GOVERNMENT OF PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF WATER RESOURCES
WATER RESOURCES PLANNING ORGANIZATION

FEDERAL REPUBLIC OF GERMANY

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WIEDERAUFBAU (KfW)

FRENCH REPUBLIC

CAISSE FRANCAISE DE
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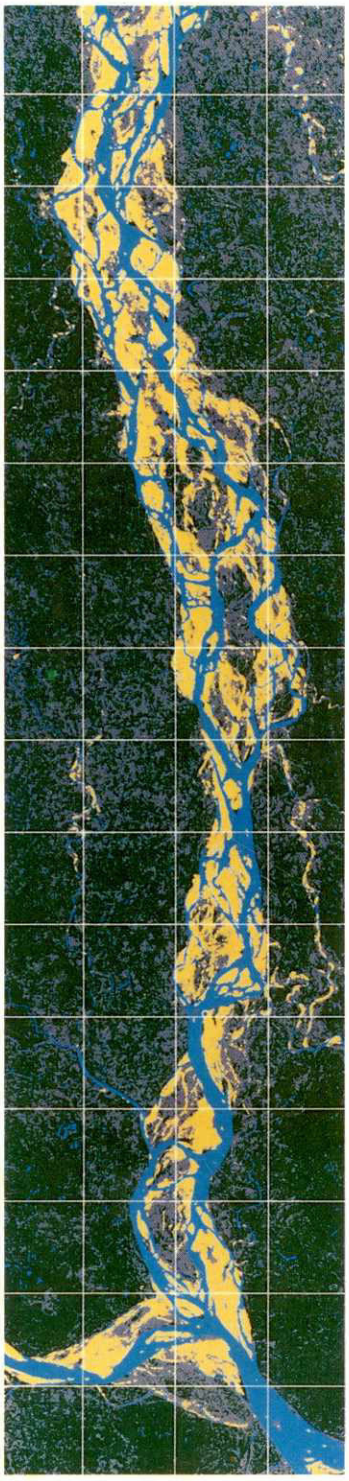

BANK PROTECTION AND RIVER TRAINING (AFPM) PILOT PROJECT FAP 21/22

TEST AND IMPLEMENTATION PHASE FAP 21

REPORT ON MONITORING AND ADAPTATION AT KAMARJANI TEST SITE

MONSOON 1999

MARCH 2001

JAMUNA TEST WORKS CONSULTANTS, JOINT VENTURE
CONSULTING CONSORTIUM FAP 21/22

RHEIN-RUHR ING.-GES.MBH, DORTMUND/GERMANY

COMPAGNIE NATIONALE DU RHONE, LYON/FRANCE
PROF.DR. LACKNER & PARTNERS, BREMEN/GERMANY
DELFT HYDRAULICS, DELFT/NETHERLANDS

In association with:

BANGLADESH ENGINEERING &
TECHNOLOGICAL SERVICES LTD. (BETS)
DESH UPODESH LIMITED (DUL)

BANK PROTECTION AND RIVER TRAINING
(AFPM) PILOT PROJECT
FAP 21/22

TEST AND IMPLEMENTATION PHASE
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FAP 21/22

REPORT ON MONITORING AND ADAPTATION AT KAMARJANI TEST SITE

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1 INTRODUCTION

1.1 BACKGROUND

The Bank Protection Pilot Project is component 21 of the Flood Action Plan (FAP). It is jointly financed by Germany and France and was awarded by the Flood Plan Coordination Organization (FPCO) represented by the Kreditanstalt für Wiederaufbau (KfW) to the joint venture Rhein-Ruhr Ingenieur-Gesellschaft mbH as lead partner, Compagnie Nationale du Rhône, Prof. Dr. Lackner & Partners and Delft Hydraulics in association with Bangladesh Engineering and Technological Services Ltd. (BETS) and Desh Upodesh Ltd. (DUL).

As per Terms of Reference the Consultancy Services are to be performed in two phases, a Planning Study Phase (Phase I) followed by a Test and Implementation Phase (Phase II).

After submission of the Draft Final Planning Study Report in January 1993 a joint mission of KfW and CFD has carried out the project appraisal to proceed into Phase II of the Project. The Mission agreed to the overall concept of Phase II proposed by the Consultant the essence of which is the construction of a combination of permeable and impermeable groynes and of various types of revetments at two different test sites in two successive seasons.

The Test and Implementation Phase started on June 01, 1993 after the "Letter to Proceed" had been issued by FPCO on May 15, 1993.

The final design of the Groyne Test Structure at Kamarjani Test Site began in September 1993 and was finalised in February 1994 based on the preliminary design and construction methods of the Planning Study, supplemented by additional studies and investigations viz. morphological studies, geotechnical investigations, physical model tests in Bangladesh and France as well as topographic and hydrographic survey. The actual construction works started at the beginning of October 1994 and were substantially completed during the month of April 1995.

1.2 OBJECTIVES OF THE PROJECT

The objectives of the Project are to find improved solutions for bank protection works against erosion by designing, specifying and constructing different types of groynes and revetments using different materials and protective layers and investigating at the same time the suitability of local materials and construction methods. After construction of the test structures their behaviour is to be monitored for a period of at least three years. The final objective is to develop and optimise design criteria, cost-effective construction and maintenance methods, which shall serve as future standards, most appropriate for the prevailing conditions at the Brahmaputra/Jamuna and other rivers of Bangladesh. Hence, the test structures were to be designed in such a way and with such a level of safety that certain damages of the structures are allowed, are even required, because a test work which does not suffer any damage in the course of the monitoring and adaptation period may be oversized and therefore not be suitable to identify the limits and to develop new standards.

To achieve the above objectives, regular monitoring of the test structures is a must after their completion as well as preventive maintenance and adaptation of the structures taking into account the results and observations of each monitoring period. For the development of suitable adaptation measures, however, further studies and investigations are possibly required.

2 THE STRUCTURE

2.1 DESCRIPTION OF THE GROYNE TEST STRUCTURE

The test structure as per original design of 1993/94 comprised 6 groynes each of them a combination of an impermeable and a permeable section with increasing permeability towards the river. Three groynes (G-1 to G-3) were partly constructed off-shore and on-shore while the other ones G-B1, G-B2 and G-A were built on the flood plain. All six structures launch from and were built against an embankment constructed under the authority of the Bangladesh Water Development Board (BWDB) (see Fig. 2.1).

The main components of the groyne test field are the groynes G-1 to G-3, whereas G-B1, G-B2 and G-A, which were built upstream and downstream respectively from the main groynes are intended to supplement the functioning and effects of the latter in the coming years.

A detailed description of the test structure is given in the "Report on Monitoring and Adaptation" of September 1996.

2.2 DAMAGES

2.2.1 Damages during the Monsoon 1995

The structure was "tested" by the river for the first time during the flood season 1995, which was marked by five flood peaks of which three represented events with more than 10 years re-occurrence and a maximum water level on July 10, 1995 corresponding to a situation of about 25 years re-occurrence.

The first four flood peaks contributed to three major damage events within the test site area:

- destruction of the impermeable groyne head of groyne G-2 and loss of piles of the permeable section;
- breach of the main embankment about 80 m downstream from groyne G-2, and
- collapsing of the impermeable part of groyne G-3 at the downstream side and destruction of the impermeable groyne head.

For details reference is made to the "Report on Monitoring and Adaptation" of September 1996.

2.2.2 Damages during the Monsoon 1996

No damages to the individual groynes had been observed throughout the entire monsoon season 1996. Only the water sided slope of the main embankment above the berm at 21.0 m+PWD between groyne G-1 and G-2 as well as between G-2 and G-3, which was protected up to the crest at 23.50 m+PWD by Durba grass sods on Geo-jute soil saver, was damaged by wave action.

Moreover, during heavy rainfall in September and October 1996 the crest and the land sided slope of the main embankment were damaged by rain cuts. For details reference is made to the "Report on Monitoring and Adaptation" of September 1998.

2.2.3 Damages during the Monsoon 1997

Throughout the entire monsoon season 1997 no damages to the individual groynes and the embankment, from which they launch, have been observed.

The first half of the year was characterised by minor morphological changes of the riverbed in the test field area due to the char in front of the test structure. However, downstream from the test site in the area of Rasulpur and Syedpur severe bank erosion occurred.

The char in front of the test structure extended further southwards resulting in shifting of the main channel direction from west to south-west. The bathymetric surveys show the changes from 255° in May to 225° in July and 195° in August. The flow attack and bank erosion moved to the south concentrating in July on the area between Syedpur and Balashi Ghat, where flow velocities of 2.5 m/s were measured.

The southward extension of the opposite char continued also during the month of August, whereas the narrow channel just in front of the test structure continuously reduced its width and depth at the same time. It started to dry up in October and this process was completed in November, when no flow was observed. Moreover, the importance of the cut-off channel opposite the test site increased significantly in August.

North of Kharjani char a mid channel bar developed, which caused a movement of the main Kamarjani channel to the west and in November the Kamarjani channel divided into two channels, the western one of which was more dominant.

In the outer bend channel between Syedpur and Balashi Ghat severe erosion was observed and end of December 1997 also the last downstream groyne of the Kamarjani Test Structure came under attack again.

2.2.4 Damages during the Monsoon 1998

Although the situation at the test site during the third quarter of the year was characterised by exceptional high water levels, which remained from beginning of July till September 08 above 21.40 m+PWD, no damages to the individual groynes and the embankment from which they launch have been observed during the entire monsoon season 1998.

The maximum scour depths downstream from groyne G-1 and G-2 were about 10 m in July and 7 m in August 1998.

However, more or less severe bank erosion continued in the outer bend channel between the test structure and Balashi Ghat throughout the whole year. From February 1998 till end of 1998 a maximum erosion of about 300 m occurred in the area of Rasulpur.

2.3 ADAPTATION WORKS

The initial findings of causes of damages in 1995 and the results of additional physical model tests performed in November/December 1995 at the River Research Institute at Faridpur had identified improvement and adaptation measures, which had to fulfil mainly the following conditions:

- to substantially reduce the magnitude of return currents and vortices within the groyne field in particular along the main embankment, and

- to further limit the development of severe return currents, turbulence and vortices.

For the design of adaptation and repair measures, the design parameters as per original design of the groyne structure were being maintained. Only the downstream part of the impermeable groyne heads received substantially increased launching aprons.

Since the main river attack during the monsoon season 1996 was expected downstream from groyne G-A threatening the main embankment near the Manos river estuary, it was decided to provide a new supplementary groyne G-A/2 about 200 m downstream from G-A.

The main adaptation and repair measures during the dry season 1995/96 were as follows:

- relocation of the main embankment starting about 30 m downstream from groyne G-1 up to about 150 m downstream from groyne G-3. The retired embankment is now 20 m behind the original one between groyne G-1 and G-2 and 50 m between groyne G-2 and G-3;
- slope protection by cc-blocks/boulders at the head of the steel sheet pile cofferdam of groyne G-1;
- driving of 44 Nos. tubular steel piles dia. 711 mm between the existing pile structure of groyne G-3 and the retired main embankment after removal of the remaining part of the impermeable groyne section;
- toe-protection of the retired embankment by cc-blocks upstream and downstream from the pile structure of groyne G-3;
- pile Nos. 21 to 24 (tubular steel piles Ø 711 mm) of groyne G-A were extended by 4.5 m and re-driven. Moreover, the pile structure was extended to the river side by 3 additional tubular steel piles Ø 1016 mm. Since 5 Nos. of totally 12 Nos. bored piles Ø 914 mm got lost during and after the monsoon season 1995 a row of additional 9 Nos. tubular steel piles Ø 711 mm have been installed 2.5 m upstream from the bored piles. The total length of the pile structure is now about 78 m;
- the new groyne G-A/2 consists of 20 Nos. bored piles Ø 914 mm and 14 Nos. tubular steel piles Ø 711 mm. The total length of the groyne is about 92 m from the centre of the main embankment;
- the river-sided slope of the retired embankment was protected between groyne G-1 and G-2 up to a level of 21.0 m+PWD by brick-mattresses and above up to the crest at 23.50 m+PWD by Durba grass sods on Geo-jute soil saver. The same holds for the section between groyne G-2 and G-3. Downstream from groyne G-3, between groyne G-A and G-A/2 as well as downstream from groyne G-A/2 the brick-mattresses are up to the crest of the embankment;

