Government of the People's Republic of Bangladesh

Ministry of Irrigation, Water Development and Flood Control
Flood Plan Coordination Organization

BANGLADESH ACTION PLAN FOR FLOOD CONTROL

COMPARTMENTALIZATION PILOT PROJECT (FAP 20)

SIRAJGANJ CPP INTERIM REPORT

AN OVERVIEW OF BRAHMAPUTRA RIGHT EMBANKMENT (BRE)

October 1993

Euroconsult/Lahmeyer International/Bangladesh Engineering & Technological Services/House of Consultants

under assignment to

DIRECTORAAT GENERAAL INTERNATIONALE SAMENWERKING
Government of the Netherlands

and

KREDITANSTALT FÜR WIEDERAUFBAU
Federal Republic of Germany

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AN INVESTIGATION OF BRAHMAPUTRA RIGHT EMBANKMENT (BRE)

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A study of the Brahmaputra Right Embankment (BRE) in the context of Sirajganj compartment, Compartmentalization Pilot Project FAP 20

1. INTRODUCTION

Different FAP projects have studied or are still studying the Brahmaputra river and its bank stabilization. A few of them have already submitted their reports recommending measures for the bank protection at appropriate places to minimize the effects of the erosion and concomitant damage to the properties, infrastructure, and land.

FAP 20 is the Compartmentalization Pilot Project having at present two compartments that will be implemented for testing of the effect of compartmentalization. One of the compartments is at Sirajganj.

At the Sirajganj compartment, situated on the right bank of the Brahmaputra river, the Brahmaputra Right Embankment (Fig.1) runs along its eastern boundary. Part of the existing BRE acts as the peripheral flood embankment of the compartment on the eastern side. The other peripheral flood embankments of the Sirajganj compartment planned in the Karatoya-Bangali flood plain (Fig.2), behind the BRE on its countryside, may be constructed by the CPP. Yet the main threat of flood will be directly from the Brahmaputra river.

1.1 Objective of the investigation

As the Sirajganj compartment will be implemented soon, it has become necessary to investigate how far the BRE is dependable as the eastern peripheral flood embankment of the project in the face of erosion of the Brahmaputra river bank creating constant threat to it.

As the information regarding the present and the future status of the BRE, recommended by different FAP projects, are scattered, it has now become necessary to compile them for a critical review. The expected performance of the Sirajganj compartment needs to be appreciated in a broader sense.

The job was assigned to an external consultant and the present report is the outcome of his endeavor.

The information on the Brahmaputra river and the Brahmaputra Right Embankment furnished in this report have been collected from various sources. Recent information was also collected from field offices of BWDB as well as from its planning offices at Dhaka. There are quite a number of FAP Projects which studied the river and the BRE in the light of their own Terms Of Reference. The concerned FAP's rendered valuable suggestions and supplied

documentary papers in support of this investigation. The BWDB offices, both in the field and at Dhaka have been consulted for information on immediate and long term programmes financed by GOB and other sources. FPCO gave the necessary approval for the assignment and helped by lending out the related FAP reports.

1.2 A brief description of the river system of Bangladesh

Rivers are the most commonplace and a very significant feature of the physical landscape of Bangladesh. In spite of their great numbers and variety, the rivers of the country, excluding the ones in the district of Chittagong and Chittagong Hill Tracts, belong to three major river systems: the Ganges, the Brahmaputra and the Meghna which are responsible for building the vast alluvial land. The general inclination of the country being from north-west to south-east, the majority of the rivers flow in that direction.

THE GANGES: It originates from the southern flank of the Himalayas and flows 2400 km eastward over Indian territory entering Bangladesh near Rajshahi. Then it flows south-eastward to reach Aricha where it meets the Brahmaputra. The Ganges receives only one tributary in this country but has a number of distributaries mostly taking off from its right bank. The river ranks among the top ten rivers in the world.

THE MEGHNA: Originating from Assam in India, the Meghna flows through the eastern part of Bangladesh and meets the Padma (combined flow of the Brahmaputra and the Ganges) in a confluence at Chandpur.

THE BRAHMAPUTRA: It is also one of the ten top ranking rivers in the world and accounts for more than 50% total inflow of water into the country from all cross border rivers. The BRE is situated on its right bank. Therefore, some more details of the river are presented in the next sub-section.

1.3 A short history of the Brahmaputra river

The Brahmaputra takes its origin in the southern slope of Kailas Range of the Himalayas and flows eastward as the Tsang Po across 1750 km of Tibetan Plateau, then turns south and enters indian territory through its north eastern frontier to become the Brahmaputra. Then flowing 640 km to west, takes a southerly turn to enter Bangladesh, hugging western boundary of the Garo Hills (Ref:L).

1.3.1 Old course of the river

Until 18th century the curve of the river continued producing a south easterly course that took the river, through the east of Modhupur Forest Tract, into the southern end of the Sylhet basin where it joined the Upper Meghna river and the combined flow entered the Bay of Bengal along the present course of Meghna Estuary.

This pattern of the flow is seen on Major Rennel's map published in 1765 which is believed to be the first dependable information on the planform of the river.

1.3.2 Avulsion and the new course

But by the time the Wilcox Map, which was drawn from a systematic triangulation land survey, was published in 1830 the situation had drastically changed. During the intervening period the river broke through the high ground along its southern flank around Gaibandha to shift 60 km to take a new course due south, to the west of Modhupur Forest Tract. This change took place gradually over a period of 30 years. The reach of this shift in Bangladesh is called the Jamuna and the name Brahmaputra being retained by the original course which is now reduced to a highflow distributary.

Out of the 520,000 km^2 of total catchment area of the Brahmaputra river, only 5% is confined within Bangladesh borders.

The most distinctive feature of the Wilcox Map is that the river south of avulsion point has a meandering single-thread planform whereas further north the braided pattern remains pronounced. The evolution of the river in its new course is consistent with theory by Bettes and White which advocates that a river has a preferred slope which it achieves by meandering if the valley slope is sufficiently flat, but if the valley slope is steeper it can only achieve stability by splitting and braiding. The fact that the river passed through the meandering stage and entered the braiding mood is a strong indication that it is now in a preferred state. By 1914 the major meander loops had broken down through a process of multiple chute channel development to create a largely braided appearance with a distinctive long straight reach north of Sirajganj. Because of fundamental change taking place it is hard to compare the two planforms in term of migration of bankline but it would appear that some progressive shifting had already been initiated (ref. A).

More modern maps based on aerial photography are available for the period 1951-57 by which time the river had taken a planform that is recognizable today with island clusters beginning to develop in approximate the same locations as the current chars.

In the River Training Studies of the Brahmaputra river of FAP 1 (ref. A), it has been concluded that:

1) the part of Jamuna north of Sirajganj is braided and the intensity of braiding may be increasing; and the part south of Siraganj shows meandering tendency with braiding characteristics present;

2) the bank to bank width is inereasing but at a rate varying from reach to reach;

3) evidence of continuing westward movement of the centerline of the river is less clear but geo-morphological indications point strongly to this conclusion; and

4) the average rate of bank movement has been quantified for the period from 1953 to 1992 which may be taken as the conservative estimate for the next two or three decades if no stabilization measures are implemented.

Now the original course is better known by the name Old Brahmaputra and the name of the Brahmaputra has frequently been used for the Jamuna which is the new part from the point of avulsion to the meeting point with the Ganges at Aricha.

The confluence of the Jamuna with the Ganges at Aricha resulted in a very large river called the Padma. For a few years the Padma followed its old course along the Arialkhan, but soon the great increase in the volume of flow led to the last major avulsive shift through a higher terrace land resulting in another confluence with the Meghna river at Chandpur. The combined flow of the three major rivers drain due south by the name of the Meghna and discharging into the Bay of Bengal.

1.4 FAP 1 Brahmaputra River Training Study (BRTS)

After conducting the Brahmaputra River Training Studies (BRTS) from 1990 to 1993, the consultants of FAP 1 have submitted in May 1993 a Master Plan Report. Its scope of work extends from the Teesta confluence to the Hurasagar confluence. The report has recommended measures to be taken to obtain improved performance of the Brahmaputra Right Embankment (BRE) and suggested river training schemes suitable for the permanent protection with a schedule of implementation for the priority schemes (Figs.4.1 to 4.7). In addition, the report has suggested continuation of tactical retiring of the BRE, if and when necessary, where protective measures are programmed for a delayed timeframe (ref:A).

1.5 Other FAP Projects related with BRE

Besides the Compartmentalization Pilot Project FAP-20 (Sirajganj compartment), the following FAP projects are linked with the Brahmaputra Right Embankment (BRE).

FAP 2 North West Regional Study: This FAP project, in their regional study showed that the area behind BRE together with the lower Atrai has severe flooding problems in the region (ref.K).

FAP 12 Agricultural review of the FCDI projects included in their study Kamarjani and Kazipur reaches of the BRE. The Rapid Rural Appraisal (RRA) at Kamarjani has found that the primary objective of the protection of the flooding from the Brahmaputra has been achieved resulting in increased rice and vegetables production. Lack of drainage facilities, however, in some places of the embankment has caused congestion resulting in a decline in the production of pulses and oilseeds. RRA found that BRE had some positive impact in improving communication and generating employment. But for Kazipur it stated this to be an unstable section and the area now is subjected to severe and unpredictable floods. BRE has been retired several times in this area but problems have included the use

of poor materials and lack of compaction, delay in starting work, non-payment of land compensation and poor O&M (ref:H).

FAP 20 Compartmentalization Pilot Project using part of the BRE in their Sirajganj compartment. The success of the realization of the Sirajganj CPP depends on a stable BRE (ref: F & G).

FAP 21/22 The Bank Protection Pilot Project (FAP 21) is directed towards the practical design and implementation of test structures, while the River Training and the Active Flood Plain Management Project (FAP 22) is to prepare the medium and the long term strategies for bank stabilization of the Jamuna and other rivers in Bangladesh. Their test programmes have been chalked out, with construction of 5 groynes at Kamarjani on the right bank and revetment at Bahadurabad on the left bank of the Jamuna River (ref:J).

CHAPTER 2

2. BRAHMAPUTRA RIGHT EMBANKMENT (BRE)

2.1 Background of the BRE

The Brahmaputra Right Embankment is one of the earliest FCD projects of Bangladesh. The purpose of the construction has been to protect approximately 240,000 ha of land on the right bank of the Brahmaputra River. But its construction created certain problems to fishery and fishermen families and those engaged in water transport.

2.1.1 Design features

The 220 km BRE has been designed for flood with a return period 1 in 100 years. The original set-back distance of the embankment was about 1.5 km with expected nominal life of 25 to 30 years. The crest width for the first 84 km from Kaunia is 4.26 m and for the remaining length is 6 m. Side slope 3H:1V on both sides for the entire length of the embankment (ref: M). Over the design flood level a 'free board' of 1.52m was provided in the part facing the Brahmaputra. For the part of length on the Teesta right bank from Kaunia to the confluence, the 'free board' was used is 0.90 m because of smaller wave height.

2.1.2 Construction of the BRE

The construction started in 1959 for the portion from Belka to Fulchari. The portion between Kaunia to Belka on the upstream side and between Fulchari to Bera on the downstream side was constructed from the year 1963 to 1968. The total length of construction is approx. 220 km (Fig.1). The BRE now includes 31 regulating structures which were constructed mostly in late 1970s. Ten of them are now having noticeable distress in their wing walls and one of them, the 12-vent Manos Regulator originally built in early 1980s, has been washed out during the last flood season (July 1993) due to bank erosion.

