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PEOPLE'S REPUBLIC OF BANGLADESH

Ministry of Irrigation, Water Development and Flood Control

Bangladesh Water Development Board

CYCLONE PROTECTION PROJECT II - FAP 7
FEASIBILITY AND DESIGN STUDIES

DRAFT PROJECT PREPARATION REPORT

VOLUME 2 - ANNEXES I - XI

February 1992

Joint Venture of
KAMPSAX INTERNATIONAL A/S,
BCEOM
DANISH HYDRAULIC INSTITUTE
in association with
DEVELOPMENT DESIGN CONSULTANTS LTD

Financed by European Community - Project No. ALA/87/05

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LIST OF ANNEXES

REPORT VOLUMES

The present Report Volume is part of the

CYCLONE PROTECTION PROJECT II - FAP 7
FEASIBILITY AND DESIGN STUDIES
BWDB COMPONENT
DRAFT PROJECT PREPARATION REPORT

Consisting of the following Volumes :

Volume 1	-	Main Report
Volume 2	-	Annexes I - XI
Volume 3	-	Annex XII - Polder Data
Appendix A	-	Hydraulic Studies
Appendix B	-	Field Surveys and Soil Investigations
Appendix C	-	Embankment Design
Appendix D	-	Agriculture
Appendix E	-	Socio-Economics
Appendix F	-	Operation & Maintenance
Appendix G	-	Cyclone Early Warning System
Appendix H	-	Afforestation
Appendix I	-	Feasibility Study on Patenga Project.
Appendix J	-	Fisheries.

ANNEX I

FIELD SURVEYS

I. FIELD SURVEYS

1.1 Reconnaissance and Condition Surveys

The existing embankments and hydraulic structures in the entire study area were covered by field reconnaissances and condition surveys (refer table 1.1).

These surveys were performed by senior members of the Consultants team and comprehensive information on the actual condition of the embankments and hydraulic structures was collected and entered into forms as shown on Figures 1 and 2. The result of these surveys were in principle used for the determination of stretches of embankment subject to resectioning or new construction and for the determination of repair of existing hydraulic structures. After the damages of the cyclone of April 1991 the result of the condition survey in a number of polders were outdated for determination of embankment construction works. Additional field surveys and air reconnaissance from helicopter with use of video were therefore performed in a number of polders as a supplement to the original condition survey.

1.2 Surveys of Embankments and Structures

For all polders within the Mid Term Plan longitudinal levelling was performed for existing and new/retired embankments with elevations at not more than 30 m intervals and cross sections were normally taken at 300 m intervals and with 100m intervals at breaches, retirements, new embankments and at stretches needing extensive resctioning.

While taking longitudinal levels bench marks were established throughout the project area approximately at 6 km intervals.

Site surveys were performed for major hydraulic structures to be constructed.

For further details reference is made to Appendix B.

1.3 Soil Surveys and Foundation Investigation

Soil investigations were carried out to determine subsoil types under the embankments and type of borrow material available for embankment construction. A number of geotechnical borings were made to determine the foundation condition for heavy hydraulic structures.

The results of the geotechnical borings and a number of similar borings performed by the BWDB in the study area indicate that the geology of the coastal area is predominantly of tidal deltaic deposit in Khulna, Barisal and Noakhali areas, estuarine deposits in Bhola area and beach/dune sand deposits in the Chittagong/ Cox's Bazar areas.

Satkhira		Bagerhat		Khulna		Barguna		Bhola	
Polder No.	Embankment Length (Km)	Polder No.	Embankment Length (Km)	Polder No.	Embankment Length (Km)	Polder No.	Embankment Length (Km)	Polder No.	Embankment Length (Km)
7/1	32	35/1	19	10-12	8	40/1	16	56/57	91
7/2	10			31	5	40/2	15	58/1	19
5	38			32	15	45	13	58/2	18
14/1	11					48	19	58/3	6
14/2	31								
15	27								
Total	149		19		28		63		134

Noakhali		Laximpur		Chittagong I		Chittagong II		Cox's Bazar	
Polder No.	Embankment Length (Km)	Polder No.	Embankment Length (Km)	Polder No.	Embankment Length (Km)	Polder No.	Embankment Length (Km)	Polder No.	Embankment
59/3B	42	59/2	10	62	16	61/1	20	64/2B	8
60	21					63/1A	15	66/1	7
59/1A	4					64/1A	24	66/3	4
59/3C	27					72	67	68	17
73/2B	29							69	23
								70	17
								71	25
Total	123		10		16		126		101
Grand Total = 769									

Table 1.1 : Outline Delineation of Polders and Embankments for Mid Term Plan Study

CPP - II CONDITION SURVEY

DATE		SIGNATURE
TIME		
FROM KM	TO KM	CHAINAGE

O&M DIVISION | POLDER NO.

EMBANKMENT — CONSTRUCTED 19 ..... REPAIRED / RESECTIONED / RETIRED 19 .....

				A	B	C	D	E
GEOMETRY	DIMENSIONS [m]							
	LEVELS [m]	Crest						
		Natural Ground R/S						
		Natural Ground C/S						
		Max. High Water						
		Storm Surge Still						
CONSTRUCTION	MATERIALS	Clay / Silty Clay						
		Silt / Sandy Silt						
		Sand						
	COMPACTION	Good / Fair / Poor						
	CREST SURFACE	Earth / Bushes						
		Brick / Asphalt						
	ENCROACH-MENT	Settlement / Path						
		Cultivation						
DAMAGE	LOCATION	Sea-River Side						
		Crest						
		Country Side						
	MAIN CAUSES	Wave Action						
		River Erosion						
		Rain Run - Off						
		Storm Surge						
		Flooding						
		Gen. Wear & Tear						
	REQUIRED REMEDIAL MEASURES	Retirement						
		Reconstruction						
		Turfing & Plantation						
		Afforestation						
		Protective Works						
		Repair / Resectioning						

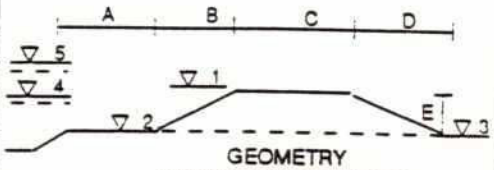
SLOPE PROTECTION — CONSTR. 19 ... REPAIRED 19 ...

TYPE	Grass / Bushes	
	Afforestation	
	Porcupines	
	Brick Mattress	
	Brick Block / C.C. Block	
	Stone Revetment	
	Foreland Accretion	
	Other	
EXTENT	Full Slope	
	Part Slope	
	Toe / Berm	
CONDITION & PERFORMANCE	Good / Fair	
	Poor / Unsuitable	

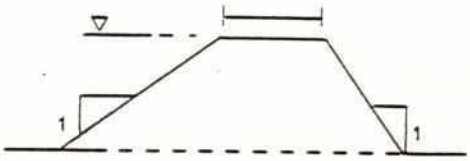
ASSESSMENT OF MAINTENANCE REQUIREMENTS	Embank-ment	Every ----- Year
		Every ----- Month
	Slope Protection	Every ----- Year
		Every ----- Month

DISTANCE TO NEAREST SOURCE OF MATERIALS	Embankment	Km	
		m	
	Slope Protection	Km	
		m	

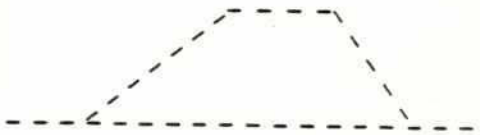
S-R/S C/S



GEOMETRY (FIELD MEASUREMENTS)



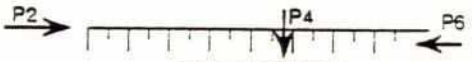
CEP DESIGN PROFILE



SKETCH OF DAMAGES

LANDUSE :

LOCATION OF PHOTOGRAPHS



SEA/RIVER SIDE

AFFORESTATION :

PHOTOGRAPHS	P1	P2	P3	P4	P5	P6
FILM NO.						
EXPOSURE NO.						

REMARKS :

FIGURE - I

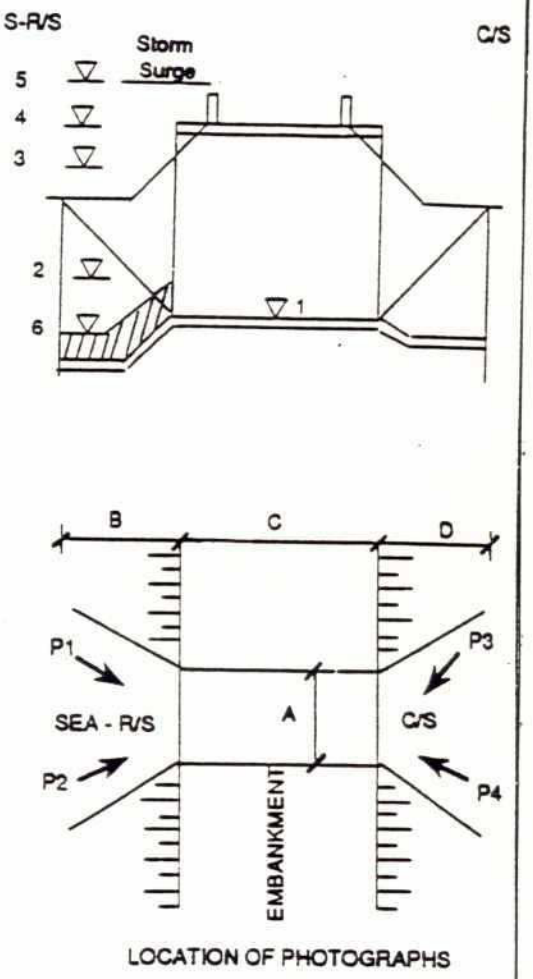
CPP - II CONDITION SURVEY

DATE		SIGNATURE
TIME		

O&M DIVISION	POLDER NO.	CHAINAGE AT	STRUCTURE NO.

STRUCTURES

GEOMETRY		A	B	C	D		
LEVELS		Cill				1	
		Low Water				2	
		High Water				3	
		Crest				4	
		Storm Surge				5	
		Silt				6	
VENT	TYPE	Box / Pipe					
	SIZE	' x ' / - Dia					
	N^0						
TYPE		Sluice					
		Regulator					
		Other					
MATERIAL		Brick					
		Reinf. Concrete					
		Other					
CONDITION	GENERAL	Good					
		Fair					
		Poor					
	FUNCTIONAL	Silted / Partially silted					
		Functioning					
		Non Functional					
CAPACITY		Normal					
		Over / Under					
DAMAGES	LOCATION	Top					
		Walls					
		Wing Walls					
		Apron					
		Base					
		Flap Gates					
		Slide Gates					
	DAMAGED BY	Settlement					
		Erosion					
		Piping					
		General Wear & Tear					
		Other					
	REPAIR NEEDED	Repairable					
		To be Replaced					
ASSESSMENT OF MAINTENANCE REQUIREMENTS		Every ——— Year					
		Every ——— Month					
		Daily					



LOCATION OF PHOTOGRAPHS

PHOTOGRAPHS	P1	P2	P3	P4
FILM NO.				
EXPOSURE NO.				

REMARKS :

FIGURE - 2

1.3.1 Embankment Soil Investigation

Auger drillings were made along the existing and new embankments at 1 to 5 km intervals and at an average depth of 3 m. Drillings were also made in potential borrow areas. Representative soil samples were collected and tested and classified in the laboratory. The results of the soil testing comprised.

- Natural Moisture Content
- Atterberg Limits
- Grain Size Analysis
- Liquid Limit
- Plasticity Index
- Specific Gravity

A total of 506 drillings were made in 193 locations and 591 soil samples were tested in the laboratory. The test results are presented in AppendixB.

The results of the soils investigations indicate generally that there will be suitable borrow materials available for embankment construction on either side of the embankments.

1.3.2 Structure Foundation Investigation

Foundation investigation were made for 20 Nos. of hydraulic structures.

Standard penetration tests were performed. Both disturbed and undisturbed soils samples were taken for visual examination and laboratory testing.

The disturbed samples were tested as mentioned under 1.3.1 above and the undisturbed samples were tested for consolidation and unconfined compression strength.

The results of the geotechnical borings are presented in Appendix B.

1.4 Afforestation Surveys

Field reconnaissance and condition surveys regarding afforestation was performed by the consultants afforestation expert in a total of 33 polders in the study area refer Table 1.2.

The existing afforestation was inspected, the conditions were recorded and more than 350 photos were taken to illustrate the present status of existing afforestation on and in front of sea facing embankments and to demonstrate the protective performance of afforestation. The requirements for new afforestation both on the embankments and on the foreland were assessed.

The results of these field surveys were shown on polder maps refer Appendix H which also presents a description of the actual condition of afforestation in each polder.

Sl. No.	Polder No.	Length of Embank-ment (Km)	Area Surveyed (Km)	Name of Upazila	District	Circle
1	5	38	35.1	Kaligonj and Shymnagar	Satkhira	
2	7/1	32	31.0	Asasuni	"	
3	7/2	10	11.4	Asasuni		
4	10-12	8	10.4	Paikgacha	Khulna	Khulna
5	14/1	11	11.8	Koyra	"	Circle
6	14/2	31	31.1	"	"	
7	15	27	27.1	Shamnagar	Satkhira	
8	31	5	1.6	Dacope	Khulna	
9	32	15	27.7	Dacope	"	
10	35/1	19	17.7	Sarankhola	Bagerhat	
11	40/1	16	16.0	Patharghata	Borguna	Barisal
12	40/2	15	4.4	Patharghata	Borguna	Circle
13	45	13	12.5	Borguna	Borguna	
	46	2	2.4			
14	48	19	16.2	Kalapara	Patuakhali	
15	54	12	12.0	Galachipa	Patuakhali	
16	56/57	91	110.7		Charfassion	
				Daulatkhan	Bhola	Bhola
				Burhanuddin		Circle
				Lalmohan		
				Tazimuddin		
17	59/2	10	10.2	Ramgati	Laxmipur	Muhuri
18	59/3B	42	30.0	Sudharam	Noakhali	Circle
19	59/3C	27	42.0	Companiganj	Noakhali	
20	60	21	22.0	Sonagazi	Feni	
21	73/2B	29	32.8	Hatiya	Noakhali	
22	61/1	20	19.0	Sitakunda	Chittagong	Chitta-
23	62	16	21.6	Chittagong	Chittagong	gong
				Patenga	Circle	Circle
24	63/1A	15	19.1	Anwara	Chittagong	
25	64/1A	24	27.9	Bash Khali	Chittagong	
26	64/2B	8	8.3	Chokoria	Cox's Bazar	
27	66/1	7	7.0	Ramu	Cox's Bazar	
28	66/3	4	5.3	Cox's Bazar	Cox's Bazar	
29	68	17	14.4	Teknaf	Cox's Bazar	
30	69	23	20.0	Moheskhali	Cox's Bazar	
31	70	17	19.7	Matherbari	Cox's Bazar	
32	71	25	23.6	Kutubdia	Cox's Bazar	
33	72	67	63.4	Sandwip	Chittagong	

Table 1.2 : Polders under Different Circles, District and Upazila Subject to Afforestation Survey.

ANNEX II

ENGINEERING ANALYSES

II ENGINEERING ANALYSES

2.1 Introduction

The present Annex includes details of the engineering analyses carried out as part of the preparation of the Mid Term Programme.

The engineering analyses have aimed at design of technically sound, cost effective and feasible embankments and hydraulic structures.

The analyses have formed the basis for preparation of detailed design and Tender Documents for embankments and hydraulic structures to be constructed under the Emergency Cyclone Protection Project and preliminary design of works to be implemented under Phase 2 of the Mid Term Programme.

Further details on hydraulic studies and details of the embankment design are included in Appendix A and C to the Main Report.

2.2 Hydraulic Studies

2.2.1 Study Objectives

The main objectives of the hydraulic studies have been:

- to prepare design parameters for waves and water levels to be used in the design of embankments
- to conduct a preliminary mathematical model study of cyclone generated surges to be used for a preliminary assessment of long term structural measures for protection against cyclonic surges
- to prepare Terms of Reference for a detailed mathematical model study of cyclone generated cyclonic surges to be used in establishing the basis for design of embankments to be constructed under the Long Term Plan.

2.2.2 Study Tasks

The following main tasks have been undertaken:

- collection of available data relating to water levels and preparation of long term statistics for extreme water levels along the coastal belt in the project area.
- determination of the corresponding wave heights and -periods as

determined by wave breaking in front of the sea facing embankments.

- collection of available data relating to the height of cyclonic surges experienced in Bangladesh.

- supplementing and verifying these data through mathematical modelling of cyclone surges based on available data on the meteorological conditions during the passage of cyclones.

- preparation of TOR for detailed mathematical model study of cyclonic surges.

2.2.3 Study Results

The detailed results are presented in Appendix A to the Main Report.

Extreme Water Levels in Monsoon Period

Water level data for 24 stations were collected. The registrations include combined tide, surge and annual mean level fluctuations.

The annual maximum water levels were extracted for each station and a Gumbel analysis performed.

Long term extreme level statistics for the individual polders have been prepared by interpolation between the stations.

Cyclone Surge Levels

A number of 8 cyclones occurring in Bangladesh in the period 1977-1991 has been simulated in the mathematical model. The modelling procedure consisted of the following tasks:

- meteorological key parameters for all cyclones occurring within a certain period were collected

- a numerical cyclone model was developed for calculating wind and pressure fields during the passage of a cyclone on basis of the collected key parameters

- a numerical surge model of the Bay of Bengal with a refined resolution along the coast of Bangladesh was set up

- the surge model complex was calibrated and verified for tide

- the cyclone model and the surge model were then used for the simulation of the selected cyclone periods

- finally the maximum surge levels occurring during the 8 cyclones were extracted

The computed surges generally turned out to be higher than the measured ones and the computed surges cannot at the present state form the basis for establishment of long term statistics for surge levels.

However, the experience gained from the modelling is found to be very useful for the future modelling - see TOR for long term studies in Appendix A.

Extreme Wave Heights

No useful wave data based on field measurements have been identified.

Based on offshore wave observations from ships, the exceedance diagram for the significant wave height in the Bay of Bengal has been established.

The nearshore wave characteristics have been calculated on basis of offshore conditions by taking shoaling and wave breaking into account.

2.3 Embankment Design

2.3.1 Existing Embankments

The poor status of the existing sea facing earth embankments is mainly a result of erosion of the outer slope, the crest and the inner slope of the embankments. The wave erosion of grass covered outer slopes is a result of frequent excessive run-up and run-down velocities on too steep slopes that are poorly compacted. Erosion of crest and inner slope is mainly due to overtopping by waves in extreme situations. Lack of repair of the erosion damages has resulted in progressive deterioration of the embankments.

The sea facing embankment slopes are originally designed 1:7 but have been steepened partly due to erosion and partly due to human activities.

The limit non-scouring up-rush velocity of the waves is 2 - 3 m/sec.. Figure 2.1 shows the up-rush velocities as function of slope for Sitakunda as an example.

Cross sections of existing embankments are shown in Enclosure 1 to the present Annex.

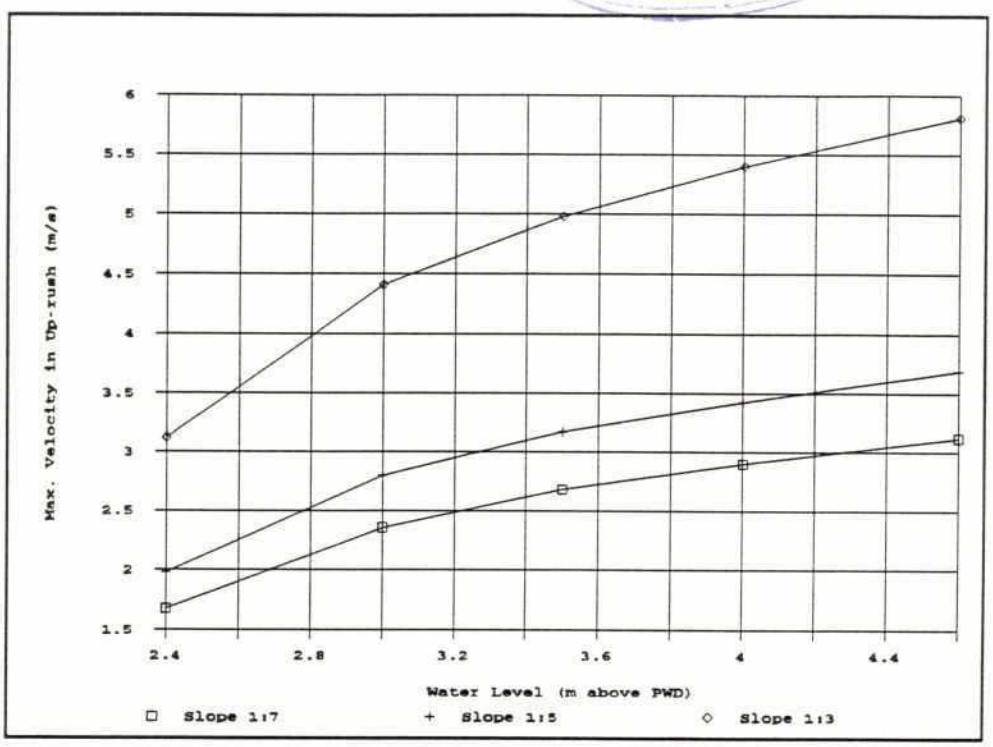


Figure 2.1 : Maximum Up-rush Velocities, Sitakunda

Protective works consisting of placed concrete blocks are generally underdesigned and most of them have suffered from extensive damages caused by extreme monsoon waves. The April 1991 cyclone has left the majority of the protective works completely destructed. The placed concrete units are not stable to even moderate wave action if (and when) they are dislocated due to settlements and erosion of the filter materials.

Figure 2.2 below shows the required thicknesses for revetment blocks designed for cyclonic conditions. The existing block thickness is typically 0.39 m.

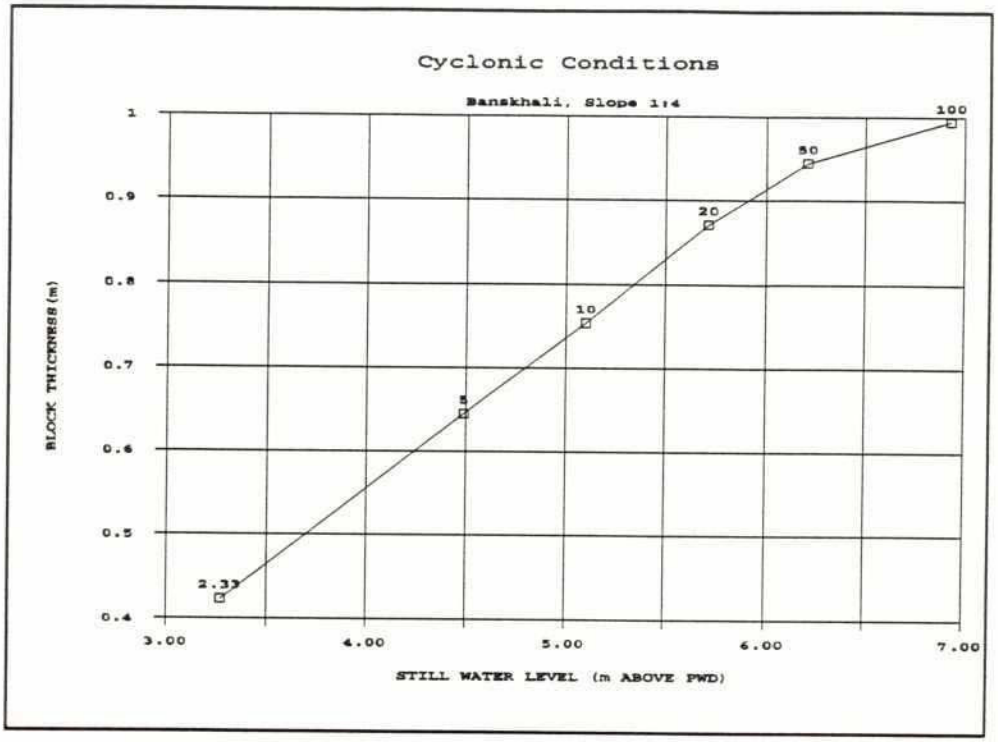


Figure 2.2: Necessary Block Thickness for Revetment, Cyclone

2.3.2 Repair and Strengthening of Embankments

Armoured embankments for protection of agricultural land and the population living in these areas is generally not economically feasible or justifiable.

The Consultant recommends the main protective embankments generally to be constructed as compacted earth embankments with a protective layer of well compacted clay soil with grass turfing and minimum 100-200 m foreshore or foreland with afforestation wherever possible.

It is recommended that slopes be 1:7 on the seaward side and 1:3 on the country side and that crest levels be established according to a technical /economical optimization.

Typical cross section in the proposed embankments are shown in Enclosure 2 to the present Annex.

The optimum crest levels are obtained by applying the following design criteria:

All polders in the emergency construction programme, except Polder 62:

- The return period of **monsoon** design condition has been set to 5 years. 'No' overtopping should occur in this situation (only 13 % of the waves should overtop).

- The return periods of **cyclonic storm** design conditions has been set to:

  - 20 years, where flooding due to wave overtopping of the sea facing embankment should not result in average water depth in the polder exceeding 1.0 m

  - 40 years, where the crest level should not be lower than the still water level

  For Polder 62, Patenga:

  - 'No' overtopping shall take place in **cyclonic storm** with return period 40 years (only 13 % of the waves should overtop)

Resulting crest levels vary between 6.0 and 8.5 m above Public Works Datum (PWD) and embankment heights vary between 4 and 6 m.

The individual crest levels and embankment slopes appear from Tables 2.1 and 2.2 below.

	Slopes R/S 1:7, C/S 1:3	
	Crest Level	
POLDER	Proposed	Present Design
61/1 SITAKUNDA	6.7	6.4/6.7
62, PATENGA	8.5/7.0	6.7
63/1A ANOWARA	6.3	6.1
64/1A BANSKHALI	6.3	6.1
64/1C CHANUA	6.2	6.1
64/2B CHOKORIA	6.2	6.1
66/3 COX's BAZAR	6.0	4.9
69 MOHESKHALI	6.0	4.9/5.5
71 KUTUBDIA, W	6.3	Uncertain
72 SANDWIP, S	7.0	6.7

Table 2.1 : Crest Levels, Emergency Programme (m above PWD)

POLDER NO	CHAINAGE	EMBANKMENT WORKS					
		RESEC-TIONING (KM)	NEW RETI-RED (KM)	EXISTING DE-SIGN (LDL)		RECOMMENDED DESIGN	
				CREST LEVEL (M)	RS/CS SLOPE	CREST LEVEL (M)	RS/CS SLOPE
35/1 SHARANKHOLA	1.6-4.1 6.3-8.1	2.5 1.8		4.9	3/2	4.9	5/2
40/2 PATHERGATA	10.0-15.0 &18.5-23	9.5		5.2	5/2	5.2	7/3
48 KUAKATA	26.0-35.0	9.0		6.1 ?	5/2	6.1	7/3
56/57 BHOLA	63.7-67.5 67.5-76.0 76.0-80.5 80.5-126	3.8 45.5	 8.5 4.5 	5.8 5.8 5.5 5.5	7/2	6.1	7/3
59/2	121-124.0 124-126.5 126.5-135	3.0 8.5	2.5	7.0	7/2	7.0	7/3
59/3B SUDHARAM	19.5-42.0 60.8-69.8	22.5 9.0	0.5	7.0/7.6	7/2	7.6	7/3
59/3C COMPANIGANJ	11.0-14.0 14.0-21.0 21.0-27.0	 7.0 	3.0 6.0	7.0/7.6	7/2	7.6	7/3
60 SONAGAZI	15.0-21.0 & 25.0-27	8.0		7.0/7.6	7/2	7.6	7/3
66/1 RAMU	0-5.0	5.0		4.9	7/2	6.0	7/3
68 TEKNAF	11.4-16.4 16.4-18.3 18.3-23.5 23.5-28.4	5.0 5.2 	 1.9 4.9	5.2	7/2	5.2	7/3
70 MATHERBARI	0-6.5 6.5-26.0	6.5	2.5	4.3	7/2	6.3 5.7	7/3 3/3
72 SANDWIP	0-3.0 3.0-8.5 46.0-51.0 51.0-52.5 52.5-57.5 57.5-59.5 59.5-60.2	 5.5 5.0 5.0 0.7 	3.0 1.5 2.0 	6.7	7/2	7.0 7.0 6.7 6.7 6.7 7.0 	7/3 7/3 5/2 5/2 5/2 7/3
73/1B HATIA	51.5-56.5		5.0	6.1	5/2	6.3	5/2
TOTAL		168.0	45.8				

R/S : River Side C/S : Country Side

Table 2.2 : Design, Mid Term Programme - Phase 2

Materials for embankment core should be silt and clay materials. Hydraulic fill will be allowed for the Patenga embankment only.

Materials for cover layer (1 m thickness on outer slope) should be good quality clay materials.

Retirement of embankments on eroding coasts is proposed where ever possible.

Retirement will not be possible in areas with dense habitation (Anowara and Kutubdia) and has not been accepted in areas where the hinterland provides potential industrial areas (Patenga).

Protection of the embankment toe by hard, flexible materials is proposed in these areas.

The cross section proposed is shown in Enclosure 3 to the present Annex.

The purpose of the protective works is to stop the erosion of the lower seaward earth slope during monsoon conditions. The protection should not be exposed directly to breaking waves during the peak of extreme cyclonic surges where the still water level is high.

The armour layer consists of rough angular stones or precast concrete blocks in random placement.

The armour stones are designed for wave conditions with 20 years return period in the monsoon period. In the design situation 5-10% damage is to be expected. The expected damage in other situations is estimated in Appendix C to the Main Report.

To protect the Naval Academy situated in polder 62, Patenga, a sea-wall consisting of gravity type concrete structure has been designed. The cross-section of the structure is shown in Enclosure 3.A to the present Annex.

2.3.3 Erosion of Embankments

The yearly average erosion of outer slope, crest and inner slope is estimated to 2.5 m^3/m embankment for all sea facing embankments under the Emergency Cyclone Protection Project (except 62, Patenga).