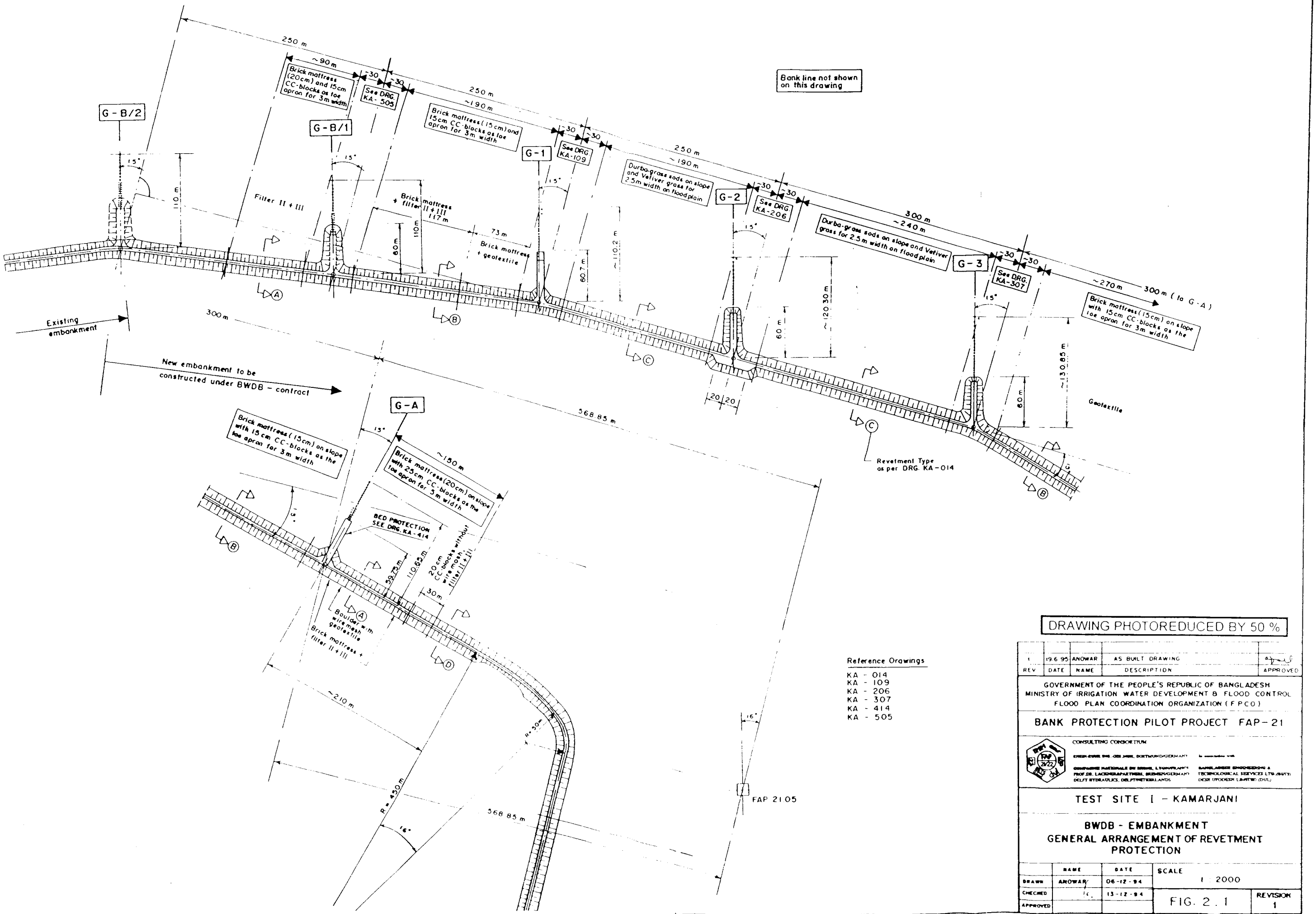
During the dry season 1996/97 the following adaptation and repair measures were carried out:

- replacement of grass sod protection in all areas by brick mattresses on geotextile filter up to the crest of the main embankment;
- repair of the crest and land sided slope of the main embankment, and
- driving of 23 Nos. steel piles Ø 711 mm and 32 m length at groyne G-2.

During the dry season 1997/98 the adaptation and repair works, which were required after the monsoon 1995, were completed by the construction of 12 Nos. reinforced in-situ concrete piles between the toe of the relocated main embankment and the pile structure of groyne G-2.

No adaptation and repair works were required after the monsoon season 1998.

The general layout of the test structure after execution of adaptation and repair works is shown in Fig. 2.2.



DRAWING PHOTOREDUCED BY 50 %

REV	DATE	NAME	DESCRIPTION	APPROVED
1	19.6.95	ANOWAR	AS BUILT DRAWING	

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL
FLOOD PLAN COORDINATION ORGANIZATION (F P C O)

BANK PROTECTION PILOT PROJECT FAP-21

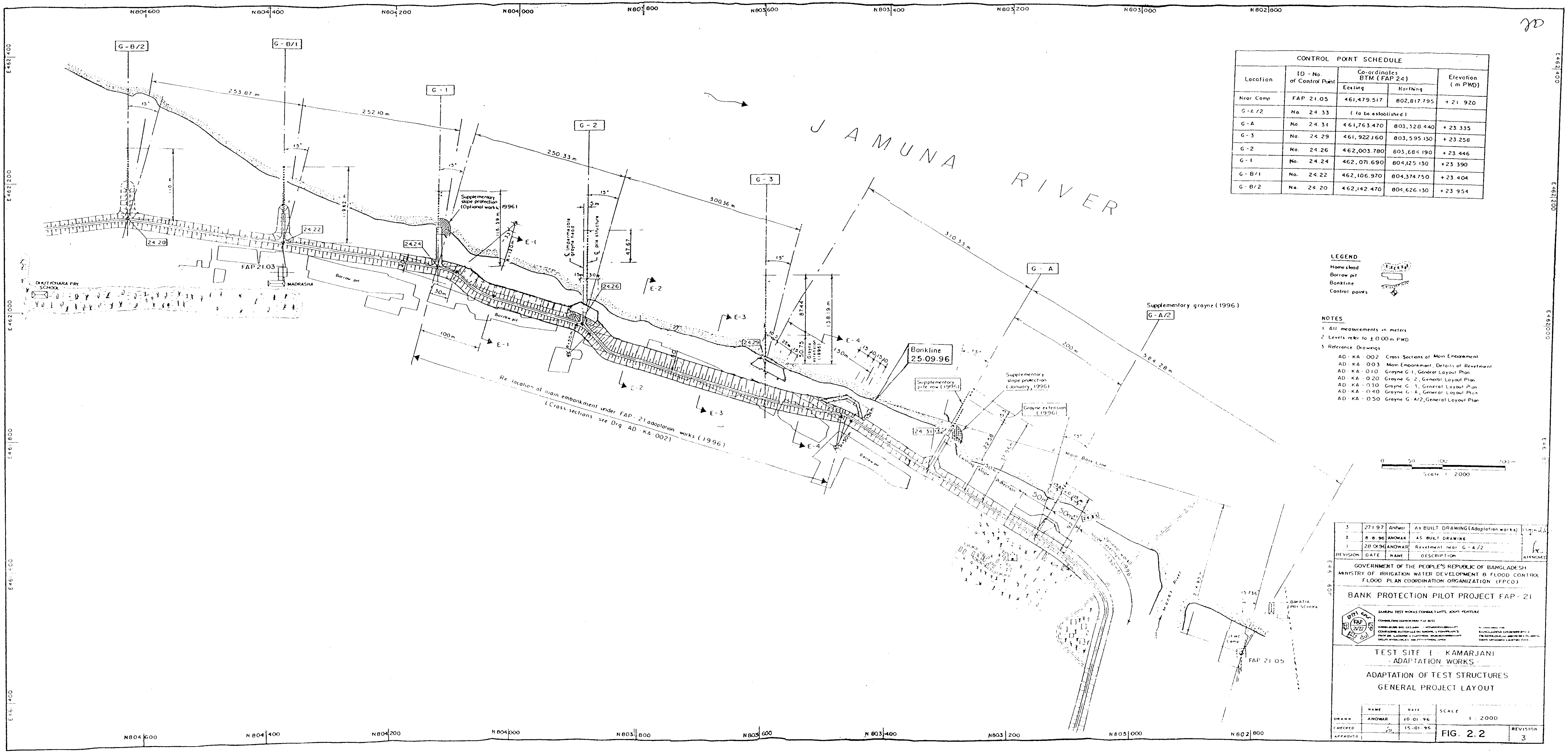
CONSULTING CONSORTIUM

PROF.DR. LACHMEIJER AACHEN, GERMANY — DELFT HYDRAULICS, DELFT, NETHERLANDS — BANGLADESH ENGINEERING & TECHNOLOGICAL SERVICES LTD. (BETS) — DESH UPODESH LIMITED (DUL)

TEST SITE I - KAMARJANI

BWDB - EMBANKMENT
GENERAL ARRANGEMENT OF REVETMENT PROTECTION

	NAME	DATE	SCALE
DRAWN	ANOWAR	06-12-94	1 2000
CHECKED		13-12-94	FIG. 2.1
APPROVED			REVISION 1



CONTROL POINT SCHEDULE				
Location	ID - No. of Control Point	Co-ordinates BTM (FAP 24) Easting	Northing	Elevation (m PWD)
Near Camp	FAP 21.05	461,479.517	802,817.795	+ 21 920
G - A/2	No. 24.33	(to be established)		
G - A	No. 24.31	461,763.470	803,328.440	+ 23.335
G - 3	No. 24.29	461,922.160	803,595.130	+ 23.258
G - 2	No. 24.26	462,003.780	603,684 190	+ 23.446
G - 1	No. 24.24	462,071.690	804,125.130	+ 23.390
G - B/1	No. 24.22	462,106.970	804,374.750	+ 23.404
G - B/2	No. 24.20	462,142.470	804,626.130	+ 23 954

LEGEND

- Homestead
- Borrow pit
- Bankline
- Control points

NOTES

1. All measurements in meters
2. Levels refer to ± 0.00 m PWD
3. Reference Drawings
   - AD - KA - 002 Cross-Sections of Main Embankment
   - AD - KA - 003 Main Embankment, Details of Revetment
   - AD - KA - 010 Groyne G-1, General Layout Plan
   - AD - KA - 020 Groyne G-2, General Layout Plan
   - AD - KA - 030 Groyne G-3, General Layout Plan
   - AD - KA - 040 Groyne G-A, General Layout Plan
   - AD - KA - 050 Groyne G-A/2, General Layout Plan

Scale 1 : 2000

REVISION	DATE	NAME	DESCRIPTION	APPROVED
3	27.1.97	Anowar	AS BUILT DRAWING (Adaptation works)	
2	8.8.96	ANOWAR	AS BUILT DRAWING	
1	28.01.96	ANOWAR	Revetment near G - A/2	

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL
FLOOD PLAN COORDINATION ORGANIZATION (FPCO)

BANK PROTECTION PILOT PROJECT FAP - 21

JAMUNA TEST WORKS CONSULTANTS, JOINT VENTURE

TEST SITE I · KAMARJANI
- ADAPTATION WORKS -

ADAPTATION OF TEST STRUCTURES
GENERAL PROJECT LAYOUT

	NAME	DATE	SCALE
DRAWN	ANOWAR	10-01-96	1 : 2000
CHECKED		15-01-96	FIG. 2.2
APPROVED			REVISION 3

3 MONITORING OF THE TEST STRUCTURE

3.1 GENERAL

Since the final objective of this pilot project is to develop and optimise design criteria, cost-effective construction and maintenance methods, which will serve as future standards appropriate for the prevailing conditions at the Jamuna and other rivers of Bangladesh, regular monitoring of the structures after their completion till end of the project is one of the focal points of this pilot project.

Monitoring of the works undertaken at the test sites shall help to

- detect damages at an early stage;
- understand failing mechanisms, and
- plan suitable adaptation/repair works.

However, monitoring does not only refer to detecting damages of the structure but to observe their behaviour under load and to relate the loads to the structure's response. This requires on the one hand to monitor the loads (especially flow velocities, wave action etc.) and on the other hand to adapt the design rules. After adapting the design rules and the design, the works are to be adapted accordingly. Hence, the requirements of monitoring are to take care of the structures features as well as on the loads and natural effects, which may influence the structures. Records are therefore to be taken of

- the natural conditions acting at the structures (water level rise and fall, waves, currents, wind, precipitation etc.);
- the morphological changes of the river in the area of the test structures;
- the movements of structures and important structural parts in vertical and horizontal direction;
- the deterioration of materials used;
- the variations of the surrounding riverbed and bankline, and
- any damage by human and/or animal action.

Thereby it is of utmost importance for drawing right conclusions to record the above information with respect to

- exact location (referred to fixed points established in the hinterland);
- exact time of occurrence/survey;
- method of recording and equipment used;
- staff involved, and
- special observations etc.

All observations and data are entered in a Logbook developed for this particular purpose, which at the same time serve as a checklist for completeness of monitoring. Besides the results of regular hydrographic surveys, the Logbook is a basis for evaluation and selection of necessary measures to be taken. The Logbook and associated records enable to keep a continuous record of events showing the development of failure mechanisms and interrelation with acting forces.

Apart from daily routine observations, regular and periodic inspection programmes are carried out for each and every subject. However, time intervals have to be shortened in case deterioration is expected to increase not in line with the expectations and linear but at an accelerated pace. Additional inspections are required after extraordinary loading conditions, accidents etc.

The monitoring activities are subdivided into two main categories:

- survey of the properties and the behaviour of the structures, and
- reference measurements of physical phenomena that produce the loads on the structure.