2.2 BRE deficiencies

From the late 1970s the BRE started showing deficiencies. From this period it became target of sporadic attack of erosion of the Jamuna river bank. During this peri[illegible]other types of failure like overtopping, piping, slumping etc. have not been reported.

2.2.1 River bank erosion

The main reason of frequent breaching in the BRE is found to be erosion. During mid-1980s the frequency of attack of bank erosion increased rapidly as greater lengths came within the

range of rapidly eroding bends, some causing erosion rate of nearly 800m per year with little warning. During the 1988 flood, the embankment was breached in three locations all due to bank erosion. In 1991 only 70 km., out of the total 220 km of the original embankment, remained intact in reaches where rate of erosion was comparatively less during the last three decades. The pattern of retirement is shown in Fig. 3. The number of retirements generally ranges from one to three. In two locations, however, four retirements were made and at Jalalpur near Hurasagar confluence the embankment was retired seven times. The greater part of the embankment is now less than 800m from the river bank and, therefore, is within one season erosion range of an aggressive bend.

2.2.2 Other type of damages

Other type of damages caused to the BRE are public cuts, rain cuts, piping and undermining although these play a comparatively minor role. Besides, there are some odd 100,000 squatters on the BRE who have constructed homesteads on the benches cut on the slopes of the embankment.

2.3 Operation and Maintenance

The Operation & Maintenance of the BRE is a critical issue. It is mainly a BWDB's taks to ensure timely maintenance of the embankment by repairing, resectioning, retiring and by providing protective works, but due to fund constraints and other bottlenecks most of the time the maintenance is delayed or not properly performed.

2.3.1 Institutional setting of the BRE

2.3.1.1 Present institutional setting

The present institutional setting for operation and maintenance of the BRE is shown in Figure 6. The Member (O&M) at Dhaka is at the top position of the chain of officers responsible for the O&M of the BRE. Under him is the Chief Engineer (CE), Northern Zone whose office is at Rajshahi. The field official in Bogra in charge of the BRE is the Superintending Engineer (SE), Bogra O&M Circle. Under him are three Executive Engineers (XEN), one each at Sirajganj, Bogra and Gaibandha,who are directly involved in the O&M activities with the help of five Sub-Divisional Engineers (SDE). The Sub-Divisional Engineers have a number of Sub-Asstt. Engineers/Sectional Officer to look after the BRE. During construction period, Work Assistants (WA) help the sub-Assistant Engineers/Sectional Officers (SAE/SO). Sometime the WA's are taken on temporary basis.

In brief, the O&M works are executed in the following way. The works are proposed from the SDE's office on the basis of actual requirement. The XEN, after field verification reports to the SE with proper estimates for supporting the proposal to the CE and the CE reports to

BWDB with a complete list of such O&M works under his zone. The member (O&M) gives the final approval in a Work Authorization. The Member (O&M) decides the allocation of finance viz: Food for Work (FFW), GOB, Flood Damage Restoration project (FDR) etc.

After the Work Authorization is available, the XEN invites tenders and generally the works is given to the lowest tender. For work of more than 50 lakhs in a single tender, it is necessary to get the intending bidders pre-qualified.

During execution the works are supervised for quality control and ensuring timely progress by the BWDB field officials viz: Work Assistants, SO's, SDE's, XEN's and the higher official pay visits occasionally. The organogram of BWDB offices responsible for O&M of the BRE is shown in Fig. 6.

2.3.1.2 Institutional setting during implementation of the priority works as proposed by FAP-1

The organization chart as proposed by the consultant of FAP-1 for the monitoring and maintenance of the river training works proposed in the Master Plan is illustrated in Figure No.5.

2.3.2 Problem of O&M, Land Acquisition and Public cuts

Due to fund constraint and lack of foresight to predict imminent erosion, the embankment at breach points is not retired in time. Due to problem of Land Acquisition, a retired embankment can not be executed in advance of the onrush of flood water even when the existing section is on the verge of breach due to erosion. This delay in putting up the retired embankment can cause damage to the crops, and properties in the 'protected' area. There may be a public cut without any acceptable reason. A retiring or resectioning of an embankment is some time executed by FFW (wheat). The quality of works of FFW is often poor as it is done through a committee of local villagers under the overall supervision of BWDB officers. All these factors make the O&M at times an uncertain job.

2.3.3 Resectioning, retiring and protective works

Due to the reason of wear on slope and crest, particularly after a flood, resectioning of embankment is often required. The retiring is required when erosion has devoured or is likely to breach the embankment shortly. Protective works are undertaken where vital installation, important places, infrastructure etc are to be saved from river erosion.

2.4 Present status of the BRE

2.4.1 Damaged sections

The present status of the BRE beyond the CPP Sirajganj compartment is not satisfactory. At 9 places measuring a total length of 20.53 km. embankment is open. The following list is given to show the locations where the embankment is open due to erosion or public cut.

Place	Km/Ch.to	Km/Ch.	Open Km.	Proposed length for retiring
Tambulpur	15.00 -	28.00	= 11.27	13.45 km.
Charitabari	22.50 -	23.50	= 1.00	1.00 km.
Rasulpur, Manos	60.00 -	65.00	= 2.00	3.20 km.
Pcut Katlamari	45.00 -		= 0.02	0.02 km.
Chandanbaisha	125.00 -	127.0	= 0.17	1.25 km.
Kamalpur	127.00 -	130.0	= 1.50	4.87 km.
Awlakandi	132.00 -	134.0	= 1.50	with Kamlpur
Khudbandi Pcut	146.50 -	148.0	= 0.60	0.60 km.
Makra	204.50 -	207.0	= 0.17	4.17 km.
Total:			20.53	28.56 k.

The last two places are in the jurisdiction of Sirajganj O&M Division but only Khudbandi 'Public Cut' is linked with the flooding of the CPP area. Makra is about 36 km. down stream of the Sirajganj Town while Khudbandi is situated about 16 km upstream of it. Due to the opening at Khudbandi some 62.79 sq.km. of Kazipur and Sirajganj were inundated iduring flood season of 1993 damaging crops, livestock, structures and roads. The positions of openings and other damages on the whole of the BRE are shown in Fig.2. Due to the opening in the BRE a total area of 110.33 sq.km. was inundated during the flood season of 1993 within the jurisdictions of Sirajganj and Bogra O&M Divisions.

2.4.2 Other sections

The status of the embankment, retired 1 or 2 years ago shows that the construction has been performed without maintaining proper slope and section. If the amount of money or the quantity of wheat is not sufficient for constructing the full length as per design, the section and height is reduced to accommodate for the full length of the retirement.

2.5 Future Status

2.5.1 Protection works as proposed under FAP-1

After a three year study of the Brahmaputra river, the BRTS under FAP-1 has submitted to the BWDB a Master Plan Report in May 1993, suggesting protective works needed for maintaining the stability of the BRE. The report has suggested a total number of 27 hardpoints to be created for the stabilization of the right bank during a 30 year implementation programme in different phases at a financial cost of US$ 433 million to US$ 487 million (1992 price). Out of the 27 proposed hardpoints, 10 have been proposed for priority implementation at Sirajganj Town, Mothurapara, Sariakandi, Simla, Kamarjani, Fulcharighat, Chandanbaisha Kazipur, Betil and Jalalpur.

2.5.1.1 Priority protection proposed by FAP-1

Implementation of protective works under priority Phase 1A consists of continuous revetment at Sirajganj incorporating the Ranigram Groyne and revetment type hard point structures at Sariakandi and Mothurapara. For most of the 2.4 km length of the proposed continuous revetment at Sirajganj, up to the Ranigram Groyne, will be replenishing and reinforcing on the already protected bankline revetted by hard materials in the Sirajganj Town Protection Scheme.

Priority Phase 1B consists of constructing more hard points further upstream of Sirajganj - at Sailabari Groyne and Simla, and at two locations north of Sarikandi - one east of Noadabaga and the other north of Kalitola Groyne.

Under the priority Phase 1C the remainder six priority locations namely Kamarjani, Fulcharighat, Chandanbaisha, Kazipur, Betil and Jalalpur - will be taken up for execution (Figs.4.1 to 4.7). (ref.C)

The priority works under Phase 1A will be taken up from July 1994 and will end in June 1997. The first phase implementation will be implemented within 5 to 10 years. Tactical retirement of the BRE throughout this period will continue where riverbank protective measures are yet to provided. Such areas, however, will generally have a lower rate of erosion than the priority locations and so the scale of the problem will be much reduced.

2.5.1.2 Long term protection FAP 1

The basic governing principle in the long term works is to conform as far as possible to natural river planform characteristics. Two options have been presented in the Long-Term bank stabilization for 17 places in the BRE by the bend, island, and node stabilization approaches which will encompass the reaches around Sirajganj and Kazipur also.

FAP-1 main report states: "Construction of Jamuna Bridge would provide a very effective node stabilization with which complementary bank hardening upstream, to prevent out flanking, would counter any tendency for the river to migrate laterally".

In the 'node' approach there would, however, remain the possibility of lateral migration further upstream and if not taken care of may create an avulsion though with a time scale of decades.

2.5.2 Protection under experiment by FAP-21/22

FAP-21: is now designing, specifying, constructing different types of groynes and revetments using different types of materials investigating the suitability of the local materials and construction methods.

The test structures will be exposed to attacks during test periods and behavior of the river on the test structures will be observed for several years to arrive at the final objective to develop and optimize design criteria and O&M methods. The test structures will allow only low safety so that certain damage will be allowed to identify the allowable limit of economy in design.

For the purpose of testing, two sites have been selected. One is on the right bank at Kamarjani and the other is on the left bank at Bahadurabad.

The Kamarjani test site is connected with the Brahmaputra Right Embankment. The works programme for the Kamarjani tests with 5 groynes of 120 m each at a spacing 250m at a cost of Tk. 174.4 million (excluding contractor's overheads and profits etc) have been drawn so as to start in October 1993 and to be completed in May 1994; and for Bahadurabad it will start in October 1994 and will be completed in May 1995.

FAP 22 After the tests are complete with sufficient time for observation in December 1997, recommendations will be made to go for further protective measures in the vulnerable places in the light of findings of the test results. FAP 22 is directed towards preparation of medium and long range strategies for designing protective work.

2.5.3 Maintenance financed by GOB

Every year BWDB spends vast financial resources for the maintenance of BRE.

For the FY.93-94, proposals for retiring and repairing all the openings mentioned in section 2.4.1 (Damaged Parts), have been under active consideration of the BWDB. Some of them already have got the "Work Authorization".

In addition to retiring of embankment, the CE, Northern Zone BWDB Rajshahi, has proposed for the rehabilitation of other structures on the BRE as described below. Some of his recommendations are included in the FAP I report:

The breach at **Tambulpur** (Fig.2) is open since 1991 when the Tambulpur Groyne was washed away. Now BWDB is studying for the rehabilitation of the embankment and structure. The CE office has proposed a T-headed groyne with one regulator at the Tambulpur area. The Painalghat X-bar, about 15 km. upstream of the Tambulpur Groyne, is also proposed for repair.

Raidashbari-Rasulpur (erstwhile Manos regulator area) is now under study by the BWDB design circle for the restoration of the Manos Regulator which has been washed out in July 1993. The proposal of CE Rajshahi includes a regulator at the outfall of the Manos river, two T-headed groynes, and a regulator at the off-take of Alai river to divert away the flow which it discharges into Manos.

