
Bituminous wearing coarse	20	234	254	m2	110	0.028	0.06	40	0.02	60	0.04
Gates+Frames+Lifting devices			14	nos	330000	4.620	9.83	20	1.97	80	7.86
						47.010	100.00		31.48		68.52

TABLE VII.2.22
Cost of Fully Controlled Regulator (see Figure VII.2.3)

REGULATOR C MAP 79 1/2 Structure n 13	Bank sections 2	Middle sections 19	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	4200	24700	28900	m3	22	0.636	0.98	100	0.98		0.00
-backfill+compaction	1000		1000	m3	15.4	0.015	0.02	100	0.02		0.00
Piles D=.06 l=15m	56	323	379	nos	75000	28.425	43.71	30	13.11	70	30.60
Slope & bottom protection											
-concrete blocks .4*.4*.3	500	2470	2970	m2 (*.3 =m3)	2182	1.944	2.99	60	1.79	40	1.20
-khoa .12m	500	2470	2970	m2 (*.12 =m3)	778	0.277	0.43	100	0.43		0.00
-sand .12m	500	2470	2970	m2 (*.12 =m3)	175	0.062	0.10	100	0.10		0.00
Blinding											
-mass concrete .075m	700	1900	2600	m2 (*.075 =m3)	2182	0.425	0.65	60	0.39	40	0.26
-khoa .12m	700	1900	2600	m2 (*.12 =m3)	778	0.243	0.37	100	0.37		0.00
-sand .12m	700	1900	2600	m2 (*.12 =m3)	175	0.055	0.08	100	0.08		0.00
R concrete (incl. shuttering)	400	3420	3820	m3	3364	12.850	19.76	40	7.90	60	11.86
+reinforcement	48	410	458	ton	23126	10.592	16.29	20	3.26	80	13.03
Sheetpiling	3600	23750	27350	kg	36	0.985	1.51	20	0.30	80	1.21
Construction steel	2500	35150	37650	kg	50	1.883	2.89	20	0.58	80	2.32
Bituminous wearing coarse	20	342	362	m2	110	0.040	0.06	40	0.02	60	0.04
Gates+Frames+Lifting devices			20	nos	330000	6.600	10.15	20	2.03	80	8.12
						65.032	100.00		31.38		68.62

TABLE VII.2.23
Cost of Fully Controlled Regulator (see Figure VII.2.3)

REGULATOR C MAP 79 I/2 Structure n blue 3	Bank sections 2	Middle sections 13	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	4200	16900	21100	m3	22	0.464	0.99	100	0.99		0.00
-backfill+compaction	1000		1000	m3	15.4	0.015	0.03	100	0.03		0.00
Piles D=.06 l=15m	56	221	277	nos	75000	20.775	44.19	30	13.26	70	30.93
Slope & bottom protection											
-concrete blocks .4*.4*.3	500	1690	2190	m2 (*.3 =m3)	2182	1.434	3.05	60	1.83	40	1.22
-khoa .12m	500	1690	2190	m2 (*.12 =m3)	778	0.204	0.43	100	0.43		0.00
-sand .12m	500	1690	2190	m2 (*.12 =m3)	175	0.046	0.10	100	0.10		0.00
Blinding											
-mass concrete .075m	700	1300	2000	m2 (*.075 =m3)	2182	0.327	0.70	60	0.42	40	0.28
-khoa .12m	700	1300	2000	m2 (*.12 =m3)	778	0.187	0.40	100	0.40		0.00
-sand .12m	700	1300	2000	m2 (*.12 =m3)	175	0.042	0.09	100	0.09		0.00
R concrete (incl. shuttering)	400	2340	2740	m3	3364	9.217	19.61	40	7.84	60	11.76
+reinforcement	48	281	329	ton	23126	7.608	16.18	20	3.24	80	12.95
Sheetpiling	3600	16250	19850	kg	36	0.715	1.52	20	0.30	80	1.22
Construction steel	2500	24050	26550	kg	50	1.328	2.82	20	0.56	80	2.26
Bituminous wearing coarse	20	234	254	m2	110	0.028	0.06	40	0.02	60	0.04
Gates+Frames+Lifting devices			14	nos	330000	4.620	9.83	20	1.97	80	7.86
						47.010	100.00		31.48		68.52

TABLE VII.2.24
Cost of Fully Controlled Regulator (see Figure VII.2.3)