The survey carried out under the monitoring programme is as follows:
- logbook of activities and daily observations;
- priority/alert information to FAP 21, Dhaka;
- bathymetric surveys and recording;
- water level recordings;
- wind and wave recordings;
- current measurements;
- flow direction measurements;
- topographic measurements;
- bankline surveys;
- groyne alignment, pile position;
- meteorological measurements;
- test pile recordings;
- floating debris at groynes;
- visual wave observations;
- site processing quality control of data;
- data transfer to FAP 21, Dhaka, and
- detailed damage surveys during/after the flood period.

Final quality control of site data, final processing, presentation and evaluation is done in the office in Dhaka. The tasks are the following:
- quality control of field monitoring;
- final processing/presentation of survey results;
- determination/confirmation of priority/alert situation;
- initiation of emergency measures;
- statistical evaluation of wind/wave records;
- evaluation of water level recordings;
- evaluation of current measurements;
- comparison of results with applied design criteria, and
- comprehensive annual report on results of field monitoring.

The organisation of the monitoring activities and adaptation of works have been explained in more detail in the "Report on Monitoring and Adaptation" of September 1996.

3.2 MONITORNG DURING THE MONSOON PERIOD 1999

3.2.1 Preliminary Remarks

During the dry season 1998/99 and the monsoon season 1999 the monitoring activities at Kamarjani Test Site were performed following the programme described in Section 3.1. Summaries of all activities have been reported in monthly monitoring reports. The progress of the whole project including the main results and observations of monitoring is reported in quarterly progress reports. In 1999 progress reports No. 23 to 26 have been published.

3.2.2 Bathymetry

Bathymetry surveys were done regularly to detect and record planform and riverbed changes and their influence on the stability of the test structure. The activities during the months of June to December 1999 are shown in Table 3.1.

The results of the main surveys from July to December are presented in Annex B and some differential models in Annex C.

3.2.3 Topographic Measurements

The topographic measurements were done by using **E**lectronic **D**istance **M**easurement (EDM) equipment and levelling instrument. During the period from June to December the following works were performed:

26/04	bankline from Syedpur to Balashi Ghat
28/05	bankline from Syedpur to Balashi Ghat
29/05	waterline at Kharjani and Batkamari chars
04/06	water level gauge at G-A shifted and zero value measured at 19.48 m + PWD
13/06	water level gauge at G-A shifted and zero value measured at 18.23 m + PWD
25/06	water level gauge at G-A shifted and zero value measured at 19.50 m + PWD
27/06	water level gauge at G-A shifted and zero value measured at 20.72 m + PWD
17/07	water level gauge at G-A shifted and zero value measured at 19.41 m + PWD
20/07	water level gauge at G-A shifted and zero value measured at 20.51 m + PWD
24-28/07	installation of new benchmarks at Kamarjani Bazar, Rasulpur and Kundarapara char
29/09	bankline from groyne G-3 to Syedpur, char survey in front of the mouth of the Manos river
30/09	bankline from Syedpur to Balashi Ghat
02/10	bankline from 1.0 km upstream from Kamarjani Bazar to 2.2 km downstream from the test structure
02/10	char in front of the test structure
23/10	char in front of the test structure and further upstream
24/10	bankline from 2.0 km upstream to 1.0 km downstream from Kamarjani Bazar
29/11	water level gauge at G-A shifted and zero value measured at 15.12 m+PWD
20/12	water level gauge at G-A shifted and zero value measured at 14.33 m+PWD
22/12	char in front of the test structure
23/12	char in front of the test structure and at Kundarapara

3.2.4 Measurement by the Monitoring System

The monitoring system is located at groyne G-2 and recording water level information, wave heights and periods, test pile inclination and acceleration, wind speed and direction as well as other meteorological data like temperature, precipitation and relative humidity. Data are shown in the monthly reports on monitoring of the test structures.

3.2.5 Measurement of Flow Velocity and Direction

Float track measurements were continued as well as measurements with the Valeport currentmeter. Results are presented in the monthly reports on monitoring of the test structures and in Annex B.

Date	Survey Area						
	June 1999	July 1999	August 1999	September 1999	October 1999	November 1999	December 1999
01		main survey					
02		main survey					
03		main survey					
04		main survey					
05		main survey					
06		main survey					
07							
08							
09							
10							
11							
12							
13							
14							
15							
16							main survey
17					main survey		main survey
18			main survey		main survey		main survey
19			main survey		main survey	main survey	
20			main survey		main survey	main survey	
21			main survey			main survey	
22			main survey			main survey	
23			main survey	main survey		main survey	
24				main survey			
25				main survey			
26				main survey			
27				main survey			
28				main survey			
29							
30							
31							

Table 3.1: Bathymetric survey at Kamarjani Test Site from June to December 1999

3.2.6 Observations

At the beginning of 1999 the water level was measured at 15.41 m+PWD, but continued to drop till mid March. The minimum was recorded at 14.62 m+PWD on March 16 and 17. Till end of March the seasonal rise, which is usually expected to start at about March 20, did not appear. Only on April 10 the water level started significantly to rise and a first peak was recorded on May 08 at 18.61 m+PWD. After a drop of 1.5 m within a fortnight, a sharp rise of 3.36 m within 11 days was observed with a peak at 20.47 m+PWD on June 05.

The third peak water level in 1999 was measured on July 05 at 21.67 m+PWD. Thereafter the water level dropped for more than one month and the minimum was recorded on August 09 at 19.83 m+PWD, which was close to the minimum of the frequency curve for the period 1957 to 1997. The highest water level of the 1999 monsoon flood was observed on August 27 at 21.74 m+PWD followed by a fall of the water level till October 08, when a minimum of 18.81 m+PWD was measured. After that a continuous drop was observed and at the end of 1999 the water level was at 15.32 m+PWD.

The following observations have been recorded for the period June to December 1999:

01 to 30/06	slow bank erosion from Rasulpur to Balashi Ghat
04 to 17/06	considerable amount of floating debris stuck into the groynes. A maximum volume of 60 m x 20 m x 05 m stuck into groyne G-2 on June 06
25 to 30/06	less amount of floating debris stuck into the groynes
01 to 31/07	no significant floating debris at groyne field
01/07	rainfall of 93 mm from 8:00 hrs. on 01/07 to 8:00 hrs. 02/07
05/07	severe bank erosion from Kamarjani Bazar to approximately 1.5 km downstream observed
10/07	bank erosion at Kamarjani Bazar towards downstream continued
18/07	rainfall of 84 mm recorded from 8:00 hrs. on 18/07 to 8:00 hrs. on 19/07
19/07	rainfall of 167 mm recorded from 8:00 hrs. on 19/07 to 8:00 hrs. on 20/07
26/07	the Kundarapara channel entrance much wider open in comparison to last year
21 to 25/08	severe bank erosion in the area of Kamarjani Bazar.

4 MORPHOLOGICAL DEVELOPMENT AT KAMRAJANI IN 1999

No significant flow was measured at the groyne field during the monsoon season 1999. Thus the bankline in the groyne field and just upstream from it remained stable throughout the whole year. Slow bank erosion downstream from the test structure in the area from Rasulpur to Balashi Ghat continued even in the dry season and intensified during the monsoon. Severe bank erosion, which had started during the monsoon season 1998 about 4 km upstream from the groyne field at Kamarjani Bazar, continued in 1999, ceased in October followed by a sedimentation process in the following months. Sedimentation was also observed in the area of the month of the Ghagot river and upstream from Rasulpur in November and December 1999.

In August the Kundarapara channel started to shift to the west. It conveyed about 52 % of the total discharge, whereas about 48 % ran along the Kamarjani channel. The relevant figures at the end of the year were 58 % and 42 % respectively. These figures show that the Kundarapara channel became more dominant in 1999.

5 STRUCTURE OBSERVATIONS - DAMAGES

During the flood season 1999 no damages of the test structure have been observed.

6 ADAPTATION AND REPAIR WORKS

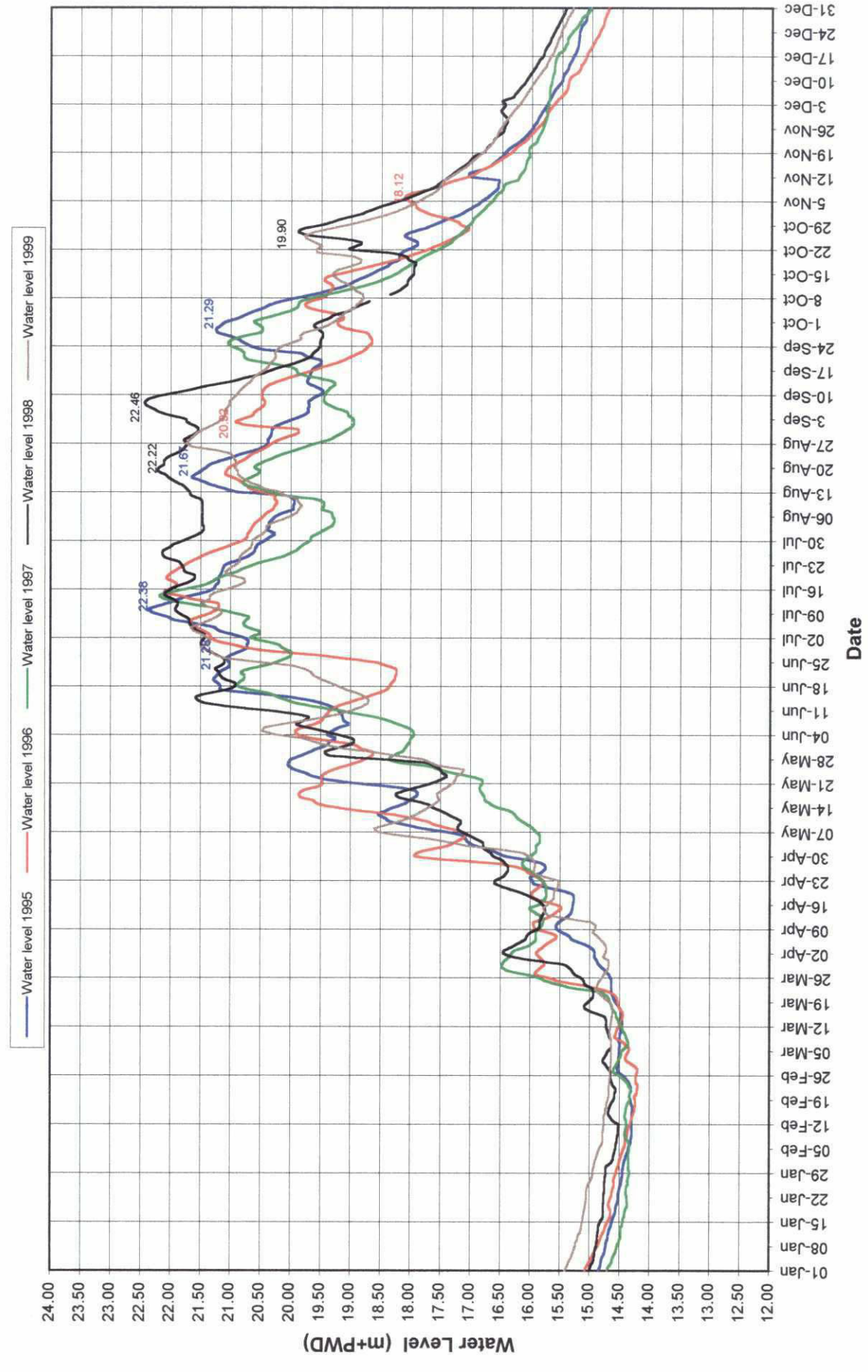
No adaptation or repair works of the test structure have been carried out in 1999.

