Borehole No.	Location	Allowable Bearing Capacities of Subsurface Soil,Qa (ft/m²)					
		Silt Soil Layer			Sandy Soil layer		
		N value	Normal Condition	Seismic Condition	N value	Normal Condition	Seismic Condition
Borehole B3	Tambulpur	3.0	4.3	8.5	17.5	21.1	40.1
Borehole B4	Tarapur	5.5	5.4	10.7	17.0	19.8	37.7
Borehole B6	Manas	7.5	10.7	21.1	38.0	51.8	98.5
Borehole B6	Gaibandha	-	-	-	25.5	29.3	55.1
Borehole B12	Bamondanga	2.0	2.6	5.2	11.0	10.3	20.4
Borehole B13	Gopalchri	5.5	9.1	17.7	17.0	18.2	34.1

On the other hand, the maximum compressive strengths which take place at the foundation of regulator with a height of 5 m are estimated to be around 10 and 15 ton/m² under the normal and seismic conditions, respectively. From the above results, therefore, the regulator would need to be founded on the sandy soil layer with N value of more than 10. On the other hand, Concerning the larger scale of regulator with a height of 5 m the compressive strength acting on soil layer below the foundation are estimated to be about 5 and 10 tf/m², respectively. Therefore, the regulators proposed for the GIP area is recommended to be founded on the sandy soil layer with N value of 10 or more.

5.4 Preliminary Design

(1) Flood embankment

Design of flood embankment is made on the basis of analysis results mentioned in the previous Section 5.3 and flood water level profile illustrated in Figures 5.14 to 5.16. As shown in Figure 5.17, typical three embankment sections are applied to the Teesta Right Embankment and Ghagot Left Embankment. Principal design values are given below.

	TRE	GLE	
		Back-water Levee	Upstream Section
Crest width	4.25 m	4.25 m	4.25 m
Free board	1.52 m	0.91 m	0.91 m
Berm width	2.0 m	2.0 m	2.0 m
Slope in R/S	1:3.0	1:2.0	1:2.0
Slope in C/S	1:3.0	1:2.0	1:2.0
Drain (filter)	without drain	with drain	without drain

Crest elevation is determined adding a free board to the design flood water level. The crest width of 4.25 m is adopted for ever flood embankment considering the function as a road for the inspection and rural traffic. In addition 2 m wide berm is provided on the country side slope for the purpose of securing the stability of the embankment slope due to seepage flow. The berm level is set at 1.0 m above the design internal water level in case that the internal water (seepage) reaches the foot of embankment, on the other hand it is set at 3.0 m below the embankment crest in case the internal water doesn't reach the foot of embankment with a total embankment height is more than 3.0 m.

According to the seepage analysis for GLE backwater levee, It is still likely to case the seepage failure during the monsoon period. To secure the stability a drain filter is planned to be provided at the toe portion of the embankment. It forms a trapezoidal section composed of sand drain and jute mat filter of 1.0 m in width.

As a result of the settlement analysis, it is concluded that total settlement of the embankment body is generally as small as 3 cm to 30 cm by the local subsurface condition. In this design 30 cm and 10 cm of the extra embankment height are adopted for TRE-2 and TRE-1/GLE respectively. Embankment material will be obtained from the borrow area adjoining the embankment site which is exploited at at the location 10 m distant from the edge of borrow area in the minimum.

It is planned that turfing is provided on the embankment slope to protect the surface from erosion due to river flow, wind, wave and rainfall.

(2) Compartment bank

Typical cross section of embankment for compartmentalisation is shown in Figure 5.18. The bank height is decided based on the internal water level obtained through the hydraulic modeling analysis taking and the free board of 0.5 m. As a side slope, 1:2 is adopted since the embankment height is rather small compared with that of TRE. The crest with a width of 3.6 m is planned to be paved with brick for the use of the public rural road. The side slopes surface are planned to be protected by turfing.

(3) Groyne

As explained in the foregoing Sub-section 5.2.3, construction of an impermeable groynes is proposed to maintain the bank line of the Teesta where at present it is subject to the severe bank erosion.

As shown in Figure 5.19, the crest elevation is set at river bank elevation adjacent thereto in the country side, and it declines riverward with the slope of 1/400. The axis is aligned that the groyne head is directed slightly upstream, making an included angle of 80 degrees with the bank line. The crest is designed to have a width of 5 m, which will enable it to use for the inspection and maintenance purposes.

As shown in Figure 5.20, the groyne is composed of compacted earth fill section and jute bag fill section. As the side slopes, 1:3 is adopted to a elevation corresponding to the dry season water level and 1:2 therefrom to the crest level. Since the design allows the flood water to overtop the crest, concrete blocks covered with wire net are provided on the crest and the up and downstream slopes to protect the body from flood attack. Further, the slope foot protection works is planned to be provided over a width of 3 m to 10 m around groyne.

(4) Regulator

The regulator is designed to function the following;

- to drain out the internal water by gravity in the post monsoon season,
- to regulate the influx of outer river water in the monsoon season, and
- to function as an intake structure for the irrigation and domestic purposes in the dry season as far as possible.

The design was made with reference to the regulators in the GIP area which has opening area of 1.52 m x 1.83 m per 1 vent. The typical sections thereat are illustrated in Figures 5.21 and 5.22. The sill elevation is set at the original river bed, while the apron elevation of both inlet and outlet sides is set at 0.3 m lower than the sill elevation to dissipate the flow energy. The vent number required is so decided as to have enough capacity to lower the internal water level upto the outer river water level in

the post monsoon season in two weeks. The basic dimensions of regulator is determined based on the embankment height and the vent number.

According to the stress analysis of foundation, there are some places where N value in the surface soil layer is less than 10, which is minimum requirement for foundation of the regulators. Taking into account the subsurface condition in the GIP area, the likely erosion of the foundation soil below the regulator due to the current in the monsoon season, precast concrete piles are provided as the foundation treatment for supporting all new regulators and extended regulators aiming at the safer side design.

The construction works are categorized into three types as follows :

- Provision of a new regulator

- Provision of new vents to the existing regulator site: A new regulator is planned to be built to complement the flow area necessary for the drainage purpose at the adjoining site considering the difficulty of combining it with a new structure.

- Rehabilitation of the existing regulator: Partial repair works will be made for the deteriorated portions of the existing regulators including change of gates, repair of slope protection and apron slab.

Principal features of all regulators planned in the project area is given in Table 5.12.

(5) Sluiceway

Sluiceway is planned to be constructed to drain out local internal water in the area enclosed by road embankments without drainage structure. A cast-in-situ box culvert with a steel flap gate is adopted as the structure type. Since the objective drainage area is rather small, the dimensions of structure are determined from the aspects of easiness in the inspection and maintenance works. A steel flap gate with an opening size of 1 m x 1 m is planned to be installed at the outer river side. The total length is determined in compliance with the embankment height and width. The structural outline is shown in Figure 5.23 and proposed sluice ways are listed in Table 5.13. In addition, side drains to be provided along the flood embankment. The water in local depressions will be collected by the side drain and drained out through the sluiceway. They are designed to be open excavation ditch with a trapezoidal section and side slopes of 1:1.

(6) Drain pipe

A drain pipes proposed to be installed over the whole GIP area will function as a waterway between sub-basins compartmentalized by the existing roads. Precast concrete pipes with diameter of 700 mm are provided on the sand base in consideration of reduction of its flow area due to siltation and/or garbage inside the pipe and the manual removal works thereof in the maintenance period. Although a severe external loading is not expected, the covering soil depth above it is secured to be 0.5 m in the minimum. The basic design is shown in Figure 5.24.

(7) Road bridge

A new road bridge is planned on a short cut channel with a total width of about 100 m. In consideration of the total span length as well as the constraint in the pier construction, a post-tension PC-girder bridge

is adopted so that the bridge is designed to have three spans. Each span length is 32 m and a post-tension type of girder is the most practical and generally adopted for this span length. From the aspect of availability of construction material as well as the economic aspect, application of a steel bridge is considered to be not suitable. Another possible selection is a pre-tension type of bridge. As discussed in the design criteria, however, this type is generally applied for a small scale of bridge with a span length less than 15 or 20 m. Thus, it is considered not preferable to adopt it for bridge with a span length more than 25 m in view of the required cost and time to take.

The bridge width and other geometric conditions are so determined as not to lower the present grade on the traffic condition. Loading condition is considered following the standard of road bridge design in this country.

Precast concrete piles are provided for the foundation of abutments and piers to keep the structures from settlement. The pile length is assumed to be 10 m, which will function as a friction pile. The principal features of the bridge is summarized below and the outline is shown in Figures 5.25 and 5.26.

- Bridge type	:	Post-tension PC-girder bridge
- Total bridge length	:	97 m
- Span length	:	32 m x 3 spans
- Bridge width	:	7.4 m
- Road width	:	6 m (3 m x 2 lanes with asphalt pavement)
- Type of foundation	:	RC-precast concrete pile

(8) Revetment

Revetment works by concrete block casting is applied for slope protection to maintain a river embankment against the erosive flood flow during the peak monsoon season. The structural outline is shown in Figure 5.27. Revetment is provided also for both side slopes in front of and behind the proposed drainage structures and abutments of the bridge.

5.5 Examination of Navigation Lock in Relation to Improvement of Inland Transportation

To improve the present situation on the inland transportation in the GIP area during the monsoon season, the study was carried out for navigation locks at each of the regulator site of Mirganj, Sarai and the proposed regulator on the Manas. These regulators are located at the downstream end of the Masankura, Matherhat and Manas rivers, which is proposed as navigation routes for inland transportation in the GIP area.

The basic dimensions were set to enable a 6 m long and 1.5 m wide boat to pass it. It was planned that a difference between inland and outer river water levels is made by means of operating two gates installed along the waterway inside the navigation lock. Piers and hoist deck were installed on the nearly embankment crest for the gate operation. On the other hand, PC-concrete piles are provided for the foundation to support it against the external loads acting on the larger scale gate structure than the proposed regulator. The principal features of the navigation lock are given below.

Type	:	Gate control type
Dimensions	:	10 m in length x 4 m in width x 6 m in depth
Gate Type	:	Steel slide gate

Gate Dimension	:	4 m in width x 4.5 m in height
Pier	:	6 m in height
Foundation	:	Precast RC-pile (400 x 400)

Since the aforesaid existing two regulators, namely Mirganj and Sarai regulators, do not have a sufficient clearance above the design water level which enables the boat to pass those regulators, the superstructures of those regulators would have to be raised to allow its passage after removal thereof. However, this would require a large amount of construction cost and be associated with uncertainty in the structural stability. Therefore, the proposed navigation lock with a trapezoidal section is planned to be constructed at the adjacent place with an approach channel leading the boat to the navigation lock from the rivers so as not to provide any modification work to the existing regulators.

Besides, the aforesaid river channels to be used for navigation purpose will have to be excavated over a bed width of 10 m at least to cope with silting problem which also hamper the smooth navigation planned in order to secure the sectional area of channel for navigation of the boat. The channel stretches to be excavated are as follows:

1)	Masankura to Pirgacha	:	15.0 km
2)	Matherhat to Sundarganj	:	31.8 km
3)	Manas to Bamondanga	:	37.2 km

A total of the excavated volume in these channels amounts approximately to 1.68 million m^3.

Table 5.1 DESIGN VALUES OF EMBANKMENT MATERIAL

Item		Foundations		Embankments	
		Silty	Sandy	Existing	Proposed
Specific gravity		2.67	2.66	2.66	2.67
Natural moisture content	(%)	27.0	23.3	25.2	25.2
Dry density	(tf/m^3)	1.25	1.42	1.25	1.33
Wet density	(tf/m^3)	1.59	1.75	1.59	1.67
Saturated density	(tf/m^3)	1.78	1.89	1.78	1.83
Submerged density	(tf/m^3)	0.78	0.89	0.78	0.83
Coefficient of permeability	(cm/sec)	1¥10^{-4}	5¥10^{-3}	2¥10^{-4}	1¥10^{-4}
Coefficient of consolidation	(cm^2/day)	250	-	-	-
Strength parameter (effective stress analysis)					
Cohesion c'	(tf/m^2)	1.0	0.0	0.3	0.3
Internal friction angle ϕ'	(degree)	22.0	27.0	20.0	24.0

Table 5.2 RESULTS OF SEEPAGE LINE ANALYSIS

Typial section	Inland Water Depth (m)	Minimum Required Filter Height (m)	Allowable Thickness of Lift (m)
TRE-1	0.0	0.7	2.2
	1.0	1.3	1.7
TRE-2	0.0	1.2	2.5
	1.0	1.6	2.1
GLE	0.0	1.2	1.6
	1.5	1.8	1.0

Table 5.3 REACHING TIME OF SEEPAGE LINE TO EMBANKMENT SLOPE

Typial section	Inland Water Depth (m)	Coefficient of Permeability (cm/sec)	Reaching Time of Seepage Line on C/S (days)
TRE-1	0.0	1.0E-4	280
	1.0	1.0E-4	389
TRE-2	0.0	2.0E-4	123
	1.0	2.0E-4	140
GLE	0.0	2.0E-4	57
	1.5	2.0E-4	79

Table 5.4 PIPING RESISTANCE OF FOUNDATION OF EMBANKMENTS

Typial section	Soil Layer	Critical Hydraulic Gradient	Hydraulic Gradient
TRE-1	Silty Soil	0.78	0.07
	Sandy soil	0.89	0.06
TRE-2	Silty Soil	0.78	0.09
	Sandy soil	0.89	0.06
GLE	Silty Soil	0.78	0.13
	Sandy soil	0.89	0.09

Table 5.5 TOTAL SETTLEMENT AND SETTLING VELOCITY OF FLOOD EMBANKMENT

Typical Cross Section	Total Settlement (cm)	Total Settlement of Embankment (cm)	Total Settlement of Silty Soil Layer (cm)	Construction Period Assumed (days)	Settlement at the time of Completion of Construction (cm)	Degree of Consolidation (%)	Residual Settlement (cm)
TRE-1	8.1	3.6	4.5	180	3.6	80.0	0.9
TRE-2	32.5	3.1	29.4	180	5.5	18.7	23.9
GLE	5.8	2.4	3.4	180	1.3	38.2	2.1

Note Settling velocity was only analyzed for the silty soil layer.

Table 5.6 RESULT OF STABILITY ANALYSIS IN CASE OF VARYING DISTANCE BETWEEN EMBANKMENT AND BORROW AREA

Typical Section	Condition	Distance between Embankment Toe and Edge of Borrow Area			
		3 m	6 m	10 m	15 m
TRE-1	NLC	1.32	1.41	1.41	1.41
	ELC	1.01	1.11	1.11	1.11
TRE-2	NLC	1.46	1.48	1.48	1.48
	ELC	1.16	1.19	1.19	1.19
GLE	NLC	1.21	1.39	1.43	1.43
	ELC	0.96	1.07	1.14	1.14

Note
NCL : Normal Loading Condition
ELC : Extreme Loading Condition

Table 5.7 RESULT OF STABILITY ANALYSIS

Typical Cross Section	Location of circle	Case-1 NLC	Case-1 ELC	Case-2 NLC	Case-2 ELC	Case-3 NLC	Case-3 ELC	Case-4 NLC	Case-4 ELC	Case-5 NLC	Case-5 ELC	Case-6 NLC	Case-6 ELC	Case-7 NLC	Case-7 ELC
TRE-1	R/S	1.86	1.41	2.40	1.66	2.46	1.69	1.41	1.11	1.43	1.13	2.04	1.18	2.10	1.20
	C/S	2.03	1.51	1.96	1.44	1.75	1.32	-	-	-	-	2.25	1.24	1.98	1.17
TRE-2	R/S	2.08	1.62	2.65	1.87	2.70	1.90	1.48	1.19	1.49	1.20	2.10	1.29	2.14	1.30
	C/S	2.25	1.72	1.92	1.47	1.78	1.38	-	-	-	-	2.29	1.35	2.12	1.28
GLE	R/S	2.16	1.58	3.14	1.94	3.24	1.98	1.43	1.14	1.48	1.18	2.42	1.27	2.56	1.30
	C/S	2.27	1.69	2.14	1.60	1.68	1.29	-	-	-	-	2.50	1.37	1.97	1.17

Notes

1.Examined cases

- Case-1 : Immediately after construction of embankment when ground surface in the both river and country sides becomes dry (kh=0.055)
- Case-2 : Water levels in the river and country sides are at the design high water level of the river (DWL) and design inland water level (DIWL), respectively (kh=0.055)
- Case-3 : Water level in the river side is at DHWL, while water level in the country side is at the ground elevation (kh=0.055)
- Case-4 : Rapid drawdown from DWL to the ground level takes place in the river side, when water level in the river side is at DIWL (kh=0.055)
- Case-5 : Rapid drawdown from DWL to the ground elevation takes place, while water level in the country side is at the ground elevation (kh=0.055)
- Case-6 : Both water levels in the river and country sides are at DIHL (kh=0.11)
- Case-7 : Water level in the river side is at DIHL, while water level in the country side is at the ground elevation (kh=0.11)

2.Abbreviations

NLC : Normal Loading Condition
ELC : Extreme Loading Condition

R/S : River side
C/S : Country side
kh : Adopted seismic coefficient

Table 5.8 DESIGN VALUES OF SUBSURFACE SOIL AT REGULATOR SITES PLANNED IN FAP2 INTERIM REGIONAL STUDY

Item		Silty	Sandy
Specific gravity		2.67	2.66
Natural moisture content	(%)	27.0	23.3
Dry density	(tf/m^3)	1.25	1.42
Wet density	(tf/m^3)	1.59	1.75
Saturated density	(tf/m^3)	1.78	1.89
Submerged density	(tf/m^3)	0.78	0.89
Coefficient of consolidation	(cm^2/day)	250	-

Table 5.9 MAJOR DIMENSIONS OF REGULATORS PLANNED IN FAP2 INTERIM REGIONAL STUDY

Design Seismic Coefficient (kh) = 0.11

Height of regulator = 4.8 m

Regulator	Vent	Width of Foundation (m)	Length of Foundation (m)	Weight of Regulator (tf)
Tambulpur	6	11.5	7.3	240
Tarapur	6	11.5	7.3	240
Manas	8	15.0	7.3	300
Gaibandha	3	6.0	7.3	145
Bamondanga	2	4.0	7.3	115
Gopalchri	3	6.0	7.3	145

NLC : Normal Loading Conditions

ELC : Extreme Loading Conditions

Table 5.10 ULTIMATE BEARING CAPACITY AT BOREHOLE SITE ON NORMAL CONDITION (1/2)

Boreholes No. : B3, B4 and B6

Strata	sandy soil layer	silty soil layer	slty soil layer
Wet density 1 (tf/m3)	1.59	1.59	1.59
Submerged density 1 (tf/m3)	0.78	0.78	0.78
Wet density 2 (tf/m3)	1.75	1.75	1.75
Submerged density 2 (tf/m3)	0.89	0.89	0.89
Tambulpur Regulator (B3)			
N value	17.5	3	
Cohesion (tf/m2)	0.0	1.9	
Internal friction angle	29.5	0.0	
Depth of foundation (m)	1.0	1.0	
Thickness of stratum (m)		2.0	
Short side of a rectangle	5.9	5.9	
Long side of a rectangle	11.5	11.5	
Bearing capacity factor	Nc = 35.7		
	Nq = 21.2		
	Nr = 17.7		
Ultimate bering capacity(tf/m2)	63.2	13.0	
Trapur Regulator (B4)			
N value	17	5.5	
Cohesion (tf/m2)	0.0	3.4	
Internal friction angle	29.3	0.0	
Depth of foundation (m)	1.0	1.0	
Thickness of stratum (m)		5.1	
Short side of a rectangle	5.9	5.9	
Long side of a rectangle	11.5	11.5	
Bearing capacity factor	Nc = 35.0		
	Nq = 20.6		
	Nr = 17.0		
Ultimate bering capacity(tf/m2)	59.5	16.2	
Manas Regulator (B6)			
N value	38		7.5
Cohesion (tf/m2)	0.0		4.7
Internal friction angle	36.4		0.0
Depth of foundation (m)	1.0		1.0
Thickness of stratum (m)			8.7
Short side of a rectangle	5.9		5.9
Long side of a rectangle	15.0		15.0
Bearing capacity factor	Nc = 65.8		Nc = 5.7
	Nq = 49.4		Nq = 1.0
	Nr = 59.5		Nr = 0.0
Ultimate bering capacity(tf/m2)	155.4		32.1

(To be continued)

Table 5.10 ULTIMATE BEARING CAPACITY AT BOREHOLE SITE ON NORMAL CONDITION (2/2)

Boreholes No. : B6', B12 and B13			
Strata	sandy soil layer	silty soil layer	slty soil layer
Wet density 1 (tf/m3)	1.59	1.59	1.59
Submerged density 1 (tf/m3)	0.78	0.78	0.78
Wet density 2 (tf/m3)	1.75	1.75	1.75
Submerged density 2 (tf/m3)	0.89	0.89	0.89
Gaibandha Regulator (B6')			
N value	25.5		
Cohesion (tf/m2)	0.0		
Internal friction angle	32.5		
Depth of foundation (m)	1.0		
Thickness of stratum (m)			
Short side of a rectangle	5.9		
Long side of a rectangle	6.0		
Bearing capacity factor	Nc = 46.0		
	Nq = 30.3		
	Nr = 29.8		
Ultimate bering capacity(tf/m2)	87.8		
Bamondanga Regulator (B12)			
N value	11	2	
Cohesion (tf/m2)	0.0	1.3	
Internal friction angle	26.5	0.0	
Depth of foundation (m)	1.0	1.0	
Thickness of stratum (m)		1.9	
Short side of a rectangle	4.0	4.0	
Long side of a rectangle	5.7	5.9	
Bearing capacity factor	Nc = 28.1		
	Nq = 15.0		
	Nr = 10.6		
Ultimate bering capacity(tf/m2)	30.9	7.8	
Gopalchri Regulator (B13)			
N value	17		5.5
Cohesion (tf/m2)	0.0		3.4
Internal friction angle	29.3		0.0
Depth of foundation (m)	1.0		1.0
Thickness of stratum (m)			5.1
Short side of a rectangle	5.9		5.9
Long side of a rectangle	6.0		6.0
Bearing capacity factor	Nc = 35.0		Nc = 5.7
	Nq = 20.6		Nq = 1.0
	Nr = 17.0		Nr = 0.0
Ultimate bering capacity(tf/m2)	54.7		27.4