Revetment at **Fulcharighat** and repair of **Munshirhat** x-bar at km.137.00 and repair of Belka X-bar no.II, repair and providing protection by hard materials to **Kalitola** Groyne and construction of 2 nos. of groynes at **Chandanbaisha** have been proposed.

North of Sirajganj a groyne at **Par Simla** has been recommended which has been already authorized by the BWDB (Fig.2).

2.5.4 Expected status in 2000 AD

By the year 1997 it is expected that the FAP 1 priority works to treat immediate problems of severe bank erosion in three places (Sirajganj, Sariakandi and Mathurapara) will be complete. The programme of implementation for protecting seven other priority points, viz: Fulcharighat, Chandanbaisha, Kazipur, Betil, Kamarjani, Sonalibazar/Simla and Jalalpur has not yet been drawn, but it is expected that by the year 1995 this will be finalized with the non-GOB finance. By the year 2000 AD most of the ten priority hard points, as they are called in the FAP 1 report, will be in operation.

FAP 21's five test groynes at Kamarjani, upstream of Gaibandha, will be completed by October 1994 and observations will be completed in December 1997. It is expected that a programme of implementation of protective works on the basis of the test results will be taken up by FAP 22 after 1997.

From the GOB's own resources the groyne at Par Simla upstream of Sirajganj will be taken up for implementation in the FY 1993-94. Besides, tactical retiring of embankment will continue, as suggested by FAP 1, where needed through FFW, FDR, GOB finance. An account of the GOB's immediate programme as proposed by the Chief Engineer, Rajshahi Zone, BWDB has been mentioned in the section 2.5.3 (Maintenance by GOB finance).

In consideration of the above, it is expected that by the year 2000 AD, the stability of the BRE will be improved and after that time onward BRE's dependability will be considerably secured.

CHAPTER 3

3. FAP 20 THE COMPARTMENTALIZATION PILOT PROJECT

The Compartmentalization Pilot Project (CPP), one of the 26 components of the Flood Action Plan (FAP).

3.1 Concept of Compartmentalization

The overall objective of the CPP is to establish an appropriate water management system in the compartment. By the regulating structure on primary embankment the flood water will flow from the river into the compartment and spread over the area in a semi controlled way through the gated or ungated openings situated in the secondary embankments. The water demand from inside the compartment will decide the degree of controlling the flood and the drainage of the excess rainfall. The area of a sub-compartment depends upon the hydrology, topography, existing infrastructure, land use and administrative boundaries. To ensure participation of the beneficiaries in all stages of the project, it is necessary to sub-divide the compartments in to smaller units.

The "Bangladesh Flood Policy Study" recommends the areas at the two banks of the Brahmaputra river to be divided into compartments.

3.2 Planning of Sirajganj Compartment in the BRE context

The Sirajganj compartment was selected on the basis of its flood protection to be ensured by the existing Brahmaputra Right Embankment that runs along its eastern periphery. The BRE rendered flood protection to the area effectively for more than 20 years. The country was hit by a severe flood in May 1984 and then by successive floods in 1987 and 1988 when the BRE suffered heavily from their onslaughts. It had a number of breaches during each of the floods mostly due to river erosion. Due its frequent breaches, the effectiveness of the BRE providing primary protection to area gradually started to be questioned.

Flooding is caused in the Sirajganj compartment by either one or a combination of a local BRE breach on the eastern boundary of the CPP, a BRE breach occurring outside the CPP project boundary, major rainfall runoff north of the compartment and back water effect from Karatoya river into the Ichamati and Baniajan rivers.

The testing of the concept of the compartmentalization calls for a protected condition of the compartment. The western and northern boundary of the compartment will be embanked to provide flood protection to the compartment. However, the BRE provides this protection to the eastern boundary. The planning of the Sirajganj compartment, therefore, envisages a stable BRE which is maintained by the O&M Divisions of BWDB while those on the other sides of the compartment will be constructed by the CPP.

3.3 Degree of dependence of Sirajganj compartment on a stable BRE

After the first reconnaissance of the area and the BRE, the Consultant stressed the need for a stable BRE. In case the BRE does not function properly during testing, compartmentalization may not prove fruitful. This issue was raised with the FPCO. The outcome of the identification mission was that Sirajganj was still the best site for testing. BWDB gave assurance that a stable BRE would be maintained.

For the part of the BRE that falls within the Sirajganj Town Protection area, it is well looked after due to the importance of valuable infrastructure in the Sirajganj Town. But north of the Sirajganj Town Protection boundary there have been breaches at Motiarpur and Chormara. Retirement of the embankment at these two places has been implemented in FY 1992-93. Further north, at Kazipur, which has been the scene of breaches since 1984 causing severe flood in the area, the embankment is open again because of public cut committed soon after the section was repaired in 1992-93.

The weak reaches at Motiarpur and Chormara can cause direct flooding in the CPP compartment while those further north (Kazipur) breach may cause flood water to enter through the northern boundary of the CPP.

However, the breach mitigation measures conceived in the Sirajganj Compartment Interim Report will minimize the extent of damage in the compartment as a whole in case of a breach in the eastern boundary of the CPP area. According to the Report, construction or upgrading of roads will serve as flood embankments sub-dividing the compartment. Flood water that has already entered in a sub-compartment through a breach in the peripheral embankment will be allowed to enter into a neighboring sub-compartment through structures (to be constructed) in a controlled way. Diversion of the flood water into the drainage system will be improved through re-excavation of the drainage khals.

3.4 Expected performance of Sirajganj compartment in the BRE context

The construction of Sirajganj compartment is scheduled to start in 1993/1994 and to end in 1994/1995. BWDB has assured of a stable BRE. By the time the compartment is completed in 1994/1995, it is expected that the priority works of the hardpoints as recommended by FAP 1 will be finished in Sirajganj and Kazipur areas. Other reaches of the BRE which are less vulnerable at this moment are likely to be taken up for implementation after the year 2000 as recommended by the FAP 1 consultant in the Long-Term plan.
BWDB is going to take up construction of a groyne at Simla, north of Sirajganj in FY 1993-94. Construction of the same is expected to be completed by the same FY. BWDB has other programmes of GOB financed protective works as mentioned in the sections 2.5.4 (Future Status).

Moreover, the BWDB is committed to go for tactical retirement in the BRE reaches when such requirement arises before the protective works proposed by FAP 1 are implemented.

Therefore it is reasonable to expect that the Sirajganj compartment will function as planned with a stable BRE and will be successful in testing compartmentalizaton concept.

4. CONCLUSIONS AND RECOMMENDATIONS

In view of the available information regarding the current and future status of the Brahmaputra Right Embankment, and taking into account the experiences with the construction, operation and maintenance the following conclusions are drawn:

* The Sirajganj compartment has been identified previously as a location where the concept of compartmentalization can be applied; based on this assumption, it is suggested to continue along this line of thought and continue assuming that this concept can be safely applied here.

* The activities on the improvement of the reliability of the BRE form the backbone of the FAP-project context: exactly that can also be the reason why it may turn out to be its weakest component. The BRE forms part of a considerable network of existing and eventually to-be-improved /upgraded embankment system in Bangladesh. Public consent with embankment policies may quickly change or fade away for various reasons. Therefore, the longterm future of the BRE and a stable environment (physical, organizational and social) may be weakened in view of an altering public opinion. However, the technical feasibility of a number of proposed interventions for the stabilization of the BRE is not proven yet and consequently should be allowed to be tested properly and monitored/evaluated.

*) Although the technical feasibility of the BRE and its protective measures has not been proven yet, the Compartmentalization Pilot Project should take the BRE and its protective measures as granted in view of the attention paid to these components of FAP. It is therefore very likely that the concept of compartmentalization can successfully be implemented in CPP-Sirajganj in the short and medium term.

Final remarks and recommendations:

For the CPP Sirajganj compartment, the potential threat is the instability of the BRE reach from Sirajganj Town up to Kazipur. The reach in the Town Protection area is now stable and will be more stable in future with the implementation of the priority works recommended by FAP I. The proposed groyne at Par Simla, scheduled to be constructed in FY 1993-94 with GOB finance, will provide protection in this weak reach which borders the CPP compartment.

The responsibility of maintenance of the BRE in the Sirajganj-Kazipur area now lies with the Sirajganj O&M Division. It might be considered to shift this responsibility to the CPP to ensure proper maintenance of this reach which is directly linked with the CPP Sirajganj compartment.

ANNEX-1

Some characteristics of the Brahmaputra River

The Brahmaputra river ranks one of the top ten in the world. It originates in the Tibetan Himalayas at an elevation of 5,150m near the Nepal-China boarder. Under the Chinese name Tsanpo and drains the dry northern side of the Himalayas. Turning southward it enters India taking the name the Brahmaputra. Turning westward it drains the Assam valley. It turns once more south ward and enters Bangladesh taking a left curve.

Inside Bangladesh, the Brahmaputra had an avulsive shift of its course about 200 years ago. It is a braided river without fixed bank and frequently shifting channel. The total river with in Bangladesh in general varies between 8-10 km but at places the river is 15-15 km wide (ref.A). The bed slope inside Bangladesh is different at different places. From Nunkhawa to Kamarjani (60km) the slope is 9.5 cm/km, from Kamarjani to Sirajganj (106 km) it is 7.6 cm/km and from Sirajganj to Aricha (92 km).(ref.M)

The river drains a total area of 552,000 sq.km. of which about 39,100 sq.km. is within the Bangladesh territory,

Three major tributaries, the Dudhkumar, Teesta and Dharla rise in the Himalayas and flow southeast across North Bengal plains before entering Bangladesh in its north west corner. These rivers bring down the Himalayas large quantities of sediment. They drain a high rainfall area and are subject to flash floods.

Snow melt in the Himalayas accounts for most of the flow of the Brahmaputra river but rainfall in Assam (India) and northern part of Bangladesh contribute significantly. Consequently the river flow has high seasonal variety.

Maximum annual average peak discharge at Bahadurabad is 65,400 m^3/sec while maximum peak discharge observed in 1988 was 98,600 m^3/sec which is the highest ever recorded. The average annual sediment load at Bahadurabad is observed to be 449 million ton.

The dominant discharge is 38,000 m^3/sec. A much smaller secondary peak is associated with a discharge of 7,500 m^3/sec which corresponds to base flow of the river.

The most important distributary of the Brahmaputra river is the Old Brahmaputra. Further downstream just below Sirajganj another distributary, the Dhaleshwari, leaves the left Bank of the Brahmaputra.

COLEMAN's REPORT:(ref:L) The first systematic morphological study was undertaken by J M Coleman between 1967 and 1968 culminating in his paper "Brahmaputra River Channel Processes and Sedimentation" published in 1969. From interpretation of aerial photography, he was the first to identify that the course of the river had progressively moved westward during the recent geological time until the major avulsion that took place around the end of the 19th century. He tentatively concluded that the westward migration was continuing.

Further, he observed and documented many of the sediment transport processes that are distinctive features of the river's braided form. Although Coleman's interpretation provide much valuable materials on the behavior of the river, he did not focus on many of the aspects that are relevant to bank stabilization.

PRINCIPAL FEATURES:

The processes of bankline retreat and accretion on the Brahmaputra river is dominated by the dynamics of sand bar, island char and anabranch evolution. The bank movement is a combination of two processes: widening of the braid belt related to char evolution and migration of the centroid of the related to long term migratory trend. The short term bank erosion is associated with concave margin of anabranch bends which typically migrate only a short distance downstream before dying out.