For Patenga South the average erosion is estimated to 0.4 m^3/m.

The average yearly damage to protective works is estimated to 5% of the armour layer (0.5 m^3/m).

The erosion will be reduced by approximately 10% if a 200 m wide belt of afforestation be established on the foreshore.

Further details on erosion and maintenance of embankments are given in Appendices C and F to the Main Report.

2.4 Hydrological Analysis and Design of Hydraulic Structures

The Hydrological aspects of the study area were investigated in details during the study. The investigation included the derivation of hydrological design parameters required for the designs of the proposed works.

The Consultants collected all the available data and other documents related to the study area from the following authorities:

- BWDB (Directorate of hydrology, LRP & MPO)
- BIWTA
- Chittagong Port Authority
- FPCO
- Bangladesh Meteorological Department
- SPARRSO
- Survey of Bangladesh.

These data and maps include: Rainfall data, Wind data, ETP, Tide levels, Bathymetric charts, Topographic maps, Contour maps, Air photos, Land sat images and Spot images.

Some general data is given in Enclosure 9 to the present Annex.

The consultants also developed a data bank with their own computer facilities.

Standard techniques and procedures were used for data analysis with the assistance of a number of computer programs. The following programs were being used for Statistical analysis, Simulation and Structural analysis.

- WFREQ.BAS	>	High and low water level analysis
- RAIN.BAS	>	Rainfall analysis
- WIND.BAS	>	Wind speed analysis
- SIMU.BAS	>	Simulation of hydraulic structures
- STAB.BAS	>	Stability analysis
- BARREL.BAS	>	Structural analysis of Barrel
- RETWALL.BAS	>	Structural analysis of Retaining wall
- UFRAME.BAS	>	Structural analysis of U-Frame.

2.4.1 Rainfall Analysis

In order to determine the desired capacities of channels and structures, frequency distribution analysis of maximum rainfall for a short and medium period is necessary. For the study area the critical drainage period is assumed to be the months in which rainfall is maximum. These are in between May to September of the year. Frequency analyses for 1, 2, 3, 4, 5, 7, 10 and 15 day consecutive rainfalls of 11 meteorological stations in and adjacent to the project area have been carried out. A sample of analysis result of rainfall depth duration frequency is furnished in Table-2.3.

Station : 331 Sandwip

Return Period / Duration Days	2.33 Year	5 Year	10 Year	20 Year	25 Year	50 Year	100 Year
1	182.6	240.9	288.4	334.0	348.4	392.9	437.1
2	274.9	381.6	468.6	551.9	578.3	659.6	740.5
3	341.2	461.5	559.6	653.5	683.3	775.0	866.2
5	453.8	601.0	721.0	835.9	872.3	984.5	1096.1
7	524.7	707.6	856.6	999.3	1044.6	1184.0	1322.7
10	626.2	843.1	1019.9	1189.2	1214.9	1408.2	1572.6
15	793.0	1060.1	1277.9	1486.3	1552.5	1755.1	1958.6
Station : 361 Hatiya							
1	178.7	220.4	254.3	286.8	297.1	328.9	360.4
2	264.1	325.3	375.2	423.0	438.1	484.8	531.2
3	307.9	374.9	429.5	481.7	498.3	549.4	600.2
5	383.6	462.7	527.1	588.8	608.3	688.6	728.5
7	438.1	511.6	571.5	628.9	647.1	703.1	758.8
10	515.7	614.5	695.0	772.0	796.5	871.7	946.6
15	627.6	720.8	796.7	869.4	892.5	963.5	1034.1
Station : 261 Daulatkhan							
1	140.8	190.0	230.2	268.6	280.8	318.4	355.7
2	240.9	333.1	408.3	480.3	503.2	573.5	643.4
3	295.9	398.8	482.7	563.0	588.5	666.9	744.9
5	369.6	487.4	583.4	675.4	704.5	794.3	883.6
7	420.9	542.7	641.9	736.9	767.1	859.9	952.2
10	498.5	624.7	727.6	826.1	857.3	953.5	1049.2
15	606.3	760.2	885.5	1005.5	1043.6	1160.9	1277.4

Table 2.3 : Rainfall Depth Duration Frequency

2.4.2 Tide Level Analysis

Two high tides and two low tides occur every 24 hours 50 minutes with a pronounced diurnal variation between the heights of two consecutive high tides. The tides approach Bangladesh coast from the Southwest and occur along the westernly side of the south coast about 3 hours earlier than in the east near Chittagong.

Seasonal variation of tide occurs due to upland flood discharge, wind and storm surges in the ocean. Tidal waves of the oceans while propagating through the surrounding rivers are deformed. Tides in estuarine channels are driven by changing water levels at the ocean boundary. During winter months when river flows are low, tidal effects extend beyond the northern boundary of the coastal area to Goalundo in the west and as far as Sylhet in the northeast. Change in tidal heights and tidal phases at different locations determine the tidal flow characteristics.

Nearly 90 water level gauging stations are maintained by the BWDB in or near the coastal embankment project area. Presently, a few number of these stations are equipped with automatic water level recorders and the remaining consist of staff gauges read by observer during day light hours (6 A.M. - 6 P.M). BIWTA also maintains several automatic and staff gauge water level stations in the project area.

For CPP-II water level data of 24 selected stations have been collected and analyzed. The results of frequency analysis of monthly high and low tide levels of 3 stations are presented in Tables 2.4 & 2.5.

Station : 122 Sandwip

Month / Return Period	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct	Nov.	Dec.	Jan.	Feb.	Mar.
2.33	3.763	3.909	4.151	4.363	4.514	4.356	4.194	3.650	3.068	2.830	3.082	3.391
5	4.518	4.548	4.759	5.049	5.141	4.962	5.021	4.213	3.600	3.363	3.683	3.995
10	5.133	5.070	5.256	5.609	5.653	5.455	5.694	4.671	4.033	3.798	4.174	4.487
20	5.722	5.569	5.731	6.144	6.143	5.928	6.339	5.110	4.449	4.214	4.643	4.958
25	5.909	5.728	5.881	6.314	6.298	6.077	6.544	5.250	4.580	4.346	4.792	5.107
50	6.484	6.215	6.345	6.837	6.777	6.539	7.174	5.679	4.986	4.753	5.250	5.567
100	7.057	6.700	6.807	7.358	7.252	6.998	7.801	6.105	5.389	5.157	5.706	6.025
Station : 321 Hatiya												
2.33	3.455	3.663	3.950	4.168	4.262	3.953	3.711	3.091	2.772	2.491	2.696	2.916
5	3.925	4.035	4.256	4.529	4.617	4.362	4.218	3.617	3.235	3.008	3.163	3.327
10	4.308	4.337	4.505	4.823	4.906	4.695	4.631	4.045	3.612	3.429	3.544	3.662
20	4.676	4.627	4.744	5.104	5.182	5.014	5.026	4.455	3.973	3.833	3.908	3.982
25	4.792	4.719	4.820	5.194	5.270	5.115	5.151	4.585	4.088	3.961	4.024	4.084
50	5.151	5.002	5.053	5.469	5.540	5.427	5.537	4.985	4.441	4.355	4.380	4.397
100	5.507	5.283	5.285	5.742	5.809	5.737	5.921	5.384	4.792	4.747	4.734	4.708
Station : 278 Daulatkhan												
2.33	2.553	2.931	3.282	3.680	3.801	3.539	3.449	2.618	2.153	1.902	1.948	2.215
5	2.787	3.221	3.533	3.945	4.049	3.828	3.803	2.944	2.467	2.101	2.102	2.391
10	2.978	3.458	3.737	4.162	4.251	4.065	4.093	3.209	2.722	2.263	2.227	2.535
20	3.161	3.684	3.933	4.369	4.445	4.291	4.369	3.463	2.967	2.418	2.347	2.672
25	3.219	3.756	3.995	4.435	4.506	4.362	4.457	3.544	3.044	2.467	2.385	2.716
50	3.398	3.978	4.187	4.637	4.695	4.583	4.728	3.792	3.283	2.619	2.502	2.851
100	3.575	4.198	4.377	4.839	4.883	4.803	4.996	4.039	3.521	2.769	2.619	2.984

Table 2.4 : Frequency Analysis of High Water Level

Station : 122 Sandwip

Month / Return Period	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct	Nov.	Dec.	Jan.	Feb.	Mar.
2.33	-1.730	-1.620	-1.367	-1.334	-1.458	-1.677	-1.801	-1.709	-1.621	-1.702	-1.777	-1.731
5	-2.584	-2.417	-2.265	-2.174	-2.224	-2.559	-2.649	-2.595	-2.492	-2.544	-2.641	-2.595
10	-3.281	-3.068	-2.998	-2.859	-2.849	-3.278	-3.340	-3.318	-3.202	-3.231	-3.346	-3.298
20	-3.948	-3.690	-3.699	-3.515	-3.447	-3.967	-4.001	-4.301	-3.882	-3.888	-4.020	-3.972
25	-4.160	-3.888	-3.922	-3.723	-3.636	-4.185	-4.211	-4.229	-4.098	-4.097	-4.234	-4.186
50	-4.811	-4.496	-4.607	-4.363	-4.221	-4.858	-4.857	-4.905	-4.762	-4.739	-4.893	-4.844
100	-5.459	-5.101	-5.288	-5.000	-4.802	-5.527	-5.500	-5.577	-5.422	-5.378	-5.549	-5.498
Station : 321 Hatiya												
2.33	-0.934	-0.866	-0.683	-0.239	-0.396	-0.438	-0.557	-0.775	-0.797	-0.894	-0.976	-1.018
5	-1.371	-1.305	-1.133	-0.886	-0.817	-0.940	-1.148	-1.281	-1.377	-1.455	-1.485	-1.503
10	-1.727	-1.664	-1.499	-1.414	-1.160	-1.348	-1.630	-1.694	-1.851	-1.912	-1.899	-1.897
20	-2.067	-2.006	-1.849	-1.919	-1.488	-1.740	-2.091	-2.089	-2.304	-2.350	-2.296	-2.275
25	-2.176	-2.115	-1.961	-2.080	-1.593	-1.864	-2.237	-2.214	-2.447	-2.489	-2.422	-2.395
50	-5.016	-2.450	-2.303	-2.573	-1.914	-2.246	-2.687	-2.600	-2.890	-2.916	-2.809	-2.764
100	-2.840	-2.783	-2.644	-3.064	-2.233	-2.626	-3.135	-2.983	-3.330	-3.341	-3.195	-3.131
Station : 278 Daulatkhan												
2.33	-1.049	-0.493	-0.152	0.332	0.509	0.773	0.443	-0.754	-0.469	-1.051	-0.620	-0.662
5	-2.124	-2.137	-0.423	0.038	0.196	-0.045	-0.385	-1.848	-0.784	-2.149	-0.927	-0.897
10	-3.000	-3.477	-0.644	-0.202	-0.059	-0.712	-1.060	-2.740	-1.041	-3.044	-1.178	-1.122
20	-3.839	-4.760	-0.856	-0.431	-0.304	-1.350	-1.707	-3.594	-1.287	-3.900	-1.417	-1.336
25	-4.105	-5.167	-0.923	-0.504	-0.381	-1.553	-1.912	-3.865	-1.366	-4.172	-1.493	-1.406
50	-4.924	-6.421	-1.130	-0.728	-0.620	-2.176	-2.543	-4.700	-1.606	-5.009	-1.728	-1.614
100	-5.739	-7.667	-1.336	-0.951	-0.858	-2.797	-3.717	-5.529	-1.845	-5.841	-1.960	-1.823

Table 2.5 : Frequency Analysis of High Water Level

2.4.3 Design of Hydraulic Structures

Drainage sluices are planned and designed to drain excess rainwater from the polders into the adjacent sea or rivers. Drainage is accomplished during the time of low tide when the water level inside the polder is higher than the water level on the river or sea side. Flap gates on the river/sea side of the sluices close automatically when the river water level rises above the country side level and prevent flow into the polder.

Planning for drainage sluices involves estimating the quantity of water to be removed from the catchment area, selecting the type, location, invert level of sluices and determining the number of vents required for each drainage units (sluice).

The first step of sluice planning is to determine the volume of water or runoff to be drained from the polder. In general terms, the runoff is equal to the quantity of rainfall in the polder reduced by evapotranspiration, surface storage and ground water seepage loss.

The second step in drainage sluice planning is to determine the hydraulic conditions for drainage. Sluice locations are selected and drainage areas are determined using maps, aerial photographs, satellite images and field reports. Stage-storage relation has been developed for each new hydraulic structure and considered in Simulation. The type of sluice to be provided is assumed taking into consideration the area to be drained, soil foundation conditions at the site, relative land and water elevations.

Tide stage records for all stations near the sluice site are analyzed to determine the design sea/river side water levels. Mean tide curves are developed for monsoon period to represent a "typical" unfavourable tide cycle. A 12.5 hour tide cycle with straight line variation between the low and high tide is assumed.

A 5-day duration rainfall with 10-year recurrence interval is taken as the design rainfall for the computation of drainage modules and planning of drainage sluices. Daily losses from rainfall for seepage, evapotranspiration etc. are obtained by analysing of evaporation and transpiration data and estimating typical ground water seepage loss and surface water storage.

To ensure the safety of the structure mainly for the design of downstream stilling basins, the design rainfall of 1 in 25 year return period is considered for deriving the hydraulic and structural design parameters.

A computer simulation model was developed for design of drainage sluices in the coastal area. Number of vents and sill elevations of sluices were determined from several alternatives by using the drainage simulation model. For sluice ventage optimization basin flood levels and the corresponding damaged crop areas have been considered. The final selection of the sluice ventage requirement was made by comparing the

incremental benefits with the incremental cost of each additional vent to be constructed. A sample outputs of drainage simulation of sluice is presented in Enclosure 4. Design of 48 Nos. of new sluices were completed.

The list of identified structures of Emergency Cyclone Protection Program and Mid-Term Program - Phase 2 are furnished in Tables 2.6 & 2.7

4 Nos. typical design drawings of new hydraulic structures are also presented in Enclosures 5, 6, 7, 8.

POLDER NO.	STRUCTURES					
	NEW			REPAIR		
	SLUICE NO.	LOCATION (KM)	VENTAGE (SIZE)	SLUICE NO.	LOCATION (KM)	VENTAGE (SIZE)
61/1				DS-16	0.50	3(1.52mx1.83m)
	SS-17A	3.55E	1(0.91mx1.22m)			
	SS-18	3.80E	2(1.22mx1.22m)			
62	SS-2	R4.84	2(0.91mx1.22m)			
	SS-8	6.00	1(1.22mx1.22m)			
	SS-9	7.40	1(0.91mx1.22m)			
	DS-10	10.40	1(1.52mx1.83m)			
	SS-10A	12.20	1(1.22mx1.22m)			
	DS-11	14.50	1(1.52mx1.83m)			
	DS-12	17.60	1(1.52mx1.83m)			
	SS-13	18.20	1(0.91mx1.22m)			
	DS-14	19.20	1(1.52mx1.83m)			
63/1A				DS-15	32.40	1(1.07m ϕ)
64/1A				DS-28	83.20	1(1.52mx1.83m)
	DS-29	85.81	2(1.52mx1.83m)			
66/3	DS-6	48.80	2(1.52mx1.83m)			
69	DS-1	11.90	2(1.52mx1.83m)			
	DS-2	4.00	2(1.52mx1.83m)			
	DS-3	3.50	1(1.52mx1.83m)			
	DS-4	1.30	2(1.52mx1.83m)			
71				DS-1	8.20	1(1.52mx1.83m)
	SS-2	6.90	2(1.22mx1.22m)			
	DS-3	3.0	2(1.52mx1.83m)			
				SS-4	1.90	2(1.07m ϕ)
	DS-5	49.20	5(1.52mx1.83m)			
	SS-6	47.10	2(0.91mx1.22m)			
				SS-7	45.70	1(0.91m ϕ)
	DS-8	43.53	2(1.52mx1.83m)			
72				DS-1R1	0.00	4(1.52mx1.83m)
				DS-2R2	6.60	5(1.52mx1.83m)
	DS-3BR2	14.875	3(1.52mx1.83m)			
				DS-3BR1	16.45	3(1.52mx1.83m)
				SS-2	22.75	1(0.91mx0.91m)
				DS-5	24.25	5(0.91m ϕ)
				SS-3	26.20	1(0.91mx0.91m)
	SS-4R1	27.70	1(0.91mx1.22m)			
				DS-6	28.80	1(1.52mx1.83m)
	SS-5A	30.27	2(1.22mx1.22m)			
				SS-5	30.40	1(0.91mx0.91m)
				SS-6	30.66	1(0.91m ϕ)
				SS-7	32.80	1(0.91mx0.91m)
				DS-7	34.17	1(1.52mx1.83m)
	SS-8R1	35.05	1(0.91mx1.22m)			
				DS-8	35.65	1(1.52mx1.83m)
				DS-9	37.35	1(1.52mx1.83m)
				SS-9	37.80	1(0.91mx0.91m)
				SS-10	38.60	1(0.91mx0.91m)
				DS-10	40.20	1(1.52mx1.83m)
				SS-11	41.28	1(0.91m ϕ)
				DS-11R1	42.30	2(1.52mx1.83m)
	SS-13	44.40	1(1.22mx1.22m)			

Note : SS - Surface Sluice, DS - Drainage Sluice

Table 2.6 : Structures of Emergency Cyclone Protection Project

POLDER NO.	STRUCTURES					
	NEW			REPAIR		
	SLUICE NO.	LOCATION (KM)	VENTAGE (SIZE)	SLUICE NO.	LOCATION (KM)	VENTAGE (SIZE)
35/1	DS-2A	8.20	3(1.52mx1.83m)			
56/57	DS-4A	67.50	3(1.52mx1.83m)			
59/2	SS-3 SS-4	127.20 128.80	1(0.91mx1.22m) 1(0.91mx1.22m)			
59/3B	DS-14 SS-5 SS-6 SS-12 SS-13 SS-14 SS-16 DS-3 SS-17	67.40 62.70 61.50 41.50 39.65 33.70 29.80 25.20 19.60	3(1.52mx1.83m) 1(0.91mx1.22m) 3(0.91mx1.22m) 3(0.91mx1.22m) 3(0.91mx1.22m) 4(0.91mx1.22m) 3(0.91mx1.22m) 12(1.52mx1.83m) 4(0.91mx1.22m)			
59/3C	DS-1 DS-2 DS-3 DS-4 DS-5	2.57 4.00 11+3.5E 17.15 19.90	2(1.52mx1.83m) 1(1.52mx1.83m) 15(1.52mx1.83m) 3(1.52mx1.83m) 2(1.52mx1.83m)			
60				DS-5 DS-6 DS-7	15.90 23.80 27.20	2(0.91m ϕ) 2(0.91m ϕ) 1(1.52mx1.83m)
66/1				SS-1	1.28	2(0.91m ϕ)
68	DS-8	11.50	2(1.52mx1.83m)			
70	SS-9 SS-10	5.0 1.0	1(0.91mx1.22m) 2(0.91mx1.22m)			

Note : SS - Surface Sluice, DS - Drainage Sluice

Table 2.7 : Structures of Mid Term Programme, Phase 2

2.5 Cost Estimates

The cost estimates for the Mid term Programme is given in Chapter 3 of the Main Report.

2.5.1 Break Down of Unit Rate for Earth Works

The unit rate for earth works has been estimated according to the break down presented in the following:

Break down of average unit rate for earth works for embankment construction. Price level January 1992.

Royalty for Earth

In order to minimize hauling distance from borrow areas to the embankment the borrow areas are assumed located along the embankment where soils suitable for both core and cover layer are available in the quantities required on either the sea side or river side in most cases.

It is further assumed that the borrow area will be minimized by excavating to average depth of 1.5 m according to usual practice, when land for borrow areas is acquired refer fig. 1.

It follows that after excavation of fill materials the borrow areas will no longer be suitable for any agricultural production except some fish cultivation.

The royalty to be paid can therefore be assumed to correspond to the full value of borrow areas as well as the approx. 10 m strip left between the borrow pits and the acquired way leave for the embankment i.e. corresponding as a minimum to the cost of land acquisition because of a strong bargaining position for the concerned private land owners.

In consideration of above the average compensation costs for the affected areas has been assessed at 25 tk/sqm corresponding to approx. 100,000 tk/acre.

The typical cross sectional areas of the embankments is 70-80 sqm corresponding to a 45-50 m wide borrow pit.

This corresponds to a royalty rate of
$(45+10)x25/70 = 19.64$ say 20 tk/cum.

Excavation, transportation and filling in position in layers by truck/dumper including levelling , dressing etc. within a distance of 1000 feet.

Rate as per BWDB schedule of 1989	28.80 tk/cum	
Add for 3 years price escalation (9% p.a)	8.50 tk/cum.	
	37.30 say	37 tk/cum

Mechanical compaction to 80/90% of maximum dry density at optimum moisture content of core fill and cover layer respectively.

Rate as per BWDB schedule for 80% compaction 4.07 tk.cum doubled i.e.	8.14 tk/cum	
Add for 3 years price escalation	2.44 -	
Total	10.58 say	11 tk/cum

Miscellaneous : clearing and stripping of way leave, dressing and turfing of embankment crest and slopes etc.

	5 tk.cum
Total	73 tk.cum

Add for construction management, mobilisation and demobilisation of construction plant and equipment to remote areas etc., 20%

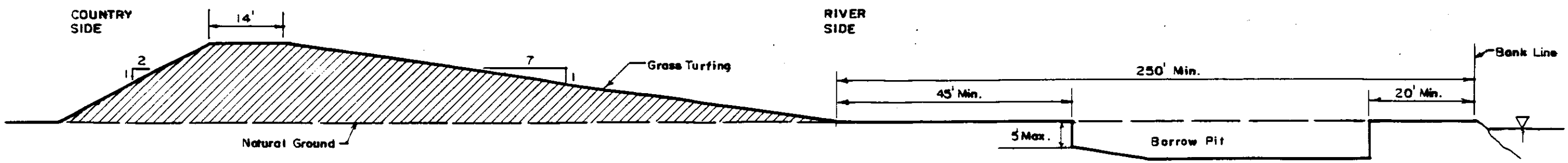
	15 tk/cum
Total unit rate	88 tk/cum

2.5.2 Estimation of Foreign Currency Component

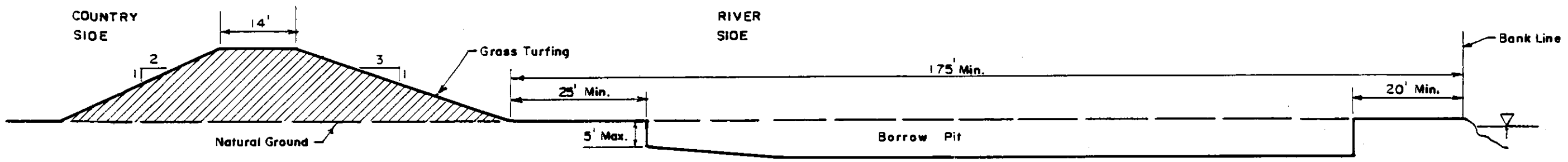
The foreign currency share of the total investment cost has been roughly estimated as follows:

Materials	% of total investment
Sheet piling Cement Steel reinforcement Geotextile.	15
Equipment	
Heavy mobile equipment Non-mobile equipment Light vehicles Laboratory equipment Communication System.	30
Staff & labour, miscellaneous	
Overseas head office Salaries & wages Freight insurance etc.	5
Total	50

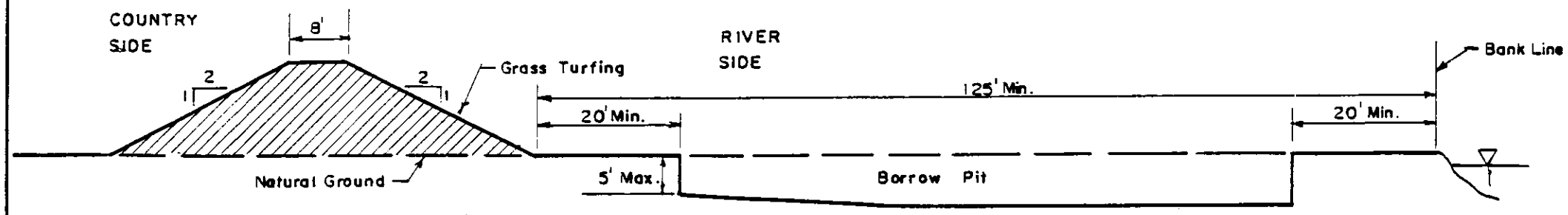
The foreign currency component will depend strongly on the nationality of the Contractor and his choice of execution method (labour intensive or non-labour intensive).



SEA DIKE



INTERIOR DIKE



MARGINAL DIKE

SECTION THROUGH DIKE & BORROW PIT

PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

CYCLONE PROTECTION PROJECT II

PROJECT PREPARATION REPORT, ANNEX II

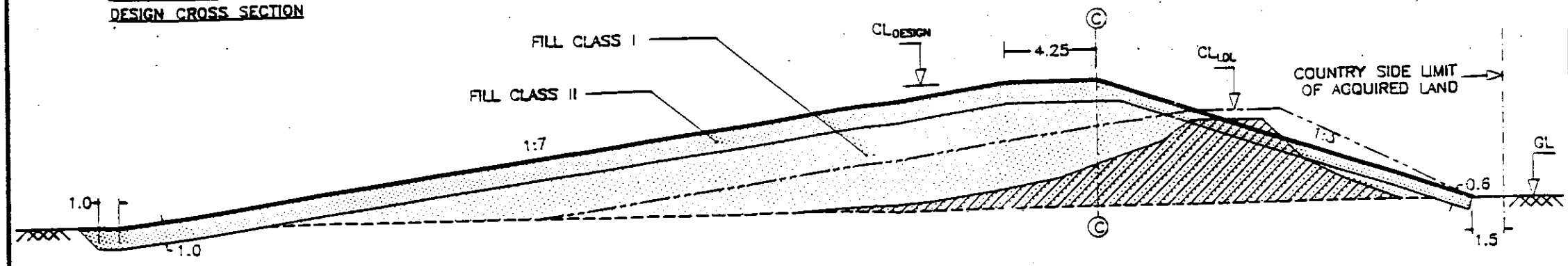
DESIGN CROSS SECTIONS, CEP EMBANKMENTS

KAMPSAX INTERNATIONAL A/S, BCEOM and DANISH HYDRAUUC INSTITUTE
in association with
DEVELOPMENT DESIGN CONSULTANTS LTD.
23, New Eskaton Road, Dhaka-1000. Tel. 405477. Fax 880 02 832951

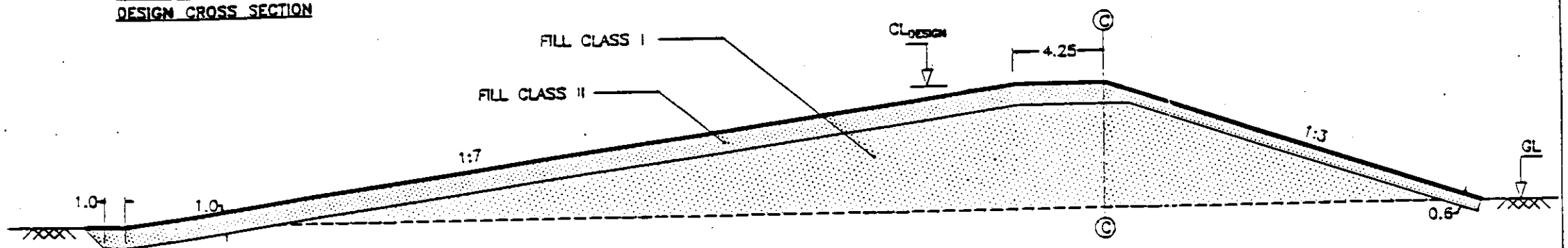
DATE: 01-02-1992

ENCLOSURE 1

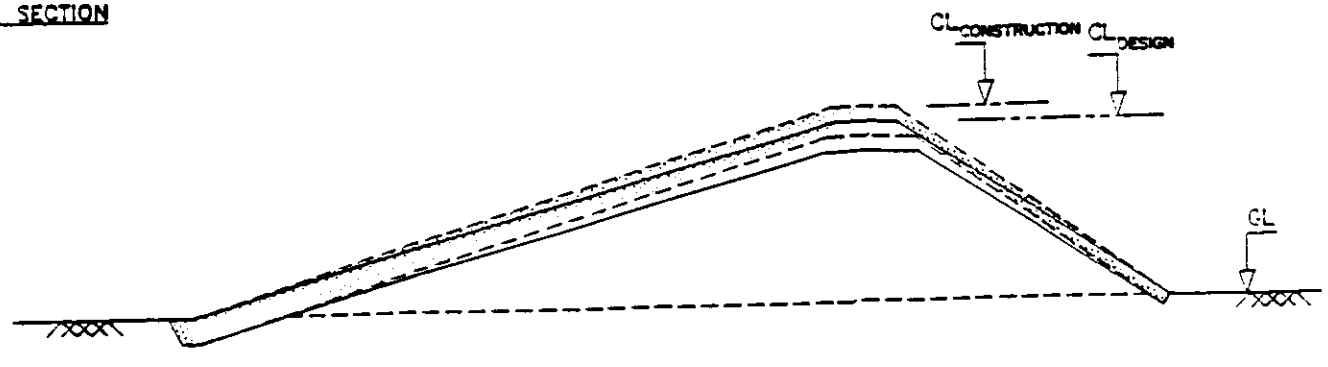
RESECTIONED EMBANKMENT
DESIGN CROSS SECTION



RETIRED EMBANKMENT
DESIGN CROSS SECTION



CONSTRUCTION CROSS SECTION
(NOT TO SCALE)



NOTES:

DIMENSIONS ARE IN METRES

: NATURAL GROUND
: EMBANKMENT FORMATION LEVEL
: MAIN REFERENCE LINE
: CORE
: COVER LAYER
: DESIGN PROFILE FOR EXISTING EMBANKMENT (LDL DESIGN)
: EXISTING EMBANKMENT (SCHEMATIC)

PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

CYCLONE PROTECTION PROJECT II

PROJECT PREPARATION REPORT, ANNEX II

EARTH EMBANKMENT, PROPOSED DESIGN.