Table 5.11 ULTIMATE BEARING CAPACITY AT BOREHOLE SITE ON EXTREME CONDITION (1/2)

Boreholes No. : B3, B4 and B6			
Strata	sandy soil layer	silty soil layer	slty soil layer
Wet density 1 (tf/m3)	1.59	1.59	1.59
Submerged density 1 (tf/m3)	0.78	0.78	0.78
Wet density 2 (tf/m3)	1.75	1.75	1.75
Submerged density 2 (tf/m3)	0.89	0.89	0.89
Tambulpur Regulator (B3)			
N value	17.5	3	
Cohesion (tf/m2)	0.0	1.9	
Internal friction angle	29.5	0.0	
Depth of foundation (m)	1.0	1.0	
Thickness of stratum (m)		2.0	
Short side of a rectangle	5.5	5.5	
Long side of a rectangle	11.5	11.5	
Bearing capacity factor	Nc = 35.7		
	Nq = 21.2		
	Nr = 17.7		
Ultimate bering capacity(tf/m2)	60.1	12.7	
Trapur Regulator (B4)			
N value	17	5.5	
Cohesion (tf/m2)	0.0	3.4	
Internal friction angle	29.3	0.0	
Depth of foundation (m)	1.0	1.0	
Thickness of stratum (m)		5.1	
Short side of a rectangle	5.5	5.5	
Long side of a rectangle	11.5	11.5	
Bearing capacity factor	Nc = 35.0		
	Nq = 20.6		
	Nr = 17.0		
Ultimate bering capacity(tf/m2)	56.5	16.1	
Manas Regulator (B6)			
N value	38		7.5
Cohesion (tf/m2)	0.0		4.7
Internal friction angle	36.4		0.0
Depth of foundation (m)	1.0		1.0
Thickness of stratum (m)			8.7
Short side of a rectangle	5.5		5.5
Long side of a rectangle	15.0		15.0
Bearing capacity factor	Nc = 65.8		Nc = 5.7
	Nq = 49.4		Nq = 1.0
	Nr = 59.5		Nr = 0.0
Ultimate bering capacity(tf/m2)	147.8		31.7

(To be continued)

Table 5.11 ULTIMATE BEARING CAPACITY AT BOREHOLE SITE ON EXTREME CONDITION (2/2)

Boreholes No. : B6', B12 and B13

Strata	sandy soil layer	silty soil layer	slty soil layer
Wet density 1 (tf/m3)	1.59	1.59	1.59
Submerged density 1 (tf/m3)	0.78	0.78	0.78
Wet density 2 (tf/m3)	1.75	1.75	1.75
Submerged density 2 (tf/m3)	0.89	0.89	0.89
Gaibandha Regulator (B6')			
N value	25.5		
Cohesion (tf/m2)	0.0		
Internal friction angle	32.5		
Depth of foundation (m)	1.0		
Thickness of stratum (m)			
Short side of a rectangle	5.3		
Long side of a rectangle	6.0		
Bearing capacity factor	Nc = 46.0		
	Nq = 30.3		
	Nr = 29.8		
Ultimate bering capacity(tf/m2)	82.7		
Bamondanga Regulator (B12)			
N value	11	2	
Cohesion (tf/m2)	0.0	1.3	
Internal friction angle	26.5	0.0	
Depth of foundation (m)	1.0	1.0	
Thickness of stratum (m)		1.9	
Short side of a rectangle	4.0	4.0	
Long side of a rectangle	5.3	5.3	
Bearing capacity factor	Nc = 28.1		
	Nq = 15.0		
	Nr = 10.6		
Ultimate bering capacity(tf/m2)	30.6	7.8	
Gopalchri Regulator (B13)			
N value	17		5.5
Cohesion (tf/m2)	0.0		3.4
Internal friction angle	29.3		0.0
Depth of foundation (m)	1.0		1.0
Thickness of stratum (m)			5.1
Short side of a rectangle	5.3		5.3
Long side of a rectangle	6.0		6.0
Bearing capacity factor	Nc = 35.0		Nc = 5.7
	Nq = 20.6		Nq = 1.0
	Nr = 17.0		Nr = 0.0
Ultimate bering capacity(tf/m2)	51.2		26.6

Table 5.12 LIST OF PROPOSED REGULATORS

	Symbol of Drainage Basin	Internal River	Location (km)	Catchment Area (sq.km)	Proposed Structure: Proposed Works	H x W x L (m)	Total Apron Length (m)	Type of Gate	Nos. of Vent	Opening Size	Sill Level (El. m)	Outer River Water Level (m)	Internal Water Level (m)
I. Teesta													
1) Mirganj regulator	G-9	Halhalia canal	16.1	112.20	Add	5.32x3.94x4.25	12	slide gate	2	1.52 m x 1.83 m	21.64	25.36	24.34
2) New regulator	G-7	Kata	25.7	15.81	New	4.63x5.76x4.25	12	slide gate	3	1.52 m x 1.83 m	23.50	26.53	24.89
3) New regulator	G-6		27.6	22.54	New	4.36x5.76x4.25	12	slide gate	3	1.52 m x 1.83 m	24.00	26.76	24.89
4) Kasiabari regulator	G-6A		32.9	0.67	Re	5.51x2.12x4.25	8	slide gate	1	1.52 m x 1.83 m	24.78	27.40	26.12
5) Narayanpur regulator	G-5		36.9	0.35	Re	4.77x2.12x4.25	10	slide gate	1	1.52 m x 1.83 m	25.74	28.02	26.15
6) New regulator	G-2	Burail	37.4	48.51	New	4.25x11.22x4.25	12	slide gate	6	1.52 m x 1.83 m	25.50	28.15	26.12
7) Bhairhat regulator	G-4		39.1	0.11	Re	4.19x2.12x4.25	15	slide gate	1	1.52 m x 1.83 m	26.69	28.59	27.47
8) Rajib regulator	G-3		41.4	1.88	Re	4.52x2.12x4.25	21	slide gate	1	1.52 m x 1.83 m	26.56	29.31	27.47
9) Kalirhat regulator	G-1		43.8	7.45	Re	4.3x2.12x4.25	21	slide gate	1	1.52 m x 1.83 m	27.80	30.09	27.47
II. Ghagot													
Left Bank													
1) New regulator	G-14-1		0.7	2.10	New	6.46x2.12x4.25	12	slide gate	1	1.52 m x 1.83 m	17.70	22.56	21.65
2) New regulator	G-14-2	Manas	2.4	148.58	New	7.82x20.32x4.25	12	slide gate	11	1.52 m x 1.83 m	16.34	22.56	21.65
3) New regulator	G-15		3.3	6.70	New	5.16x3.94x4.25	12	slide gate	2	1.52 m x 1.83 m	19.00	22.56	21.65
4) South Gagoa regulator	G-16-1		5.4	14.99	Add	6.66x2.12x4.25	12	slide gate	1	1.52 m x 1.83 m	17.50	22.56	21.65
5) New regulator	G-16-2		10.4	12.27	New	4.36x2.12x4.25	12	slide gate	1	1.52 m x 1.83 m	19.80	22.56	21.65
6) Bheramara regulator	G-17		11.8	10.47	Add	6.16x2.12x4.25	12	slide gate	1	1.52 m x 1.83 m	18.00	22.56	21.65
7) New regulator	G-18/19		20.9	19.35	New	4.16x5.76x4.25	12	slide gate	3	1.52 m x 1.83 m	20.00	22.56	21.66
8) New regulator	G-21		28.5	6.88	New	3.96x2.12x4.25	12	slide gate	1	1.52 m x 1.83 m	20.20	22.56	21.68
9) Kantanagar regulator	G-22		30.3	21.81	Add	3.93x2.12x4.25	12	slide gate	1	1.52 m x 1.83 m	20.23	22.56	22.21
10) Bhangamor North regulator	G-23		35.9	12.87	Add	3.93x3.94x4.25	12	slide gate	2	1.52 m x 1.83 m	20.60	22.93	22.21
11) New regulator	-	Bamondanga Beel	48.8	-	New	3.94x2.12x4.25	12	slide gate	1	1.52 m x 1.83 m	22.00	24.34	22.21
12) New regulator	G-26		60.4	14.75	New	3.98x3.94x4.25	12	slide gate	2	1.52 m x 1.83 m	23.10	25.48	23.70
Right Bank													
1) New regulator	-	Arai	10.1	-	New	8.63x2.12x4.25	12	slide gate	1	1.52 m x 1.83 m	15.53	22.56	17.51
III. BRE													
1) New regulator	G-11			34.75	New	6.9x7.58x4.25	12	slide gate	4	1.52 m x 1.83 m	19.00	24.28	22.32

Note
New : Provision of new regulator
Add : Construction of additional regulator
Re : Rehabilitation of existing regulator

H x W x L : Height x Width x Length

Table 5.13 LIST OF PROPOSED SLUICEWAYS

No.	Location (km)	Proposed Sluiceway Type of Gate	Nos. of Vent	Size	Sill Level (m)	Outer River Water Level (m)	Length (m)
I. Teesta							
S- 1	12.6	flap gate	1	1.00 m x 1.00 m	21.00	24.93	33.0
S- 2	19.3	flap gate	1	1.00 m x 1.00 m	23.00	25.75	25.9
S- 3	20.0	flap gate	1	1.00 m x 1.00 m	24.00	25.83	20.3
S- 4	26.7	flap gate	1	1.00 m x 1.00 m	24.70	26.65	21.1
S- 5	30.6	flap gate	1	1.00 m x 1.00 m	24.70	27.12	23.9
II. Ghagot							
Left Bank							
S- 1	14.9	flap gate	1	1.00 m x 1.00 m	20.20	22.56	17.8
S- 2	17.0	flap gate	1	1.00 m x 1.00 m	20.00	22.56	18.1
S- 3	26.0	flap gate	1	1.00 m x 1.00 m	21.40	22.56	18.3
S- 4	42.1	flap gate	1	1.00 m x 1.00 m	24.40	23.66	12.3
S- 5	42.6	flap gate	1	1.00 m x 1.00 m	23.50	23.70	10.1
S- 6	52.9	flap gate	1	1.00 m x 1.00 m	24.00	24.53	8.0
S- 7	54.1	flap gate	1	1.00 m x 1.00 m	23.50	24.97	11.8
S- 8	57.5	flap gate	1	1.00 m x 1.00 m	24.30	25.38	10.2
S- 9	59.7	flap gate	1	1.00 m x 1.00 m	23.50	25.54	14.1
S- 10	61.9	flap gate	1	1.00 m x 1.00 m	25.50	25.66	6.5
S- 11	70.9	flap gate	1	1.00 m x 1.00 m	26.00	26.05	6.1
S- 12	72.2	flap gate	1	1.00 m x 1.00 m	25.20	26.05	9.3
S- 13	74.9	flap gate	1	1.00 m x 1.00 m	26.50	26.68	6.6
Right Bank							
S- 1	0.7	flap gate	1	1.00 m x 1.00 m	20.53	22.56	16.4
S- 2	3.1	flap gate	1	1.00 m x 1.00 m	20.34	22.56	17.2
S- 3	10.9	flap gate	1	1.00 m x 1.00 m	21.67	22.56	11.9
S- 4	11.6	flap gate	1	1.00 m x 1.00 m	21.61	22.56	12.1
S- 5	11.9	flap gate	1	1.00 m x 1.00 m	21.70	22.56	11.8
S- 6	14.1	flap gate	1	1.00 m x 1.00 m	21.43	22.56	12.9
S- 7	16.3	flap gate	1	1.00 m x 1.00 m	21.29	22.56	13.4
S- 8	20.6	flap gate	1	1.00 m x 1.00 m	21.57	22.56	12.3
S- 9	25.5	flap gate	1	1.00 m x 1.00 m	22.08	22.56	10.3
S- 10	29.4	flap gate	1	1.00 m x 1.00 m	22.77	22.56	7.5
S- 11	31.4	flap gate	1	1.00 m x 1.00 m	22.85	22.56	7.2

Figure 5.1 PROPOSED FCD PLAN FOR THE GIP AREA

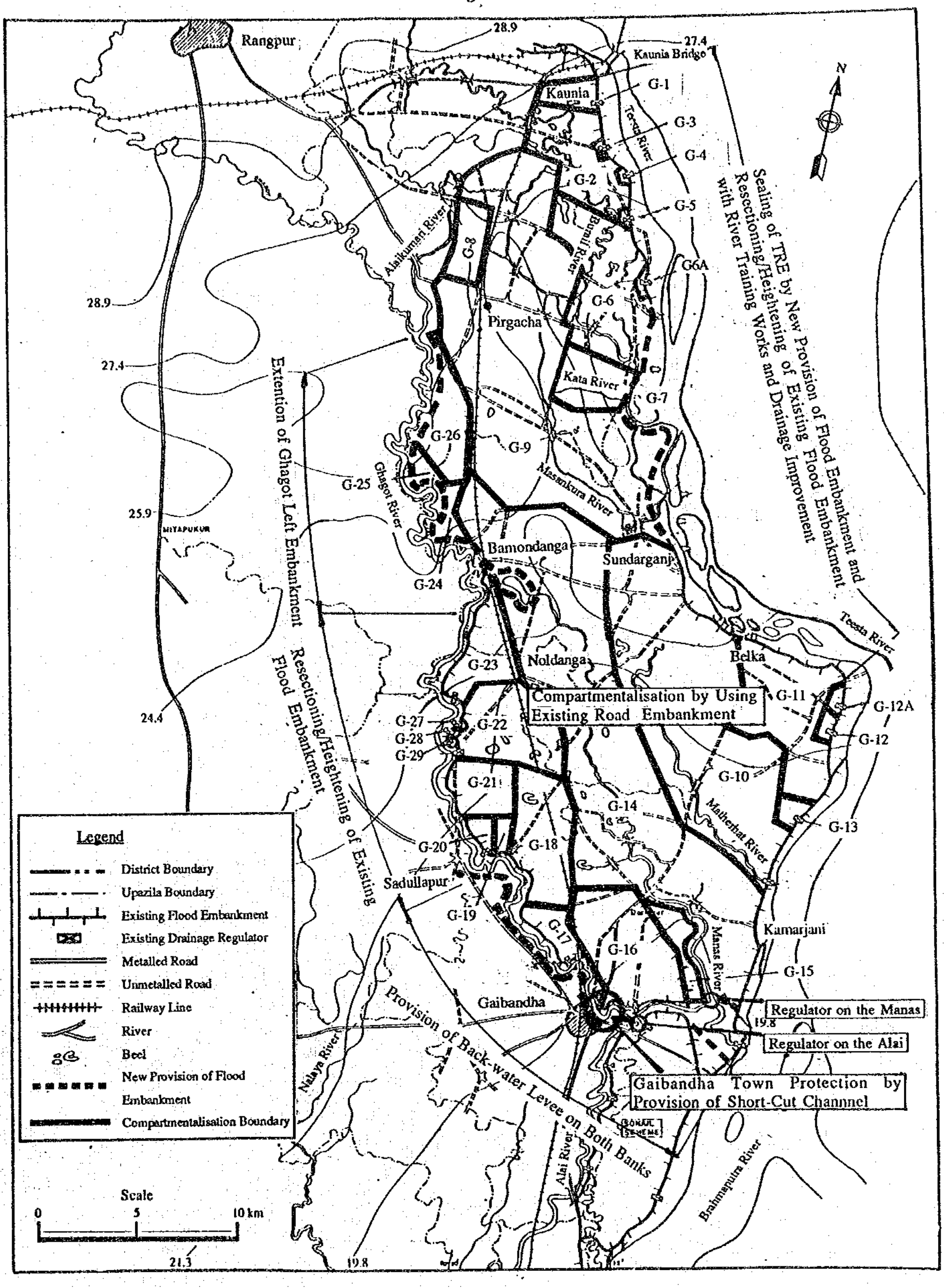


Figure 5.2 PROPOSED ALIGNMENT OF FLOOD EMBANKMENT AND LOCATIONS OF THE FCD STRUCTURES ALONG THE TEESTA (1/3)

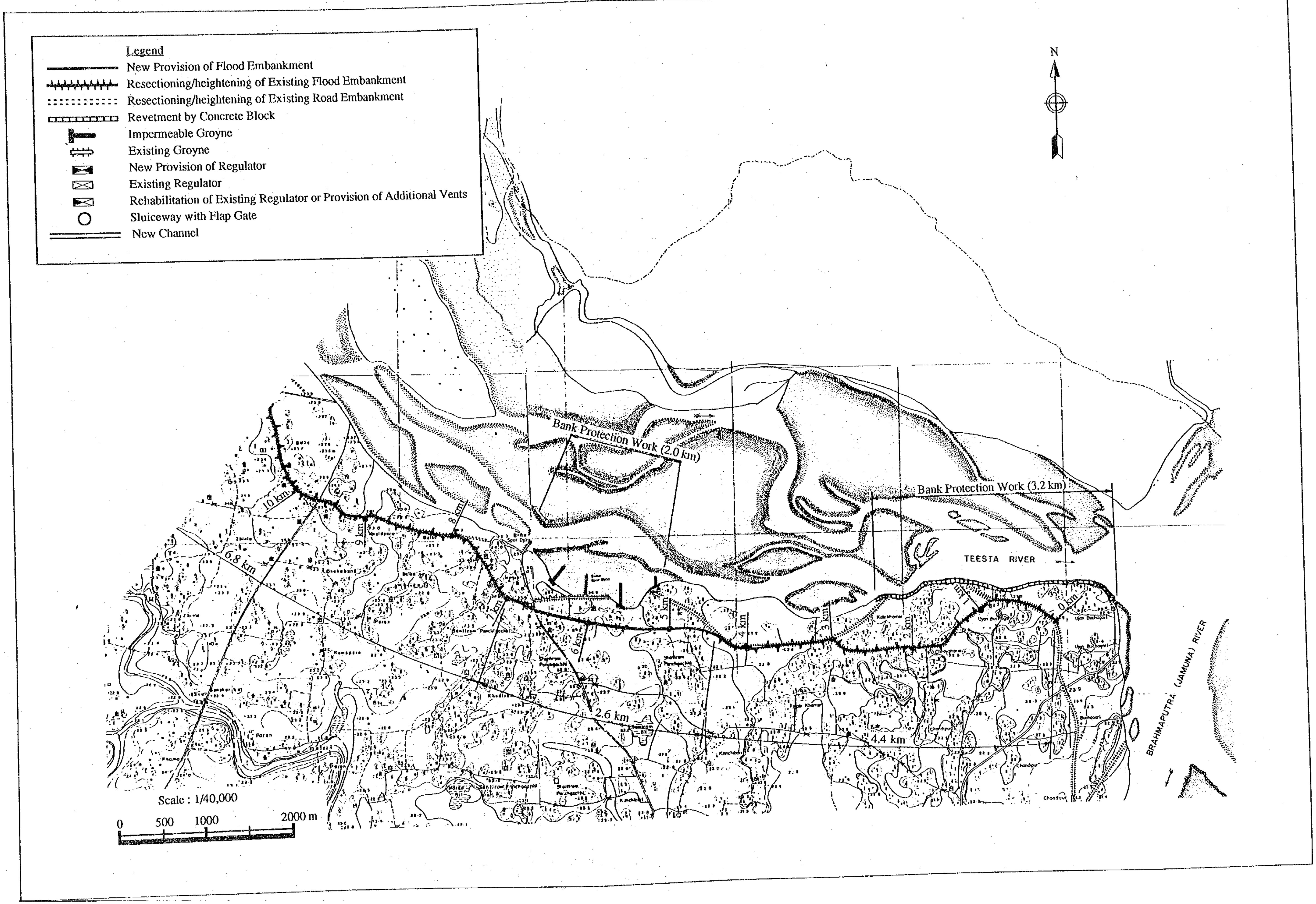


Figure 5.2 PROPOSED ALIGNMENT OF FLOOD EMBANKMENT AND LOCATIONS OF THE FCD STRUCTURES ALONG THE TEESTA (2/3)

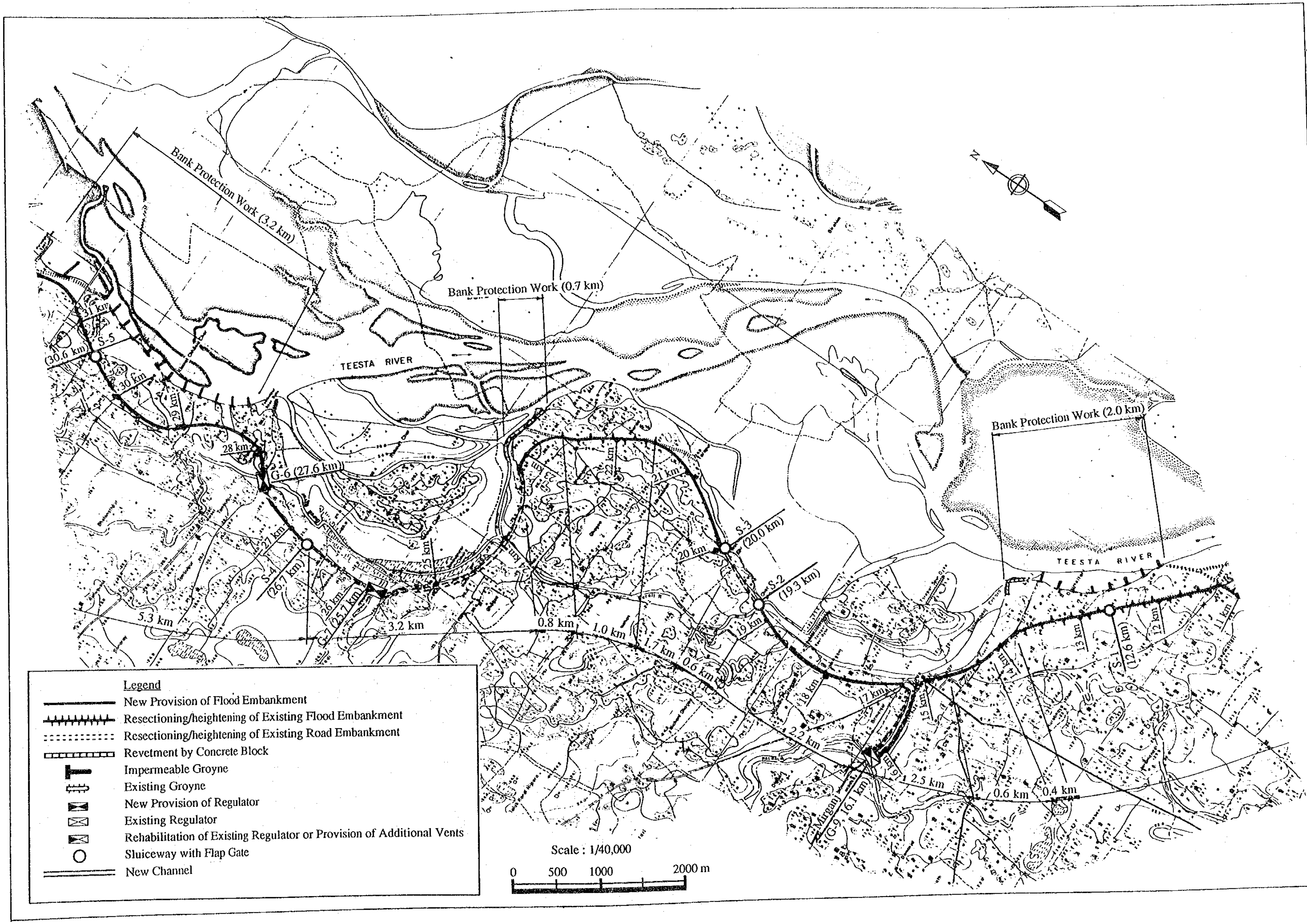


Figure 5.2 PROPOSED ALIGNMENT OF FLOOD EMBANKMENT AND LOCATIONS OF THE FCD STRUCTURES ALONG THE TEESTA (3/3)