REGULATOR C MAP 78 H/13 Structure Bausie Bridge	Bank sections 2	Middle sections 4	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	4200	5200	9400	m3	22	0.207	1.04	100	1.04		0.00
-backfill+compaction	1000		1000	m3	15.4	0.015	0.08	100	0.08		0.00
Piles D=.06 l=15m	56	68	124	nos	75000	9.300	46.63	30	13.99	70	32.64
Slope & bottom protection											
-concrete blocks .4*.4*.3	500	520	1020	m2 (*.3 =m3)	2182	0.668	3.35	60	2.01	40	1.34
-khoa .12m	500	520	1020	m2 (*.12 =m3)	778	0.095	0.48	100	0.48		0.00
-sand .12m	500	520	1020	m2 (*.12 =m3)	175	0.021	0.11	100	0.11		0.00
Blinding											
-mass concrete .075m	700	400	1100	m2 (*.075 =m3)	2182	0.180	0.90	60	0.54	40	0.36
-khoa .12m	700	400	1100	m2 (*.12 =m3)	778	0.103	0.51	100	0.51		0.00
-sand .12m	700	400	1100	m2 (*.12 =m3)	175	0.023	0.12	100	0.12		0.00
R concrete (incl. shuttering)	400	720	1120	m3	3364	3.768	18.89	40	7.56	60	11.33
+reinforcement	48	86	134	ton	23126	3.099	15.54	20	3.11	80	12.43
Sheetpiling	3600	5000	8600	kg	36	0.310	1.55	20	0.31	80	1.24
Construction steel	2500	7400	9900	kg	50	0.495	2.48	20	0.50	80	1.99
Bituminous wearing coarse	20	72	92	m2	110	0.010	0.05	40	0.02	60	0.03
Gates+Frames+Lifting devices			5	nos	330000	1.650	8.27	20	1.65	80	6.62
						19.944	100.00		32.02		67.98

TABLE VII.2.25
Cost of Fully Controlled Regulator (see Figure VII.2.3)

REGULATOR C MAP 79 I/5 Structure n 4	Bank sections 2	Middle sections 3	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	4200	3900	8100	m3	22	0.178	1.05	100	1.05		0.00
-backfill+compaction	1000		1000	m3	15.4	0.015	0.09	100	0.09		0.00
Piles D=.06 l=15m	56	51	107	nos	75000	8.025	47.34	30	14.20	70	33.14
Slope & bottom protection											
-concrete blocks .4*.4*.3	500	390	890	m2 (*.3 =m3)	2182	0.583	3.44	60	2.06	40	1.37
-khoa .12m	500	390	890	m2 (*.12 =m3)	778	0.083	0.49	100	0.49		0.00
-sand .12m	500	390	890	m2 (*.12 =m3)	175	0.019	0.11	100	0.11		0.00
Blinding											
-mass concrete .075m	700	300	1000	m2 (*.075 =m3)	2182	0.164	0.97	60	0.58	40	0.39
-khoa .12m	700	300	1000	m2 (*.12 =m3)	778	0.093	0.55	100	0.55		0.00
-sand .12m	700	300	1000	m2 (*.12 =m3)	175	0.021	0.12	100	0.12		0.00
R concrete (incl. shuttering)	400	540	940	m3	3364	3.162	18.65	40	7.46	60	11.19
+reinforcement	48	65	113	ton	23126	2.613	15.42	20	3.08	80	12.33
Sheetpiling	3600	3750	7350	kg	36	0.265	1.56	20	0.31	80	1.25
Construction steel	2500	5550	8050	kg	50	0.403	2.37	20	0.47	80	1.90
Bituminous wearing coarse	20	54	74	m2	110	0.008	0.05	40	0.02	60	0.03
Gates+Frames+Lifting devices			4	nos	330000	1.320	7.79	20	1.56	80	6.23
						16.952	100.00		32.17		67.83

TABLE VII.2.26
Cost of Navigation Lock (see Figure VII.2.4)

