

8

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**

BN-290
A-348

**FINAL PROJECT PREPARATION REPORT
APPENDIX B - FIELD SURVEYS AND SOIL INVESTIGATIONS**

May 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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REPORT VOLUMES

The present Report Volume is part of the

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

Consisting of the following Volumes :

- | | | |
|------------|---|---------------------------------------|
| Volume 1 | - | Main Report |
| Volume 2 | - | Annexes I - XI, XIII |
| 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. |

FIELD SURVEYS AND SOIL INVESTIGATIONS

1. INTRODUCTION

This appendix presents Engineering Surveys, Soil Surveys and Foundation Investigations for the study area encompassing sea-facing polders, off-shore islands (Sandwip, Hatia, Bhola, Kutubdia) and embankments vulnerable to monsoon waves and cyclone surges as shown on the base map Figure 1.1.

2. FIELD SURVEYS

The existing embankments and hydraulic structures in the entire study area were covered by field reconnaissances and condition surveys followed by engineering surveys.

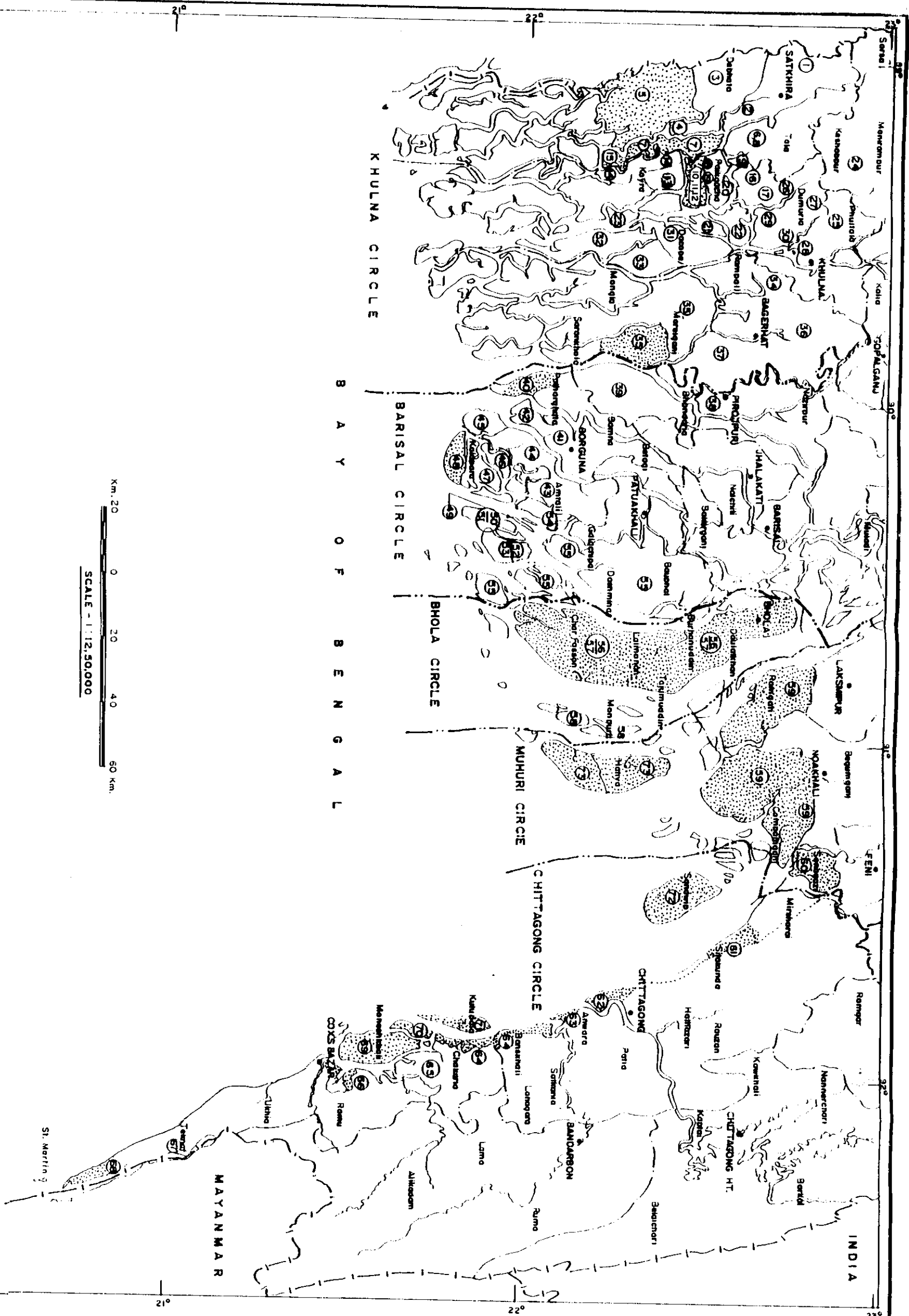
2.1 Reconnaissance and Condition Survey

With the inception of the task the Consultant contacted the local BWDB field officials and collected the reports from the Executive Engineers about the damages caused to the embankment and structures in the respective divisions. Altogether 998 schemes for repair and new construction programme were received covering the construction of 626 Km embankment and 333 no. structures and repair of 856 Km embankment and 268 structures.

For the delineation of the project, several discussions were held with the senior officials of BWDB and the representatives of the Donor Agencies. It was decided that the sea-facing embankments and the embankments along the banks of the wide rivers and estuarine-channels should be included in the study.

Senior members of the Consultants team conducted condition survey in the entire study area (refer table 1.1) to collect comprehensive information on the actual conditions of the embankments, structures, protective works. The findings were recorded in forms as shown in figure 1.2 and 1.3. The collected data were compiled, studied and analyzed. After a thorough study it was decided that the Cyclone Protection Project-II should be comprised of 769 Km of the embankment, including allied structures and protective works.

The findings of the surveys were in principle used for the determination of stretches of embankment to be resectioned or newly constructed and for construction of new hydraulic structures and repairing 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. Additional field surveys and air reconnaissance from helicopter with video were performed in a number of polders to supplement the original condition survey.



LEGEND

International Boundary
 District Boundary
 BWDB Circle Boundary
 Rivers
 Polder Number
 Polders Surveyed for Mid Term Program
 55

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

CYCLONE PROTECTION PROJECT II

PROJECT PREPARATION REPORT

BASE MAP

Client: KAWASAT INTERNATIONAL, A/S, SØNDØS AND DANISH HYDRAULIC INSTITUTE
 Address: 23, New Station Road, Dhaka-1000, Tel. 0017, Fax 0017 02 00391
 Date: 01-02-1992
 Figure 1.1

CPP - II CONDITION SURVEY										DATE	SIGNATURE			
										TIME				
O&M DIVISION			POLDER NO.					FROM KM	TO KM	CHAINAGE				
EMBANKMENT REPAIRED / RESECTIONED / RETIRED 19	GEOMETRY	DIMENSIONS [m]	A	B	C	D	E	S-R/S	C/S					
		LEVELS [m]	Crest						<p>GEOMETRY (FIELD MEASUREMENTS)</p>					
			Natural Ground R/S											
			Natural Ground C/S											
			Max. High Water											
	CONSTRUCTION	MATERIALS	Storm Surge Still						<p>CEP DESIGN PROFILE</p>					
			Clay / Silty Clay											
			Silt / Sandy Silt											
		Sand												
		COMPACTION	Good / Fair / Poor											
		CREST SURFACE	Earth / Bushes											
		ENCROACHMENT	Brick / Asphalt											
	DAMAGE	LOCATION	Settlement / Path						<p>SKETCH OF DAMAGES</p>					
			Cultivation											
			Sea-River Side											
		MAIN CAUSES	Crest											
			Country Side											
			Wave Action											
			River Erosion											
			Rain Run - Off											
REQUIRED REMEDIAL MEASURES		Storm Surge												
		Flooding												
	Gen. Wear & Tear													
	Retirement													
	Reconstruction													
	Turfing & Plantation													
	Afforestation													
SLOPE PROTECTION CONSTR. 19 ... REPAIRED 19	TYPE	Protective Works						<p>LANDUSE :</p> <p>LOCATION OF PHOTOGRAPHS</p> <p>SEA/RIVER SIDE</p> <p>AFFORESTATION :</p>						
		Repair / Resectioning												
		Grass / Bushes												
		Afforestation												
		Porcupines												
		Brick Mattress												
		Brick Block / C.C. Block												
		Stone Revetment												
		Foreland Accretion												
		Other												
EXTENT	Full Slope													
	Part Slope													
	Toe / Berin													
CONDITION & PERFORMANCE	Good / Fair													
	Poor / Unsuitable													
ASSESSMENT OF MAINTENANCE REQUIREMENTS	Embankment	Every --- Year						PHOTOGRAPHS	P1	P2	P3	P4	P5	P6
		Every --- Month						FILM NO						
	Slope Protection	Every --- Year						EXPOSURE NO.						
		Every --- Month						REMARKS						
DISTANCE TO NEAREST SOURCE OF MATERIALS	Embankment	Km												
		m												
	Slope Protection	Km												
		m												

FIGURE-1.2

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		Pile			
		SIZE	x		Dia			
	TYPE		Sluice					
			Regulator					
			Other					
	MATERIAL		Brick					
			Reint. 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					
	DAMAGED BY		Flap Gates					
			Slide Gates					
			Settlement					
			Erosion					
			Piping					
			General Wear & Tear					
			Other					
	REPAIR NEEDED		Repairable					
			To be Replaced					
ASSESSMENT OF MAINTENANCE REQUIREMENTS		Every ——— Year						
		Every ——— Month						
		Daily						
					PHOTOGRAPHS P1 P2 P3 P4			
					FILM NO.			
					EXPOSURE NO.			
REMARKS :								

FIGURE-1.3

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)	Polder No.	Embankment Length (Km)	Polder No.	Embankment Length (Km)	Polder No.
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 Length (Km)	Polder No.	Embankment Length (Km)	Polder No.	Embankment Length (Km)	Polder No.
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

Surveys of Embankment and Structures

For all the polders in the Mid Term Plan engineering surveys of embankments and structures were carried out as follows:

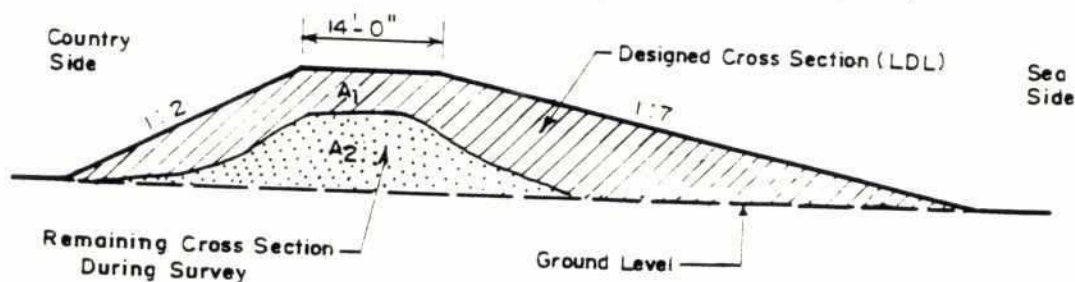
- i) Longitudinal levelling of existing embankments and new or retired embankments with elevations at not more than 30 meter intervals.
- ii) Cross sections generally at 300 meter intervals and specifically at breaches, retirements, new embankments at 100 meter intervals and at sections of embankments which are new or needing, extensive re-sectioning and/or improvements.
- iii) Site surveys for major hydraulic structures.
- iv) Establishment of permanent bench marks at max. 6 Km intervals.

Detail engineering surveys for the 1st Year Construction Programme/Emergency Cyclone Protection Programme includes:

- i) Cross sections at 30 meter intervals.
- ii) Grid survey in polder-62 where the embankment needs retirement.
- iii) Site surveys for hydraulic structures.

Engineering Surveys carried out for Mid Term Plan are shown in table 1.2 and detail engineering surveys for 1st Year Construction/Emergency Cyclone Protection Programme are shown in Table 1.3

Upon completion of the field survey a data bank of records was made by using the consultants computer facilities. Field survey results of 1st Year Construction Programme/Emergency Cyclone Protection Programme are presented in enclosures 1 to 15. Two enclosures are presented for each polder. One enclosure shows the existing crest level compared to the original design crest level and the other enclosures graphically presents the areas of the cross section of the existing embankment as a percentage of the area of the cross section of the existing embankment as a percentage of the area of the original design cross-section. The altitude of the shaded area at any section represent the percentage of remaining embankment cross-section with respect to that of design cross-section (LDL).



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If the area of design cross-section (LDL) is A1 and that of remaining cross-section during survey is A2 then the altitude = $\frac{A2}{A1} \times 100 \%$

The altitude of the firm line represent the design cross-sectional area (LDL) which is equal to 100 %.

The enclosures show the deplorable condition and extent of damage of the embankments in different polders at the time of surveying. It also helps in the assessment of quantum of reconstruction required.

The actual quantity of earthwork for reconstruction of embankment has been computed from the consultants data bank for project preparation. However the cyclone of April 1991 rendered the survey results obsolete in several polders. The consultants have carried out new detail survey for Polder-62 and site survey for structures in different polders under Emergency Cyclone Protection Project. New survey is to be conducted in remaining polders of the programme to assess the actual volume of the work during execution.

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POLDER NO.	CHAINAGE	EMBANKMENT WORKS		STRUCTURES (NO.)	
		RESECTIONING (KM)	NEW RETIRED (KM)	NEW	REPAIR
5	32.0-46.0 92.2-114.8	14.0 22.6			2
7/1	0-31.0	31			
7/2	0-6.0 & 54.0-58.2	10.2			
10-11-12	16.0-23.5	7.5			1
14/1	0-11.5	11.5			
14/2	0-10.0	10.0			
15	0-20.5 & 20.8-26.8	26.5			
35/1	1.6-4.1 6.3-8.1	2.5 1.8		1	
40/2	10.0-15.0 & 18.5-23	9.5			
48	26.0-35.0	9.0			
56/57	63.7-67.5 67.5-76.0 76.0-80.5 80.5-126	3.8 45.5	8.5 4.5	1	
59/2	121-124.0 124-126.5 126.5-135.0	3.0 8.5	2.5	2	
59/3C	11.0-14.0 14.0-21.0 21.0-27.0	7.0	3.0 6.0	5	
60	15.0-21.0 & 25.0-27.0	8.0			3
66/1	0-5.0	5.0			1
68	11.4-16.4 16.4-18.3 18.3-23.5 23.5-28.4	5.0 5.2	1.9 4.9	1	
70	0-6.5 "6.5-26.0"	6.5	2.5	2	
72	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		
73/1B	51.5-56.5		5.0		
TOTAL		269.8	45.3	12	7

Table 1.2 : Engineering Survey for Mid Term Plan (Exclusive of 1st Year Construction/Emergency Programme)

POLDER NO.	CHAINAGE	EMBANKMENT WORKS		STRUCTURES (NO.)	
		RESECTIONING (KM)	NEW RETIRED (KM)	NEW	REPAIR
59/3B	27.5-69.5	42	0.5	9	
61/1	1-2.6 0.5E-2.11E R2.11E-R4.98E	1.6 1.61	2.87	2	1
62	0-1.3 R1.98-R5.485 5.55-11.0 11.0-18.705 18.705-22.2	1.30 5.45 7.705 3.495	3.505	9	
63/1A	28.5-32.0 32.0-33.98 R33.98-R37.04 36.8-38.1 R38.31-R42.02 41.8-43.0	3.5 1.98 1.3 1.2	3.06 3.71		1
64/1A	81.0-83.25 R83.25-R90.11 90.7-100.5 R100.4-R107.82	2.25 9.8	6.86 7.42	1	1
64/1C	11.0-21.0	10.0			
64/2B	10.8-14.2 116.8-126.8 104.0-107.0	3.4 10.0 3.0			
66/3	R44.3-R45.9 46.3-49.3	3.0	1.6	1	
69	0-12.9	12.9		4	
71	0-11.7 R11.7-R25.1 R25.1-28.5 "28.5-41.0" 41.0-50.0	11.70 3.40 1.25 9.0	13.4	5	3
72	R8.4-R21.25 21.5-46.5	25.0	12.85	5	18
TOTAL		175.84	55.77	36	24

Table 1.3 : Detail Engineering Survey for 1st Year Construction/Emergency Cyclone Protection Programme.

3. SOIL SURVEYS AND FOUNDATION INVESTIGATION

The geological and geotechnical study were carried out for the project to assess the general geological formation of the area and sub-soil conditions for the foundation of embankments and hydraulic structures and also to explore the availability of embankment construction materials.

3.1 Geological Study

Sub-surface geology of the project area has been interpreted from different studies and publications. Most of the area except Chittagong district is formed by the deltaic action of the Ganges-Padma, Brahmaputra- Jamuna and Meghna river system.

Khulna district which constitute the western part of the project is formed entirely by the deltaic action of the river Ganges which brought mud and lime stone from the Himalays. The soil is composed of recent alluvium and to a great extent uniform in character and varies only by greater and smaller admixture of sand. Presence of organic soil such as peaty clay at different locations at shallow depth indicate that the deltaic tract must at some time have undergone a subsidence.

