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FAP-21/22

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

FEDERAL REPUBLIC OF GERMANY

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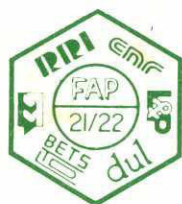
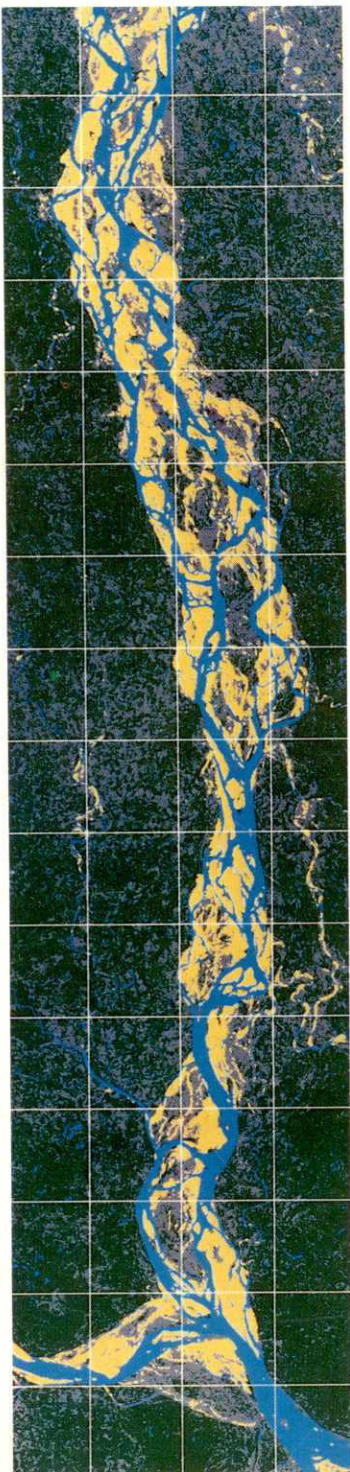
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**BANK PROTECTION AND  
RIVER TRAINING (AFPM)  
PILOT PROJECT  
FAP 21/22**

**TEST  
AND  
IMPLEMENTATION  
PHASE**

**PROGRESS REPORT  
NO. 21**

JULY TO SEPTEMBER 1998



**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

PROGRESS REPORT  
NO. 21



A-45

MFN-2294  
20/02  
C-1

JULY TO SEPTEMBER 1998



6

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

**PROGRESS REPORT NO. 21**

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## 1 GENERAL

### 1.1 THE PROJECT

The Project FAP 21/22 consisting of the two components

- Bank Protection Pilot Project (FAP 21) and
- River Training and Active Flood Plain Management Pilot Project (FAP 22)

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) for the FAP 21 component.

The Consultancy Agreement was signed on October 14, 1991. The date of commencement was fixed on December 01, 1991.

The Inception Report was issued on March 21, 1992 and the Interim Report on July 16, 1992. The Draft Final Planning Study Report for the FAP 22 component was presented on December 19, 1992 and that for the FAP 21 component on January 18, 1993.

A joint mission of KfW and Caisse Française de Développement (CFD) had carried out from January 26 to February 07, 1993 the Project appraisal of Phase II. The Mission together with FPCO agreed with the overall concept for the Test and Implementation Phase of the FAP 21 component which started on June 01, 1993 after the "Letter to Proceed" had been issued by FPCO on May 15, 1993.

After a meeting held on June 21, 1993 the FAP Review Committee of the Ministry of Irrigation, Water Development and Flood Control recommended the Draft Final Planning Study Report of both the components for approval by the Technical Committee.

The Final Planning Study Report FAP 21/22 was presented on June 30, 1993 and approved by the FAP Technical Committee of the Ministry of Irrigation, Water Development & Flood Control on August 09, 1994.

With effect of January 01, 1996 the responsibilities of the client passed to the Water Resources Planning Organization (WARPO) of the in 1995 renamed Ministry of Water Resources.

The Bank Protection Pilot Project (FAP 21) consists of the construction of a Groyne Test Structure and a Revetment Test Structure at different test sites. The subcontract for the Groyne Test Structure at Kamarjani Test Site was awarded to the Consortium: The Engineers Limited and Corolla Corporation (BD) Ltd. on September 07, 1994. The actual construction works on site started on October 01, 1994 and were substantially completed end of April 1995. The subcontract for the construction of the Revetment Test Structure at Bahadurabad Test Site was awarded to the Joint Venture The Engineers Ltd.-Corolla Corporation (BD) Ltd. and Monico Ltd.-Boskalis International on September 30, 1995. The execution of works started in December 1995 but had to be suspended in January 1996 for various reasons. The construction works were resumed in November 1996 and substantially completed end of May 1997.



With reference to the suspension of works on the Revetment Test Structure early 1996 and the incomplete adaptation / repair works at the Groyne Test Structure, the Consultant recommended in July 1996 an extension of the monitoring period of the FAP 21 component by one year up to end of 1999 which was approved by the Ministry of Water Resources in March 1997. Hence, work plan and staffing schedule were adapted accordingly up to December 31, 1999.

The River Training and Active Flood Plain Management Pilot Project (FAP 22) was formally finalized by holding an international experts discussion from November 02 to 04, 1993 on the new concepts presented in the Final Planning Study Report. Based on the recommendations of the Experts a combination of two different recurrent measures was built in the dry season 1996/97 at Katlamari Test Site and monitored during the flood season 1997. Early January 1998, however, it emerged that the investigations at Katlamari could not be continued due to the morphological development in the test site area. Therefore, a new test site had to be selected which was finally found at Kunderapara, about 5 km east of Kamarjani Test Site.

## 1.2 THE REPORT

As per Section 12.01 and Appendix 1 of the Consulting Agreement as well as according to the Work Plan of the Test and Implementation Phase (Table 1 of Attachment 1 to "Letter to Proceed") a Progress Report is due at the end of September 1998. This report is the Progress Report as indicated above and spells out the work progress of Consulting Services and Construction Works in the period from July to September 1998.

This report presents for the two components of the pilot project a description in brief of the activities performed during this period.

## 1.3 PERSONNEL DEPLOYMENT

After issue of the "Letter to Proceed" the expatriate Consultants and their local counterparts took up their assignment. The personnel deployment during the period under review is shown in Table 1.1-1, 1.1-2 and 1.1-3 for the FAP 21 component and in Table 2.1-1 and 2.1-2 for FAP 22.

## 1.4 IMPORTANT DATES AND EVENTS

15.05.1993	Letter to Proceed
01.06.1993	Start of Test and Implementation Phase
12.06.1993	Subcontract for the construction and installation of the Filter Test Rig
21.06.1993	Meeting of FAP Review Committee on Draft Final Study Report FAP 21/22
30.06.1993	Submission of Final Study Report FAP 21/22
14.07.1993	Subcontract for Physical Model Tests
23.07.1993	Collapse of Manos Regulator at Kamarjani Test Site
08. to 12.08.1993	Visit of Members of the German Parliament
18.09.1993	Submission of Final Invoice Phase I
28.09.1993	Subcontract for topographic and hydrographic survey at Kamarjani Test Site
31.10.1993	Subcontract for subsoil investigations at Kamarjani Test Site
02. to 04.11.1993	Experts Discussion FAP 22
10.02.1994	Coordination meeting for Kamarjani Test Site with FPCO and BWDB
23.02.1994	Issue of Tender Documents for Kamarjani Test Site
28.02.1994	Submission of Experts Recommendations FAP 22
20.03.1994	Pre-bid meeting for Test Site I
17.04.1994	Tender opening for Kamarjani Test Site



08. to 20.06.1994	Technical Assessment of Procurement Arrangements of the Consultant by Dr. Friedrich von Raumer on behalf of FPCO/KfW/CFD
14. to 20.06.1994	Review Mission of KfW/CFD
18.06.1994	Submission of Consultants Report on the results of the Experts Discussion FAP 22
09.08.1994	Approval of Consultants Final Study Report by the FAP Technical Committee
04.09.1994	Order to Commence construction works at Kamarjani Test Site
07.09.1994	Subcontract signed for construction works at Kamarjani Test Site
22.09.1994	Submission of Tech. Report No.1 on Physical Model Tests
22.09.1994	Submission of Tech. Report No.2 on Morphological Prediction for Test Areas
26.09.1994	Coordination meeting for Kamarjani Test Site with FPCO and BWDB
28. to 03.10.1994	KfW mission for definition of Kamarjani Test Site location and discussions on import of geotextile material
01.10.1994	Start of Construction Works at Kamarjani Test Site.
12. to 17.02.1995	Review Mission of KfW/CFD
26.02.1995	Submission of Technical Report No. 3 on Filter Stability Investigation
16.04.1995	Issue of Tender Documents for Test Site II
18.04.1995	Submission of Technical Report No. 4 on Falling Apron Investigation
15.05.1995	Pre-bid meeting for Test Site II
20. to 25.05.1995	Audit of the Project (Test Site I at Kamarjani)
30.05.1995	Completion of construction works at Kamarjani Test Site
11.06.1995	Tender opening for Test Site II
31.08.1995	Order to Commence construction works at Bahadurabad Test Site
10.09.1995	Coordination meeting for Bahadurabad Test Site with FPCO
20. to 26.09.1995	KfW mission for definition of Bahadurabad Test Site location
30.09.1995	Subcontract signed for construction works at Bahadurabad Test Site
01.12.1995	Start of construction Works at Bahadurabad Test Site
01.02.1996	Suspension of Construction Works at Bahadurabad Test Site
12.03.1996	Submission of Technical Report No. 5 on Additional Model Tests
20.03.1996	Submission of letters of FORCE MAJEURE to WARPO for both Test Sites
22.04.1996	Proposal for Final Implementation of Revetment Test Structure at Test Site II
26.06 to 03.07.96	Review Mission of KfW/CFD
18.07.1996	Proposal for Modification of Consulting Services
05.09.1996	Submission of Report on Extended Studies on Recurrent Measures (FAP 22)
30.09.1996	Submission of Report on Monitoring and Adaptation 1995 at Test Site I
29.10.1996	Proposal for location of FAP 22 Test Site (Katlamari)
13. to 17.11.1996	Technical Review Mission of KfW/CFD
26.11.1996	Resumption of construction works at Bahadurabad Test Site
24.12.1996	Start of construction works at Katlamari Test Site (FAP 22)
02.03.1997	Approval of extension of the monitoring period up to December 31, 1999
20.03.1997	Completion of construction works at Katlamari Test Site (FAP 22)
31.05.1997	Completion of construction works at Bahadurabad Test Site
20. to 29.06.1997	Technical Assessment of Procurement Arrangements of the Consultant by Dr. Friedrich von Raumer on behalf of WARPO/KfW/CFD
11. to 19.07.1997	Audit of the Project (Test Site I and II)
14. to 21.07.1997	Technical Review Mission of KfW/CFD
14.09.1997	Submission of Technical and Financial Proposal for Consultancy Services and Construction of Low Cost and Recurrent Measures (FAP 22)
06.01.1998	Approval of modified Proposal of September 1997 for Consultancy Services and Construction of Low Cost and Recurrent Measures (FAP 22)
07.02.1998	Start of construction works at Kundarapara Test Site
05.05.1998	Submission of Technical Report No. 6 on Additional Model Tests
14. to 23.07.1998	Technical Review Mission of KfW/AFD

## 2 BANK PROTECTION COMPONENT (FAP 21)

### 2.1 PRELIMINARY REMARK

The Consultant's services of the Test and Implementation Phase (Phase II) comprise all engineering and management tasks relating to the planning and execution of test structures at two test sites, their monitoring, adaptation, repair measures during subsequent years and handing over to the Client at the end of the contract period.

After submission of the Draft Final Planning Study Report 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 permeable groynes and of various types of revetments at two different test sites in two successive seasons.

However, the remaining lead time of the programme as presented in the Draft Final Planning Study Report for additional studies, final design, procurement, subcontracting and preparation of construction was found to be too short in view of the administrative and technical difficulties identified by the Consultant and the Mission. There seemed to be unacceptable risks that the construction of the test works at the first test site could not be completed successfully during the dry season 1993/94 which in turn would have led to major cost increases and endangered the achievement of meaningful test results.