KAMPSAX INTERNATIONAL A/S, BCEOM and DANISH HYDRAULIC INSTITUTE
in association with
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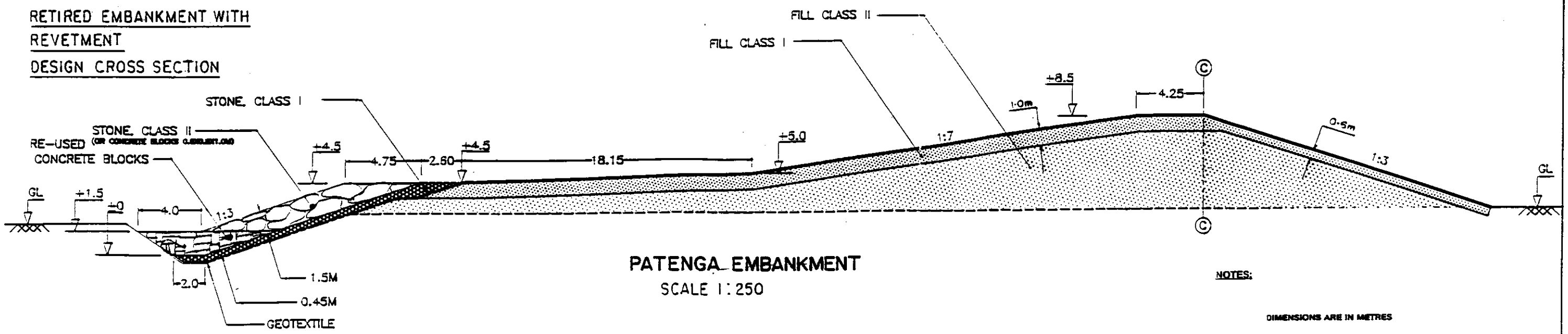
23, New Eskaton Road, Dhaka-1000. Tel. 405477. Fax 880 02 832951

DATE: 01-02-1992

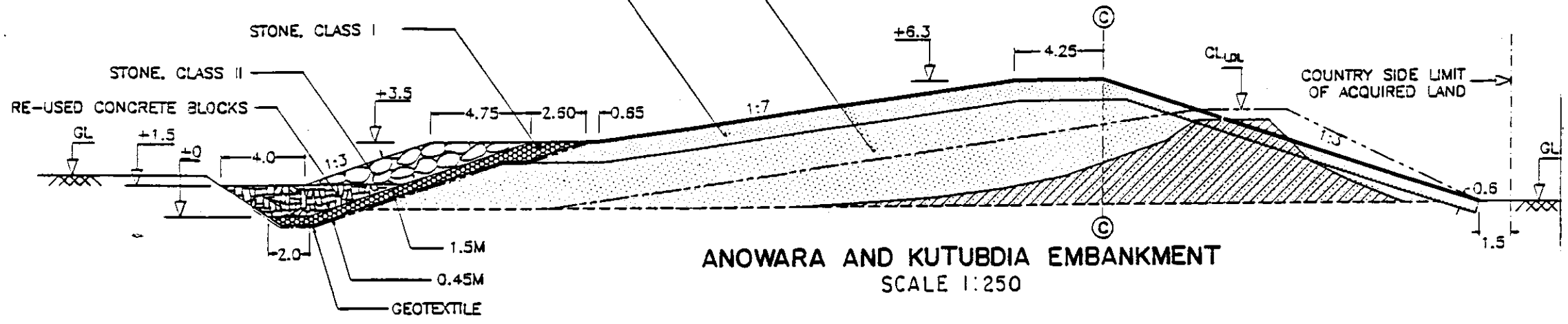
ENCLOSURE 2

RETIRED EMBANKMENT WITH REVETMENT DESIGN CROSS SECTION



PATENGA EMBANKMENT
SCALE 1:250

RESECTIONED EMBANKMENT WITH REVETMENT DESIGN CROSS SECTION



ANOWARA AND KUTUBDIA EMBANKMENT
SCALE 1:250

NOTES:

DIMENSIONS ARE IN METRES

- : NATURAL GROUND
- : EMBANKMENT FORMATION LEVEL
- Ⓒ—Ⓒ : MAIN REFERENCE LINE
- : CORE
- : COVER LAYER
- : DESIGN PROFILE FOR EXISTING EMBANKMENT (LDL DESIGN)
- : EXISTING EMBANKMENT (SCHEMATIC)

PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

CYCLONE PROTECTION PROJECT II

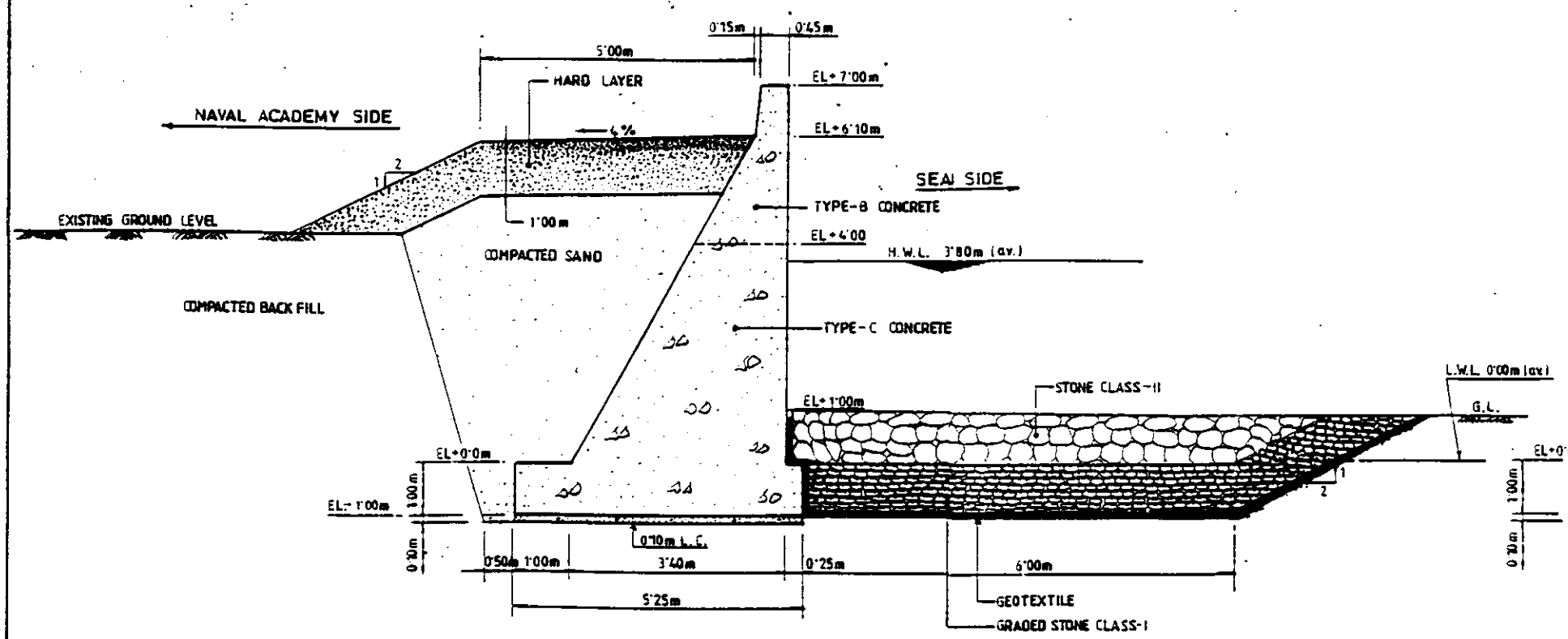
PROJECT PREPARATION REPORT, ANNEX II

SLOPE PROTECTION, PROPOSED DESIGN

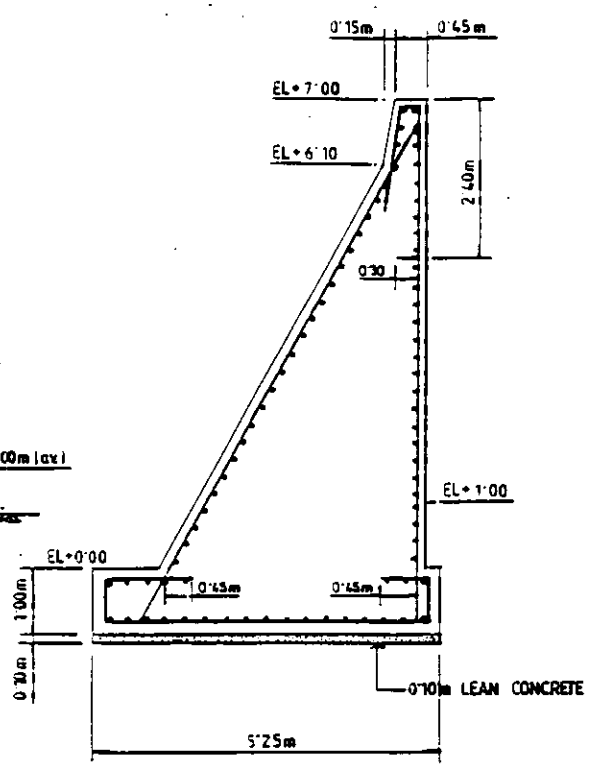
KAMPSAX INTERNATIONAL A/S, BCEOM and DANISH HYDRAULIC INSTITUTE
in association with
DEVELOPMENT DESIGN CONSULTANTS LTD.
23, New Eskaton Road, Dhaka-1000. Tel. 405477. Fax 880 02 832951

DATE: 01-02-1992

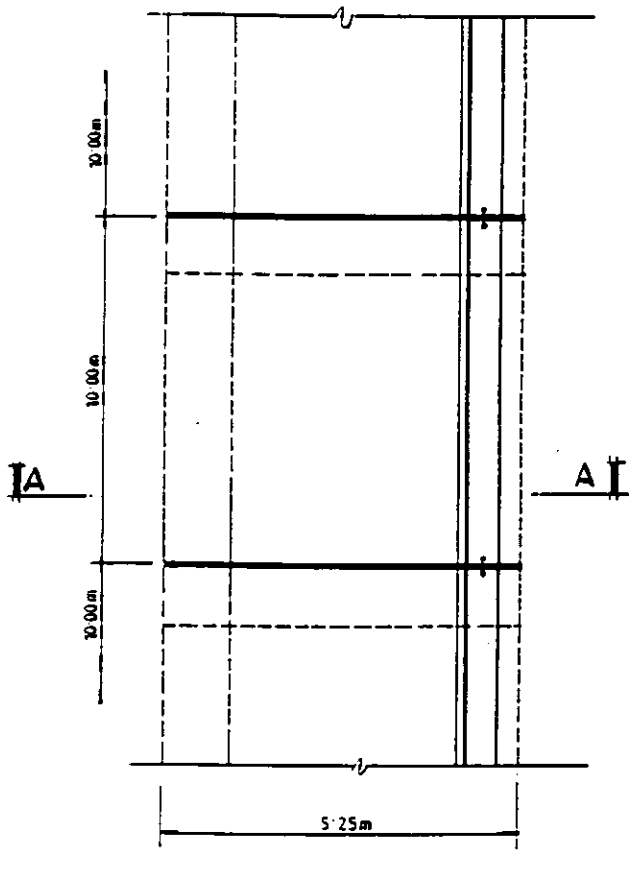
ENCLOSURE 3



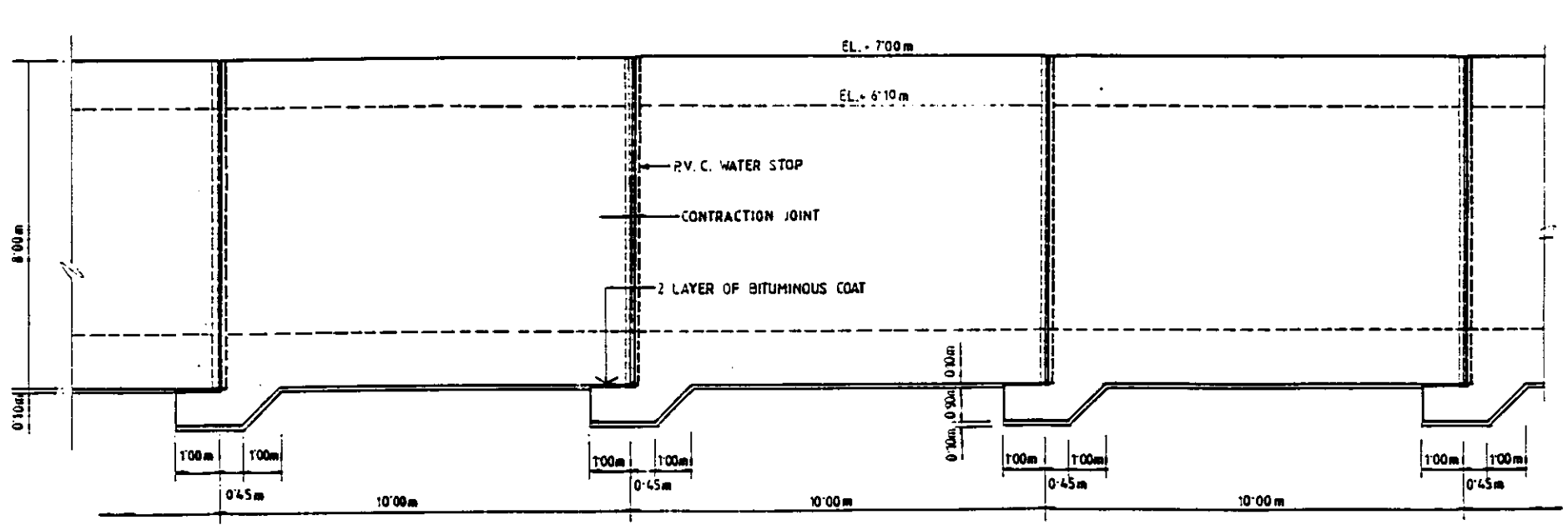
SECTION A–A
SCALE : 1:75



REINF. DETAILS OF SEC. A–A
SCALE : 1:75



PLAN OF SEA WALL
SCALE 1:75



SEA SIDE ELEVATION
SCALE : 1:100

PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

CYCLONE PROTECTION PROJECT II

PROJECT PREPARATION REPORT, ANNEX II

SEA-WALL, PROPOSED DESIGN

KAMPSAX INTERNATIONAL A/S, BCEOM and DANISH HYDRAULIC INSTITUTE
in association with
DEVELOPMENT DESIGN CONSULTANTS LTD.
23, New Eskaton Road, Dhaka-1000. Tel 405477. Fax 880 02 832951

DATE: 01-02-1992

ENCLOSURE **3.A**

PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

CYCLONE PROTECTION PROJECT II

PROJECT PREPARATION REPORT, ANNEX II

SIMULATION OF DRAINAGE STRUCTURE

KAMPSAX INTERNATIONAL A/S, BCEOM and DANISH HYDRAULIC INSTITUTE
in association with
DEVELOPMENT DESIGN CONSULTANTS LTD.
23, New Eskaton Road, Dhaka-1000, Tel. 405477, Fax 880 02 832951

DATE: 01-02-1992

ENCLOSURE **4**

SIMULATION OF DRAINAGE STRUCTURE

"DS-5 Simulation" Ref 'O' Evelation=2.40 m (PWD)

"Program Operation and Control Variables"

0.01	"Max error control for section continuity (Ha-m)"
0.5	"Max error control for overall continuity (Ha-m)"
0.1	"First trial H1 offset control: rising tide & open gates (m)"
100	"Max no. of iterations before manual control starts"
1	"0 for DS-5, Polder 71 Simulation"

2	"Channel Side Slope"
0.025	"Manning's n for channel"
3	"Number of most upstream reach prior to storage reservoir"

"Station Starting Conditions"

"Station Number"	"Section Length (metres)"	"Station Bottom Elevation (m, PWD)"	"Section Bottom Width (metres)"	"Stage * Downstr. (m, PWD)"	"Stage * Upstream (m, PWD)"	"Channel Flowrate (CMS)"
				(* must be equal)		
" 1"	0	-1.75	20	0	0	0
" 2"	1000	-1.95	20	0	0	0
" 3"	1000	-2.15	20	0	0	0
" 4"	1000	-2.35	20	0	0	0
" 5"	50	-2.55	10	0	0	0
" 6"	0	0	0	0	0	0
" 7"	0	0	0	0	0	0
" 8"	0	0	0	0	0	0
" 9"	0	0	0	0	0	0
"10"	0	0	0	0	0	0
"11"	0	0	0	0	0	0
"12"	0	0	0	0	0	0
"13"	0	0	0	0	0	0

"River tide function:"

5	"Number of time points used to describe one cycle"
3	"Hour of tide cycle at simulation time zero"

"Time point in the cycle (hours, starting at zero)"

0 4 5.5 7 12.5

"Tide elevation corresponding to the above time point (metres, PWD)"

-2.6 0.6 1.7 0.6 -2.6

"Excess Runoff:"

0	"Starting time for excess runoff (should be hour zero)"
96	"Ending time for excess runoff (hours)"
0.0035	"Excess runoff rate (metres per hour)"
0.000246	"EvapoTranspiration rate after excess runoff period (metres per hour)"

0.5	"Simulation time step in hours (0.5 hours preferred)"
0	"Starting hour for simulation"
120	"Ending hour for simulation"

```
          "Gate Coefficients:"
 11.04955   "Type 1  (1.8m X 2.2m)  submerged vent: BWDB Type 1"
 7.773556   "Type 2  (5 ft X 6 ft)  submerged vent: BWDB Type 1"
 1.831601   "Type 3  (3 foot diam)  submerged vent: BWDB Type 1"
    1.52    "Sluice Gate Width (metres)"
    1.83    "Sluice Gate Height (metres)"
    -2.4    "Sluice Sill Elevation (m, PWD)"
"-------------------------------------------------------------------"
 "Number     Type"
 "of         of      Identification"
 "Gates      Gate"
       5       2   "#1   SLUICE (Types 4, 5, 6 used automatically)"
       0       3   "#2   1st Reach (zero gates, zero inflow)"
       0       3   "#3   2nd Reach (zero gates, zero inflow)"
       0       3   "#4   3rd Reach (zero gates, zero inflow)"
       0       3   "#5   4th Reach (zero gates, zero inflow)"
       0       3   "#6   The Polder (no gates, free channel outflow)"
       0       3   "#7          "
       0       2   "#8          "
       0       2   "#9          "
       0       2   "#10         "
       0       2   "#11         "
       0       2   "#12         "
       0       2   "#13         "
"-------------------------------------------------------------------"
"Basic Polder Data:                                          Starting"
 "Total          Stage vs Area Co-ordinates: (Area lying between      Polder"
 "Area           indicated elevation and next higher elevation (Ha)   Water      Identification"
 "(Ha)       0      0.305    0.610    0.914    1.219    1.524    Blank  Level (m)"
    2049     434      553     1062        0        0        0        0      0   "#1   SLUICE (specify Type 2)"
    2049     434      553     1062        0        0        0        0      0   "#2   1st Reach (zero gates)"
    2049     434      553     1062        0        0        0        0      0   "#3   2nd Reach (zero gates)"
    2049     434      553     1062        0        0        0        0      0   "#4   3rd Reach (zero gates)"
    2049     434      553     1062        0        0        0        0      0   "#5   4th Reach (zero gates)"
    2049     434      553     1062        0        0        0        0    0.3   "#6         "
    2049     434      553     1062        0        0        0        0      0   "#7         "
    2049     434      553     1062        0        0        0        0      0   "#8         "
    2049     434      553     1062        0        0        0        0      0   "#9         "
    2049     434      553     1062        0        0        0        0      0   "#10        "
    2049     434      553     1062        0        0        0        0      0   "#11        "
    2049     434      553     1062        0        0        0        0      0   "#12        "
    2049     434      553     1062        0        0        0        0      0   "#13        "
"-------------------------------------------------------------------"
"Output File Options: (Y or N)"
      "Y      ","File #1: Sluice flows, Channel, Polder levels"
      "N      ","File #2: N/A"
      "N      ","File #3: N/A"
      "N      ","File #4: N/A"
      "N      ","File #5: N/A"
      "N      ","File #6: N/A"
"Simulation Identification Label (maximum 36 characters)"
      " DS-5, Polder 71 Simulation      "
"-------------------------------------------------------------------"
```

DS-5, POLDER 71 SIMULATION

Hour	TIDE	H1	WL 2	WL 3	QSLU	QPOL	AREA	STOR
0.00	0.000	0.000	0.000	0.000	0.0	0.0	0	0
0.50	0.200	0.022	0.022	0.022	0.0	0.8	99	3
1.00	0.600	0.065	0.065	0.065	0.0	1.5	139	7
1.50	0.967	0.098	0.098	0.098	0.0	1.2	170	10
2.00	1.333	0.121	0.121	0.121	0.0	0.8	197	14
2.50	1.700	0.137	0.137	0.137	0.0	0.6	220	17
3.00	1.333	0.154	0.154	0.154	0.0	0.6	242	21
3.50	0.967	0.169	0.169	0.169	0.0	0.5	261	24
4.00	0.600	0.183	0.183	0.183	0.0	0.5	280	28
4.50	0.280	0.196	0.196	0.196	0.0	0.5	297	31
4.61	0.209	0.209	0.209	0.209	0.0	2.0	301	32
5.00	-0.040	0.133	0.174	0.207	10.8	9.1	308	33
5.50	-0.360	0.037	0.156	0.204	20.6	19.4	308	33
6.00	-0.680	-0.124	0.106	0.202	26.8	24.5	304	32
6.50	-1.000	-0.402	0.070	0.196	32.7	29.7	296	31
7.00	-1.320	-0.307	0.069	0.187	30.5	31.1	286	29
7.50	-1.640	-0.356	0.071	0.181	30.6	30.2	277	27
8.00	-1.960	-0.373	0.062	0.174	29.9	29.5	268	25
8.50	-2.280	-0.381	0.057	0.167	29.6	29.4	258	23
9.00	-2.600	-0.395	0.050	0.160	29.3	29.1	249	22
9.50	-2.200	-0.407	0.043	0.152	29.1	28.8	240	20
10.00	-1.800	-0.422	0.037	0.144	28.8	28.5	231	19
10.50	-1.400	-0.435	0.030	0.137	28.5	28.2	221	17
11.00	-1.000	-0.450	0.023	0.129	28.2	27.9	212	16
11.50	-0.600	-0.310	-0.014	0.121	28.3	28.7	201	14
12.00	-0.200	-0.175	-0.147	-0.123	20.8	17.4	204	15
12.07	-0.142	-0.142	-0.143	-0.143	4.1	5.3	207	15
12.50	0.200	0.131	0.129	0.136	0.0	11.3	216	16
13.00	0.600	0.152	0.152	0.152	0.0	0.7	237	20
13.50	0.967	0.166	0.166	0.166	0.0	0.5	258	23
14.00	1.333	0.180	0.180	0.181	0.0	0.5	276	27
14.50	1.700	0.194	0.194	0.194	0.0	0.5	294	30
15.00	1.333	0.206	0.206	0.206	0.0	0.5	310	34
15.50	0.967	0.218	0.218	0.218	0.0	0.4	326	37
16.00	0.600	0.229	0.229	0.229	0.0	0.4	341	41
16.50	0.280	0.239	0.239	0.239	0.0	0.4	355	44
16.55	0.249	0.249	0.249	0.250	0.0	4.0	356	45
17.00	-0.040	0.168	0.216	0.246	11.8	10.3	363	46
17.50	-0.360	0.068	0.187	0.245	21.8	20.4	362	46
18.00	-0.680	-0.076	0.150	0.241	27.9	26.0	358	45
18.50	-1.000	-0.351	0.098	0.235	34.0	30.8	350	43
19.00	-1.320	-0.222	0.111	0.229	31.7	32.9	340	41
19.50	-1.640	-0.295	0.106	0.222	32.2	31.5	332	39
20.00	-1.960	-0.304	0.101	0.215	31.3	31.1	323	37
20.50	-2.280	-0.315	0.094	0.209	31.1	30.8	314	35
21.00	-2.600	-0.325	0.089	0.202	30.8	30.6	305	33
21.50	-2.200	-0.338	0.081	0.194	30.6	30.3	296	31
22.00	-1.800	-0.348	0.076	0.189	30.3	30.1	287	29
22.50	-1.400	-0.358	0.070	0.182	30.1	29.9	278	27

E4-4

23.00	-1.000	-0.370	0.064	0.175	29.9	29.6	269	25
23.50	-0.600	-0.460	-0.247	-0.178	26.5	17.2	272	26
23.86	-0.310	-0.310	-0.314	-0.284	13.2	12.0	277	27
24.00	-0.200	-0.200	-0.201	-0.202	0.0	12.7	279	27
24.50	0.200	0.180	0.178	0.187	0.0	13.4	285	29
25.00	0.600	0.201	0.201	0.201	0.0	0.7	302	32
25.50	0.967	0.212	0.212	0.212	0.0	0.4	318	36
26.00	1.333	0.223	0.223	0.223	0.0	0.4	333	39
26.50	1.700	0.234	0.234	0.234	0.0	0.4	348	43
27.00	1.333	0.244	0.244	0.244	0.0	0.4	362	46
27.50	0.967	0.254	0.254	0.254	0.0	0.4	376	50
28.00	0.600	0.264	0.264	0.264	0.0	0.4	389	53
28.50	0.280	0.280	0.273	0.273	0.0	0.3	402	57
29.00	-0.040	0.186	0.234	0.278	12.3	10.8	407	58
29.50	-0.360	0.106	0.229	0.277	22.8	22.0	406	58
30.00	-0.680	-0.052	0.170	0.273	28.7	26.3	402	57
30.50	-1.000	-0.291	0.133	0.267	35.1	32.5	394	54
31.00	-1.320	-0.223	0.154	0.261	32.3	33.1	385	52
31.50	-1.640	-0.252	0.132	0.255	32.7	32.0	377	50
32.00	-1.960	-0.249	0.135	0.249	32.4	32.4	368	48
32.50	-2.280	-0.266	0.124	0.243	32.2	31.9	360	46
33.00	-2.600	-0.270	0.122	0.237	32.0	31.9	351	43
33.50	-2.200	-0.283	0.114	0.230	31.8	31.5	343	41
34.00	-1.800	-0.293	0.108	0.223	31.6	31.3	334	39
34.50	-1.400	-0.303	0.102	0.217	31.3	31.1	326	37
35.00	-1.000	-0.313	0.096	0.210	31.1	30.9	317	35
35.50	-0.600	-0.244	0.067	0.204	31.5	31.5	307	33
35.98	-0.214	-0.214	-0.215	-0.208	21.4	12.7	313	34
36.00	-0.200	-0.200	-0.203	-0.193	0.0	12.8	313	34
36.50	0.200	0.200	0.196	0.197	0.0	13.9	318	36
37.00	0.600	0.224	0.224	0.224	0.0	1.0	333	39
37.50	0.967	0.234	0.234	0.234	0.0	0.3	348	42
38.00	1.333	0.244	0.244	0.244	0.0	0.4	362	46
38.50	1.700	0.254	0.254	0.254	0.0	0.4	376	50
39.00	1.333	0.264	0.264	0.264	0.0	0.4	389	53
39.50	0.967	0.273	0.273	0.273	0.0	0.3	401	57
40.00	0.600	0.282	0.282	0.282	0.0	0.3	414	60
40.48	0.290	0.290	0.290	0.290	0.0	0.3	425	64
40.50	0.280	0.292	0.293	0.298	2.9	7.4	426	64
41.00	-0.040	0.214	0.269	0.294	13.6	12.4	430	65
41.50	-0.360	0.107	0.226	0.294	23.3	21.5	429	65
42.00	-0.680	-0.015	0.206	0.289	29.2	27.7	424	63
42.50	-1.000	-0.287	0.132	0.284	35.7	32.1	417	61
43.00	-1.320	-0.189	0.178	0.277	32.7	34.2	408	58
43.50	-1.640	-0.234	0.142	0.272	33.3	32.2	400	56
44.00	-1.960	-0.221	0.155	0.266	32.9	33.2	392	54
44.50	-2.280	-0.241	0.139	0.261	32.9	32.4	383	52
45.00	-2.600	-0.242	0.140	0.254	32.6	32.5	375	49
45.50	-2.200	-0.257	0.129	0.247	32.4	32.0	367	47
46.00	-1.800	-0.265	0.126	0.241	32.2	32.0	358	45
46.50	-1.400	-0.275	0.118	0.235	32.0	31.7	349	43
47.00	-1.000	-0.285	0.113	0.228	31.7	31.5	341	41