Barisal, Patuakhali and Bhola area constitute the central part of the project and is typical part of alluvial delta formed by the Ganges, Brahmaputra and Meghna river system. The soil is fine silt or sandy mud. In the Meghna estuary and along the banks of the Meghna and the Arial Khan rivers where the alluvium is more recent, the soil is sandy loam. The southern part lies along the shores of the Bay of Bengal. There the ground is steadily advancing to the south as the silt held in suspension by numerous streams is being deposited when it reaches the resisting mass of sea water. Sand banks thus formed gradually rise above the water level and the land formation process continues.

Unconsolidated sediments underline the southern part of Noakhali district. They are mainly recent and subrecent in age. A major part of the river flood plain sediments was deposited by the old Brahmaputra river before it changed its course to the west of the Madhupur Tract some 200 years ago. The rest of the sediment laid down principally by the Meghna river and by minor rivers draining from Trippera Hills.

Coastal belt of Chittagong district form the eastern part of the project. It can be divided in two units. i) the coastal plains and ii) the tidal mangrove swamps.

The coastal plains underlain by heavy marine or tidal clays but have been buried by sandy or silty deposits near the foot of the hills and along the course of rivers and streams. The tidal mangrove swamps are most extensive at the mouth of the Matamuhari river, where they form the

Chakaria Sunderbans and they also occur along the sides of other tidal rivers and creeks in Cox's Bazar.

Bangladesh Water Development Board (BWDB) had carried out an extensive soil investigation programmes for hydraulic structures and embankments in and around the project area. Available bore log data of these investigations have also been collected and consulted.

The above investigations revealed that the geology of the coastal area is predominantly of tidal deltaic deposit in Khulna, Barisal and Noakhali areas; estuarine deposits in Bhola areas and beach/dune sand deposits in Chittagong and Cox's Bazar areas.

3.2 Geotechnical Study

Sub-soil investigation for the project area have been carried out to assess the sub-soil conditions of embankments and the foundation requirements of hydraulic structures and to explore the availability of embankment construction materials.

3.2.1 Embankment Soil Investigation

Sub-soil investigation for embankment and the exploration of embankment construction materials involves a total of 506 drillings in 193 locations and testing of 591 nos. soil samples in the laboratory.

The polders and chainage for the location of drillings are shown below:

Area	Polder No.	Soil Samples Taken		Soil Samples Tested Nos.
		Location Km	Location Nos.	
Satkhira	5	90.016, 96.097, 104.095, 109.048 & 114.031	5	25
	7/1	0.805, 6.0 & 10.083	3	9
	7/2	47.0, 50.0 & 56.035	3	9
Barguna	46	28.5, 29.4 & 30.0	3	3
	48	19.6, 20.5, 20.95, 22.25, 24.37, 25.75, 27.07, 29.78, 32.2, 32.4, 33.81, 35.35 & 37.195	13	13
Noakhali	59/1A	8.0 & 12.0	2	6
	59/3B	27.5, 30.0, 33.0, 37.0, 42.0, 63.0, 64.0, 65.0, 66.0, 67.0, 68.0, 69.0 & 70.0	13	38
	59/3C	0.3, 5.0, 9.8, 15.0, 16.5 & 21.0	6	18
	73/2B	1.0, 6.5, 13.5, 19.2, 24.0, 28.6 & 32.7	7	20
Chittagong-I	62	2.0, 6.0, 10.0, 6.5, 6.53, 10.3, & 10.32	13	61

Area	Polder No.	Soil Samples Taken		Soil Samples Tested Nos.
		Location Km	Location Nos.	
Chittagong-II	61/1	0.4E, 4.0E, 0.5, 2.5, 8.11, 0.4 & 2.6	8	27
	63/1A	10.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 28.0, 30.0, 36.0, 39.0, 42.0, 45.0, 48.0, 33.2, 36.23 & 36.2	17	55
	64/1A	86.48, 87.8, 88, 89, 90, 101.09, 102.0, 103.0, 104.08, 105.0 & 106.0	11	32
	64/1C	11.5, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0 & 19.0	9	28
	72	0.1, 1, 2, 3, 4, 5, 6, 7.24, 8, 9, 10, 10.34, 11.5, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23.39, 25, 30, 35, 40.2, 45.2, 50.2, 54.5, 56, 57, 58, 59, 60, 61.62, 63, 64, 0.3 & 0.78	43	125
Cox's Bazar	64/2B	116.0, 120.0 & 124.0	3	10
	66/1	2.0 & 7.0	2	7
	66/3	43.0, 47.0 & 50.0	3	11
	68	12.9, 18.0, 25.0 & 28.0	4	13
	69	0.5, 4.8, 9.5, 14.0 & 19.0	5	15
	70	3.0, 8.0, & 15.0	3	9
	71	11.26, 12.26, 13.426, 14.426, 15.63, 18.001, 19.001, 20.011, 21.27, 22.27, 23.27, 25.12, 26, 27.2, 28.0, 31.0 & 34.0	17	57
Total	22		193	591

Field Exploration and Soil Sampling

A set of three bore holes at the selected location of embankment was chosen with the central hole on the crest centre and the other two on the adjacent borrow area (one at sea/river side and the other at country side). Top 15.0 cm soil was removed, generally 3.0 m deep auger holes were made and disturbed soil samples weighing about 1.0kg were collected in polythene bags for each type of soil layer encountered in the hole. Any change in soil characteristic was also recorded. The polythene bags were marked with identification number to avoid any amalgamation during laboratory testing.

Laboratory Testing Standards

The collected soil samples were tested in the laboratory according to the standards as mentioned below:

- Natural Moisture Content : ASTM D2216
- Atterberg Limits : ASTM D423 & D424

- Grain Size Analysis : ASTM D432
(Sieve & Hydrometer)
- Specific Gravity : ASTM D854

Laboratory Soil Testing and Results

Soil samples have been classified as per Unified Soil Classification System and also analysed for physical properties i.e. Natural Moisture Content, Liquid Limit, Plasticity Index and Grain Size Analysis. The sample results have been presented in soil bore logs, tables, and gradation curves in Enclosure 16. The result of the soil investigations in the borrow area generally indicate that there will be suitable borrow materials available for embankment construction on either side of the embankment.

3.2.2

Sub-soil Investigation for Hydraulic Structures

Sub-soil investigation for hydraulic structures involved 66 nos. boreholes drilled at proposed 20 nos. structure sites, collection of disturbed and undisturbed soil samples and sub-segment laboratory testing. Particulars of the structure sites are given below.

Division	Polder No.	Sl. No.	Sluice No.	Location (Km)
Noakhali	59/3B	1	SS-23	12.70
		2	SS-22	13.80
		3	SS-21	15.50
		4	SS-17	19.60
		5	DS-3	25.20
		6	SS-16	29.80
		7	SS-14	33.70
		8	SS-13	39.65
		9	SS-12	41.50
		10	DS-14	67.40
	59/3C	11	DS-1	2.57
		12	DS-3	11+3.5E
		13	DS-4	17.15

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Division	Polder No.	Sl. No.	Sluice No.	Location (Km)
Noakhali	59/3C	14	DS-5	19.90
	73/2B	15	DS-1	5.80
		16	DS-4	23.30
		17	DS-6	32.40
Chittagong II	72	18	DS-3BR2	14.875
		19	SS-4R1	27.70
		20	SS-12	44.40

Field Exploration and Soil Sampling

Bore holes were drilled at the site by wash method. Standard Penetration Test (SPT) was done at every 1.5 m except the depth where undisturbed sample was taken. Split spoon samples were taken and preserved in airtight plastic containers with proper identifications for necessary tests in the laboratory. A few undisturbed soil samples in 75 mm thin-walled seamless steel tube (shelby tube) were collected by pressing the tube in to the cohesive soil layer by static force. When the tube was almost full, avoiding over-penetration, it was withdrawn from the hole, removed from the drill rod, sealed at both ends with paraffin, properly identified and transported to the soil laboratory for the determination of different physical and engineering properties. No undisturbed sample was collected from the cohesionless strata. During the advancing of the bore hole, cutting of soil brought up by the boring and the disturbed samples collected from split spoon were examined visually at the site. When the soil indicated change in its characteristics, the depth where the change occurred was recorded and a field bore log was prepared with field identification and classification of soil samples. The field log also include information on ground level, ground water table of each bore hole.

The boring would cease when the S.P.T. value of each of the last three consecutive layers (each layer 1.5 m thick) were more than or equal to 12. The minimum and maximum depth of a bore hole was specified as 20.0 m and 30.0 m respectively.

Laboratory Soil Testing Standards

The disturbed soil samples were tested in the laboratory for soil classification. Undisturbed soil samples were tested for consolidation and unconfined compression strength according to the standard mentioned below:

- Unconfined compression test : ASTM D2166
- Consolidation test : ASTM D2435

Laboratory Soil Testing and Results

All the disturbed samples were visually examined in the laboratory and representative samples were selected for detailed classification test. Natural Moisture Content, Atterberg Limits, Grain Size Analysis, Specific Gravity and Hydrometer tests were done on representative disturbed soil samples.

Unconfined compression test was done on undisturbed samples to determine the unconfined compression strength (q_u). Unconfined compression strength of the remoulded specimen (q_{ur}) at the same density and moisture content of the undisturbed specimen was determined to estimate the sensitivity of the soil sample.

Consolidation test on the selected undisturbed sample was done to obtain data for the settlement analysis. During preparation of samples adequate care was taken to avoid undesirable disturbances. The preconsolidation pressure had been determined following Casagrande method.

The field e -log p curve was drawn after Schmertmann (1955). The relevant parameters such as Recompression Index (C_r), Compression Index from laboratory virgin slope (C_c), Compression Index from field virgin slope (C'_c), Preconsolidation pressure (P_c) and present overburden pressure (P_o) along with void ratio vs. log pressure (e -log P) curve and coefficient of consolidation vs. log pressure (C_v -log P) curve are drawn. A Sample Soil investigation results for a hydraulic structure are presented in Enclosure 17.

3.3

Conclusion

The main geotechnical parameters relevant to the design are i) instability of slopes due to shear failure along circular or straight sliding surfaces ii) settlement in sub-soil due to the increase in loading conditions.

The slope stability is dependent on the undrained shear strength of the sub-soil, unit weight of the soil along with the height of the embankment and the slope angle. The undrained shear strength of soil in the project area varies from 10 Kn/m^2 to 25 Kn/m^2 . It is found that even for 10 Kn/m^2 undrained shear strength and embankment height of 4.0 m with a maximum gradient of 1:2, the embankment slope instability will not occur. It may be noted that the height of embankment is unlikely to exceed 4.0m -6.0 m and slope of embankment may vary from 1:2 to 1:7.

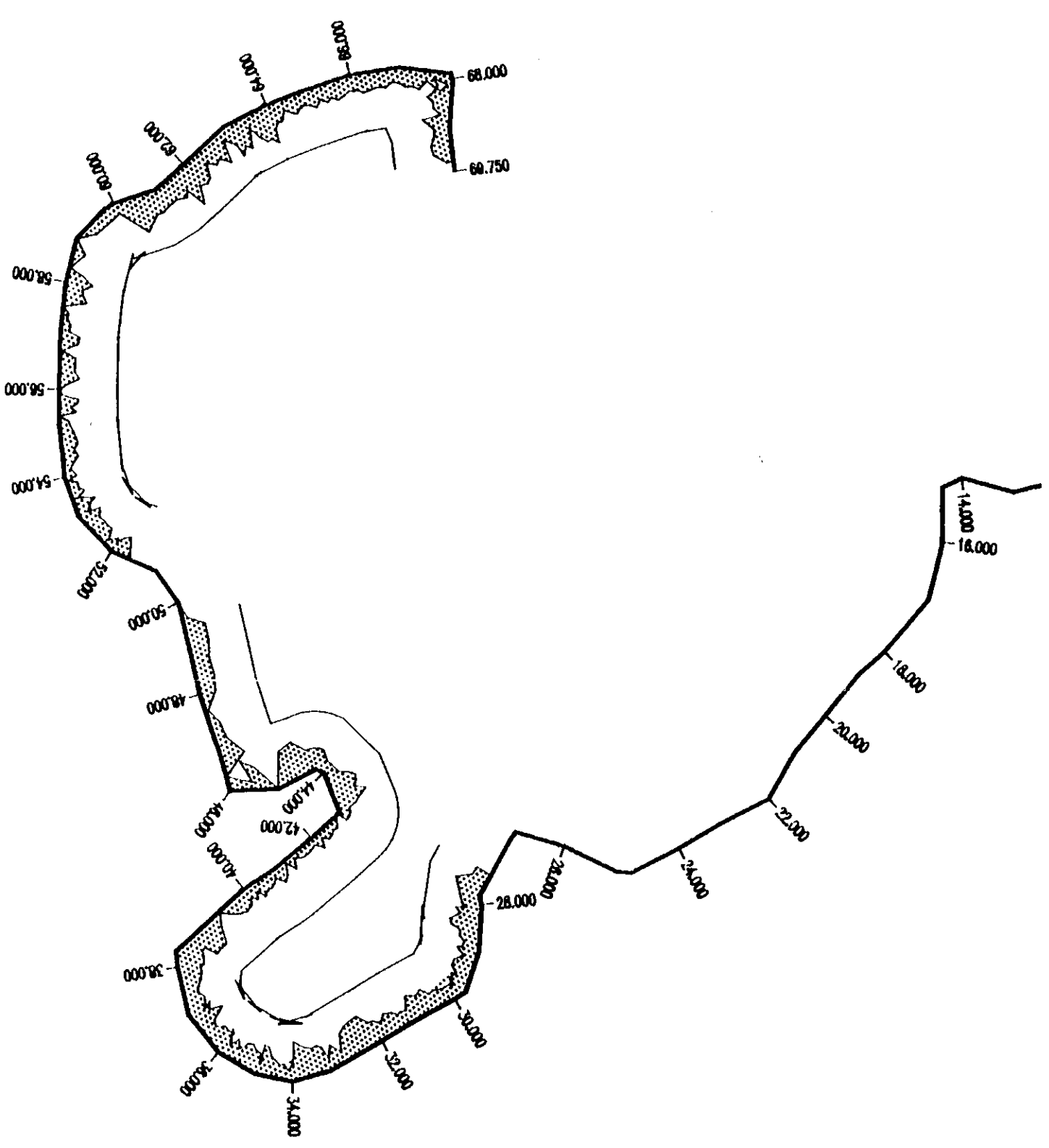
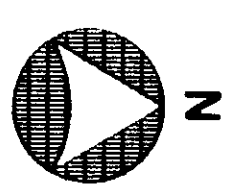
Shrinkage in the poorly compacted embankments may be quite substantial and may be even 20 % during the first monsoon period after construction of the embankment. It is found that the shrinkage of a well compacted embankment will be negligible.

The long term consolidation of the underlain soil conditions in the project area would be around 150 mm.

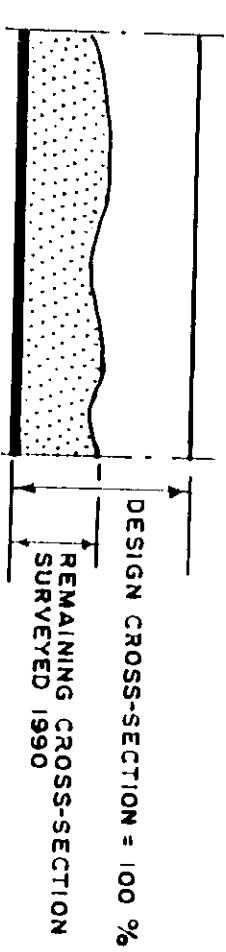
The sub-soil investigation carried out for the structures in polders 59/3B, 59/3C, 72 and 73 show that underlying strata in those area is sandy and no special foundation measures are required for the structures.

The sub-soil investigation report collected from the BWDB for the polders 35/1 and 70 reflect that the underlying layers in those areas are very poor exhibiting very low SPT values. Thus, it is expected that deep foundations will be required for the structures in those areas. For the reaming structures of different polders soil investigation is provided for during execution.