A mutual understanding between all parties concerned had been reached on a postponement of the start of the construction period and of the end of the Project by one year. Moreover, it was decided to reduce the magnitude of the test works on the two selected test sites in order to reserve funds for further improvement of the test structures or, if necessary and possible, for the construction of new structures.

The Table 1.2-1.1 is showing the Work Plan and Table 1.2-3.1 the Staffing Schedule of the Test and Implementation Phase as per "Letter to Proceed" of May 15, 1993. Table 1.2-3.2 presents the revised Staffing Schedule submitted along with the Progress Report No. 6 and adapted to the donors' comments, whereas Table 1.2-1.2 and Table 1.2-3.3 are showing the Work Plan and the Staffing Schedule as per proposal of July 1996, approved in March 1997. Table 1.2-2 is indicating the actual progress of works and Table 1.2-4 and Table 1.2-5 the actual deployment of the expatriate and local professional staff respectively during the period under review.

### 2.2 TEST SITE I AT KAMARJANI

#### 2.2.1 General

Initially, the test structure comprised of 6 groynes, each of them a combination of an impermeable and a permeable section with increasing permeability towards the river of which 3 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).

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.

The "Order to Commence" the construction works was issued on September 04, 1994 and the works were substantially completed in April 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 represent 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.

The initial findings of damage causes 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 improve the transition between the permeable and impermeable part of the groynes with the aim to further limit the development of severe return currents, turbulences 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, a new supplementary groyne G-A/2 was built 200 m downstream from G-A. However, the execution of the adaptation and repair works was hampered by the political situation in the country in 1995 and the first quarter 1996 with the result that the works could not be completed in time due to the rising water level. Especially, groyne G-2 remained incomplete because the gap between the remaining pile structure built in 1995 and the relocated main embankment could not be closed by driving further piles as per design.

During the flood season 1996 the river banks in the area of Kamarjani continued to be eroded and also the Groyne Test Structure came under attack again due to the attraction of the flow by the scour hole in front of the groynes. However, due to the adaptation of the structure and the morphological development in the test site are no damages to the structure occurred during the monsoon season 1996 except to the main embankment which was slightly damaged by wave erosion in those areas where the upper part was only protected by grass sods. Repair works were carried out in November 1996 and the grass sod protection was replaced by brick mattressing. Further repair works of the pile structure of groyne G-2 was carried out by driving 23 Nos steel piles  $\phi$  711 mm and 32 m length as well as by construction of 12 Nos of reinforced in-situ concrete piles between the toe of the relocated main embankment and the pile structure left over and intact after the monsoon 1995.

From September 1997 to end of January 1998 ten additional physical model tests were performed in the River Research Institute in Faridpur, the objective of which was (1) to investigate the causes of damages observed in 1995 and (2) to gain more information/knowledge of the behaviour of the groynes/groyne field in order to be in a position to formulate design rules at the end of the Project in 1999 and to work out guidelines and manuals for their application.

The general layout of the test structure after the execution of adaptation and repair works is shown in Fig. 1.



CONTROL POINT SCHEDULE			
ID - No. of Control Point	Coordinates of Control Point		Elevation (m PWD)
	Eastings	Northings	
Neat Line	FAP 21.05	802,817.795	+21.920
G-B/2	No. 24.33	(to be established)	
G-A	No. 24.31	803,328.440	+23.335
G-3	No. 24.29	803,595.150	+23.258
G-2	No. 24.26	803,684.190	+23.446
G-1	No. 24.24	804,025.150	+23.390
G-B/1	No. 24.22	804,334.750	+23.404
G-B/2	No. 24.20	804,626.150	+23.954

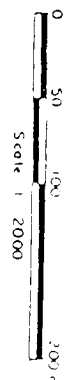
**LEGEND**

Home shed  
Barrow pit  
Bankline  
Control points

**NOTES**

1 All measurements in meters  
2 Levels refer to 10.000 m PWD  
3 Reference Drawings

AD - KA - 002 Cross Section of Main Embankment  
AD - KA - 003 Main Embankment: Details of Revetment  
AD - KA - 010 Groynes G-1, General Layout Plan  
AD - KA - 020 Groynes G-2, General Layout Plan  
AD - KA - 030 Groynes G-3, General Layout Plan  
AD - KA - 040 Groynes G-A, General Layout Plan  
AD - KA - 050 Groynes G-A/2, General Layout Plan



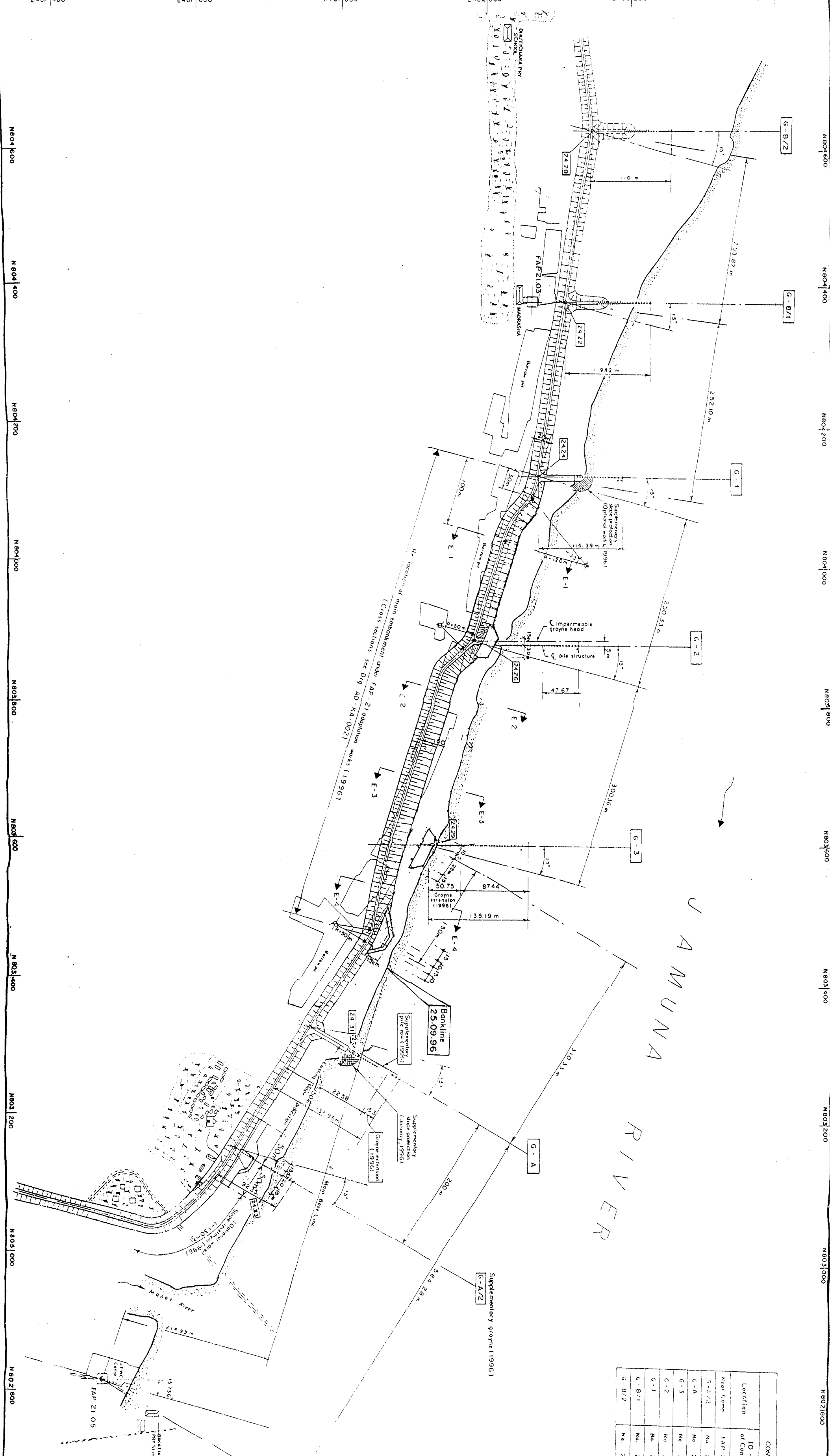
REVISION	DATE	DESCRIPTION	APPROVED
3	27/1/97	AS BUILT DRAWING (Adaptation works)	
2	8/8/96	AS BUILT DRAWING	
1	28/9/96	Revetment near G-A/2	

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**

TEST SITE 1 - KAMARJANI  
ADAPTATION WORKS  
GENERAL PROJECT LAYOUT

DATE	SCALE	FIGURE NO.	REVISION
10-01-96	1:2000	1	3



### 2.2.2 Monitoring of the Test Structures

Since the final objective of the bank protection pilot project is to develop and optimize 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, preventive maintenance and adaptation of the works is a must after installation of the test structure. Hence, monitoring started immediately after completion of the works in 1995. The following activities have been performed during the period under review:

#### (1) Bathymetry

Bathymetry surveys were done to detect and record planform and riverbed changes and their influence on the stability of the test structure. The activities during the months of July to September 1998 are shown in Table 1. All the surveys were finally processed in the office in Dhaka and the results are shown in contour charts.

The results of the main surveys during the period under review are given in Annex B.

Date	Survey Area		
	July 1998	August 1998	September 1998
01			
02			
03			
04			
05			
06			
07			
08	groyne field		
09		groyne field	
10			
11			
12			
13			
14			
15			
16			
17			groyne field
18			
19			
20			
21			
22	main survey	main survey	
23	main survey	main survey	main survey
24	main survey	main survey	main survey
25	main survey	main survey	main survey
26	main survey	main survey	main survey
27		main survey	main survey
28		main survey	main survey
29		main survey	
30	main survey		
31			

Table 1: Bathymetry surveys at Kamarjani Test Site from July to September 1998

## (2) Topographic Measurements

The topographic measurements were done by using Electronic Distance Measurement (EDM) equipment & levelling instrument. During the period under review the following works were performed:

07/07	waterline of Batkamari char
15/08	polygon survey from Kamarjani test site to Balashi Ghat
02/09	survey of Kamarjani market
22/09	survey of Kamarjani market
27/09 to 25/09	bankline from Kamarjani market to Balashi Ghat
28/09	survey of char opposite the groyne field
29/09	waterline of Kharjani char

## (3) 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.

## (4) 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.

Additional current measurements were carried out by an engineer of "Labor für Wasserbau" of Hochschule Bremen with drifter buoys using DGPS from mid June till end of July.

## (5) Observations

The situation at Kamarjani Test Site during the period under report is characterised by exceptional high water levels. At the beginning of July 21.49 m+PWD were measured and the water level remained above 21.40 m+PWD till September 08. Three peaks were recorded viz. 22.14 m+PWD on July 26, 22.22 m+PWD on August 19 and 22.46 m+PWD on September 07. The average water level in July was the highest one of July during the last 4 years and about 1 m higher than in July 1997. The total rainfall in July was 767 mm which was significantly higher compared to the other years after 1995. Also in August 619 mm rainfall was recorded which was 370 mm more than in August 1997. And even in September 301 mm were measured. The average water level in August was 1.9 m higher than in August 1997 and that one of September 1.45 m above the average in September 1997. At the end of the period under report the water level was at 19.63 m+PWD.

The site surveys at the test site showed only shallow water with maximum scour depths downstream from groyne G-1 and G-2 of 10 m in July and 7 m in August. No damages of the structure were observed. However, the bank erosion process between the test site area and Balashi Ghat continued. At the same time the depth and the width of the Kundarapara channel continued to increase.