E4-5

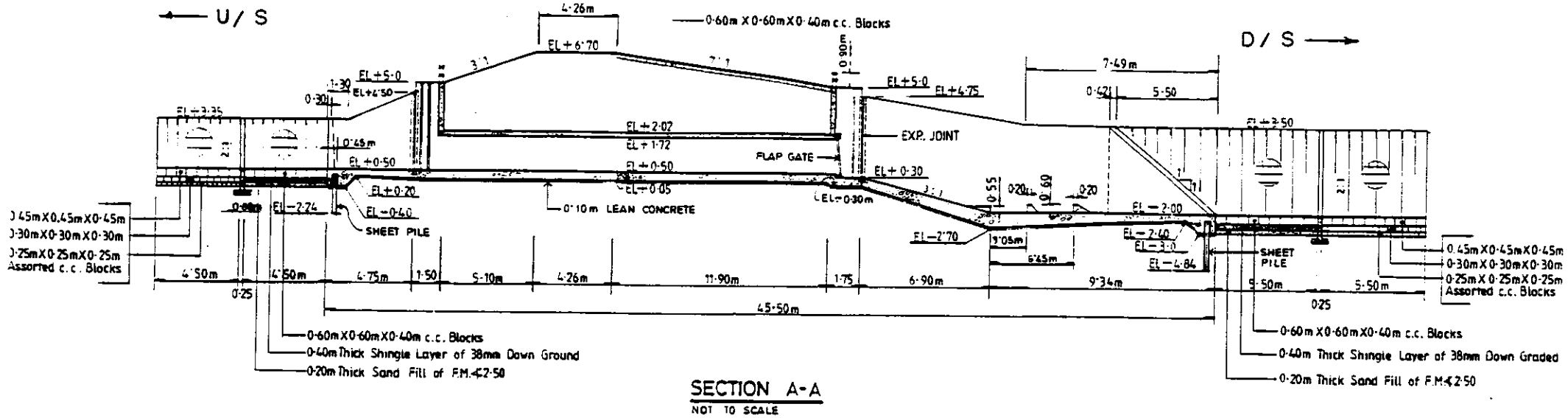
47.50	-0.600	-0.295	0.106	0.221	31.5	31.2	332	39
47.96	-0.230	-0.230	-0.230	-0.229	19.8	9.6	340	40
48.00	-0.200	-0.240	-0.240	-0.240	0.0	0.0	341	41
48.50	0.200	-0.240	-0.240	-0.240	0.0	0.0	356	44
49.00	0.600	-0.240	-0.240	-0.240	0.0	0.0	370	48
49.50	0.967	-0.240	-0.240	-0.240	0.0	0.0	383	52
50.00	1.333	-0.240	-0.240	-0.240	0.0	0.0	396	55
50.50	1.700	-0.240	-0.240	-0.240	0.0	0.0	409	59
51.00	1.333	-0.240	-0.240	-0.240	0.0	0.0	421	62
51.50	0.967	-0.240	-0.240	-0.240	0.0	0.0	433	66
52.00	0.600	-0.240	-0.240	-0.240	0.0	0.0	448	70
52.50	0.280	-0.240	-0.240	-0.240	0.0	0.0	462	73
53.00	-0.040	-0.240	-0.240	-0.240	0.0	0.0	476	77
53.31	-0.240	-0.240	-0.240	-0.240	0.0	0.0	484	79
53.50	-0.360	-0.345	-0.334	-0.333	3.2	3.0	491	81
54.00	-0.680	-0.555	-0.407	-0.334	10.0	7.1	499	83
54.50	-1.000	-0.854	-0.384	-0.336	15.8	14.0	503	84
55.00	-1.320	-1.063	0.146	0.195	15.2	27.7	498	83
55.50	-1.640	-1.072	0.321	0.333	16.0	20.5	498	82
56.00	-1.960	-1.073	0.307	0.334	15.7	15.5	501	83
56.50	-2.280	-1.077	0.323	0.335	15.7	16.0	503	84
57.00	-2.600	-1.074	0.311	0.337	15.7	15.5	506	85
57.50	-2.200	-0.199	0.161	0.335	24.3	28.0	501	83
58.00	-1.800	-0.104	0.236	0.328	34.7	36.8	490	80
58.50	-1.400	-0.167	0.189	0.324	35.0	33.6	480	78
59.00	-1.000	-0.139	0.209	0.316	34.6	35.2	470	75
59.50	-0.600	-0.169	0.189	0.312	34.6	34.0	460	73
60.00	-0.200	0.040	0.207	0.306	31.7	33.7	450	70
60.50	0.200	0.287	0.305	0.306	15.6	19.5	451	70
60.63	0.302	0.302	0.300	0.313	7.6	8.1	453	71
61.00	0.600	0.315	0.315	0.315	0.0	0.5	463	73
61.50	0.967	0.322	0.322	0.322	0.0	0.2	477	77
62.00	1.333	0.328	0.328	0.328	0.0	0.2	490	80
62.50	1.700	0.336	0.336	0.336	0.0	0.3	503	84
63.00	1.333	0.343	0.343	0.343	0.0	0.3	516	87
63.50	0.967	0.350	0.350	0.350	0.0	0.3	528	91
64.00	0.600	0.356	0.356	0.356	0.0	0.3	540	95
64.37	0.363	0.363	0.363	0.363	0.0	0.3	549	97
64.50	0.280	0.347	0.357	0.367	6.7	5.9	551	98
65.00	-0.040	0.272	0.332	0.364	16.6	15.4	553	99
65.50	-0.360	0.176	0.297	0.363	25.2	23.7	551	98
66.00	-0.680	0.060	0.271	0.360	31.0	29.5	545	96
66.50	-1.000	-0.175	0.200	0.355	38.0	34.7	537	94
67.00	-1.320	-0.090	0.247	0.349	35.1	36.6	526	91
67.50	-1.640	-0.134	0.211	0.344	35.6	34.5	517	88
68.00	-1.960	-0.118	0.225	0.338	35.3	35.6	507	85
68.50	-2.280	-0.140	0.208	0.333	35.2	34.7	498	82
69.00	-2.600	-0.138	0.209	0.327	35.0	34.9	488	80
69.50	-2.200	-0.151	0.201	0.322	34.8	34.5	478	77
70.00	-1.800	-0.156	0.197	0.315	34.6	34.4	468	75
70.50	-1.400	-0.166	0.191	0.311	34.5	34.2	458	72
71.00	-1.000	-0.173	0.185	0.303	34.3	34.0	447	69

71.50	-0.600	-0.183	0.179	0.298	34.1	33.8	437	67
72.00	-0.200	0.027	0.189	0.293	31.0	32.9	429	65
72.50	0.200	0.277	0.292	0.294	15.0	19.1	429	65
72.62	0.292	0.292	0.291	0.301	7.2	8.0	431	65
73.00	0.600	0.302	0.302	0.303	0.0	0.4	441	68
73.50	0.967	0.309	0.309	0.309	0.0	0.2	456	71
74.00	1.333	0.317	0.317	0.317	0.0	0.3	470	75
74.50	1.700	0.324	0.324	0.324	0.0	0.3	483	79
75.00	1.333	0.332	0.332	0.332	0.0	0.3	496	82
75.50	0.967	0.339	0.339	0.339	0.0	0.3	509	86
76.00	0.600	0.346	0.346	0.346	0.0	0.3	521	89
76.39	0.353	0.353	0.353	0.353	0.0	0.3	531	92
76.50	0.280	0.340	0.349	0.358	6.3	5.7	533	92
77.00	-0.040	0.264	0.322	0.354	16.2	15.0	536	93
77.50	-0.360	0.166	0.287	0.353	25.0	23.4	534	93
78.00	-0.680	0.049	0.261	0.350	30.8	29.2	528	91
78.50	-1.000	-0.190	0.191	0.345	37.7	34.4	519	88
79.00	-1.320	-0.104	0.237	0.338	34.8	36.3	508	85
79.50	-1.640	-0.148	0.201	0.334	35.3	34.2	499	83
80.00	-1.960	-0.132	0.214	0.328	34.9	35.3	489	80
80.50	-2.280	-0.154	0.198	0.322	34.9	34.3	479	78
81.00	-2.600	-0.153	0.199	0.316	34.6	34.6	469	75
81.50	-2.200	-0.165	0.191	0.312	34.5	34.2	459	72
82.00	-1.800	-0.170	0.187	0.305	34.3	34.1	449	70
82.50	-1.400	-0.183	0.179	0.298	34.1	33.8	439	67
83.00	-1.000	-0.188	0.175	0.294	33.9	33.7	430	65
83.50	-0.600	-0.198	0.169	0.287	33.7	33.5	421	62
83.88	-0.295	-0.295	-0.295	-0.295	22.4	3.8	429	65
84.00	-0.200	-0.200	-0.205	-0.185	0.0	13.6	430	65
84.50	0.200	0.200	0.196	0.196	0.0	13.9	433	66
85.00	0.600	0.303	0.303	0.303	0.0	3.9	445	69
85.50	0.967	0.311	0.311	0.311	0.0	0.3	459	72
86.00	1.333	0.319	0.319	0.319	0.0	0.3	473	76
86.50	1.700	0.326	0.326	0.326	0.0	0.3	486	79
87.00	1.333	0.334	0.334	0.334	0.0	0.3	499	83
87.50	0.967	0.341	0.341	0.341	0.0	0.3	512	86
88.00	0.600	0.348	0.348	0.348	0.0	0.3	524	90
88.38	0.355	0.355	0.355	0.355	0.0	0.3	534	93
88.50	0.280	0.341	0.351	0.360	6.4	5.8	536	93
89.00	-0.040	0.265	0.324	0.356	16.3	15.1	539	94
89.50	-0.360	0.168	0.289	0.355	25.0	23.5	537	94
90.00	-0.680	0.050	0.263	0.352	30.8	29.3	531	92
90.50	-1.000	-0.188	0.192	0.347	37.8	34.4	522	89
91.00	-1.320	-0.101	0.238	0.340	34.8	36.3	511	86
91.50	-1.640	-0.146	0.203	0.335	35.3	34.2	502	84
92.00	-1.960	-0.130	0.216	0.329	35.0	35.3	492	81
92.50	-2.280	-0.152	0.200	0.324	34.9	34.4	482	78
93.00	-2.600	-0.150	0.201	0.318	34.7	34.7	472	76
93.50	-2.200	-0.163	0.192	0.314	34.5	34.2	462	73
94.00	-1.800	-0.168	0.189	0.307	34.3	34.2	452	71
94.50	-1.400	-0.180	0.181	0.300	34.1	33.8	442	68
95.00	-1.000	-0.185	0.176	0.296	33.9	33.8	432	66

E4-7

95.50	-0.600	-0.195	0.171	0.289	33.8	33.5	424	63
96.00	-0.200	0.021	0.181	0.284	30.6	32.5	416	61
96.50	0.200	0.269	0.283	0.284	14.6	18.6	417	61
96.60	0.283	0.283	0.281	0.291	6.8	7.5	416	61
97.00	0.600	0.291	0.292	0.293	0.0	0.4	415	60
97.50	0.967	0.291	0.292	0.292	0.0	0.0	414	60
98.00	1.333	0.290	0.291	0.291	0.0	0.0	413	60
98.50	1.700	0.290	0.290	0.291	0.0	0.0	412	60
99.00	1.333	0.289	0.290	0.290	0.0	0.0	412	59
99.50	0.967	0.288	0.289	0.289	0.0	0.0	411	59
100.00	0.600	0.288	0.288	0.289	0.0	0.0	410	59
100.49	0.288	0.287	0.288	0.288	0.0	0.0	409	59
100.50	0.280	0.280	0.287	0.287	1.9	0.2	409	59
101.00	-0.040	0.191	0.239	0.283	12.4	10.7	401	57
101.50	-0.360	0.103	0.225	0.272	22.8	21.7	386	52
102.00	-0.680	-0.067	0.157	0.259	28.5	25.7	368	48
102.50	-1.000	-0.326	0.114	0.243	34.5	31.5	344	42
103.00	-1.320	-0.232	0.105	0.225	31.9	32.3	318	36
103.50	-1.640	-0.316	0.095	0.205	31.9	30.8	291	30
104.00	-1.960	-0.350	0.075	0.186	30.6	29.8	262	24
104.50	-2.280	-0.384	0.056	0.163	29.8	29.0	231	19
105.00	-2.600	-0.429	0.033	0.138	28.9	28.0	195	13
105.50	-2.200	-0.484	0.008	0.107	27.9	26.7	154	8
106.00	-1.800	-0.562	-0.020	0.070	26.4	25.0	101	4

SCHEMATIC DRAWING



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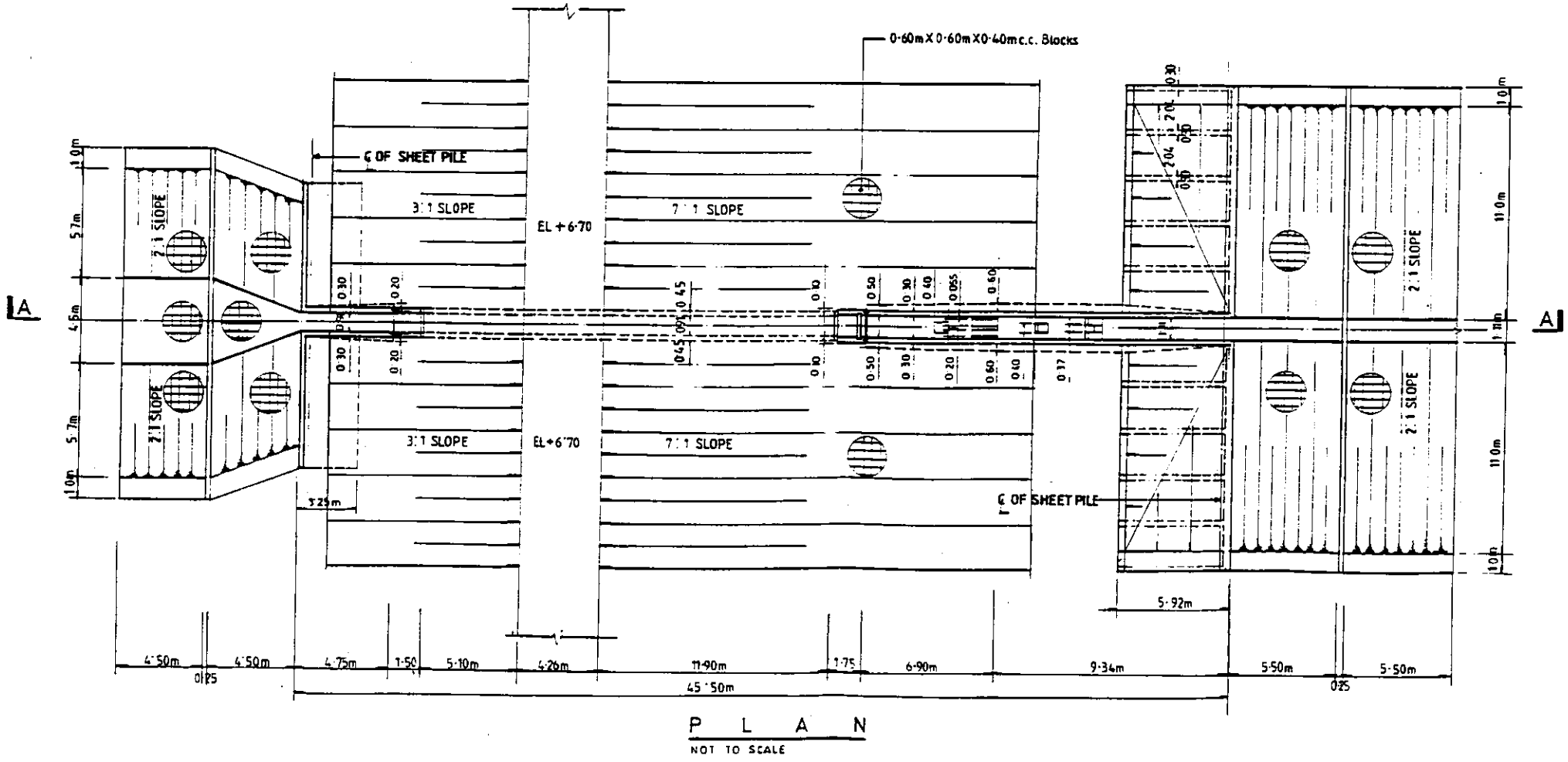

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PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

CYCLONE PROTECTION PROJECT II

PROJECT PREPARATION REPORT, ANNEX II

STRUCTURE, 1 VENT

KAMPSAX INTERNATIONAL A/S, BCEOM and DANISH HYDRAULIC INSTITUTE
in association with
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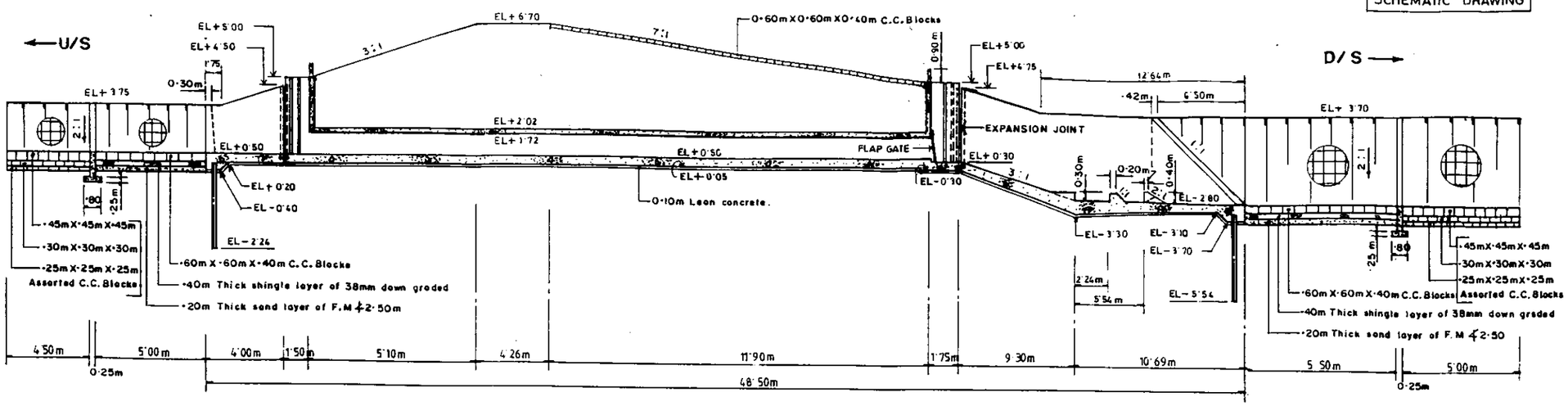
DATE: 01-02-1992

ENCLOSURE 5

SCHEMATIC DRAWING



SECTION A-A

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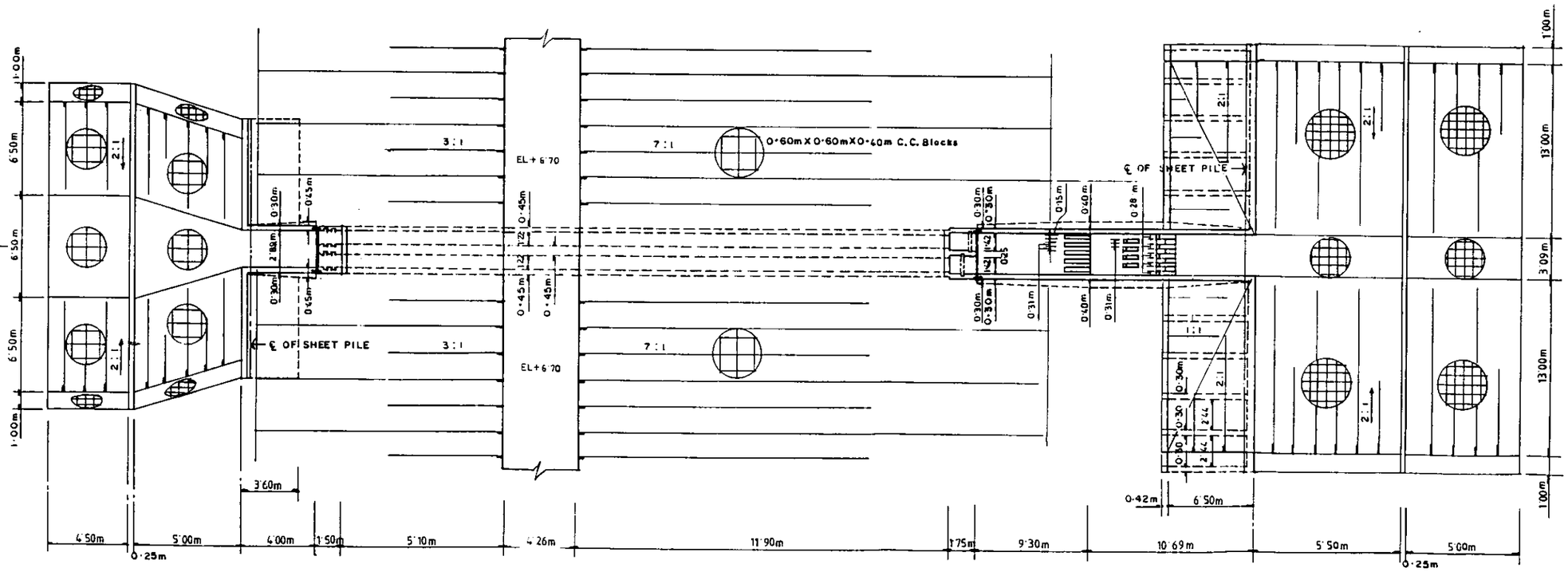

PLAN

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MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

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STRUCTURE, 2 VENTS

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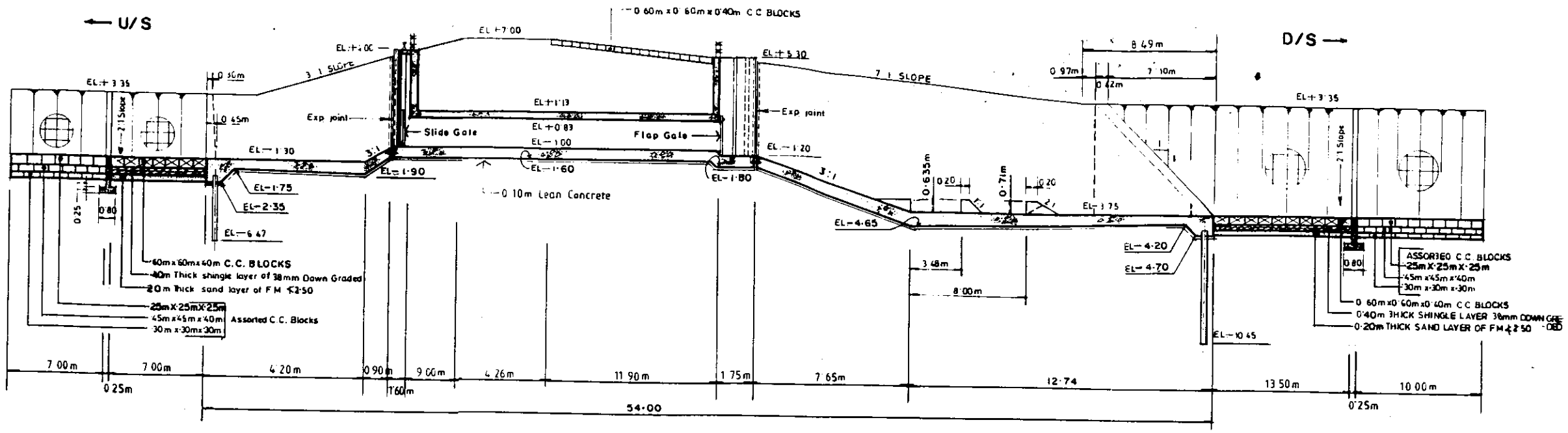
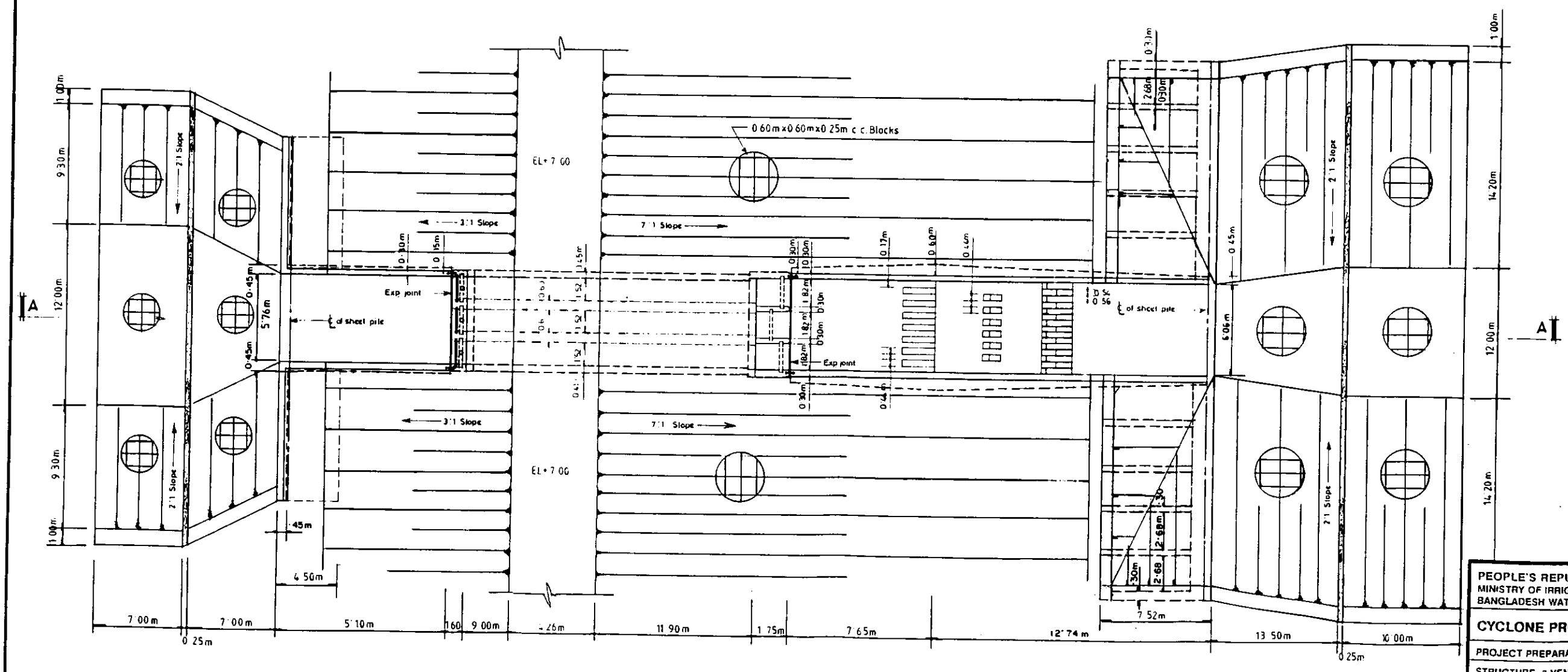
ENCLOSURE 6

SCHEMATIC DRAWING



SECTION A-A
NOT TO SCALE



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BANGLADESH WATER DEVELOPMENT BOARD

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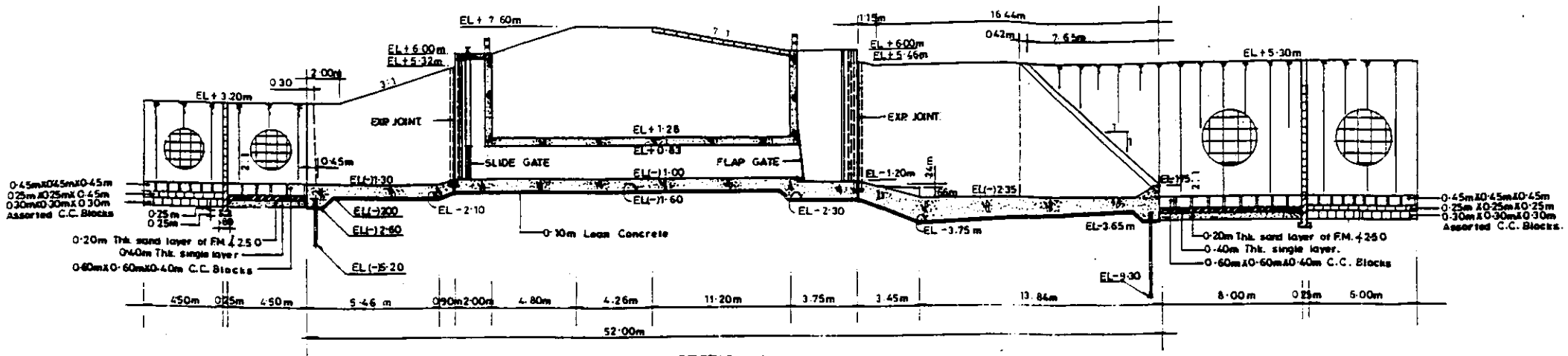
ENCLOSURE 7

SCHEMATIC DRAWING



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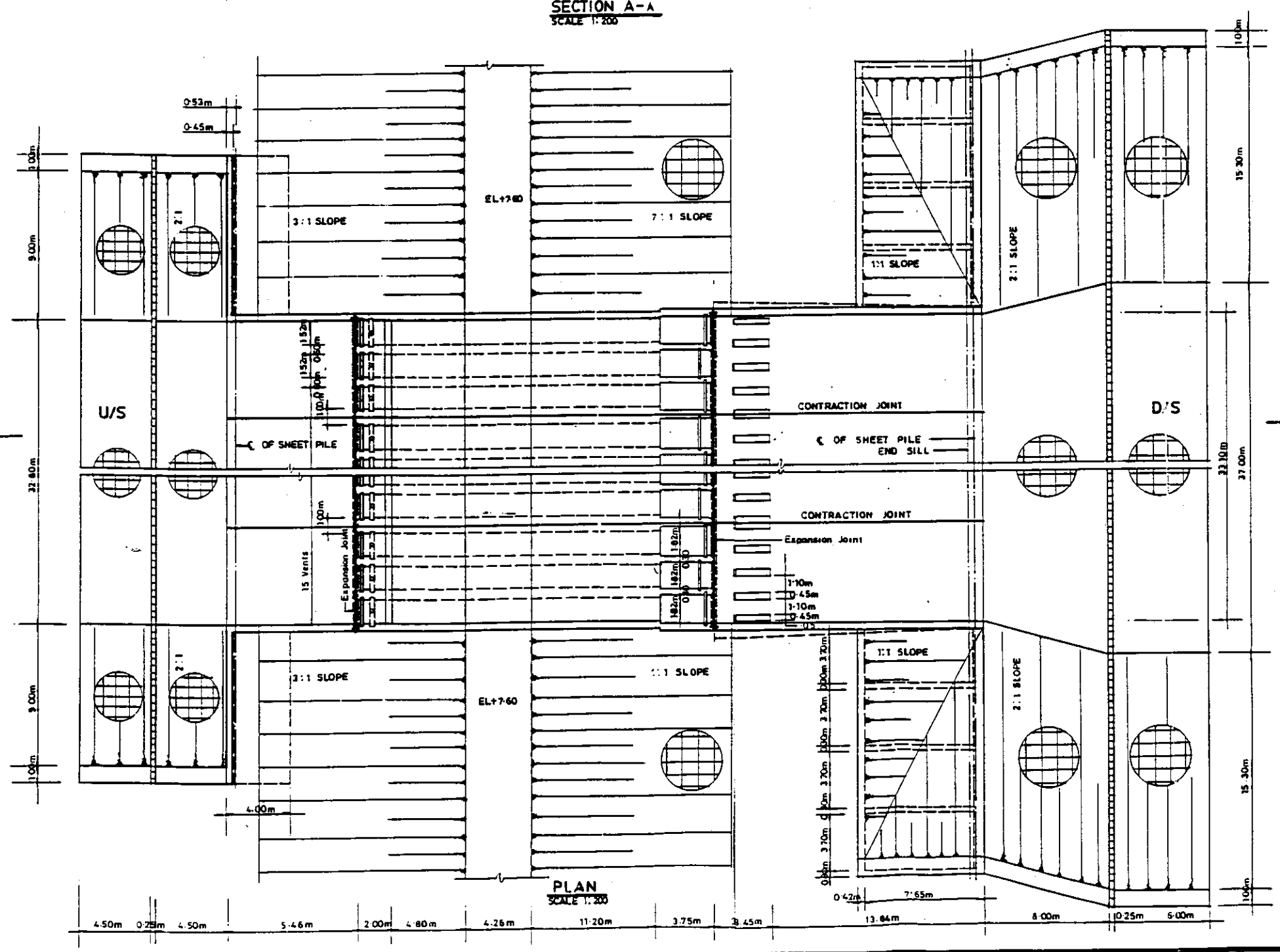