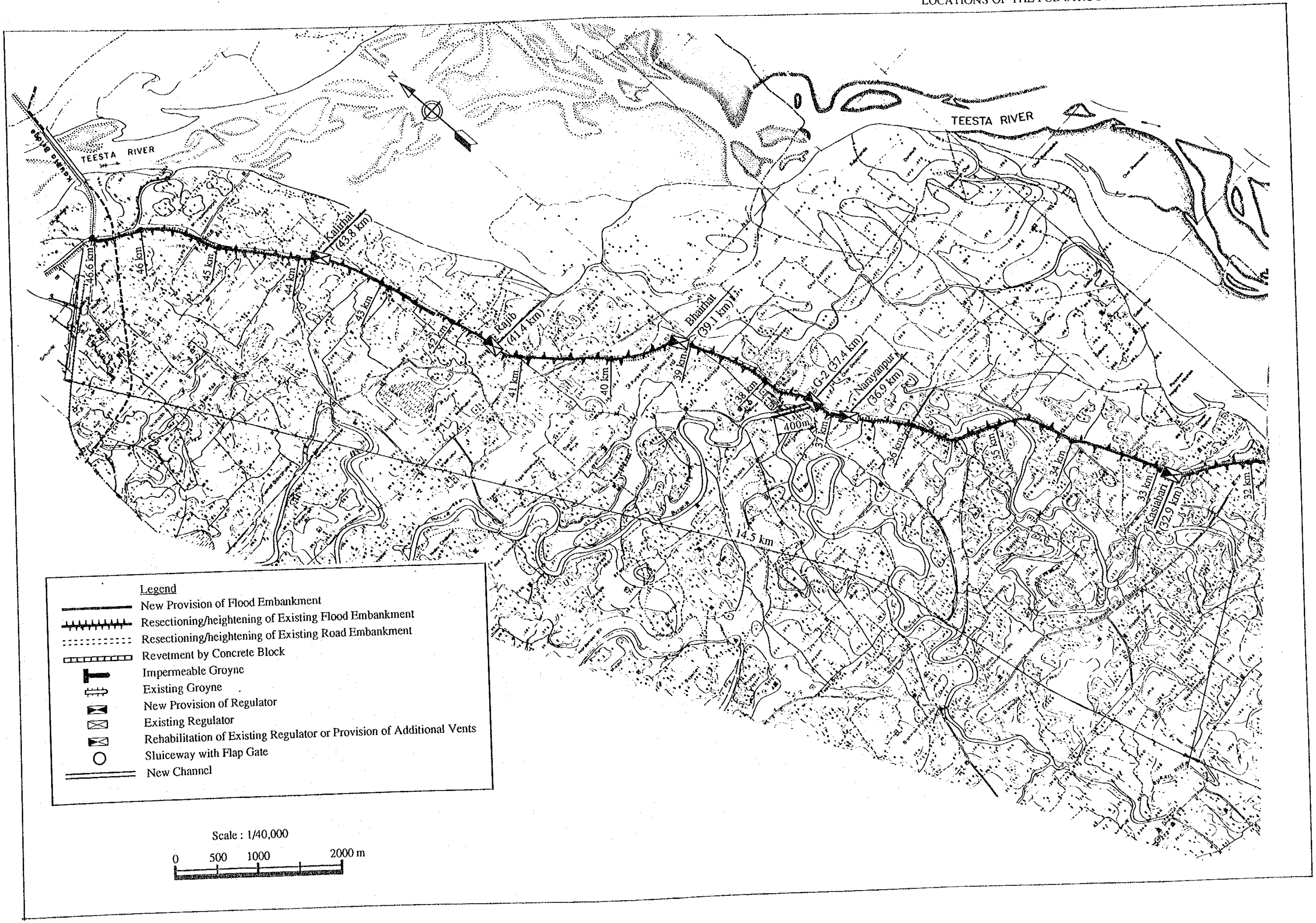


Figure 5.3 PROPOSED ALIGNMENT OF FLOOD EMBANKMENT AND LOCATIONS OF THE FCD STRUCTURES ALONG THE GHAGOT (1/4)

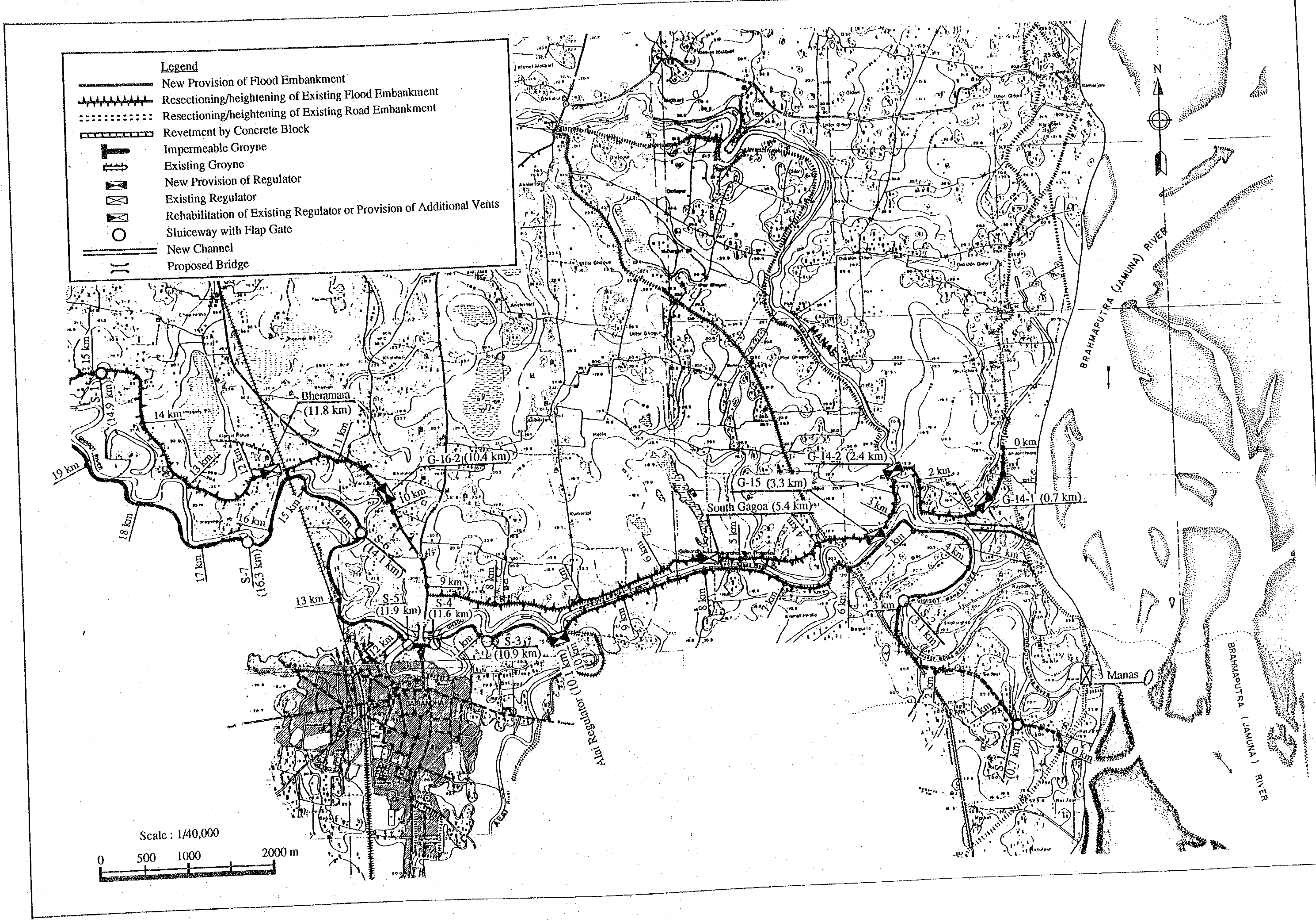


Figure 5.3 PROPOSED ALIGNMENT OF FLOOD EMBANKMENT AND LOCATIONS OF THE FCD STRUCTURES ALONG THE GHAGOT (2/4)

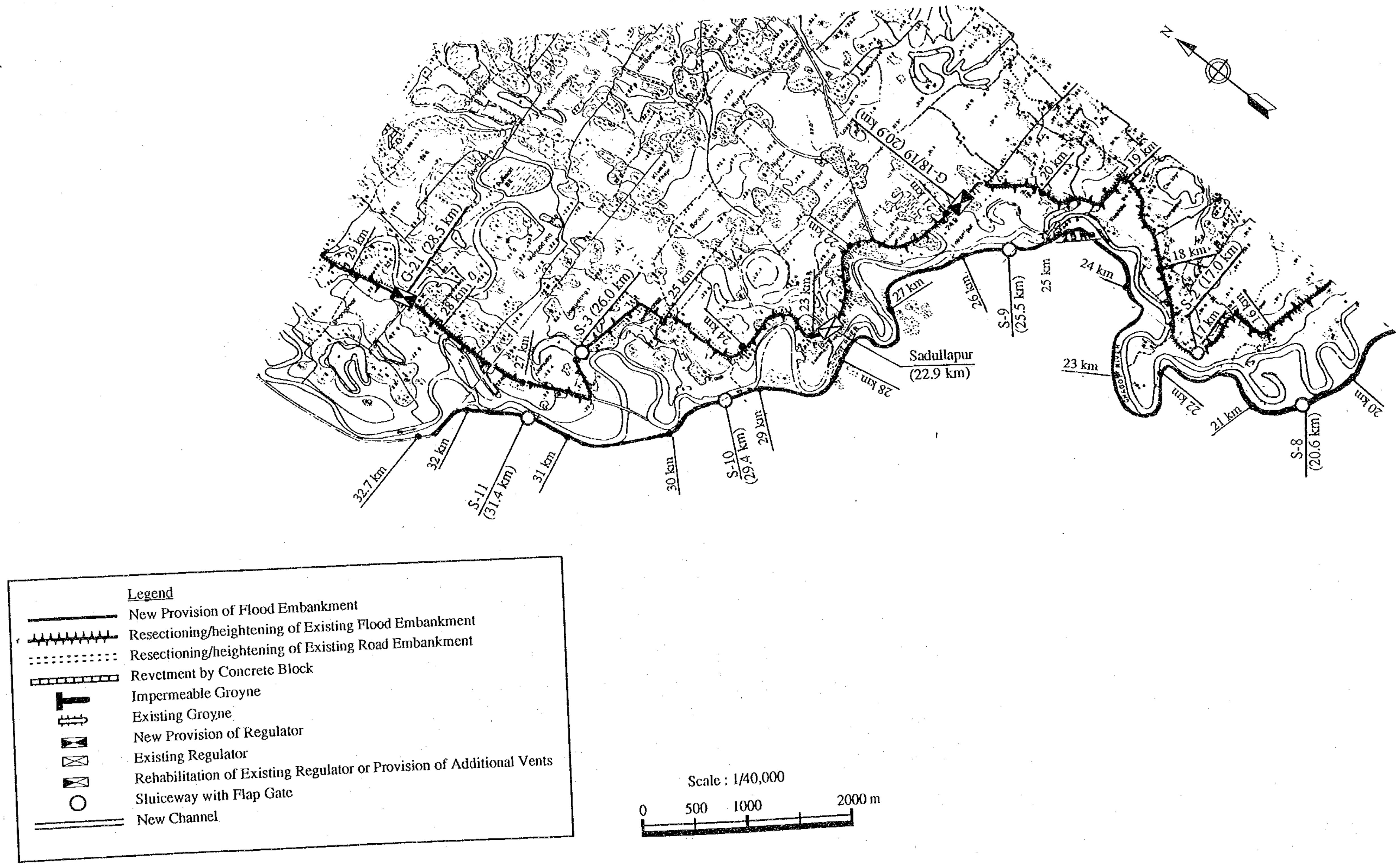


Figure 5.3 PROPOSED ALIGNMENT OF FLOOD EMBANKMENT AND LOCATIONS OF THE FCD STRUCTURES ALONG THE GHAGOT (3/4)

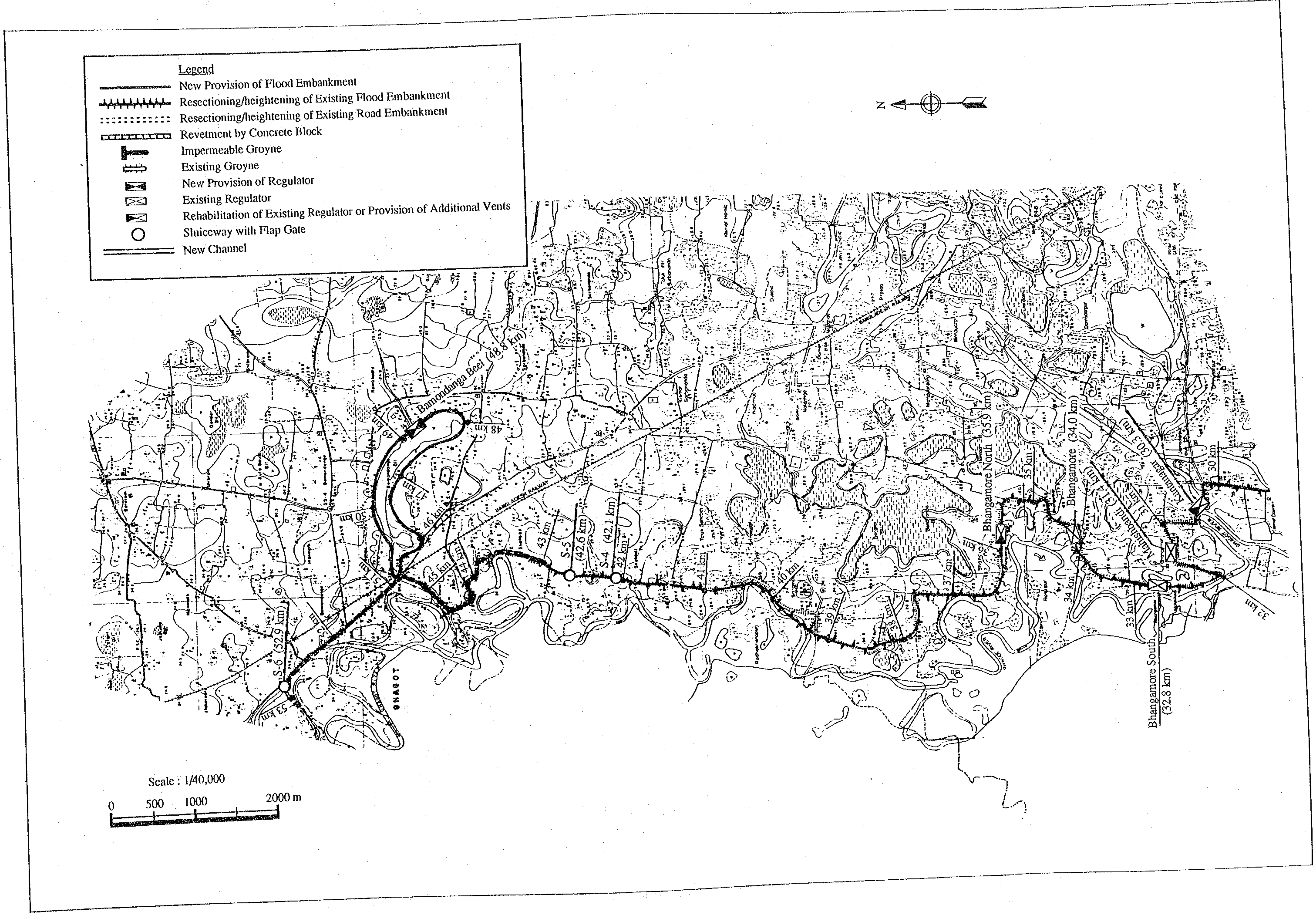


Figure 5.3 PROPOSED ALIGNMENT OF FLOOD EMBANKMENT AND LOCATIONS OF THE FCD STRUCTURES ALONG THE GHAGOT (4/4)