## 2.3 TEST SITE II AT BAHADURABAD

### 2.3.1 Introduction

The construction of the Revetment Test Structure was originally planned about 4 km south of Bahadurabad Ghat based on the investigations during the Study Phase. Since, however, no substantial erosion occurred at the pre-selected test site, this area was abandoned and a more suitable one was selected in September/October 1995 at Kulkandi-village just downstream from Bahadurabad Ghat. The decision on the final location of the test structure was taken on October 11, 1995. However, end November 1995 it emerged that the Subcontractor could not mobilize the main construction equipment for dredging and under water works in time. After he had admitted his inability to do so, the Consultant



informed the Subcontractor on December 05, 1995 of his failure to comply with the contractual obligations in accordance with Sub-Clause 63.1 (b) of the Conditions of Contract. On January 20, 1996 the Subcontractor was notified in accordance with Sub-Clause 46.1 of the Conditions of Contract that the rate of progress of works was too slow to comply with the contractual Time of Completion and finally it was decided on January 31, 1996 to defer the final completion of the test structure until next dry season.

Based on the experience in 1995 and January 1996, and after identification of the main constraints preventing the completion of Works as per original schedule, a proposal for the final implementation of the Revetment Test Structure during the dry season 1996/97 was submitted in April 1996 taking into account the morphological analysis of the test area in March and May 1996 and the expected morphological development during the monsoon season 1996.

However, in August 1996 a deep channel shifted towards the bank of the selected test site and over the full length of the planned structure with severe erosion of the river bank resulting in a complete loss of the unprotected structure of 1995/96. Hence, another location of the Revetment Test Structure had to be determined and the design of the structure to be adapted accordingly. A proposal was presented to WARPO on October 19, 1996 which was discussed with the client and the donors during a review mission of the latter from November 13 to 17, 1996 with the final decision in favour of the location as shown in Fig. 2.

The start and the implementation of works was strongly affected by the land acquisition problem and the progress of works was already behind schedule at the end of 1996, because the subcontractor could only start the actual works on November 20, 1996 and concentrated till the end of the year mainly on earth works. Even after the client and the donors had decided during their meeting in November 1996 to proceed with the construction works, the concerned authorities of the Government of Bangladesh took almost another month for compensation payment to the local population after the donors had agreed to advance necessary funds.

Due to the above mentioned circumstances the delay of the actual construction works accumulated to almost 2.5 months. However, the Consultant and his Subcontractor made every effort to make up for lost time and on June 15 the Client had been informed that the Revetment Test Structure was complete in all respects on June 12, 1997.

### **2.3.2 Monitoring of the Test Structures**

Monitoring of the Revetment Test Structure started already during the construction phase in January 1997. During the period under report the following activities have been performed:

#### **(1) Bathymetry**

Bathymetry surveys are mainly done to record riverbed changes in front of the test structure and to detect their influence on the stability of the structure, in particular to find out the behaviour / functioning of the falling aprons and launching aprons, since this is decisive for the overall stability of the test structure.

The activities during the months of July to September 1998 are shown in Table 3. All the surveys were finally processed in the office in Dhaka and the results are shown in contour charts as well as differential models (see Annex F and G).





# REVETMENT TEST STRUCTURE DEFINITION SKETCH

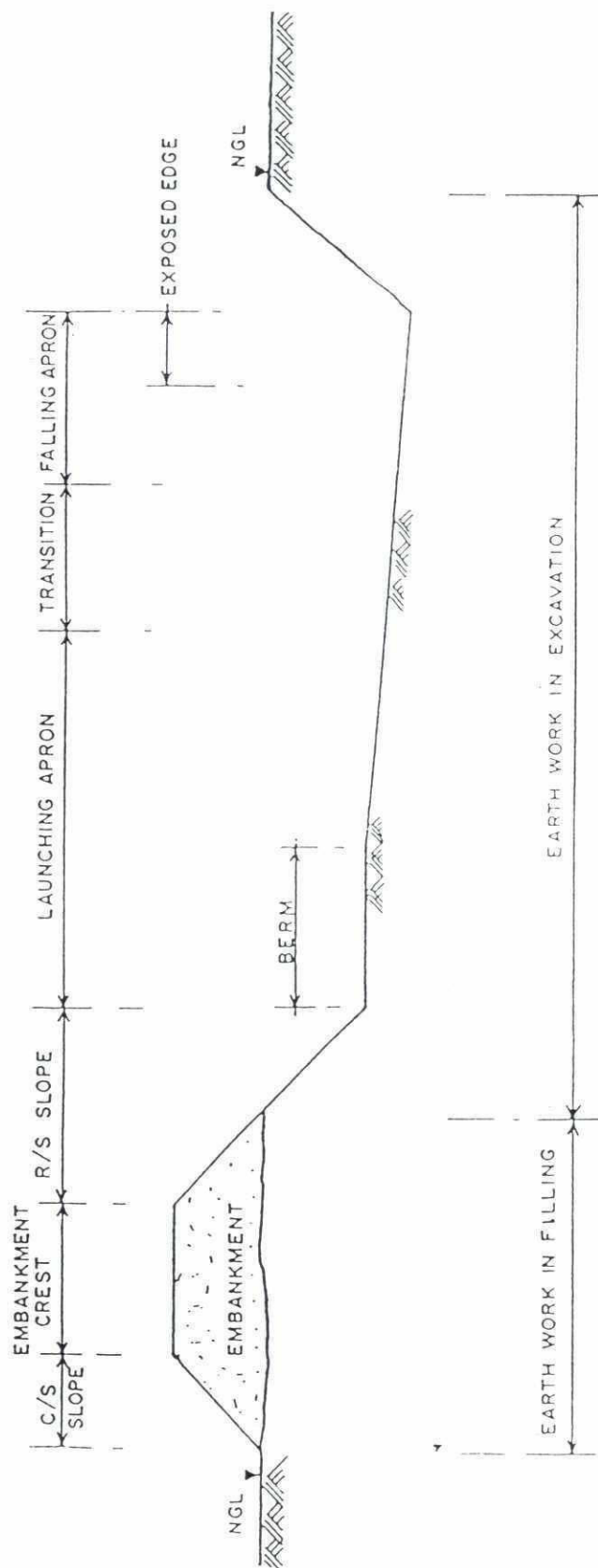


Figure 3: Definition Sketch of the Revetment Test Structure

Test Structure	A - end	A - 1	A - 2	B	C	D	E
	Rock mottress						
	In all sections Durba grass sods laid on Geo - jute soil cover						

```

ns : upstream
ps : downstream

```

Test Structure	A - end	A - 1	A - 2	B	C	D
					In all sections	Geo - lute Soil Cover

Table 2: Details of Revetment Composition



Date	Survey Area		
	July 1998	August 1998	September 1998
01			
02			
03			
04			
05			
06			
07			
08			
09		site survey	
10		site survey	site survey
11			
12			
13			
14			
15			
16			
17	main survey		main survey
18	main survey		main survey
19	main survey		main survey
20			
21	main survey		
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			

**Table 3: Bathymetry surveys at Bahadurabad Test Site from July to September 1998**

Moreover, measurements have been carried out regularly in the individual sections of the structure. The aim of these activities is to get more information on erosion and sedimentation in the channel in front of the structure, in the area of the falling aprons and on the functioning of the falling/launching aprons. The results of these measurements are given as cross-sections in Annex I.

## **(2) Topographic Measurements**

No topographic survey in the test site area during the period under review.

## **(3) Measurement of Flow Velocity and Direction**

Float track measurements were continued as well as measurements with the Valeport currentmeter. Results of flow measurements are presented in Annex H.

Additional current measurements were started mid of June by an engineer of "Labor für Wasserbau" of Hochschule Bremen with drifter buoys using DGPS and continued till end of July.

#### (4) Observations

The water levels at Bahadurabad Test Site were as unusual high as at Kamarjani. Peaks were recorded at 19.71 m+PWD on July 26, at 19.82 m+PWD on August 20 and at 20.12 m+PWD on September 08, which was the highest one in 1998. At the end of the period under report 17.61 m+PWD were measured.

No damage of the Revetment Test Structure was reported. In July the process of sedimentation in front of the structure continued with maximum deposition of about 17.5 m along Section H-2. However, in August erosion started along the structure and maximum values of 6 m were observed at Section E-1 and H-1. This process continued also in September and maximum erosion of more than 3 m were recorded at Section D.

### 3 RIVER TRAINING (AFPM) COMPONENT (FAP 22)

#### 3.1 PRELIMINARY REMARK

After the activities under FAP 22 had been suspended in 1995, the Consultant was requested by WARPO on March 06, 1996 to take up recurrent measure activities. Therefore, the project works were resumed at the beginning of April 1996 and concentrated mainly on the completion of the desk study and a report on the activities in 1995/96 which was submitted on September 05, 1996 along with a proposal and work plan for the project continuation for the implementation of recurrent measures during the lean season 1996/97. The work plan covered the selection of suitable test sites as well as the design, implementation and testing of appropriate recurrent measures as Low Water Bandals, Improved Bandals and Sills.

Immediately after the positive comments of KfW on the Consultants programme of investigations in 1996/97 were received in September 1996, a suitable test site had been selected in the outflanking Katlamari channel just upstream from Fulchari where a combination of two measures viz. a 210 m long bandal structure and an earth dam about 600 m downstream from the bandals (see Fig. 4) was built. Design and construction works started in the last quarter of 1996 and were completed mid March 1997. These measures were tested by the Jamuna river and monitored by the Consultants during the monsoon season 1997. It was intended to supplement/modify the test structures based on the experience of the first test season and to continue the investigations during the monsoon season 1998. A technical and financial proposal for further investigations was submitted to the client and the donors in the last quarter of 1997, but at the end of the flood season 1997 it emerged that the overall morphological development in the test site area and the Fulchari channel did not allow the continuation of the tests at Katlamari Test Site. Therefore, at the beginning of January 1998 a new test site was selected for testing of recurrent measures during the monsoon season 1998 which is located about 5 km east of the Groyne Test Structure of FAP 21 at Kamarjani.

Table 2.2-1 and Table 2.2-3 are showing the Work Plan as per proposal of August 1996 and December 1997 respectively whereas Table 2.2-5 the Staffing Schedule for the study period 1996 till 1998 including that one of the modified proposal of December 1997. Table 2.2-2 and 2.2-4 are showing the actual activities up to the end of the period under report and Table 2.2-6 and 2.2-7 the actual input of the expatriate and the local professional staff fielded up to end of September 1998.



## 3.2 TEST SITE I AT KATLAMARI

### 3.2.1 The Test Structures

Two different structures were built at Katlamari:

- a) improved bandals with a total length of 210 m and consisting of 4 main components at the off-take of the Katlamari channel with the aim to deflect the flow and to encourage siltation behind the structure;
- b) an earth dam 600 meters downstream from the bandal structure with the aim to close the Katlamari channel at the beginning of the flood season.

The idea behind these measures was to deflect the flow into the Fulchari channel, to decrease the size of the Katlamari channel and thus concentrate more flow in the Fulchari channel, to deepen the latter and to improve the ferry operations to Fulchari Ghat. In parallel it was expected that the size of the Katlamari channel would decrease, that bank erosion would diminish and arable land could be won.

Both the structures were designed to support the effectiveness of each other and thus to increase their overall efficiency.

### 3.2.2 Monitoring of the Test Structures

Monitoring of the structures started immediately after their completion. The valuable and good results were presented and explained in the previous progress reports.

After the Fulchari channel started to move westwards and finally washed away Section E of the bandal structure, it was decided to abandon this test site. In January/February 1998 dismantling of the remaining sections of the structure except Section A was started and only on January 07, 1998 another far and near field bathymetric survey was performed as well as bankline and topographic survey in the test site area. The dismantled material of the bandal structure was transported to the new test site at Kundarapara and partly used for the construction of low water bandals.

Recording of water levels, bathymetric surveys and flow measurements were continued during the period under report. In July no major changes were observed. The Fulchari channel was even silting up in the area of the bifurcation point to the Katlamari channel which showed shallow water only. The deepest part was found north of the bandal structure along the bank where flow velocities of more than 2 m/s were measured. In August the bathymetric survey was extended upto 4.5 km north of the test structure. Maximum water depths of 16 to 17 m were recorded in the Fulchari channel upstream from the test site whereas in the area of Katlamari no significant changes occurred. Only in September erosion in front of the char between the Katlamari channel and the Fulchari channel was observed.

The highest water levels were recorded at 20.81 m+PWD on August 20 and at 21.08 m+PWD on September 08.