SUDHARAM(59/3b)

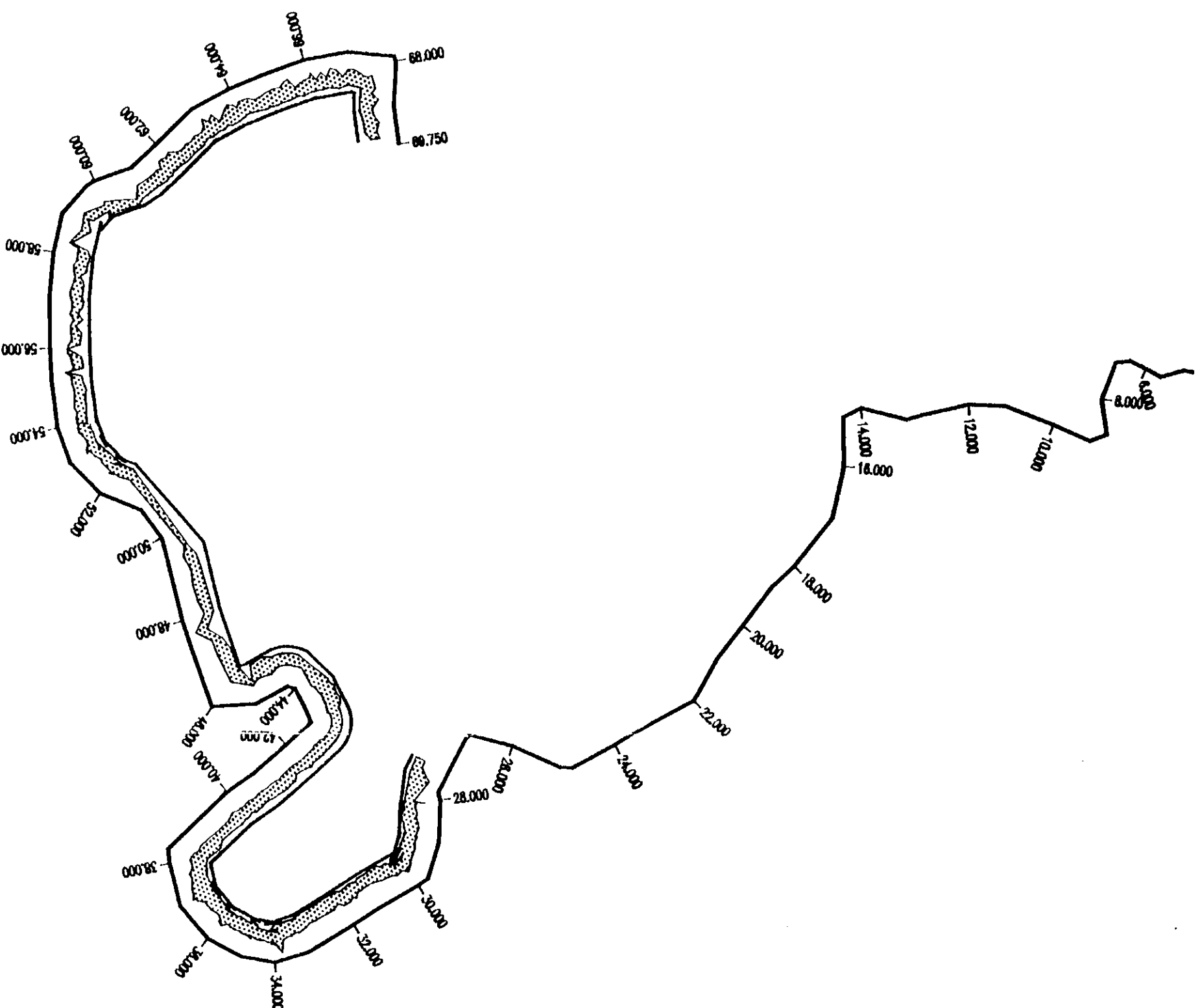


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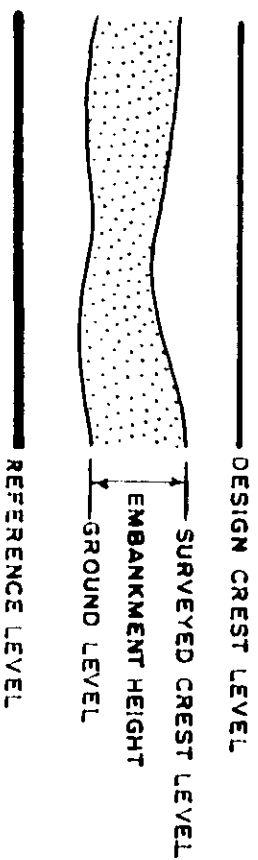


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ENCLOSURE 1	

SUDHARAM(59/3b)



LEGEND



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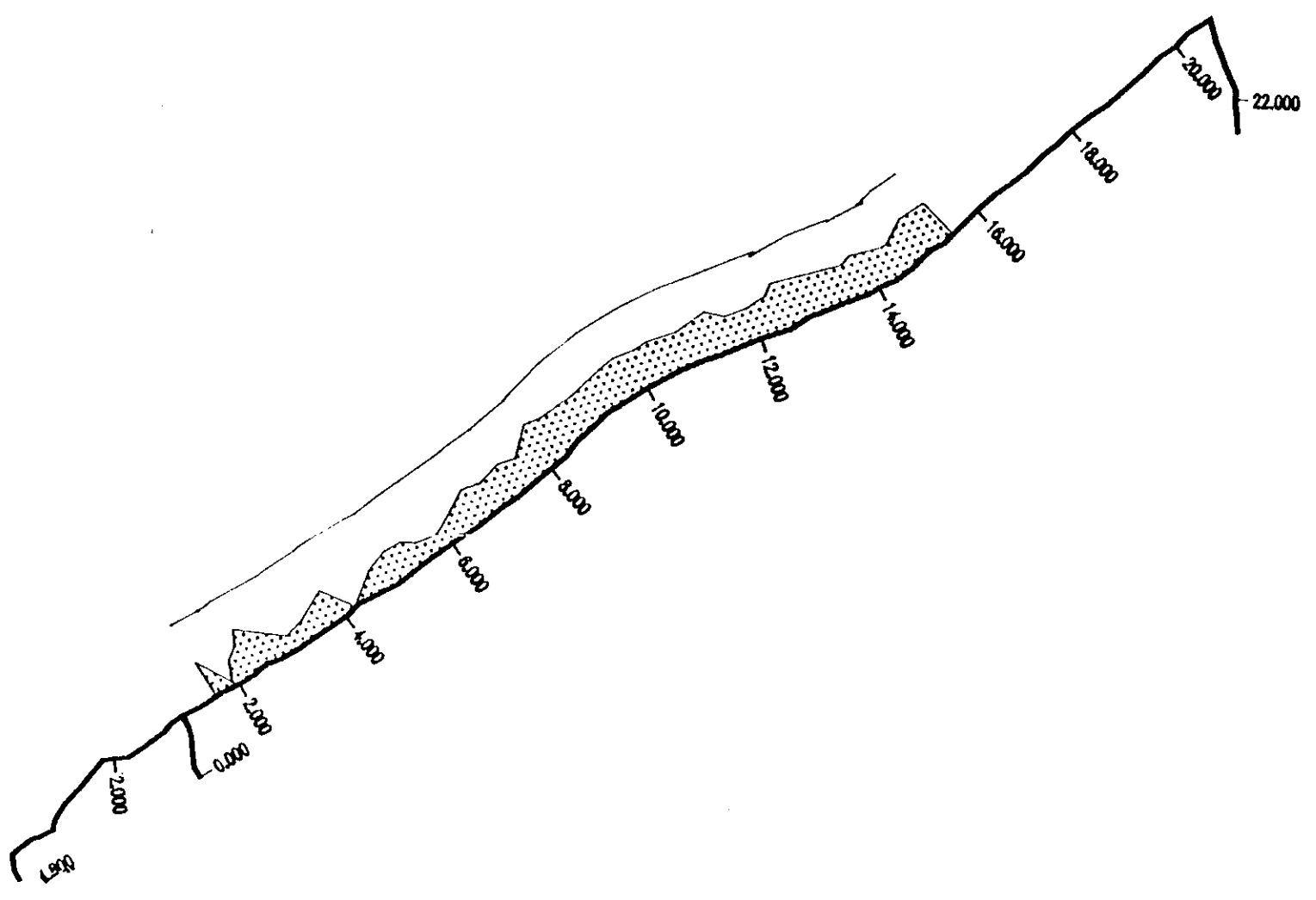
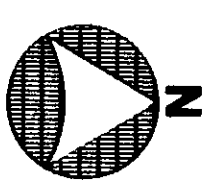
**POLDER 59/3B
SUDHARAM**

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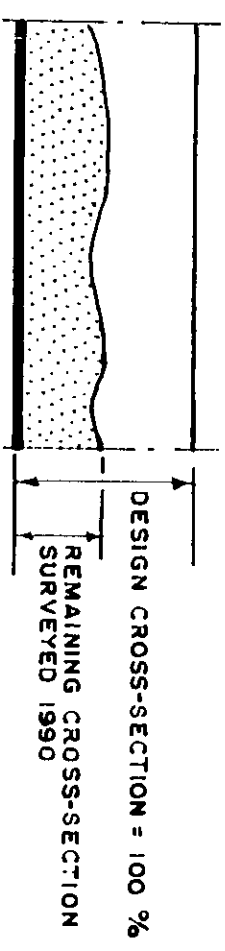
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ENCLOSURE 2

SITAKUNDA(61/1)



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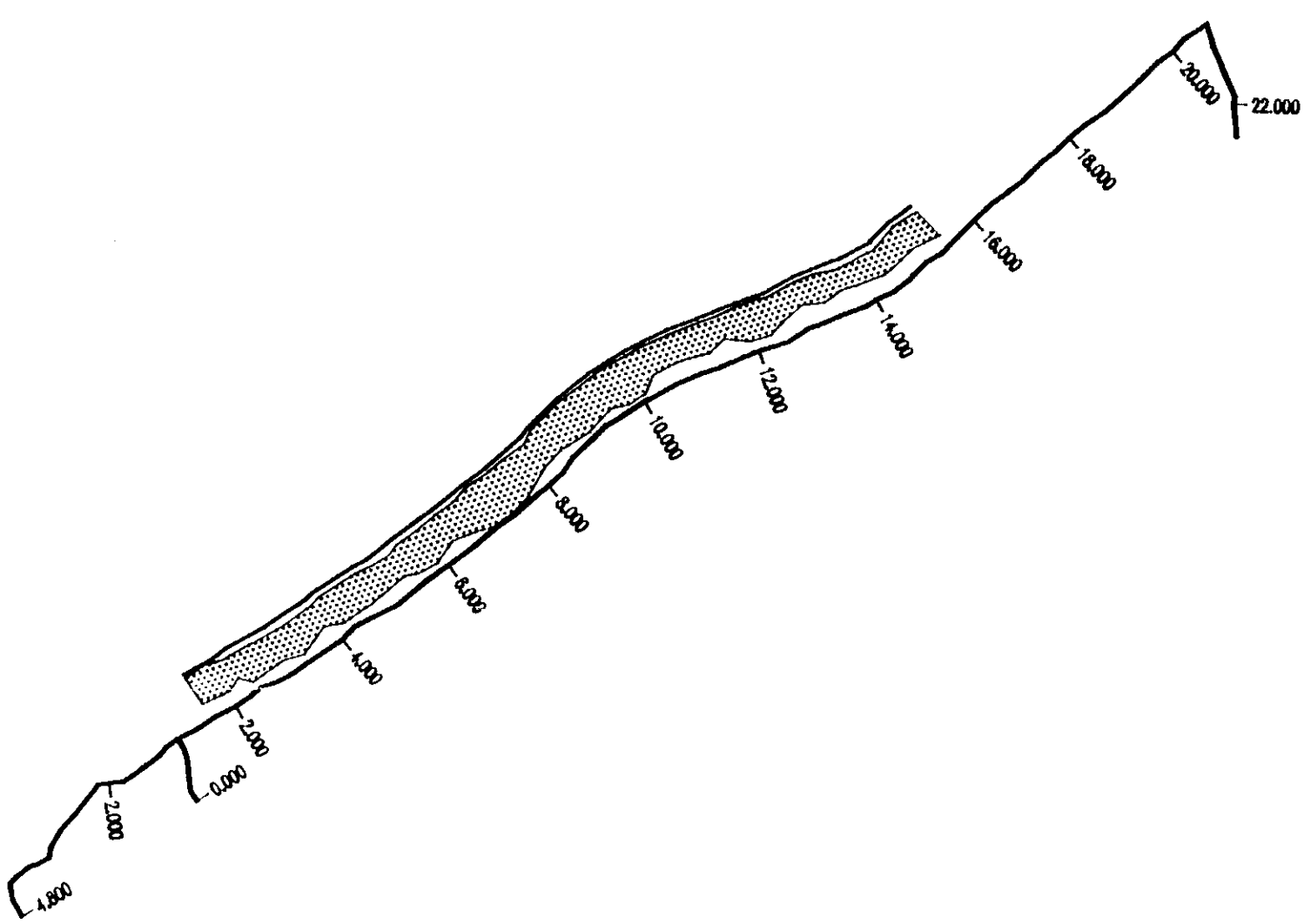
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SITAKUNDA

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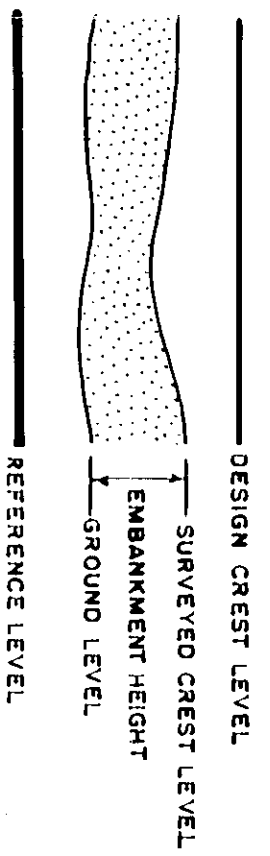
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ENCLOSURE 3

SITAKUNDA(61/1)



LEGEND



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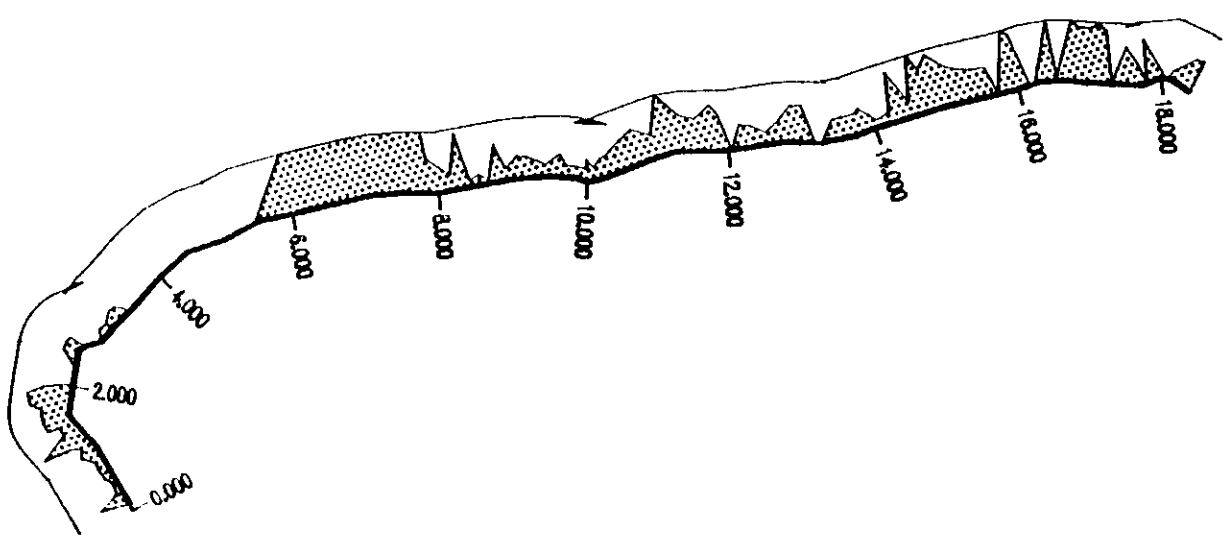
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SITAKUNDA

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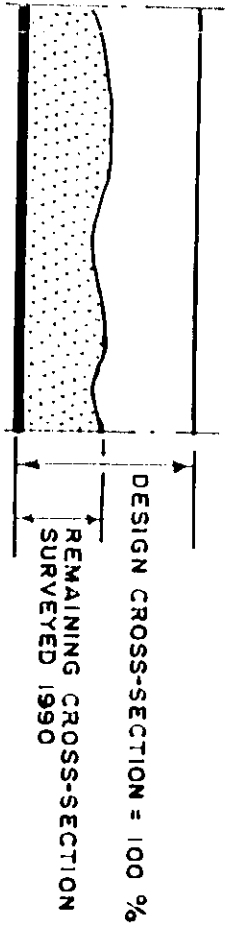
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ENCLOSURE 4

PATENGA (62)



LEGEND



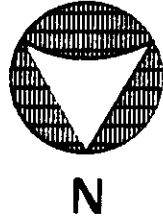
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POLDER 62
PATENGA