It has been confirmed that the right bank has experienced net erosion over its full length since 1953 and that some reaches have suffered more than others. The extent of erosion for the period from 1973 to 1992 (with the accretion north of Sirajganj due to Ranigram groyne) is shown in the fig.no.8.

There is convincing evidence that the river has as whole moved consistently westward during the last 200 years and is sill continuing.

The Brahmaputra river between the Teesta and Bahadurabad has moved westward by a fairly uniform 14 km during 225 years. Near the Dharla confluence the shift is 8 km. This suggests the river is capable of a bodily movement of 60 m/year. Over shorter time span the rate could be considerably higher or lower than this long-term average. South of Bahadurabad this rate is only 27 m/year while the left bank remained almost static. The right bank may shift westward @ 100 m/y during the next decade.

The Brahmaputra can classified as a braided river channel. During low the channels shift back and forth between the mainstream banks, which are often 6 to 13 km apart. The river is having many channels, shoals and islands which indicate a river of low hydraulic efficiency and heavy sediment load.

Sediment transport characteristics

The Brahmaputra's catchment supplies vast quantities of sediment from the actively uplifting fold mountains in the Himalayas. Consequently Brahmaputra in Bangladesh carries a heavy sediment load estimated to be over 500 million tonnes annually. Most of this is in the silt size class but around 15 to 25 percent is sand. Owing to the geology of the catchment, the clay fraction is very small. The sand size sediment is relatively uniformly graded.

The silt fraction, often referred to as wash load, is carried in suspension by the river and it is believed that most passes through the study reach, with only a small proportion becoming deposited in the lower velocity zones on char tops and flood plain during the limited period

when the river level is higher than the bank level. The silt load is not therefore important in term of river morphology.

The sand fraction is transported through a combination of true bed load, which probably represents about 10% of the total sand fraction movement, and a complex pattern of partial suspension that occurs mainly in the zone close to the bed but is seen at higher flows in the form od dramatic "boils" in which the heavier fractions are carried temporarily to the upper levels. The second process is closely linked with to the movement of both the smaller dunes and the massive sandbars that are dominant feature of the braid pattern. Dune tracking results indicate that the former were about 3 m high and perhaps about 200 m long and their migration rate was about 35 m/hour. The larger sand bar vary in size but most lie in the range from 3 to 6 km in length and 1 to 2 km in width; they are typically drowned at flows between 30,000 and 40,000 m^3/sec and are capable of travelling downstream during the monsoon season at around 30 m/day although when associated with an actively eroding bank they may scarcely move for several seasons. There is evidence that these massive sandbars are the primary manifestation of the sand fraction transport.

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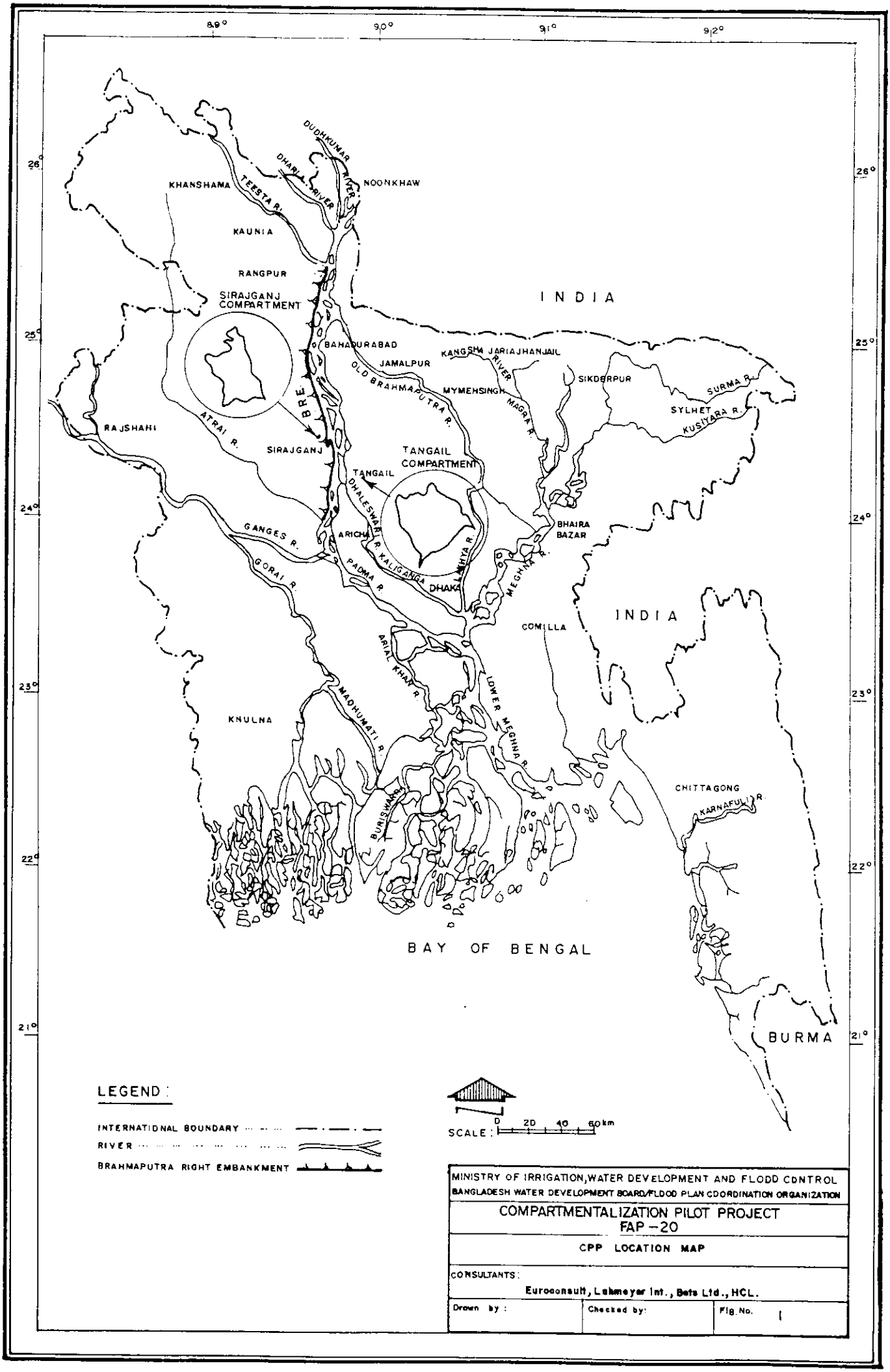


MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD/FLOOD PLAN COORDINATION ORGANIZATION

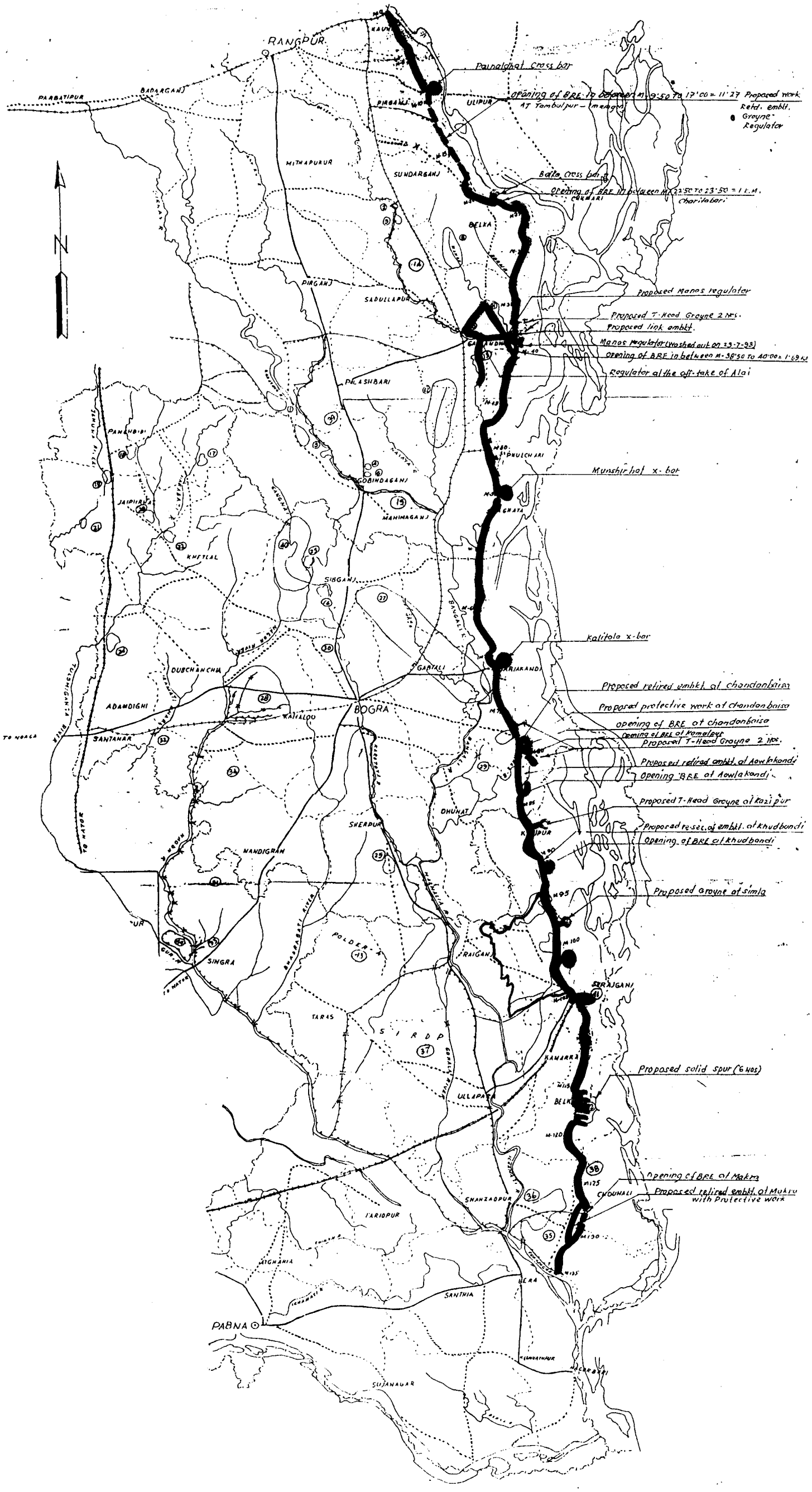
COMPARTMENTALIZATION PILOT PROJECT
FAP – 20

CPP LOCATION MAP

CONSULTANTS :
Euroconsult, Lahmeyer Int., Bets Ltd., HCL.