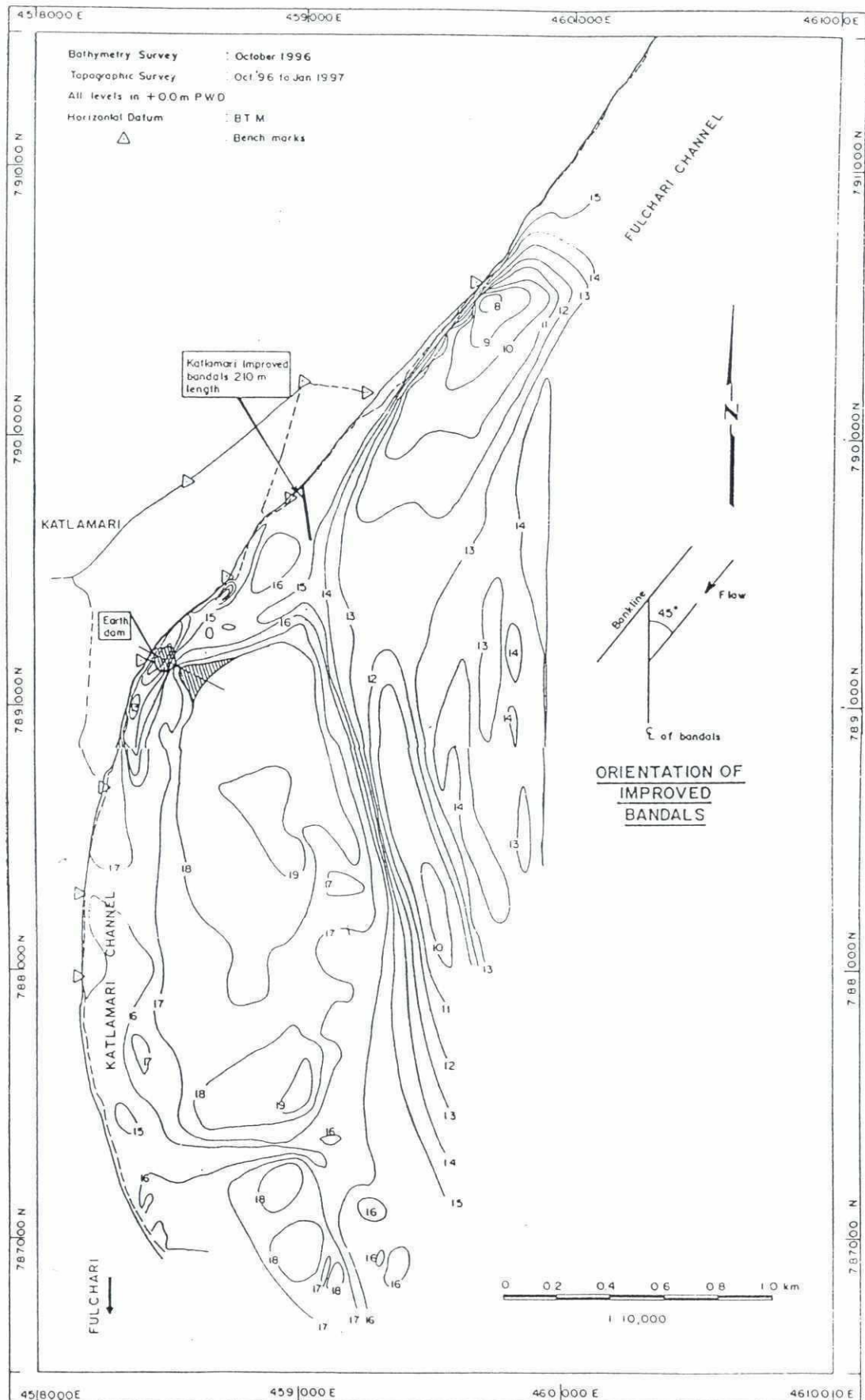


Fig. 4: Site Plan of Katlamari



### 3.3 TEST SITE II AT KUNDARAPARA

#### 3.3.1 The Test Structures

In order to reduce the severe erosion in the outer bend of the Kamarjani channel between Syedpur and Balashi Ghat it was planned to promote the development of the Kundarapara cut-off channel. The following recurrent measures were planned to be constructed and investigated:

##### (a) **Low Water Bandals**

Low water bamboo bandals were installed in February / March 1998 at the entrance of the Kamarjani bypass channel in order to increase the inflow into the Kundarapara channel and at the same time to reduce the inflow into the Kamarjani bypass channel.

##### (b) **Improved Bandals with adjustable Screens**

The height of these bandals were planned to be 4.5 m only with 2 m high adjustable screens. Hence, they can only be installed in areas with a limited water depth or at such places which will fall dry during the lean season. Therefore, it was intended to build them as a connection between the bankline on the char and the deeper part of the Kundarapara channel where floating screens will be installed. The adjustability of the screens will increase the efficiency during the rising and falling limb of the hydrograph and contribute to the further development and improvement of bandals.

However, after permanent problems with the local population, it was decided on March 10, 1998 to stop the construction of the improved bandals when it became obvious that they could not be completed in time before the flood season 1998.

##### (c) **Floating Screens**

The first promising tests with floating screens were carried out in July 1997 at Katlamari Test Site. These tests showed that it is possible to fix adjustable screens to floating elements and to handle and anchor these elements also at high water stages in deeper channels with higher flow velocities. For the new test site it was proposed to construct floating elements of about 5.7 x 11.3 m with a maximum screen depth of 4 m. Hence, even in 8 m deep channels a depth blockage ratio of 0.5 can be obtained. They were planned to be installed with a total length of 100 m as an extension of the improved bandals in the Kundarapara channel. Their main objective was to influence the flow in such a way that the development of the Kundarapara cut-off will be accelerated, but also to gain more experience in handling and anchoring of this type of recurrent measure. Since they are flexible and allow for use on repeated occasions in subsequent years, they are an ideal tool in the sense of recurrent measure.

Construction and assembling of the floating elements was started in February at Kamarjani Test Site. Since, however, the import of anchoring equipment was delayed, the elements with a total length of about 100 m could only be completed in June 1998. In the course of positioning and anchoring of the elements, local people sabotaged again the activities so that the Consultant had no choice but to stop the investigations with floating screens for the flood season 1998.

#### 3.3.2 Monitoring of the Test Structures

During the period under report bathymetric surveys and flow measurements were continued. However, testing of the floating elements was not possible, since the elements could not be shifted to any other suitable test site due to the strong current in the channels of the Jamuna.