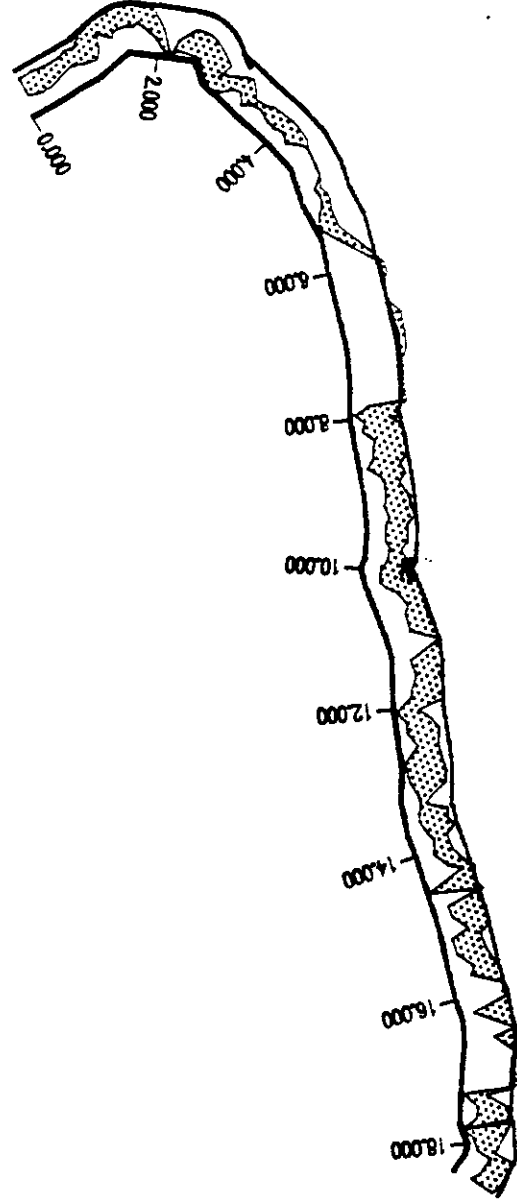
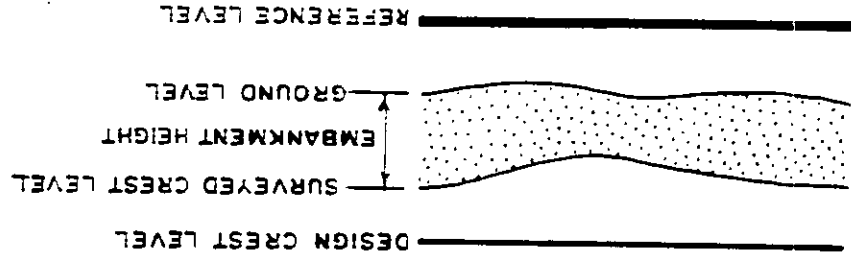
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ENCLOSURE 5

PATENGA (62)



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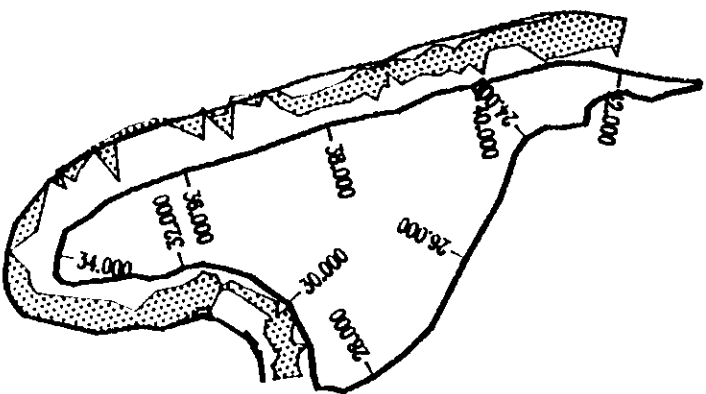
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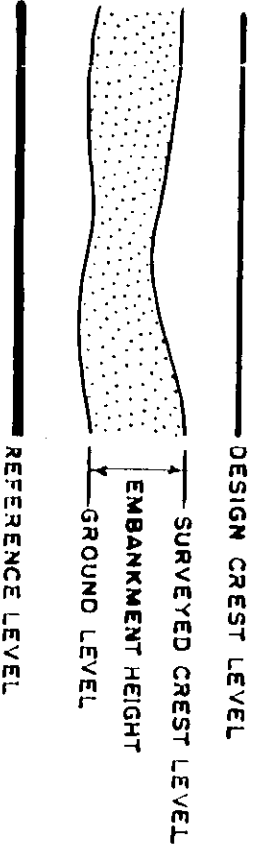
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ENCLOSURE 6

ANOWARA(63/1A)



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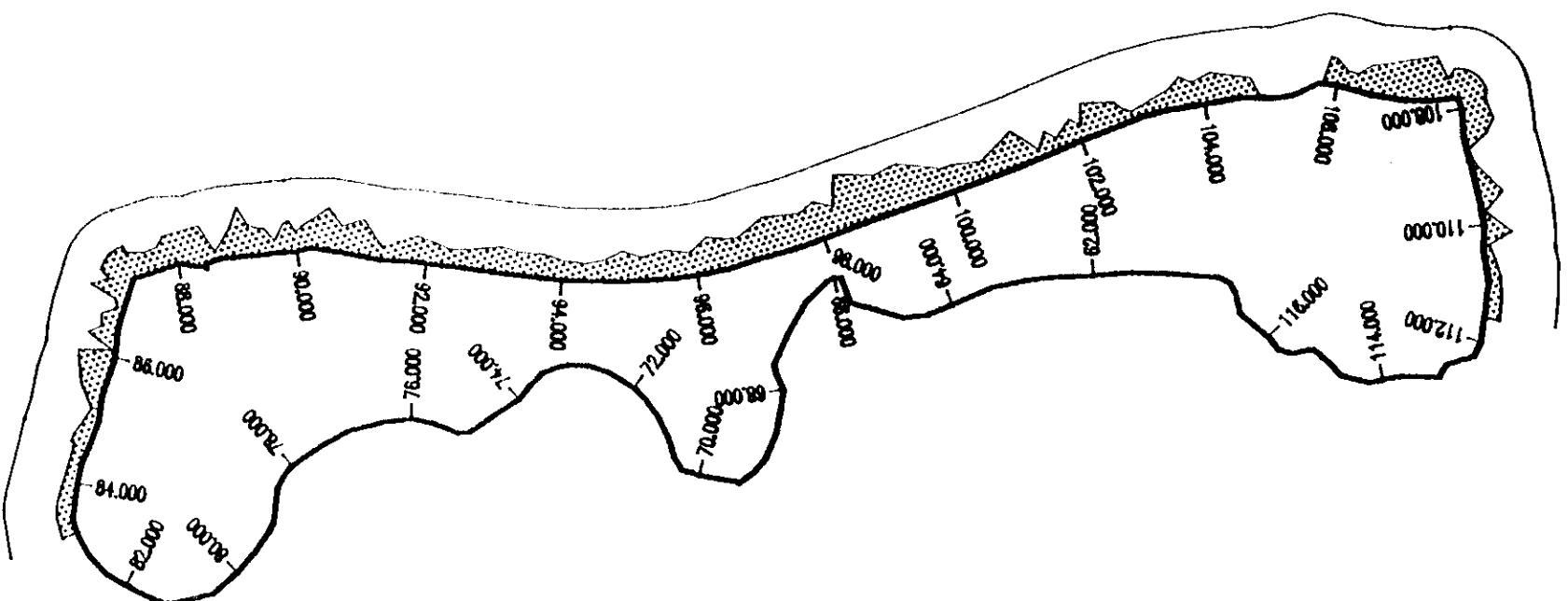
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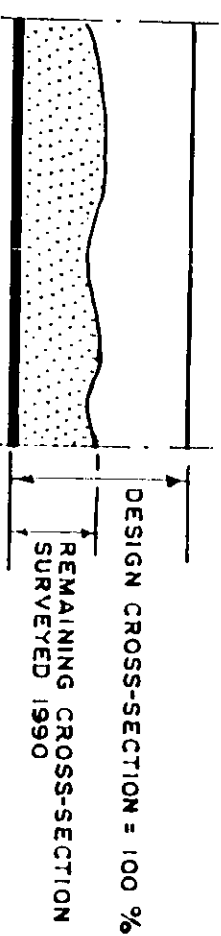
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ENCLOSURE 7

BANSKHALI(64/1A)



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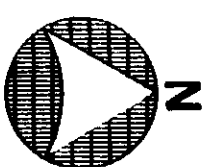
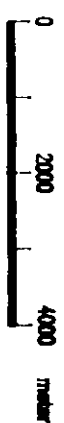
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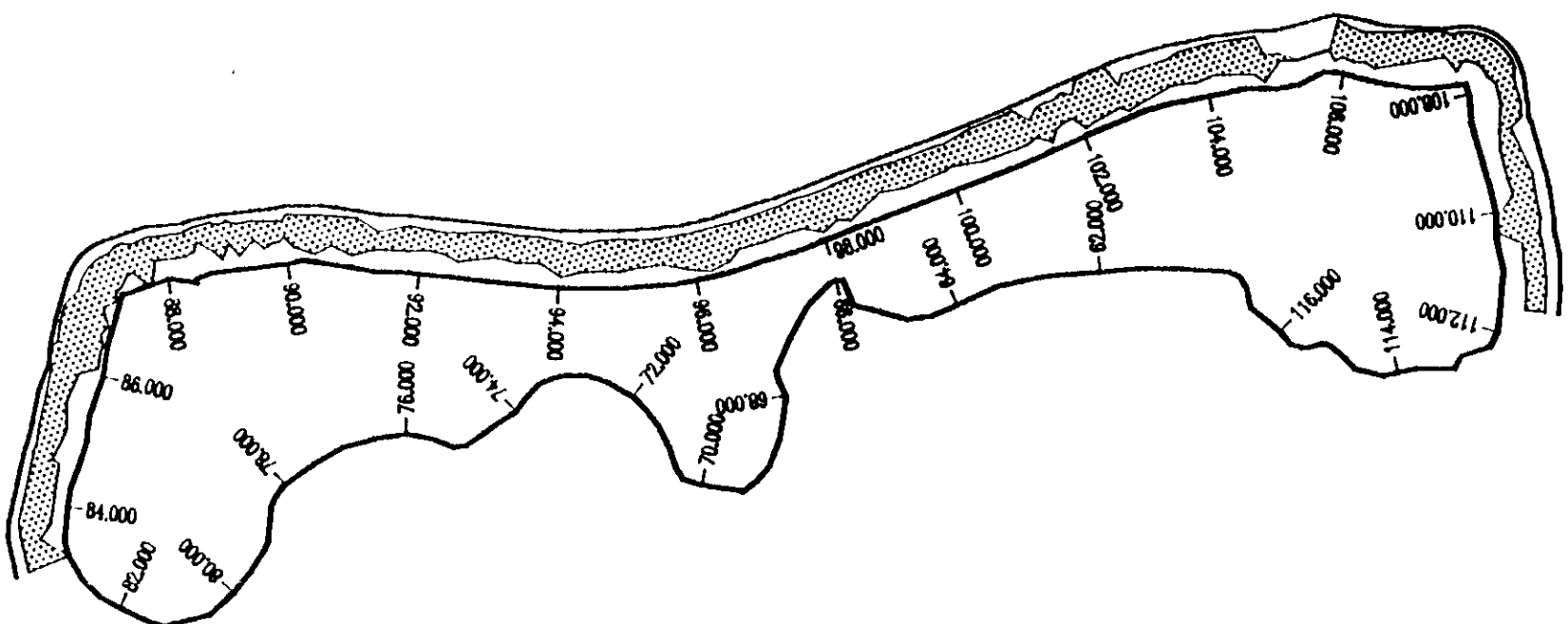
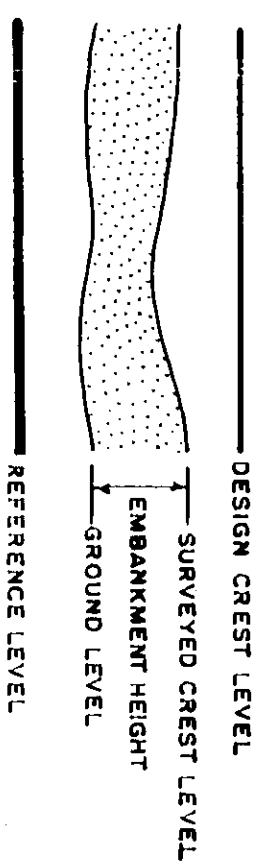
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ENCLOSURE 8

BANSKHALI(64/1A)



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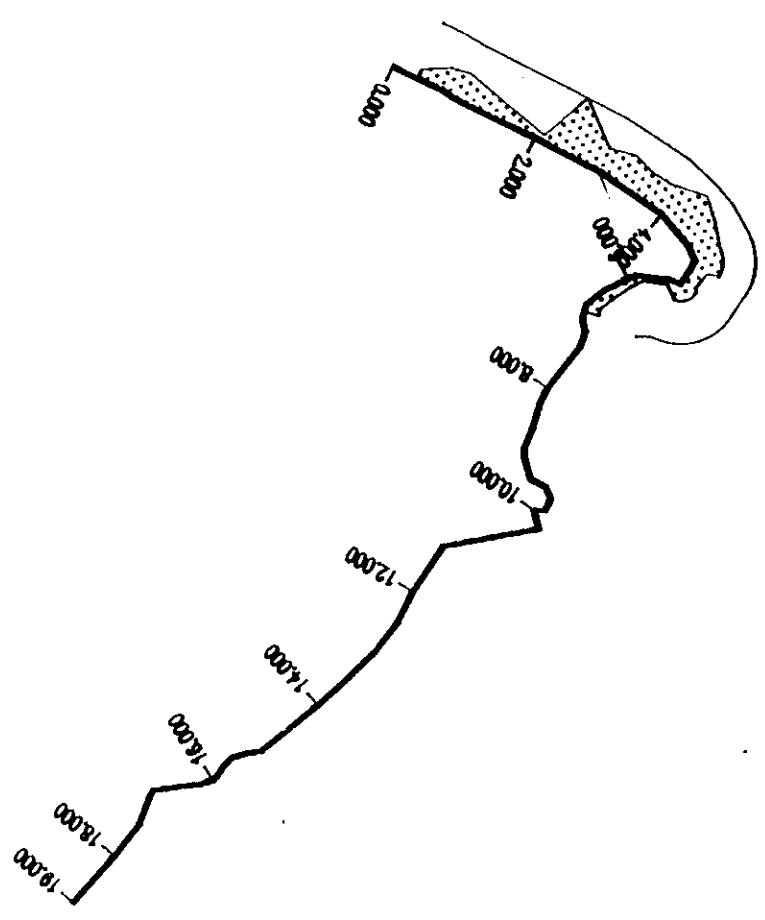
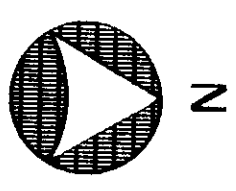
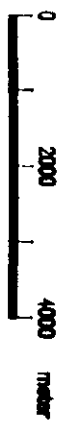
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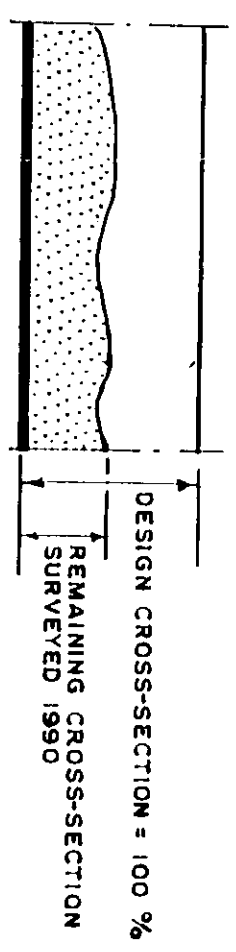
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ENCLOSURE 9

COX'S_BAZAR(66/1)



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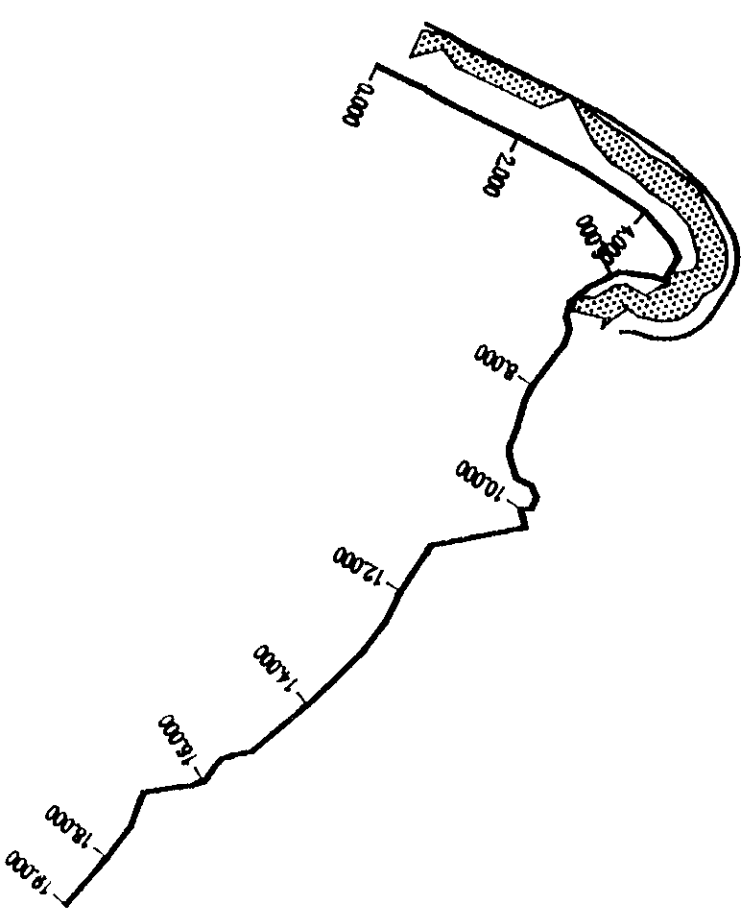
POLDER 66/1
COX'S BAZAR