PLAN
SCALE 1:200

PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

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ENCLOSURE 8

PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

CYCLONE PROTECTION PROJECT II

PROJECT PREPARATION REPORT, ANNEX II

CLIMATOLOGICAL DATA

KAMPSAX INTERNATIONAL A/S, BCEOM and DANISH HYDRAULIC INSTITUTE
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DATE: 01-02-1992

ENCLOSURE **9**

Stations	Features	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Khulna	Mean Monthly Max.Temp(°C)	26.3	28.9	34.2	35.6	34.4	32.6	30.8	31.2	31.1	30.9	28.8	26.6
	Mean Monthly Min.Temp(°C)	11.1	16.2	21.2	24.9	25.8	26.4	26.1	26.3	25.8	24.4	19.0	14.6
	Mean Monthly Humidity (%)	62	59	60	65	74	83	84	83	81	78	72	73
	Mean Monthly Evaporation (mm)	58	72	107	136	138	95	84	80	77	83	77	67
	Mean Monthly Evapotranspiration (mm/day)	3.4	4.2	5.6	5.9	5.3	4.0	3.9	3.9	4.0	3.9	3.9	3.1
Barisal	Mean Monthly Max.Temp(°C)	24.9	27.3	32.3	35.4	33.8	32.2	31.6	31.6	31.4	31.2	28.8	25.9
	Mean Monthly Main.Temp(°C)	10.3	12.3	16.7	21.2	23.7	25.3	26.2	26.0	25.5	22.3	16.1	11.7
	Mean Monthly Humidity (%)	60.0	56.0	56.0	66	74	82	83	83	82	77	69	64
	Mean Monthly Evaporation (mm)	74	91	139	162	167	131	132	133	127	120	91	70
	Mean Monthly Evapotranspiration (mm/day)	2.87	4.1	5.26	5.91	5.5	4.21	4.40	4.23	4.26	3.96	3.70	3.05
Chittagong	Mean Monthly Max.Temp(°C)	25.9	28.2	30.8	32.1	32.3	31.1	30.5	30.7	31.4	31.0	29.1	26.5
	Mean Monthly Min.Temp(°C)	14.3	16.6	20.4	23.8	25.0	25.2	25.2	25.1	25.1	24.0	19.8	15.5
	Mean Monthly Humidity (%)	68	65	66	76	82	87	86	86	85	82	75	71
	Mean Monthly Evaporation (mm)	84	97	127	136	133	109	97	97	92	97	88	84
	Mean Monthly Evapotranspiration (mm/day)	2.35	4.02	4.93	5.93	5.70	4.42	4.78	4.56	4.52	4.02	3.49	2.99
Cox's Bazar	Mean Monthly Max.Temp(°C)	26.4	28.1	30.5	31.8	32.1	30.3	29.6	29.6	30.4	30.8	29.3	26.9
	Mean Monthly Min.Temp(°C)	14.7	16.3	20.4	23.1	25.4	25.6	25.0	24.8	24.9	24.1	20.4	16.2
	Mean Monthly Humidity (%)	68	65	66	75	81	87	88	86	84	80	74	70
	Mean Monthly Evapotranspiration (mm/day)	3.99	4.84	5.55	6.23	6.26	4.47	4.46	4.26	4.50	4.39	4.27	3.72

Enclosure 9.1 : Climatological Data of Coastal Area

Month		Rainfall in mm at Indicated Station										
		Satk -hira R518	Khulna R510	Barg -una R256	Patua -khali R266	Barisal R258	Noak -hali R369	Mirs -arai R320	Sand -wip R331	Chi- ttag- ong R306	Kutub -dia R316	Cox's Bazar R307
Jan	Max	79.25	91.19	116.59	138.43	105.41	83.57	87.12	223.77	68.33	124.46	88.14
	Mean	12.95	14.22	9.65	10.92	12.95	7.62	5.84	7.11	8.89	9.65	7.37
Feb	Max	136.65	114.81	103.63	119.89	83.82	183.90	102.87	88.90	227.33	148.84	108.97
	Mean	23.88	21.34	18.80	26.42	19.05	21.34	20.83	19.81	27.69	18.29	13.97
Mar	Max	204.98	212.09	264.92	452.37	212.60	234.44	316.74	343.15	377.44	598.93	345.95
	Mean	38.35	37.85	46.74	64.77	41.66	53.34	52.32	39.62	60.20	57.40	32.00
Apr	Max	217.93	270.76	454.41	378.71	320.29	398.53	414.78	398.02	680.72	351.03	290.83
	Mean	69.09	87.12	79.50	117.09	105.92	129.79	148.08	112.78	145.80	118.11	90.93
May	Max	677.93	529.84	638.30	939.55	521.72	814.32	528.07	668.78	634.75	920.24	966.72
	Mean	178.56	178.05	214.12	294.89	203.71	300.99	259.08	247.90	255.78	291.34	297.18
Jun	Max	901.45	725.93	1775.97	1780.54	1038.86	882.90	1245.87	944.88	1100.07	1257.05	1654.56
	Mean	319.28	311.40	571.75	563.12	431.04	535.43	579.12	486.41	525.02	646.43	777.246
Jul	Max	755.40	638.30	1725.93	1269.24	1116.84	1019.56	1045.72	1305.56	1527.05	1497.84	1432.31
	Mean	364.49	350.77	670.81	686.82	464.82	588.26	635.00	623.57	642.87	792.48	942.34
Aug	Max	499.36	548.39	1129.54	1064.01	782.07	1584.45	1173.99	1607.82	1271.27	1553.46	1676.91
	Mean	297.43	297.94	562.36	582.17	391.41	601.98	624.84	582.42	571.50	727.71	746.76
Sep	Max	530.61	478.79	807.21	701.29	719.07	906.02	835.15	1079.75	997.46	857.25	786.13
	Mean	233.68	203.71	316.99	407.16	277.11	441.96	414.02	410.46	354.33	381.00	416.10
Oct	Max	368.81	532.89	371.50	864.36	598.17	431.80	485.39	543.56	636.27	403.86	984.00
	Mean	129.29	133.86	254.76	288.80	186.44	206.25	183.39	204.98	218.44	179.83	241.30
Nov	Max	87.63	218.19	147.32	262.89	258.06	242.82	265.18	378.46	267.21	5.59	489.46
	Mean	21.34	25.65	29.72	45.21	35.81	40.13	37.85	44.70	52.58	9.14	72.64
Dec	Max	34.04	58.93	53.34	145.29	134.87	62.99	129.03	118.11	127.00	241.30	423.93
	Mean	3.05	3.81	7.62	12.19	5.84	6.60	7.87	6.10	13.46	21.59	19.81
Ann -ual	Max	2518.41	2689.35	5204.97	4841.49	3204.97	3997.96	3855.72	4533.14	4276.60	4776.72	5742.18
	Mean	1696.72	1697.74	2762.00	3076.96	2153.92	2964.94	3049.52	2781.05	2905.00	3318.76	3703.83
	Min	1120.39	1213.10	1457.20	1877.31	1460.50	1754.63	1359.41	1324.61	1701.04	2107.95	2443.48

Enclosure 9.2: Rainfall Data of Coastal Area

ANNEX III

AGRICULTURE

III. AGRICULTURE

3.1 Introduction

Bangladesh lies in the delta region formed where the rivers Ganges and the Jumuna merge together to form the Meghna on the final stretch to the sea in the Bay of Bengal. The land is largely flat and fertile and has a typical tropical monsoon climate, with temperatures varying from 4 degrees centigrade in the winter to almost 40 degrees in the summer. Relative humidity is high (80% to 90%).

Agriculture is an important sector in the Bangladeshi national economy, providing half of the nations GDP and 40% of its export earnings as well as providing employment to 60% of the population. However, agricultural productivity is low in the coastal belt. This is due to salinity problems, poor communication, extension service and credit facilities. These constraints are compounded by natural calamities, such as cyclones, storm surges and floods, which can cause devastating damage to property, crops, livestock as well as human lives.

Coastal embankments have been constructed in the endeavour to protect the low lying land along the coastal belt from intrusion and inundation by saline waters and thereby increase cultivable land, cropping intensity and yields.

3.2. Soils

The soils in the project area are mainly of Calcareous and Noncalcareuos Alluvial or Flood Plain soil types. The soils are generally classified as poor to moderately good agricultural land, containing various levels of salinity, with the highest levels closest to the coast on newly accreted land. The salinity level drops with increasing distance to the coast.

Strong embankments and protection against intrusion of saline water and flooding would raise the productivity of all classes of soils in the project area.

3.3 Land Use

Of the projects total gross area of 401,000 ha., 312,000 ha. (78.5% of the gross area) is cultivated. The rest is utilized for homesteads, markets, schools, roads, embankments, water bodies etc.

The main crop for the area is the Aman rice of which the local variety of transplanted T.Aman is by far the most dominant. Lack of sufficient irrigation water and high salt contents in the soils inhibits the utilisation of the soils during the dry season. Where cultivation is possible, due to

sufficient residual moisture or irrigation facilities, vegetables, pulses chillis and to some extent wheat are grown.

3.4 Farming Practices

The Agricultural calender is divided into two principal seasons : the Kharif or pre-monsoon (Kharif I) and monsoon (Kharif II) period from March to November and the Rabi season which is the dry and cold period from November to March.

Aman rice varieties are the predominant crops during the Kharif season. In areas where sufficient moisture is available for land preparation Aus rice is planted in the pre-monsoon period and harvested in July. This crop is then immediately followed by the transplanted Aman rice.

If the soil moisture content is still high after the Aman crop, Rabi crops (pulses, vegetables, chillis, mustard and wheat etc.) are planted. Yields from these Rabi crops will vary depending on a range of factors like, watering facilities, salinity level in the soils, quality of seed material etc.

Where sufficient irrigation water is made available Boro rice (winter rice) is planted. This is especially common under the different irrigation schemes under BWDB.

3.5 Present Cropping Patterns.

The cropping patterns in the project area are conditioned by flooding characteristics (depth and timing), topography, rainfall pattern and the quality of the soils. The development of the agricultural infrastructure, such as irrigation and drainage facilities, Institutional set-up, credit and marketing facilities also play an important role in the selection of cropping patterns.

Of the total 312,000 ha. under cultivation in the project area, 215,000 ha. or 70% is single cropped, 87,000 ha. (27%) is double cropped and only 10,000 ha. (0.3%) is triple cropped. This means that the cropping intensity is 134% in the project area as compared to the national average of 150%.

Rice is by far the most dominant crop, occupying almost 87% of the total cropped area, of which T. Aman alone accounts for the 62%. Winter crops comprise the remaining cropped area.

3.6 Constraints to the present Agricultural Production.

Not only is the cropping intensity in the project area lower than the national average, but so are the average yields from the different crops grown. There are a wide range of reasons for the low productivity level of which the most important are listed below:

- High salinity levels in the soils, which inhibits plant growth
- Limited water resources and inadequate management of the potential resources.
- Large land ownership, which leads to the lack of interest from the shareholder to invest in land improvement due to the shareholding system.
- Poor communication facilities hampering services such as extension, credit and marketing.
- Limited knowledge of improved technology by the farmers.
- Poor quality draught power due to poor management and lack of fodder.

3.7 Projected Cropping Patterns.

Protection of crops against natural hazards like storm surges and flash floods and improvement of irrigation and drainage as well as of the communication and institutional facilities could increase agricultural production immensely in the project area.

It is anticipated that the cropping patterns will be very much the same, but more land will come under double and triple cropping. It can be expected that the cropping intensity will increase from the current 134% to reach the national average of approximately 152%.

3.8 Projected Production and Input Levels.

With a better protection of crops against losses incurred due to natural disasters as well as the improvement of communication and infrastructure it is anticipated that crop yields / ha. will also increase to at least the national average.This increase will not only be attributed to improved farming practices adapted through the extension system, but also because of a increased utilization of credit facilities, marketing possibilities and an increase in the use of improved seeds and chemical fertilizers and pesticides.

ANNEX IV

FISHERIES

IV FISHERIES

4.1. Introduction

Macroeconomic Contribution

Fisheries subsector contributes 3.5 per cent of the country's GDP. Within the agriculture sector, fisheries accounts for about 10 per cent of the gross value added. The subsector contributes about 80 per cent to the nation's animal protein intake. There are over 1.2 million commercial fishermen; out of which 60 per cent are in inland fisheries and 40 per cent in marine fisheries. Around 9.5 million households or about 64 per cent of all the households in Bangladesh get involved in the seasonal or part-time fishing in floodplains during the monsoon months. The share of fisheries in the total export earnings is about 12 per cent and currently occupies the third highest position after jute and readymade garments.

Fisheries Resources and Production

Bangladesh has extensive water resources within her boundaries and the territorial and economic zones in the Bay of Bengal. The water resources are broadly divided into inland and marine resources. In 1987-88, the area of inland fisheries totaled 4.3 million ha, of which 94 per cent was open water capture areas (which accounted for 71 per cent of inland fish production) and the remaining 6 per cent was closed water culture fisheries (29 per cent of inland fish production). In case of marine fisheries, Bangladesh has a coastal belt of 480 km. Fishing area is estimated to be 14,000 km2. Marine fish catch is divided into industrial and artisanal. The artisanal fishery extends upto a depth of 40m in the Bay and harvests more than 95 per cent of the total marine landings.

Types of Fisheries

There are two types of fisheries in the project coastal zone: (1) capture (open water fisheries) and (2) culture (closed water) fisheries. Broadly, culture fisheries are of two types in the project areas: (a) fish culture and (b) shrimp culture. Shrimp culture is again of two types: (i) freshwater shrimp culture and (ii) brakishwater shrimp culture.

4.2 Open Water Fisheries

The former greater coastal districts of Chittagong, Noakhali, Barisal, Patuakhali and Khulna, which together amount to some 14000 km2, cover the project area. The total area of rivers and estuaries in the project area is 642902 hectares, corresponding to 62 percent of the area under rivers and estuaries of Bangladesh.

The project area's share is around 40 per cent of the total capture fish from the inland open water sources in Bangladesh. In case of rivers and estuaries, the project share is more than 61 per cent of Bangladesh total.

4.3 Shrimp Cultivation and Aquaculture

The project area has 49265 hectare of pond fishery area, which accounts for onethird of the total area of fish ponds in Bangladesh. More than 99% of the shrimp farm area of Bangladesh is in the project area.

61% of the total pond area in the project districts are cultured, 29% are culturable and the remainder 10% are derelict. Fish production from pond aquaculture in the project area corresponds to 36% of the total pond fish production in Bangladesh).

In recent years coastal aquaculture has expanded rapidly in Bangladesh because of its profitability and the high expectation of a continuing good export market. A total of 108.3 thousand hectare of coastal area have been under shrimp cultivation in the traditional manner yielding 251 kg/ha. Bangladesh exported 17505 metric tons of shrimp and earned foreign exchange worth Tk. 4143 million during 1989-90 (Bhuiyan 1992).

Trapping and growing of shrimps and fish in the tidal channels and low lying intertidal areas has been an age long practice in the coastal areas of old Khulna district. This practice was interrupted during the 1960's by the construction of coastal embankments to create polders in the interest of rice production. With the increasing demand and high price of shrimp in the international markets, shrimp farming in the traditional way of trapping and growing started and expanded rapidly in the low lying areas inside and outside the polders in the Khulna and Cox's Bazar regions in the post Liberation period.

4.4 Current Status of Aquaculture in the Project Area

Shrimp farming alone contributes more than 80 percent of the total foreign exchange earnings from fishery products, which is the third largest source of foreign exchange earnings of the country. The major coastal acquacultural activities include trapping and growing of shrimp and fish in the low lying areas inside and outside the polder in the Khulna and Cox's Bazar regions. Slender peripheral earthen dykes with improvised sluice gates for intake and discharge of tidal waters are generally constructed around the farming areas. Shrimp/fish larval and juveniles coming with the incoming tidal waters are trapped, grown and ultimately harvested after a period of time.

Trapping and growing of shrimp has opened up an avenue for better utilization of the land. Even after being poldered, the land in the Khulna region, in general remains a monocrop area, producing rice during the

Kharif season; the land stays fallow during the rest of the year. The land in the Cox's Bazar region is utilized for salt manufactured in the dry season and used to remain fallow during wet months. Now, the majority of farmers in the Khulna region cultivate shrimp in rotation with rice, growing shrimp from January to the end of July and rice from August to December. In the Cox's Bazar region, salt is manufactured from December/January to June and shrimp from July to November. Thus, there has been year round utilization of land with the introduction of shrimp culture.

In areas where shrimp and rice are grown together or side by side, conflicts may arise when shrimp farming imposes new or unwanted conditions upon adjacent rice fields. The direct effects of shrimp farming on adjacent rice fields depend on local conditions and water control systems. While these effects may harm HYV rice in the winter, the cultivation of Aman rice on land that had been flooded with saline water during winter is possible and is currently in practice in the Khulna region.

4.5 Constraints to Development of Aquaculture

Constraints to the development of coastal aquaculture in Bangladesh have been identified by ASR/UNDP (1989). Out of those constraints, the following below relates to cyclones and tidal bores:

- High tidal amplitude leads to soil erosion and washes away the essential natural food.
- Frequent cyclones accompanied by tidal bore in recent years make any capital investment very risky.
- Change in the ecological condition of the coastal areas through conversion of mangroves to ponds. Mangroves are believed to be important breeding and nursery grounds for many aquatic species which are later caught in the nearshore areas by capture fisheries.

4.6 Mangrove and Shrimp Cultures

Bangladesh has a continuous coastal line along the Bay of Bengal, which is about 710 km in length. It supports about 587,380 ha of natural mangrove forests and a further 24,120 ha of planted mangrove forests (Mahmood, 1986).

The mangroves are believed to be important breeding and nursery grounds for many aquatic species that are later caught in the nearshore areas. Moreover, inter alia, they are supposed to play a vital role in -

- Creating a protection belt along the sea coast;
- Protecting the coastal fisheries against cyclones and storm surges.

Inspite of the above there are institutional weaknesses that encourage the

conversion of mangroves to shrimp culture under private ownership or use rights. Positive correlations have been found between the extent of mangroves and the size of shrimp fishery in adjacent waters in several countries. The potential fisheries losses that may occur by clear cutting the mangroves are usually understated, if stated at all, in cost/benefit studies of coastal aquaculture. Other traditional users of mangroves areas such as shellfish gatherers, charcoal makers and nipa palm or golpata growers are frequently ignored in these calculations, though the value of these activities may be substantial.

4.7 Potential Impact of Project on Fisheries

Positive Impact

The potential positive impact of the project on fisheries will mainly be in the form of protection, extension and improvement of cultural fisheries:

Cultural fisheries resources (shrimp farming, pond aquaculture) inside the embankment will be protected from floods and cyclonic surges. In the absence of embankments for cyclone protection, the ponds and shrimp farms in the project areas are subject to overflow of their bunds during cyclonic surges and floods. Ponds and shrimp farms are likely to be less prone to such overflow if sea defence and associated water control structures are rehabilitated, improved or extended. In the past the owners were hesitant and even reluctant to stock their ponds and apply inputs because of the perceived risks, this risky situation has improved today after the construction of coastal embankments. The proposed project will further improve the situation. More and more culturable and derelict ponds are expected to be brought under fish culture with the implementation of project. In general, the level of technology use in coastal aquaculture will be improved in the risk-free situation.

High tidal amplitude causes soil erosion and washes away the essential natural food for shrimp. The project will help solution of this problem.

Negative Impact

There are evidences that construction of coastal embankments have eliminated or reduced the periodically available nursery and grazing grounds (during the high tides) for the young and juveniles for a number of marine and estuarine shrimp and fin fish (MPO 1987).

4.8 Economic Effects of Project Impact on Fisheries

More accurate social and economic data are required for actual estimation of economic effect of the project impact on the fisheries sector. However, from the available evidences and potential positive and negative impacts described in this report, it appears that the net economic effect of project

impact on the fisheries subsector would be positive. In fact, the economic value of the positive impact of the project in the form of protection, expansion and improvement of cultural fisheries is expected to be substantially greater than that of the negative impact on open water fisheries.

ANNEX V

INDUSTRIAL PRODUCTION

V. INDUSTRIAL PRODUCTION

5.1 Industrial Production at Chittagong

Polder 62, Patenga, which is a part of Chittagong, is different from the other polders covered by CPP II. The main reason for this is that Patenga has the highest concentration of industrial production in Bangladesh. Two major industrial centres are situated there: The Patenga Industrial Area and The Industrial Export Processing Zone of Bangladesh.

Among the major industries in the Patenga Industrial Area should be mentioned Chittagong Steel Mill, General Electrical Manufacturing, Eastern Cable, Chittagong Cement Factory, Eastern Refinery and the Triple Super Phosphate Complex.

The Bangladesh Export Processing Zone (EPZ) was established in 1983. The aim is to attract foreign investment and to create employment opportunities.

The Zone is established in accordance with international well known principles such as tax holidays for 10 years, exception of income taxes on borrowed capital, duty free import of machinery, duty free export of goods etc.

The export processing zone is competing with other similar zones on conditions regarding local salary, stability etc.

The zone covers an area of 412 acres(167 ha) which is divided into plots of 0.5 acre. The land is developed and the zone authority is leasing the land to the industries on a 30 years term with possibility for extension.

As of October 1991, 74 industries have been approved. Out of which 39 are in operation in October 1991. The remaining ones are expected to commence production within half a year. There are presently employed 9,600 workers in the factories.

The Consultant has been informed that when all the aforesaid industries are established the value of all the investment is expected to reach 473 million USD.

Due to the low labour cost industrial production of garments is a dominating activity. But other productions requiring a relatively high labour input are also established in the Export Processing Zone.

The yearly turnover for the major industries will within a few years reach a level of approximately 16,000 million Taka and the value added will

reach almost 5,000 million Taka including the industries in the Export Processing Zone. In view of the above it is clear that the agricultural aspect should be given limited considerations when looking at the present project from the development point of view. Consequently, preventive measures against inundation should primarily be constructed with the aim of protecting industrial production.

The benefits from protection of industrial production in the area can be divided into 3 groups:

- saved damages to industrial buildings
- saved damages to production equipment, raw material and products
- saved losses in value added in connection with down-time periods caused by the inundation.

The above benefits are estimated on the basis of the losses incurred by the April 1991 cyclone.

During the cyclone saline water inundated both the Export Processing Zone and Chittagong Industrial Area. The down time was between 1 and 4 months.

The total industrial losses incurred by the April 1991 cyclone has on this basis been estimated at:

Direct losses	3200 million Taka
Down time	620 million Taka
Total	3820 million Taka

In addition to the above should be added loss related to the cottage industry and infrastructure amounting to approximately 200 million Taka.

A separate feasibility study of the Patenga area has been carried out. The study showed that even under conservative estimates the proposed solution will yield a EIRR between 50 to 60%.

For further details reference is made to Appendix I: Feasibility Study on Patenga Project.

5.2 Salt Production in Cox's Bazar

Of the 2.85 million hectare of the coastal areas about 0.87 million hectare is saline, the degree of salinity ranges from moderate to very high. Crop production during dry season is limited in these areas due to serious lack of quality irrigation.

A sizable portion of such areas are situated in the coastal areas of Cox's Bazar. Under polder 66/3 there are four salt centres covering over 50% of the total salt producing areas of Cox's Bazar. The areas of the major salt making centres are:

	Area		Hectar
1.	Gomatali	-	1342
2.	Choufaldandi	-	842
3.	Dulahazra	-	50
4.	Fulchari	-	1321
	Total		3555

The production is related to the size of salt beds used to produce salt. There is no standard size of salt bed, and they vary from 0.4 ha to 2.02 ha. The labour input is 1.5 to 3.5 person per ha.

The price at the producer level is about 2000 Tk.to 2500 Tk. per ton.

The total production has varied over the years. In normal years the annual production is 500.000 ton but in years with late monsoon rains combined with early pre-monsoon rains the production has been as low as 220.000 tons.

Most of the salt producing centres are situated within the embankments. The cost of land is increasing and the investors are minimising the use labour by establishing salt plants with more efficient labourers and paying higher daily wages.

Since 1981 it has become necessary to import salt due to unreliable weather conditions, frequent cyclones, tidal surges etc. causing the investor to be reluctant on new investments.

The 1991 cyclone caused heavy damages to conventional salt stores on the coastal areas.

Total import of salt is shown in Table 5.1

Period	Import	Period	Import
1977-78	17	1984-85	186
1978-79	02	1985-86	345
1979-80	-	1986-87	166
1980-81	-	1987-88	220
1981-82	762	1988-89	376
1982-83	322	1989-90	644
1983-84	517		

Table 5.1 : Total Import of Salt (1000 Ton).

ANNEX VI

AFFORESTATION

VI AFFORESTATION

6.1 Introduction

The following section examines the role that afforestation has played in protecting the coastal embankment against monsoon waves and cyclonic surges, Particular species suitable for foreshore areas and embankment slopes are noted, including those with potential multiple uses, benefitting the local population.

6.2 Existing Afforestation

In the western sector of the project area lies the largest contiguous mangrove forest in the world, the Khulna Sunderbans. A forest reserve of 401,600 hectares has been set aside in this deltaic swamp which is fed by nutrient-laden freshwater form tributaries of the Ganges River and affected by salinity of tidal waters.

The protection by over 100 years of management of Khula Sunderbans reserve contrasts with the Chakarla Sunderban within the Cox's Bazar District. Only 7,500 hectares in area, the mangrove forest was reserved in 1903 to protect human settlements damaged by an earlier cyclone. Since the 1970's over 3000 hectares of the mangrove forest have been converted to shrimp cultivation and illicit felling of trees caused further damage.

Elsewhere in the project area, human habitation and livestock grazing have impaired natural vegetation succession, particularly on newly accreted lands which is unstable and fragile.

In 1975 the Forestry Department embarked upon a major coastal afforestation project whose objectives were to:

- Accelerate the process of siltation and the stabilization of soil
- Create forest shelterbelts to protect embankment, life and property inland from tidal bores
- Create an urgently needed resource to add to the national wealth
- Create job opportunities for the rural communities
- Create an environment for wild life, fishes and other estuaries and marine fauna

By 1990 over 108,000 hectares had been planted of which 35% were in Noakhali Division, 27% in Chittagong Division, 23% in Barisal Division and 15% in Patuakhali Division.

6.3 Protective Performance of Afforestation

Observations indicate that afforestation of the foreland and foreshore areas as well as on the seaward slope of coastal embankment provide very efficient protection against damage by waves generated by high tides and cyclonic surges. This is particularly true of seaward facing embankments of Barisal, Bhola and Muhuri Circles.

In contrast in areas where afforestation is absent, the embankments and their costly protective works are significantly more susceptible to such damage. A condition survey of 33 polders throughout the coastal zone showed that the protection provided by afforestation has been adversely affected in some areas by damage caused by local people's quest for fuelwood. The result has been a substantial thinning of forest cover which is often discontinuous on embankment slopes and foreland, significantly reducing the effectiveness of protection.

6.4 Ongoing Afforestation Programme

The coastal afforestation programme is continuing, albeit at a slower rate than the 1980's, with a further 4066 hectares per year scheduled for 1991 and 1992. Nearly half the planting is allocated to the Noakhali Division (2023 ha per year) with lesser areas designated for afforestation in Chittagong Division (830 ha per year), Barisal Division (809 ha per year) and Patuakhali Division (404 ha per year).

6.5 Species for Afforestation

The primary species used in the Forestry Department's coastal afforestation programme to date have been Acacia arabic (Babla tree), Acacia catechu (Khair tree) on higher land along the slopes of embankment and Sonneratia apatala (Keora), Avicinea officinalis (Baen), Bruguiera gymnorhiza (Kankra) and Nypa fruiticans (Gulpata) in new accretions in lower areas of embankment .

Through cooperation between the Water Development Board (BWDB) and the Forest Department, afforestation on the foreland with mangrove species and other tree species on the slopes of the embankment can be established as protection from tidal waves and cyclonic surges.

Such planting of tree species is considered crucial to stabilization of embankment and foreshores and would provide a fuelwood resource through controlled management. Tree species should have characteristics such as strength and hardiness, deep and well spread root system, rapid growth, heavy branching and regenerative ability, ideally, they should serve several purposes as well as embankment protection eg. providing fuel wood, fodder, timber, food, wind-breaks and soil nutrition.

Detailed lists of recommended species are given in Appendix H.

The turfing of embankments with dubra grass (Cynodon dactyion) can provide good protection against erosion by rain and moderate wave action. However, grazing by animals must be strictly controlled on the embankment and regular maintenance of the grass cover would be necessary.

Local bushes such as Dhol Kalimi (pomea fistu losa), Shada Akanda (Calotropis procera) and Keya (pendenus odoratissima) can be grown on the slope of the embankments and Hogla pata (typha angustata) in the berm also provides good protection of the embankment. These bushes can easily be reproduced by stem and root cuttings and, apart from Hogla pata, are not palatable to livestock.