NAVIGATION LOCK TYPE D (to be combined with regulator)	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks									
-excavation	13000	m3	22	0.286	0.85	100	0.85		
-backfill+compaction	2000	m3	15.4	0.031	0.09	100	0.09		
Piles D=.06 l=10m	200	nos	50000	10.000	29.69	30	8.91	70	20.78
Slope & bottom protection									
-concrete blocks (.4*.4*.3m)	1700	m2 (*.3 =m3)	2182	1.113	3.30	60	1.98	40	1.32
-khoa .15m	1700	m2 (*.15 =m3)	778	0.198	0.59	100	0.59		
-sand .1m	1700	m2 (*.1 =m3)	175	0.030	0.09	100	0.09		
Blinding									
-mass concrete .1m	800	m2 (*.1 =m3)	2182	0.175	0.52	60	0.31	40	0.21
-khoa .15m	800	m2 (*.15 =m3)	778	0.093	0.28	100	0.28		
-sand .15m	800	m2 (*.15 =m3)	175	0.021	0.06	100	0.06		
R concrete (incl. shuttering)	2800	m3	3364	9.419	27.96	40	11.18	60	16.78
+reinforcement	336	ton	23126	7.770	23.07	20	4.61	80	18.45
Sheetpiling	2880	kg	36	0.104	0.31	20	0.06	80	0.25
Construction steel	10	ton	50000	0.500	1.48	20	0.30	80	1.19
Wood for guide structures						20	0.00	80	0.00
-piles (wood) d=.35/.15m	16	nos	16150	0.258	0.77	20	0.15	80	0.61
-beams .3*.25m	120	m (*.3*.25 =m3)	22300	0.201	0.60	20	0.12	80	0.48
Counterweight steel	30	ton	35000	1.050	3.12	20	0.62	80	2.49
Gates+guide struct.+lift devices (1.52*1.83m)	2	nos	90000	0.180	0.53	20	0.11	80	0.43
Gates+guide struct.+elec. op. lift devices (7m * 10m)	2	nos	1125000	2.250	6.68	15	1.00	80	5.34
Bituminous wearing coarse	70	m2	110	0.008	0.02	40	0.01	80	0.02
				33.687	100.00		31.33		68.34

TABLE VII.2.27
Controlled Flooding Inlet (see Figure VII.2.5)

CFI/CDO Type E 2 barrels	Outer wall sections	Inner wall sections	Total Quantity	Unit	Rate per unit (Tk)	Amount	6 structures	Weight	Local %	Wt	Foreign %	Wt
Earthworks												
-excavation	500	250	750	m3	20	0.015	0.090	1.15	100	1.15		
-backfill+compaction	160		160	m3	15.4	0.002	0.015	0.19	100	0.19		
Slope & bottom protection												
-filtercloth terram 2000	300	15	315	m2	150	0.047	0.284	3.61	20	0.72	80	2.89
-gabions filled with												
broken bricks (h=.25m)	300	15	315	m2	400	0.126	0.756	9.63	60	5.78	40	3.85
Blinding												
-mass concrete .05m	90	50	140	m2 (*.05 =m3)	2182	0.015	0.092	1.17	60	0.70	40	0.47
-khoa .1m	90	50	140	m2 (*.1 =m3)	778	0.011	0.065	0.83	100	0.83		
-sand .1m	90	50	140	m2 (*.1 =m3)	175	0.002	0.015	0.19	100	0.19		
R concrete (incl. shuttering)	100	40	140	m3	3364	0.471	2.826	35.99	40	14.40	60	21.60
+reinforcement 120kg/m3	12	5	17	ton	23126	0.393	2.359	30.05	20	6.01	80	24.04
Construction steel												
(hot dip galvanised)	400	500	900	kg	50	0.045	0.270	3.44	20	0.69	80	2.75
Gates (1.52*1.83)+lift devices			2	nos	90000	0.180	1.080	13.76	20	2.75	80	11.01
						1.308	7.851	100.00		33.401		66.599

TABLE VII.2.28
Controlled Flooding Inlet (see Figure VII.2.5)