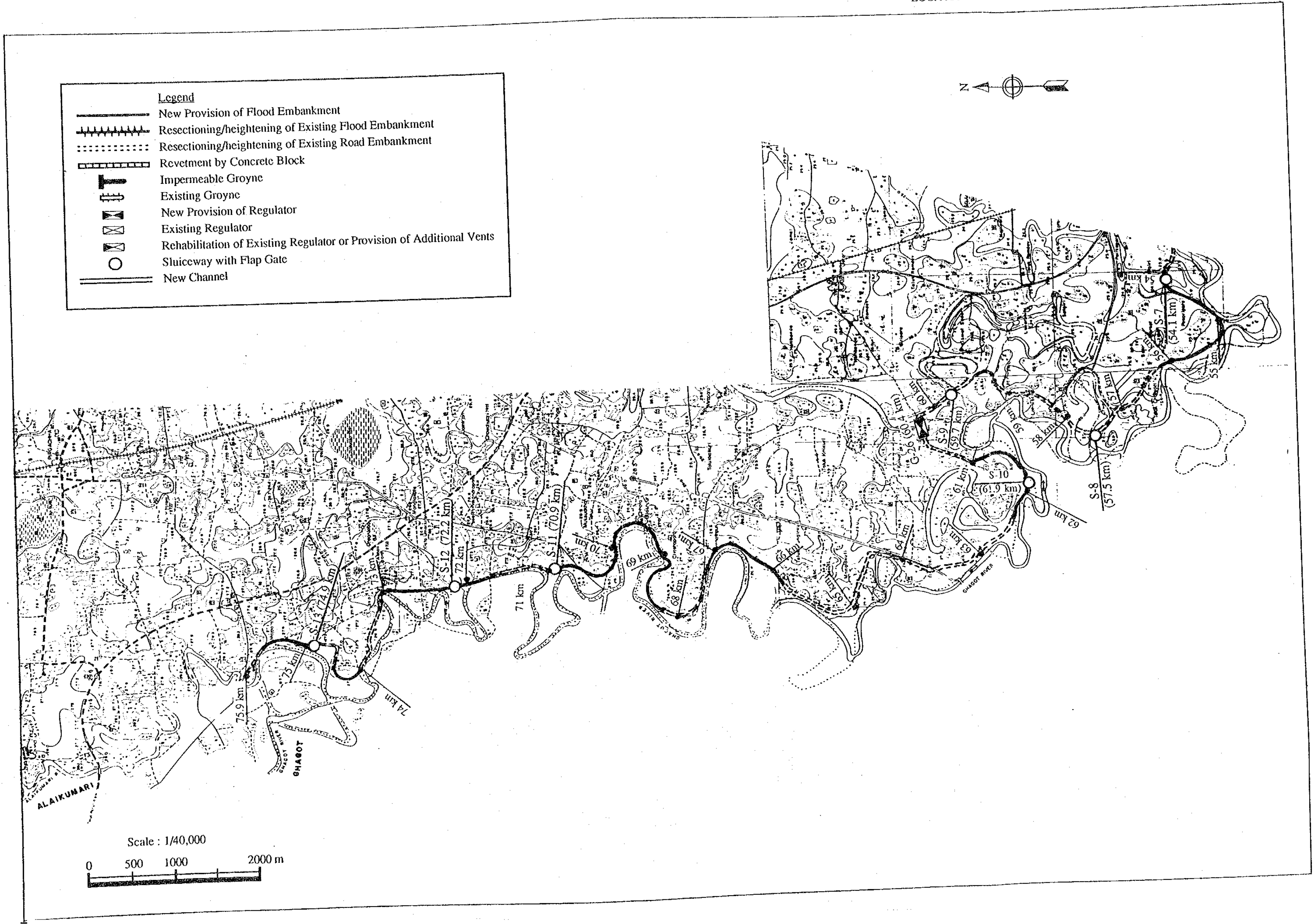
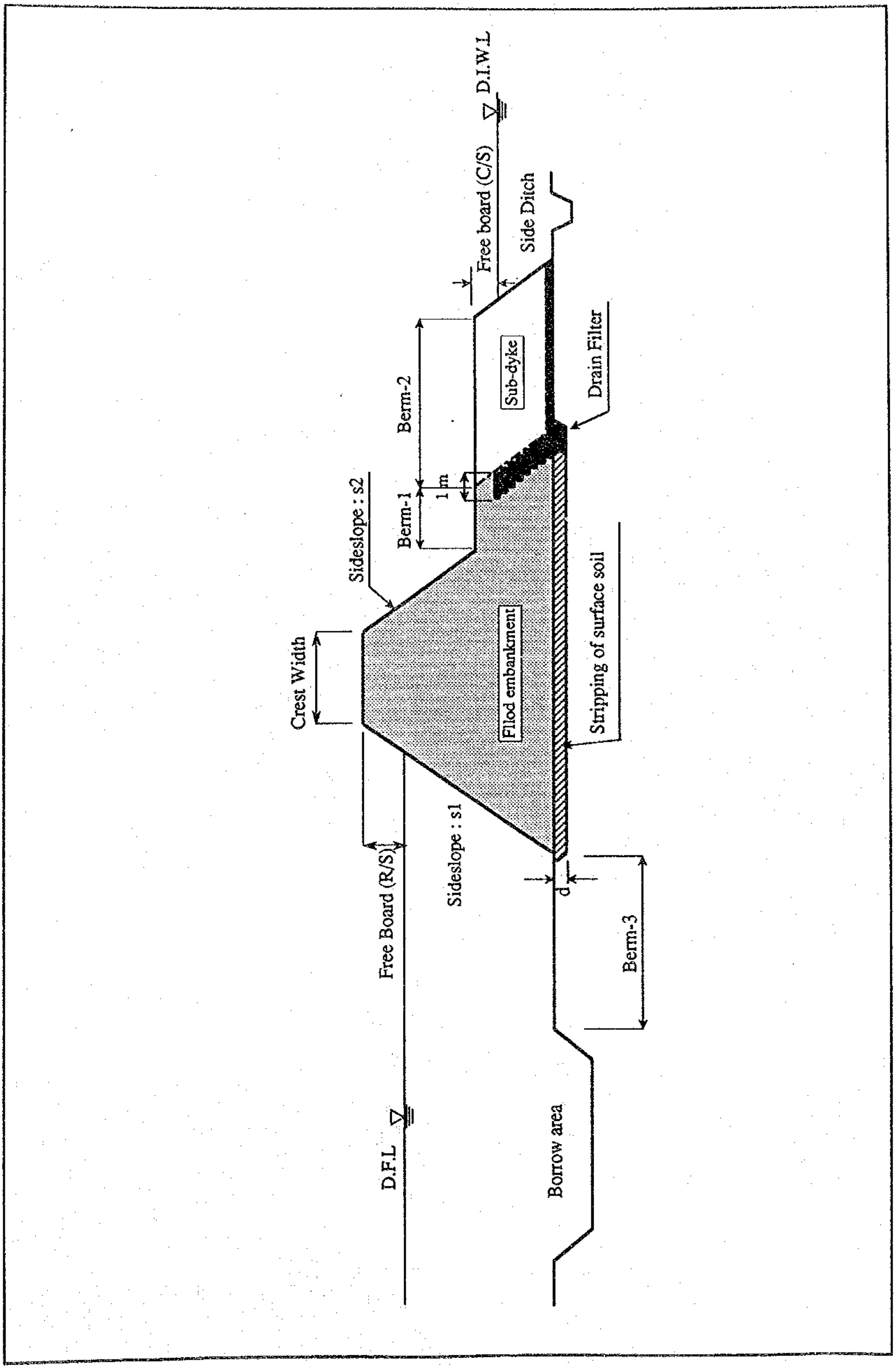
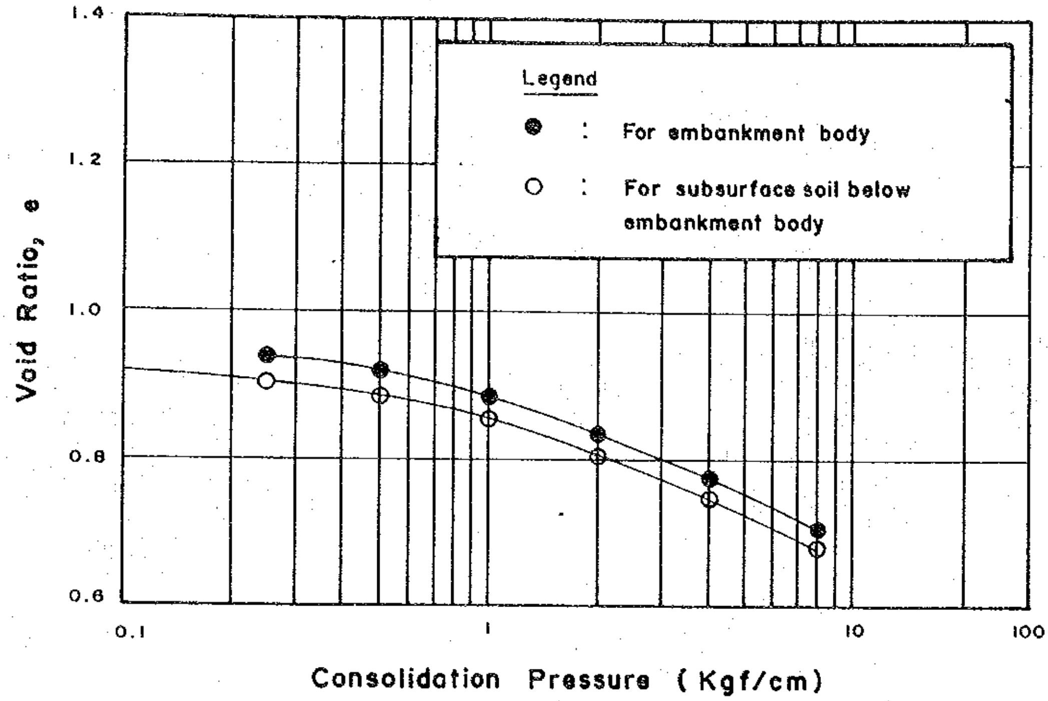
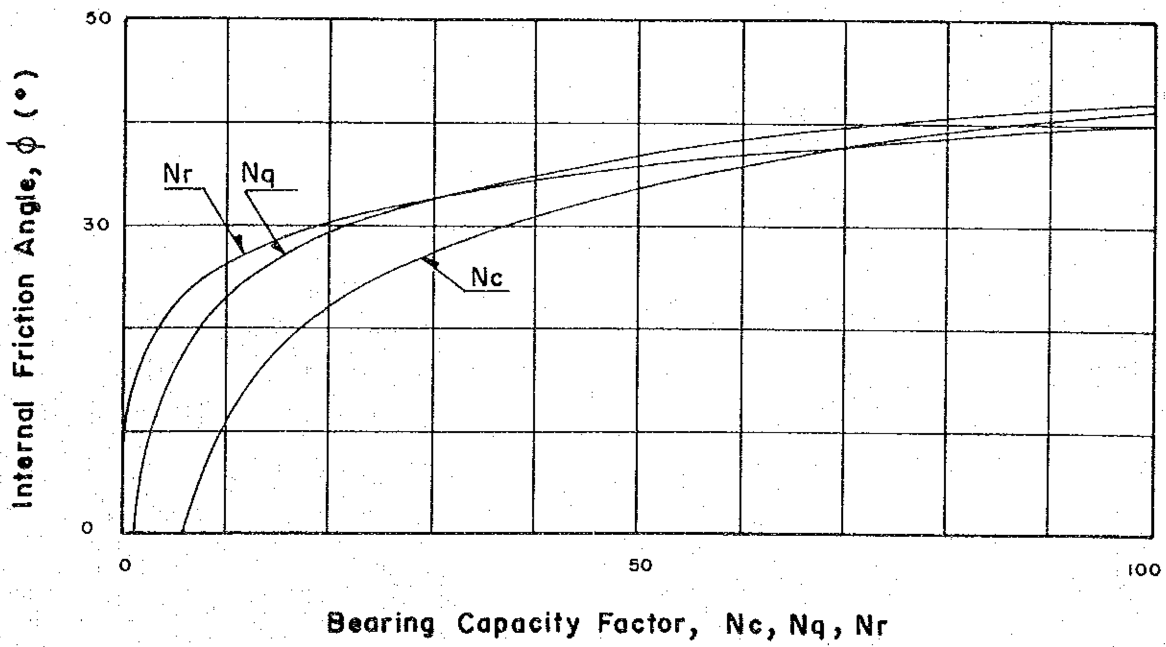


Figure 5.4 GUIDELINE OF FLOOD EMBANKMENT DESIGN





1.4
1.2
1.0
0.8
0.6
Void Ratio, e
Legend
For embankment body
For subsurface soil below embankment body
0.1
1
10
100
Consolidation Pressure (Kgf/cm)



50
30
0
Internal Friction Angle, ϕ (°)
Nr
Nq
Nc
0
50
100
Bearing Capacity Factor, Nc, Nq, Nr

Figure 5.6 TYPICAL SECTIONS OF EMBANKMENT APPLIED FOR ANALYSIS

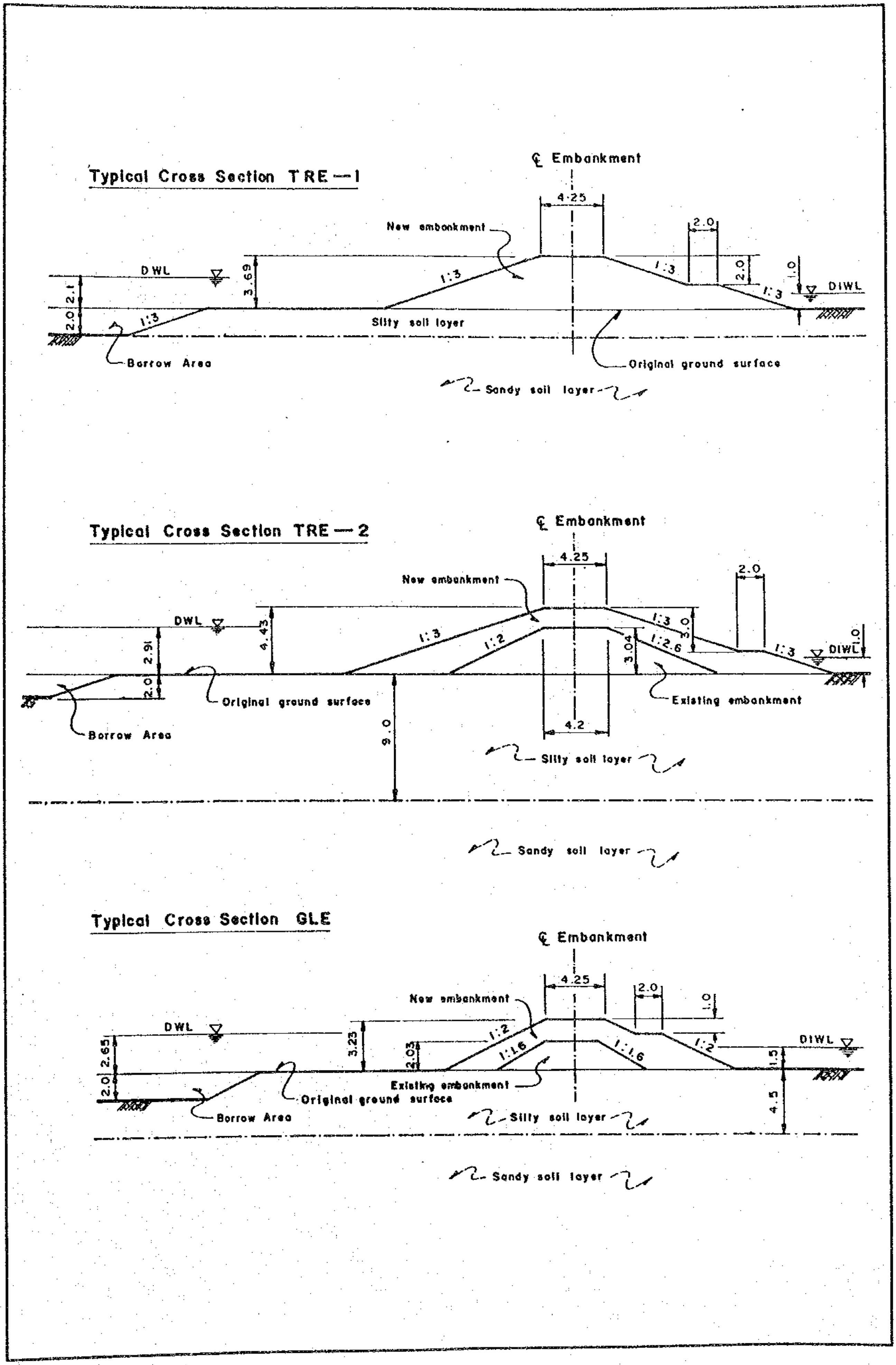
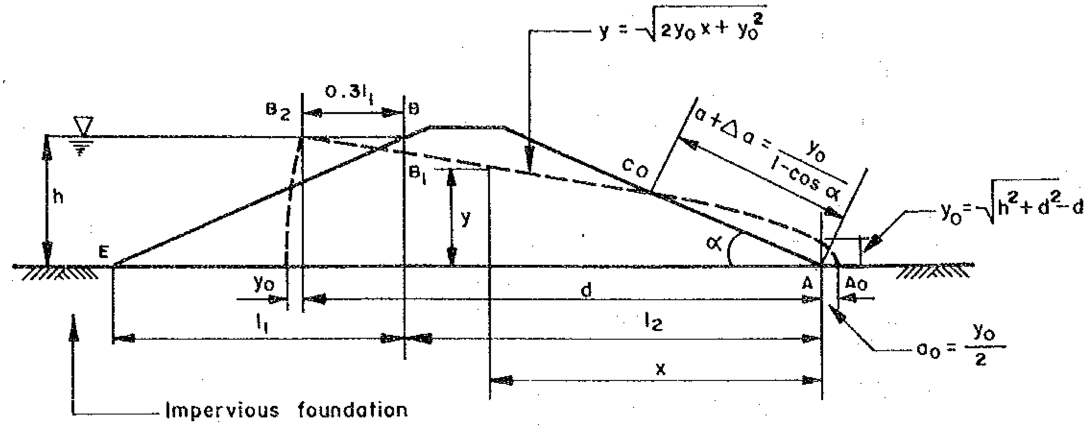
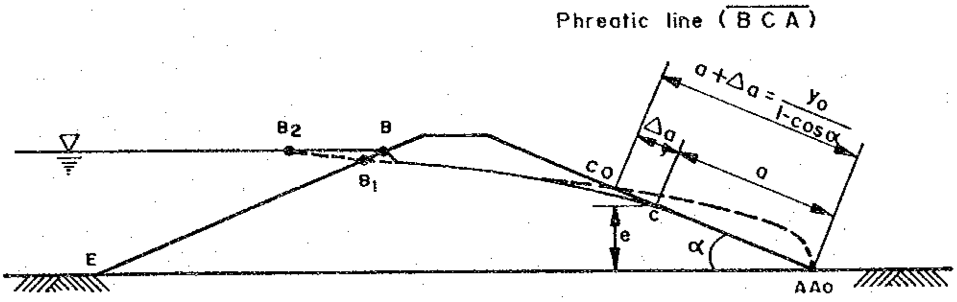


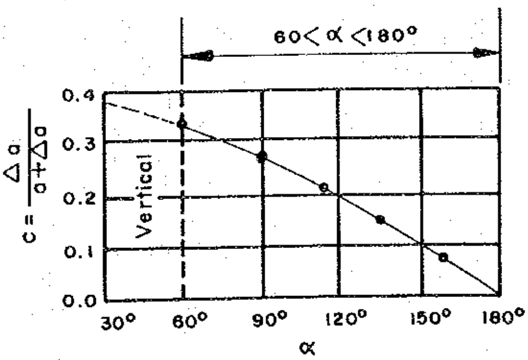
Figure 5.7 CASAGRANDE'S METHOD



(a) BASIC PARABOLA



(b) PHREATIC LINE (Modified parabola)



i) $\alpha \geq 30°$:

$$c = \frac{a}{a+\Delta a}$$

(Obtained from the left figure)

$$a+\Delta a = \frac{y_0}{1-\cos\alpha}$$

ii) $\alpha < 30°$

$$a = \frac{\alpha}{\cos\alpha} - \sqrt{\left(\frac{d}{\cos\alpha}\right)^2 - \left(\frac{h}{\sin\alpha}\right)^2}$$

Figure 5.8 SEEPAGE LINE ANALYZED

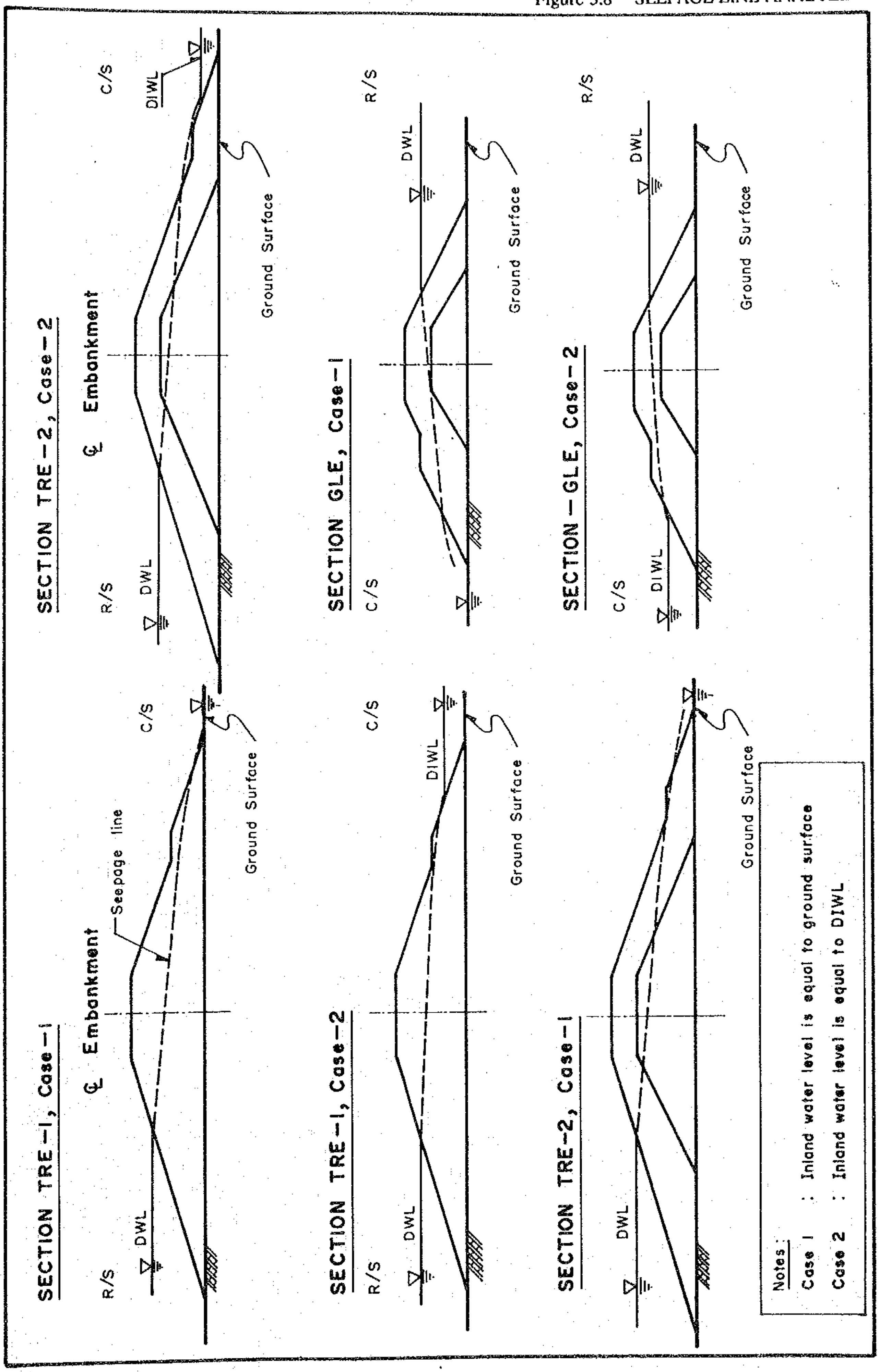
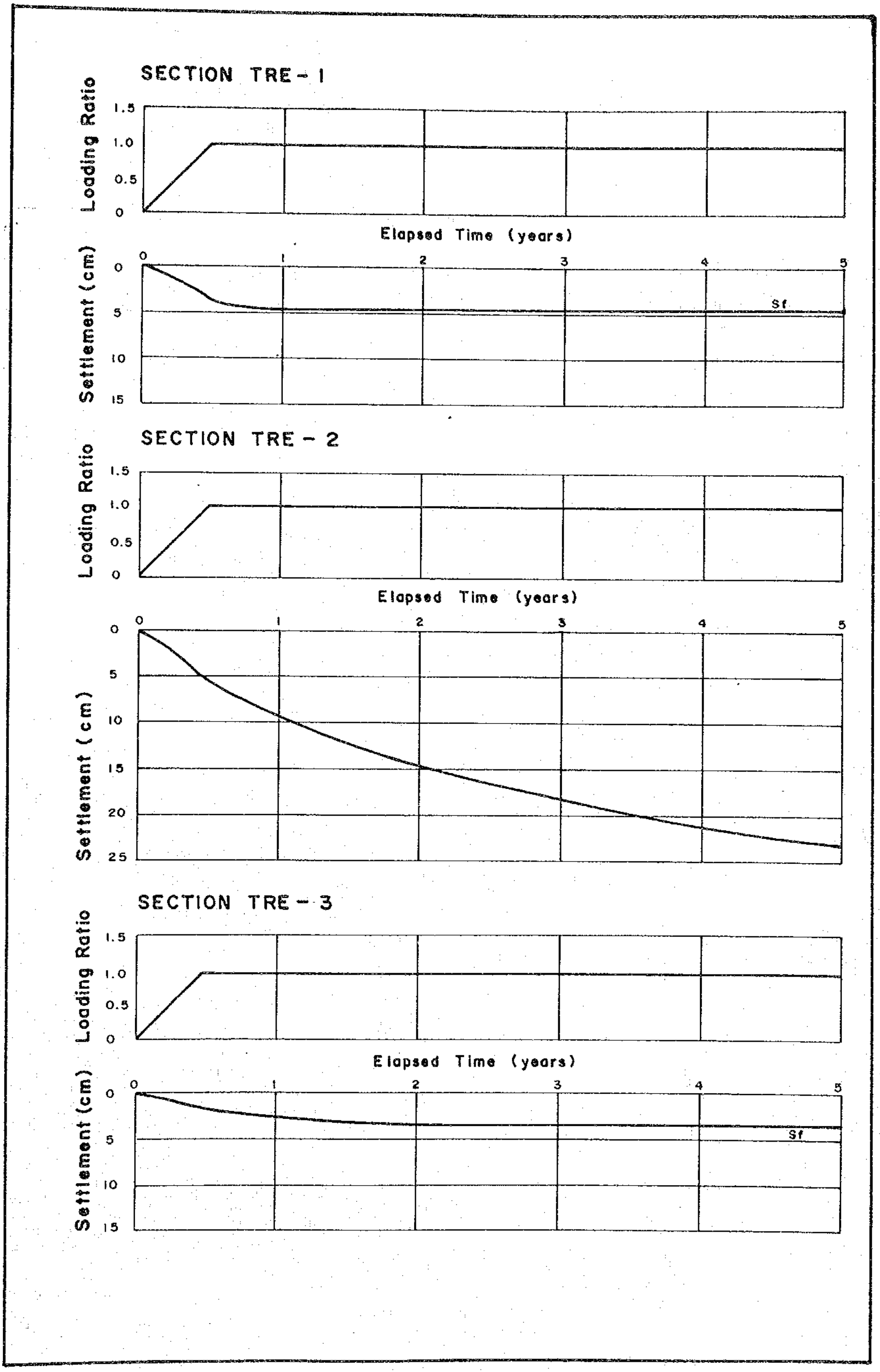