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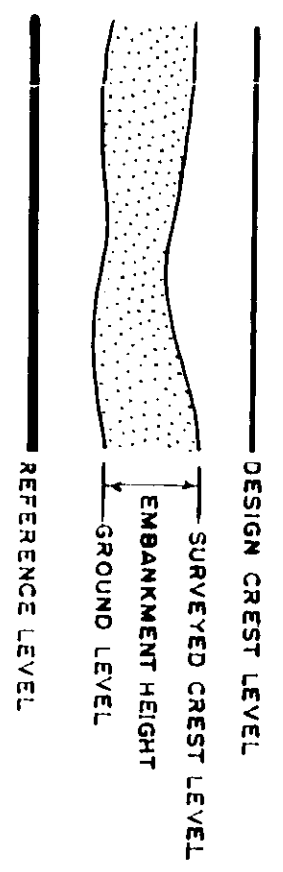
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ENCLOSURE 10

COX'S_BAZAR(66/1)



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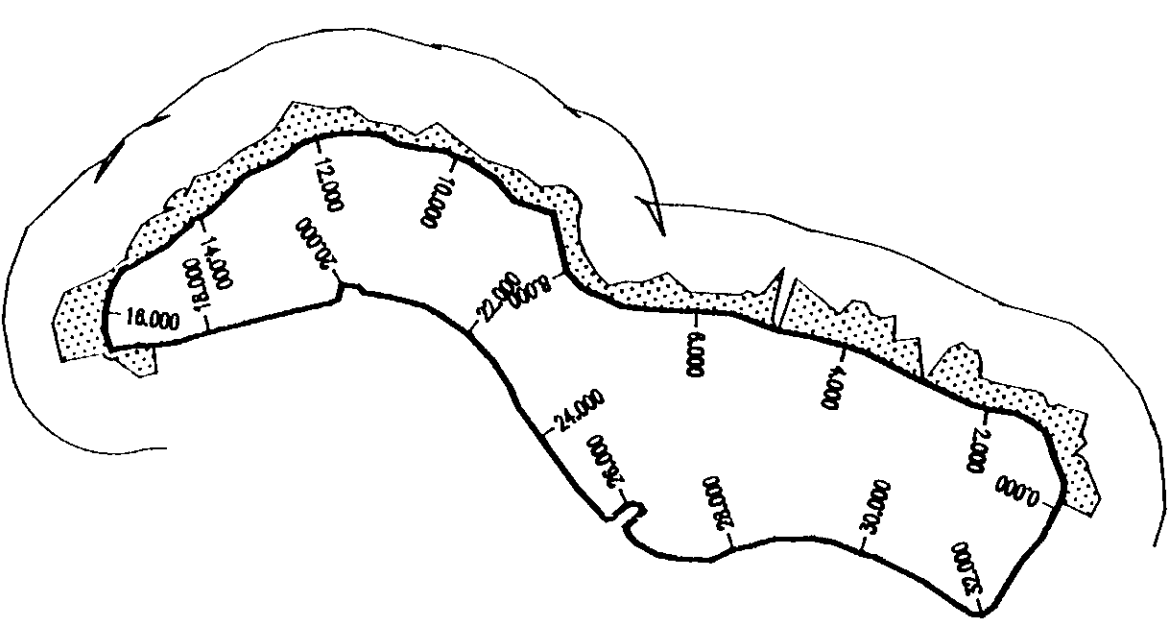
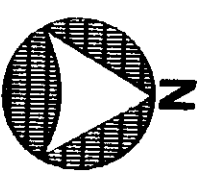
**POLDER 66/1
COX'S BAZAR**

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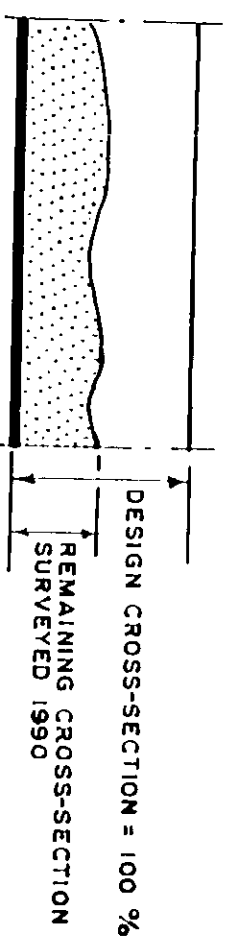
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ENCLOSURE 11

MOHESKHALI(70)



LEGEND

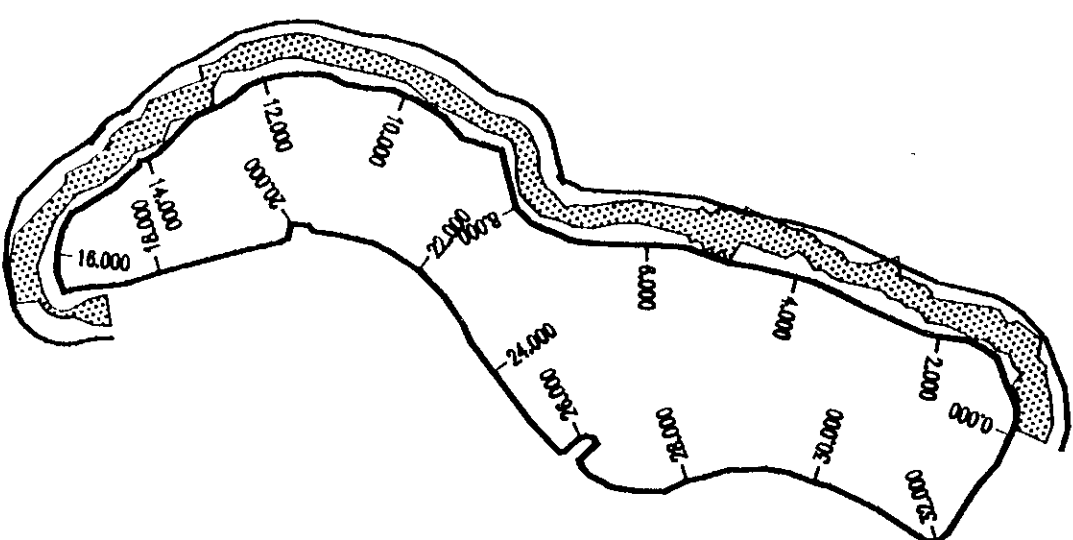
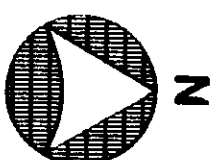


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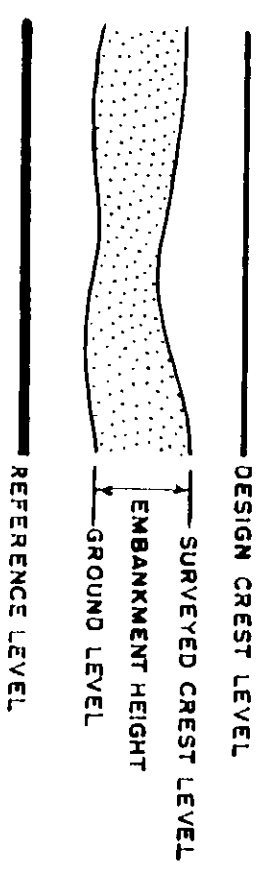
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**POLDER 70
MOHESKHALI**

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ENCLOSURE **12**

MOHESKHALI(70)



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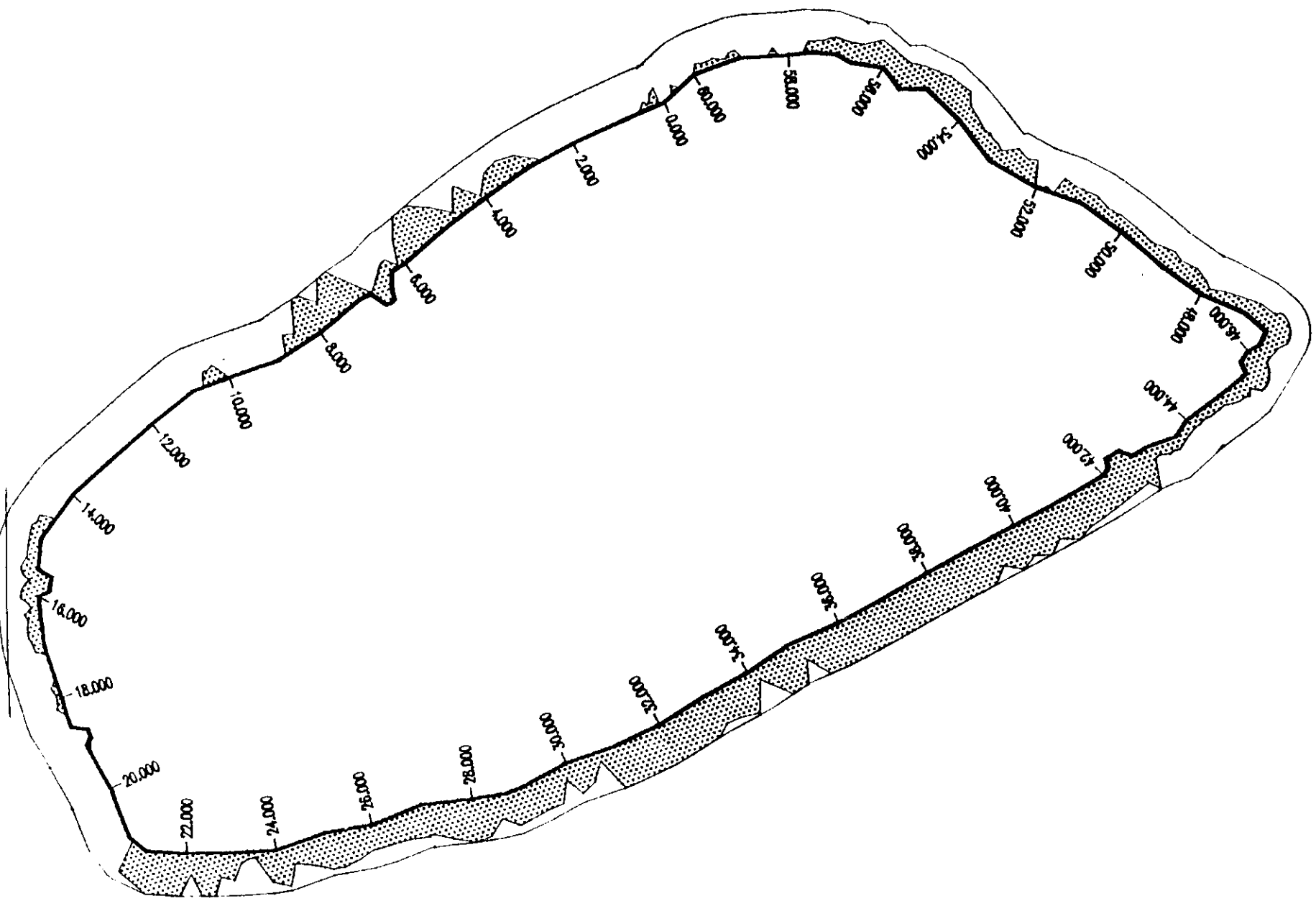
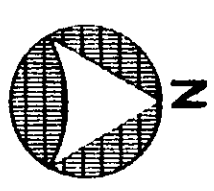
POLDER 70
MOHESKHALI

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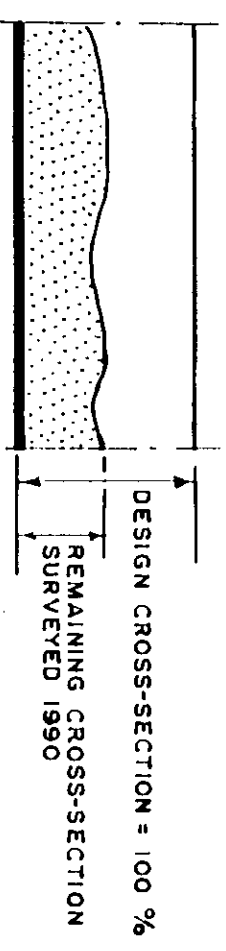
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ENCLOSURE 13

SANDWIP(72)



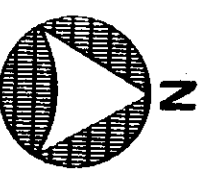
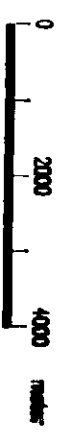
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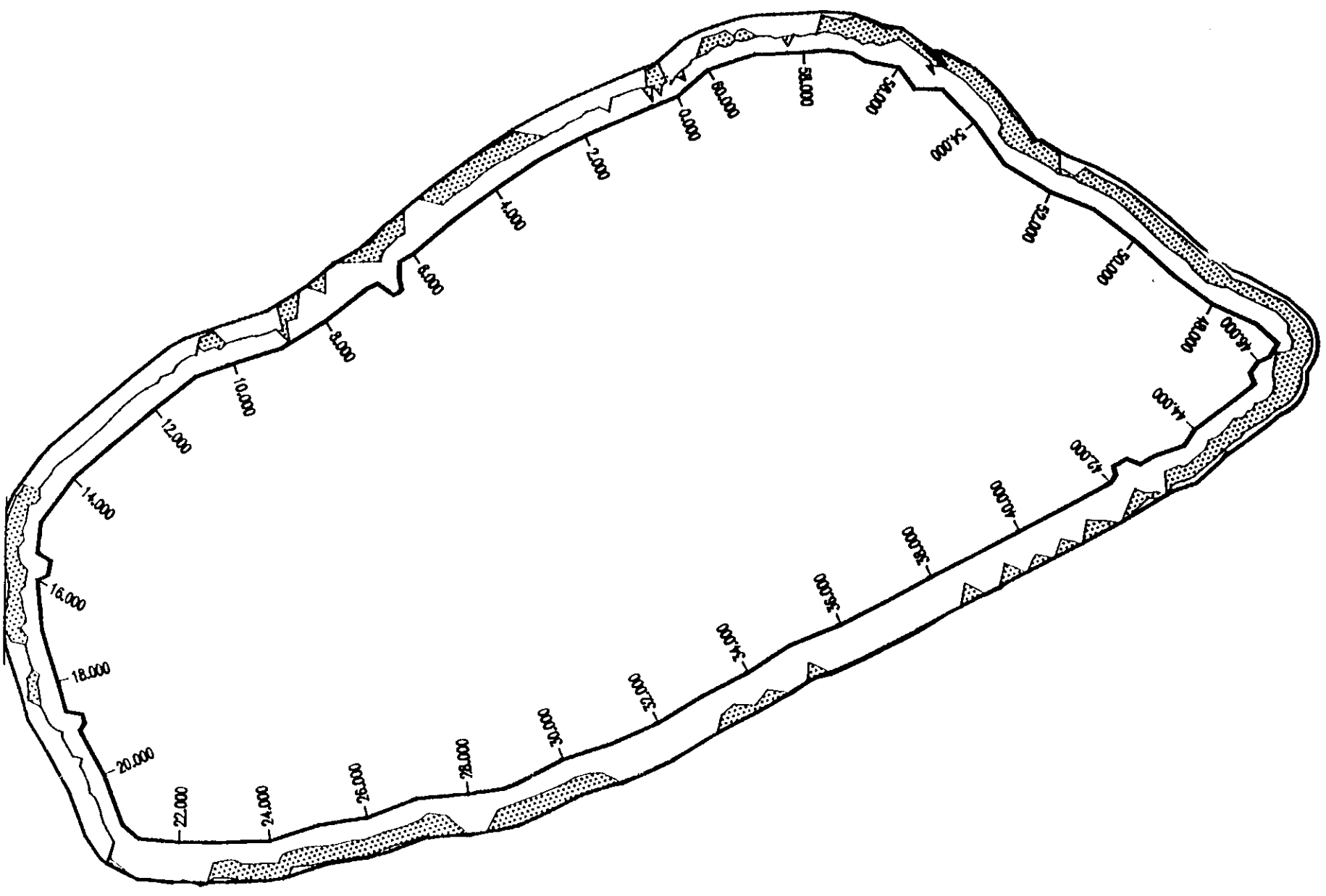
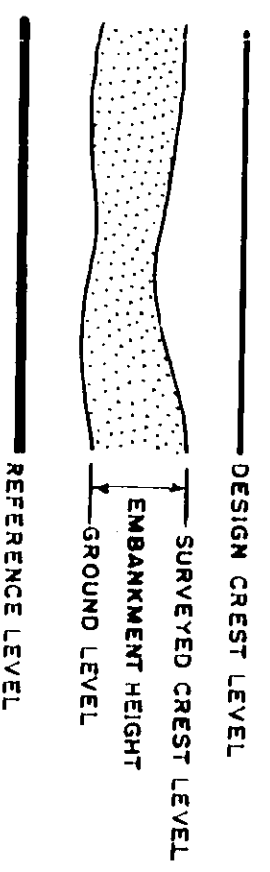
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ENCLOSURE 14	

SANDWIP(72)

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LEGEND



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ENCLOSURE 15

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CYCLONE PROTECTION PROJECT II