Drawn by :	Checked by:	Fig. No. 1

JURISDICTION MAP SHOWING SCHEMES UNDER BOGRA O&M CIRCLE



COMPLETED SCHEMES AND PROJECTS

Gaibandha O&M Division

	Name	Scheme	Thana	District
1.	Ghoraghat	L.L.P.I.	Ghoraghaj	Dinajpur
2.	Talukshahbaz-I	L.L.P.I.	Sundargonj	Gaibandha
3.	Talukshahbaz-II	L.L.P.I.	Gobindagonj	Gaibandha
4.	Deghulia-Fulbari	L.L.P.I.	Gobindagonj	Gaibandha
5.	Katabari	L.L.P.I.	Gobindagonj	Gaibandha
6.	Boalia	L.L.P.I.	Gobindagonj	Gaibandha
7.	Katlar Beel	Drainage	Sadullapur	
8.	Kashdada	Drainage	Sadullapur	
9.	Kamarnai	Bundh	Gaibandha	Gaibandha
10.	Gaibandha	Town Protection	Gaibandha	Gaibandha
11.	Sardaghari Beel	Drainage	Palashbari	Gaibandha
12.	Nalaya River	Improvement	Palashbari	Gaibandha
13.	Sonail Sub-Project	Embankment	Gaibandha	Gaibandha
14.	Saddamua Katlar Bl	Drainage	Sadullapur	
15.	Nurullar Beel	Drainage	Gobindagonj	

Bogra O&M Division

16.	Banail	L.L.P.	Shibgonj	Bogra
17.	Bharahut	L.L.P.	Panchbibi	Joypurhat
18.	Mohipur	L.L.P.	Panchbibi	Joypurhat
19.	Bankhur	L.L.P.	Panchbibi	Joypurhat
20.	Mamudpur	L.L.P.	Panchbibi	Joypurhat
21.	Pathuria	L.L.P.	Panchbibi	Joypurhat
22.	Telabadal	L.L.P.	Khetlal	Joypurhat
23.	Aladipur	L.L.P.	Sibgonj	Bogra
24.	Halhalia	L.L.P.	Akkelpur	Joypurhat
25.	Madanpur	L.L.P.	Sherpur	Bogra
26.	Gagnai River	Improvement	Sibgonj	Bogra
27.	Gozaria-Ichamati	Improvement	Gabtali	Bogra
28.	Protappur	SRP sub-project	Kahaloo	Bogra
29.	Mora Bangali River	Joregacha Bridge	Sariakadi	Bogra
30.	Shewra Beel	Drainage	Bogra	Bogra
31.	Nagor River	Embankment	Singra	Nawdigram
32.	WRS over Irrimati Khari, Dakhin Sajapur		Dubchanchia	
33.	Damdama Khari	SSFC sub-project	Singra	Singra
34.	Upper Nagar	Embankment	Adamdighi	

Sirajganj O&M Division

35.	Hurasagar	Sub-project	Shazadpur	Sirajganj
36.	Shazadpur	Town protection	Shazadpur	Sirajganj

Ullapara W.D. Division

37.	Sirajganj	Integrated Rural Development	Sirajganj
38.	Brahmaputra Right	Flood Embankment	

ONGOING SCHEMES AND PROJECTS

Gaibandha O&M Division

39.	Karatoya	Flood Control		

Bogra O&M Division

40.	Gagnai	SRP Sub-project	Sibgonj	Bogra

Sirajganj O&M Division

41.	Sirajganj	Town Protection	Sirajganj	Sirajganj
42.	Belkuchi	Town Protection		

SCHEMES AND PROJECTS UNDER INVESTIGATION

43.	Bogra Polder 4	Polder	Di. Bogra, Natore & Sirajganj	
44.	Gur-Nagor	Mini polder	Singra	Natore

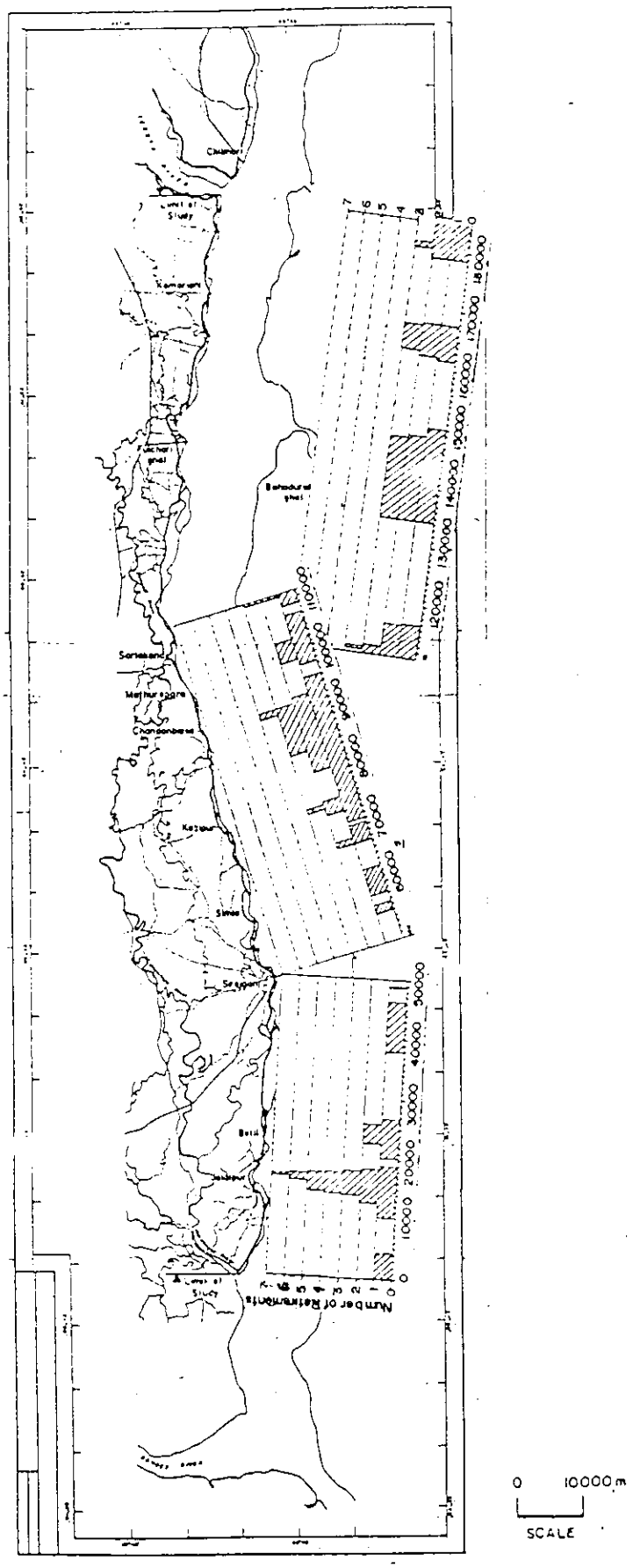
LEGEND

1. District Boundary .....
2. Thana Boundary .....
3. River with Khals .....
4. Embankment .....
5. Regulator .....
6. Re-excavation of Rivers and Khals ....
7. Jurisdiction Boundary .
8. Completed Scheme .....
9. On-going Scheme .....
10. Under Investigation ...
11. Existing Embankment BRE
12. Proposed Retired Embankment BRE
13. Opening in BRE
14. Existing X-bar
15. Proposed Solid Spur (6)
16. Proposed Groyne
17. Existing Groyne

0 5 10 15 km.
SCALE

Figure: 2

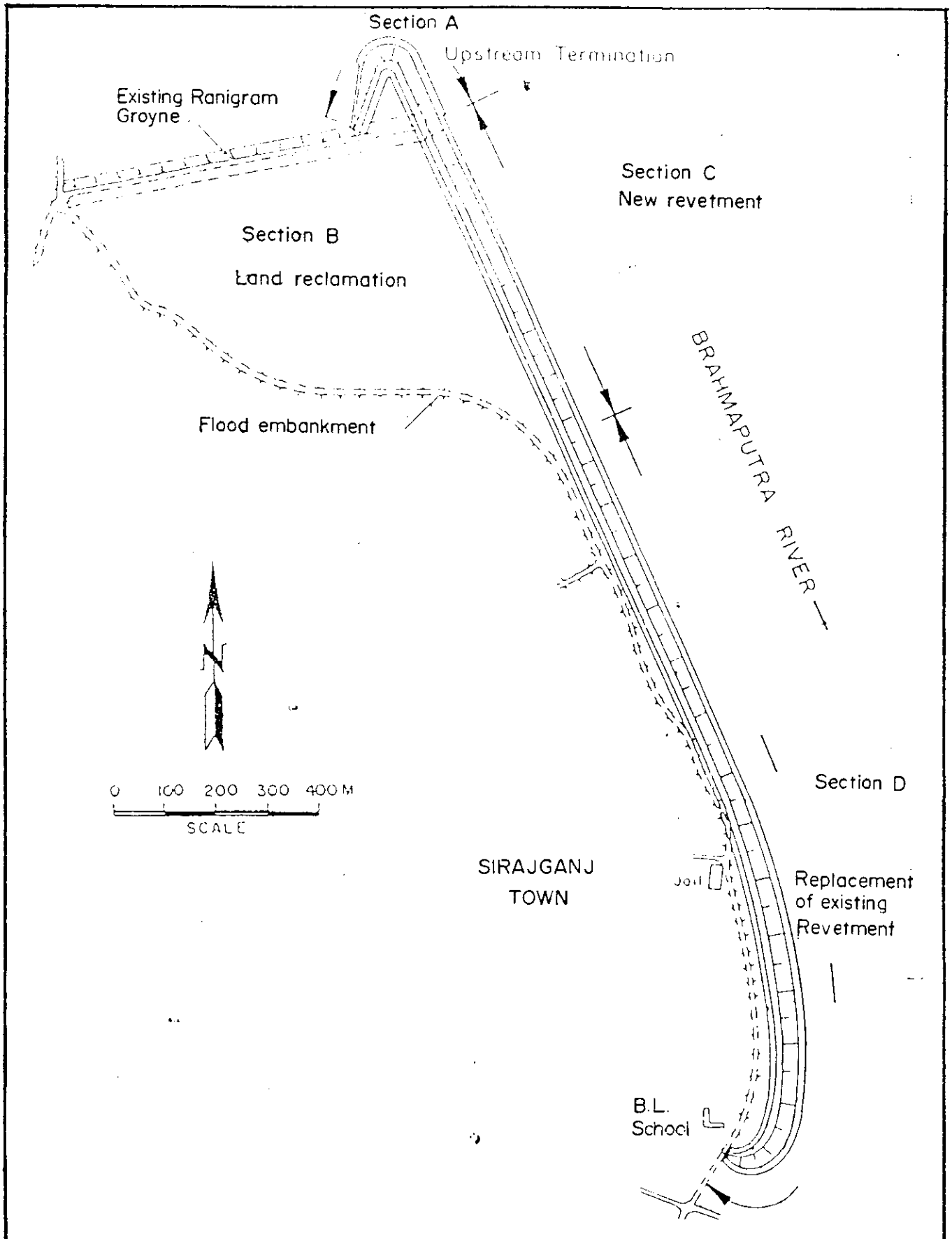
SUPERINTENDING ENGINEER
BOGRA O&M CIRCLE
BOGRA



Characteristics of the BRE: Pattern of Retirements

(Source FAP I, May 1993 Main vol.)