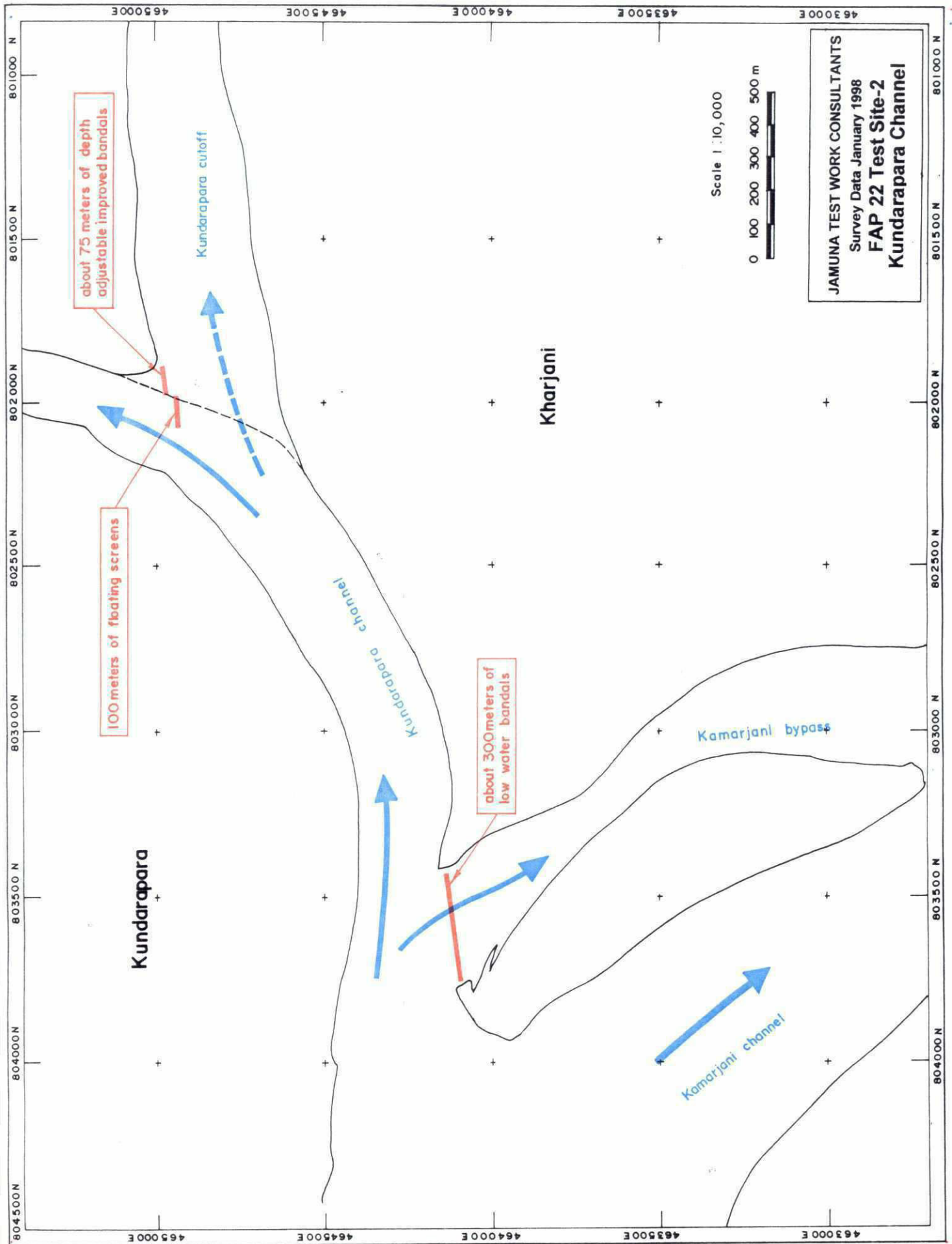


Fig. 5: Location of the Test Structures



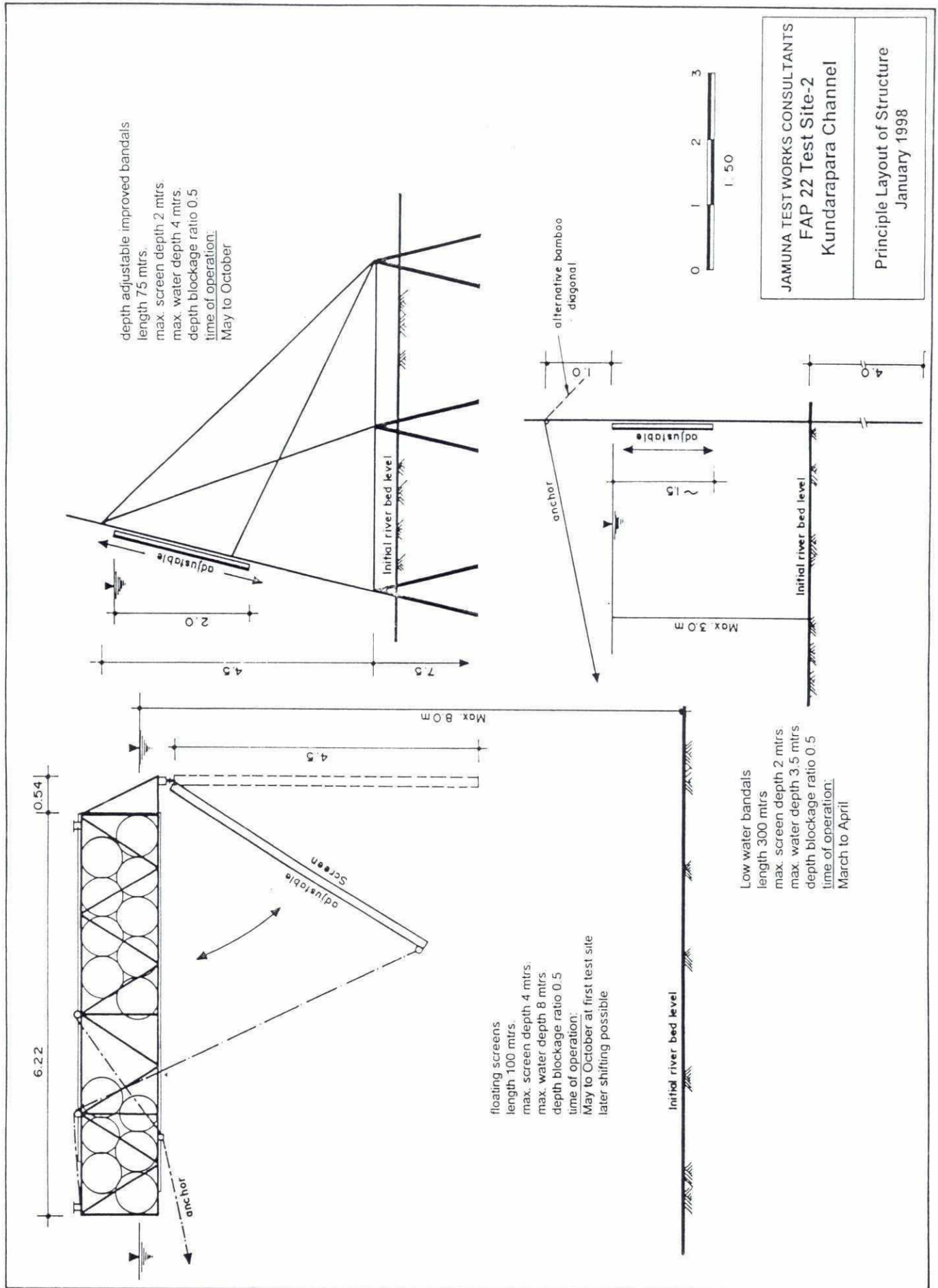


Fig. 6: Layout of the Structures

Table 1.1-1

**BANK PROTECTION TEST STRUCTURES - FAP 21**  
**EXPATRIATE PROFESSIONAL STAFF**  
**Activities during the period of 07/98 to 09/98**

VERSION: 22.11.98

Sl. No.	Function	Person	Code	Company	Period		Remarks
					From	To	
1.1	Project Director	Dr. D. Neuhaus / Dr. H. Kramer	DN / HK	RRI	01/07	30/09	Part time in Europe
1.2	Home Office Support						
1.3.1	Project Manager	C. Netzeband	CN	RRI	01/07	07/08	Part time in Europe
					21/09	30/09	Part time in Europe
1.4	Chief Hydraulic Design Engineer	Dr. H. Kramer	HK	L&P	01/07	30/09	Part time in Europe
					19/07	20/07	In Bangladesh
					16/08	20/09	In Bangladesh
2.1.1	Hydraulic Design Engineer	M. Schwarz	MS	L&P	-	-	
2.2	Structural Engineer	-	-	-	-	-	
2.3	Mechanical Engineer	-	-	-	-	-	
2.4	Procurement Expert	-	-	-	-	-	
2.5.1	Subsoil Expert	H. Wessling	HW	L&P	-	-	
3.1.	Chief Supervising Engineer	-	-	-	-	-	
3.2.1	Supervising Engineer	-	-	-	-	-	
3.4.1	Surveyor	J. Heise	JH	RRI	-	-	
3.5.1	Administrator	B. Thomas	BT	CNR	-	-	
3.6.1	Monitoring Expert	T. Döscher	TD	RRI	01/07	07/09	
4.1.1	Morphologist	Dr. E. Mosselman	EM	DELFT	27/08	10/09	
4.2.1	Modelling Expert	M. v. d. Wal	MvdW	DELFT	27/08	27/09	
		D. Carrion	DC	CNR	-	-	
		E. Divet	ED	CNR	-	-	
4.3.1	Environmental Expert	C. Bertrand	CB	CNR	-	-	
4.5.1	Economist	--	-	-	-	-	
4.6.1	Unallocated	--	-	-	-	-	



Table 1.1-2

**BANK PROTECTION TEST STRUCTURES - FAP 21**  
**LOCAL PROFESSIONAL STAFF**  
**Activities during the period of 07/98 to 09/98**

VERSION: 22.11.98

Sl. No.	Function	Person	Code	Company	Period		Remarks
					From	To	
1.2	Home Office Support	NN					
1.3.2	Deputy Project Manager	S. M. Mansur	SM	BETS	01/07	30/09	
2.1.2	Hydraulic Design Engineer 2	A. Q. Mohammed Ali	MA	BETS	-	-	
2.3.2	Mechanical Engineer 2	Masih-ur-Rahman	MR	DUL	-	-	
2.4.2	Procurement Expert 2	Masih-ur-Rahman	MR	DUL	-	-	
2.5.2	Subsoil Expert 2	-	-	-	-	-	
3.2.2	Supervising Engineer 2	Fazlur Rahman / Sk. Golam Kader	FR	BETS	-	-	
3.3	Quantity Surveyor	Faizur Rahman Khan	SGK	BETS	01/07	30/09	
3.4.2	Surveyor 2	-	FRK	DUL	-	-	
3.6.2/3/4	Monitoring Expert 2	A.B.M. Anwar Haider	-	-	-	-	
	Jr. Monitoring Expert	Pankaj K. Maitra	AH	BETS	01/07	30/09	
	Monitoring Data Processor	Yasmin Khayer	PKM	BETS	01/07	30/09	50 % for FAP 22
4.1.2	Morphologist 2	M. H. Sarker	YK	FL	01/07	30/09	
4.2.2	Modelling Expert 2	Monjur Kader	MHS	FL	-	-	
4.3.2	Environmental Expert 2	Dr. A.K.M. Nazrul Islam	MoK	BETS	-	-	
4.4	Socio-Economist	Tauhidun Nabi	NI	BETS	-	-	
4.5.2	Economist 2	NN	TN	BETS	-	-	
4.6.2	Unallocated 2		-	-	-	-	

Table 1.1-3

**BANK PROTECTION TEST STRUCTURES - FAP 21**  
**LOCAL SUPPORT STAFF**  
**Activities during the period of 07/98 to 09/98**

VERSION : 22.11.98

Sl. No.	Function	Person	Company	Period		Remarks
				From	To	
1	Bilingual Secretary	Sk. Zakirul Islam	BETS	01/07	30/09	
2	Receptionist	Md. Razaul Karim	BETS	01/07	30/09	
3	Operator / Data Input	Md. Khorshed Alam	BETS	01/07	30/09	
4	Senior Draftsman	Anowarul Alam	BETS	01/07	30/09	
5	Draftsman	Md. Fazle Hossain Bhuiyan	BETS	01/07	30/09	
6	Photocopy Operator	Md. Q M Hussain (Babu)	BETS	01/07	30/09	
7	Accountant	A.B.M Bazlur Rashid	BETS	01/07	30/09	
8	Asstt. Acct. Purchase	Md. Shafiuddin	BETS	01/07	30/09	
9	Messenger	Md. Aziz	BETS	01/07	30/09	
10	Peon	Md. Habibur Rahman Hawladar	BETS	01/07	30/09	
11	Guards ( 8 hours shift )	Md. Farid Sikder / Md. Moqbul Hossain / Md. Shakawat Hossain	BETS	01/07	30/09	
12-19	Drivers	Eight Drivers	L&S	01/07	30/09	





BANK PROTECTION TEST STRUCTURES FAP 21

15.03.1995

\*) AS PER LETTER TO PROCEED OF MAY 1993

MONSOON

\*) AS PER LETTER TO PROCEED OF MAY 1993





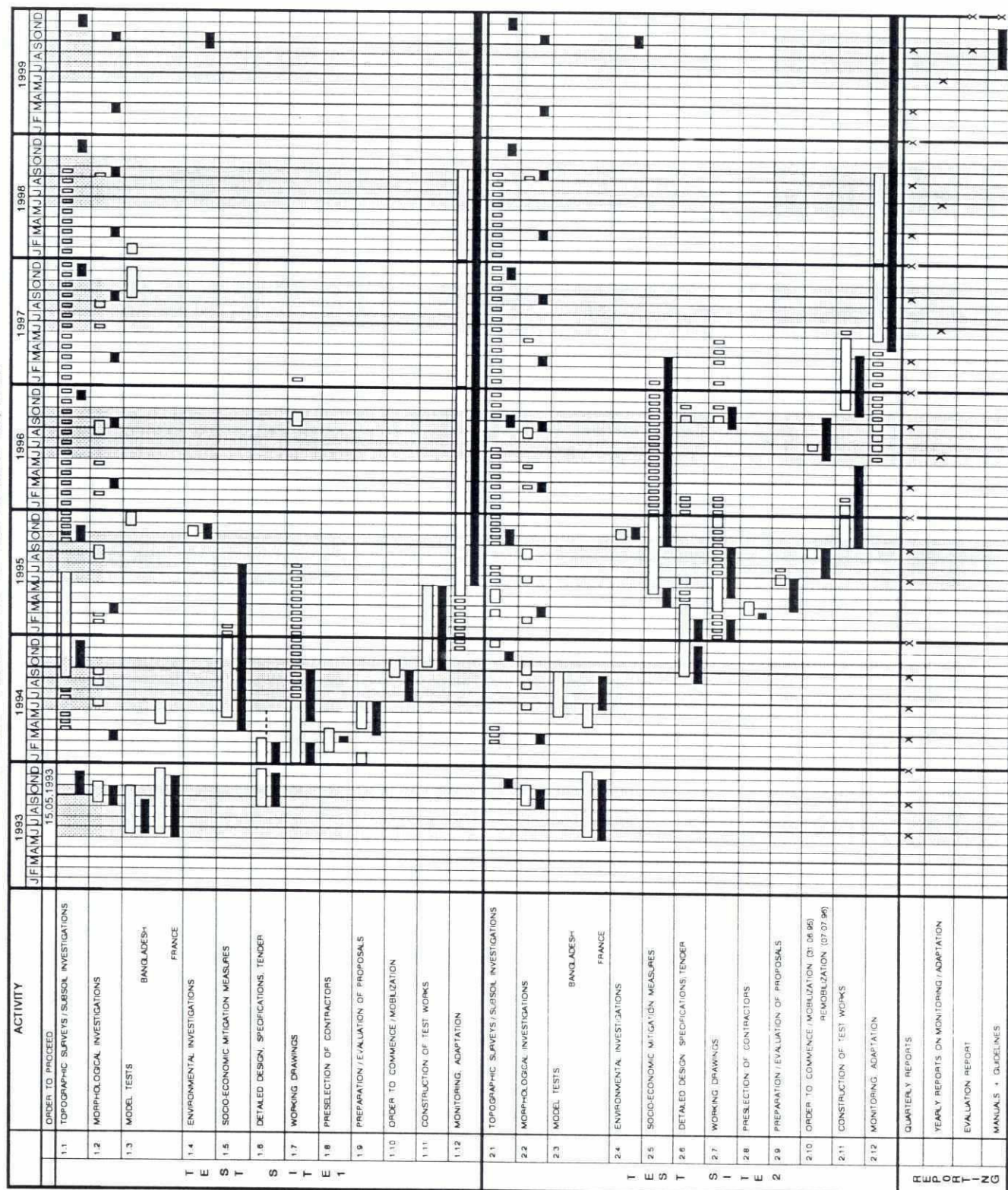


TABLE 1.2 - 2

## BANK PROTECTION TEST STRUCTURES FAP 21

REVISION NO. 1 \*)

WORK PLAN - FIELDIED UP TO SEPTEMBER 30, 1998



\*) AS PER PROPOSAL OF SEPTEMBER 1996



**BANK PROTECTION TEST STRUCTURES - FAP 21**

\*) AS PER LETTER TO PROCEED OF MAY 1993



**BANK PROTECTION TEST STRUCTURES - FAP 21**

[illegible]











TABLE 1.2 - 5

## BANK PROTECTION TEST STRUCTURES - FAP 21

REVISION NO. 2 \*)