In areas exposed to erosion, protection can be provided by plantation on the foreland of fruit trees like coconut (cocos nucifera), Date palm (Phoenix dacy-lifera) and Palm tree (Borassus flabellifer) which can grow well in areas affected by salinity. The plantation should be established in belts perpendicular to the embankments to form a system of natural growth. Different types of industries like coconut oil, mattresses, ropes, etc. could be established from the produced coconuts, and juices, molasses etc, could be obtained from date palm and tal palm trees.

In areas where there is greater salinity and regular tidal influences, mangrove species like Keora (Sanneratia apatala), Baen (Avicinea officinalis) Gewa (Excecaria agallocha), Kankra (Bruguiera gymnorhiza) and Gulpata (Nupa frulticans) etc can be successfully planted. In borrow-pits, Gulpata (Nypa frulticans) is the most suitable species.

In the foreland where the sand is more or less stable and fine in texture, longer seedlings of mangrove species can be planted by digging a deep hole where roots of the mangrove seedlings reach the clay soil and can become established.

In the berm and foreland of the sea shore where coarse and moving sand have been accumulated, only species of causarina wauisetifolia and Tamarix galiyoha can be successfully established as was seen earlier at Cox's Bazar Beach and a small plantation at Kutubdia sea front. Both species can resist salinity and flood water for a short time during the high tides and monsoons.

Remedial measures are required for certain species already established in the earlier coastal afforestation programme. For example, in most areas where babla (Acacia arabica) trees were planted during 1986-1970 these have now become over matured. These trees are very susceptible to insect and pest attack as well as damage during strong winds and cyclone surges. A controlled programme of felling and replacement by new seedlings is now required.

In the foreland and sea shore along the embankment, many mangrove plantations have become very thinly populated, as local people have cut the lower branches of the trees for fuel wood. These trees no longer provide adequate protection of the embankments from tidal waves, and new planting is required to fill the gaps.

Banana (Musa Paradisiacal) plants are grown extensively on the slopes of embankments especially in settled areas. However, these plants are detrimental to soil compaction owing to the rapid disintegration and rotting of the roots, leading to a type of plant erosion. It is recommended that this be replaced by alternative more suitable species.

Typical designs of afforestation are shown on figures 6-1 and 6-2.

6.6 Availability and Acquisition of Land for Afforestation

Mangrove afforestation will primarily take place on newly accreted foreshore land. Significant areas of such land are available, largely unoccupied and require no expenditure on land acquisition.

Afforestation on the embankment slopes faces greater problems given the extensive settlements already existing on these slopes eg. in Noakhali, Hatya, Sandwip and Bhola. Land acquisition and wholesale clearance would be difficult and costly to implement, instead it is proposed that the BWDB and Forestry Department enlist cooperation of local cooperative groups on the afforestation programme as outlined in the following sections.

6.7 Implementation

Some 33 polders (out of more than 100 throughout the coastal area) were selected for afforestation during the Mid-Term Programme for the Cyclone Protection Project II.

The programme covers about 700 km embankments and foreland, for further details reference is make to Appendix H.

The implementation could start early 1993 and would cost 3-5 years.

6.8 Operation and Maintenance

In areas where the local population is already utilizing the embankment slopes, it is proposed that cooperative groups be organized with responsibility for planting, maintenance and production of trees for a certain length (area of embankment). The BWDB and Forestry Department would need to be closely involved with the latter providing seedlings and technical advice.

Different categories of plantation would be set up such as

i. Short maturing tree species like Ipil-Ipil, Babla, Arhar, Eucalyptus and Acacia for fuel and fodder

ii. Fruit bearing trees like coconut, date palm, Tal trees, Mango, Jack fruit and Kulboroi and

iii. Long maturing tree species for timber production like Mahogany, Shil Koroi, Rain Tree, etc.

In the foreshore areas, mangrove afforestation would be implemented by the Forestry Department as has previously been the case. However, stronger emphasis would be given to maintenance with assignment of a forest watchmen for every 4 km of embankment.

6.9 Costs and Benefits

The total cost of afforestation 700 km of embankment slopes and foreshores has been estimated as Tk 200 million with an average cost per km of Tk 285,000. This includes the cost of raising seedlings, surveys and preparation of land, establishment costs etc.

Afforestation will provide a cost-effective form of embankment protection. Furthermore, appropriate species selection, maintenance and management will yield a useful and renewable resource. The Afforestation programme can provide timber, fuel ward, fruit, food and fodder and agro forestry products, yielding benefits to the nation and to the local population engaged in implementation, maintenance and operation of afforestation on the embankment slopes.

6.10 Summary and Recommendations

The project area has a major area of over 400,000 ha of mangrove forest in the south-west, providing protection against the erosive impact of monsoon waves and cyclonic surges.

A further 108,000 hectares of coastal afforestation had been implemented by the Forestry Department since 1975 providing efficient protection especially for seawardfacing embankment in Barisal, Bhola and Muhuri Circles. However, time and illicit activities by local settlers have resulted in damage to significant sections of the afforested embankments.

An expanded afforestation programme is recommended for the Mid Term, covering 33 selected polders in Chittagong, Cox's Bazar, Noakhall, Bhola, Satkhira, Bagerhat, Khulna and Barguna Division. Planting, maintenance and production associated with afforestation on embankment slopes should involve close cooperation between BWDB. Forestry Department and local inhabitants, whereas the mangrove afforestation of foreshore should remain the traditional province of the Forestry Department.

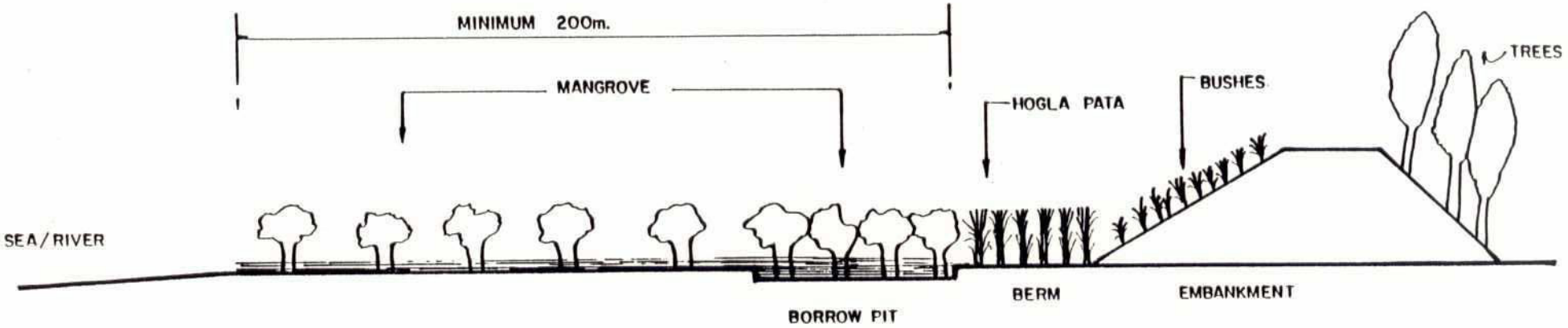

FIGURE 6-1 TYPICAL DESIGN OF AFFORESTATION (NORMAL CONDITION)

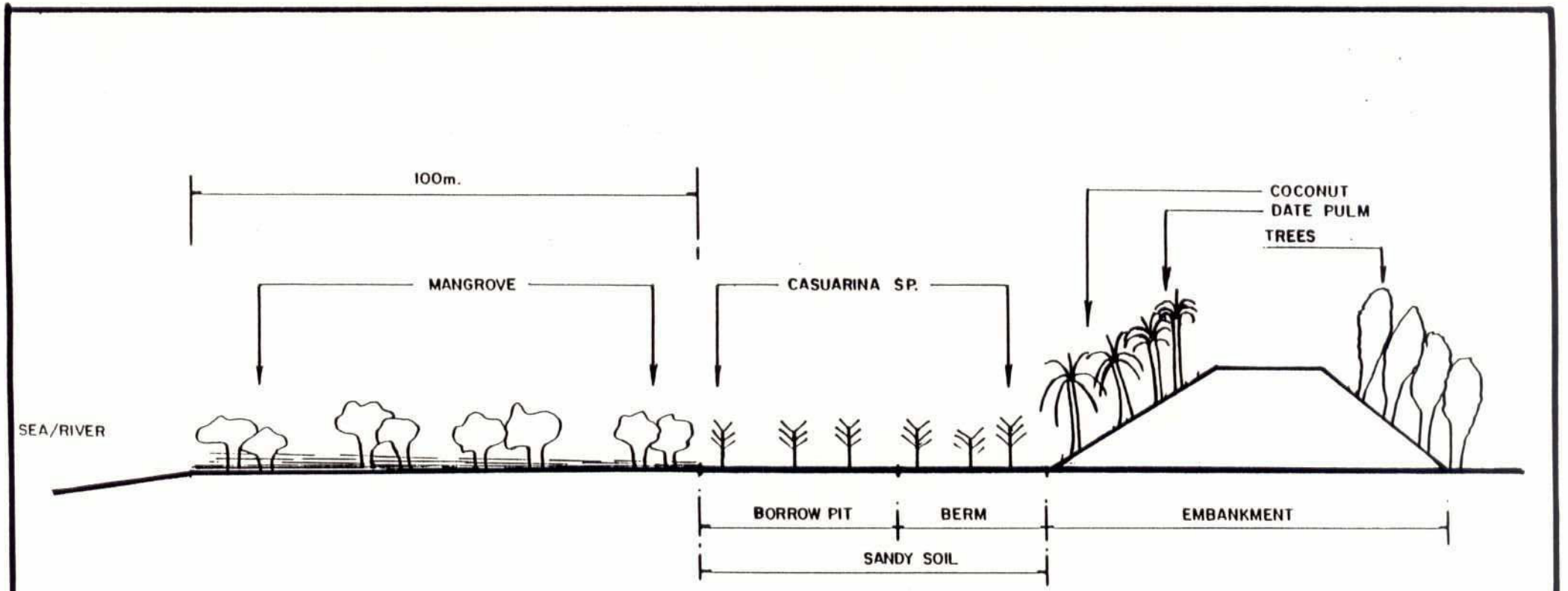

FIGURE 6-2 TYPICAL DESIGN OF AFFORESTATION (SANDY SOIL IN THE BERM AND FORELAND)

ANNEX VII

ENVIRONMENTAL IMPACT ASSESSMENT

VII ENVIRONMENTAL IMPACT ASSESSMENT

7.1 Introduction

The scope of the environmental impact assessment is limited to the impact of the Cyclone Protection Project II, which mainly consists of rehabilitation, strengthening or improvement of a small part of the Coastal Embankment Project (CEP) in the cyclone prone coastal areas.

Assessments of environmental impacts of the CPP-II have thus been made within the following relevant fields.

- Impact on Agriculture
- Impact on Fisheries
- Impact on Forestry
- Social Impact.

7.2 Impact on Agriculture Production

Initially after the inception of the Coastal Embankment Project in the project area of CPP-II, the desired increased agricultural production began to materialize. But after a few years it was hampered due to frequent intrusion of saline water through breaches in the most exposed embankments mainly caused by high tide waves during the monsoon season and cyclonic surges during the pre- and post monsoon season.

The impact of CPP-II on the agricultural production will be to restore and sustain the cropping capacity of the protected areas and to encourage farmers to increase the cropping intensity and shift to high yield varieties (HYV) of paddy.

Beneficial Impact

After implementation of CPP-II the project area will regain its lost productive capacity and the agricultural yields will be increased along with cropping intensity. The adoption of HYV paddy will gradually be increased, in particular in polders with access to fresh water irrigation.

Hence the project will help reducing the present food deficiency in the coastal area and improve the financial security and living standard of the farmers.

Adverse Impact

The re-construction and construction of new embankments with flatter slopes and raised crest level will incure loss of agricultural land for the embankment bases and borrow pits for construction soils.

The adverse effect of this will be offset by the increased production in the protected areas. It may be further mitigated by using the borrow pits for shrimp cultivation of freshwater fish pond culture and by allowing plantation and exploitation of selected species of cultural trees and bushes on the embankments against responsibility for maintenance of the embankments under lease agreements with groups of landless people and destitute women.

The increased agricultural production involve greater land use, reducing the grazing area, which together with adoption of HYV paddy with shorter stem may create acute shortage of fodder, causing reduction of livestocks.

Since livestock play a very vital role in the rural economy of Bangladesh, as it provides meat, milk, hides, fertilizer, fuel and draft power to the farmers in the coastal belt, the reduction of especially cattle may have serious negative effects upon agriculture in particular for small farmers.

To mitigate this problem the inside slope of embankments can be used as grazing area.

7.3 Impact on Fisheries

In Bangladesh fisheries rank next to agriculture in economic importance and furnish over 80% of the animal protein consumption in the diet of people. The inland fisheries area contribute about 88% of the total fish production in the coastal region and are divided into the following categories: (1) Open Water Fisheries (2) Shrimp Cultivation and (3) Close Water Fisheries.

The original coastal embankment project has caused a very significant impact on inland fisheries in the coastal area whereas CPP-II will only effect Shrimp Cultivation and to some extent Close Water Fisheries as described in the following.

7.3.1 Impact on Shrimp Cultivation

The increased international demand for shrimps and the prospect of earning considerable amounts of foreign exchange has encouraged many people to cultivate shrimps in suitable parts of the study area, in particular in Khulna-Satkhira and Cox's Bazar region of the coastal belt.

The construction of CEP embankments created great opportunities for shrimp cultivation inside the protected polders at less costs and lesser risks than outside the polders in particular Cox's Bazar region.

The strike of the severe cyclone of April 1991 caused damage to hundreds of shrimp farms in this area which may have discouraged many of the shrimp farmers.

Beneficial Impacts

The CPP-II will create new hope and aspiration to shrimp farmers inside the polders by greatly improving the protection against damages by cyclonic surges. The CPP-II will create further opportunity for improvement of the shrimp culture, expansion of shrimp farms and shrimp processing industries; thereby increasing the very much needed earnings of foreign exchange to the country.

Adverse Impacts

The main adverse impacts caused by possible expansion of the shrimp cultivation in polders in the study area are as follows:

i) The increased earning of foreign currency and its economic benefits will be limited to relatively few and rich shrimp farmers living in the capital city while local marginal cultivators may generally be deprived from the benefit.

ii) The shrimp cultivation discourages the agriculture as local marginal farmers may be forced to lease their small pieces of land on nominal prices or they are harassed by the rich shrimp farmers by destruction of their crops or by intrusion of saline water.

iii) The intrusion of saline water for shrimp cultivation may cause long term increase in soil salinity and loss of soil fertility.

The adverse impacts of shrimp cultivation inside polders may be mitigated by separating shrimp ponds from agricultural land by subdivision of the polders with interior embankments and by imposing more government control on shrimp cultivation.

Further shrimp cultivation outside the polders in borrow pits along the embankments should be encouraged.

7.3.2 Impact on Close Water Fisheries (Pond Fisheries)

About 20% of the total fish production in Bangladesh is produced form freshwater pond fisheries (dominated by carps) and an estimated 5-10% of the freshwater ponds are located in the study area.

Beneficial Impact

The CPP-II will protect the freshwater pond fish cultivation from damages from cyclone surges and intrusion of saline water into the ponds. Borrow pits along the inside of embankments can be used to increase pond fish cultivation and thereby mitigate the negative impact of loss of agricultural land to borrow pits for embankment construction.

Adverse Impact

None

7.4 Impact on Forestry

Forestry plays one of the most important roles in maintaining ecological balance in nature and out of many reasons for ecological imbalances, the inadequate vegetation cover is considered one of the prime factors. To maintain a conducive ecological balance a minimum of approximately 25% vegetation coverage is considered necessary in climatic and ecological environments like Bangladesh.

The present vegetation coverage in Bangladesh as claimed by the forest department is approx. 16% but unofficially it is not more than 4 to 5%. The indiscriminate cutting of trees or forest by the rural people for meeting the ever increasing demand of firewood, house construction, boat building and furnitures etc. are the major causes for reduction of vegetation coverage of the country. The recent impact of increased demand for bricks for construction of roads and other infrastructure have further caused a huge demand of firewood from the scarce forest areas.

The provision of afforestation on the foreshore areas of embankments and on the embankments for protection of the embankments against wave action and erosion by rainwater and wind is one of the vital components of CPP-II and afforestation programs are now widely supported by GOB.

One major obstacle for implementation of afforestation of foreshore areas is private ownership of this land in most of the study area and present unwillingness by GOB to acquire private land for afforestation.

Beneficial Impact

Implementation of the recommended afforestation program of CPP-II will have the following beneficial impacts upon the environment:

i) Provide protection of the embankments and foreshore area against erosion by waves.

ii) Reduce the wind velocity of cyclones and strong monsoon winds and thereby reduce wind generated damages and soil erosion.

iii) Protect the pollen of the paddy from strong monsoon wind, resulting in increase of crop yields.

iv) Increase the vegetation coverage of the area which will facilitate restoration of the ecological imbalances and erratic behavior of the nature.

v) Provide suitable habitats for a diversity of wildlife which may help establishing biological control and reduce the need of pesticides for protection of crops.

vi) Meet the demand of fuel energy in the study area. Further the plantation of economic trees will provide valuable food, wood and cash money to the local farmers resulting in uplift of the rural economy.

Adverse Impacts

The recommended afforestation of foreshore areas will initially reduce the available area of cultivable land, but this effect will be offset by the long term reduction of erosion by waves, litoral drift and wind.

Trees on embankment slopes may be uprooted by the rare cyclonic storm winds and thereby damage the embankment slope and grass coverage. Experience has, however, shown that this effect is negligible and more than offset by the protection of the embankment provided by the trees during normal monsoon conditions and the other beneficial impacts of tree plantation.

7.5 Social Impacts

The social impacts of CPP-II are generally positive for the majority of the affected population of more than 3 million. The exceptions are those being displaced or loosing land by implementation of the project and those left unprotected due to retirement of embankments.

7.5.1 Displacement of People by Embankment Project

The most serious social impact by CPP-II as well as other embankment projects is displacement of people residing on land to be acquired for embankment construction.

Approximately 110 Km of embankments of the CPP-II emergency program and Mid Term Programme will be retired embankments requiring acquisition of approximately 800 ha of agricultural land.

The total number of effected households is estimated at 2-3,000 corresponding to 10-20,000 people. Of these 10-15% will be displaced from their land and may become landless.

The suffering of people having been displaced or become landless can be mitigated by

i) ensuring prompt and proper payment for their land to be acquired for the project.

ii) by giving this group of people preferential status to get lease agreements to reside on berms on the inside slope of embankment and introduce a beneficiaries maintenance arrangement.

ANNEX VIII

SOCIO-ECONOMICS

VIII SOCIO-ECONOMICS

8.1 General

The polders at the study area are located in three major agro-ecological zones roughly corresponding to 3 study regions: South-West, Central and South-East. These regions have by the large distinct agricultural, physical and socio-economical characteristics.

The study polders are inhabited by an estimated number of 3 million people having 528,900 households. Of these, about 30% are non-farmers and 70% are farmers. The portion of non-farm holdings is generally lower in the South-West region compared to the other two regions.

8.2 Demographic Characteristics

The rural landless and landpoor households can be categorized as squatters, sharecroppers, small farmers cum sharecroppers and marginal farmers.

Squatters are homestead and landless people settled on public land, such as coastal embankments and road-sides on newly gained coastal areas (char land). Squatters gain an income from agricultural labour, capture fisheries and traditional culture fisheries in road-side ditches and small canals. Sharecroppers without own homestead and land may be settled by absentee private large size or medium size landowners in the char land and earn their income from sharecropping plus capture fisheries in nearby rivers and irrigation canals.

There is a wide range of polderwise variation in the proportion of holdings having no owned land and homestead and no cultivated land. Percentage of holdings having no owned land ranges between 3-16% in the South-West, 1-19% in the Central and 1-36% in the South-East regions. Proportion of holdings having no homestead ranges between 1-6%, 2-3% and 2-7% respectively. Many of such landless and homesteadless people, particularly those affected by river bank erosion, have taken shelters on embankments.

An example from one of the surveyed areas, namely Patuakhali:
In this area 31% of the land is homestead land. Average size of homestead land is increasing with the increase in landownership. 62.6% of landless, 35.2% of marginal and 14.3% of small households own no homestead land living on relatives land mainly.

93.1% of the households in the Patuakhali project area own their own housing units.

8.3 Literacy and Education

Availability of primary schools in desired number and quality is a basic necessity to provide fundamental education to the people. Governments's involvement in providing such facilities is another important element in view of the growing pauperization of the rural economy.

The upazilawise availability of the educational institutions shows that there is a relatively larger number of high schools and madrashas in the South-West compared to the other two regions.

Literacy rates for population of 5 years and above in the study upazilas are generally lower than Bangladesh average. Literacy rates for male, female and both sexes range higher in the South-West compared to the other two regions. Highest literacy rates are in Patharghata having 39.3%, 44.5% and 33.1% for both sexes, male and females respectively against the Bangladesh average of 23.8%, 31.0% and 16.0%. The lowest literacy rates are in Teknaf with 8.8% 13.9% and 3.3% respectively.

8.4 Land Use in the Polder Areas

There are about 196,000 ponds in the study upazilas. These ponds have several functions providing drinking water, water for washing, cooking and sometimes for animals as well as fish cultivation.

Nearly 54% of these ponds are cultured, while 32% are culturable and 14% derelict ones. 22% of them are located in the South-West region having 12% of the ponded area. The average size of pond is comparatively higher in the Central region (0.19) ha.) and lower in the South-West region (0.09 ha) with an average of 0.16 ha in the entire study areas.

In Noakhali 60% of rural households have access to a backyard pond. Most of these ponds, however, are jointly owned by a number of relatives. This often constitutes a constraint to utilization for aquaculture purposes as the co-owners do not easily agree on joint production patterns. A survey made by Danida/NRDP from 1986 shows that only 36% of the ponds had individual ownership, 45% had two to four owners and 14% had more than 6 owners.

8.5 Livestock Rearing

Rearing of livestock is undertaken by farm and non-farm households in varying degrees to provide nutritious animal products, augment family income and provide traction power. These resources are subject to periodic cyclones and storm surges hazards when thousands of them are washed away.

Bovine animals are primarily for draught power, milk and meat purposes. Availability of bovine animals per 100 ha decreased with increase in farm sizes. Small farmers rear more of these animals mainly to supplement their meagre farm income as animals are less susceptible to damages/losses due to climatic hazards than crops.

Many small farmers and tenants have even started to dig the fields with a hoe once or twice in order to save one or two of the ploughings (total 3-6 depending on the soil conditions).

The average number of bovine animal per 1000 population is 300. this figure reflects big differences varying from 464 in Kalapara and 145 in Sitakundu.

A high proportion of both farm and non-farm holdings particularly in the Central and the South-East regions rear, poultry birds. The number of households having 50 or more poultry birds recorded highest number (721) in Chokoria, followed by Sudharam (688) and lowest in Dacope (12). These data relate to the year 1983-84. Latest upazilawise data on poultry are not available with the Dept. of Animal Husbandry and Livestock Resources. It was observed during the field trips that the commercial rearing of poultry birds is getting increasingly popular among the affluent rural families. In Dacope, about 200 of such farms have reportedly been set up.

8.6 Structure of Land Holdings

The proportion of area operated by small farms is lowest in the South-West region and highest in the South-East region.

Following are two examples from Noakhali and Patuakhali :
36.9% of all rural households are entirely without arable land in Noakhali. Another 27.6% own up to merely 0.5 acres of land, an area by far too insufficient to generate enough income for a family. 17.7% of households own up to 1.5 acres which is still an area too small to rely on entirely for a family income.

It is estimated that 82.2% of all rural households in old Noakhali District depend on incomes from other sources. (NRDP/DANIDA, Survey of 10 Villages, October 1989.) It should be noted, that these figures may not be representative for the char areas.

In the survey of Patuakhali 5% of the households own more than 30% of the land. Landless households constitute a third of the total households and own 2% of the land. Large and medium landowning groups account for 16% of the total households, but owning more than 60% of the land, while the poorest group constituting 83% of the households own 40% of the total land and 38% of the cultivable land. On an average large

landowners own 13.7 acres while landless households own 0.12 acres and no cultivable land.

Generally speaking 50% of the households in the project area can be regarded as functionally landless as they own less than 0.5 acres each. Apart from the seriousness of such an unequal distribution of property rights the two most important problems seem to be the following : Each individual farm holding is highly fragmented. Small fields belonging to one single farm might be located in all directions from the village. Fragmentation is brought about by the inheritance system where each field may be divided between sons. Another problem is that sharecropping is widespread.

8.7 Land Tenurial Aspects

There is an active land leasing market in the project area of Patuakhali, which to some extent redistributes the amount of land economically operated. All landowning groups take in land and all groups except landless give out land.

Land lease takes place in two forms: Share-cropping and cash leasing. The share-cropping in Patuakhali is in kind like elsewhere in Bangladesh, but share varies between cropping seasons. One season (aus) the landowners receive two thirds of the produce and tenants receive one third. For the aman harvest landowners receive three fourths and the tenant one fourth. Input costs are normally borne by the tenants. The share difference between seasons is due to lower land requirement and higher production in the aman season.

Cash leasing takes two forms: leasing for one year and leasing for seven years. For one year leases the normal rate is Tk. 2,500-3,000 per acre and seven years leases vary from Tk. 9,000-12,000 per acre.

The terms of sharecropping in Patuakhali are harsh deviating from the normal 50-50% share in many parts of the country. Wage employment exists but constitutes about a fourth of the total labour used in crop cultivation. A form of bonded labour still exists in the permanent labourers. The absent landlord, does not exist in this area.

In Noakhali the landowner takes half of the harvest and the cultivator gets the other half as his share. In many cases the tenant is not even certain about the duration of his lease; it might last only one season if he displeases the landowner, or it might last a lifetime.

Large landowners are cultivators, too. They lease sometimes out land expropriating a part of production through (harsh) share cropping terms. In their own land they expropriate a part of the surplus by providing subsistence wages to hired labourers. Landowners have, however, not

resorted to reinvestments in agricultural production or attempted increased production through the adoption of modern inputs. They prefer investments in land, preperably urban land, for speculation and expenditures for increased consumption. Huge profits are sucked out by townspeople too, a situation which further hastens the process of landlessness and pauperization, a tendency specially visible in char areas.

Poor landowning households are caught in the trap of low landownership levels, low productivity, natural problems with waterlogging, low production, low consumption or borrowing. Even a slight destabilizing factor, higher crop damage, extra expenditure for health or wedding or court cases, is enough to push them towards landlessness. increased marginalisation without increased alternative employment opportunities will create strong social disharmony.

8.8 Labour Market

Kinship norms say that the more well-off households within a lineage are responsible for the poorer households, and thus should provide the poor households of their own lineage with land as share-croppers, employ their own poor kinsmen as daylabourers or with urban jobs within a family owned factory.

The local power structure is built around the patron-client relationship. In order to secure support, be it for local elections or to built up a strong support when conflicts arise, the more wealthy households who want to compete or play a role in local politics will organize production in such a way that they get as many supporters as possible.

Labour is hired on a permanent basis (one year contracts) or on daily basis in Patuakhali. Permanent labourers receive 20 maunds (744 kg) of paddy or the equivalent in money per year and new clothes yearly. Old and young/child labourers receive less. All permanent labourers receive 3 meals daily. Day labourers also receive food, 2 meals and about twenty-five taka during the peak season, and 15 taka during the slack season.

During the peak season of the harvest, workers in the project area may get as much as 50 takas per day, because work has to be completed within a very limited time, before fields get flooded again. Some go to work in the low lying areas where there are no permanent settlements and get paid in kind according to the amount of work they do. After four weeks of work they may bring home 8-10 maunds of rice, which is equivalent to Tk. 1,600-2,000.

Due to the rather short peak season for the most important activities in agriculture, even small farmers frequently require extra hands and employ wage labourers.

The large number of migrant labourers is a predominant feature of Noakhali. Between 18 and 27% of the male population work so far away from their homes that they may become temporary visitors and supporters of women and children living in the village. They go to Dhaka, Sylhet, Chittagong, Pakistan and the Middle-East retaining their families in their home villages and keep their landholding, if they have any.

Rural households take up a variety of undertakings on cottage industries to augment their income. A fairly good proportion of farm and non-farm holdings is taking up such enterprises in several upazilas, particularly in the South-West region. Smaller the farm sizes larger the percentage of such holdings taking up cottage industries.

The labour market has also undergone some changes with a gender focus. A few generations ago most of the rural households making their living from agriculture had sufficient land so that the women of the households could be employed with rice processing and household chores. But in the landless and landpoor families today, the traditional female activities are not sufficient to make a full working day. There is no rice to process, no vegetables to tend to and preserve and on some days there is not even any food to cook. A very strong illustration of this decrease in the "value" of women, can be observed in relation to marriage negotiations and arrangements in Muslim families.

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ANNEX IX

OPERATION AND MAINTENANCE

IX. OPERATION AND MAINTENANCE

9.1 Introduction

Due to the nature of the work the Cyclone Protection Project II (Feasibility and Design Studies) have not been directly involved in the operation and maintenance of polders.

It is, therefore, considered that the overall organisation of polders is not within the scope of the present studies, however a contribution is made, in particular for maintenance, which the Consultants, suggest could be considered together with any future reviews aimed at improving the BWDB operation and maintenance.

The O&M report takes into account the current BWDB O&M organisation and management, also relying considerably on those FAP studies aimed at improving O&M within the BWDB.

9.2 Maintenance Definitions & Objectives

There appears, at present, to be some confusion in interpretation of maintenance definitions and objectives, therefore there is clearly a need for universal understanding throughout the BWDB organisation of maintenance definitions and objectives.

Maintenance definitions and objectives are a priority requirement for any future reviews of BWDB O&M organisation and management. The consultations have used the following definitions and objectives for the purpose of this report.

Maintenance (General)

The work required to maintain a structure in, as near as possible to, its original as constructed condition.

Routine Maintenance

The year round day to day, work to repair defects caused by ordinary wear and tear.