FINAL PROJECT PREPARATION REPORT, APPENDIX B

SOIL INVESTIGATION RESULTS (EMBANKMENT)

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ENCLOSURE 16

CYCLONE PROTECTION PROJECT - II (13th COMPONENT)

EMBANKMENT SOIL TEST RESULTS

Polder No. 59/3B

Location	Chainage km	Position of Soil Sampling	Depth m	Natural Moisture Content %	Liquid Limit %	Plasticity Index %	Particle Size Distribution (Finer)					Specific Gravity	Description (Unified Soil Classification System)
							Sieve Analysis & Passing			By Hydrometer Analysis			
							# 40 0.425 mm	# 100 0.15 mm	# 200 0.075 mm	0.063 mm	0.002 mm		
Zillar Khal, Laksmir Khal, Noakhali	27.500	C/S	0-3	35	43	13	100	99	99				Grey SILT, trace fine sand, low to medium plastic (ML)
	"	E/C	0-3	31	39	11	100	98	97				Light grey SILT, trace fine sand, low to medium plastic (ML)
	"	R/S	0-3	28	44	15	100	100	99				Grey SILT, trace fine sand, low to medium plastic (ML)
	30.000	E/C	0-3	35	38	14	100	99	96				Light grey CLAY, trace fine sand, low to medium plastic (CL)
	33.000	E/C	0-3	32	36	12	100	98	93		2.67		-do-
	"	R/S	0-3	34	55	22	100	100	99.80				Light grey SILT, trace fine sand, high plastic (MH)
	37.000	E/C	0-3	34	44	12	100	99	96				Light grey SILT, trace fine sand, low to medium plastic (ML)
	"	R/S	0-3	36	47	24	100	100	99.56				Light grey CLAY, trace fine sand, low to medium plastic (CL)
	42.000	C/S	0-3	39	49	23	100	100	99.72				Light grey CLAY, trace fine sand, medium to high plastic (CL)
	"	E/C	0-3	34	44	21	100	99	97		2.677		Light grey CLAY, trace fine sand low to medium plastic (CL)

EMBANKMENT SOIL TEST RESULTS

Charbata,
Panditer hat,
Noakhali

[illegible]

CYCLONE PROTECTION PROJECT - II

(IS-DB COMPONENT)

EMBANKMENT SOIL TEST RESULTS

Polder No. 59/3B

Location	Chainage km	Position of Soil Sampling	Depth m	Natural Moisture Content %	Liquid Limit %	Plasticity Index %	Particle Size Distribution (Finer)					Specific Gravity	Description (Unified Soil Classification System)
							Sieve Analysis & Passing			By Hydrometer Analysis			
							# 40 0.425 mm	# 100 0.15 mm	# 200 0.075 mm	0.063 mm	0.002 mm		
Charbata, Panditerhat, Noakhali	66.000	C/S	0-3	35	36	4	100	100	99				Light brown SILT, trace fine sand, low to medium plastic (ML)
	"	E/C	0-3	27	35	3	100	99	94				Light brown SILT, trace fine sand, low to medium plastic (ML)
	"	R/S	0-3	31	35	7	100	100	98	96	17	2.66	Light brown SILT, trace fine sand, low to medium plastic (ML)
	67.000	C/S	0-3	41	39	10	100	100	99	97	15	2.67	Light brown SILT, trace fine sand, low to medium plastic (ML)
	"	E/C	0-3	28	37	8	100	100	99				Light brown SILT, trace fine sand, low to medium plastic (ML)
	"	R/S	0-3	31	34	9	100	100	99				Light brown SILT, trace fine sand, low to medium plastic (ML)
	68.000	C/S	0-3	32	37	5	100	99	92				Light brown SILT, trace fine sand, low to medium plastic (ML)
	"	E/C	0-3	24	30	6	100	99	94				Light brown SILT, trace fine sand, low to medium plastic (ML)
	"	R/S	0-3	31	NP	NP	100	98	92				Light brown SILT, trace fine sand, non-plastic (ML)
	69.000	C/S	0-3	41	38	17	100	100	99.55	96	19	2.66	Brown CLAY, trace fine sand, low to medium plastic (CL)
"	E/C	0-2	22	34	7	100	99	93				Light grey SILT, trace fine sand, low to medium plastic (ML)	

CYCLONE PROTECTION PROJECT - II

(LINEAR) O(1) (100%)

EMPAKMENT SOIL TEST RESULTS

Polder No. 59/3B

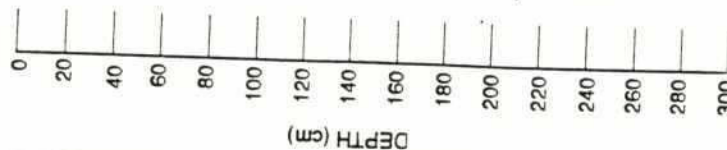
[illegible]

**CYCLONE PROTECTION PROJECT-II
(BWDB COMPONENT)
EMBANKMENT SOIL BORE LOGS**

Location : Noakhali Area
Polder No. : 59/3B

Chainage=27.500 km

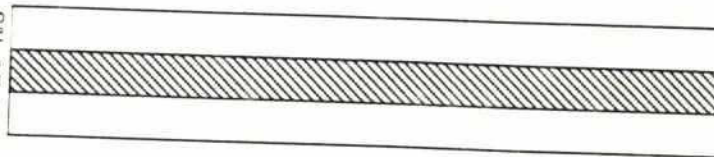
C/S E/C R/S



Country Side (C/S) : GL= 5.46 ; LL= 43 ; PI= 13
Embk. Centre(E/C) : GL= 6.79 ; LL= 39 ; PI= 11
River Side (R/S) : GL= 5.16 ; LL= 41 ; PI= 15

Chainage=30.000 km

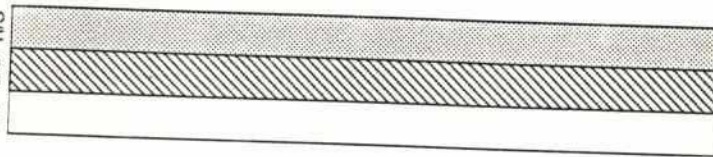
C/S E/C R/S



Under water
GL= 6.78 ; LL= 38 ; PI= 14
Under Water

Chainage=33.000 km

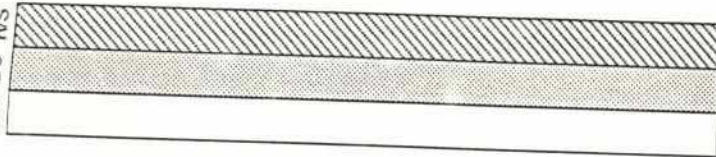
C/S E/C R/S



Under water
GL= 6.81 ; LL= 36 ; PI= 12
GL= 5.5 ; LL= 55 ; PI= 22

Chainage=37.000 km

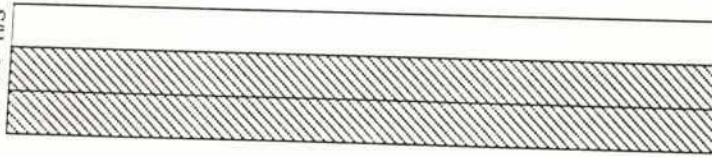
C/S E/C R/S



Under water
GL= 7.4 ; LL= 44 ; PI= 12
GL= 5.4 ; LL= 47 ; PI= 24

Chainage=42.000 km

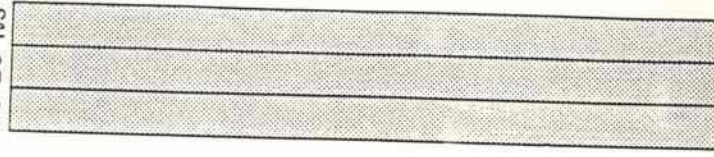
C/S E/C R/S



GL= 4.18 ; LL= 49 ; PI= 23
GL= 6.18 ; LL= 44 ; PI= 21
Under Water

Chainage=63.000 km

C/S E/C R/S



GL= 3.9 ; LL= 35 ; PI= 6
GL= 6.7 ; LL= 35 ; PI= 8
GL= 3.4 ; LL= 42 ; PI= 8

REMARKS



CLAY



SILT



CLAY/SILT



FINE SAND

DEPTH (cm)

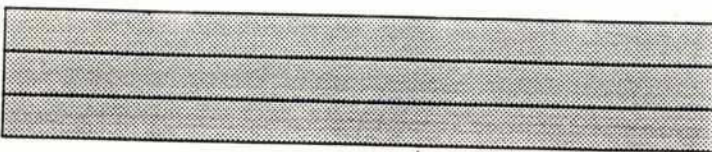
**CYCLONE PROTECTION PROJECT-II
(BWDB COMPONENT)
EMBANKMENT SOIL BORE LOGS**

Location : Noakhali Area
Polder No. : 59/3B

Chainage=64,000 km

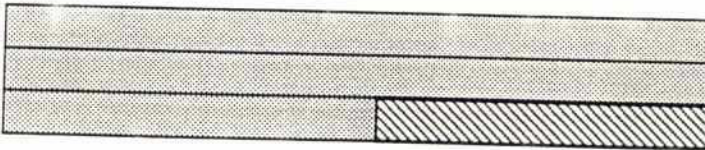
DEPTH (m)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

C/S E/C R/S



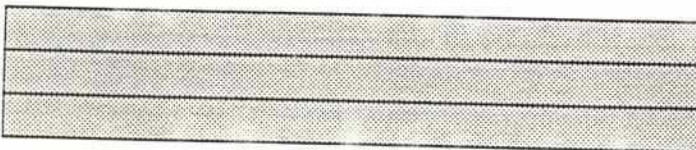
Chainage=65,000 km

C/S E/C R/S



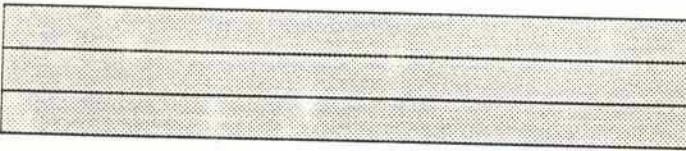
Chainage=66,000 km

C/S E/C R/S



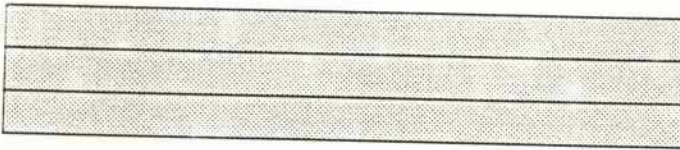
Chainage=67,000 km

C/S E/C R/S



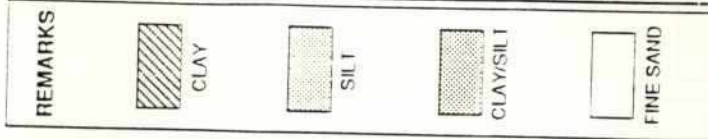
Chainage=68,000 km

C/S E/C R/S



Chainage=69,000 km

C/S E/C R/S



Country Side (C/S) : GL=3.9 ; LL=39 ; PI=11

Embk. Centre(E/C) : GL=6.5 ; LL=37 ; PI=11

River Side (R/S) : GL=3.4 ; LL=35 ; PI=09

GL=4.2 ; LL=36 ; PI=12

GL=6.6 ; LL=35 ; PI=08

GL=2.3 ; LL=36 ; PI=11

GL=4.9 ; LL=36 ; PI=04

GL=6.4 ; LL=35 ; PI=03

GL=3.4 ; LL=35 ; PI=07

GL=4.34 ; LL=39 ; PI=10

GL=6.18 ; LL=37 ; PI=08

GL=2.10 ; LL=34 ; PI=09

GL=4.09 ; LL=37 ; PI=05

GL=6.13 ; LL=30 ; PI=06

GL=3.20 ; Non Plastic

GL=4.26 ; LL=38 ; PI=17

GL=6.84 ; LL=38 ; PI=10

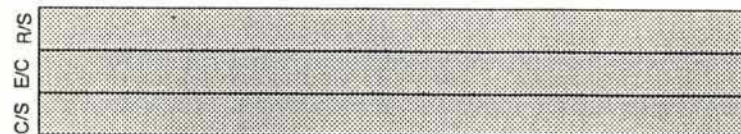
GL=2.64 ; LL=37 ; PI=09

**CYCLONE PROTECTION PROJECT-II
(B&DB COMPONENT)
EMBANKMENT SOIL BORE LOGS**

Location : Noakhali Area
Polder No. : 59/3B

Chainage=70.000 km

DEPTH (cm)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300



Chainage=
C/S E/C R/S

Chainage=
C/S E/C R/S

Chainage=
C/S E/C R/S

Chainage=
C/S E/C R/S

Chainage=
C/S E/C R/S

REMARKS

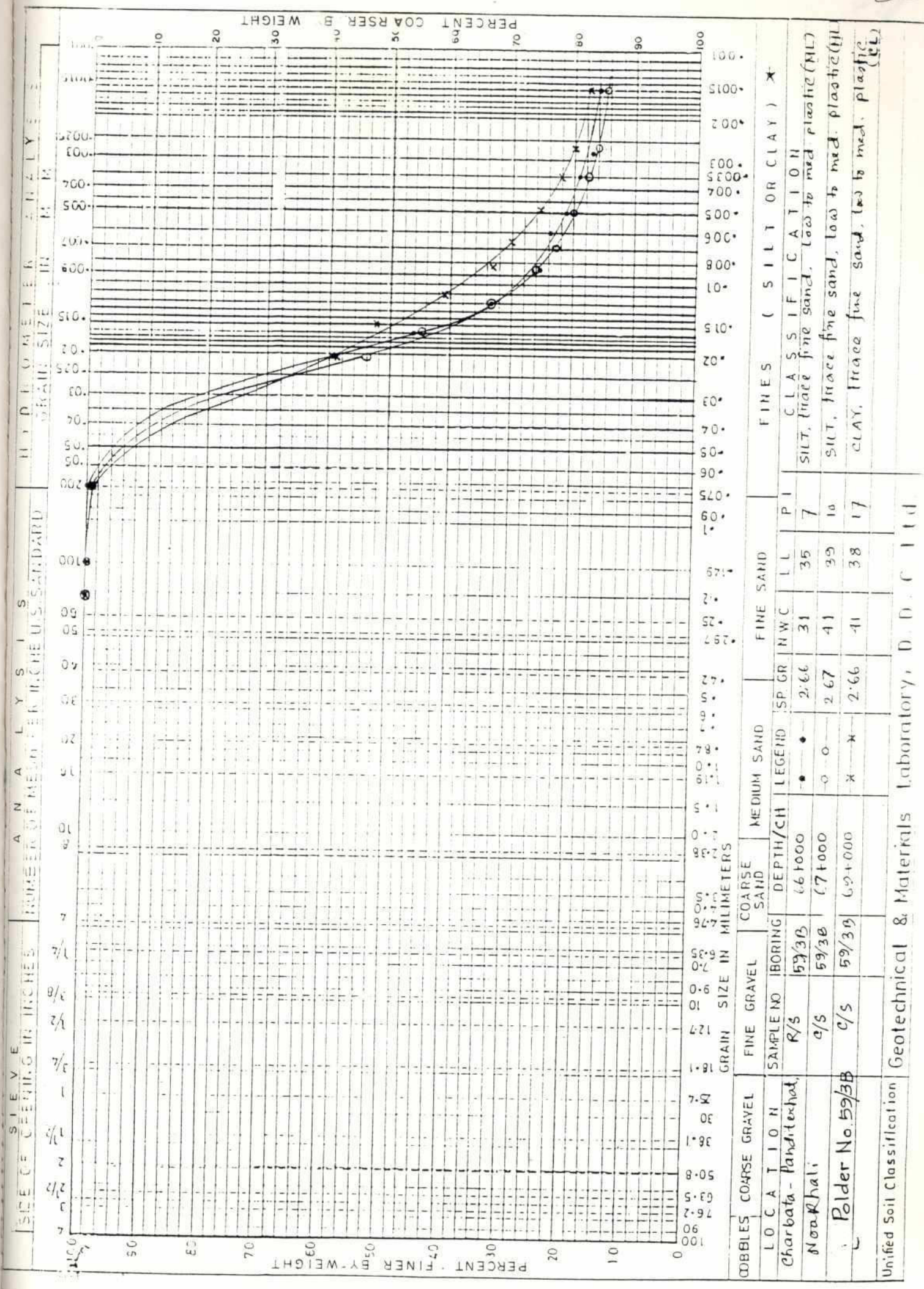
CLAY

SILT

CLAY/SILT

FINE SAND

Country Side (C/S) : GL= 4.10 ; LL= 37 ; PI = 12
Embk. Centre(E/C) : GL= 6.51 ; LL= 37 ; PI = 09
River Side (R/S) : GL= 2.92 ; LL= 34 ; PI = 08



GRAIN SIZE IN MILLIMETERS
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
SIEVE SIZE IN INCHES
NUMBER OF MILLIMETER U.S. STANDARD
ANALYSIS
HYDROMETER ANALYSIS