ANNEX A

Water Level

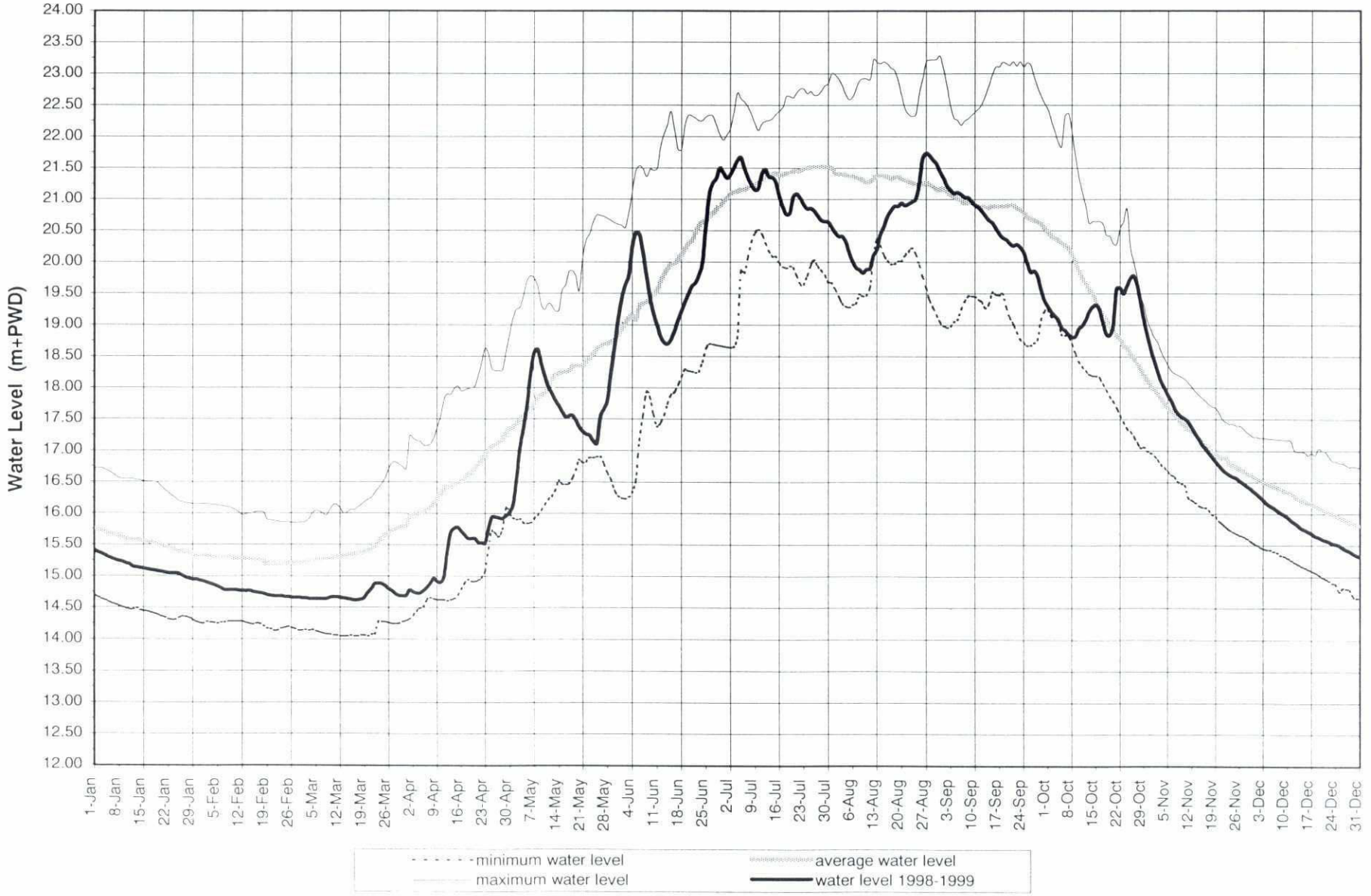
20

BANK PROTECTION TEST STRUCTURES - FAP 21
WATER LEVEL AT KAMARJANI TEST SITE
(January to December)



BANK PROTECTION TEST STRUCTURES - FAP 21

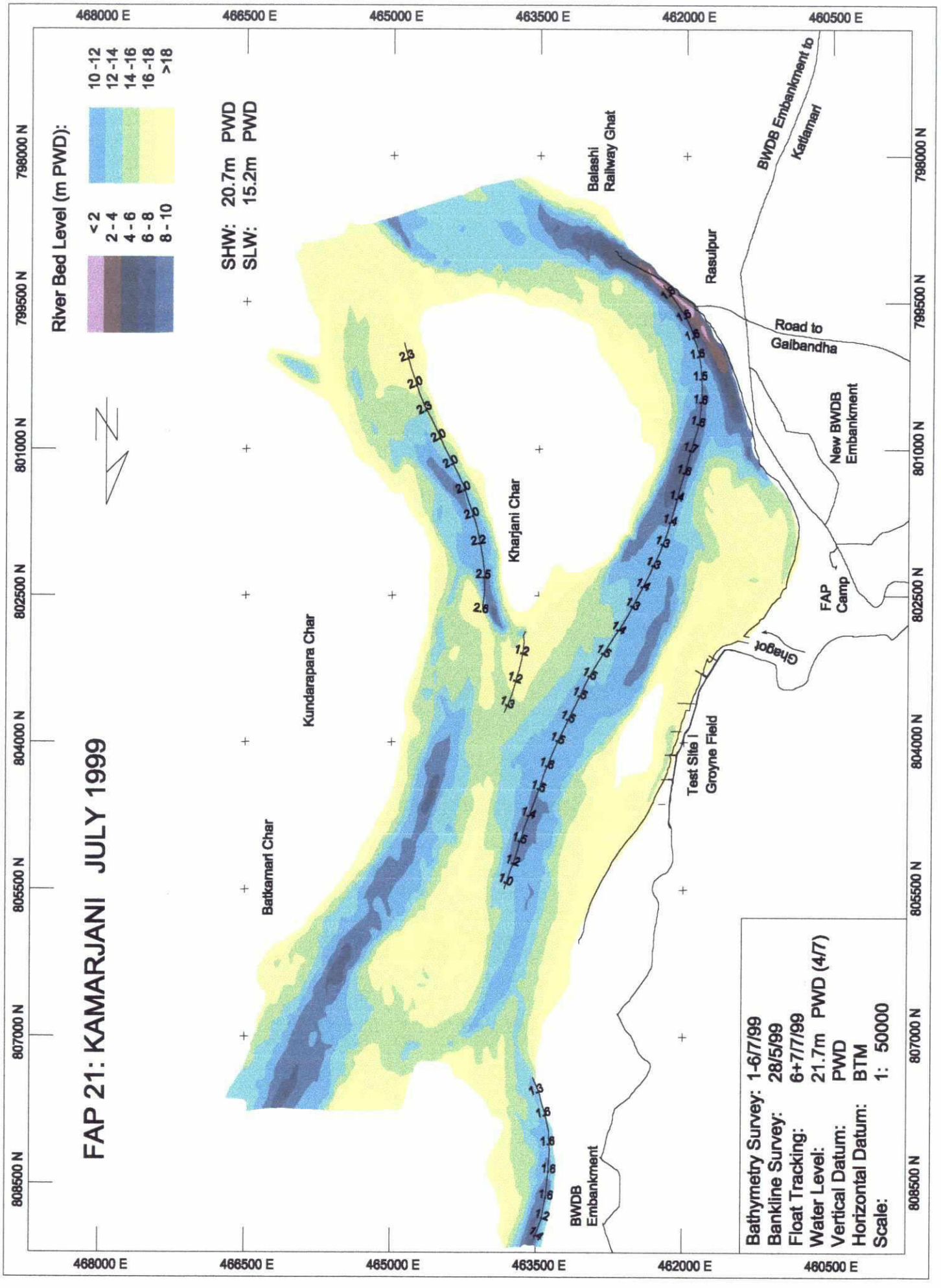
BWDB WATER LEVEL FREQUENCY CURVES VERSUS ACTUAL FAP 21 WATER LEVEL AT KAMARJANI TEST SITE UP TO DECEMBER '99