Periodic Maintenance

The work required to repair defects which can be carried out only when climatic or physical conditions allow, or when routine maintenance alone is no longer sufficient to preserve the structures (embankments, protective works, water control structures, plantation, buildings and equipment).

Objectives of maintenance :

- To maintain the embankment, protective works, hydraulic structures, plantation, buildings and equipment in such a manner that polders can operate productively and safely.
- To protect the capital investment provided for the construction of the polders.

Major damage caused by floods and cyclones is not considered within the scope of normal maintenance resources (labour, materials equipment and finance). It is anticipated that BWDB will make contingency plans together with reserve finance to cover major damage separately.

9.3 The BWDB O&M Organisation and Management

The establishment of an O&M Technical Unit (HQ) is a major step toward rationalisation of the BWDB O&M organisation and management. The separation of O&M from major construction works should enable a career structure to be set up specifically for O&M to provide, in future, capable and experienced personnel to the benefit of polder operation and maintenance.

The duties of BWDB O&M personnel are at present specified by job description, however personnel are some what disillusioned by the alleged lack of O&M funding, and consequently lack motivation. It is anticipated that the conclusions and recommendations of current O&M studies will result in an improvement in all aspects of the BWDB O&M organisation and management.

Review studies into the benefits achieved by FCD/I projects identified lack of O&M as a major constraint, the problems being identified as :

- Over emphasis on construction works to the detriment of O&M.
- Insufficient funding and inefficient use of prevailing O&M funds
- Overstaffing and lack of motivation
- Inadequate budgeting and cost control
- Lack of training specifically aimed at O&M
- Unsuitable non standard production of O&M manuals
- Lack of beneficiary participation

9.4 Annual O&M Budget

The BWDB receives its O&M budget from four main sources which therefore requires the preparation of four separate budgets, however at present there is no system to extract and develop an overall O&M work programme and budget.

An overall O&M work programme and budget is essential to good management and is a priority requirement for the O&M Technical Unit (HQ) to operate efficiently.

9.5 O&M Planning

The present absence of clear definitions of O&M (in particular maintenance) and its objectives provides a severe restraint on the annual and long term planning of O&M works.

Planning of annual or long term maintenance work requires :

- A clear definition of maintenance and its objectives
- The work activities involved
- Inspection to identify, locate and quantify the repair works necessary (i.e. work load).
- Work importance in priority order.
- Work standards and output
- An assessment of the resources (manpower, materials & equipment) required to carry out the repair works.
- Preparation of work programmes and schedules.
- An upto date O&M manual for standardisation of work processes and communication throughout the BWDB.

9.6 Maintenance Work Activities

A series of work activities are necessary to repair defects found during inspections of both embankments and hydraulic structures. Typical work activities are shown as follows :

Embankments

Routine Maintenance :

- Repair rat holes.
- Temporary sealing of minor leaks
- Ringing the minor leaks with dirt filled bags on countryside
- Draining and filling minor depressions
- Repairs to turf and rain cuts
- Maintain recently planted approved type of vegetation.

Periodic Maintenance

- Repair protection works
- Repair slips
- Repair erosion
- Planting approved type of vegetation
- Resectioning to original design section

- Permanent repair of leaks

Hydraulic Structures

Routine Maintenance

- Clean and grease moving parts of the gates with water proof grease
- Remove silt and debris that affect operation
- Remove weeds & water hyacinth in areas near intake
- Patch minor damage to the concrete structure
- Clean and maintain the khalashi shed
- Care and maintain area around the structure and khalashi shed
- Maintain and keep off all problems in the embankment and channel within 200 m of the sluice
- Check bolts.

Periodic Maintenance (low/nil water level)

- Replace water seals when necessary
- Check bolts and tighten where necessary
- Repair or replace damaged metal work
- Wire brush or chip loose paint and rust from all metal work.
- Paint all metal work and bolts with rust preventive paint
- Clean and grease moving parts of the gates with water proof grease
- Patch minor damage to the concrete structure
- Repair defective areas to blockwork aprons
- Repair and consolidate any erosion/scour in the immediate vicinity of the structure.
- Clean and repaint both upstream and downstream gauges.

9.7 Project Condition Survey

Condition surveys were carried for the project by senior engineers and are fully described in a separate report.

Location Reference System

The current BWDB location reference system was used throughout the condition survey, for the purpose of recording embankment and structure conditions and locations.

The BWDB location system consists of an embankment chainage system in kms from a specified zero chainage point, structures also have reference numbers allocated to them by the BWDB.

9.8 Participation by Local Bodies in Maintenance

Routine maintenance of embankments and hydraulic structures require

labour intensive operations with little need for equipment. This type of work is very suitable for destitute women, landless or the needy.

The consultants consider that the following alternatives require further consideration for routine maintenance; i). long term leasing of embankments to destitute women and landless ii) employment of destitute women on maintenance of embankments and iii). either long term leasing or honorarium for khalashi

i. Long term leasing would enable participants to become "beneficiaries" with a vested interest in preserving the condition of the embankment. However, participants must be instructed on the work activities required and given on the job training, also methods of cultivation and planting allowed should be specified in the terms of the lease. This method of maintenance would be at no cost to the BWDB with a resulting saving of O&M funds.

ii. Employment of destitute womens' groups on embankment routine maintenance would provide continuity of employment for the groups, with vested interest in preserving the condition of the embankment. Allocation of 0.5 km of embankment per woman has been proposed with a 6 hour 6 days working week at Tk. 25 per day including equipment amounting to Tk. 9125 per women for year round work or Tk. 18,250 per km of embankment.

iii. Leasing of embankment plus hut in the immediate vicinity of hydraulic structures to a khalashi would provide similar benefits as described in i) or alternatively paying an honorarium to the khalashi would reduce present costs.

Periodic maintenance will require a mixture of i). labour intensive groups (e.g. repair of embankment slopes) and ii). specific skills groups which require skilled manpower, special materials and equipment and are not labour intensive.

The following alternatives should be given further consideration :

i. Labour Intensive Groups

Labour intensive groups, as in routine maintenance, could consist of destitute women or landless paid either on a daily rate or a negotiated lump sum basis. However groups already being used on routine maintenance should not be allocated to this work to the detriment of routine maintenance, rather other groups should be used. Alternatively the use of Landless Contracting Societies (LCS) as developed by EIP could be considered for this type of work.

ii. Specific Skills Groups

The groups require specialist tools and equipment but will only be required for relatively short periods of time, and the use of LCS should be considered for this type of work.

9.9 Basic O&M Maintenance System

Procedures for a basic O&M management system have been included in this report and could be considered as a contribution to any reviews of the BWDB O&M organisation & management. The basic elements of an O&M management system should consist of :

- A location reference system
- An inventory of O&M facilities
- An identification of work activities
- A system of inspection to identify defects
- Quantification of defects
- Preparation of a Annual Work Programme (based on need)
- Preparation of work activity methods and assessment of productivity
- An assessment of resources (manpower, plant/equipment and materials,) to complete the Annual Work Programme (need)
- Preparation of the Annual Work Schedule (need)
- Preparation of the Annual Work Budget (need)
- Review of Annual Work Programmes, schedules and budgets to comply with actual budget allocation
- Finalise Annual Work Programme, schedules and budgets related to actual allocated O&M funds
- Monitor work implementation
- Annual review.

9.10 Maintenance Costs

The following yearly unit costs have been estimated for routine and periodic maintenance of embankments, hydraulic structures (average cost per unit) and protection works.

Yearly contribution to a reserve fund for repair of cyclone damages was also estimated

The costs include 25% establishment costs.

For further details reference is made to Appendix F.

The estimated costs are :

	Tk.
Routine Maintenance	
Embankments	25,000 per km
Hydraulic Structures	33,100 per unit
Periodic maintenance	
Embankments	50,000 per km
Hydraulic structures	52,800 per unit
Protection work	120,000 per km
Repair of Cyclone Damages	
Embankments	150,000 per km
Hydraulic structures	25,000 per unit
Protection work	580,000 per km
Yearly Budget for Routine or Periodic Maintenance	
	38.3 Million Taka
Yearly Allocation for Repair of Cyclone Damages	
	65.0 Million Taka

9.11 Training

The establishment of an O&M Technical Unit (HQ), divided from new construction works, should provide the basis for the creation of a new career structure specifically for personnel who will be involved solely in O&M. This career structures will enable the BWDB to build up progressively an O&M organisation staffed by personnel experienced in O&M and motivated to attain the required objectives. Care of personnel for O&M is essential, poor quality staffing can result in the system failing or falling into disrepute.

The formation of a new O&M organisation should be accompanied by a planned training programme for the tasks required of each category of personnel from management through to work implementation. Planning of training should involve close co-operation between the O&M Technical Unit (HQ) and BWDB's Training Director.

ANNEX X

ECONOMIC ANALYSES

X. ECONOMIC ANALYSES

All costs and prices used in the economic analyses are economic costs and prices related to the price level of January 1992.

The economic costs and prices have been estimated by applying conversion factors to the financial costs and prices in accordance with the guidelines issued by the Flood Plan Coordination Organisation (FPCO).

The project period has been fixed at 30 years.

10.1 Costs

The cost input to the analyses are the following :

Investment Costs. These costs cover construction costs and cost of engineering and land acquisition as described in Volume 1, Chapter 3. A conversion factor of 0.75 has been applied to convert financial costs to economic costs.

Operation and Maintenance costs. O&M costs cover routine maintenance, periodic maintenance and repair of cyclone damage to the embankment and structures as described in Volume 1, Chapter 3. A Conversion Factor of 0.75 has been applied.

Maintenance of the embankments and structures covered by the Mid Term Programme is virtually non existent except in a few cases. Consequently, no benefits will be achieved from savings on existing maintenance cost except for a few polders (40/2, 48, 60 and 66/), where the existing embankments still provide protection against the intrusion of saline water despite their poor conditions. Maintenance is carried out by Food For Work. On the basis of information provided by Food For Work, an average yearly maintenance cost has been estimated for these polders and included in the analysis. A conversion factor of 0.71, reflecting unskilled labour, has been applied to the financial costs.

Cost of Land. The land acquisition costs have been estimated as described in Volume 1, Chapter 3.

10.2 Agricultural Benefits

Yearly Agricultural Benefits have been estimated on the basis of farm budget in the WithOut (WO) and the With Project (WP) situations. The farm budget analysis computes the quantity of all input and the sales value in economic prices. The difference between production cost and sales value represents agricultural surplus.

It is assumed that in the WO project situation agricultural yield per hectare will decrease due to lack of protection from intrusion of saline water. The impact of yearly floods is anticipated to reduce output by 10% over a 5 year period in polders without irrigation and by 20% over a 5 year period in polders with irrigation. The polders with irrigation are : 63/1A, 64/1A, 64/1C, 64/2B, 66/3, 69 and 70.

In the WP situation the yield per ha for existing crops is expected to raise, the cropping intensity to increase, and the cropping pattern to switch towards cultivation of high yield variety (HYV). All these effects lead to a higher surplus per ha.

The surplus is calculated as the difference between the WO and the WP situation. The difference represents the net agricultural surplus. The full impact is envisaged after 5 years.

For the polders 40/2, 48, 60 and 66/1 the agricultural benefits are not counted from the start of the project period as the existing embankments presently provide protection against saline water. However, the embankments are in a poor condition and subject to erosion. Agricultural benefits have consequently been counted 5 years later than for the other projects.

For each polder the benefitted areas were determined through studies of the related polder maps.

The areas used are shown on polder maps in Annex XII to the present report.

Cyclone Caused Losses to Agricultural Production. Damages caused by cyclone surges have also been counted. It is assumed that high water levels corresponding to a return period of 40 years or more result in severe flooding both in the Without Project and in the With Project situation. Estimation of Benefits from this source will therefore be limited to cyclone surges with 10 and 20 years return periods.

For surges with a return period of 10 years it has been assumed that the embankment will save 50 percent of the crops. For a 20 years return period the corresponding figure is 40 percent. It should be observed that cyclones normally occur during germination period of the crops which make them more vulnerable. It has also been considered that part of the cyclone damages to the crops will be due to high wind speed.

Livestock. Official figures show that e.g. on Sandwip over 40 percent of the livestock was lost during the April 1991 cyclone. On the basis of this registration, combined with indications from other sources, it is anticipated that in a similar WP situation 30 percent of the livestock will be lost. This ratio has been applied for all the polders.

The number of livestock has been computed on the basis of information regarding number of livestock per 1000 inhabitants for the relevant Upazilas.

10.3 Non-agricultural Benefits

Estimation of the non-agricultural benefits has mainly been based of official damage reports which were prepared by the respective ministries after the April 1991 cyclone.

To the extend possible the information has been cross checked by comparing unit prices and number of livestock, houses damaged etc. with other sources of information. Some of the figures have consequently been revised.

The results are shown in Table 10.1.

Houses. Damage to homes (houses and cottages) are caused by the cyclonic storm as well as the surge. As a rough estimate it is assumed that half of the damages to homes have been caused by the wind.

The value of totally damaged houses has been assessed at 15,000 Taka per house. This low figure reflects the fact that it is the poorest constructed houses which mainly are exposed to total damage by cyclones.

Infrastructure. Only damages to roads and culverts have been taken into consideration as the damages to telephone lines and power supply would mainly be caused by the high wind speed.

The assessment of damage has been based on field observations which showed very limited damages to the roads but visible signs of damages to the culverts caused by scouring water. The damage has been assessed as 5 percent of the replacement value for roads and 30 percent for culverts.

Based on a sample of 4 polders where the road categories and number of culverts have been registered and valued the average losses have been estimated at 2,000 Taka per ha. This value has been applied for all the polders.

Shrimps. Shrimp farming is a major economic activity in Cox's Bazar (66/3) and Moheskhali (69 and 70). The average catch per ha is about 150 kg per year. The export price is about 270 Tk. per kg.

In connection with the April 1991 cyclone all the shrimps were washed away. Assuming a total loss of harvest, although the shrimps had not grown to full size, the loss will correspond to 40,500 Tk. per ha of shrimp farms.

Salt Production. Salt production is also vulnerable to intrusion of saline

water in particular at the end of the production period in April.

The cyclone seasons are October-November and April-May, thus there is approximately 25 percent possibility that a cyclone, in any one year, will occur in April. Consequently the probability for cyclone damage has been adjusted by a factor of 0.25 when estimating the losses of salt production.

Benefits from Hinter Land Areas. For polders no 63/1A, 64/1A, 64/1C and 64/2B the project will also protect areas in the hinterland. Benefits from protection of these areas have been assessed on the basis of the average value of non-agricultural benefits per ha. Because it is likely that the damages in the hinterland are less than in the polder area nearest to the sea a correction factor of 0.6 has been applied.

The polderwise registration of losses are shown in Table 10.1

Escalation of Benefits. The value of non-agricultural benefits have in accordance with the FPCO Guidelines been escalated by an annual increase of 3% reflecting an anticipated increase in the value of the infrastructure and property.

Frequency of Extreme Water Level. The calculation of non-agricultural benefits has been carried out on the assumption of a return period of 40 years for the surge level generated by the April 1991 cyclone. Frequency of other cyclones are shown Appendix C. The model from the FPCO Guidelines regarding accumulated benefits has been used.

Annual Cumulated Benefits. Table 10.2 presents an example of calculation of the annual cumulated benefits in accordance with the FPCO Guidelines. The table shows the relationship between damages by surges with different return periods and the anticipated damage. The damage index is 100 for the 40 years return period.

The damage indices corresponding to other return periods are the following:

Return Period	Damage Index
10	20
20	40
40	100
100	150
200	200

10.4 Standard Conversion Factors

For the investment and maintenance costs a conversion factor of 0.75 has been applied. This value has been estimated on the basis of a breakdown

of the construction cost and applying the conversion factors for each item in accordance with the FPCO Guidelines.

For non-agricultural benefits which mainly relate to houses and infrastructure a conversion factor of 0.78 has been applied.

For agricultural prices a detailed productwise estimation of economic prices based on import prices has been carried out. On the basis of the World Bank Commodity Price forecasts the prices have been converted to mid 1991 prices by using the Manufacturing Unit Values (MUV) index for international inflation. This is slightly on the conservative side compared to the price level of January 1992 applied to the investment costs, but the difference is considered insignificant compared to the inherent uncertainties in the assumptions for cost and price estimations.

10.5 Economic Indicators

All cost and benefits have been compiled in a spread sheet and the EIRR, NPV and NPVR and switching values have been computed. An example is shown in Table 10.3.

Base table for non-agricultural losses in the cyclone prone area.

Registret losses for one event in 40 years.

All amounts in million Taka (financial prices)

	POLDER	gross protected area	direct protected area	net agricult area	Losses shrimps area	Losses shrimps Value	Losses salt	Losses houses	Losses Roads & culver	losses direct protected area	benefits from other protected area (gross area- direct protect) houses	roads etc	Total
		ha	ha	ha	ha								
The Emergency Project													
61/1	SITAKUNDA	730	730	600	50	2.0		71.3	1.5	74.7			
63/1A	ANOWARA	4,100	1,500	1,250				45.0	3.0	48.0	78	5.2	83.2
64/1A	BANSKHALI	12,700	4,700	4,300	50	2.0		150.0	9.4	161.4	255.3	16.0	271.3
64/1C	CHANUA	3,000	1,500	1200				21.0	3.0	24.0	21.0	3.0	24.0
64/2B	CHOKORIA	7,000	4,100	3250				49.5	8.2	57.7	49.5	5.8	55.3
66/3	COX'S BAZAR	3,000	3,000	900	1,500	60.8	32	20.3	6.0	119.0			
69	MATHARBARI	2,800	2,800	1,400	750	30.4	16	52.5	5.6	104.1			
71	KUTUBDIA	5,450	5,450	4,400	90	3.6	28	150.0	10.9	192.7			
72	SANDWIP I	18,700	11,500	9,300				218.6	23.0	241.6			
The Mid-term Programme Phase II													
35/1	Sarankhola		4800	3840				60.0	9.6	69.6			
40/2	Patherghata		4400	2860				51.0	8.8	59.8			
48	Kalapara		5000	3250				31.5	10.0	41.5			
56/57	Charfasson	30000	9000	7000				202.5	18.0	220.5			
59/2	Rangati		5200	4160				97.5	10.4	107.9			
59/3b	Sudaram		4000	3750				127.5	8.0	135.5			
59/3c	Companyganj		10000	9750				75.0	20.0	95.0			
60	Sunagazi		4000	3750				79.5	8.0	87.5			
66/1	Cox's Bazar		700	600				26.3	1.4	27.7			
68	Teknaf		1200	1000				31.5	2.4	33.9			
70	MOHESKHALI	2,850	2,850	400	750	30.4	88	75.0	5.7	80.7			
72	Sandwip II	18700	7200	5700				134.0	14.4	148.4			
73/1b	HATIA	1,600	1,600	1,400				37.5	3.2	40.7			
		27,530	12,530	10,600									

Sources:

Shrimps: according to the statistical year book of Bangladesh is
the average catch of shrimps per ha 171 kg.
The export price was in 1988-89 271 Tk per kg. making the value per ha to 46,300 Tk

Table 10.1 : Non-agricultural Losses, Example.

ANNUAL CUMULATED BENEFIT POLDER 64/1A BANSKHALI					
DESIGN RETURN PERIOD		20 YEARS			
Return period	Estimated damage without project	Frequency	Annual cost frequency	Estimated degree of protection	Annual Cumulated benefits
5	0	0.80		1.00	
			3.6		3.6
10	71.344	0.90		1.00	
			5.0		8.6
20	142.688	0.95		0.90	
			4.3		12.8
40	356.72	0.975		0.60	
			2.4		15.2
100	535.08	0.990		0.20	
			0.3		15.5
200	713.44	0.995		0.00	

Table 10.2 : Annual cumulated Benefit, Example.

POLDER 64/1a: Banskhali Length of embank km: 27.4

Total financial cost: 267.3 Ec. Cost: 200.5

YEAR	O&M	TOTAL BENEFIT	CASH FLOW	AGRICULT. BENEFITS	NON-AGRI. BENEFITS	AGRI.LOSS CYCLONES
1	80.20	0	(80.2)	0	0	0
2	120.30	0	(120.3)	0	0	0
3	4.58	21.5	17.0	4.3	11.5	5.7
4	4.58	26.2	21.6	8.7	11.8	5.7
5	4.58	30.9	26.4	13.0	12.2	5.7
6	4.58	33.6	29.0	15.3	12.5	5.7
7	4.58	36.3	31.7	17.6	12.9	5.7
8	4.58	36.7	32.1	17.6	13.3	5.7
9	4.58	37.0	32.5	17.6	13.7	5.7
10	4.58	37.5	32.9	17.6	14.1	5.7
11	4.58	37.9	33.3	17.6	14.5	5.7
12	4.58	38.3	33.7	17.6	15.0	5.7
13	4.58	38.8	34.2	17.6	15.4	5.7
14	4.58	39.2	34.6	17.6	15.9	5.7
15	4.58	39.7	35.1	17.6	16.3	5.7
16	4.58	40.2	35.6	17.6	16.8	5.7
17	4.58	40.7	36.1	17.6	17.3	5.7
18	4.58	41.2	36.6	17.6	17.9	5.7
19	4.58	41.8	37.2	17.6	18.4	5.7
20	4.58	42.3	37.7	17.6	19.0	5.7
21	4.58	42.9	38.3	17.6	19.5	5.7
22	4.58	43.5	38.9	17.6	20.1	5.7
23	4.58	44.1	39.5	17.6	20.7	5.7
24	4.58	44.7	40.1	17.6	21.3	5.7
25	4.58	45.3	40.7	17.6	22.0	5.7
26	4.58	46.0	41.4	17.6	22.6	5.7
27	4.58	46.7	42.1	17.6	23.3	5.7
28	4.58	47.4	42.8	17.6	24.0	5.7
29	4.58	48.1	43.5	17.6	24.7	5.7
30	4.58	48.8	44.2	17.6	25.5	5.7
NPV@12%		196.7	221.6	24.9	93.4	93684

All calculations are based on a project period of 30 years.

EIRR base case 13.6 %

Benefits-cost ratio agricul effects 0.66

Benefits-cost ratio non-agri effects 0.47

Benefits-cost ratio total 1.13

* Comprising: changes in cropping pattern and intensity
and a 20% reduction in yield in the without project situation.

Sensitivity Analysis

Parameters tested	Switching Value (percentage change)
Increase of Investment and O&M cost	13
Reduction of Project Benefits	-11
Reduction of Agricultural Benefits	-19
Reduction of Non-agricultural Benefits	27

NPVR 0.10

Table 10.3 : Economic Indicators, Example.

ANNEX XI

OTHER CYCLONE PROTECTIVE MEASURES

X1. OTHER CYCLONE PROTECTIVE MEASURES

11.1 Introduction

Besides the coastal embankments the Cyclone Early Warning System and Cyclone shelters constitute the most important protective measures against disasters caused by cyclonic storms and storm surges.

Other important protective measures to mitigate the effect of damages by cyclones are protective belts of afforestation, a proper functioning communication and transport network for warning, evacuation and relief operations, improved design and construction of houses in the coastal area to resist strong wind forces, prohibition of human settlements in high risk zones like newly created char land and education of local officials, administrators, police, NGO's etc. on cyclones and precautions against cyclones.

11.2 The Cyclone Early Warning System

One of the main reasons that cyclone surges are so disastrous is that they build up suddenly, within hours, and not during several days as floods caused by precipitation. The damages and especially the loss of lives can therefore be greatly reduced by a reliable early warning system informing about the advent of cyclonic storms early enough to enable people in the likely affected areas to prepare for the event and be evacuated if necessary before the cyclone strikes.

The cyclone early warning system in Bangladesh was incepted after the disastrous cyclone November 1970 and has two main components :

i. The meteorological forecasting of the cyclone in Special Weather Bulletins issued by the Storm Warning Center of Meteorological Department in Dhaka.

ii. The communication system broadcasting and transmitting the Special Weather Bulletins to all the affected areas.

11.3 Cyclone Forecasting

Cyclones normally occur during the pre- and post monsoon period when they develop from depressions formed in the southern part of the Bay of Bengal when the sea temperature is above 27°C and the cloud coverage is moderate. Due to the special funnel shaped configuration of the Bay of Bengal most of the cyclones move in northerly and northeasterly direction towards Bangladesh where they normally cross the coast near the mouth of Meghna or along the Chittagong coast.

Due to the anticlockwise rotation of cyclones on the northern hemisphere the strongest winds and most severe storm surges occur along the south eastern coastline and at the off-shore islands near the Meghna delta as experienced during the April 1991 cyclone.

The depiction and forecasting of depressions and cyclones is the responsibility of the Storm Warning Center (SWC) of Meteorological Department in Dhaka. So far SWC has mainly used conventional synoptic meteorology on basis of meteorological data from land surface observations in India and Bangladesh together with some ships observations.

However, because the distribution of surface observations is heavily biased towards well populated land regions and as the ships avoid the cyclones, many vital data on cyclones are left out rendering this convential method of cyclone forecasting rather unreliable.

Far more reliable data on the development and tracks of cyclones and other weather phenomena can now be obtained from weather satellites surveying the earth's weather from a point well above the earth' surface. The advantages of space meteorology over the conventional methods are as follows :

i. Spatial continuity : The observations are horizontally continuous, this eliminates interpolation and thus the ambiguity often present in synoptic charts.

ii. Provides information on a synoptic scale with virtually no time lag.

iii. Visual Integration : Permits integrated visualization of weather systems in a way readily acceptable to the human mind.

iv. Independence of Communication System : Provides large scale weather information even if normal system of communications have broken down.

Thus the superior quality of space meteorology is unquestionable. But this does not render the traditional synoptic meteorology obsolete; it rather supplements the old system where improvements and innovations are continually taking place.

An APT ground station for the reception of imagery from weather satellites was established in Bangladesh in 1968 and recently SPARRSO has established advanced receiving and analyzing equipment including VAX computers, printers and international imaging system monitors for the reception and analysis of satellite data under its agroclimatic/environmental monitoring project.

With the help of these and other equipment both low and high resolution data from US NOAA-10 and NOAA-11 and Japanese CHS-3 satellites are received every 3 hours from the latter and twice daily from the two former satellites. Thus SPARRSO can detect any depression and cyclone developing in the Bay of Bengal, analyze their intensity, determine their position and track their motion with great accuracy.

From the degree of organization of the cloud patterns and their sizes the maximum wind speed and the magnitude of the wind field of the cyclone can be deduced. The most characteristic feature of very severe cyclonic storms is a clearly visible and prominent "eye" in the center of the cyclone.

The precise forces responsible for the motion of tropical cyclones is not understood clearly and hence determination of the path of the cyclone in advance is one of the most difficult tasks in meteorology.

The classical methods for forecasting cyclone tracks are judicious consideration of climatology of cyclones, persistence of motion and some steering current of the upper atmosphere. Tropical cyclones often show different preferred paths in different times of the year. Hence, climatology of cyclones provides some good guess for considerations to base the initial forecast. However, as there are large number of exceptions, forecast based on climatology alone cannot be entirely relied upon.

Recently various statistical and numerical dynamical methods have also been introduced for the forecast of cyclone paths, SPARRSO has installed a model named TYAN for predicting the track of a cyclone based on climatology of Bay of Bengal Cyclones for the last hundred years. The model has shown promising results for the forecast of cyclones movement twenty hour ahead of landfall and the forecast made for the April 1991 cyclone was very accurate.

The meteorological data obtained by SPARRSO and copies of satellite images are transmitted to SWC but have not been used so far for the special weather bulletins on cyclones.

The result of this is a time lag of 4 hours from the time of observation to issue of the bulletin of the observation of the cyclone.

Because the travelling speed of a severe cyclone during its final stage before landfall often exceed 30 to 40 km per hour such time lag in the issue and broadcast of bulletins may be fatal and should be avoided or reduced by all means.

The special weather bulletins on cyclones include information on location of the center, likely track, maximum wind speed and the probable areas it may hit.

The bulletins further include special maritime and river port warning signal numbers (1 to 11 for maritime ports and 1 to 4 for river ports) intended for warning the port authorities as well as the general public of the danger of an impending cyclone. Unfortunately the warning system, which is described in detail in appendix G, is both inadequate and complicated and therefore of little use for the general public.

11.4 Broadcasting and Transmission of SWC Special Bulletins and Warning Signals

The special weather bulletins and warning signals on cyclones are broadcasted through press, radio and television and issued to the Cyclone Preparedness Programme (CPP).

The CPP, administered jointly by the Government and the Bangladesh Red Cross Society (BDRCS), is organized in 2089 units of 207 unions under 24 Upazilas in 8 districts. 100 Professional staff support the activities of more than 20,000 trained volunteers, who dissimate the warning signals, alert people, evacuate them to safe places if possible, rescue marooned people and provide injured people with first aid.

Each unit is provided with transistor radio, megaphone, siren, signal light and first aid kit.

The CPP control room in Dhaka transmit the bulletins to 24 Upazila headquarters by H. F. wireless and 30 union and offshore islands through V. H. F. wireless. In unions with no V. H. F. wireless messages are passed from Upazila headquarters by liaison volunteers. The union team leaders in their turn pass the messages to the unit team leaders who tune their transistor radios to listen to the weather forecasts regularly.

From 25th to 30th April 1991 the SWC issued 29 special weather bulletins which were all transmitted by CPP.

The wireless network of CPP is shown on Figure 11.1.

For unknown reasons Chittagong district is not included in the CPP command area and wireless network. This is probably the main cause for the delay of relief operations in Chittagong after the April 1991 cyclone, when all telecommunication from Chittagong to the outside world had been disrupted.

11.5 Recommendations

i. The SWC should recognize the advantages of space meteorology make full use of the weather data available from SPARRSO in order to improve the reliability and accuracy of the special weather bulletins and to minimize time gap between observation & issuance of Bulletin.