88

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

CYCLONE PROTECTION PROJECT II

FINAL PROJECT PREPARATION REPORT, APPENDIX B

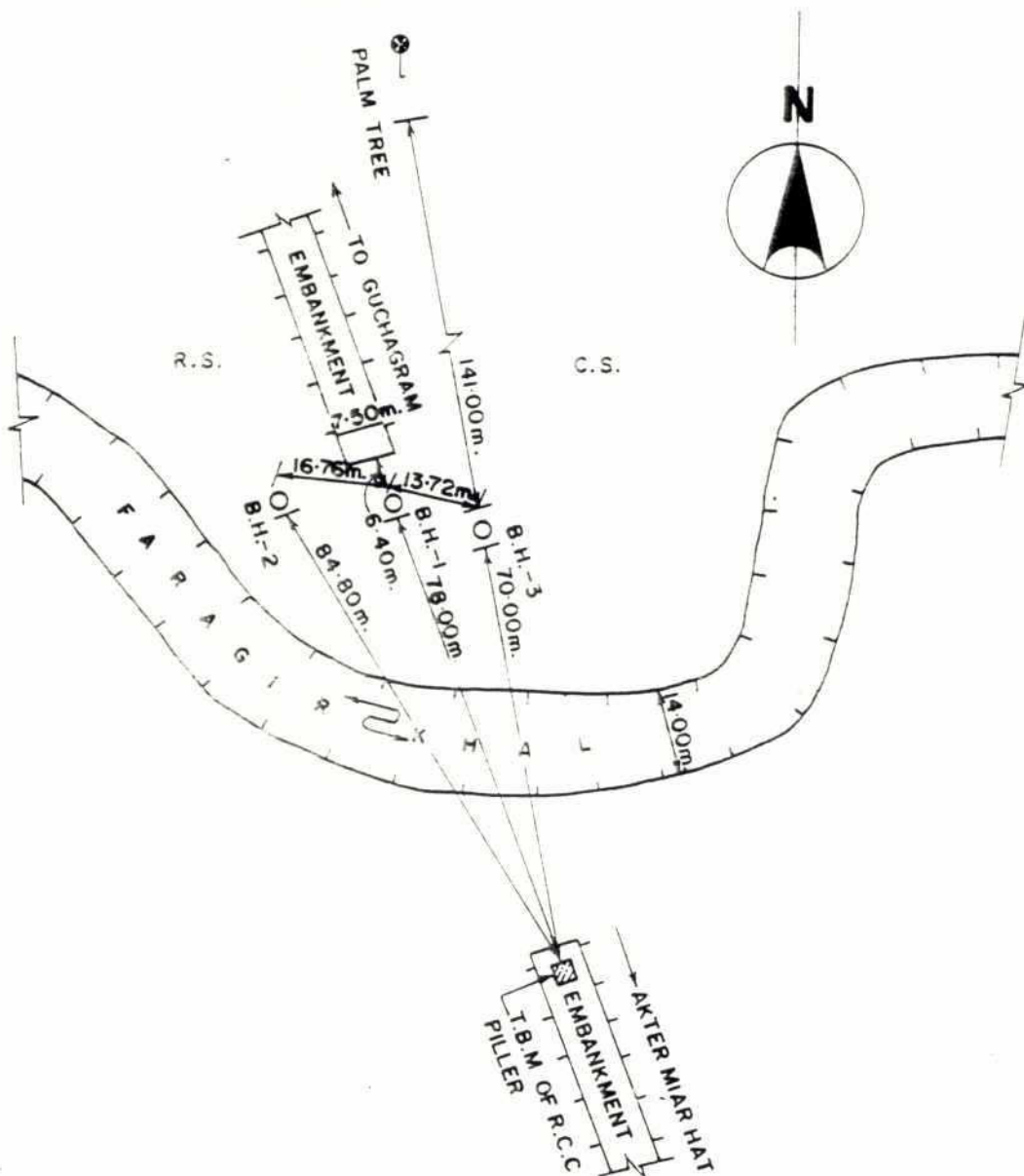
SOIL INVESTIGATION RESULTS (HYDRAULIC STRUCTURE)

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 17

BORE HOLE LOCATION POLDER -59/3B ON FARAGIR KHAL







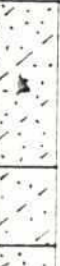


















RECORD OF BORING AND FIELD TESTS

Project: C.P.P-II BWDB NOAKHALI		Bridge Name: FARAGIR KHAL	
Polder No: 59/3B		Bridge Location: AT 41.3km ON FARAGIR KHAL (S.S/12)	
Borehole No.: 1	High Flood Level (m)	Date Started: 20.1.91	Method of Boring: WASH
Borehole Location: Shown in Site Plan	Ground Level (m): (-) 1.60 m	Date Completed: 20.1.91	Boring Dia (cm): 10.16
	Water Level (m): (-) 2.60 (E.G.L)	Date of W.L.: 21.10.91.	Casing Used (m): 3.0
	Weather: DRY		
Any other information:			

STRATIFICATION

STANDARD PENETRATION TEST

NUMBER OF SAMPLE	TYPE OF SAMPLE	DEPTH BELOW GL / R.L. (m)	THICKNESS (m)	DESCRIPTION OF MATERIAL	SYMBOL	DEPTH (m)	BLOWS ON SPOON FOR 15 cm PENETRATION			N-Measured	N-Corrected	STANDARD PENETRATION RESISTANCE						INDEX		REMARKS	
							15 cm	15 cm	15 cm			BLOWS PER 30 cm OF PENETRATION						<input checked="" type="checkbox"/> DISTURBED	<input type="checkbox"/> UNDISTURBED		
												0	10	20	30	40	50				
D ₁		1.5	4.8	Grey med.stiff SILT, trace fine sand, low to medium plastic.		15	1	3	3	6	6								GWL - 2.60 m		
D ₂		3.0					30	2	3	3	6	6									
D ₃		4.5					45	3	3	3	6	6									
D ₄		6.0	3	Grey med.dense FINE SAND, some silt trace mica, N.P.		60	7	7	8	15	15								Using Terzaghi's Reduction N-Corr = 15-12 (N-15) m = measured		
D ₅		7.2	1.2	Grey loose SILT, some fine sand, N.P.		75	3	5	5	10	10										
D ₆		9.0	1.8				90	3	3	3	6	6									
D ₇		10.5	7.5	Grey loose/med. dense FINE SAND, some silt, N.P.		105	6	11	12	23	19										
D ₈		12.0				120	7	13	15	28	21										
D ₉		13.5				135	7	11	16	27	21										
D ₁₀		15.0				150	7	3	4	7	7										
D ₁₁		16.5	1.5	Grey dense FINE SAND, some silt, N.P.	165	7	9	14	23	19								SAND - 			
D ₁₂		18.0	1.5			180	14	23	24	47	31							SILT 			
D ₁₃		19.5	1.5			195	16	22	26	48	31							CLAY 			
D ₁₄		21.0				210															MICA 
																			ORGANIC 		

RECORD OF BORING AND FIELD TESTS

Project: C.P.P-II BWDB, NOAKHALI.

Bridge Name No. FARAGIR KHAL.

, AT 42.3km.

Polder No. 59/3B

Bridge Location ON FARAGIR KHAL (S.S./12).

Borehole No. : 2

High Flood Level (m)

Date Started: 21.1.91

Method of Boring: WASH

Borehole Location : Shown in Site Plan

Ground Level (m) (-) 1.80
(top of embk.)

Date Completed: 21.1.91

Boring Dia (cm) : 10.16

Water Level (m) (-) 2.15 (E.G.L.)

Date of W.L. 22.1.91.

Weather: DRY

Casing Used (m) : 3.0

Any other Information :

STRATIFICATION

STANDARD PENETRATION TEST

NUMBER OF SAMPLE	TYPE OF SAMPLE	DEPTH BELOW GL / R.L. (m)	THICKNESS (m)	DESCRIPTION OF MATERIAL	SAMPLE	DEPTH (m)	BLOWS ON SPOON PER 15 cm PENETRA			N Measured	N-Corrected	STANDARD PENETRATION RESISTANCE	INDEX	REMARKS
							15 cm	15 cm	15 cm					
D ₁		1.5	3.3	Grey soft/med. stiff SILT, trace fine sand, low to med. Plastic.		1.5	1	1	1	2	2			
C ₁														
E ₂		3.0				3.0	1	0	1	1	1			
D ₃		4.5	4.5	Grey loose/med. dense SILT, trace fine sand, N.P.		4.5	3	3	6	9	9			
D ₄		6.0				6.0	6	6	6	12	12			
D ₅		7.5				7.5	3	5	4	9	9			
D ₆		9.0	4.5	Grey med. dense FINE SAND and SILT non plastic.		9.0	4	6	8	14	14			
D ₇		10.5				10.5	8	10	10	20	18			
D ₈		12.0				12.0	10	13	14	27	21			
D ₉		13.5				13.5								
D ₁₀		15.0				15.0								
D ₁₁		16.5				16.5								
D ₁₂		18.0				18.0								
D ₁₃		19.5				19.5								
D ₁₄		21.0				21.0								

GWL = 2.15 m

Using Terzaghi's Correction (1948)

N - corr. = 15.12 (m, 15)

m = measured

SAND

SILT












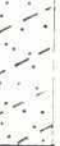











CLAY






MICA

ORGANIC

RECORD OF BORING AND FIELD TESTS

Project : C.P.P-II BWDB, NOAKHALI		Bridge Name No. : FARAGIR KHAL	
Polder No : 59/3B		Bridge Location : AT 41.3km. ON FARAGIR KHAL (S.S./12).	
Borehole No. : 3	High Flood Level (m)	Date Started : 21.1.91.	Method of Boring : WASH
Borehole Location : Shown in Site Plan	Ground Level (m) (-)1.70 m	Date Completed : 21.1.91.	Boring Dia (cm) : 10.16
	Water Level (m) (-)2.25 (E.G.L)	Date of W.L. : 22.1.91.	Casing Used (m) : 3.0
	Weather : DRY.		
Any other Information :			

STRATIFICATION						STANDARD PENETRATION TEST						INDEX	
NUMBER OF SAMPLE	TYPE OF SAMPLE	DEPTH BELOW GL / R.L. (m)	THICKNESS (m)	DESCRIPTION OF MATERIALS	SYMBOL	DEPTH (m)	BLOWS ON SPOON PER 15 cm PENETRATION			N-Measured	N-Corrected	STANDARD PENETRATION RESISTANCE	DISTURBED
							15 cm	15 cm	15 cm			BLOWS PER 30 cm OF PENETRATION	
												0 10 20 30 40 50	REMARKS
D ₁		1.5	3.3	Light grey med. stiff SILT, trace fine sand, low to med. plastic.		15	2	2	3	5	5		GWL -2.25m
D ₂		3.0				30	1	2	2	4	4		
D ₃		4.5	1	Grey soft CLAY, trace fine sand, low to med. plastic.		45	1	4	4	8	8		
D ₄		6.0	3.5			60	7	7	7	14	14		
D ₅		7.5	4.5	Grey loose/med. dense SILT, some fine sand, N.P		75	5	3	4	7	7		Using Terzaghi & Peck eq. (1949) N ₆₀ = 15-12 (ft-m:15) m = measured
D ₆		9.0				90	3	5	7	12	12		
D ₇		10.5	4.5	Light grey med. dense FINE SAND, and SILT, non plastic.		105	4	5	10	15	15		
D ₈		12.0				120	6	8	12	20	18		
D ₉		13.5				135							
D ₁₀		15.0				150							
D ₁₁		16.5				165							SAND 
D ₁₂		18.0				180							
D ₁₃		19.5				195							CLAY 
D ₁₄		21.0				210							MICA 
													ORGANIC 

SAND 
 SILT 
 CLAY 
 MICA 
 ORGANIC 

SUMMARY OF SOIL TEST RESULTS

ROAD SECTION: Polder No. 59/3B

Table : 1
Sheet 1 of 2

Location	Bore Hole No.	Sample No.	Depth m	Wet Unit Weight g/cm ³	Natural Moisture Content %	Liquid Limit %	Plasticity Index %	Sand %	Silt/Clay %	Specific Gravity	Description (Unified Soil Classification Symbol)	Unconfined Compression Test				Consolidation Test						
												qu kg/cm ²	qu _r kg/cm ²	Eu kg/cm ²	Sensitivity	Cv cm ² /min	Cr	Cc	Cc'	Po kg/cm ²	Pe kg/cm ²	O.C.R
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
At 41.3 Km on Farazir Khal, Noakhali	1 (One)	D1	1.3 - 1.8		31	37	11	2	98	2.66	Grey medium stiff SILT, trace fine sand, low to medium plastic (ML)											
		D4	5.8 - 6.3			NP	NP	63	37		Grey medium dense FINE SAND, some silt, non-plastic (SM)											
		D6	8.8 - 9.3			NP	NP	32	68		Grey loose SILT, some fine sand, non-plastic (ML)											
		D7	10.3 - 10.8			NP	NP	67	33		Grey medium dense FINE SAND, some silt, non-plastic (SM)											
		D10	14.8 - 15.3			NP	NP	65	35		Grey loose FINE SAND, some silt, non-plastic (SM)											
	2 (Two)	D1	1.3 - 1.8		36	37	10	1	99	2.68	Grey soft SILT, trace fine sand, low to medium plastic (ML)											
		UD1	2.4 - 2.8	1.96	38	43	12	1	99	2.68	Grey medium stiff SILT, trace fine sand, low to medium plastic (ML)	0.613	0.384	40.2	1.59	0.102	0.039 to 0.305	0.236	0.32	0.467	1.7	3.64
		D3	4.3 - 4.8			NP	NP	15	85			Grey loose SILT, trace fine sand, non-plastic (ML)										
		D6	8.8 - 9.3			NP	NP	51	49			Grey medium dense FINE SAND and SILT, non-plastic (SM)										

qu - Undisturbed specimen
C_c - Compression Index from Laboratory Virgin Stress

qu - Undisturbed specimen

qu_r - Remoulded specimen

Eu - Undrained Modulus

Cv - Coefficient of Consolidation

Cr - Recompression Index

Cc - Compression Index from Laboratory Virgin Slope

Cc' - Compression Index from Estimated Field Virgin Slope

Po - Existing Overburden Pressure

Pe - Pre-consolidation Pressure

OCR - Over Consolidation Ratio = Pe/Po

SUMMARY OF SOIL TEST RESULTS

PROJECT: CPP-II (Water Component)

ROAD SECTION: Polder No. 59/3B

[illegible]

qu - Undisturbed specimen
 qr - Remoulded specimen
 Lu - Undrained Modulus
 Cv - Co-efficient of Consolidation
 Cr - Recompression Index

Cc - Compression Index from Laboratory Virgin Slope
Cc' - Compression Index from Estimated Field Virgin Slope
Po - Existing Overburden Pressure
Pe - Pre-consolidation Pressure
OCR - Over Consolidation Ratio = P_c/P_o

GEOTECHNICAL AND MATERIALS LABORATORY
DEVELOPMENT DESIGN CONSULTANTS LTD.
23, New Esplanade Road, Dhaka-1000

Project/Client : C.R.P.-II (WATER COMPONENT)

Location : NOAKHALI

BH/Pit No. : B.H-2

Sample No. : U.D-1

Depth (m) : 2.40 - 2.80

Chainage : 413 km

Bridge/Section No. : FARAZIR KHAL

Date : 3.4.91.