STAFFING SCHEDULE - LOCAL PROFESSIONAL STAFF - FIELDIED UP TO SEPTEMBER 30, 1998

	FUNCTION	1995												1996												1997												1998													
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D														
1.3.2	DEPUTY PROJECT MANAGER																																																		
2.1.2	HYDRAULIC DESIGN ENGINEER 2																																																		
2.3.2	MECHANICAL ENGINEER 2																																																		
2.4.2	PROCUREMENT EXPERT 2																																																		
2.5.2	SUBSOIL ENGINEER 2																																																		
3.2.2	SUPERVISING ENGINEER 2																																																		
3.3	QUANTITY SURVEYORS																																																		
3.4.2	SURVEYOR 2																																																		
3.6.2	MONITORING EXPERT																																																		
4.1.2	MORPHOLOGIST 2																																																		
4.2.2	MODELLING EXPERT 2 + 3																																																		
4.3.2	ENVIRONMENTAL EXPERT 2																																																		
4.4	SOCIO-ECONOMIST																																																		
4.5.2	ECONOMIST 2																																																		

\*) AS PER PROPOSAL OF SEPTEMBER 1996

TABLE 2.1-1

**STUDIES ON RECURRENT MEASURES - FAP 22**  
**EXPATRIATE PROFESSIONAL STAFF**  
**Activities during the period of 07/98 to 09/98**

VERSION : 22.11.98

Sl. No.	Function	Person	Code	Company	Period		Remarks
					From	To	
1.1	Project Director	Dr. D. Neuhaus	DN	RRI	-	-	
1.2	Home Office Support	Dr. H. Kramer	HK		-	-	
1.3.1	Project Manager	C. Netzeband	CN	RRI	-	-	
1.4	Chief Hydraulic Design Engineer	Dr. H. Kramer	HK	L&P	-	-	
5.1.1	River Engineer	P. van Groen	PvG	DELFT	-	-	
5.2	Hydraulic Design Engineer	M. Schwarz	MS	L&P	-	-	
5.3.1	Surveyor	-	-	-	-	-	
5.4.1	Morphologist	Dr. E. Mosselman	EM	DELFT	-	-	
5.5	System Analyst	R. H. Buijsrogge	RHB	DELFT	-	-	
5.6	Programmer	M. Witteveen	MW	DELFT	-	-	
5.6.A	Programmer / Modeller	J. I. Crebas	JIC	DELFT	-	-	
5.7	GIS Specialist	G.K.F.M. Hesselmans	GMH	DELFT	-	-	
5.8.1	Supervising Engineer	K. Oberhagemann	KO	RRI	-	-	
5.9.1	Monitoring Expert	T. Döscher	TD	L&P	-	-	
5.10	Economist	-	-	-	-	-	

TABLE 2.1-2

## STUDIES ON RECURRENT MEASURES - FAP 22

## LOCAL PROFESSIONAL STAFF

Activities during the period of 07/98 to 09/98

VERSION : 22.11.98

Sl. No.	Function	Person	Code	Company	Period		Remarks
					From	To	
1.2	Home Office Support	NN	-	-	-	-	
1.3.2	Deputy Project Manager	S. M. Mansur	SM	BETS	-	-	
5.1.2	River Engineer 2	S. R. Khan	SRK	BETS	-	-	
5.3.2	Surveyor 2	--	-	-	-	-	
5.4.2	Morphologist 2	Salahuddin Khan	SK	BETS	01/07	31/07	
5.8.2	Supervising Engineer 2	F. R. Khan	FRK	DUL	-	-	
5.9.2/3/4	Monitoring Expert 2	A.B.M. Anwar Haider	AH	BETS	-	-	
	Jr. Monitoring Expert	Pankaj K. Maitra	PKM	BETS	01/07	30/09	50 % for FAP 21
	Monitoring Data Processor	Yasmin Khayer	YK	FL	-	-	
5.10.2	Economist 2	--	-	-	-	-	

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TABLE 2.2 - 1

STUDIES ON RECURRENT MEASURES - FAP 22  
WORK PLAN AS PER PROPOSAL OF AUGUST 1996

SL. NO.	ACTIVITY	1996				1997											
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	PRE-SELECTION	■	■														
2	VERIFICATION SURVEY	■															
3	FIELD CHECKS		■	■	■	■											
4	FIELD SELECTION		■	*	*	*											
5	DETAILED SURVEY		■	■	■	■											
6	FINAL DESIGN		■	■	■	■											
7	TENDERING			■	■												
8	CONSTRUCTION				■	■	■	■									
9	OPERATION AND MAINTENANCE						■	■	■	■	■	■	■	■	■	■	■
10	MONITORING AND EVALUATION						■	■	■	■	■	■	■	■	■	■	■

NOTE: \* DENOTES REVIEW OF FINAL SELECTION

TABLE 2.2 - 2

STUDIES ON RECURRENT MEASURES - FAP 22  
 WORK PLAN AS PER PROPOSAL OF AUGUST 1996  
 ACTIVITIES FIELDIED UP TO DECEMBER 31, 1997

SL. NO.	ACTIVITY	1997															
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	PRE-SELECTION	<div></div> <div></div>	<div></div>														
2	VERIFICATION SURVEY		<div></div>														
3	FIELD CHECKS		<div></div> <div></div>	<div></div> <div></div>	<div></div> <div></div>	<div></div>											
4	FIELD SELECTION		<div></div> <div></div>	<div></div> <div></div>	<div></div> <div></div>	<div></div>											
5	DETAILED SURVEY			<div></div>													
6	FINAL DESIGN		<div></div> <div></div>	<div></div> <div></div>	<div></div> <div></div>	<div></div> <div></div>											
7	TENDERING		<div></div> <div></div>														
8	CONSTRUCTION				<div></div>	<div></div>	<div></div>	<div></div>	<div></div>	<div></div>	<div></div>	<div></div>	<div></div>	<div></div>	<div></div>	<div></div>	<div></div>
9	OPERATION AND MAINTENANCE																
10	MONITORING AND EVALUATION																

NOTE: \* DENOTES REVIEW OF FINAL SELECTION



TABLE 2.2 - 3

STUDIES ON RECURRENT MEASURES - FAP 22  
WORK PLAN AS PER PROPOSAL OF DECEMBER 1997

SL. NO.	ACTIVITY	1997				1998											
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	PRE-SELECTION OF SITE																
2	VERIFICATION SURVEY / FIELD CHECK																
3	MAINTENANCE/ADAPTATION OF EXISTING BANDALS																
4	ELONGATION OF IMPROVED BANDALS																
5	DESIGN OF FLOATING SCREEN ELEMENTS																
6	CONSTRUCTION OF FLOATING SCREEN ELEMENTS																
7	FINAL SITE SELECTION																
8	DETAILED SURVEY																
9	POSITIONING AT TEST SITE																
10	OPERATION AND MAINTENANCE																
11	MONITORING																
12	EVALUATION																

TABLE 2.2 - 4

STUDIES ON RECURRENT MEASURES - FAP 22  
WORK PLAN AS PER PROPOSAL OF DECEMBER 1997  
FIELDIED UP TO SEPTEMBER 30, 1998

SL. NO.	ACTIVITY	1997				1998											
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	PRE-SELECTION OF SITE																
2	VERIFICATION SURVEY / FIELD CHECK																
3	MAINTENANCE/ADAPTATION OF EXISTING BANDALS																
4	ELONGATION OF IMPROVED BANDALS																
5	DESIGN OF FLOATING SCREEN ELEMENTS																
6	CONSTRUCTION OF FLOATING SCREEN ELEMENTS																
7	FINAL SITE SELECTION																
8	DETAILED SURVEY																
9	POSITIONING AT TEST SITE																
10	OPERATION AND MAINTENANCE																
11	MONITORING																
12	EVALUATION																



TABLE 2.2 - 5

# STUDIES ON RECURRENT MEASURES - FAP 22

## STAFFING SCHEDULE \* )

FUNCTION		NAME	1996												1997												1998												Man-Months			FLIGHTS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	BD	EU	LOCAL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
1.1	PROJECT DIRECTOR	Dr. D. Neuhaus / Dr. H. Kramer																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														

NOTE: \* Some of the working time of the Professionals will be charged to FAP 21 project

\*) AS PER PROPOSAL OF AUGUST 1996 AND DECEMBER 1997

MONSOON

EXPATRIATE

LOCAL

FAP 21



STUDIES ON RECURRENT MEASURES - FAP 22

## STAFFING SCHEDULE \* )

EXPATRIATE PROFESSIONAL STAFF - FIELDLED UP TO SEPTEMBER 30, 1998

[illegible]

NOTE : • Some of the working time of the Professionals will be charged to FAP 21 project

• ) AS PER PROPOSAL OF AUGUST 1996 AND DECEMBER 1997

MONSOON

EXPATRIATE

FAP 21

RELIABILITY





## ANNEX A

FAP 21 / Test Site I

- Water Level -



**BANK PROTECTION TEST STRUCTURES - FAP 21**  
**WATER LEVEL AT KAMARJANI TEST SITE**  
**MONTH : JULY 1998**

DAYS	T I M E			REMARKS
	8.00	13.00	17.00	
1	21.490	21.470	21.460	
2	21.440	21.440	21.450	
3	21.450	21.460	21.480	
4	21.570	21.590	21.600	
5	21.620	21.640	21.660	
6	21.690	21.690	21.690	
7	21.690	21.690	21.690	
8	21.750	21.760	21.800	
9	21.870	21.890	21.920	
10	21.930	21.920	21.910	
11	21.910	21.900	21.890	
12	21.880	21.880	21.890	
13	21.960	21.980	22.020	
14	22.090	22.110	22.110	
15	22.090	22.070	22.050	
16	22.000	21.990	21.960	
17	21.860	21.820	21.790	
18	21.700	21.680	21.660	
19	21.610	21.600	21.600	
20	21.610	21.710	21.730	
21	21.760	21.760	21.740	
22	21.790	21.810	21.810	
23	21.820	21.850	21.870	
24	21.890	21.940	21.990	
25	22.080	22.100	22.120	
26	22.140	22.140	22.140	
27	22.130	22.090	22.070	
28	22.030	22.020	22.000	
29	21.950	21.930	21.890	
30	21.790	21.750	21.730	
31	21.650	21.620	21.610	

**BANK PROTECTION TEST STRUCTURES - FAP 21**  
**WATER LEVEL AT KAMARJANI TEST SITE**  
**MONTH : AUGUST 1998**

DAYS	T I M E			REMARKS
	8.00	13.00	17.00	
1	21.530	21.510	21.490	
2	21.460	21.460	21.460	
3	21.460	21.470	21.480	
4	21.480	21.490	21.490	
5	21.470	21.470	21.460	
6	21.480	21.490	21.490	
7	21.470	21.470	21.470	
8	21.470	21.470	21.470	
9	21.470	21.470	21.470	
10	21.480	21.480	21.490	
11	21.510	21.510	21.520	
12	21.660	21.670	21.670	
13	21.690	21.690	21.690	
14	21.740	21.760	21.770	
15	21.810	21.820	21.850	
16	21.940	21.960	21.980	
17	22.040	22.060	22.070	
18	22.100	22.140	22.150	
19	22.220	22.220	22.220	
20	22.200	22.190	22.170	
21	22.110	22.110	22.110	
22	22.120	22.120	22.110	
23	22.050	22.020	22.010	
24	21.930	21.900	21.880	
25	21.820	21.810	21.810	
26	21.770	21.750	21.720	
27	21.720	21.740	21.760	
28	21.790	21.780	21.760	
29	21.690	21.660	21.640	
30	21.580	21.580	21.580	
31	21.540	21.540	21.540	