Figure 5.9 SETTLING VELOCITY OF PLANNED EMBANKMENT



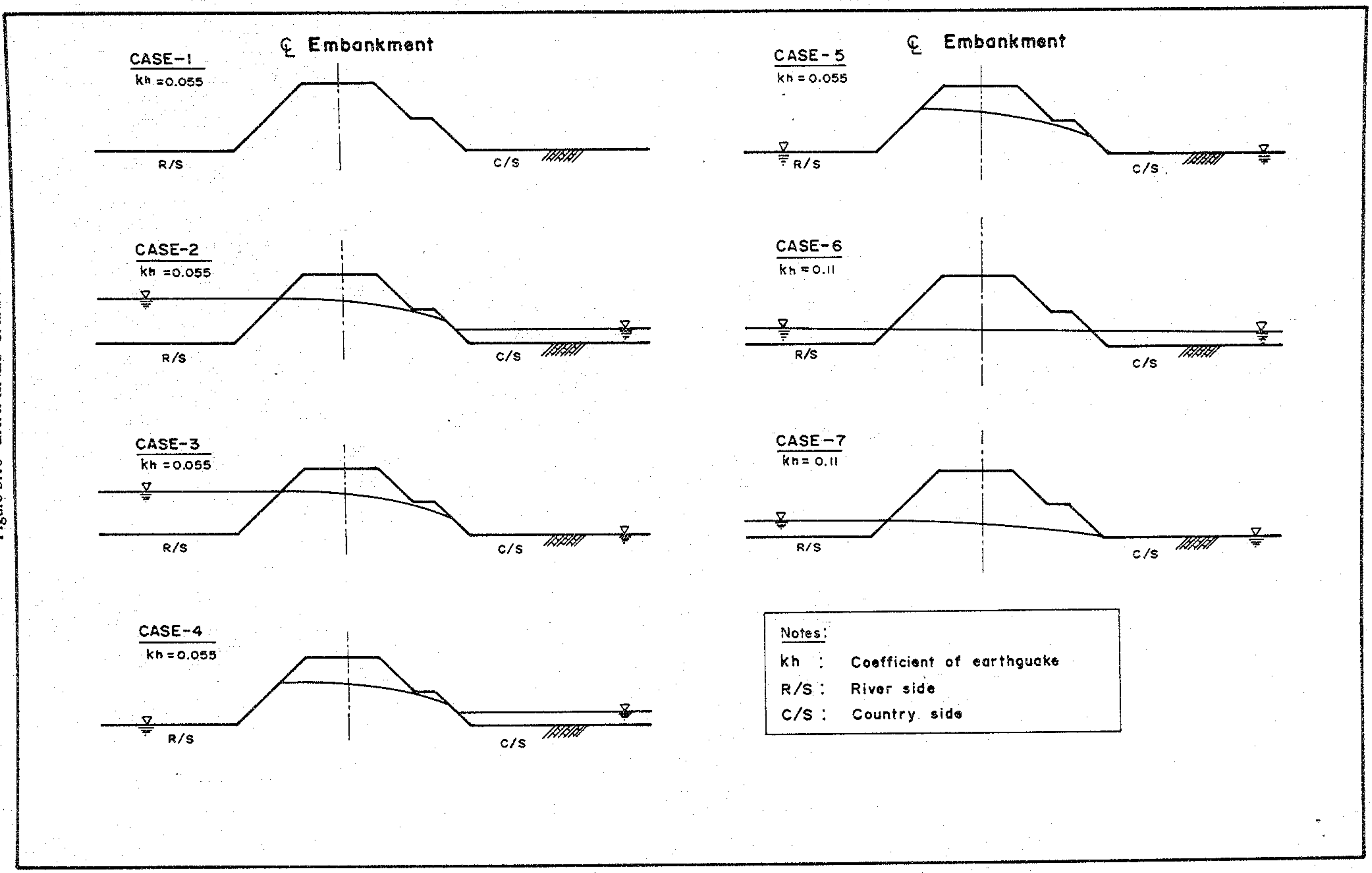


Figure 5.10 EXAMINED CASE FOR SLOPE STABILITY ANALYSIS

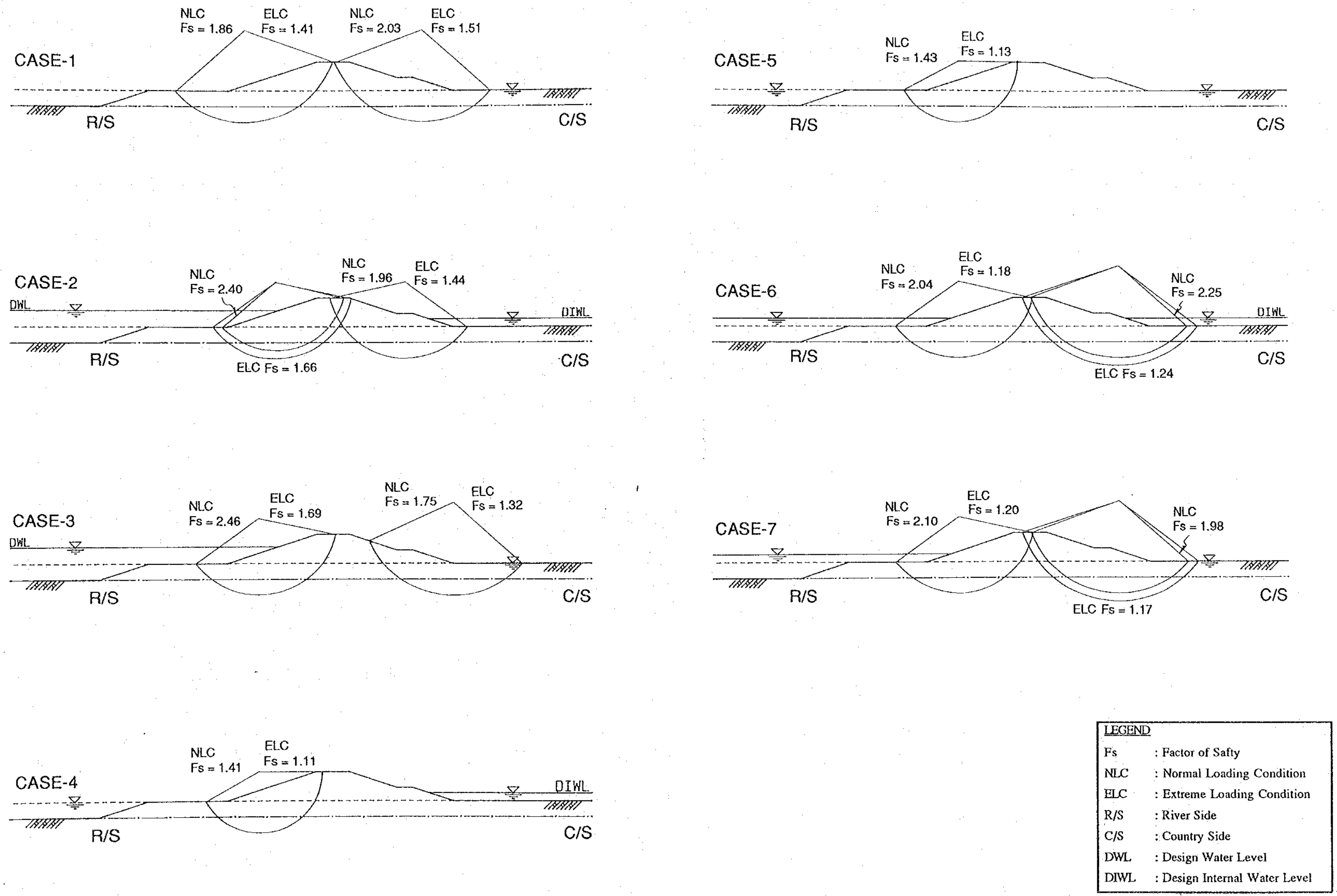


Figure 5.11 RESULT OF SLOPE STABILITY ANALYSIS ON TYPICAL CROSS SECTION TRE-1

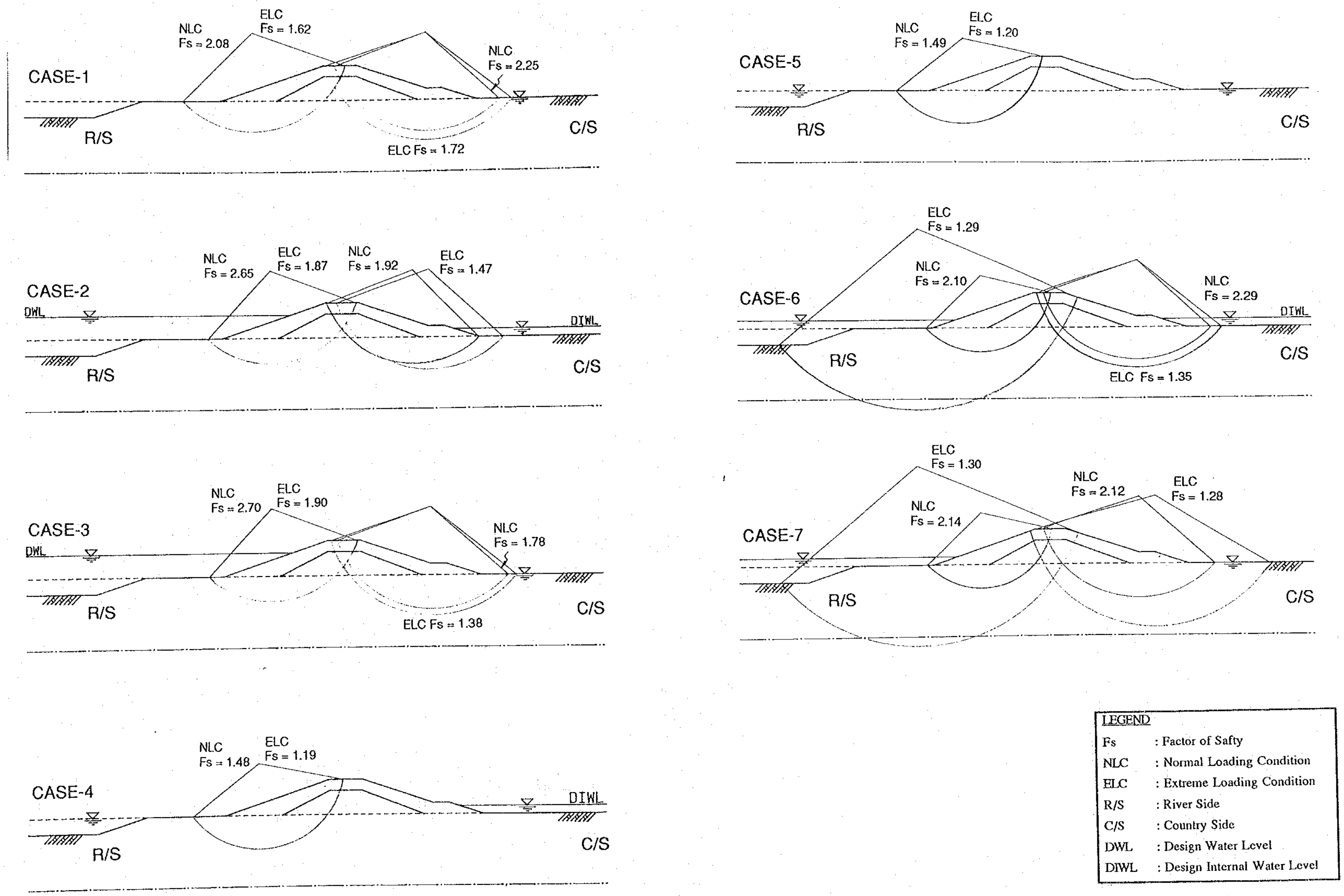
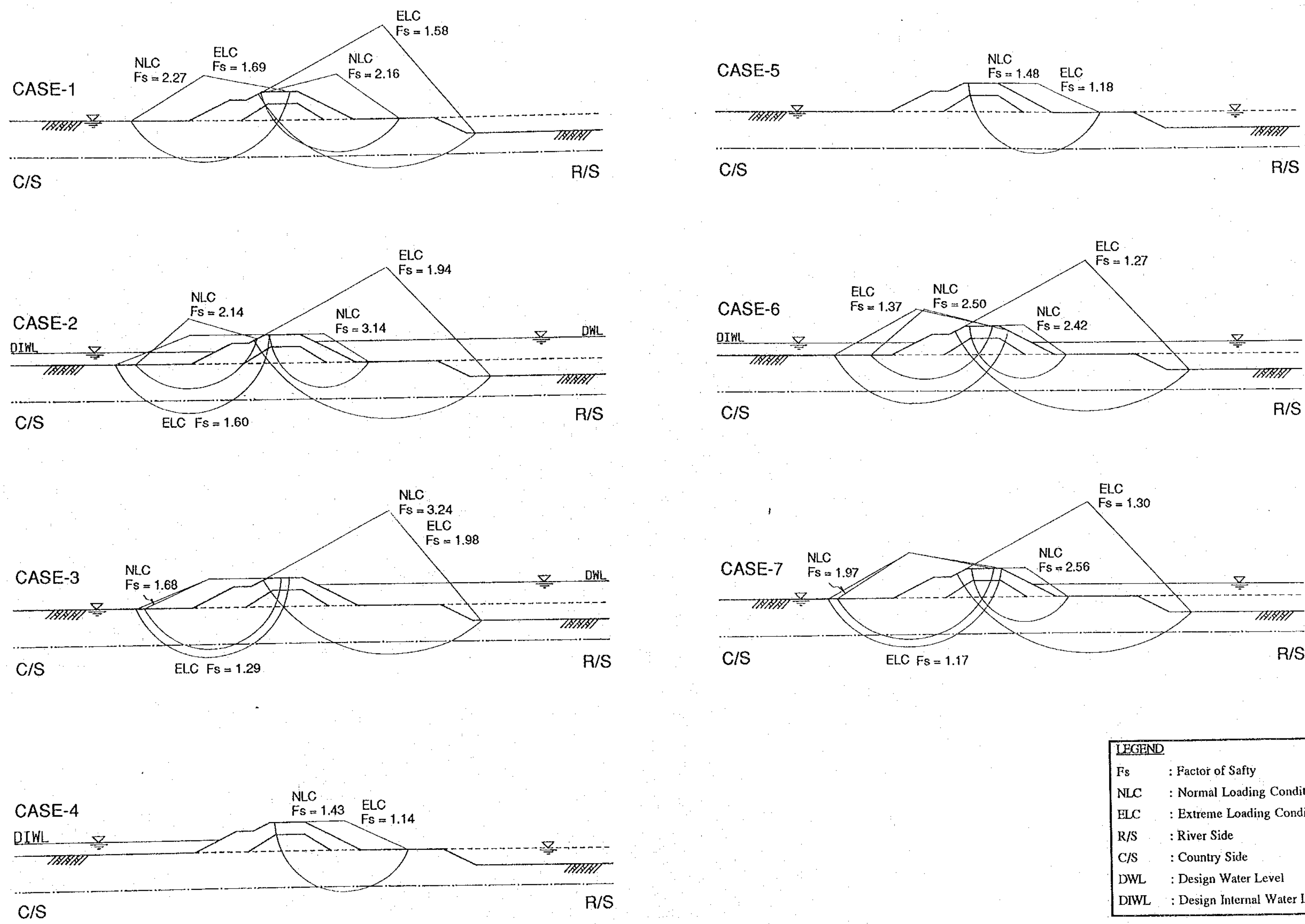


Figure 5.12 RESULT OF SLOPE STABILITY ANALYSIS ON TYPICAL CROSS SECTION TRE-2



LEGEND

Fs	: Factor of Safty
NLC	: Normal Loading Condition
ELC	: Extreme Loading Condition
R/S	: River Side
C/S	: Country Side
DWL	: Design Water Level
DIWL	: Design Internal Water Level