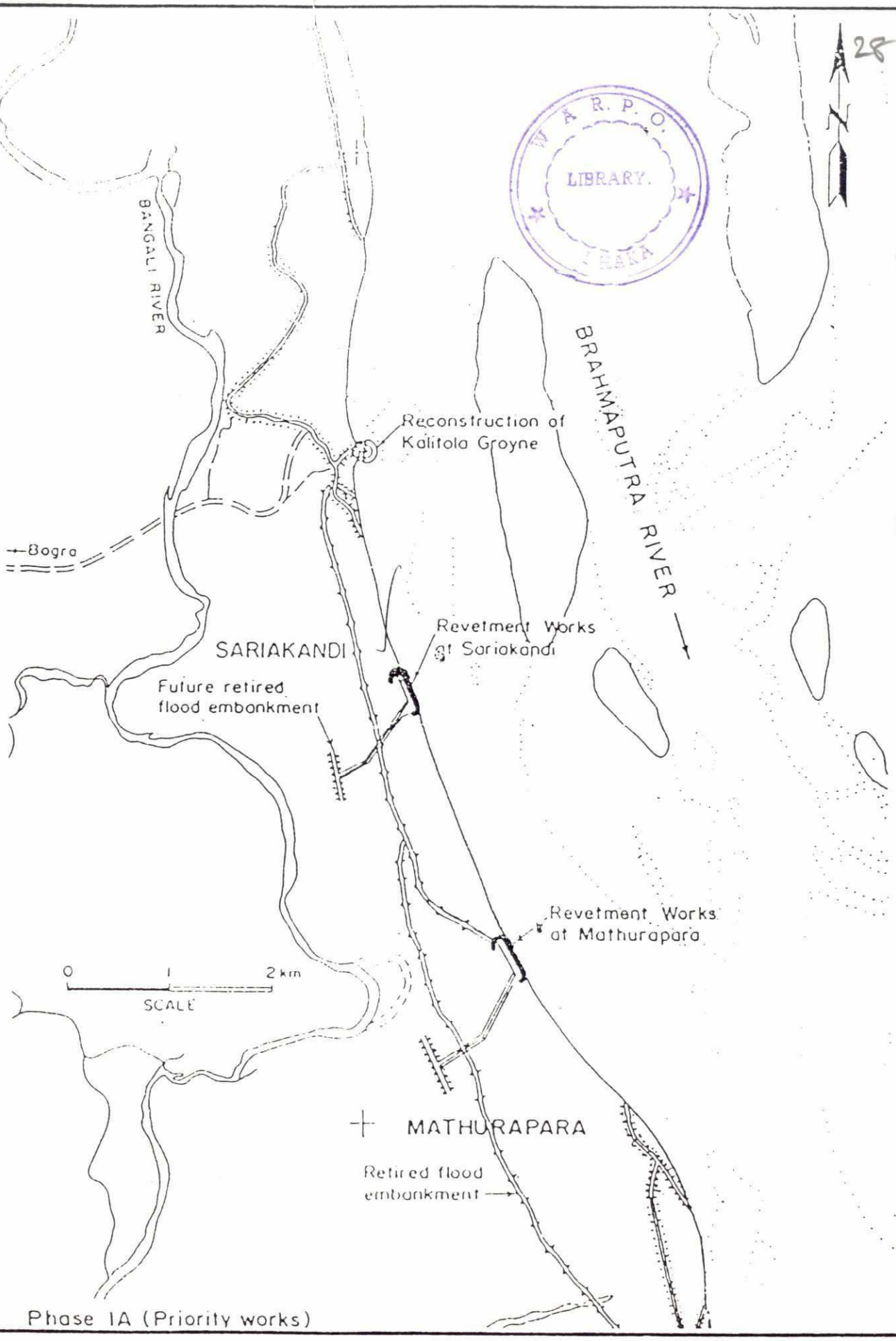
Figure : 3



Layout of Works at Sirajganj

(Source FAP 1, May 1993)

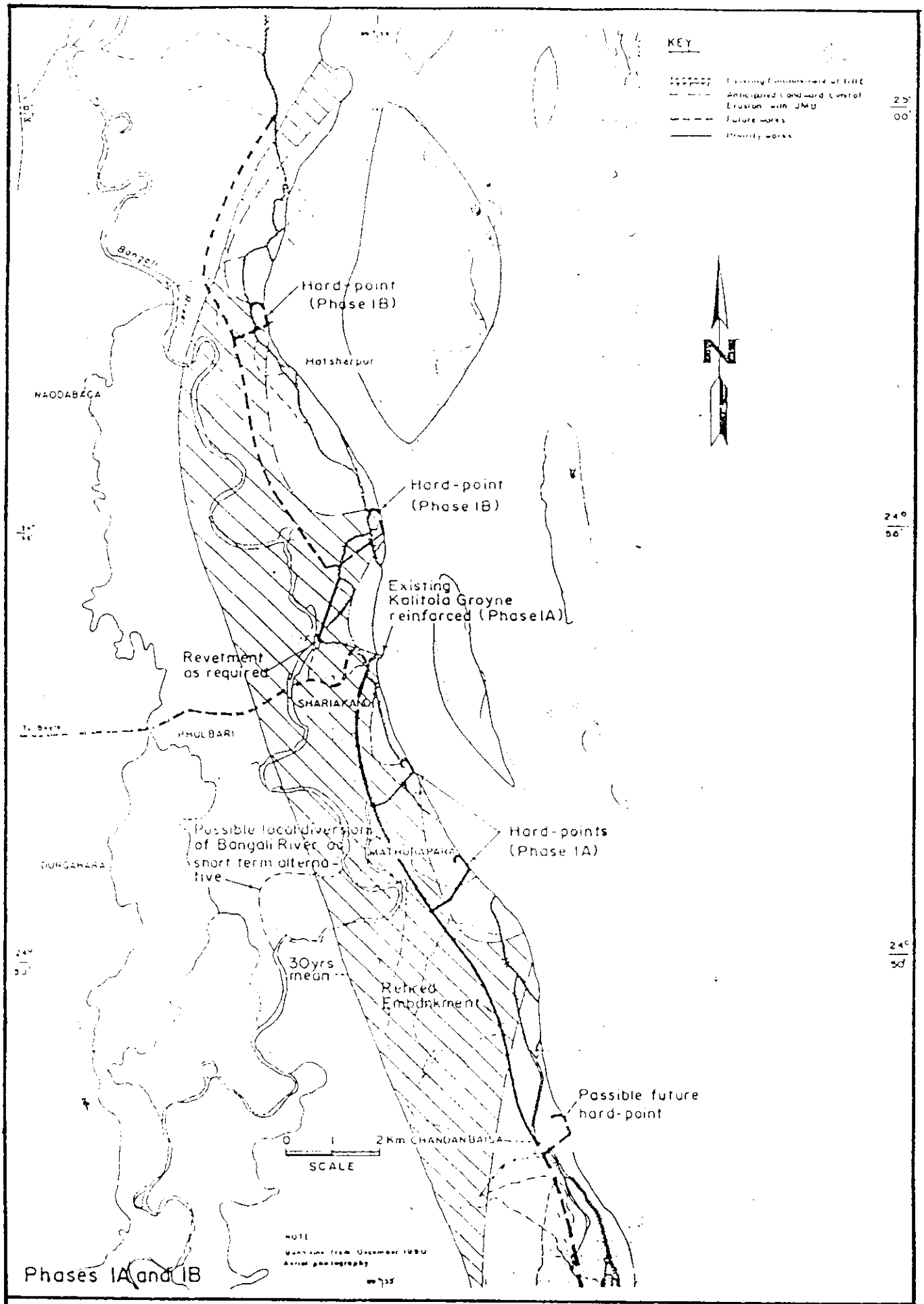
Figure : 4.1



Layout of Works at Sariakandi and Mathurapara

(Source FAP 1, May 1993)

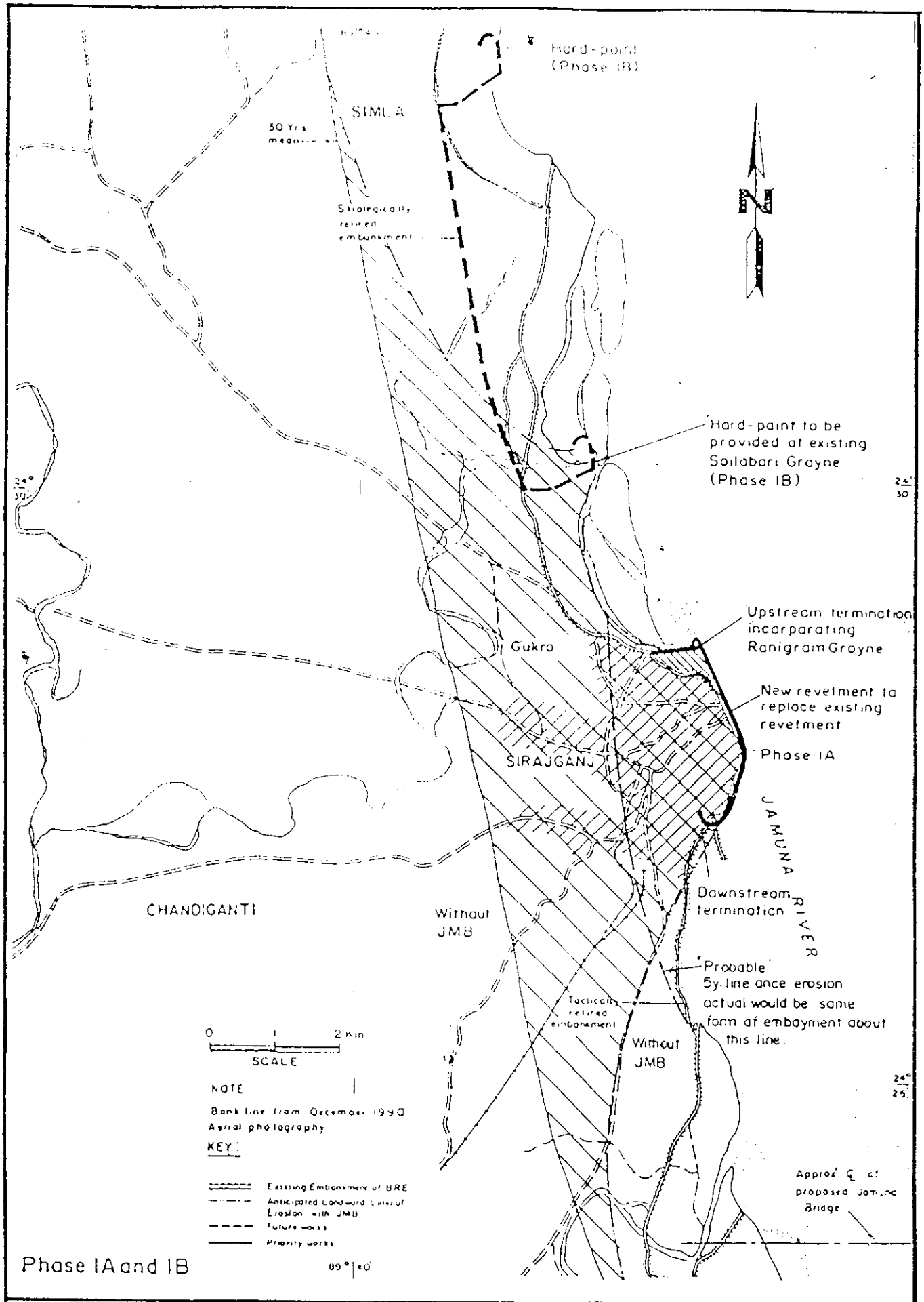
Figure : 4.2



Priority and Future Works at Sariakandi and Mathurapara

(Source FAP 1, May. 1993)