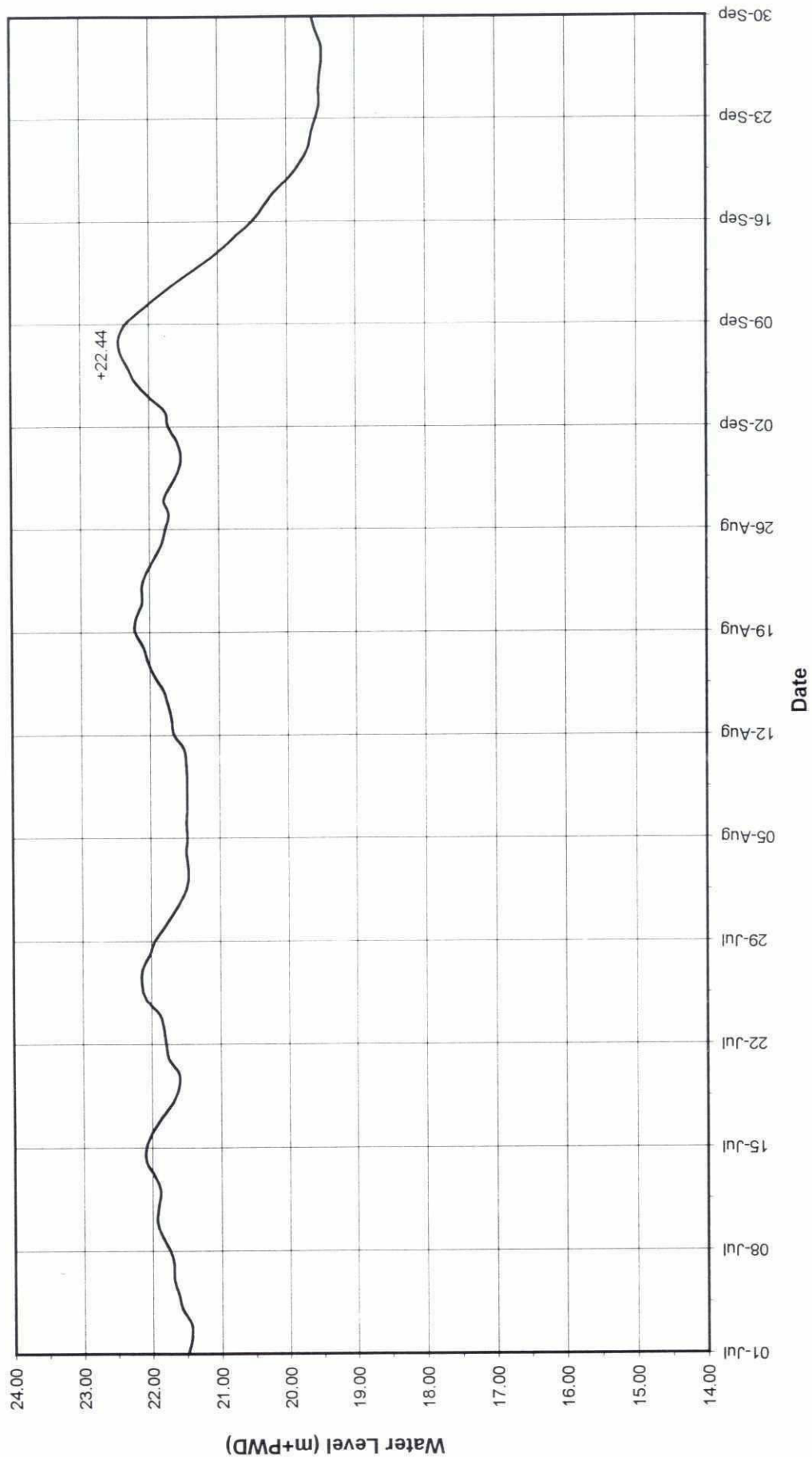


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**BANK PROTECTION TEST STRUCTURES - FAP 21**  
**WATER LEVEL AT KAMARJANI TEST SITE**  
**MONTH : SEPTEMBER 1998**

DAYS	T I M E			REMARKS
	8.00	13.00	17.00	
1	21.600	21.620	21.640	
2	21.730	21.710	21.710	
3	21.770	21.790	21.810	
4	22.000	22.050	22.090	
5	22.200	22.210	22.230	
6	22.310	22.350	22.370	
7	22.420	22.460	22.450	
8	22.440	22.420	22.410	
9	22.340	22.290	22.250	
10	22.090	22.050	22.000	
11	21.820	21.760	21.710	
12	21.550	21.480	21.430	
13	21.250	21.200	21.150	
14	20.970	20.930	20.880	
15	20.740	20.700	20.640	
16	20.500	20.470	20.440	
17	20.340	20.320	20.290	
18	20.180	20.100	20.070	
19	19.960	19.930	19.910	
20	19.800	19.780	19.760	
21	19.680	19.660	19.650	
22	19.640	19.620	19.600	
23	19.570	19.560	19.550	
24	19.520	19.510	19.510	
25	19.530	19.530	19.530	
26	19.510	19.510	19.510	
27	19.480	19.470	19.490	
28	19.490	19.490	19.510	
29	19.570	19.630	19.650	
30	19.630	19.610	19.600	

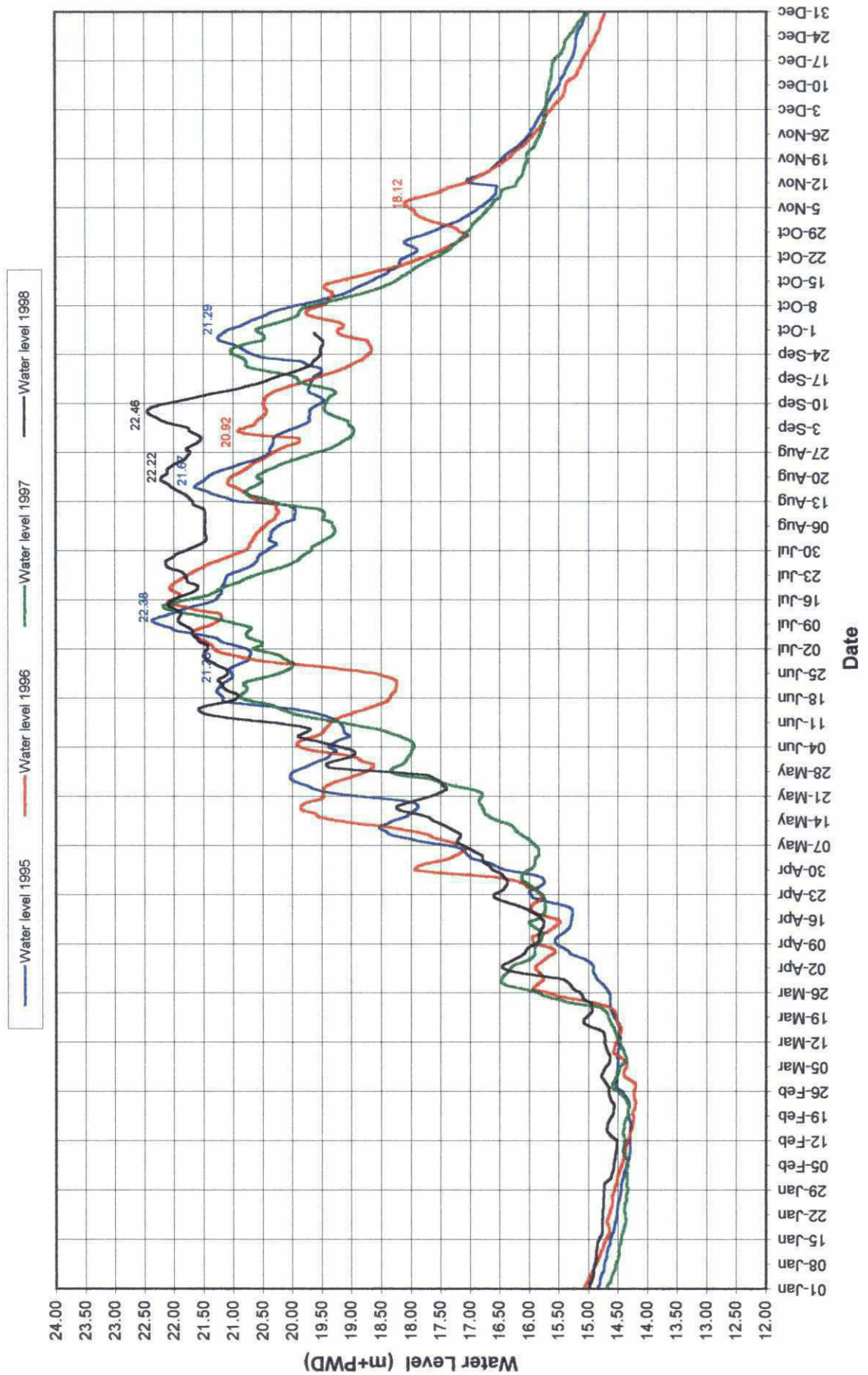
# **BANK PROTECTION TEST STRUCTURES - FAP 21** **WATER LEVEL AT KAMARJANI TEST SITE** **(July to September 1998)**