Figure 5.13 RESULT OF SLOPE STABILITY ANALYSIS ON TYPICAL CROSS SECTION GLE

Figure 5.14 LONGITUDINAL PROFILE OF PROPOSED TEESTA RIGHT EMBANKMENT

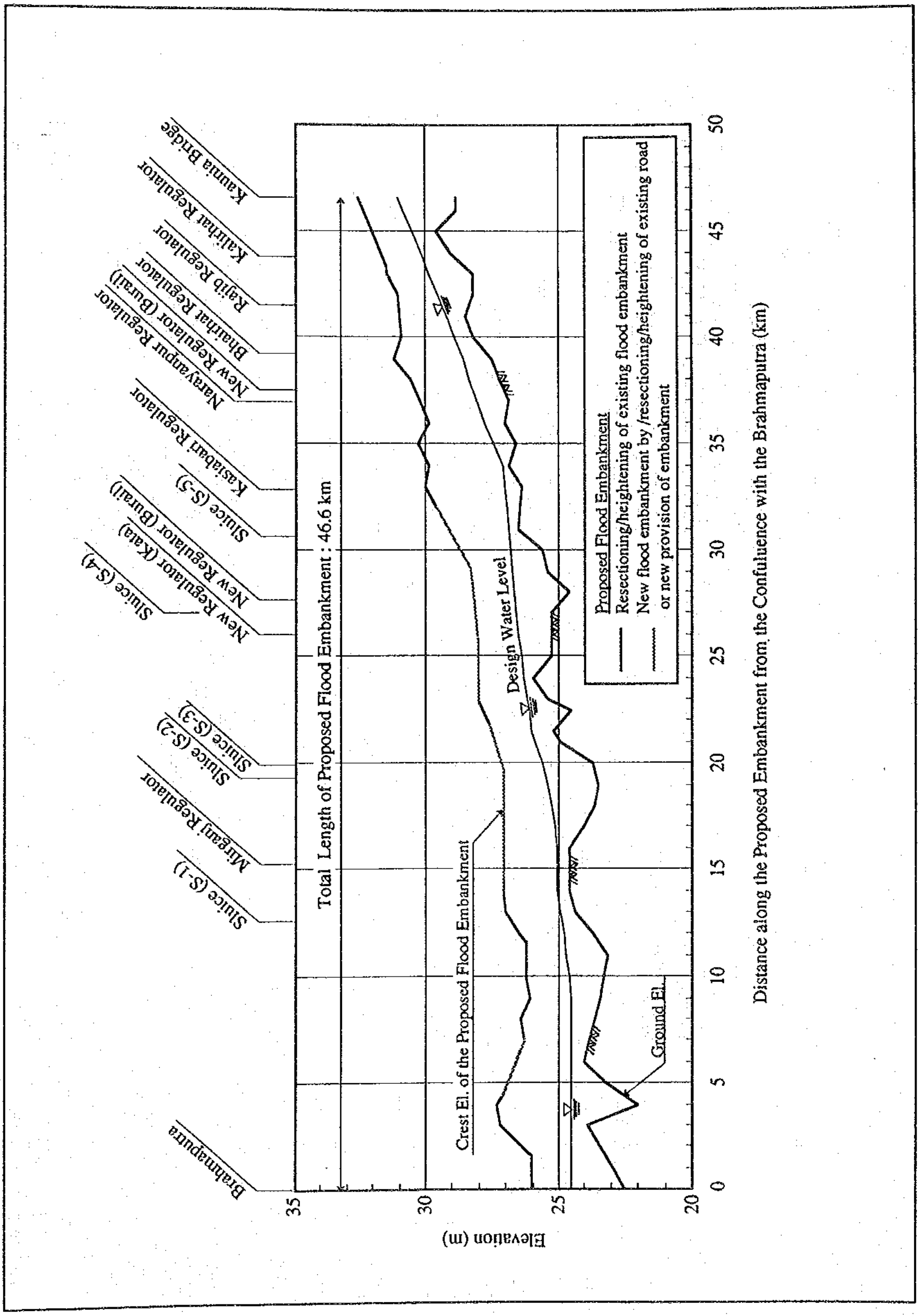


Figure 5.15 LONGITUDINAL PROFILE OF PROPOSED GHAGOT LEFT EMBANKMENT

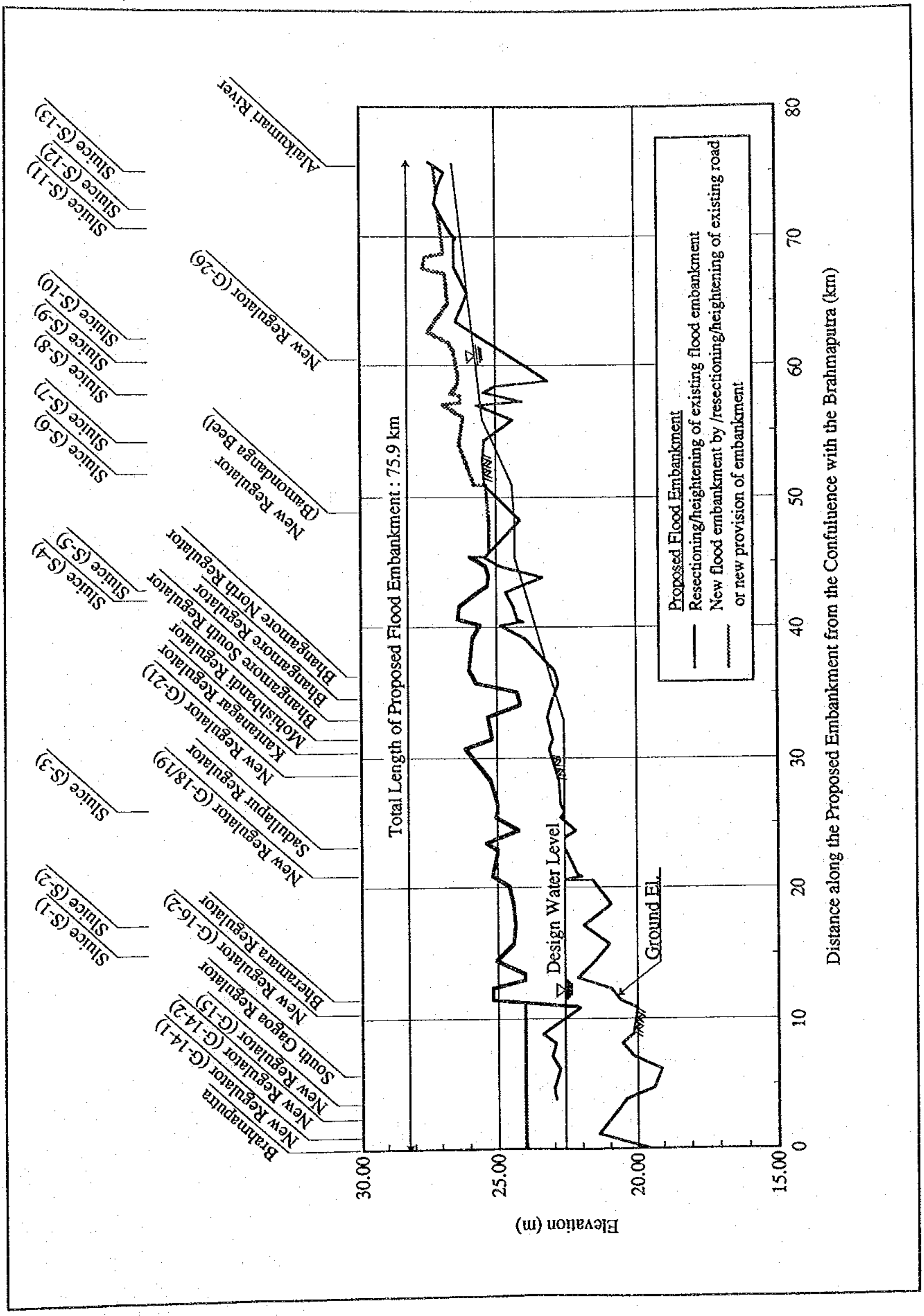
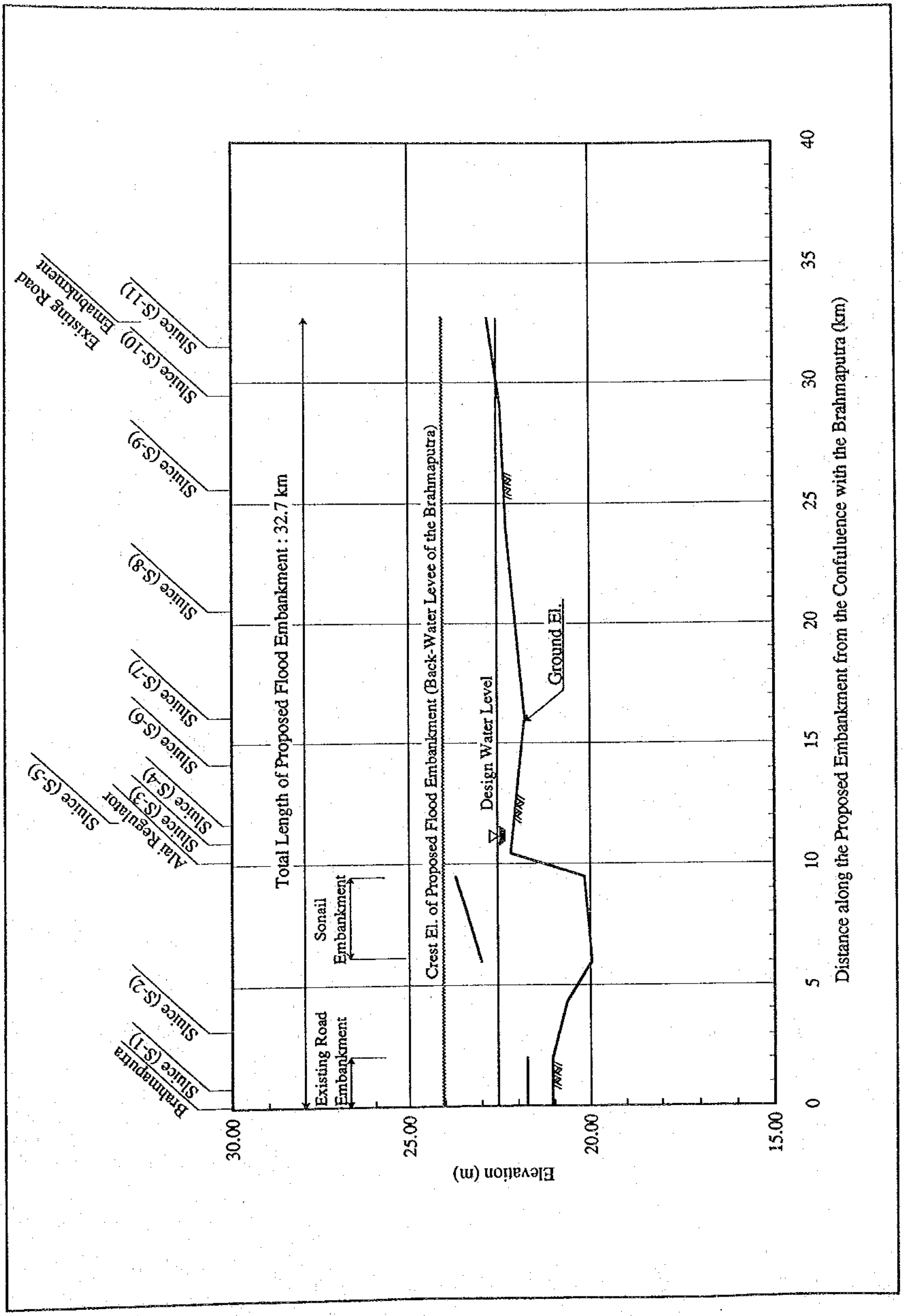


Figure 5.16 LONGITUDINAL PROFILE OF PROPOSED GHAGOT RIGHT EMBANKMENT



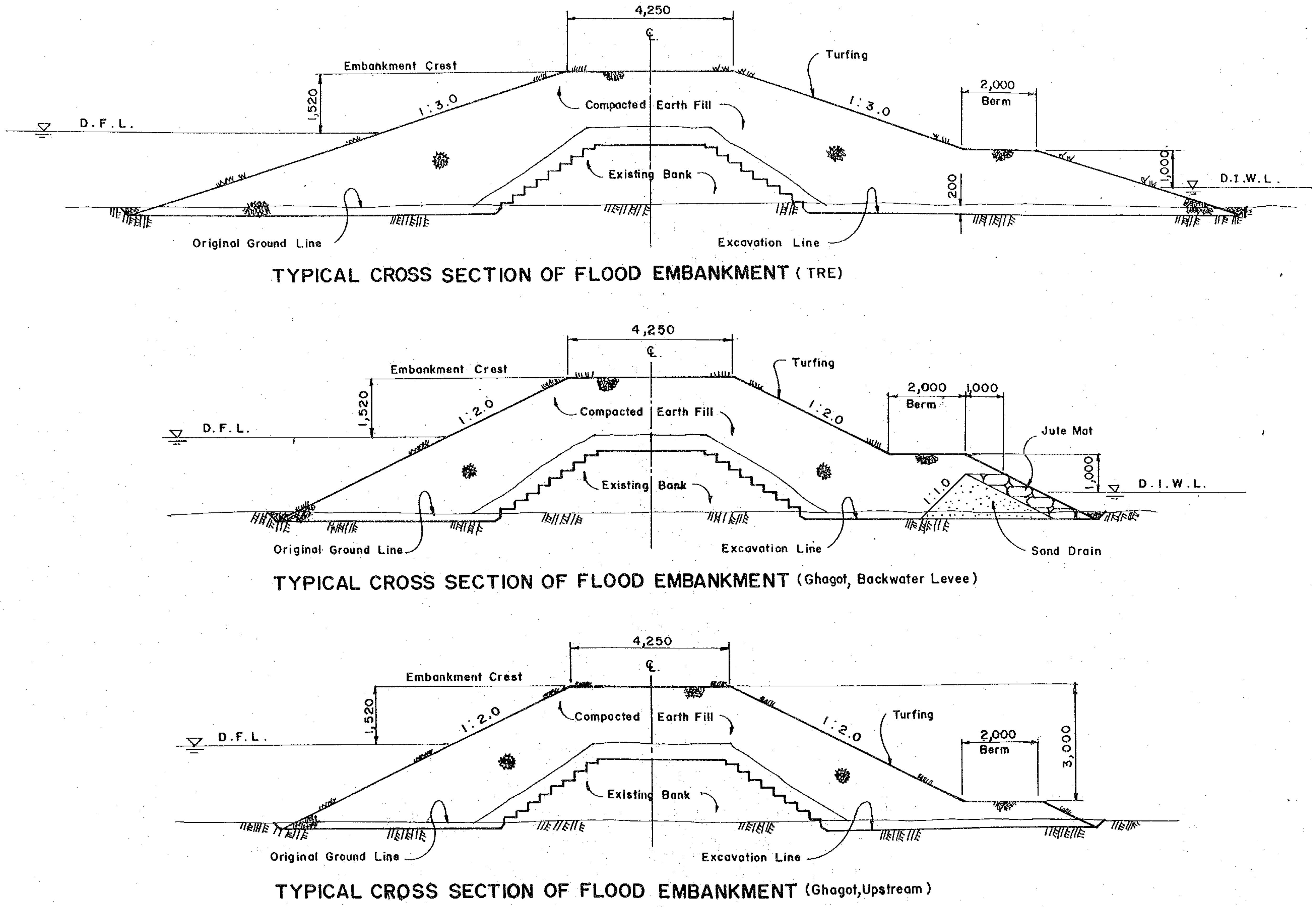
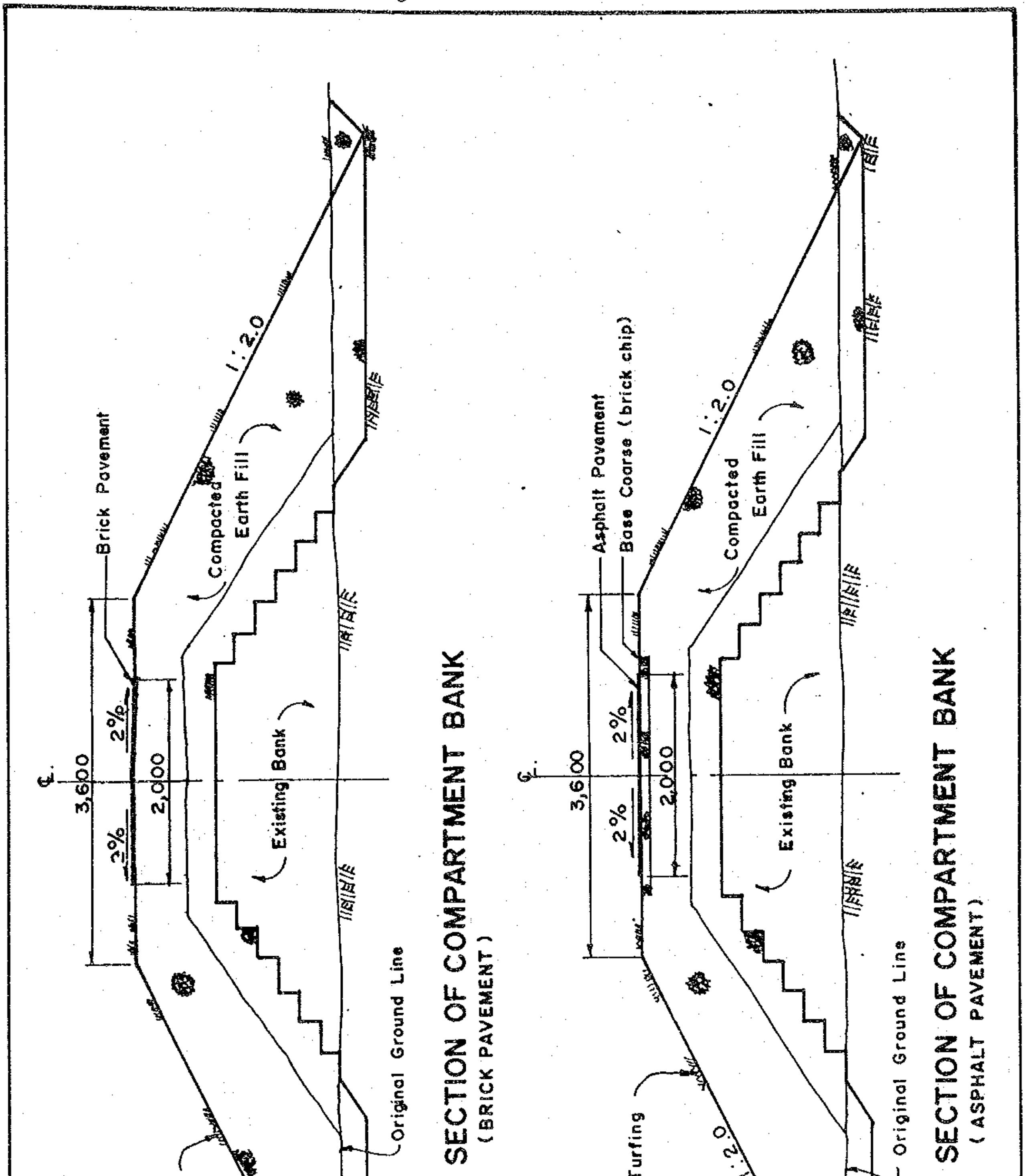


Figure 5.17 TYPICAL CROSS SECTIONS OF FLOOD EMBANKMENT

Figure 5.18 TYPICAL CROSS SECTION OF COMPARTMENT BANK



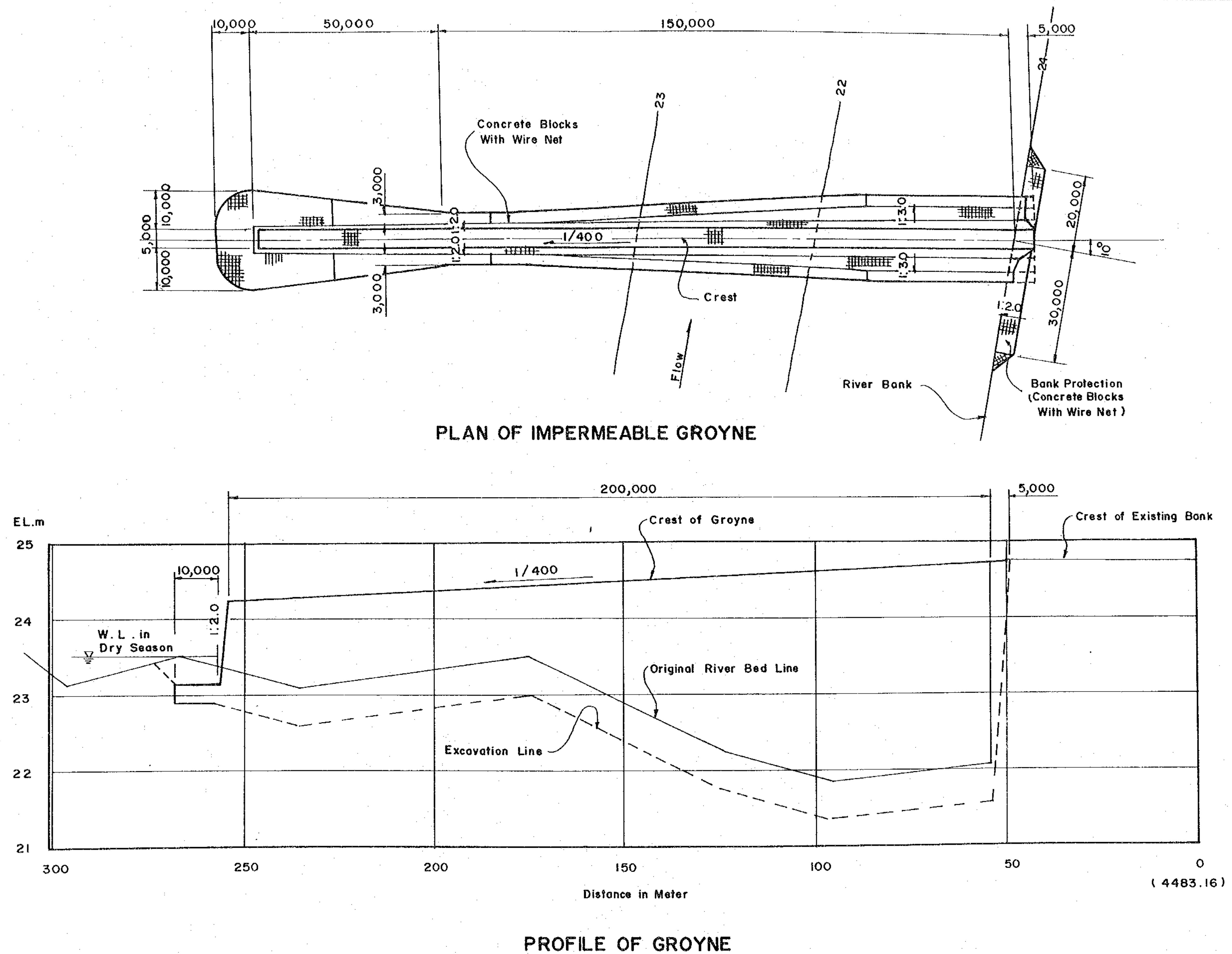
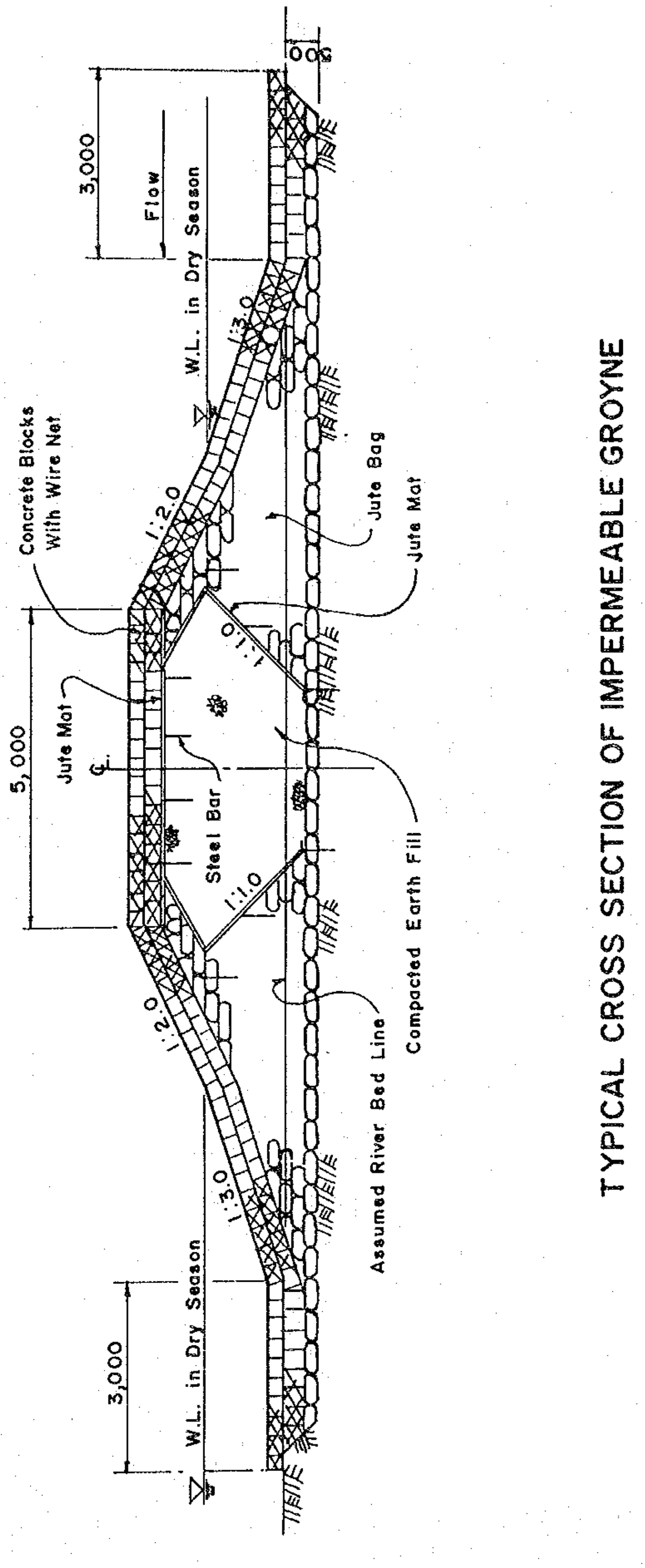