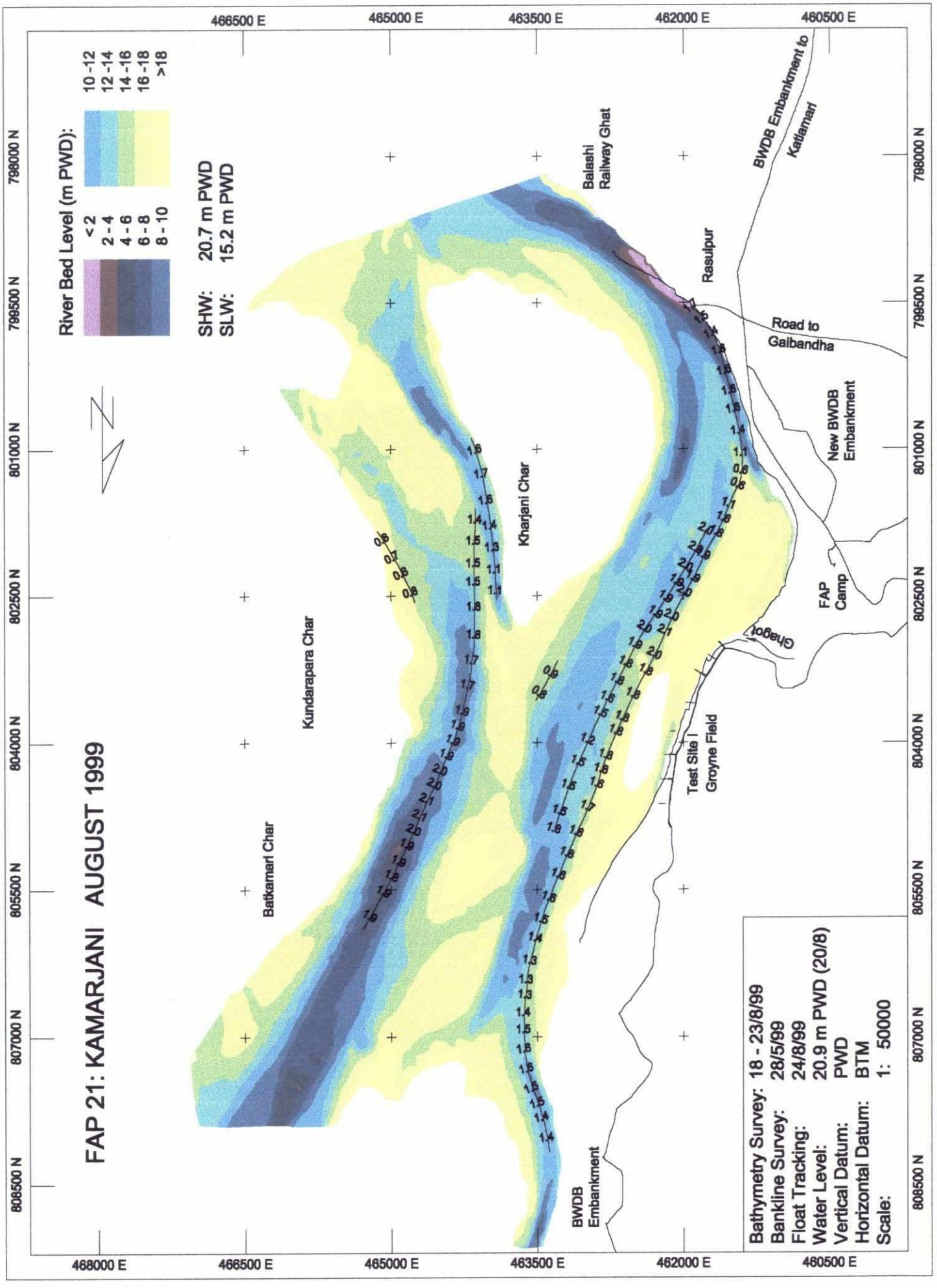


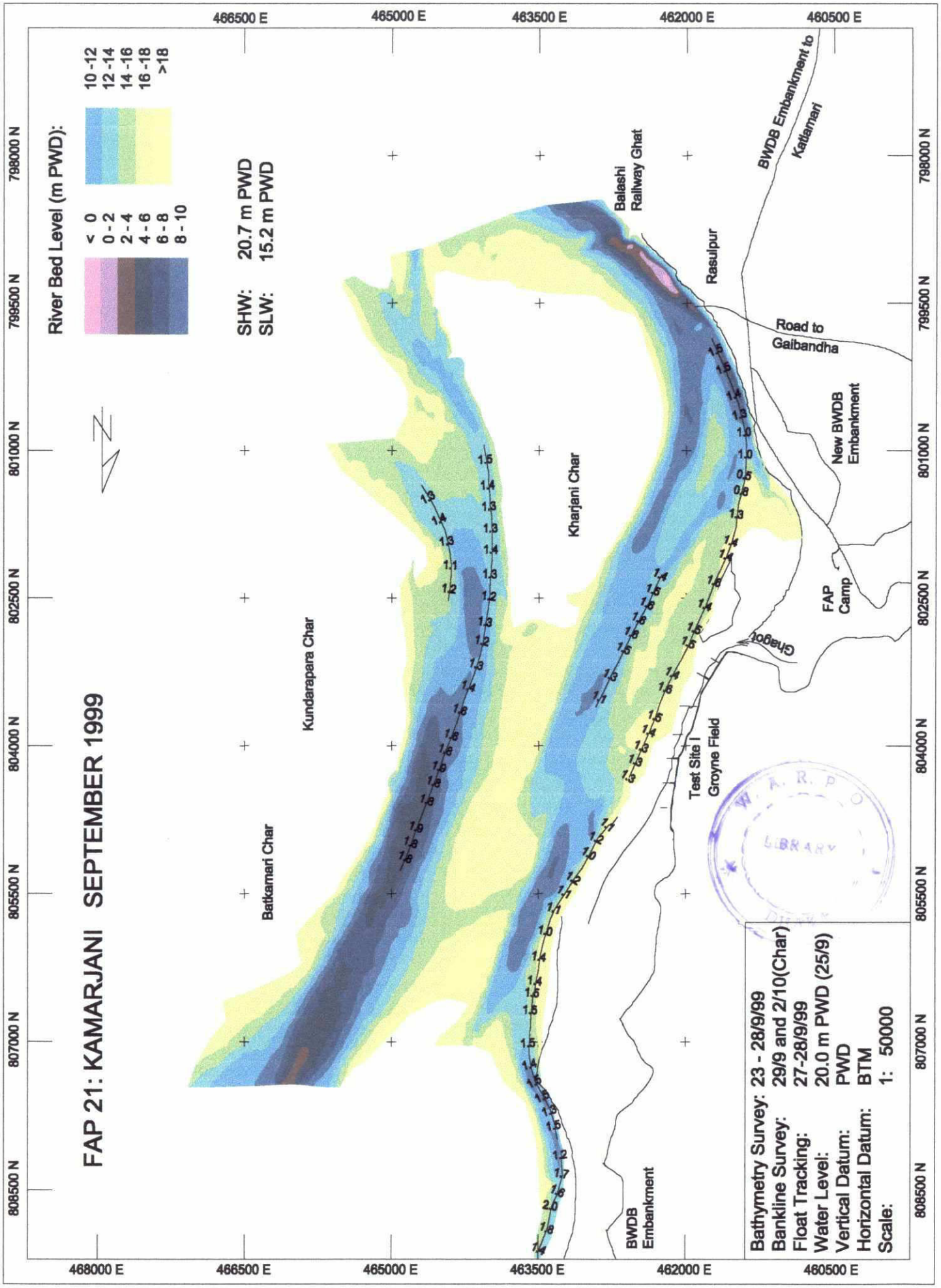
BWDB Data: Period of Record 1957 - 1997

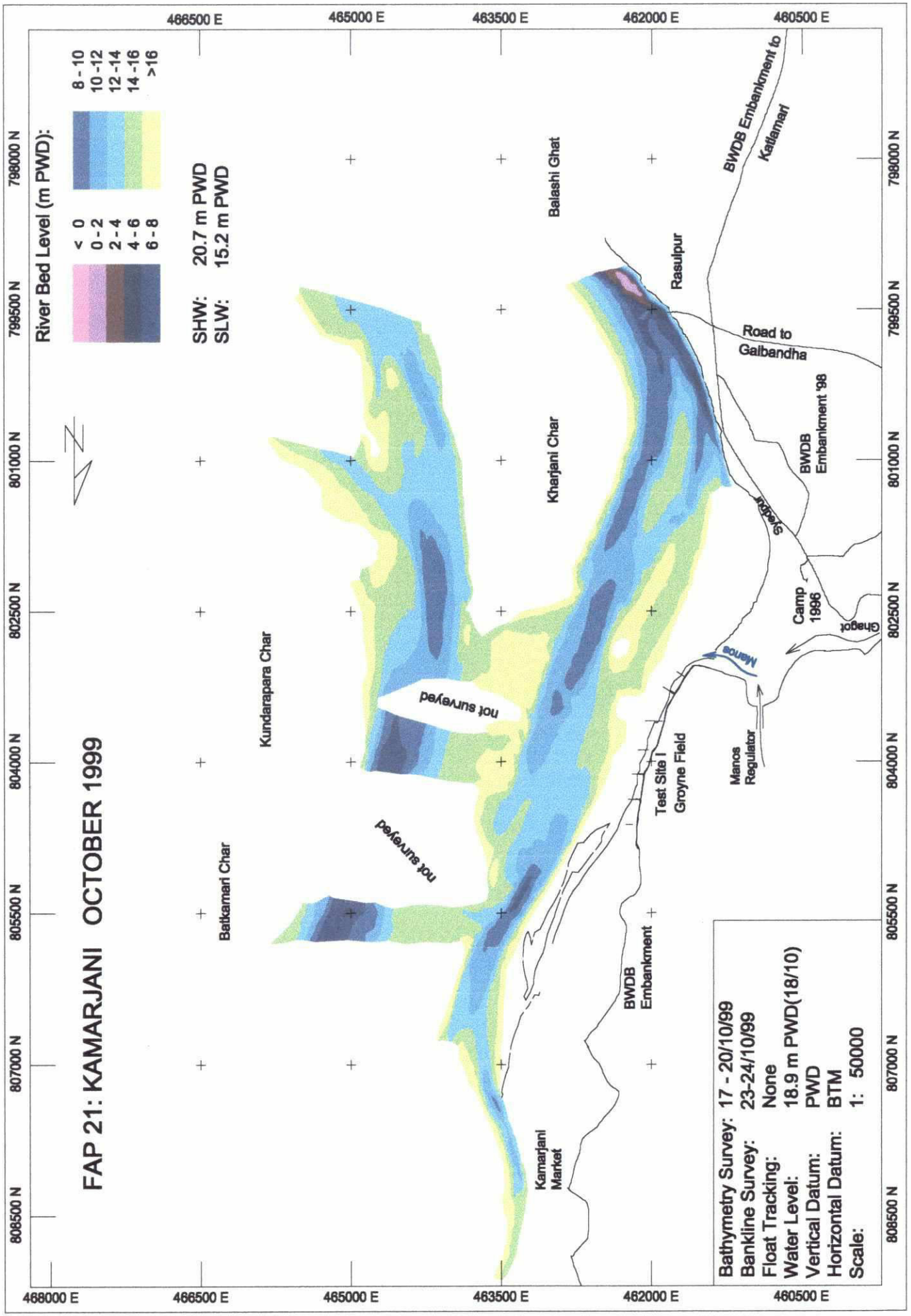
ANNEX B

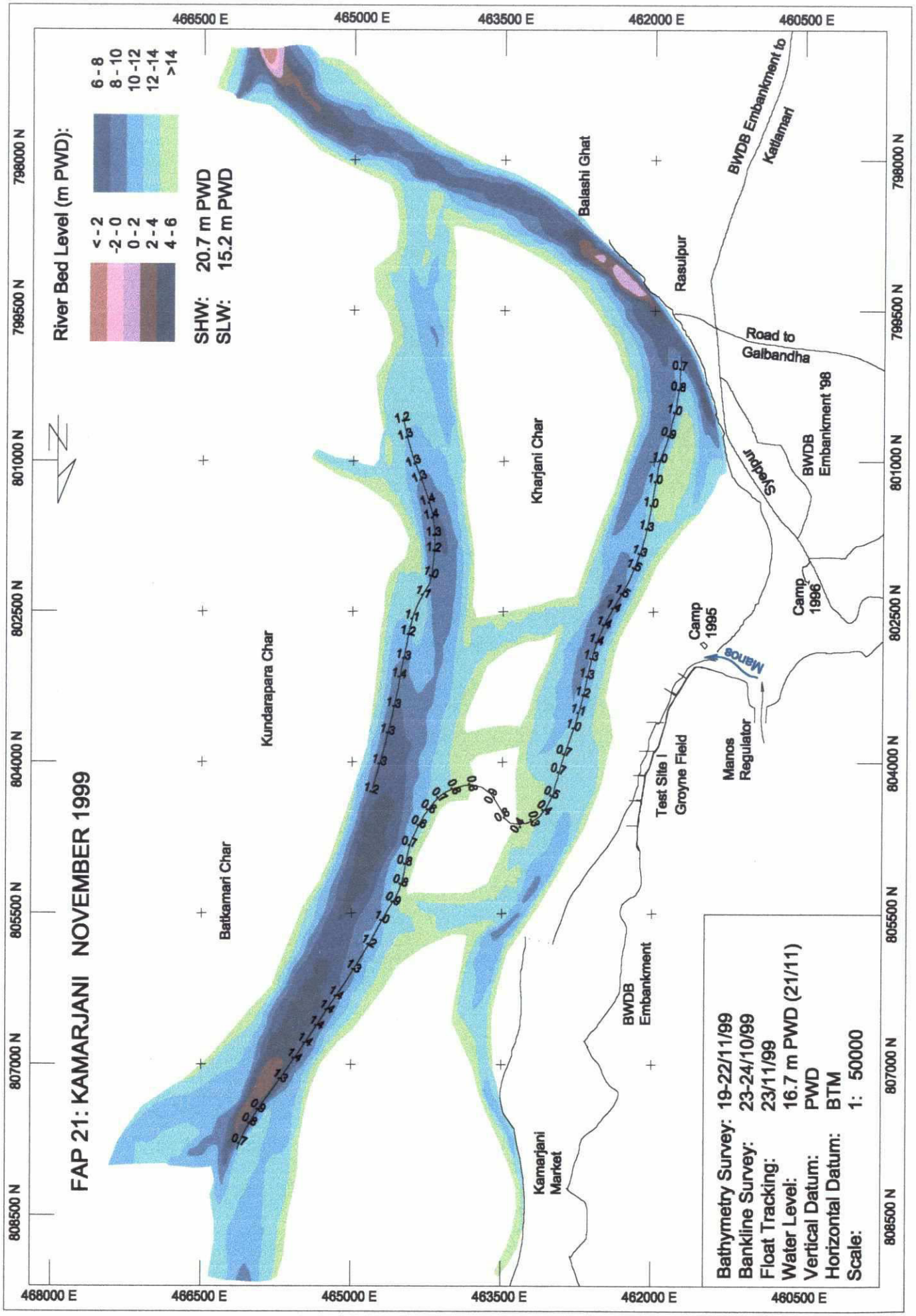
Bathymetric Survey and
Flow Lines

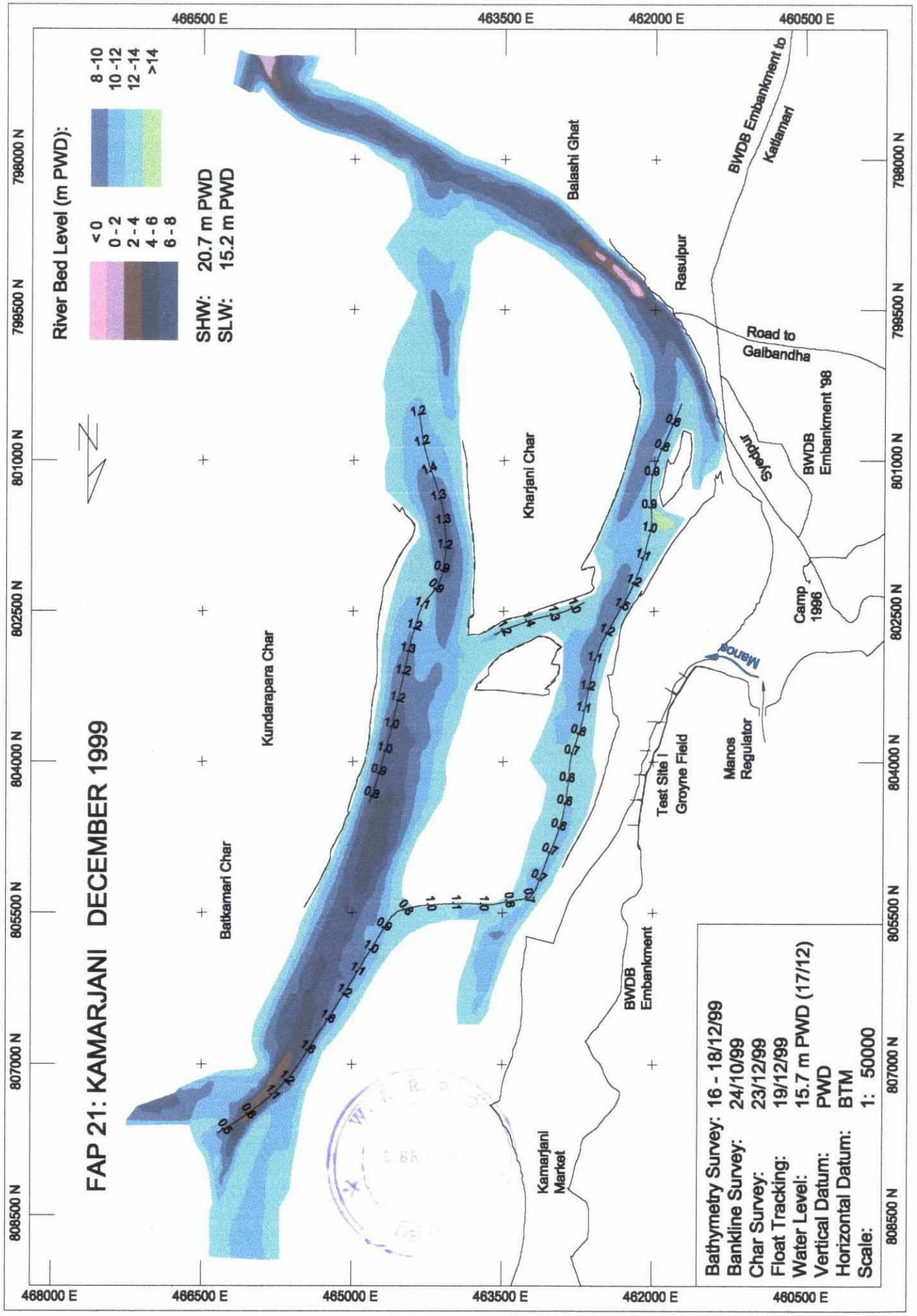

FAP 21: KAMARJANI JULY 1999
River Bed Level (m PWD):
< 2
2 - 4
4 - 6
6 - 8
8 - 10
10 -12
12 -14
14 -16
16 -18
>18
SHW: 20.7m PWD
SLW: 15.2m PWD
Kharjani Char
Kundarapara Char
Batkamari Char
Balashi Railway Ghat
Rasulpur
BWDB Embankment to Katlamari
Road to Gaibandha
New BWDB Embankment
FAP Camp
Ghagot
Test Site I
Groyne Field
BWDB Embankment
Bathymetry Survey: 1-6/7/99
Bankline Survey: 28/5/99
Float Tracking: 6+7/7/99
Water Level: 21.7m PWD (4/7)
Vertical Datum: PWD
Horizontal Datum: BTM
Scale: 1: 50000
468000 E
466500 E
465000 E
463500 E
462000 E
460500 E
798000 N
799500 N
801000 N
802500 N
804000 N
805500 N
807000 N
808500 N