CFI/CDO Type E 4 barrels	Outer wall sections	Inner wall sections 3	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks											
-excavation	500	750	1250	m3	20	0.025	1.20	100	1.20		
-backfill+compaction	160		160	m3	15.4	0.002	0.12	100	0.12		
Slope & bottom protection											
-filtercloth terram 2000	300	50	350	m2	150	0.053	2.51	20	0.50	80	2.01
-gabions filled with											
broken bricks (h=.25m)	300	50	350	m2	400	0.140	6.70	60	4.02	40	2.68
Blinding											
-mass concrete .05m	90	150	240	m2 (*.05 =m3)	2182	0.026	1.25	60	0.75	40	0.50
-khoa .1m	90	150	240	m2 (*.1 =m3)	778	0.019	0.89	100	0.89		
-sand .1m	90	150	240	m2 (*.1 =m3)	175	0.004	0.20	100	0.20		
R concrete (incl. shuttering)	100	120	220	m3	3364	0.740	35.44	40	14.17	60	21.26
+reinforcement 120kg/m3	12	15	27	ton	23126	0.624	29.90	20	5.98	80	23.92
Construction steel											
(hot dip galvanised)	400	1500	1900	kg	50	0.095	4.55	20	0.91	80	3.64
Gates (1.52*1.83)+lift devices			4	nos (1+3)	90000	0.360	17.24	20	3.45	80	13.79
						2.089	100.00		32.198		67.802

TABLE VII.2.29
Controlled Flooding Inlet (see Figure VII.2.5)

CFI/CDO Type E 1 barrel	Total Quantity	Unit	Rate per unit (Tk)	Amount	23 structures	Weight	Local %	Wt	Foreign %	Wt
Earthworks										
-excavation	500	m3	20	0.010	0.230	1.09	100	1.09		
-backfill+compaction	160	m3	15.4	0.002	0.057	0.27	100	0.27		
Slope & bottom protection										
-filtercloth terram 2000	300	m2	150	0.045	1.035	4.89	20	0.98	80	3.91
-gabions filled with broken bricks (h=.25m)	300	m2	400	0.120	2.760	13.05	60	7.83	40	5.22
Blinding										
-mass concrete .05m	90	m2 (*.05 =m3)	2182	0.010	0.226	1.07	60	0.64	40	0.43
-khoa .1m	90	m2 (*.1 =m3)	778	0.007	0.161	0.76	100	0.76		
-sand .1m	90	m2 (*.1 =m3)	175	0.002	0.036	0.17	100	0.17		
R concrete (incl. shuttering)	100	m3	3364	0.336	7.737	36.57	40	14.63	60	21.94
+reinforcement 120kg/m3	12	ton	23126	0.278	6.383	30.17	20	6.03	80	24.14
Construction steel (hot dip galvanised)	400	kg	50	0.020	0.460	2.17	20	0.43	80	1.74
Gates (1.52*1.83)+lift devices	1	nos	90000	0.090	2.070	9.79	20	1.96	80	7.83
				0.920	21.155	100.00		34.791		65.209

TABLE VII.2.30
Controlled Drainage Outlet (see Figure VII.2.6)

CDO Type F 1 barrel	Total Quantity	Unit	Rate per unit (Tk)	Amount	13 structures	Weight	Local %	Wt	Foreign %	Wt
Earthworks										
-excavation	300	m3	20	0.006	0.078	0.84	100	0.84		
-backfill+compaction	100	m3	15.4	0.002	0.020	0.22	100	0.22		
Slope & bottom protection										
-filtercloth terram 2000	100	m2	150	0.015	0.195	2.10	20	0.42	80	1.68
-gabions filled with broken bricks (h=.25m)	100	m2	400	0.040	0.520	5.60	60	3.36	40	2.24
Blinding										
-mass concrete .05m	90	m2 (*.05 =m3)	2182	0.010	0.128	1.38	60	0.83	40	0.55
-khoa .1m	90	m2 (*.1 =m3)	778	0.007	0.091	0.98	100	0.98		
-sand .1m	90	m2 (*.1 =m3)	175	0.002	0.020	0.22	100	0.22		
R concrete (incl. shuttering)	80	m3	3364	0.269	3.499	37.70	40	15.08	60	22.62
+reinforcement 120kg/m3	10	ton	23126	0.231	3.006	32.40	20	6.48	80	25.92
Construction steel (hot dip galvanised)	400	kg	50	0.020	0.260	2.80	20	0.56	80	2.24
Gates (1.52*1.83)+lift devices	1	nos	112500	0.113	1.463	15.76	20	3.15	80	12.61
				0.714	9.280	100.00		32.138		67.862

TABLE VII.2.31
Fully Controlled Drainage Outlet (see Figure VII.2.7)