Figure 5.19 PLAN AND PROFILE OF IMPERMEABLE GROYNE

Figure 5.20 TYPICAL CROSS SECTION OF IMPERMEABLE GROYNE



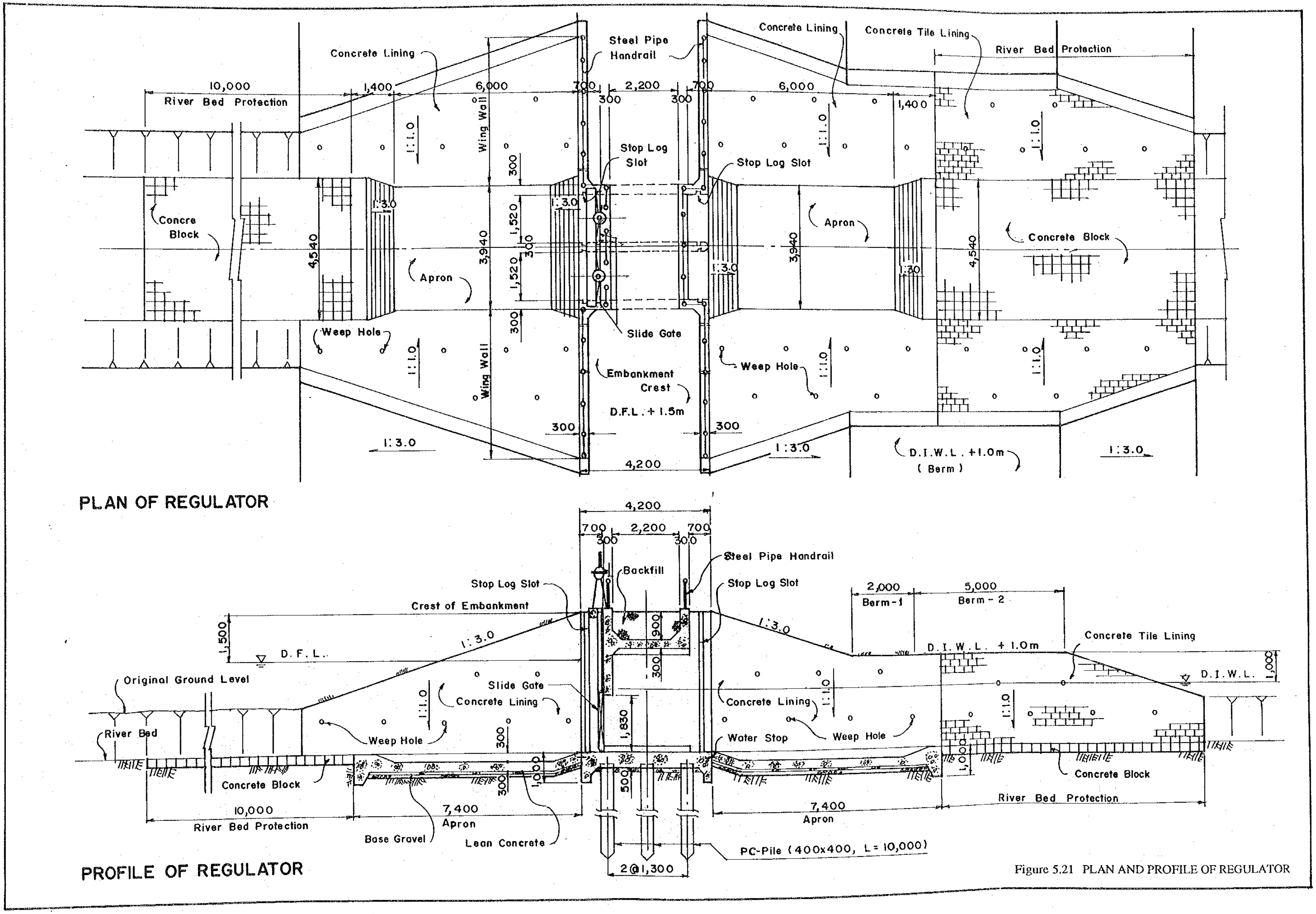
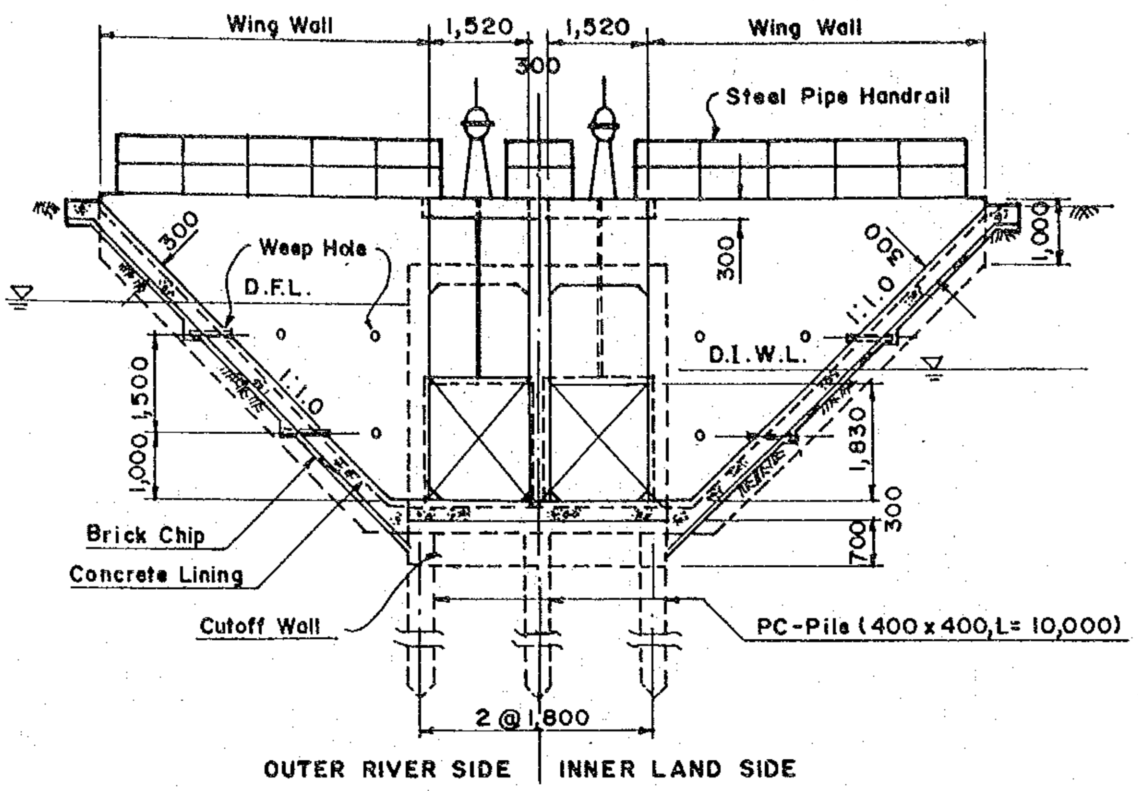
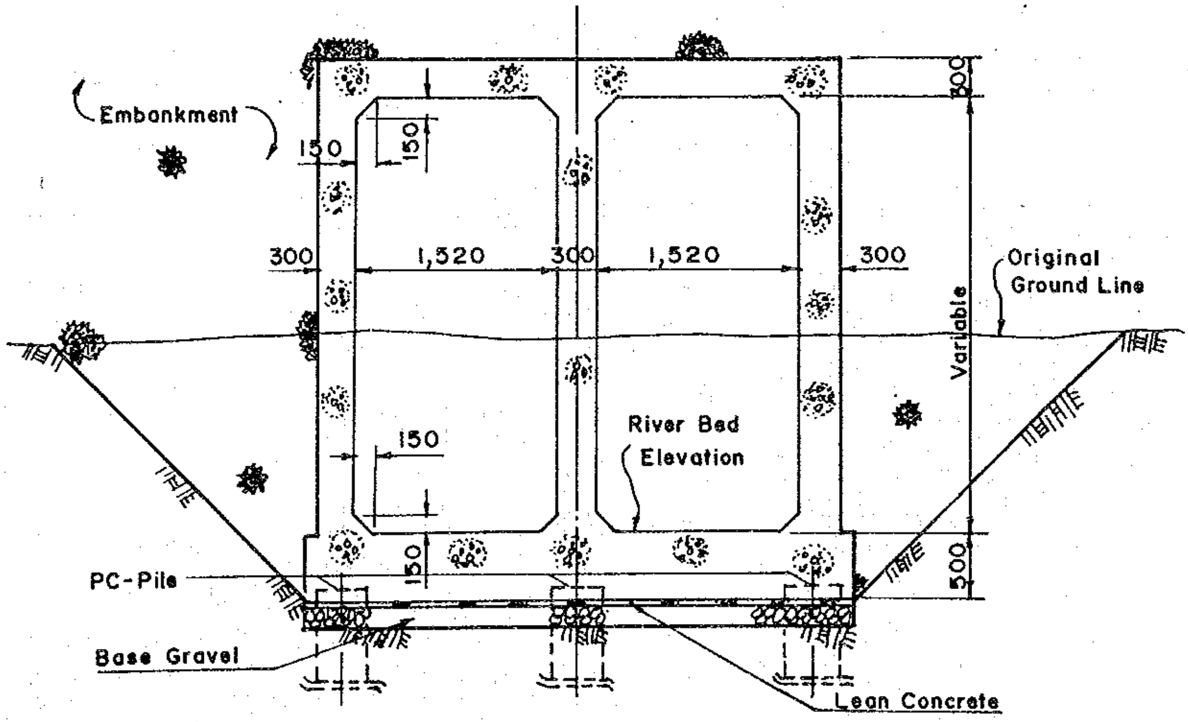


Figure 5.21 PLAN AND PROFILE OF REGULATOR

Figure 5.22 CROSS SECTIONS OF REGULATOR



FRONT SECTION



TYPICAL CROSS SECTION OF REGULATOR

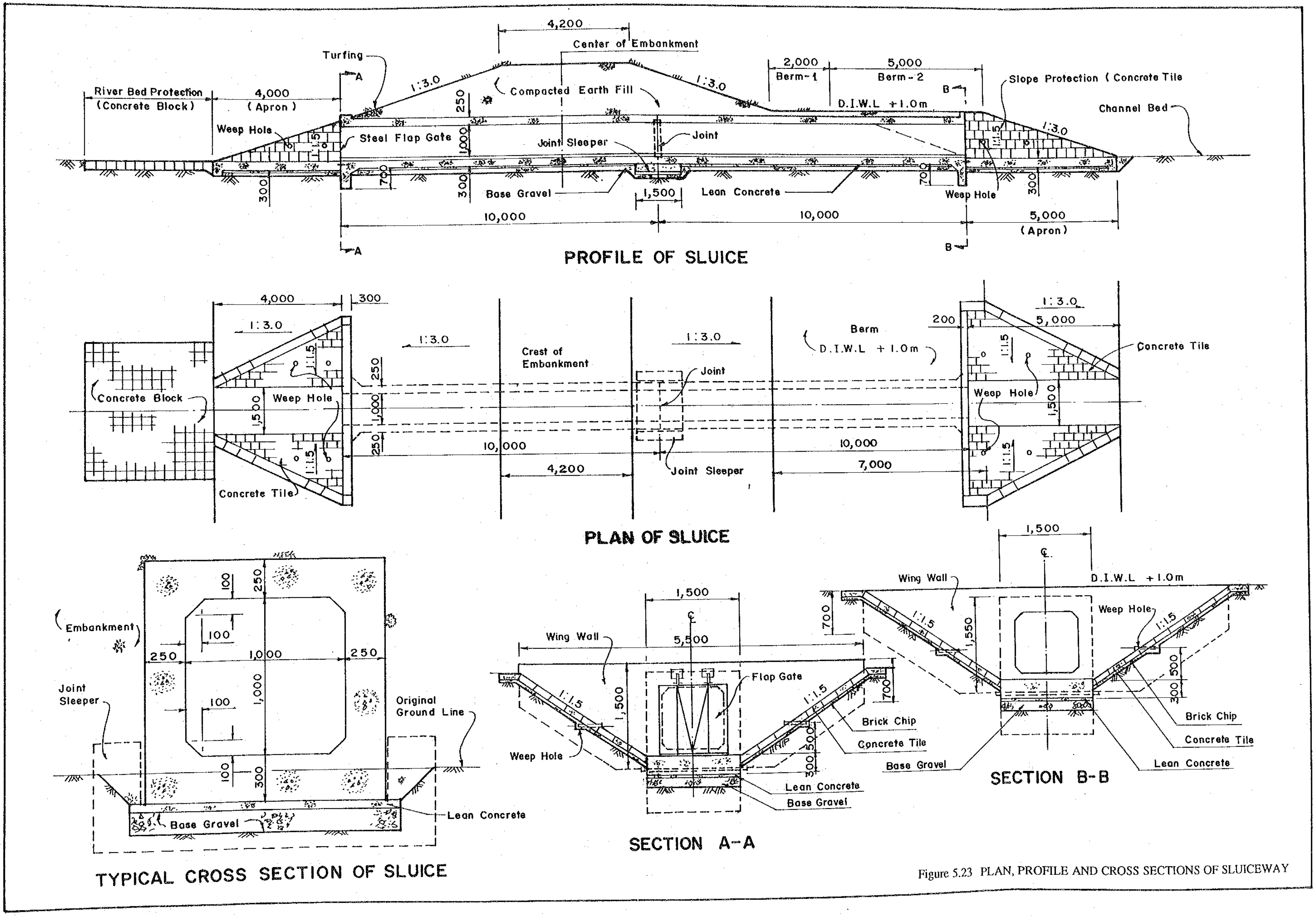
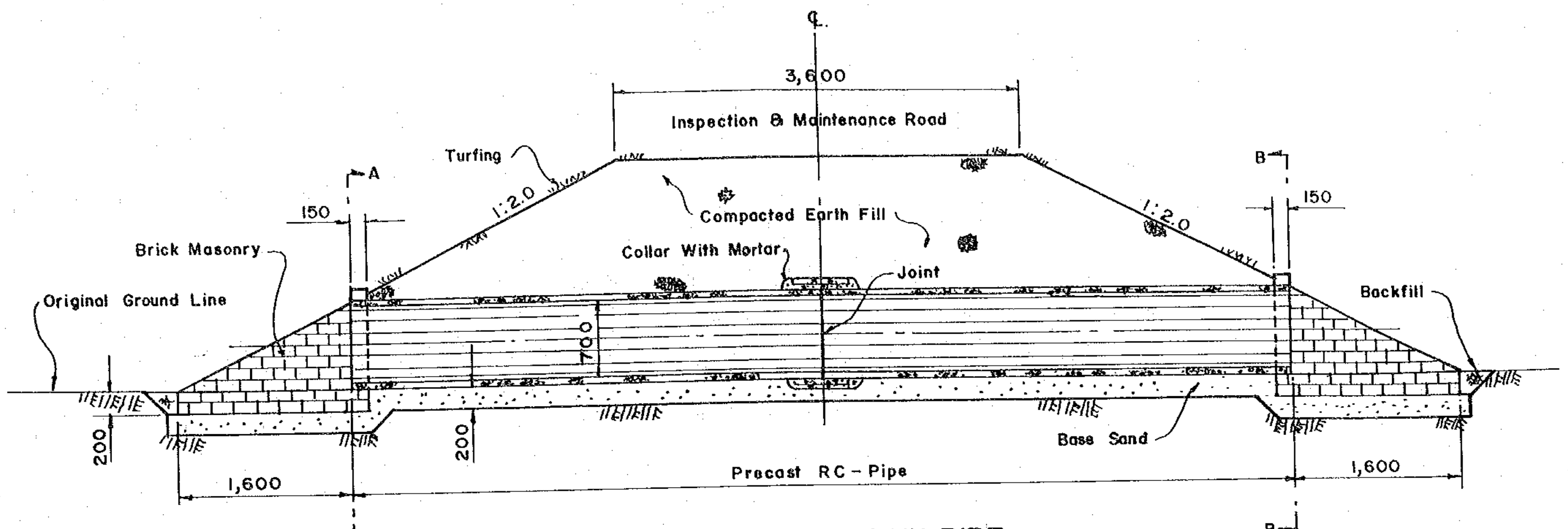
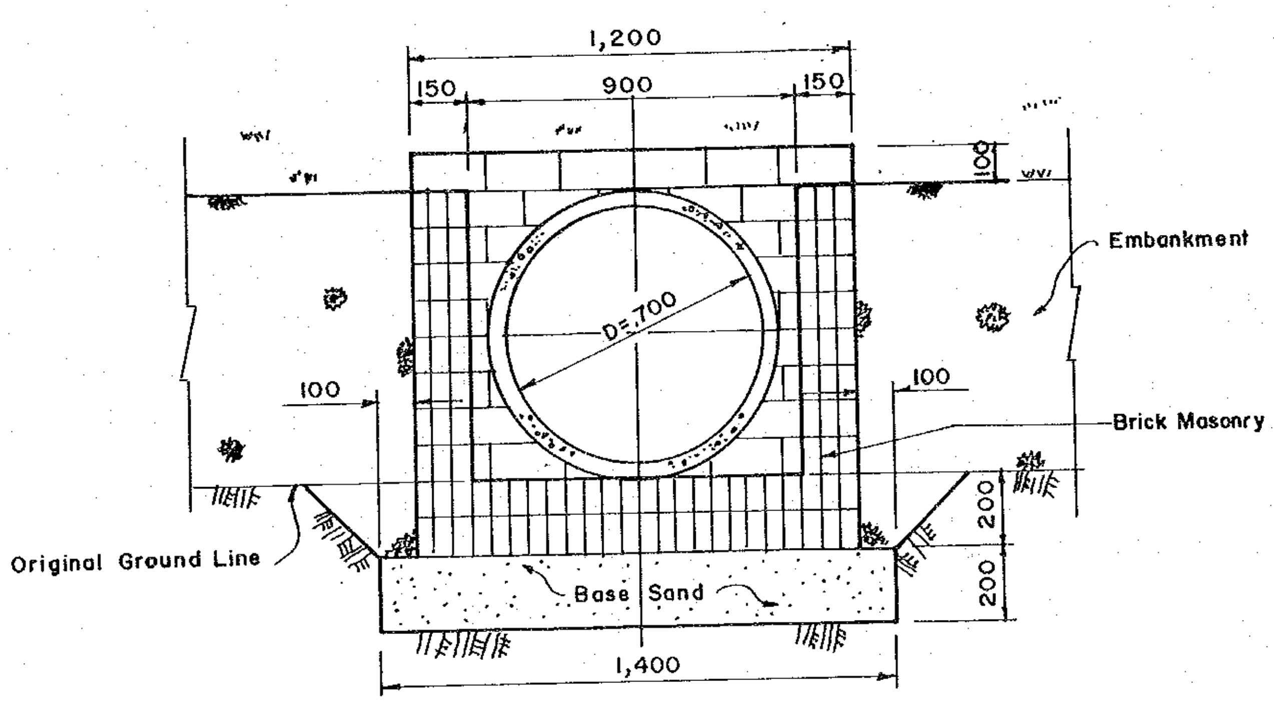


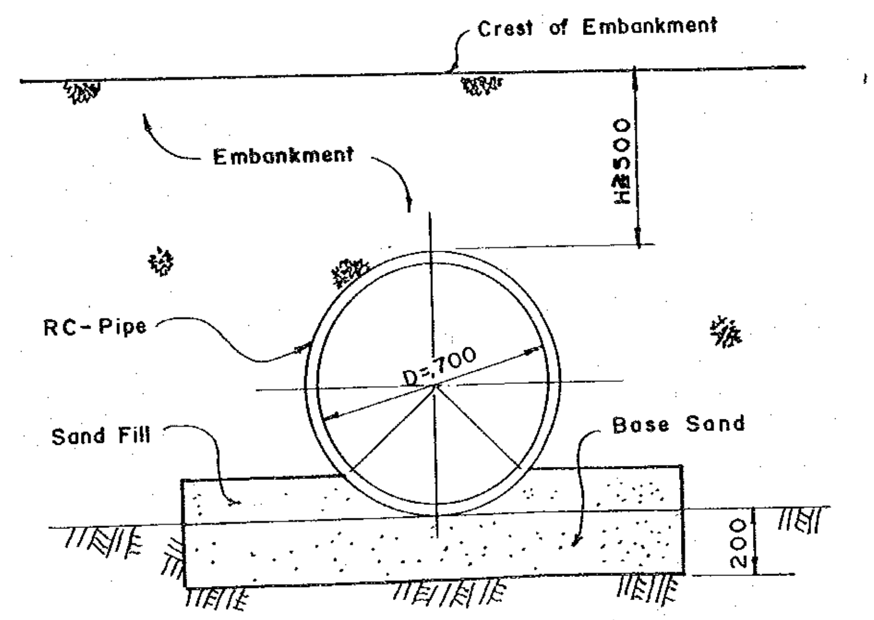
Figure 5.23 PLAN, PROFILE AND CROSS SECTIONS OF SLUICEWAY