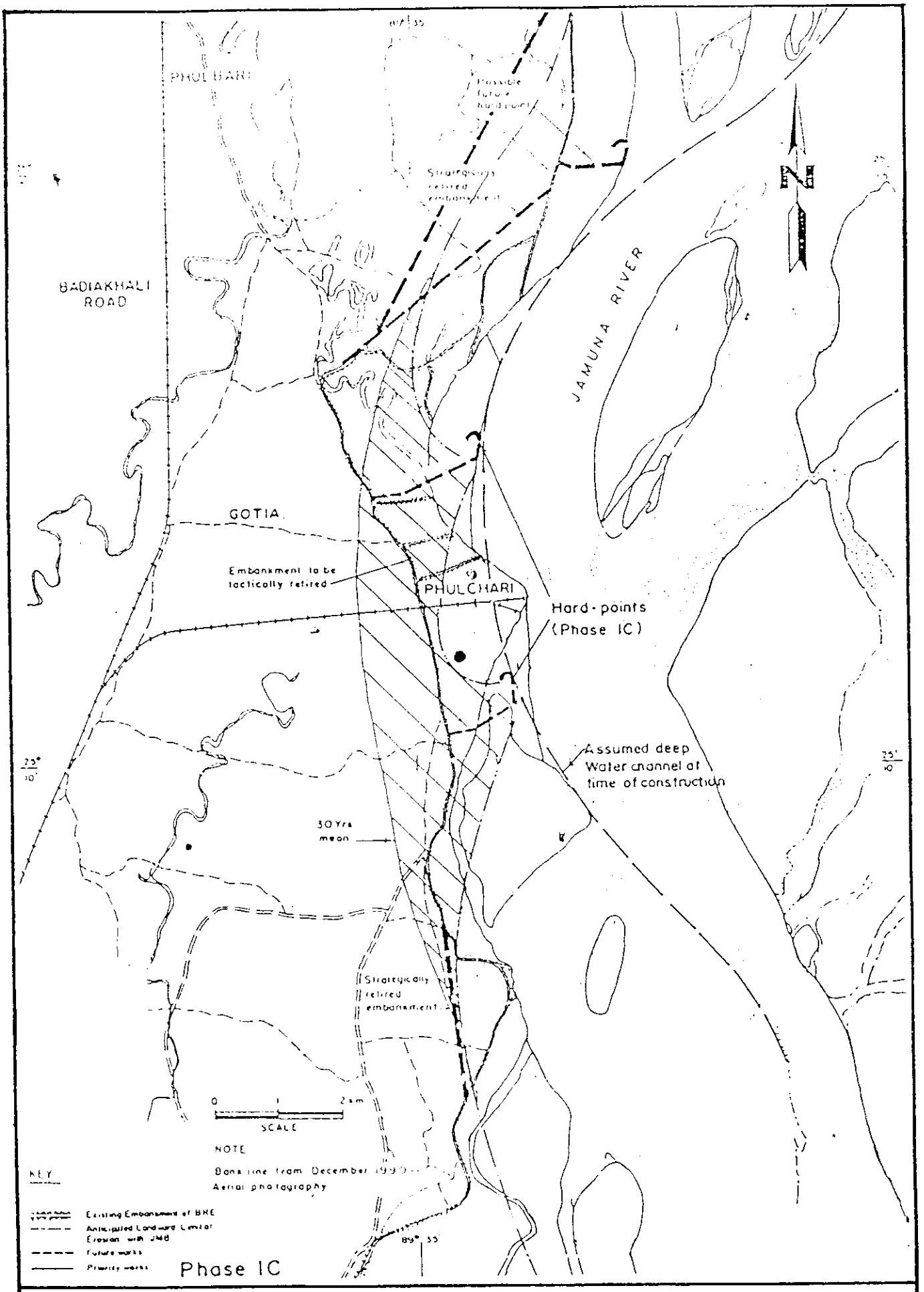
Figure : 4.3



Priority and Future Works at Sirajganj

(Source FAP 1, May 1993)

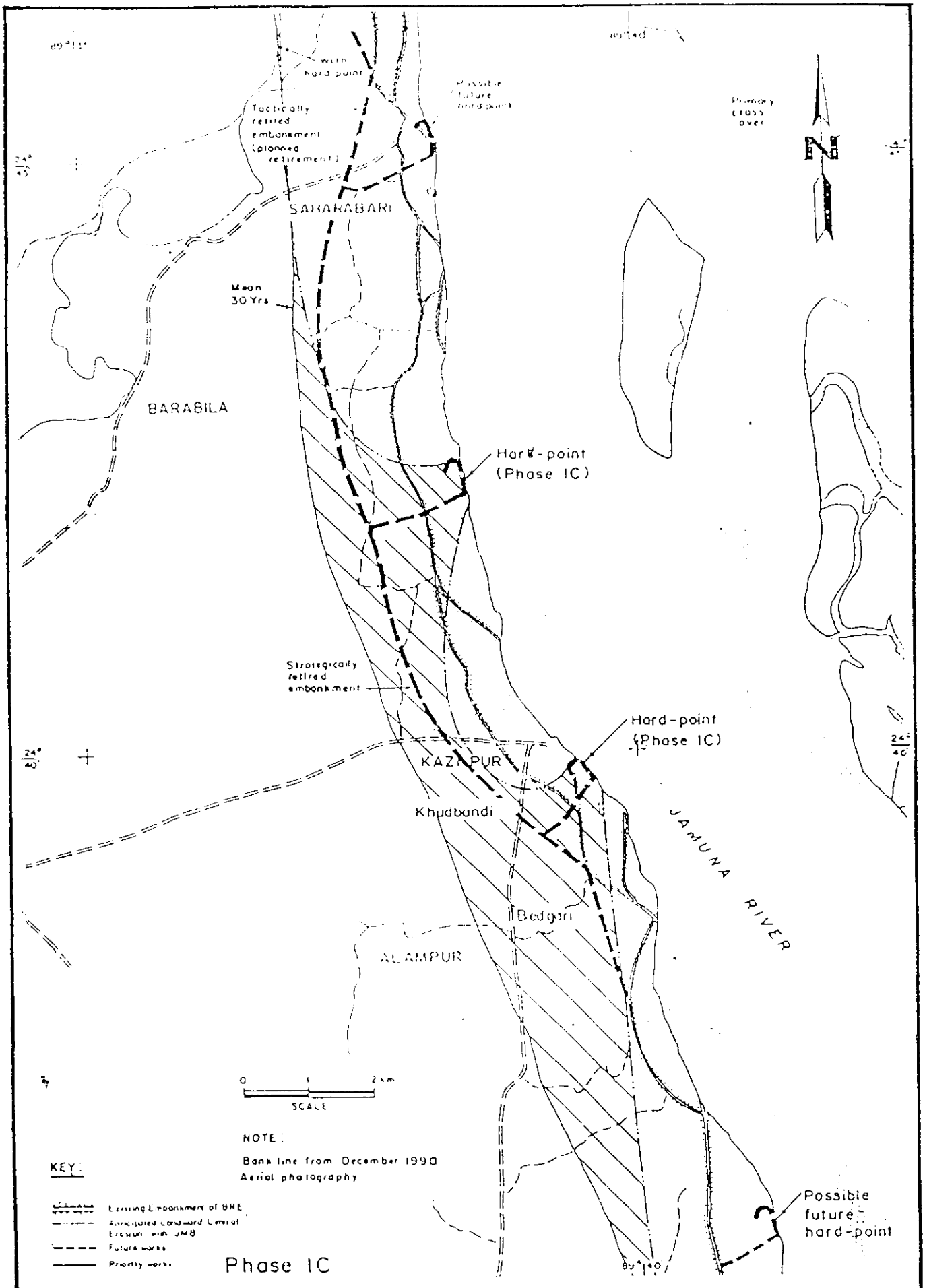
Figure : 4.4



Priority and Future Works at Fulchari

(Source FAP 1, May 1993)

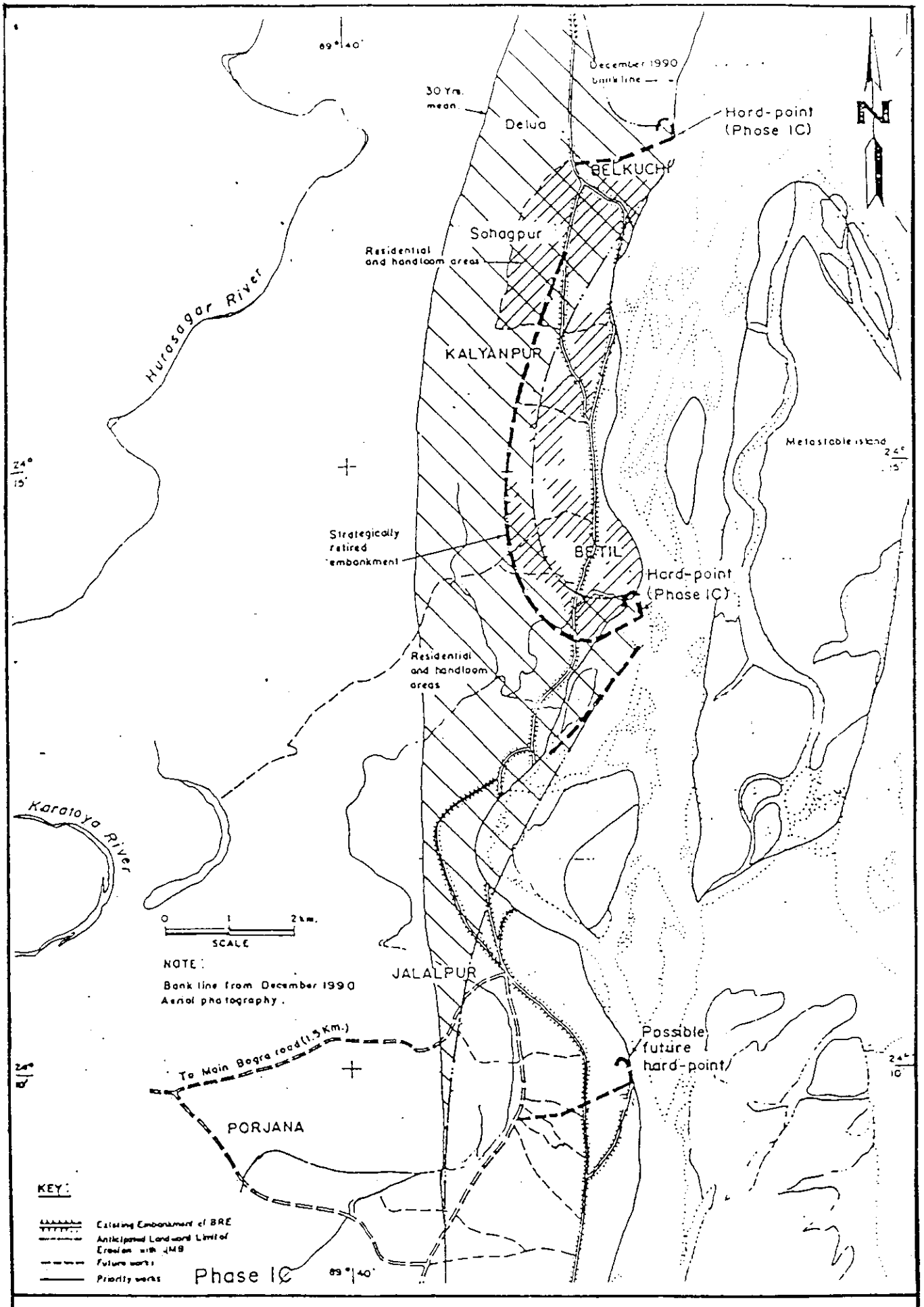
Figure : 4.5



Priority and Future Works at Kazipur

(Source FAP I, May 1993)