CDO Type G 1 barrel	Total Quantity	Unit	Rate per unit (Tk)	Amount	3 structures	Weight	Local %	Wt	Foreign %	Wt
Earthworks										
-excavation	300	m3	20	0.006	0.018	1.28	100	1.28		
-backfill+compaction	80	m3	15.4	0.001	0.004	0.26	100	0.26		
Slope & bottom protection										
-filtercloth terram 2000	170	m2	150	0.026	0.077	5.44	20	1.09	80	4.35
-gabions filled with broken bricks (h=.25m)	170	m2	400	0.068	0.204	14.50	60	8.70	40	5.80
Blinding										
-mass concrete .05m	40	m2 (*.05 =m3)	2182	0.004	0.013	0.93	60	0.56	40	0.37
-khoa .1m	40	m2 (*.1 =m3)	778	0.003	0.009	0.66	100	0.66		
-sand .1m	40	m2 (*.1 =m3)	175	0.001	0.002	0.15	100	0.15		
R concrete (incl. shuttering)	40	m3	3364	0.135	0.404	28.68	40	11.47	60	17.21
+reinforcement 120kg/m3	5	ton	23126	0.116	0.347	24.66	20	4.93	80	19.72
Construction steel (hot dip galvanised)	400	kg	50	0.020	0.060	4.26	20	0.85	80	3.41
Gates (1.52*1.83)+lift devices	1	nos	90000	0.090	0.270	19.19	20	3.84	80	15.35
				0.469	1.407	100.00		33.791		66.209

TABLE VII.2.32
Fully Controlled Drainage Outlet (see Figure VII.2.7)

CDO Type G 2 barrels	Outer wall sections	Inner wall sections	Total Quantity	Unit	Rate per unit (Tk)	Amount	2 structures	Weight	Local %	Wt	Foreign %	Wt
Earthworks												
-excavation	300	100	400	m3	20	0.008	0.016	1.08	100	1.08		
-backfill+compaction	80		80	m3	15.4	0.001	0.002	0.17	100	0.17		
Slope & bottom protection												
-filtercloth terram 2000	170	20	190	m2	150	0.029	0.057	3.83	20	0.77	80	3.07
-gabions filled with broken bricks (h=.25m)	170	20	190	m2	400	0.076	0.152	10.23	60	6.14	40	4.09
Blinding												
-mass concrete .05m	40	21	61	m2 (*.05 =m3)	2182	0.007	0.013	0.90	60	0.54	40	0.36
-khoa .1m	40	21	61	m2 (*.1 =m3)	778	0.005	0.009	0.64	100	0.64		
-sand .1m	40	21	61	m2 (*.1 =m3)	175	0.001	0.002	0.14	100	0.14		
R concrete (incl. shuttering)	40	26	66	m3	3364	0.222	0.444	29.87	40	11.95	60	17.92
+reinforcement 120kg/m3	5	3	8	ton	23126	0.185	0.370	24.89	20	4.98	80	19.91
Construction steel (hot dip galvanised)	400	200	600	kg	50	0.030	0.060	4.04	20	0.81	80	3.23
Gates (1.52*1.83)+lift devices			2	nos	90000	0.180	0.360	24.22	20	4.84	80	19.37
						0.743	1.486	100.00		32.042		67.958

TABLE VII.2.33
Fully Controlled Drainage Outlet (see Figure VII.2.7)

CDO Type G 3 barrels	Outer wall sections	Inner wall sections 2	Total Quantity	Unit	Rate per unit (Tk)	Amount	3 structures	Weight	Local %	Wt	Foreign %	Wt
Earthworks												
-excavation	300	200	500	m3	20	0.010	0.030	0.98	100	0.98		
-backfill+compaction	80		80	m3	15.4	0.001	0.004	0.12	100	0.12		
Slope & bottom protection												
-filtercloth terram 2000	170	40	210	m2	150	0.032	0.095	3.10	20	0.62	80	2.48
-gabions filled with broken bricks (h=.25m)	170	40	210	m2	400	0.084	0.252	8.26	60	4.95	40	3.30
Blinding												
-mass concrete .05m	40	42	82	m2 (*.05 =m3)	2182	0.009	0.027	0.88	60	0.53	40	0.35
-khoa .1m	40	42	82	m2 (*.1 =m3)	778	0.006	0.019	0.63	100	0.63		
-sand .1m	40	42	82	m2 (*.1 =m3)	175	0.001	0.004	0.14	100	0.14		
R concrete (incl. shuttering)	40	52	92	m3	3364	0.309	0.928	30.42	40	12.17	60	18.25
+reinforcement 120kg/m3	5	6	11	ton	23126	0.254	0.763	25.00	20	5.00	80	20.00
Construction steel (hot dip galvanised)	400	400	800	kg	50	0.040	0.120	3.93	20	0.79	80	3.15
Gates (1.52*1.83)+lift devices			3	nos	90000	0.270	0.810	26.54	20	5.31	80	21.23
						1.017	3.052	100.00		31.236		68.764