PROFILE OF DRAIN PIPE



SECTION A-A & B-B



TYPICAL CROSS SECTION OF DRAIN PIPE

Figure 5.24 PROFILE AND CROSS SECTIONS OF DRAIN PIPE

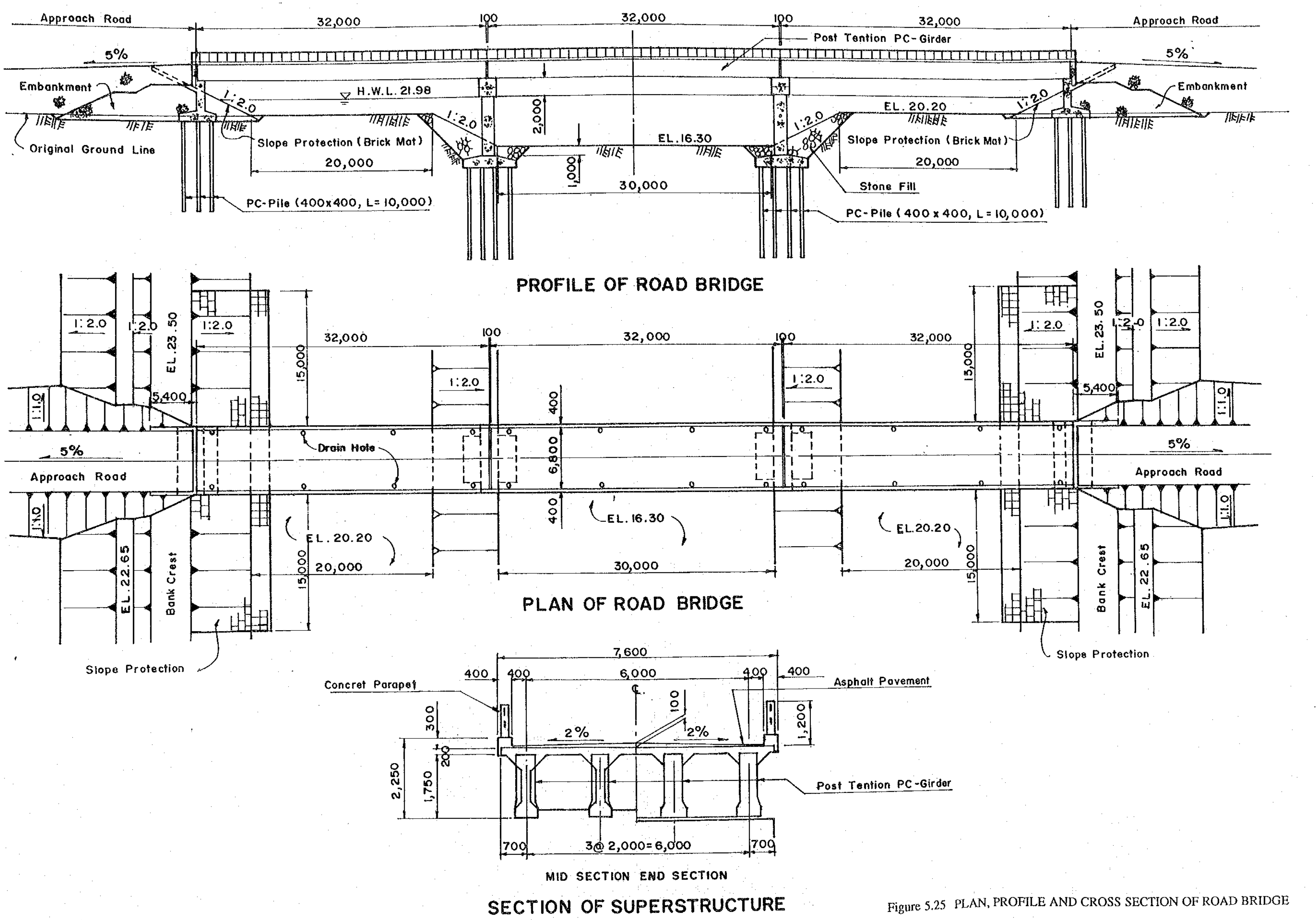


Figure 5.25 PLAN, PROFILE AND CROSS SECTION OF ROAD BRIDGE

Figure 5.26 ABUTMENT AND PIER OF ROAD BRIDGE

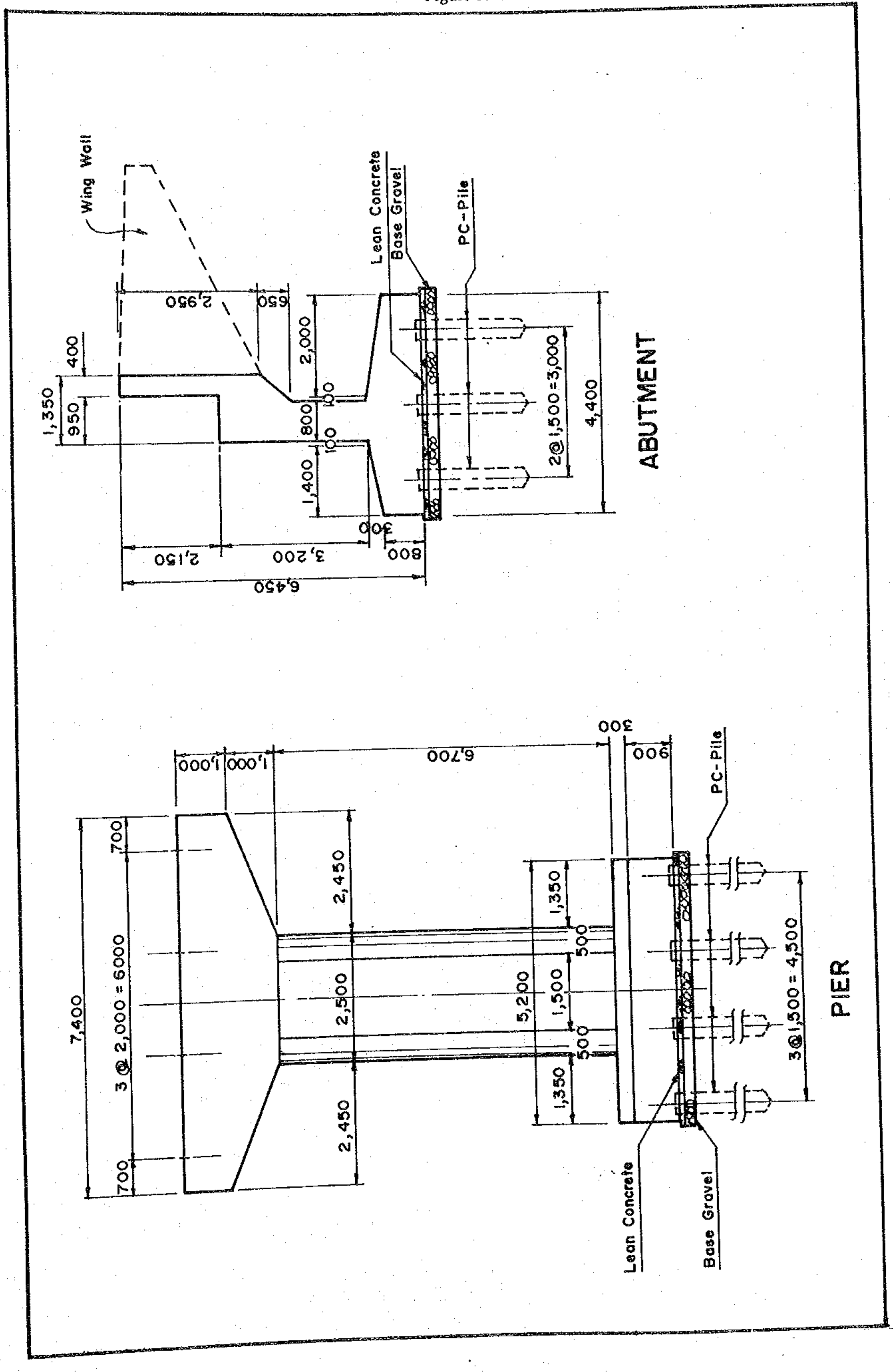
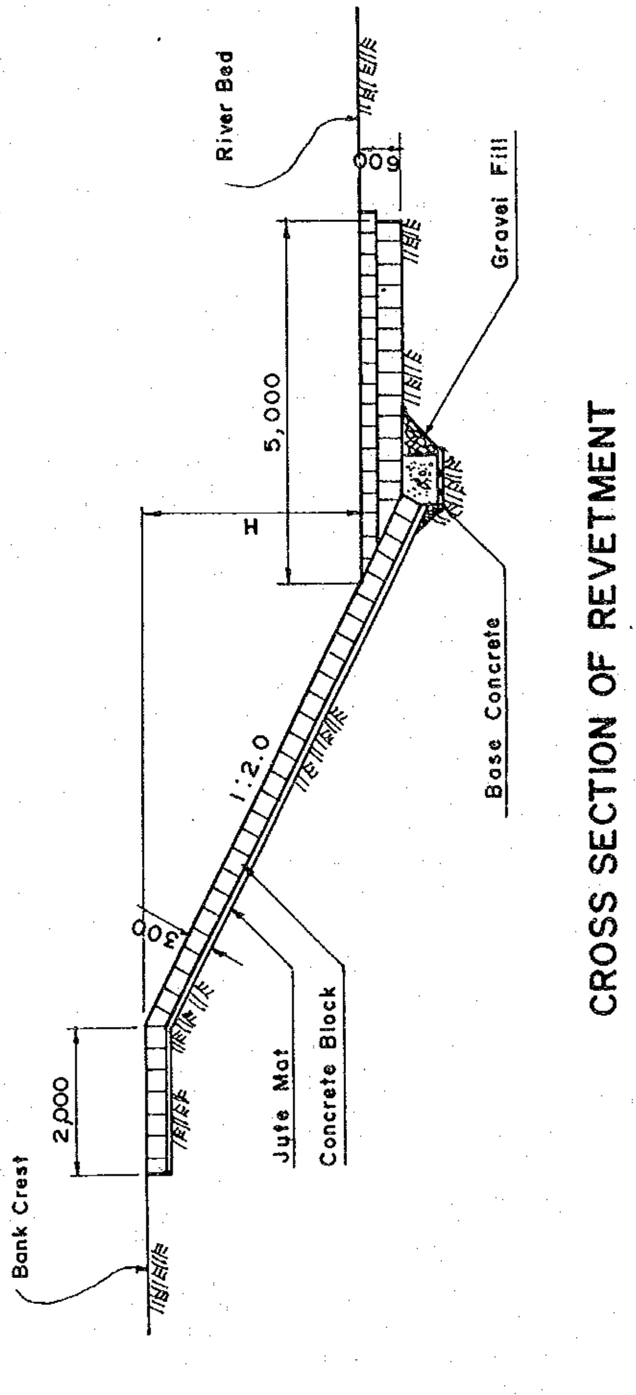


Figure 5.27 CROSS SECTION OF REVETMENT



6. IMPLEMENTATION PLAN

6.1 General

This chapter is prepared for formulation of implementation plan for the Gaibandha Improvement Project (GIP). The implementation plan was examined placing emphasis on set-up of construction plan consisting of construction method and organization required for implementation. For this reason, the existing construction systems have been assessed from both engineering and socio-economic aspects, and their concepts as well as problems are presented hereinafter.

Implementation schedule with phasing of construction works and engineering costing was then worked out following the construction plan identified as described in the succeeding Chapter 7.

6.2 Ordinary Construction Methods of Earthwork in Bangladesh

Construction works for the FCD projects are executed as per the construction manual which is prepared for each project and approved by the governmental agencies concerned. According to the construction manuals so far referred to, manual construction methods have commonly been adopted in most of works, and use of mechanical equipment is very rare.

In Bangladesh, the FCD project is performed by flood embankment system due to the topographic condition of very flat elevations with little undulation. The flood embankment is usually constructed with earth material near the embankment site in order to meet the requirement of a huge amount of material therefor. Earth material is suitable for the flood embankment in respect of low price, availability, less deterioration than steel and concrete, etc., and better fitness to the ground. Besides, the embankment with earth material is easy for future maintenance and repair works which might be necessary. But the flood embankment with earth material is rather affected by flood flow through erosion and seepage, which might result in breaching of the embankment. In order to cope with these situations, the best quality of construction work is required for the flood embankment. The best quality of construction work is perfomed by reliable compaction methods to be adopted when the embankment is raised up layer by layer.

Though the flood embankment is the key structure for flood control and drainage purposes, it is still constructed by manual construction methods in this country. Appropriate compaction to maintain the function of the flood embankment can not be attained by manual works only. Manual works are commonly adopted not only in construction of the flood embankment but also in other field of construction as far as it is earthwork. For example, such hydraulic structures as regulators and culverts are backfilled manually without proper compaction. As they are constructed into the flood embankment, their locations might be rather weak points of the embankment for flood. In slope protection of the flood embankment, enough treatment is not observed yet. Only in road improvement project, mechanical compaction method has been adopted in construction of many highways.

Typical construction sequence of flood embankment by manual work is shown below;

Earth material is taken from borrow pits nearby the site to be embanked, and transported manually with baskets. The earth is then thrown from the baskets, and is placed in thicknesses of 225 mm (9 in) or less. The earth of each layer is compacted by 7 kg rammer fitted with a bamboo butt to thicknesses of 150 mm (6 in) or less. After covering the entire process for the first layer, the subsequent layers are created in the same manner until the crest level is reached. When embankment in any reach is complete,

side slopes are graded. A rope is tightly stretched marking the accurate side slope, and the side slope is trimmed of filled to the required grade leaving 150 mm (6 in) for final spreading of top soil on the surface. All clods are broken and the surface is tightly rammed over the whole length of the slope. The same procedure is followed in the opposite side slope and embankment crest.

Earthwork is regarded as an easy task suitable for labour intensive type works, but quality control of earthwork is not easy when accomplished manually. The flood embankment is a very long structure, and performance with the same quality is especially expected in all the stretches. Since all of embankment works are undertaken by labour without mechanical equipment, a strict enforcement is provided only by the appropriate supervision. Sufficient quality of embankment may not be expected when the supervision is lacking.

Excavation of channels and structure sites are likewise carried out manually. This type of work does not require high quality of performance like the flood embankment. But progress control might be difficult because a flexible time schedule is requisite for implementation.

6.3 Evaluation of Construction Works by Contractor

In Bangladesh, most of construction works for flood control and drainage facilities have been performed by local contractors as a standard practice. At present 530 local contractors are listed by BWDB as class-A contractors, and those class-A contractors are normally entitled to participate in tenders with work values of more than five (5) million taka. But really qualified local contractors with capability of performing reliable construction works are limited to top ranking contractors. Annual turnover of the qualified contractors is deemed to reach a hundred million taka or less which depends on year, and the target work value is around five (5) to ten (10) million taka on average per a project. They may perform any types of the construction works proposed for the Gaibandha area. They are likewise able to execute mechanical construction works by use of their own equipment. On the other hand, ordinary local contractors except the qualified contractors do not own construction machinery (even the class-A contractors).

As stated in reports of FAP 20 and Early Implementation Project (EIP), production of low quality works and deprivation of labour's due wages by local contractors have often been observed during implementation. Rather low offers from a considerable number of local contractors for competition of bidding may result in those situations. Nevertheless a method of execution by local contractors is still most appropriate for performance of construction works in this country in spite of the above situations. Because there is no alternative to meet the requirement of construction works in both quality and quantity for the time being. Besides, the root of problems and evil-doing, which are both caused by local contractors, is deemed to lie in the formalities of tender and budgetary constraint of the government. Establishment of proper evaluation method of contractors and of certain payment process to contractors will be necessary to improve those situations.

International contractor is a better choice for successful performance of construction works. There are several flood control and drainage facilities constructed by international contractors, but they are normally invited for foreign aid projects with financial assistance from the international agencies and donor countries. Contract values more than 10 million US$ (equivalent to 380 million Taka) have been observed for the foreign aid projects, and projects with contract values of 20 to 25 million US$ (equivalent to 760 to 950 million Taka) deemed to be very attractive for foreign contractors from developed countries including the United States, Japan and Europe.

6.4 Examples of Labour Intensive Project

There are some labour intensive projects supported by the government agencies and donors. Those projects put emphasis on local people's participation in earthwork in order to cope with the following socio-economic issues concerned with construction and maintenance of infrastructures;

- to create short term employment through construction activities
- to create regular employment through maintenance activities
- to ensure participation of poor women in construction and maintenance activities
- to provide training program to develop skill of poor

For successful and effective performance of the above issues, a model has been devised of a local society group consisting of local landless/poor people. The group is organized for a project, and it executes the work as a contractor but fully complying with wishes and willingness of the group members. Since the group is not familiar with the procedure of the work, technical guidance and supervision from outside is required. Generally the work is performed under a contract between the group and the governmental agency or donor, and so the group is called the contracting society hereafter. Examples of contracting societies are outlined in the following sub-sections;

6.4.1 Landless Contracting Society in Early Implementation Project

Landless Contracting Society (LCS) was devised by the Early Implementation Project (EIP) for the purpose of motivating landless people to execute civil works in line with the principles of increasing people's participation. EIP cell does not implement LCS by itself, and LCS is organized through the cooperation of NGO available within the project area. The organization chart is shown in Figure 6.1. It takes approximately 6 months for EIP cell and assigned NGO to initiate an understanding of cooperation including negotiation, preparation within the NGO, LCS group formation and training etc. When no NGO can be found, the possibilities to implement LCS are limited. The involvement of BWDB staff in organizing LCS is almost nil although BWDB is likewise concerned with LCS activities.

During the execution of civil work, LCS is registered as a D-class contractor with the acceptance of his enlistment by BWDB. LCS does not bid, and their wages are determined by averaging other contractors' bids in tendering. LCS is subject to all the rules and regulations of BWDB as same as other ordinary contractors except for the advantage in selection of the work site. Civil work in the field is executed under the technical supervision by NGO's engineers maintaining liaison with BWDB officers and EIP cell to keep a progress and quality of the work. Post work measurement is finally made by BWDB officers when completed, and LCS body is dissolved unless additional civil work is available. Only earthwork is currently allotted to LCS with the maximum value of work of 300,000 Taka, not exceeding 25 % of total earthwork value, but the rate of 25 % has never been attained in most cases because NGOs do not have sufficient group members fully experienced in earthwork. There is no intention to expand the rate currently allotted, and likewise no attempt to perform other types of civil works than earthwork except for very small drainage structures.

LCS is a very fruitful option for execution of civil works from socio-economic viewpoint. It is an income-generating activity for landless people yielding an opportunity for employment with high wages which is not given while they work under local contractors. Nevertheless this option may still encounter problems. The most serious problem is a heavy dependence on NGOs in organizing LCS and executing civil works. No implementation is expected without NGOs, and alternative body instead

of NGOs should be found for the successful implementation. The second is uncertainness in labour force. Many farmers and migrant labourers are included in a group of landless people. During a busy season on farm they are unable to work for the project, and migrant labourers are not sure to come back for the project after the farm work. Since LCS is an unified collection of labourers, the progress of civil work is disturbed once the foundation of LCS solidarity is loosened by such factors. Those situations might occur even in manual works under local contractors, but the effect will not be so serious because labourers are certainly controlled by the contractors not by their solidarity.

In recent study of the System Rehabilitation Projects under BWDB, Bangladesh Rural Development Board (BRDB) is proposed to be initiated into the LCS activities instead of NGOs. BRDB will guide the LCS activities in all stages with the assistance of BWDB which takes responsibility for the implementation of LCS activities. This alternative option might improve the present situations of the heavy dependence of LCS activities on NGOs, although LCS organization by BRDB for EIP has not yet been set up since it was proposed.

6.4.2 Labour Contracting Society in Rural Employment Sector Programme by Local Government Engineering Department

Local Government Engineering Department (LGED) introduced an innovative mode of construction in the name of Labour Contracting Society (LCS) in 1983/84 on experimental basis in addition to such usual modes of construction as contractors and project committees. This mode of construction has successfully been undertaken under Infrastructure Development Project (IDP) of the Rural Employment Sector Programme (RESP) financed by the international donors of SIDA and NORAD since 1983/84. LCS is a group of landless people including women, and is given a contract directly for construction of small infrastructure development schemes and other earthwork schemes under IDP. Official publication from LGED states the purposes of LCS to be attained through their activities. They are as follows;

- to directly involve the landless groups in infrastructure development work
- to eliminate such intermediaries as contractors and project committees in construction of schemes
- to provide employment opportunity and additional income to the landless group
- to ensure fair wage to the landless people

LCS schemes are normally prepared by the Thana technical staff, and LCS body itself is organized by the Production and Employment Project (PEP) under BRDB, Bangladesh Rural Development Board (BRDB) or NGOs available in the project site under IDP investment fund. The organization chart is shown in Figure 6.2. LCS is a collection of formal landless labour in principle. Where the formal landless groups are not available, informal groups are organized to form LCSs. The members of LCSs targeted by RESP or IDP represent households of landless people who depend on manual labour as their main sources of income and who do not own or operate more than 0.5 acres of land.

LCSs' activities are mainly involved in earthwork, casting and installation of concrete pipes, construction of box culverts, etc. LCS members are imparted four days training in respect of social, motivational, technical and management aspects by IDP before the commencement of the work and exceptionally likewise shortly after the commencement of the work. During the training food and allowance are paid to them as compensation for lost wages. The LGED engineers directly supervise the LCSs's works with assistance from consultants assigned by IDP. It has been reported that technical quality of LCS schemes be achieved at a higher level as compared with other schemes through project committees and contractors.

The contract value allotted to a LCS does not normally exceed 75,000 Tk, but it can be divided into several portions when a large scheme is identified for implementation by LCSs under the conditions that the same LCS is unable to be awarded more than one contract at a time. LCS's work is scheduled to complete within one working season from November to May the following year.

It may be noted that the LCS schemes have gradually been increased under IDP. The annual employment generation in terms of mandays has increased from 197,896 in 1986/87 to 1,283,744 in 1989/90 yielding a total of 3,785,559 mandays within four years. Short term employment covers 61 % (2,302,738 mandays) of the total mandays, and remaining 39 % (1,482,821 mandays) is shared by long term employment.

Although the detailed survey on LCS schemes is not performed by our study yet, it might be rather complicated that many governmental agencies be involved in preparation, formation and execution. An executive unit, which is responsible for all the LCS activities, should be established for successful and effective performance even if it is composition of related agencies.

6.4.3 Manual construction works under food for work programme

Project Implementation Committee (PIC) is formed for implementation of Food for Work (FFW) programme of which donor is the World Food Program. PIC is a subordinate committee at local level, while there are National Coordination Committee at the national level and District Steering Committee at the district level for FFW programme, respectively. PIC is composed of influential persons including at least one woman, and they are individually and collectively responsible for the execution of earthwork under FFW programme.

PIC is organized as per the allotment order given by BWDB, and is finally approved by the executive engineer from BWDB. PIC chairman determines the number of working groups of labour for earthwork depending on the quantity of wheat to be given to the labourers after the completion of earthwork. Each working group consists of 15 to 20 labourers. The wage rates for every cubic meter of earthwork varies from 1.42 kg to 1.65 kg of wheat. It depends on types of earthwork of channel excavation, canal excavation and embankment, etc.

The executive engineer from BWDB is responsible for the overall execution of earthwork, but actual supervision in the field is done by the PIC representative designated by PIC chairman. Meeting are held by PIC members twice a month to perform the proper implementation of earthwork during the execution.

The most serious problem of earthwork in FFW programme is the direct guidance of local influential persons, who may not be capable in technical matters and not be interested in the quality of works. The quality of earthwork done by FFW programme is often poor. Another problem is that the FFW program is controlled only by the persons who have powerful influence in the community. PIC chairman takes responsibility for solving land problem either by acquisition or donation. But the case of non-payment for land acquisition and compensation to small land owners are reported in FAP 20. These circumstances do not comply with the policy of people's participation project, even though earthwork under FFW program aims to generate labour intensive type projects for poor people including small land owners in the community. This FFW program will not be considered in our project unless the existing system is improved.