TEST RESULTSMoisture Content = 38 % Wet Unit Weight = 1.96 g/cm³ Dry Unit Weight = 1.42 g/cm³Liquid Limit = 43 % Plasticity Index = 12 % Description : Grey med Stiff SILT trace
Fine sand L.P./M.P.Unconfined Compressive Strength, q_u (Undisturbed) = 0.0601 N/mm² or 0.613 kg/cm²Unconfined Compressive Strength, q_u (Remoulded) = 0.0377 N/mm² or 0.384 kg/cm²

Percent Strain at failure = 19 % (Undisturbed), 19 % (Remoulded)

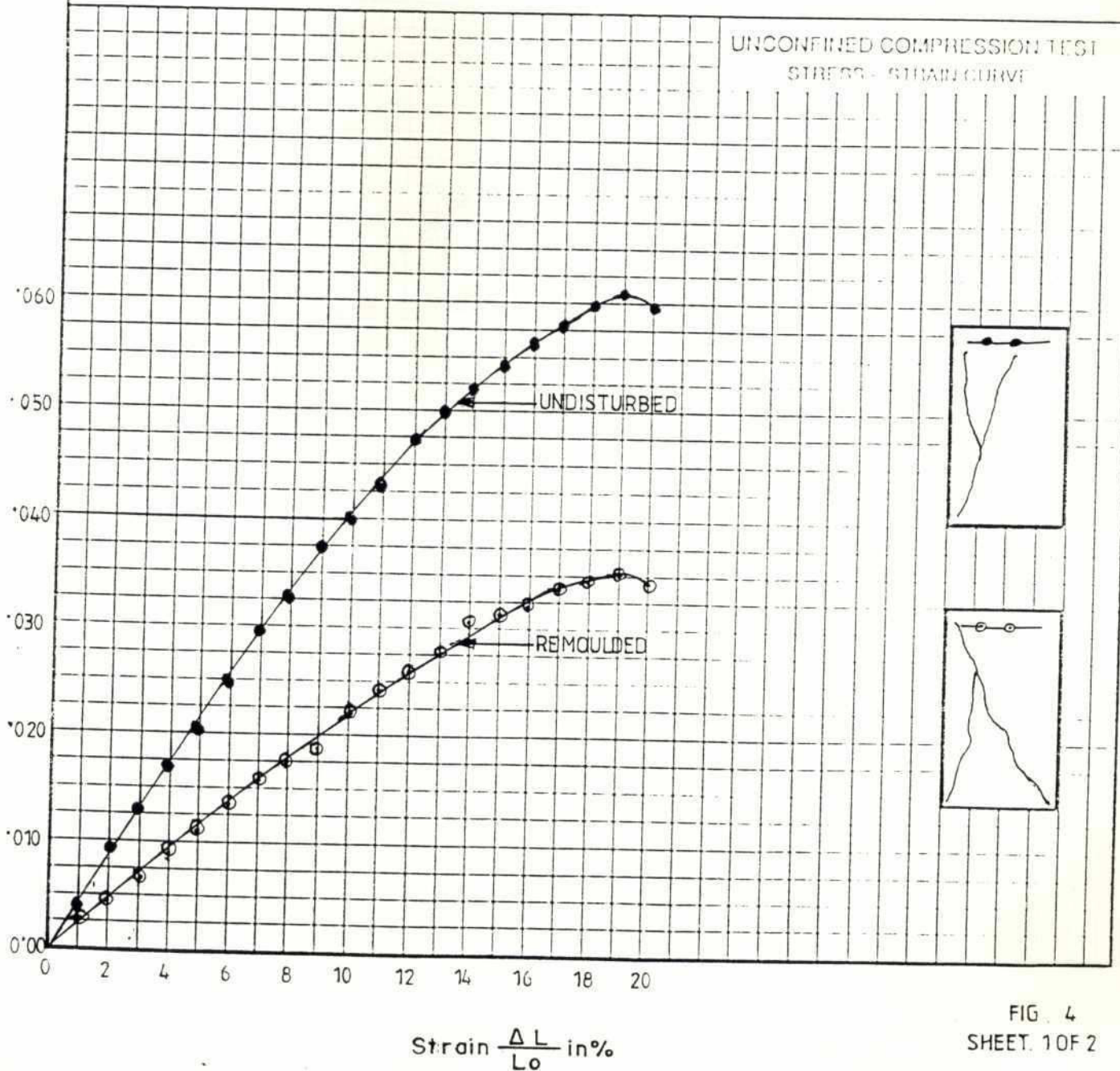
Sensitivity, S_t = 1.59 Undrained Modulus, E_u = 4 N/mm² or 40.2 kg/cm²

FIG. 4
SHEET. 1 OF 2

Project/Client : C.P.P-II (WATER COMPONENT)

Location : NOAKHALI

BH/Pit No. : B.H.-3

Sample No. : U.D.-1

Depth (m) : 3.9-4.3

Chainage : 41.3 km

Bridge/Section No. : FARAZIRKHAL

Date : 3.3.91.

TEST RESULTSMoisture Content = 38 % Wet Unit Weight = 1.97 g/cm³ Dry Unit Weight = 1.43 g/cm³Liquid Limit = 45 % Plasticity Index = 24 % Description : Grey soft CLAY^{trace} Fine sand L.P./M.P.Unconfined Compressive Strength, q_u (Undisturbed) = 0.060 N/mm² or 0.612 kg/cm²Unconfined Compressive Strength, q_u (Remoulded) = 0.0407 N/mm² or 0.416 kg/cm²

Percent Strain at failure = 17 % (Undisturbed), 19 % (Remoulded)

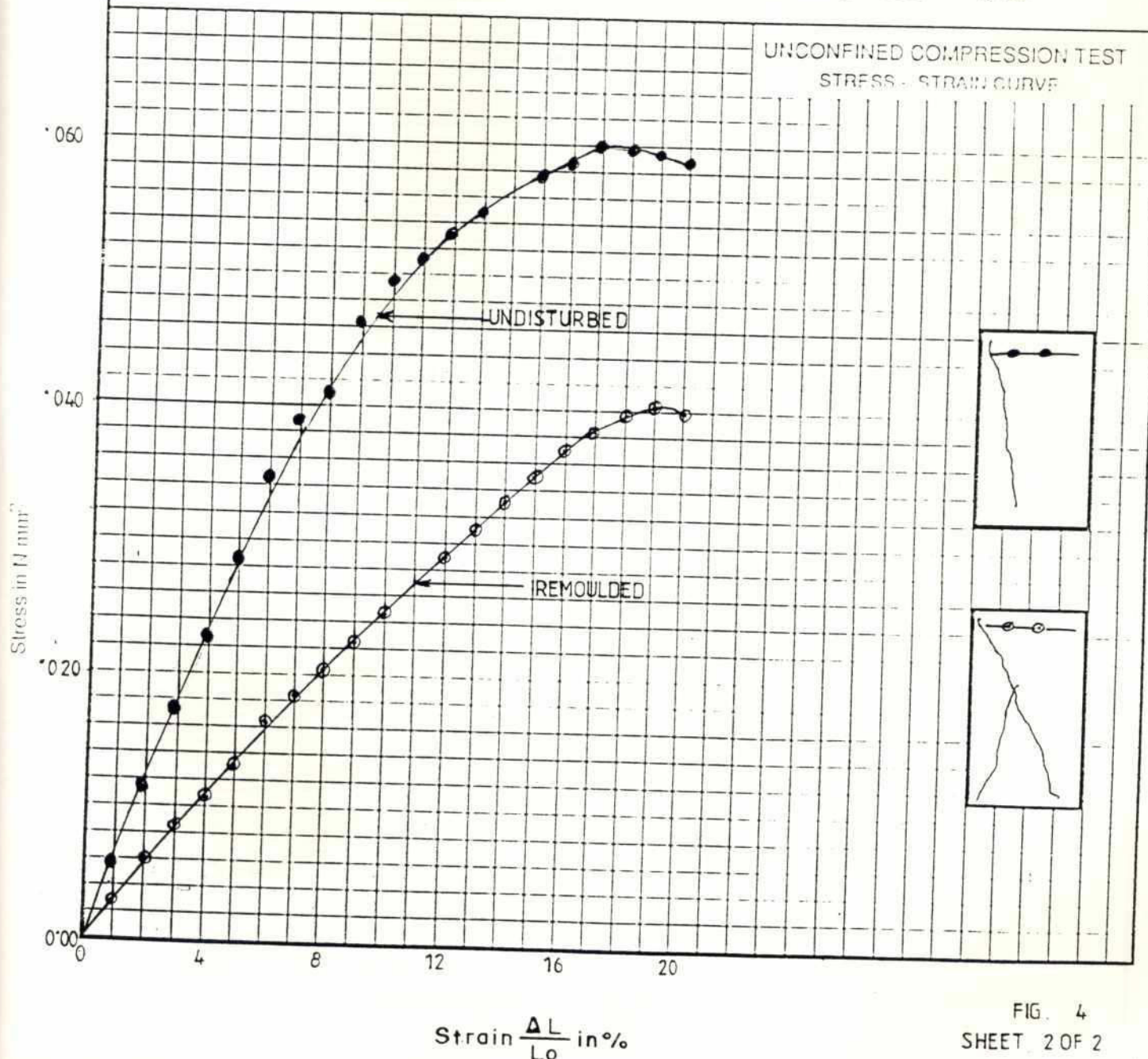
Sensitivity, S_t = 1.47 Undrained Modulus, E_u = 5.12 N/mm² or 52.30 kg/cm²

FIG. 4
SHEET 2 OF 2

e-LOG P AND C_v -LOG P RELATION

GEOTECHNICAL AND MATERIALS LABORATORY D.D.C LTD.

PROJECT / CLIENT: C.R.P-II (WATER COMPONENT)

DATE: 13.3.91 - 21.3.91

LOCATION: POLDER NO 59/3B AT 41.3 km ON FARAZIR KHAL

BORING NO- 2

SAMPLE NO- UD-1

DEPTH-(2'40-2'85)m

DESCRIPTION:

Grey med stiff SILT
trace fine sand Low
to medium Plastic
(ML)

LL - 43%

PI - 12%

DIA - 6.33 cm

HT - 2.445 cm

Hs - 1.17 cm

W_i - 37%

W_f - 30%

e_o - 1.089

G_s - 2.68

Cr - 0.039

C_c - 0.236

C'_c - 0.32

P_o - 0.467 Kg/cm²

P_c - 1.7 Kg/cm²

OCR - 3.64

SATURATION:

Initial - 91%

Final - 100%

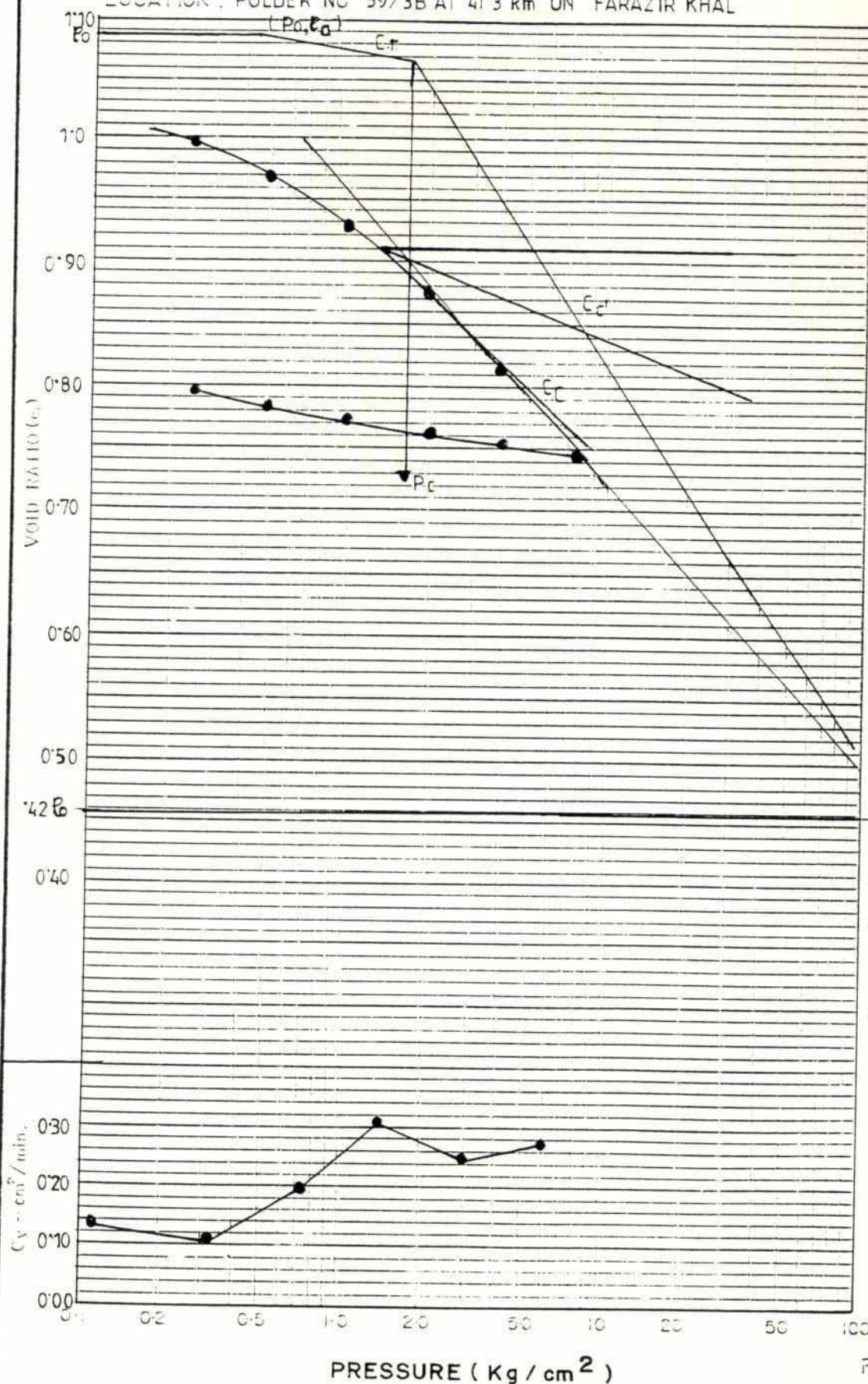


FIGURE: 5

SHEET: 1 OF 2

e-LOG P AND Cv-LOG P RELATION

GEOTECHNICAL AND MATERIALS LABORATORY D.D.C LTD.

PROJECT / CLIENT: CRP-II (Water Component)

DATE: 24.3.91 - 1.4.91

LOCATION: Polder NO. 59/3B at 41.3 km on Farazir Khal

BORING NO- 3

SAMPLE NO- UD-1

DEPTH- (3.9 - 4.3) m

DESCRIPTION: Grey soft CLAY, trace fine sand, LP/M.P (CL)

LL - 45%

PI - 24%

DIA - 6.33 cm

Hi - 2.40 cm

Hs - 1.22 cm

W_L - 35%

W_p - 30%

e₀ - 0.967

G_s - 2.69

C_r - 0.035

C_c - 0.209

C_{c'} - 0.327

P_b - 0.622 kg/cm²

P_c - 2.20 kg/cm²

OCR - 3.54

SATURATION:

Initial - 98%

Final - 100%

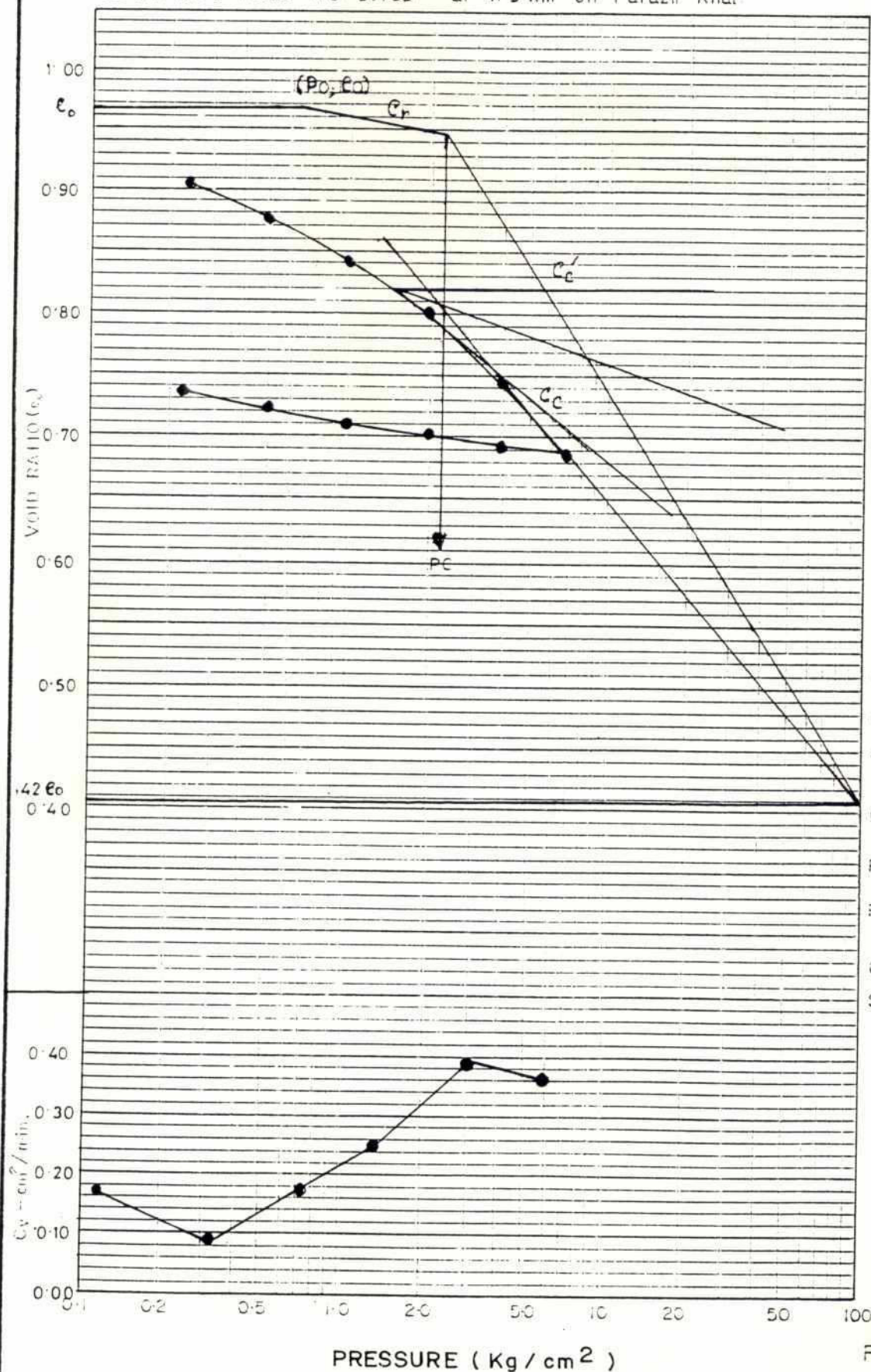


FIGURE: 5

SHEET.2 OF 2