TABLE VII.2.34
Fully Controlled Drainage Outlet (see Figure VII.2.7)

CDO Type G 2 barrels Large gate size	Outer wall sections	Inner wall sections	Total Quantity	Unit	Rate per unit (Tk)	Amount	3 structures	Weight	Local %	Wt	Foreign %	Wt
Earthworks												
-excavation	650	250	900	m3	20	0.018	0.054	1.25	100	1.25		
-backfill+compaction	160		160	m3	15.4	0.002	0.007	0.17	100	0.17		
Slope & bottom protection												
-filtercloth terram 2000	210	30	240	m2	150	0.036	0.108	2.50	20	0.50	80	2.00
-gabions filled with broken bricks (h=.25m)	210	30	240	m2	400	0.096	0.288	6.68	60	4.01	40	2.67
Blinding												
-mass concrete .05m	65	35	100	m2 (*.05 =m3)	2182	0.011	0.033	0.76	60	0.46	40	0.30
-khoa .1m	65	35	100	m2 (*.1 =m3)	778	0.008	0.023	0.54	100	0.54		
-sand .1m	65	35	100	m2 (*.1 =m3)	175	0.002	0.005	0.12	100	0.12		
R concrete (incl. shuttering)	62	31	93	m3	3364	0.313	0.939	21.76	40	8.70	60	13.06
+reinforcement 120kg/m3	7	4	11	ton	23126	0.254	0.763	17.69	20	3.54	80	14.16
Construction steel (hot dip galvanised)	500	250	750	kg	50	0.038	0.113	2.61	20	0.52	80	2.09
Gates (2.44*3.55)+lift devices			2	nos	330000	0.660	1.980	45.91	20	9.18	80	36.73
						1.438	4.313	100.00		28.996		71.004

TABLE VII.2.35
Fully Controlled Drainage Outlet -Pipe Culvert (see Figure VII.2.8)

CDO Type H 1 barrel	Total Quantity	Unit	Rate per unit (Tk)	Amount	325 structures	Weight	Local %	Wt	Foreign %	Wt
Earthworks										
-excavation	60	m3	20	0.001	0.390	0.85	100	0.85		
-backfill+compaction	25	m3	15.4	0.000	0.125	0.27	100	0.27		
Slope & bottom protection										
-filtercloth terram 2000	30	m2	150	0.005	1.463	3.17	20	0.63	80	2.54
-gabions filled with broken bricks (h=.25m)	30	m2	400	0.012	3.900	8.47	60	5.08	40	3.39
Mass concrete fond. for pipe	2	m3	2182	0.004	1.418	3.08	60	1.85	40	1.23
RC pipe d=1.0m	10	m	3700	0.037	12.025	26.10	60	15.66	40	10.44
Blinding										
-mass concrete .075m	7	m2 (*.05 =m3)	2182	0.001	0.248	0.54	60	0.32	40	0.22
-sand .1m	20	m2 (*.1 =m3)	175	0.000	0.114	0.25	100	0.25		
R concrete (incl. shuttering)	5	m3	3364	0.017	5.467	11.87	40	4.75	60	7.12
+reinforcement 120kg/m3	0.6	ton	23126	0.014	4.510	9.79	20	1.96	80	7.83
Construction steel (hot dip galvanised)	50	kg	50	0.003	0.813	1.76	20	0:35	80	1.41
Gates (1.2*1.2)+lift devices	1	nos	48000	0.048	15.600	33.86	20	6.77	80	27.09
				0.142	46.071	100.00		38.738		61.262

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TABLE VII.2.36
Stepped Weir (see Figure VII.2.9)