FAP 21: KAMARJANI AUGUST 1999
River Bed Level (m PWD):
<2
2 - 4
4 - 6
6 - 8
8 - 10
10 -12
12 -14
14 -16
16 -18
>18
SHW: 20.7 m PWD
SLW: 15.2 m PWD
Batkamari Char
Kundarapara Char
Kharjani Char
Balashi Railway Ghat
Rasulpur
BWDB Embankment to Katlamari
Road to Gaibandha
New BWDB Embankment
FAP Camp
Ghagot
Test Site I
Groyne Field
BWDB Embankment
Bathymetry Survey: 18 - 23/8/99
Bankline Survey: 28/5/99
Float Tracking: 24/8/99
Water Level: 20.9 m PWD (20/8)
Vertical Datum: PWD
Horizontal Datum: BTM
Scale: 1: 50000
466500 E
465000 E
463500 E
462000 E
460500 E
468000 E
798000 N
799500 N
801000 N
802500 N
804000 N
805500 N
807000 N
808500 N


FAP 21: KAMARJANI SEPTEMBER 1999
River Bed Level (m PWD):
< 0
0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 -12
12 -14
14 -16
16 -18
>18
SHW: 20.7 m PWD
SLW: 15.2 m PWD
N
Batkamari Char
Kundarapara Char
Kharjani Char
Balashi Railway Ghat
Rasulpur
BWDB Embankment to Katlamari
Road to Gaibandha
New BWDB Embankment
FAP Camp
Test Site I
Groyne Field
BWDB Embankment
Bathymetry Survey: 23 - 28/9/99
Bankline Survey: 29/9 and 2/10(Char)
Float Tracking: 27-28/9/99
Water Level: 20.0 m PWD (25/9)
Vertical Datum: PWD
Horizontal Datum: BTM
Scale: 1: 50000
466500 E
465000 E
463500 E
462000 E
460500 E
468000 E
798000 N
799500 N
801000 N
802500 N
804000 N
805500 N
807000 N
808500 N


FAP 21: KAMARJANI OCTOBER 1999
River Bed Level (m PWD):
< 0
0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 -12
12 -14
14 -16
>16
SHW: 20.7 m PWD
SLW: 15.2 m PWD
N
466500 E
465000 E
463500 E
462000 E
460500 E
808500 N
807000 N
805500 N
804000 N
802500 N
801000 N
799500 N
798000 N
468000 E
466500 E
465000 E
463500 E
462000 E
460500 E
Batkamari Char
Kundarapara Char
Kharjani Char
Balashi Ghat
Rasulpur
BWDB Embankment to Katlamari
Road to Gaibandha
BWDB Embankment '98
Manos
Camp 1996
Ghagot
Manos Regulator
Test Site I
Groyne Field
BWDB Embankment
Kamarjani Market
not surveyed
not surveyed
Bathymetry Survey: 17 - 20/10/99
Bankline Survey: 23-24/10/99
Float Tracking: None
Water Level: 18.9 m PWD(18/10)
Vertical Datum: PWD
Horizontal Datum: BTM
Scale: 1: 50000

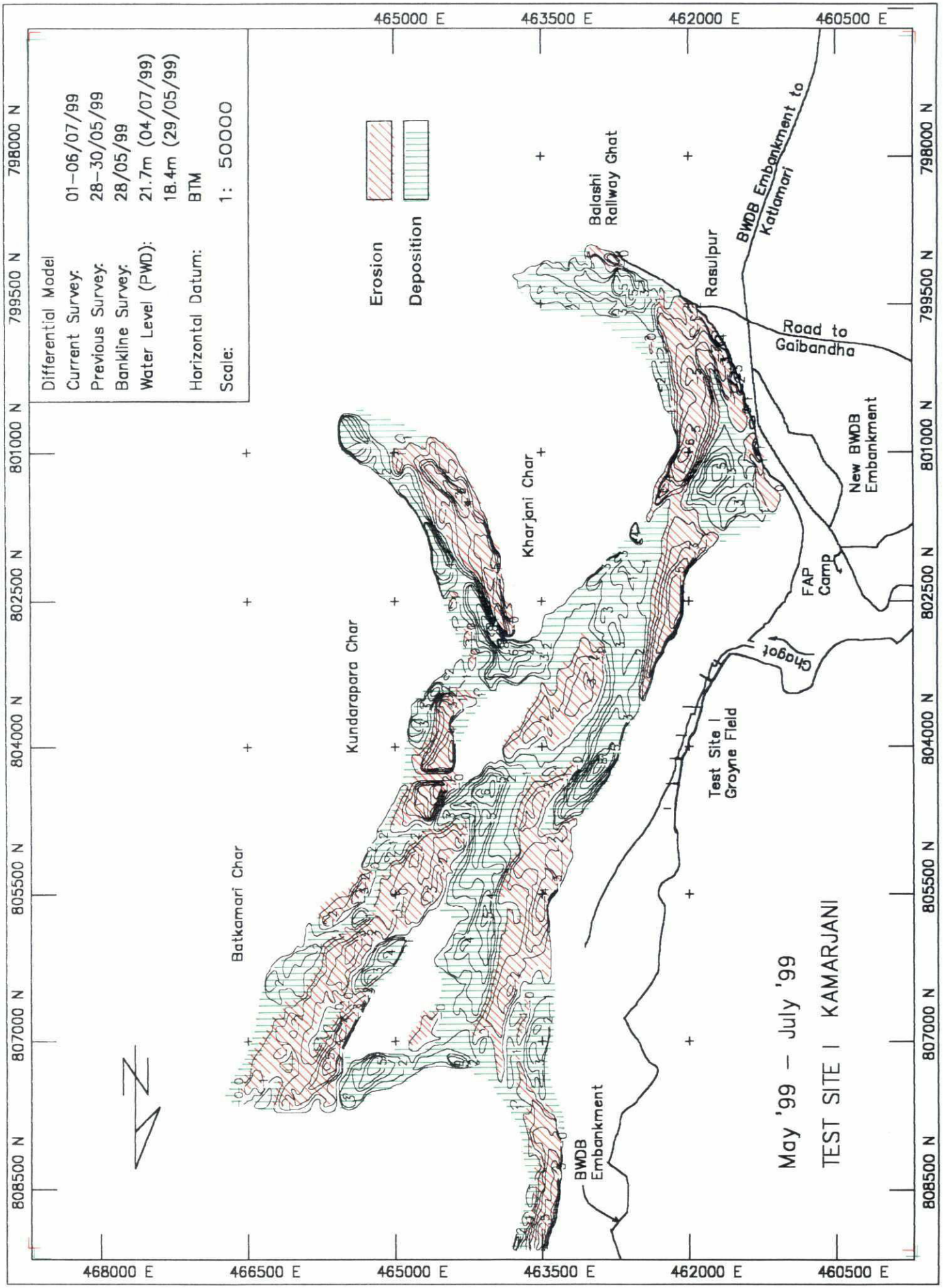

FAP 21: KAMARJANI NOVEMBER 1999
River Bed Level (m PWD):
< - 2
-2 - 0
0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 -12
12 -14
>14
SHW: 20.7 m PWD
SLW: 15.2 m PWD
Batkamari Char
Kundarapara Char
Kharjani Char
Balashi Ghat
Rasulpur
BWDB Embankment to Katlamari
Road to Gaibandha
BWDB Embankment '98
Kashipur
Camp 1996
Camp 1995
Manos
Manos Regulator
Test Site I
Groyne Field
BWDB Embankment
Kamarjani Market
Bathymetry Survey: 19-22/11/99
Bankline Survey: 23-24/10/99
Float Tracking: 23/11/99
Water Level: 16.7 m PWD (21/11)
Vertical Datum: PWD
Horizontal Datum: BTM
Scale: 1: 50000
468000 E
466500 E
465000 E
463500 E
462000 E
460500 E
808500 N
807000 N
805500 N
804000 N
802500 N
801000 N
799500 N
798000 N

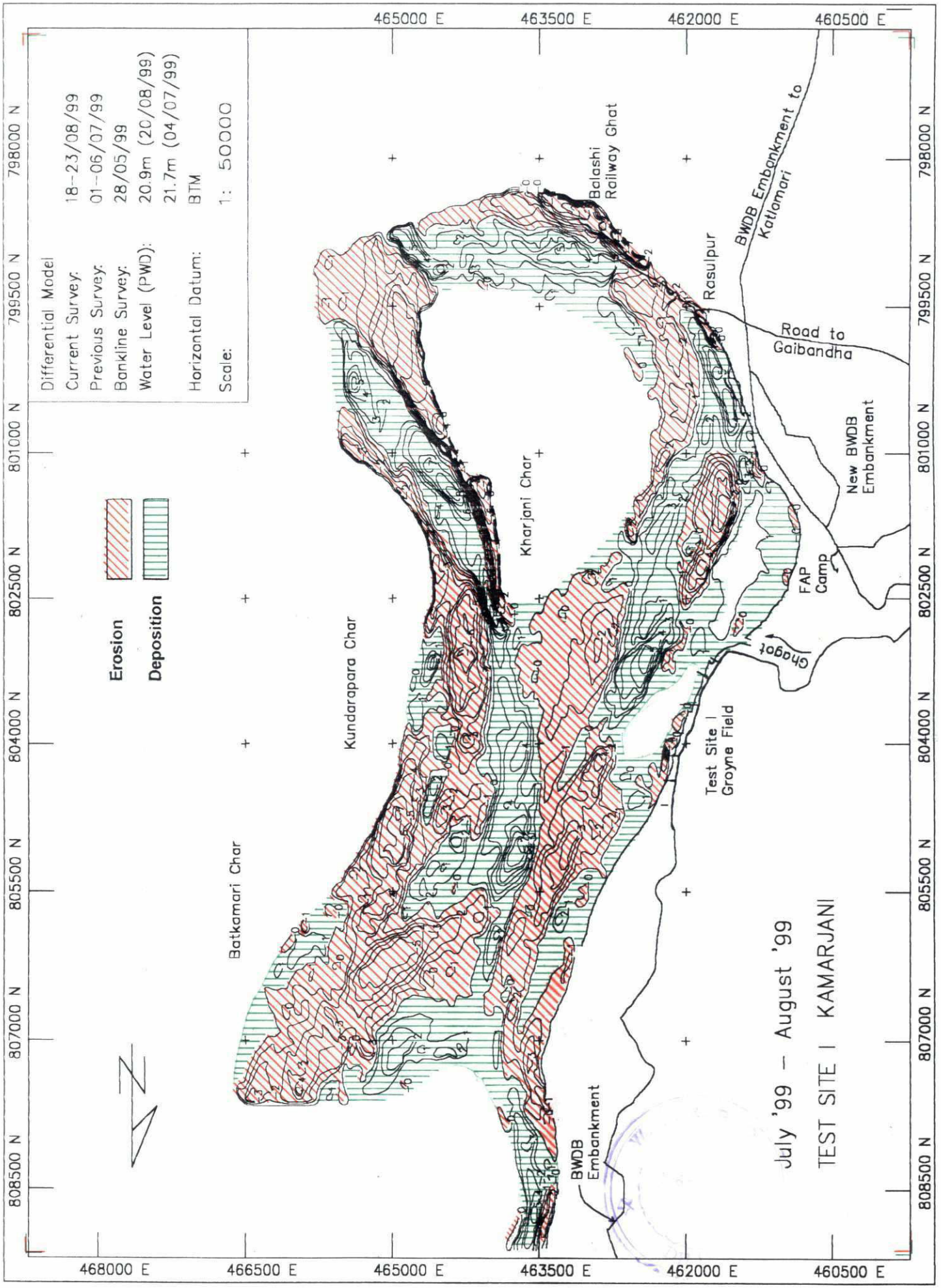

FAP 21: KAMARJANI DECEMBER 1999
River Bed Level (m PWD):
< 0
0 - 2
2 - 4
4 - 6
6 - 8
8 -10
10 -12
12 -14
>14
SHW: 20.7 m PWD
SLW: 15.2 m PWD
Batkamari Char
Kundarapara Char
Kharjani Char
Balashi Ghat
Rasulpur
BWDB Embankment to Katlamari
Road to Gaibandha
BWDB Embankment '98
Camp 1996
Manos
Manos Regulator
Test Site I
Groyne Field
BWDB Embankment
Kamarjani Market
Bathymetry Survey: 16 - 18/12/99
Bankline Survey: 24/10/99
Char Survey: 23/12/99
Float Tracking: 19/12/99
Water Level: 15.7 m PWD (17/12)
Vertical Datum: PWD
Horizontal Datum: BTM
Scale: 1: 50000
468000 E
466500 E
465000 E
463500 E
462000 E
460500 E
808500 N
807000 N
805500 N
804000 N
802500 N
801000 N
799500 N
798000 N