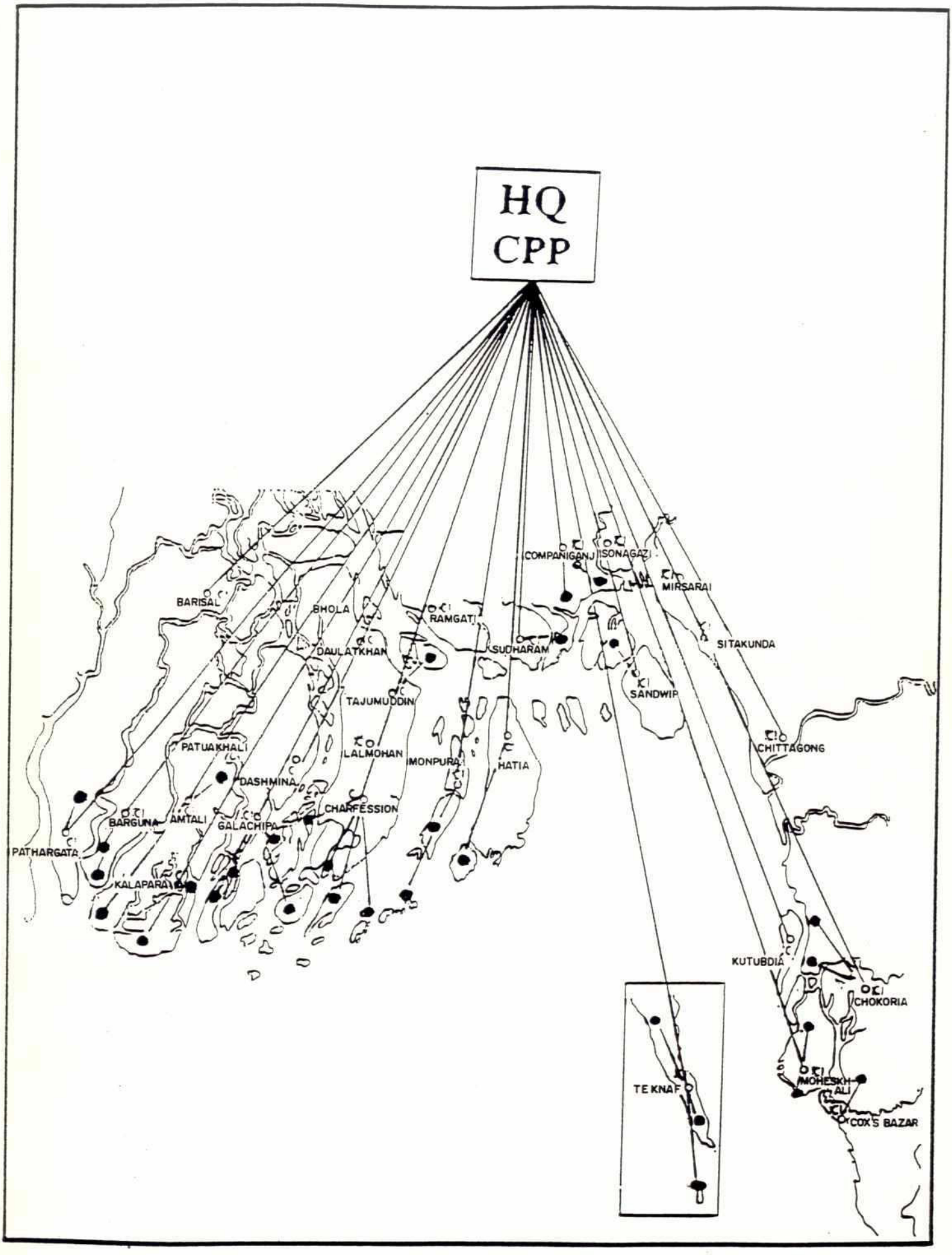


Figure 11.1 : CPP WIRELESS NETWORK

ii. The SWC bulletins should inform the public about the proximity of the outer edge of the Cyclone and not only about the distance of the Storm Entre. The Warning should, as far as possible, be specific for different areas in respect of wind directions, wind speeds, time of occurrence, time of high tide and expected elevation of storm surge if any.

iii. The maritime signals should be omitted or changed, so that public at large can readily understand their intended meanings and implications. Separate signals should be included for different wind speeds above 55 miles per hour.

iv. Mass media should be used for educating public in Cyclone Preparedness.

v. The CPP should be strengthened and given more resources for :

- Procurement & maintenance of field equipment.
- Training for Volunteers.
- Printing and distribution of booklets, posters on disaster preparedness & showing documentary films.
- The CPP command area should be extended to cover all cyclone prone coastal areas and off-shore islands.
- Wireless Communication facilities between upazila CPP offices and CPP Union Team Leaders of farflung unions and off-shore islands should be extended.

11.6 CYCLONE SHELTERS

The cyclone shelters are the most important infrastructures for accommodation distressed people during a severe cyclone. At present there are a little more than 300 cyclone shelters scattered through the whole coastal area, refer Table 11.1 Most of the cyclone shelters were constructed in the 1970's by the Bangladesh Red Cross Society and are generally in a very dilapidated stage due to complete lack of maintenance.

Besides cyclone shelters some 160 killas for protection of livestock exist in the coastal belt.

Most cyclone shelters are designed to accommodate approximately 2,000 people corresponding to a total capacity of approximately 600,000 people.

The distribution of cyclone shelters in the various parts of the coastal area is however very uneven, as can be seen from Table 11.1, and reflects the fact that political influence rather than exposure to cyclones has determined the number and location of cyclone shelters.

TABLE - 11.1
LIST OF CYCLONE SHELTERS

Division	Polder No.	No. of Cyclone Shelters
Noakhali O&M Division	60	12
	73/1A	5
	73/1B	11
	73/2A	12
	59/1A	5
	59/3C	7
	59/3A	3
	59/3B	21
	Total	76
Laxmipur O&M Division	59/2	12
	Comprehensive Drainage Scheme	4
	Total	16
Chittagong O&M Division-I	62	2
	Total	2
Chittagong O&M Division-II	72	18
	64/1A	3
	64/1B	1
	63/1A	5
	61/1	3
	61/2	1
	Total	31
Satkhira O&M Division-I	-	Nil
Satkhira O&M Division-II	-	Nil
Jessore O&M Division-I	-	Nil
Khulna O&M Division-II	-	Nil
Patuakhali O&M Division	Sadar	1
	43/2D	1
	41/7	1

Division	Polder No.	No. of Cyclone Shelters
	43/2B	2
	55/1	8
	55/2B	5
	55/2C	5
	43/2C	1
	55/3	6
	55/4	2
	52/53A	2
	52/53B	2
	50/51	2
	43/1	3
	47/4	3
	46	2
	47/5	3
	48	5
	44	1
	54	1
	47/1	1
	47/2	1
	47/3	1
	43/2A	2
	Total	61
Barguna O&M Division	39/1	4
	40/2	1
	42	1
	41/2	1
	44	5
	54	2
	Total	14
Cox's Bazar O&M Division	71	7
	70	1

Division	Polder No.	No. of Cyclone Shelters
	69	3
	66/3	3
	66/4	1
	64/2B	4
	68	4
	Total	23
Bhola O&M Division	58/1	2
	58/2	2
	58/3	2
	56/57	73
	Total	79
	Grand Total	302

All existing cyclone shelters are 2 or 3 storey concrete building which lack fo any kind of sanitary installations, water supply, food storage, furniture etc. and they are generally not being used by the communities for other purposes except as shools in some districts.

During the severe storm surge caused by the April 1991 Cyclone most cyclone shelters in the affected areas were occupied by people living in their immediate vicinity. People living further away are generally afraid of leaving their homes because they fear that their property and private belongings may be stolen.

Regardless of the protection provided by the improved embankments there will still be a huge demand for many new cyclone shelters in the most cyclone prone coastal areas.

This has been recognized by GOB and several donor agencies.

After the April 1991 cyclone a number of studies on cyclone shelter have been initiated. The most important ones are :

1. Multipurpose Cyclone Shelter Program.

2. Cyclone Damage Assessment

3. Task Force Report by Institute of Engineers Bangladesh.

4. Cyclone and Tidal Bore by Operation Seba.

5. Cyclone 1991 by Bangladesh Centre for Advance Studies.

On the basis of previous experience it is strongly recommended that new cyclone shelters be constructed as multipurpose buildings which can serve as schools, madrassas, mosques and community centres during normal periods.

There should preferably be a small cyclone shelter in each village within a short distance from all homesteads and constructed on elevated land which can serve as refuge for livestock. The elevated land can be constructed in combination with a reservoir for drinking water during disasters.

ANNEX XIII

TERMS OF REFERENCE FOR CONSULTANCY SERVICES DURING IMPLEMENTATION

XIII. TERMS OF REFERENCE FOR CONSULTANCY SERVICES DURING IMPLEMENTATION

DRAFT, February 2, 1992.

1. BACKGROUND

The severe cyclone, which hit the south eastern part of Bangladesh on 29-30 April 1991 caused extensive damages to the coastal protection dykes in this part of the country and left large areas virtually unprotected against tidal flooding and cyclone surges. The Government of Bangladesh has therefore decided to implement a two year emergency construction programme covering reconstruction of about 200 km coastal embankments and construction of about 60 km of new retired embankments, all with appurtenant hydraulic structures and allied protective works.

This construction programme will be financed by the international Development Association (IDA) in cooperation with other Donor Agencies.

Tendering for the construction programme is done partly as International Competitive Bidding (ICB) and partly as Local Competitive Bidding (LCB). The number of contracts is 8 for ICB and 15 for LCB.

The construction works are scheduled to start February 1992 (LCB works) and March 1993 (ICB works). All works should be completed before 30 June 1993.

Due to the timing of the preparation of the tender documents these do not cover all details of hydraulic structures. Such details and related field surveys will be undertaken during the construction period as required. The tender documents do however include such details of hydraulic structures as considered adequate for tendering purpose.

It is anticipated that some of the construction works will have to be discontinued during the rainy season of 1992. It is therefore foreseen that the detailed design and the tender documents for the construction programme under the Mid Term Plan from 1993 to 1996, expected to encompass 350 km of new or reconstructed embankments, will be prepared during the rainy season of 1992.

For the implementation of the above programme the executing agency for the implementation, Bangladesh Water Development Board (BWDB) requires consultancy services as stipulated in the following.

An outline programme showing the various phases of the consultancy services is shown in Appendix 1.

An outline Staffing Schedule is shown in Appendix 2.

2. OBJECTIVES

The purpose of the services is to

- undertake supervision of the emergency construction works under ICB contracts including supplementary detailed design as and when required.

- undertake detailed design and preparation of tender documents for the construction programme of the Mid Term Plan for the period 1993-1996.

- undertake monitoring of the overall social impacts of the emergency construction programme. Plan social development programmes as required, including a system for the future operation and maintenance of the completed works by involving beneficiaries and local councils.

3. SCOPE OF SERVICES

3.1 Supervision

The consultant shall undertake the supervision of all ICB contracts under the Emergency Cyclone Protection Project under the direction of the BWDB, and in cooperation with BWDB chief Engineer South Eastern Zone together with superintending Engineers and Executive Engineers of the relevant divisions.

The Consultant shall analyze bids received for ICB contracts, assist the BWDB in processing of contract award and prepare formal documents for execution.

Prior to the start of the supervision in the field the Consultant shall conduct training courses for Resident and Assistent Resident Engineers and a number of BWDB senior staff involved in the project. The training courses shall deal with the following main subjects:

- Introduction to International FIDIC Contract Documents

- Supervision organisation

- Quality control, testing and procedures

- Site administration

- Contractual and legal aspects

The Consultant shall set up suitable site supervision organisations to supervise and report on the works under the contracts in accordance with the contract

documents. Specially, the Consultant will be required to :

- approve the contractors' superintendence and key personnel.
- approve the contractors' plant and equipment.
- order the removal and replacement of improper materials and works.
- check and approve the necessary measurements and calculations for the contractors' interim certificates and certify the certificates correct for payments.
- examine and attend the measurement of any work which is about to be covered up or put out of view before permanent work is placed thereon and/or examine and attend the measuring of the completed works.
- call and keep minutes of routine site meeting between the parties to the contract.

In addition the Consultant will be required to:

- carry out supplementary field surveys and investigations as required for completion of detailed design of hydraulic structures in the Emergency Construction Programme.
- complete supplementary details of hydraulic structures as required by the contractors for timely construction of structures in the Emergency Programme. Required soils Investigations will be carried out by the contractors under direction of the consultant who will analyse the results of the soils Investigation.
- provide such information as is necessary for the contractor to set out the works and check that this setting out is correct.
- review the contractors' work proposals, working drawings etc. to the extent required by the contract, advise modifications where necessary and recommend these proposals for approval.
- review the contractors' works programmes and, where necessary request revisions of these to account for the current status of the works.
- through Resident Engineers, inspectors and other staff as may be required, supervise the day to day operations of the Contractor to ensure compliance with the contract.

- test materials to be used in the works prior to incorporation, approve type, quality and source of materials and test completed parts of the works for compliance with the Contract.

- make recommendations to BWDB on the contractor's claims for additional payment, extensions of time and other matters, based on the Consultant's interpretation of the Contract Documents, the relevant site conditions and the Contractor's detailed submissions.

- in the event of variations to the works being required, prepare the necessary documents, negotiate these with the Contractor and submit the agreed Variation Order to BWDB for approval.

- maintain detailed diaries of relevant events and activities.

- set up and maintain a correspondence and document storage and retrieval system to record all relevant communications between the parties to the Contract, all measurement and quality control details and variations to the works as they occur.

- maintain as built drawings and documents.

- prepare monthly progress reports for each contract in a form acceptable to BWDB and IDA. These reports will include as a minimum details of the physical and financial status of each contract, details of delays and the budgetary effect of these and particular problems with suggested solutions.

- carry out final inspections of the works and recommend the issue of completion certificates.

- check the Contractors' final accounts and certify them correct for payment.

- prepare completion reports in a form acceptable to BWDB and IDA.

- during the twelve month maintenance period the Consultants will periodically check the completed work. Shortly before the end of the Maintenance Period the Consultant shall carry out the necessary inspections, specify the rectification work to be done, supervise this as required and, finally issue a Maintenance Certificate after consultation with BWDB.

In setting up the management and cost accounting systems it is anticipated that the Consultant will make appropriate use of microcomputer based methods.

3.2 Detailed Design and Tender Documents for Mid Term Plan, 1993-1996 Programme

The Consultant shall prepare detailed design and tender documents and perform field surveys for the construction programme under the Mid Term Plan scheduled for implementation 1993/94 to 1995/96. It is anticipated that the field surveys will be carried out during the dry season 1991/92 and that the detailed design and tender documents will be prepared during the wet season of 1992. The Consultant shall undertake the following tasks

- engineering surveys and soil and foundation investigations for the Mid Term 1993-1996 Programme covering.

  (i) cross sections at 50 m intervals for new and existing embankments to be resectioned.
  (ii) site surveys and foundation investigations for hydraulic structures, and
  (iii) foundation investigations for embankments and soils investigation of borrow areas.

- preparation of plans and longitudinal profiles at suitable scales of new or reconstructed coastal embankments on the basis of the recommendations for the Mid Term Plan.

- preparation of detailed drawings at suitable scales of new and rehabilitated hydraulic structures.

- preparation of tender documents for international tendering based on the division of the construction programme in a suitable number of contracts.

- preparation of a design report including cost estimates for each contract package.

The draft tender drawings and documents and design report shall be submitted for the comments and/or approval of BWDB. Final tender drawing and final design report shall be submitted after receipt of BWDB's comments and/or approval.

3.3 Social Development Programme

The Consultant shall plan and monitor the implementation of a social development programme including:

- monitoring the process of land acquisition and planning and supervising of resettlement and rehabilitation, where necessary, of households whose land is acquired

- monitoring the overall social impact of the project both on those whose land has been acquired and others who have been positively or adversely affected

- developing a system for the future operation and maintenance of the completed works, involving the participation of beneficiaries and local councils.

The Consultant shall provide a social development team to undertake the above mentioned tasks. This team shall work in close contact and liaison with relevant governmental organisations, local councils, non-governmental organisations and other development projects.

4. DURATION OF CONSULTANCY

The consultancy will be provided for a period of 18.5 months followed by 12 months' maintenance and defects identification period. Date of commencement of the consultancy services with evaluation of Tenders and initiation of engineering surveys is 15 February 1992.

5. STAFFING

The estimated required inputs of professional staff for the consultancy services is set out in Table 1 and Table 2 below:

A total of 71 expatriate and 331 local professional man-months are envisaged.

A Staff Schedule is enclosed as Appendix 1.

DESIGNATION	NOS.	PERIODS OF ASSIGNMENT	EFFECTIVE MAN-MONTHS
Team Leader	1	15.02.92-01.09.93 01.06.94-01.07.94	18.5
Chief Engineer Design	1	15.02.92-15.08.92	6
Tender Advisor	1	15.02.92-15.03.92	1
Chief Resident Engineer-1	1	15.03.92-01.09.93 01.06.94-01.07.94	17.5
Chief Resident Engineer-2	1	01.04.92-01.09.93	16
Social Development Advisor	1	15.03.92-15.05.92 15.10.92-15.12.92 15.03.93-15.05.93	6
Economist	1	15.03.92-07.04.92 15.10.92-07.11.92 15.03.93-07.04.93	2
Environmentalist	1	15.03.92-07.04.92 15.10.92-07.11.92 15.03.93-07.04.93	2
Training Specialist	1	15.02.92-15.04.92	*) 2
Total	9		71.0

*) Includes 1 man month preparation at Consultants Head Office

Table 1: Expatriate Professionals
(Based on 1 month mid tour leave for long term staff).

DESIGNATION	NOS.	PERIODS OF ASSIGN-MENT	EFFECTIVE MAN-MONTHS
Senior Engineer Design	1	15.02.92-01.07.93	15.5
Senior Engineer Design	1	15.02.92-15.08.92	6
Assistant Engineer Design	1	15.02.92-01.07.93	*) 12
Assistant Engineer Design	1	15.02.92-15.08.92	6
Deputy Chief Resident Engineer	1	15.03.92-01.07.93	14.5
Site Resident Engineer	7	15.03.92-01.08.93 01.04.94-01.05.94	**) 110
Ass. Site Resident Engineer	8	01.08.92-01.07.93	80
Senior Materials Testing Engineer	1	15.03.92-01.07.93	14.5
Chief Social Development Officer	1	15.03.92-01.07.93	14.5
Social Development Officer	1	15.03.92-01.07.93	14.5
Field Officers	3	15.03.92-01.07.93	43.5
Total	26		331

*) Part time from 01.01.93 to 01.07.93
**) Only 2 Site Res. Eng. from 01.06.94 to 01.07.94

Table 2: Local Professionals.

6. REPORTS

The following reports shall be submitted to the BWDB with copies to IDA and EEC.

6.1 Progress Report

During the construction period the Consultant shall submit monthly progress reports for each contract and a monthly summary progress report dealing with the progress of the entire project. During the period of design for the Mid Term Plan 1993-1996 Programme the Consultant shall submit monthly progress reports dealing with survey, design and preparation of tender documents. The progress reports shall be submitted in 20 copies each.

6.2 Completion Report

At the completion of each contract the Consultant shall prepare a completion

report to be submitted in 20 copies each. As built drawings shall be submitted in 5 copies.

6.3 Tender Documents

Draft tender documents for Mid Term Plan Projects 1993 -1996 shall be submitted in 10 copies for the general part and 10 copies for each contract for the particular part.

Draft design report shall be submitted in 10 copies.

Final tender documents shall be submitted in 10 copies for each contract.

Final design report shall be submitted in 20 copies.

6.4 Social Development Report

Draft report on Social Development Programme shall be submitted in 10 copies.

Final report shall be submitted in 20 copies.

7. ASSISTANCE TO BE PROVIDED BY BWDB

The Government of Bangladesh/BWDB undertakes the following:

7.1 Staff

The BWDB will undertake to :

- nominate a Directorate which will be responsible for routine contact between the BWDB and the Consultant and will be responsible for ensuring that the services proceed in accordance with the Consultancy Contract and conform to the requirements and policies of the BWDB.

The BWDB may also require that the Consultant include in his teams some of its engineers and technical staff, to gain experience in the supervision of contract works. These individuals will not be substitutes for the Consultant's own staff. They may act as counterparts for the Consultant for the Consultant's staff but the responsibilities for adequate supervision of the works will remain with the latter. The BWDB will continue to pay their salaries and allowances and will provide accommodation as necessary.

7.2 Facilities and Equipment

Each construction contract includes the provision and maintenance, by the Contractor, of vehicles, laboratory and survey equipment, computers, furnished office space and fully furnished accommodation for the Consultants site staff. BWDB will provide these at no cost to the Consultant for the duration of his service.

Should the Consultant find that additional items are considered necessary to adequately supervise the works and if the BWDB accepts that these additional items are required, then the Consultant shall provide these on a reimbursable basis. At the conclusion of the consultancy such items will be handed over to the BWDB.

7.3 Freedom From Taxation and Duties

The Government/Executing Agency shall bear the cost of any taxes, duties, fees levies and other impositions under the laws and regulations in effect in Bangladesh on the Consultant and expatriate personnel in respect of:

- any payments made to the consultants or their staff other than Bangladesh nationals, in connection with the carrying out of the services;

- any materials, equipment and supplies brought into Bangladesh for the purpose of carrying out the services and which after having been brought to the country will be subsequently withdrawn therefrom;

- any equipment imported for the purpose of carrying out the services and paid out from the funds provided by the Government and which is treated as property of the Government.

Provided that:

(a) the consultant or any of the expatriate personnel shall follow the usual customs procedure of the government in importing property into Bangladesh;

(b) if the Consultant or any of expatriate personnel does not withdraw, but disposes of any property in Bangladesh upon which custom duties and taxes have been exempted, the Consultant shall bear such custom duties and taxes in conformity with the regulations of the Government.

7.4 Other Priviliges and Exemptions

The Government shall:

- provide the expatriate personnel with work permits and such other documents as shall be necessary to enable them to perform the services including privileges specified in the Government of the peoples Republic of Bangladesh notification No/RO 88-L85/906/CUS dated 13 th February, 1985 and No/RO 89/85/907/CUS dated 13th February 1985 (circular of 1988 is to be incorporated);

- arrange for the personnel and his authorised dependants to be provided promptly with all necessary exchange permit and travel documents required for their stay in Bangladesh;

- facilitate clearance through customs of any property required for the services and of the personal effects of the expatriate personnel and the prompt issue to the Consultants expatriate personnel of Custom Pass Books;

- issue to officials, agents and representatives of the Government all such instructions as may be necessary for implementation of the services;

- exempt the consultant and the personnel for the devices from any requirement to register or obtain any permit to practice the profession of Engineer or Architect or to establish himself either individually or as a corporate entity according to the laws of Bangladesh;

- arrange for duties and taxes on the imported equipment, vehicles and other materials relating to the project which will be retained in Bangladesh, to be paid by the implementing agency in Bangladesh.

7.5 Services

- The Government shall provide assistance to collect pertinent data, maps and information available for the performance of the Services under this Contract.

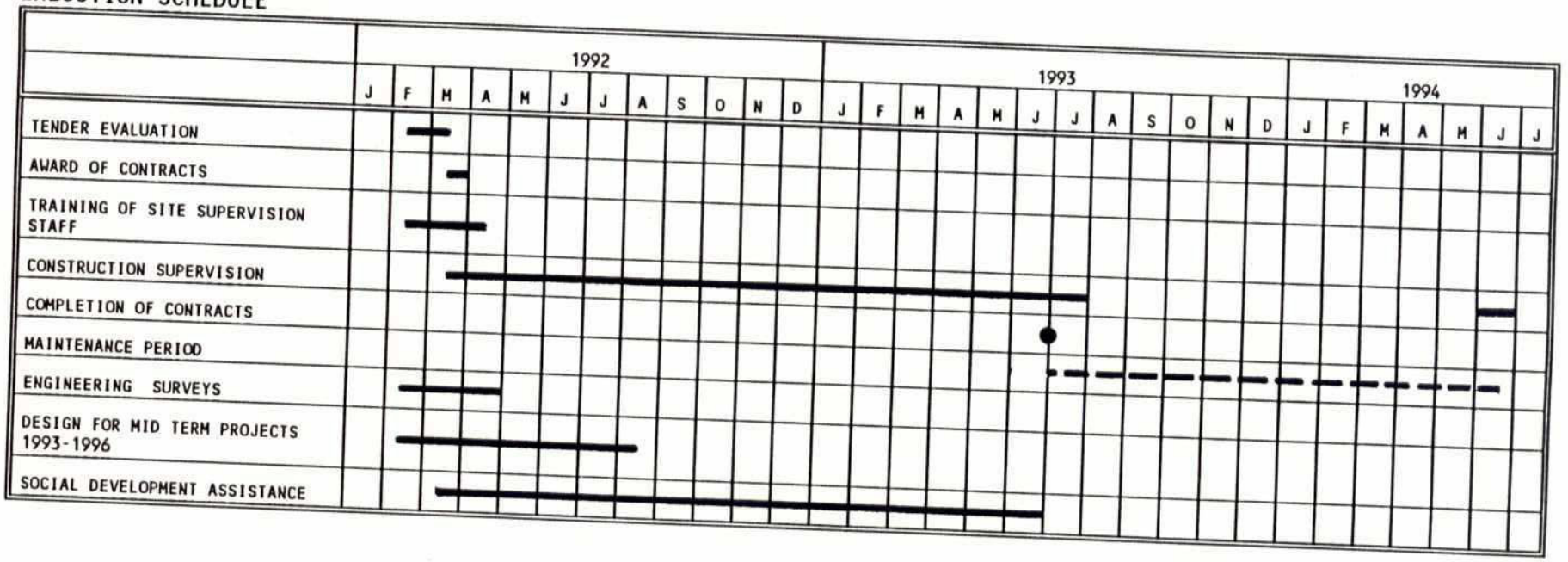
- The Govt. shall, if available, provide accommodation in the BWDB Rest House at usual rate.

- Indemnify, save and hold harmless the Consultant and its personnel from and against all claims, demands or suits, that may be made or brought against the Consultant and the personnel arising directly from the performance of the services provided that, such claims, demands or suits are not the result of negligence or wilful acts of the Consultant and its personnel.

APPENDIX 1

EMERGENCY CYCLONE PROTECTION PROJECT
TERMS OF REFERENCE FOR CONSULTANCY SERVICES DURING IMPLEMENTATION

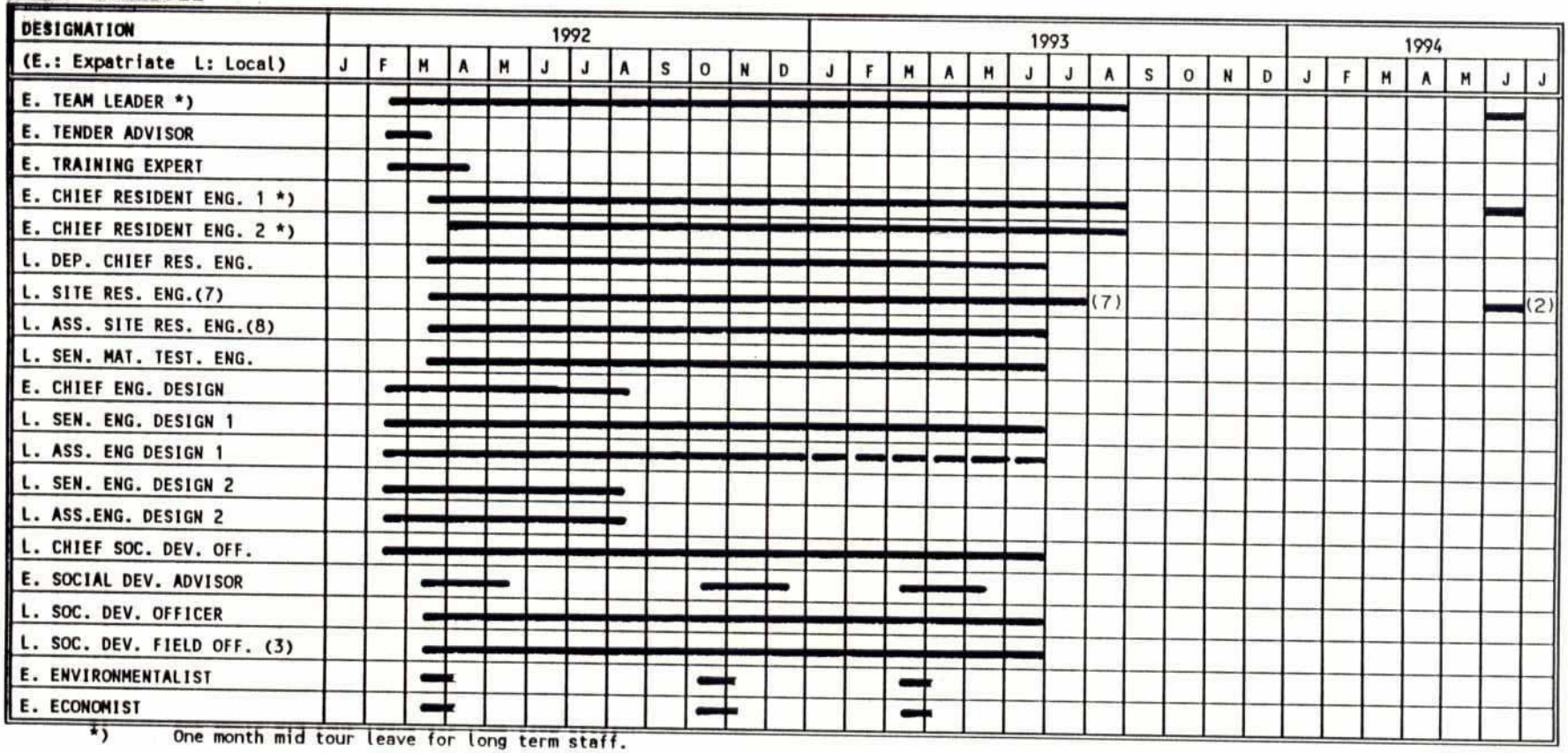
EXECUTION SCHEDULE



APPENDIX 2

EMERGENCY CYCLONE PROTECTION PROJECT
TERMS OF REFERENCE FOR CONSULTANCY SERVICES DURING IMPLEMENTATION

STAFF SCHEDULE



*) One month mid tour leave for long term staff.