Figure : 4.6

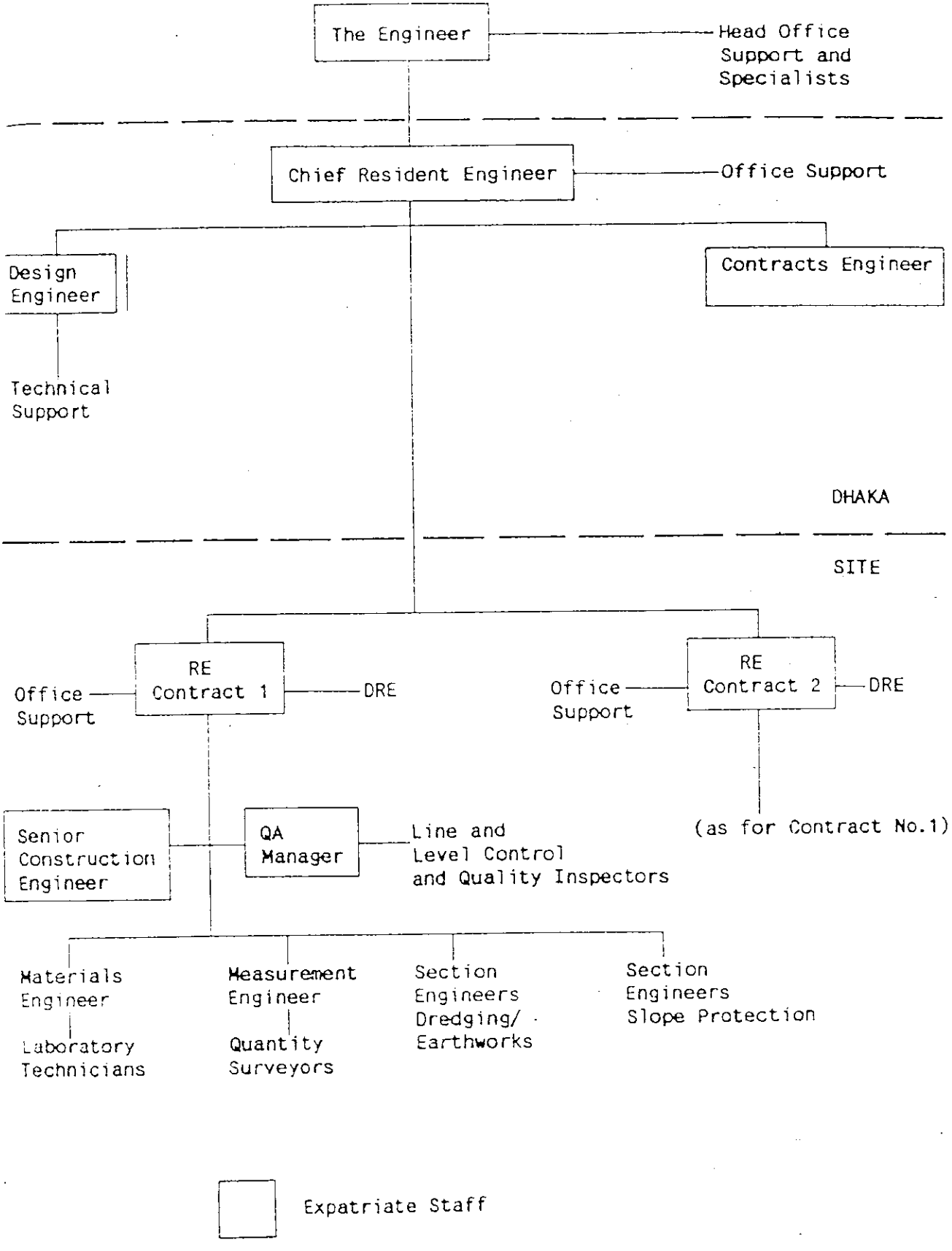


Priority and Future Works at Betil

(Source FAP 1, May 1993)

Figure : 4.7

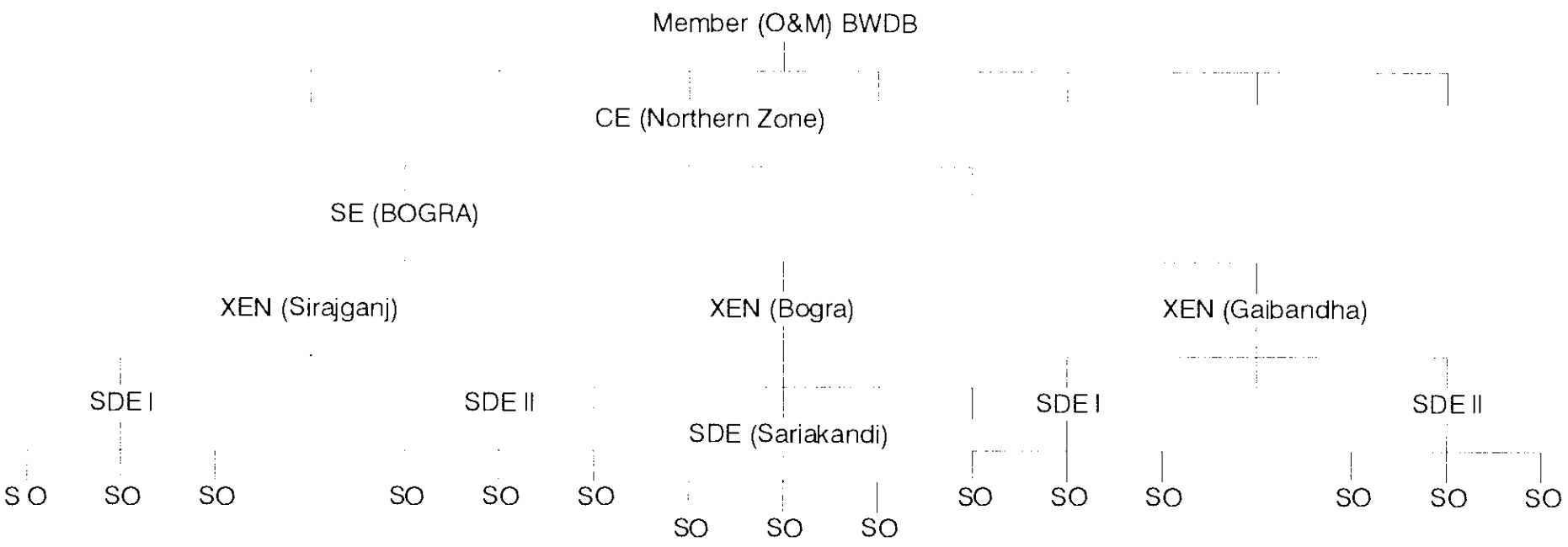
As proposed by FAP I for priority river training works



Construction Supervision: Staff Organogram

Figure :5

FIGURE 6 : ORGANISATION CHART FOR O&M OF THE BRE



LEGEND:

CE	:	CHIEF ENGINEER
XEN	:	EXECUTIVE ENGINEER
SDEI	:	SUB–DIVISIONAL ENGINEER
SDEII	:	SUB–DIVISIONAL ENGINEER
SO	:	SECTIONAL OFFICER

C:\WORK\CHART–O&M.WK1

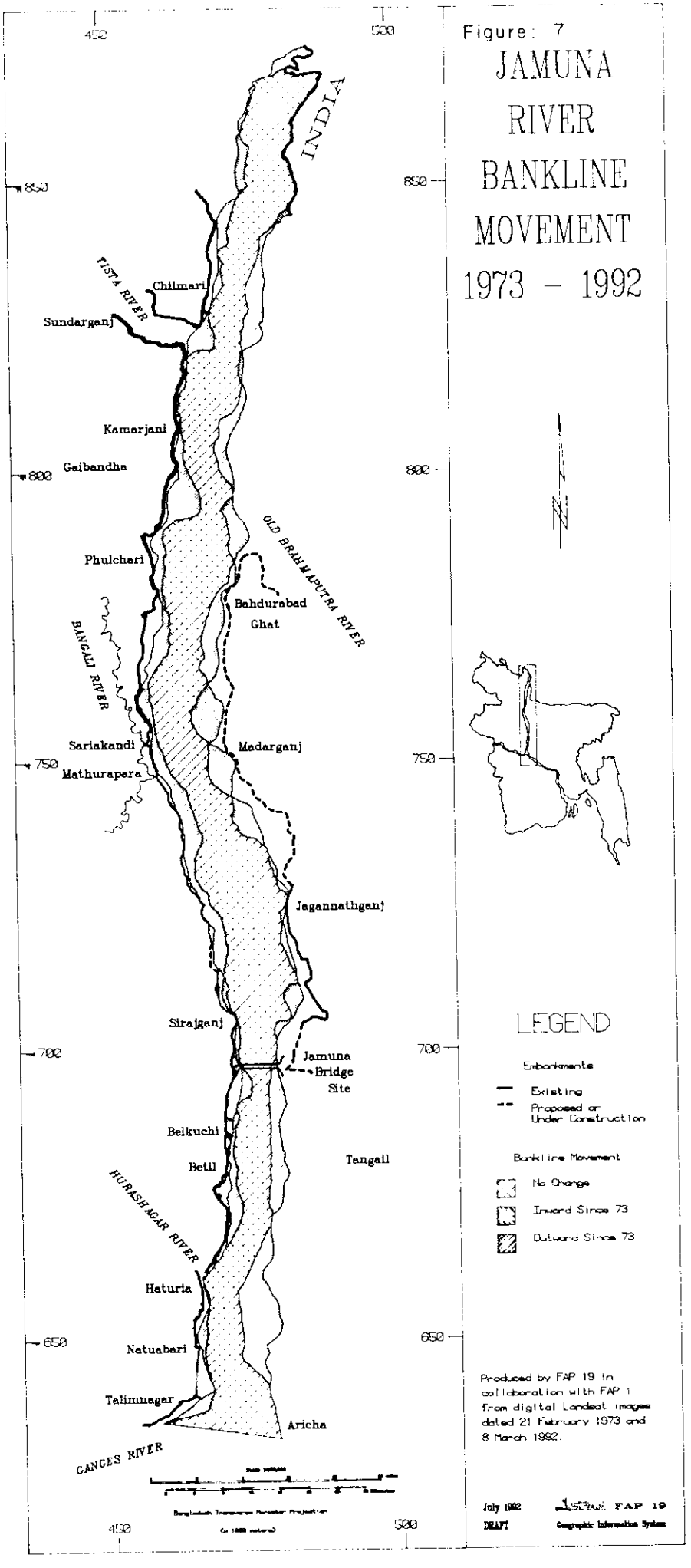


Figure: 7
JAMUNA
RIVER
BANKLINE
MOVEMENT
1973 – 1992
INDIA
TISTA RIVER
Chilmari
Sundarganj
Kamarjani
Gaibandha
OLD BRAHMAPUTRA RIVER
Phulchari
Bahdurabad
Ghat
BANGALI RIVER
Sariakandi
Madarganj
Mathurapara
Jagannathganj
Sirajganj
Jamuna
Bridge
Site
Belkuchi
Betil
Tangail
HURASHAGAR RIVER
Haturia
Natuabari
Talimnagar
Aricha
GANGES RIVER
LEGEND
Embankments
Existing
Proposed or
Under Construction
Bankline Movement
No Change
Inward Since 73
Outward Since 73
Produced by FAP 19 in
collaboration with FAP 1
from digital Landsat images
dated 21 February 1973 and
8 March 1992.
July 1992
DRAFT
FAP 19
Geographic Information System