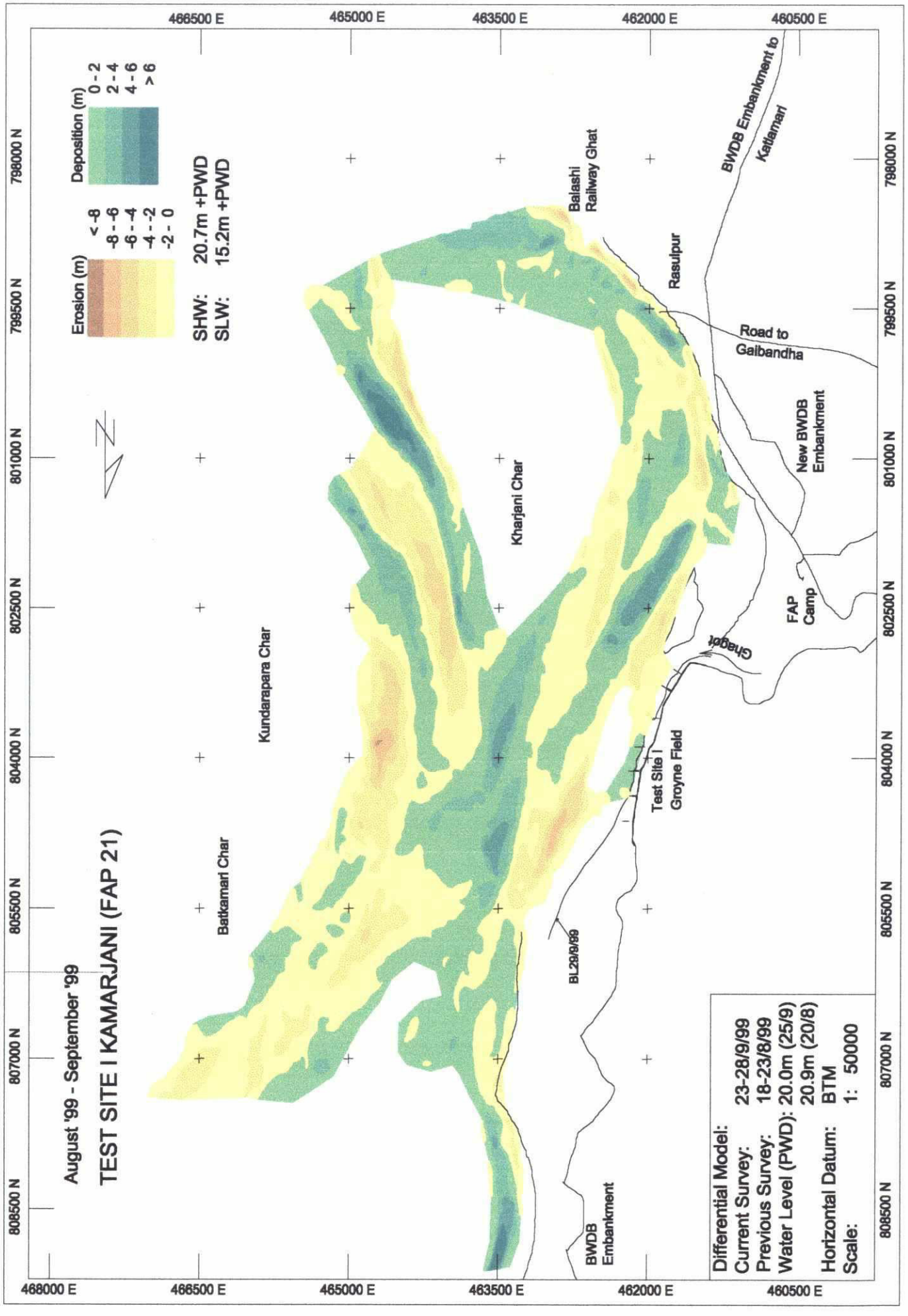
ANNEX C

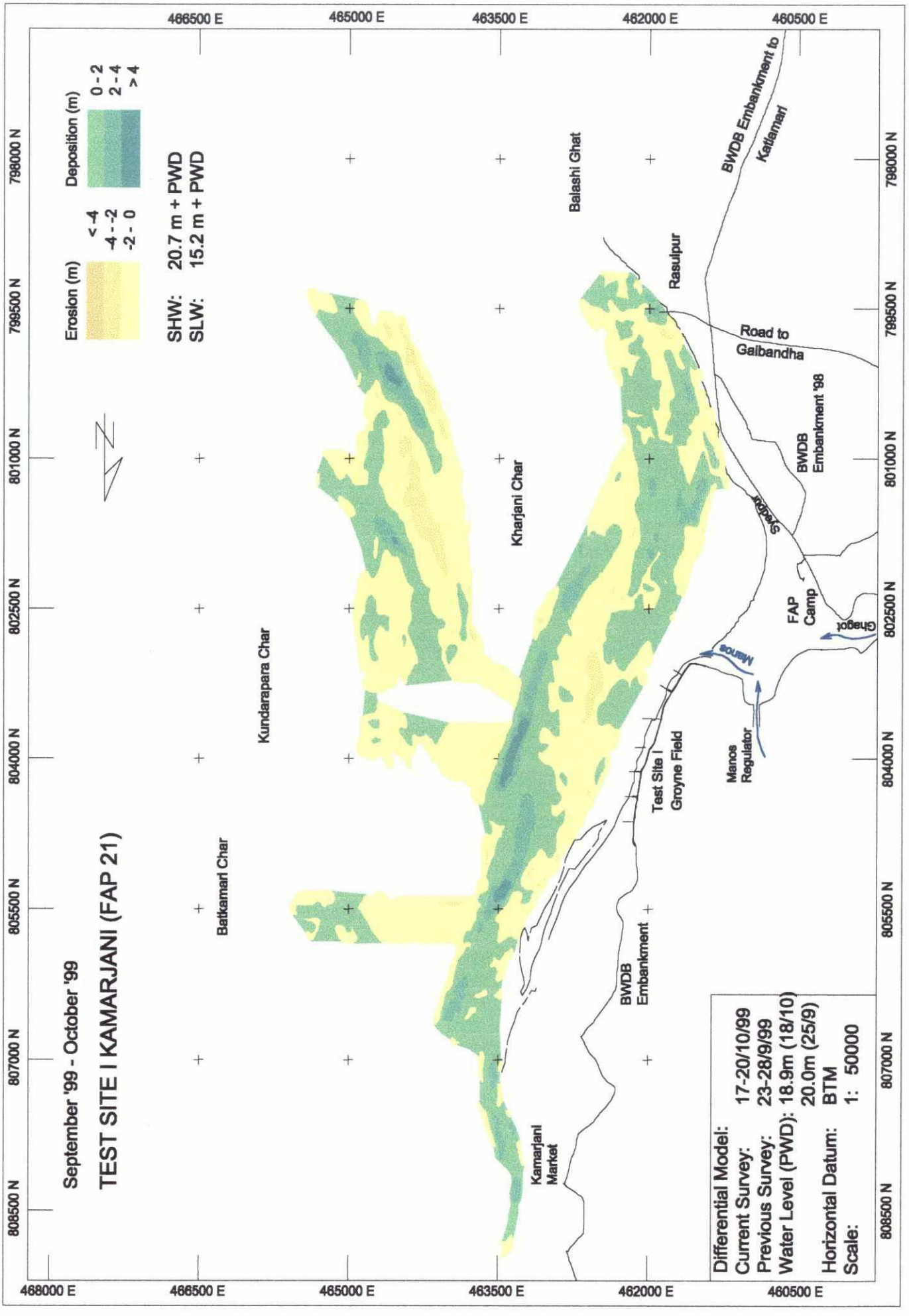
Differential Models

60

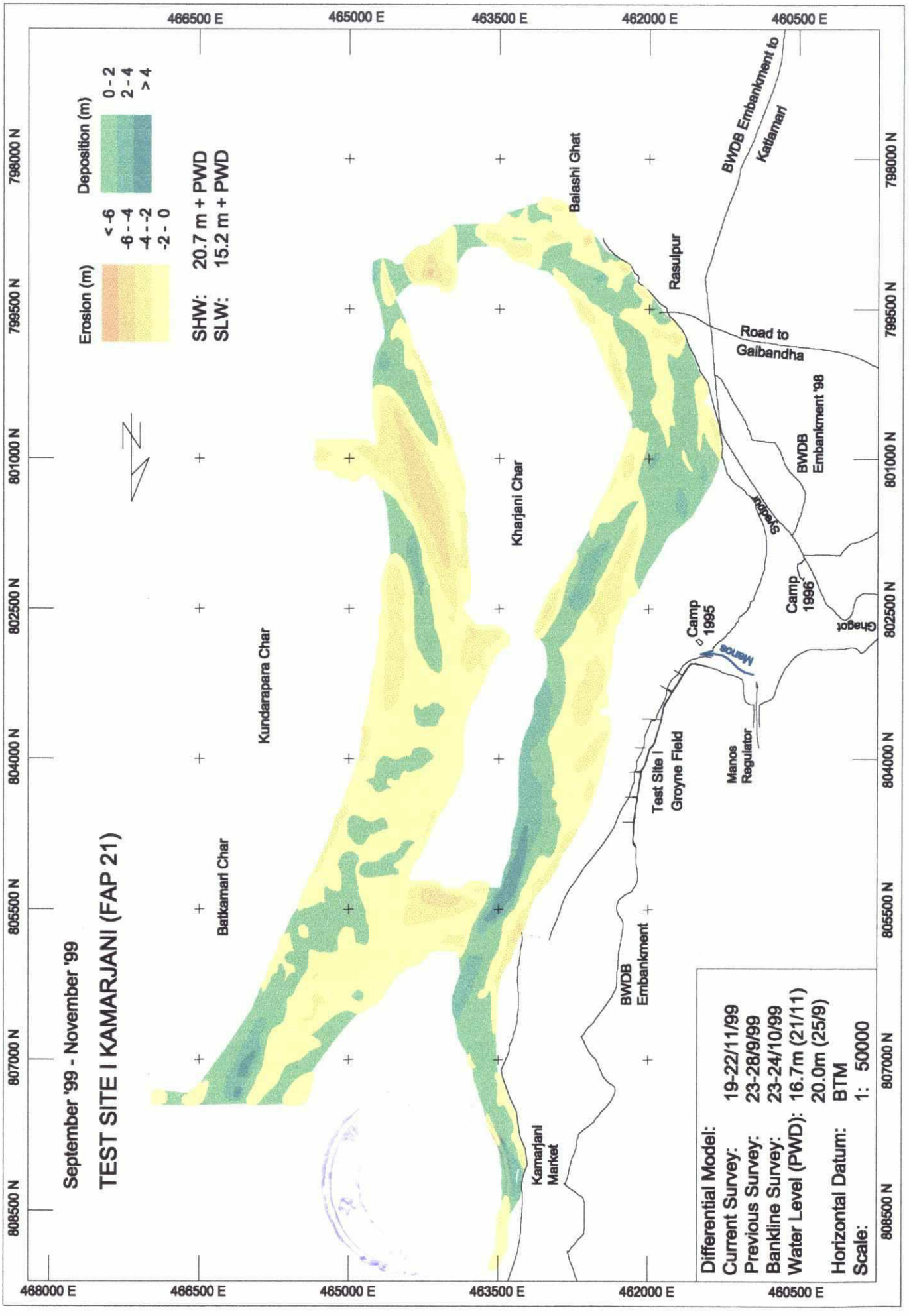

Differential Model
Current Survey: 01-06/07/99
Previous Survey: 28-30/05/99
Bankline Survey: 28/05/99
Water Level (PWD): 21.7m (04/07/99)
18.4m (29/05/99)
Horizontal Datum: BTM
Scale: 1: 50000
Erosion
Deposition
465000 E
463500 E
462000 E
460500 E
798000 N
799500 N
801000 N
802500 N
804000 N
805500 N
807000 N
808500 N
468000 E
466500 E
Balashi Railway Ghat
BWDB Embankment to Katlamari
Rasulpur
Road to Gaibandha
New BWDB Embankment
FAP Camp
Kharjani Char
Kundarapara Char
Batkamari Char
Test Site I Groyne Field
BWDB Embankment
May '99 - July '99
TEST SITE I KAMARJANI