STEPPED WEIR, GATED SECTION TYPE J MAP 79 L/4 Structure south Bangshi	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks									
-excavation	6000	m3	22	0.132	2.18	100	2.18		
-backfill+compaction	2000	m3	15.4	0.031	0.51	100	0.51		
Piles D=.06 l=15m	15	nos	75000	1.125	18.60	30	5.58	70	13.02
Slope & bottom protection									
-filtercloth Terram 2000	4000	m2	150	0.600	9.92	20	1.98	80	7.94
-gabions filled with									
broken bricks (h=.25m)	1500	m2	400	0.600	9.92	60	5.95	40	3.97
-concrete blocks (.3*.3*.3m)	2000	m2 (*.3 =m3)	2182	1.309	21.65	60	12.99	40	8.66
-khoa .1m	3500	m2 (*.1 =m3)	778	0.272	4.50	100	4.50		
Blinding									
-mass concrete .075m	285	m2 (*.075 =m3)	2182	0.047	0.77	60	0.46	40	0.31
-khoa .1m	285	m2 (*.1 =m3)	778	0.027	0.44	100	0.44		0.00
-sand .1m	285	m2 (*.1 =m3)	175	0.006	0.10	100	0.10		0.00
R concrete (incl. shuttering)	180	m3	3364	0.606	10.01	40	4.00	60	6.01
+reinforcement	22	ton	23126	0.509	8.41	20	1.68	80	6.73
Construction steel	1000	kg	50	0.050	0.83	20	0.17	80	0.66
Gates+frames+lift devices									
(2.44m * 3.35m)	1	nos	330000	0.330	5.46	20	1.09	80	4.37
(3m * 3.35m)	1	nos	405000	0.405	6.70	20	1.34	80	5.36
				6.048	100.000		42.985		57.015

TABLE VII.2.37
Raised Fixed Sill Weir (see Figure VII.2.10)

WEIR TYPE K MAP 79 L/4 Structure south Bangshi n 5B	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks									
-excavation	1000	m3	22	0.022	1.43	100	1.43		
-backfill+compaction	1800	m3	15.4	0.028	1.80	100	1.80		
Slope & bottom protection									
-filtercloth Terram 2000	2000	m2	150	0.300	19.46	20	3.89	80	15.57
-gabions filled with									
broken bricks (h=.25m)	1500	m2	400	0.600	38.91	60	23.35	40	15.57
-concrete blocks (.3*.3*.3m)	500	m2 (*.3 =m3)	2182	0.327	21.23	60	12.74	40	8.49
-khoa .1m	500	m2 (*.1 =m3)	778	0.039	2.52	100	2.52		
Arbestos pipes d=.3m	320	m	550	0.176	11.41	20	2.28	80	9.13
Bullahs d=.2m lgth=2m	100	nos	500	0.050	3.24	100	3.24		
				1.542	100.000		51.248		48.752

TABLE VII.2.38
Throttled Opening (see Figure VII.2.1)

THROTTLED OPENING TYPE A MAP Structure	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks, site facilities & diversion									
Slope & bottom protection									
*heavy protection 100m -filtercloth(woven 2 layers)	21900	m2	300	6.570	5.63	20	1.13	80	4.50
-faggot mat struct. bamboo +.5m bolders	21900	m2	1700	37.230	31.90	40	12.76	60	19.14
*lighter protection -filtercloth (non woven)	72900	m2	200	14.580	12.49	20	2.50	80	9.99
Gabions filled with broken bricks h=.5m	72900	m2	800	58.320	49.97	60	29.98	40	19.99
				116.700	100.00		46.37		53.63

TABLE VII.2.39
Multiple Span Bridge (see Figure VII.2.11)

2 SPAN LARGE BRIDGE TYPE L MAP 79 I/2 Structure Dhaleswari/Padma project 16	Total Quantity	Unit	Rate per unit (Tk)	Amount	Weight	Local %	Wt	Foreign %	Wt
Earthworks, site facilities & diversion				0.800	7.31	90	6.58	10	0.73
Slope & bottom protection				0.500	4.57	50	2.28	50	2.28
Foundation works (incl. piling				1.800	16.44	30	4.93	70	11.51
Abutments & piers				1.600	14.62	30	4.39	70	10.23
Trusses				5.906	53.96	20	10.79	80	43.17
Steel deck slab				0.300	2.74	20	0.55	80	2.19
Wearing coarse				0.040	0.36	40	0.14	60	0.22
				10.946	100.00		29.67		70.33