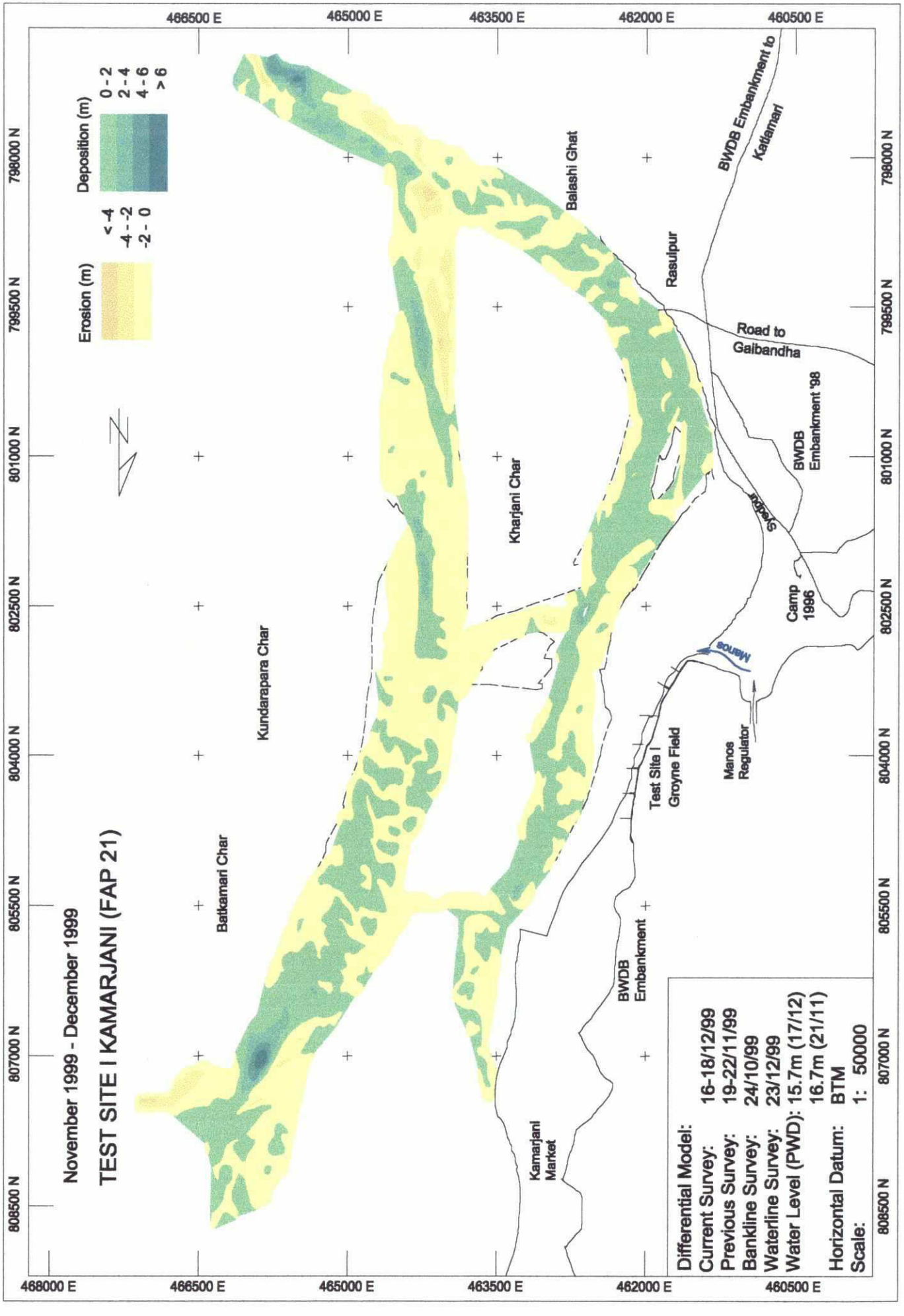

Differential Model
Current Survey: 18-23/08/99
Previous Survey: 01-06/07/99
Bankline Survey: 28/05/99
Water Level (PWD): 20.9m (20/08/99)
21.7m (04/07/99)
Horizontal Datum: BTM
Scale: 1: 50000
Erosion
Deposition
July '99 – August '99
TEST SITE I KAMARJANI
Batkamari Char
Kundarapara Char
Kharjani Char
Balashi Railway Ghat
Rasulpur
BWDB Embankment to Katlamari
Road to Gaibandha
New BWDB Embankment
FAP Camp
Ghagot
Test Site I Groyne Field
BWDB Embankment
465000 E
463500 E
462000 E
460500 E
468000 E
466500 E
808500 N
807000 N
805500 N
804000 N
802500 N
801000 N
799500 N
798000 N


TEST SITE I KAMARJANI (FAP 21)
August '99 - September '99
Erosion (m)
< -8
-8 - -6
-6 - -4
-4 - -2
-2 - 0
Deposition (m)
0 - 2
2 - 4
4 - 6
> 6
SHW: 20.7m +PWD
SLW: 15.2m +PWD
N
Batkamari Char
Kundarapara Char
Kharjani Char
Balashi Railway Ghat
Rasulpur
BWDB Embankment to Katlamari
Road to Gaibandha
New BWDB Embankment
FAP Camp
Ghagot
Test Site I
Groyne Field
BL29/9/99
BWDB Embankment
Differential Model:
Current Survey: 23-28/9/99
Previous Survey: 18-23/8/99
Water Level (PWD): 20.0m (25/9)
20.9m (20/8)
Horizontal Datum: BTM
Scale: 1: 50000
466500 E
465000 E
463500 E
462000 E
460500 E
468000 E
808500 N
807000 N
805500 N
804000 N
802500 N
801000 N
799500 N
798000 N


TEST SITE I KAMARJANI (FAP 21)
September '99 - October '99
Erosion (m)
< -4
-4 - -2
-2 - 0
Deposition (m)
0 - 2
2 - 4
> 4
SHW: 20.7 m + PWD
SLW: 15.2 m + PWD
Batkamari Char
Kundarapara Char
Kharjani Char
Balashi Ghat
Rasulpur
BWDB Embankment to Katlamari
Road to Gaibandha
BWDB Embankment '98
Sladder
FAP Camp
Ghagot
Manos
Manos Regulator
Test Site I Groyne Field
BWDB Embankment
Kamarjani Market
Differential Model:
Current Survey: 17-20/10/99
Previous Survey: 23-28/9/99
Water Level (PWD): 18.9m (18/10)
20.0m (25/9)
Horizontal Datum: BTM
Scale: 1: 50000
468000 E
466500 E
465000 E
463500 E
462000 E
460500 E
808500 N
807000 N
805500 N
804000 N
802500 N
801000 N
799500 N
798000 N

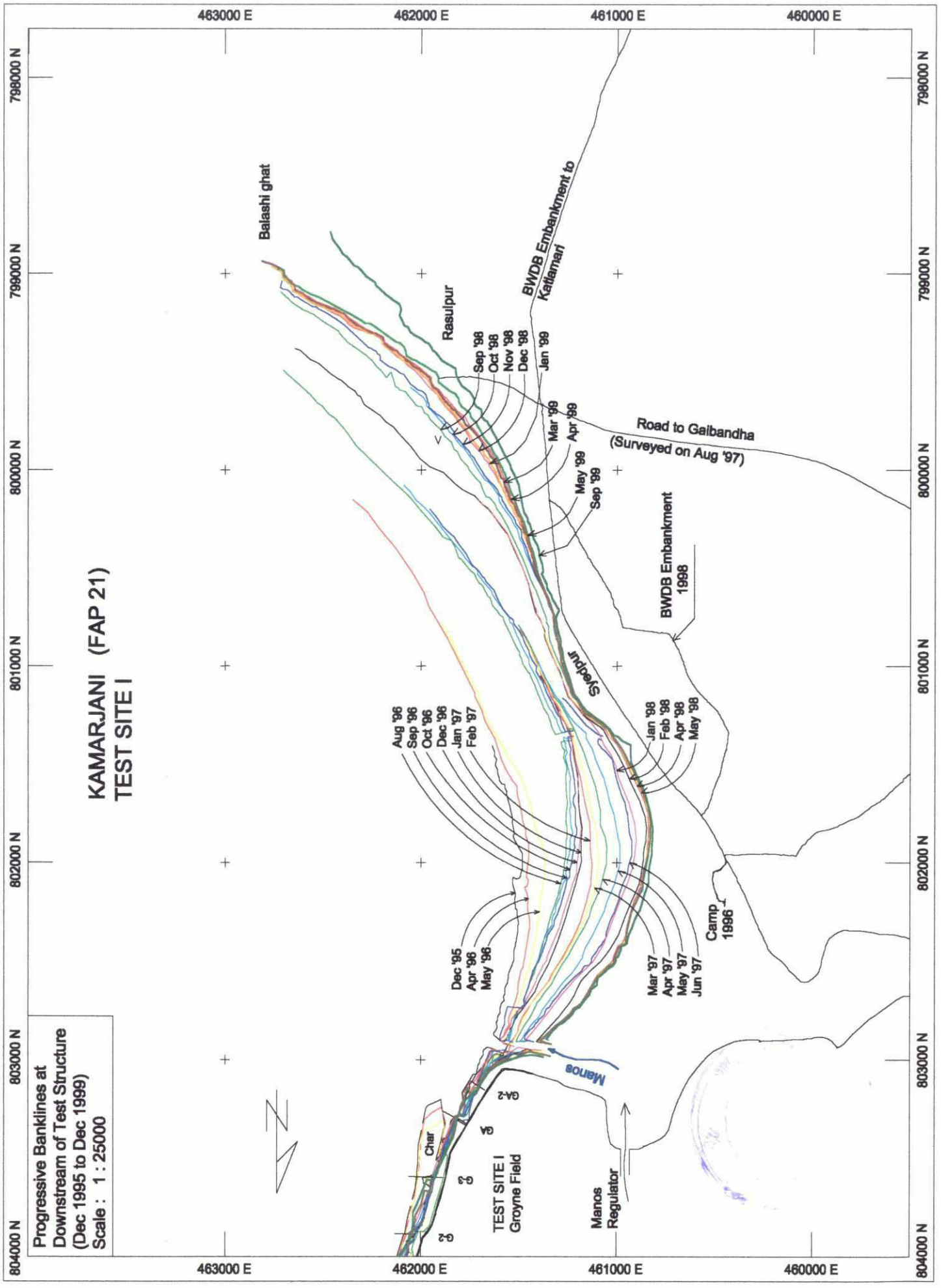
G8


TEST SITE I KAMARJANI (FAP 21)
September '99 - November '99
Erosion (m)
< -6
-6 - -4
-4 - -2
-2 - 0
Deposition (m)
0 - 2
2 - 4
> 4
SHW: 20.7 m + PWD
SLW: 15.2 m + PWD
N
466500 E
465000 E
463500 E
462000 E
460500 E
808500 N
807000 N
805500 N
804000 N
802500 N
801000 N
799500 N
798000 N
468000 E
Batkamari Char
Kundarapara Char
Kharjani Char
Balashi Ghat
Rasulpur
BWDB Embankment to Katlamari
Road to Gaibandha
BWDB Embankment '98
Camp 1995
Camp 1996
Manos Regulator
Test Site I Groyne Field
BWDB Embankment
Kamarjani Market
Differential Model:
Current Survey: 19-22/11/99
Previous Survey: 23-28/9/99
Bankline Survey: 23-24/10/99
Water Level (PWD): 16.7m (21/11)
20.0m (25/9)
Horizontal Datum: BTM
Scale: 1: 50000


November 1999 - December 1999
TEST SITE I KAMARJANI (FAP 21)
Erosion (m)
< -4
-4 - -2
-2 - 0
Deposition (m)
0 - 2
2 - 4
4 - 6
> 6
Batkamari Char
Kundarapara Char
Kharjani Char
Balashi Ghat
Rasulpur
BWDB Embankment to Katlamari
Road to Gaibandha
BWDB Embankment '98
Camp 1996
Manos
Manos Regulator
Test Site I Groyne Field
BWDB Embankment
Kamarjani Market
Differential Model:
Current Survey: 16-18/12/99
Previous Survey: 19-22/11/99
Bankline Survey: 24/10/99
Waterline Survey: 23/12/99
Water Level (PWD): 15.7m (17/12)
16.7m (21/11)
Horizontal Datum: BTM
Scale: 1: 50000
468000 E
466500 E
465000 E
463500 E
462000 E
460500 E
808500 N
807000 N
805500 N
804000 N
802500 N
801000 N
799500 N
798000 N

ANNEX D

Change of Bankline


KAMARJANI (FAP 21)
TEST SITE I
Progressive Banklines at Downstream of Test Structure (Dec 1995 to Dec 1999)
Scale : 1 : 25000
463000 E
462000 E
461000 E
460000 E
798000 N
799000 N
800000 N
801000 N
802000 N
803000 N
804000 N
Balashi ghat
Rasulpur
BWDB Embankment to Katamari
Sep '98
Oct '98
Nov '98
Dec '98
Jan '99
Mar '99
Apr '99
May '99
Sep '99
Road to Gaibandha (Surveyed on Aug '97)
BWDB Embankment 1998
Syedpur
Aug '96
Sep '96
Oct '96
Dec '96
Jan '97
Feb '97
Jan '98
Feb '98
Apr '98
May '98
Dec '95
Apr '96
May '96
Mar '97
Apr '97
May '97
Jun '97
Camp 1996
Manos
Char
TEST SITE I
Groyne Field
Manos Regulator