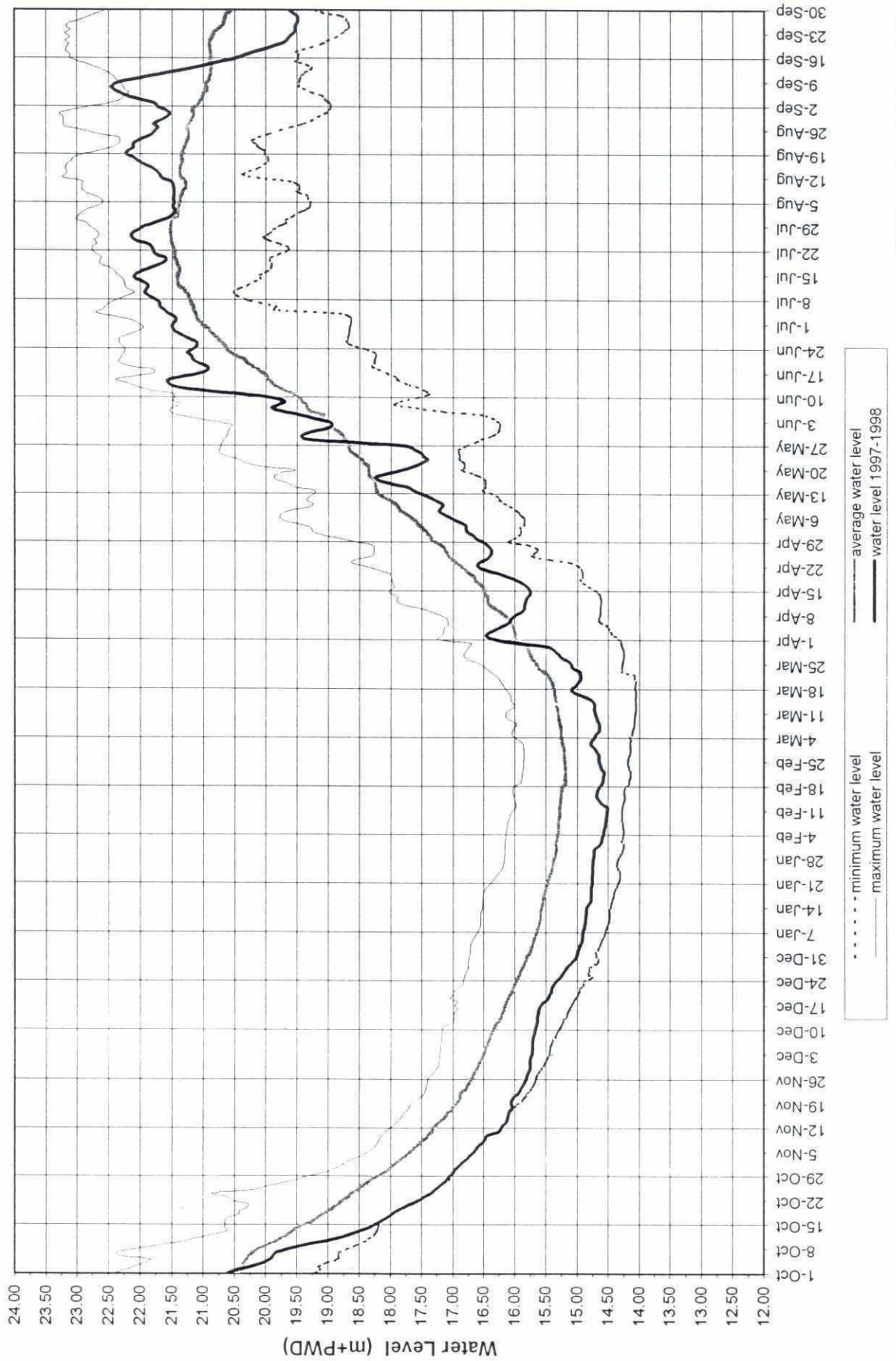
DD



# **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 SEPTEMBER '98**

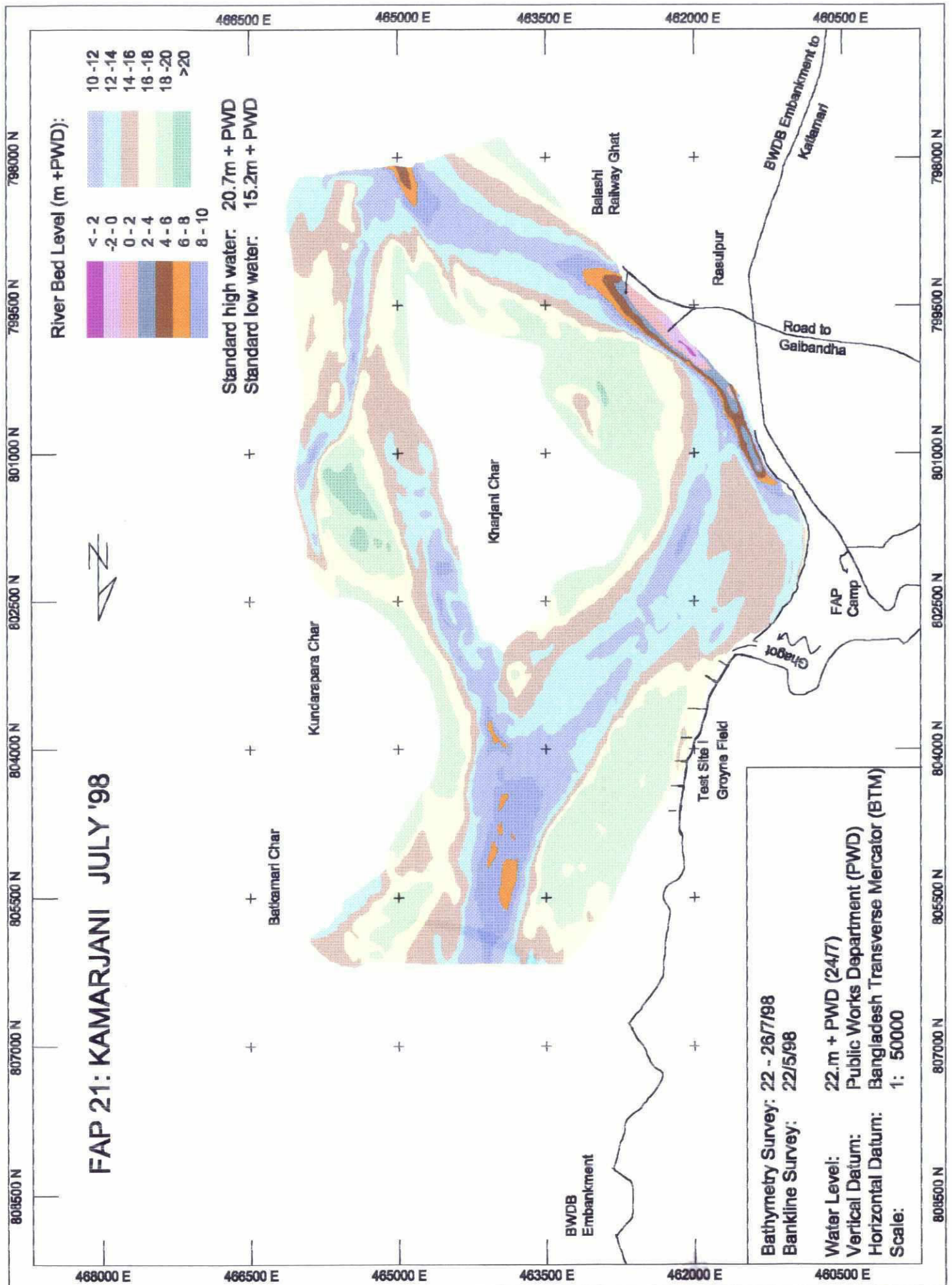


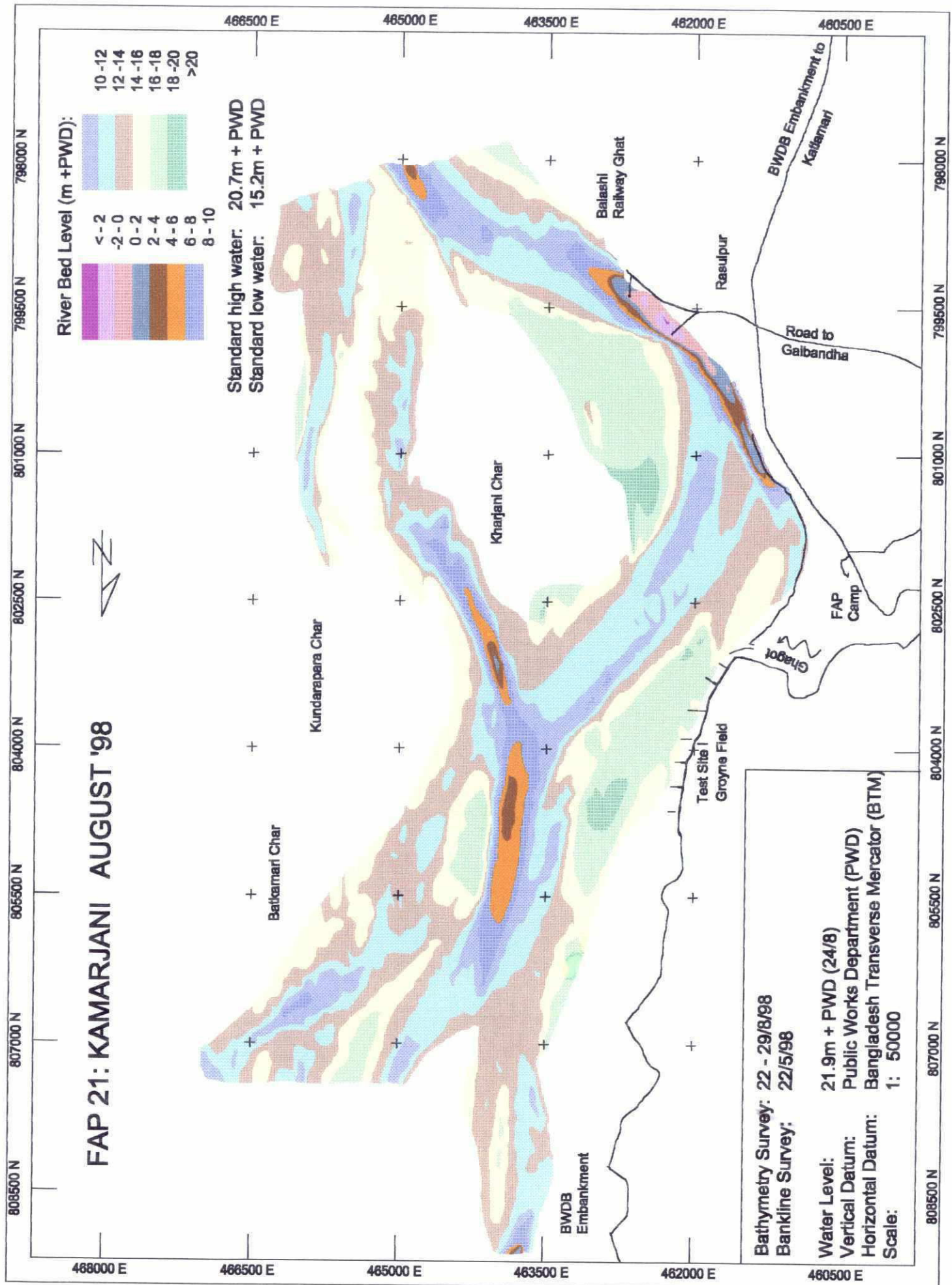
## **ANNEX B**

**FAP 21 / Test Site I**

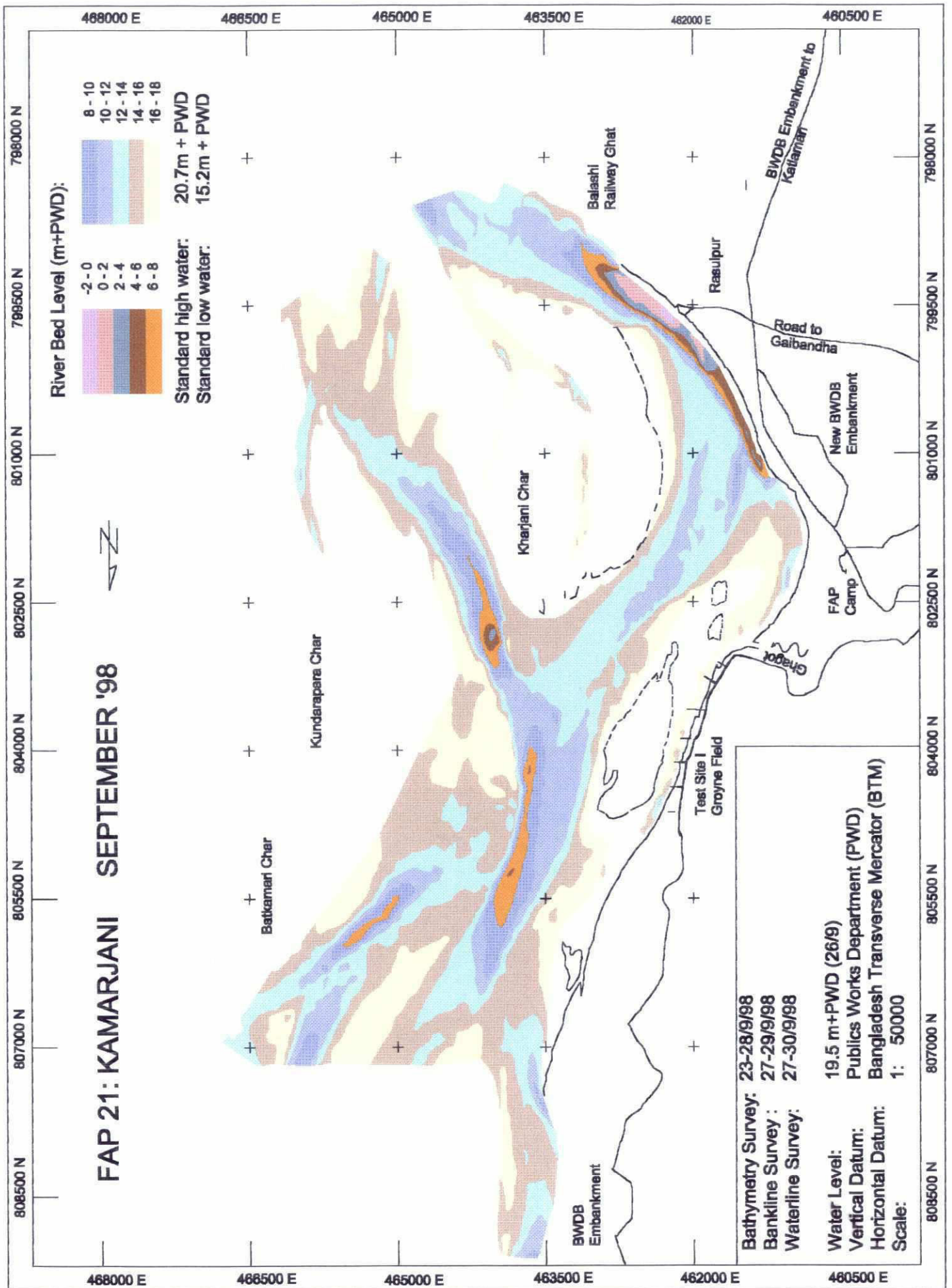
- Bathymetric Survey









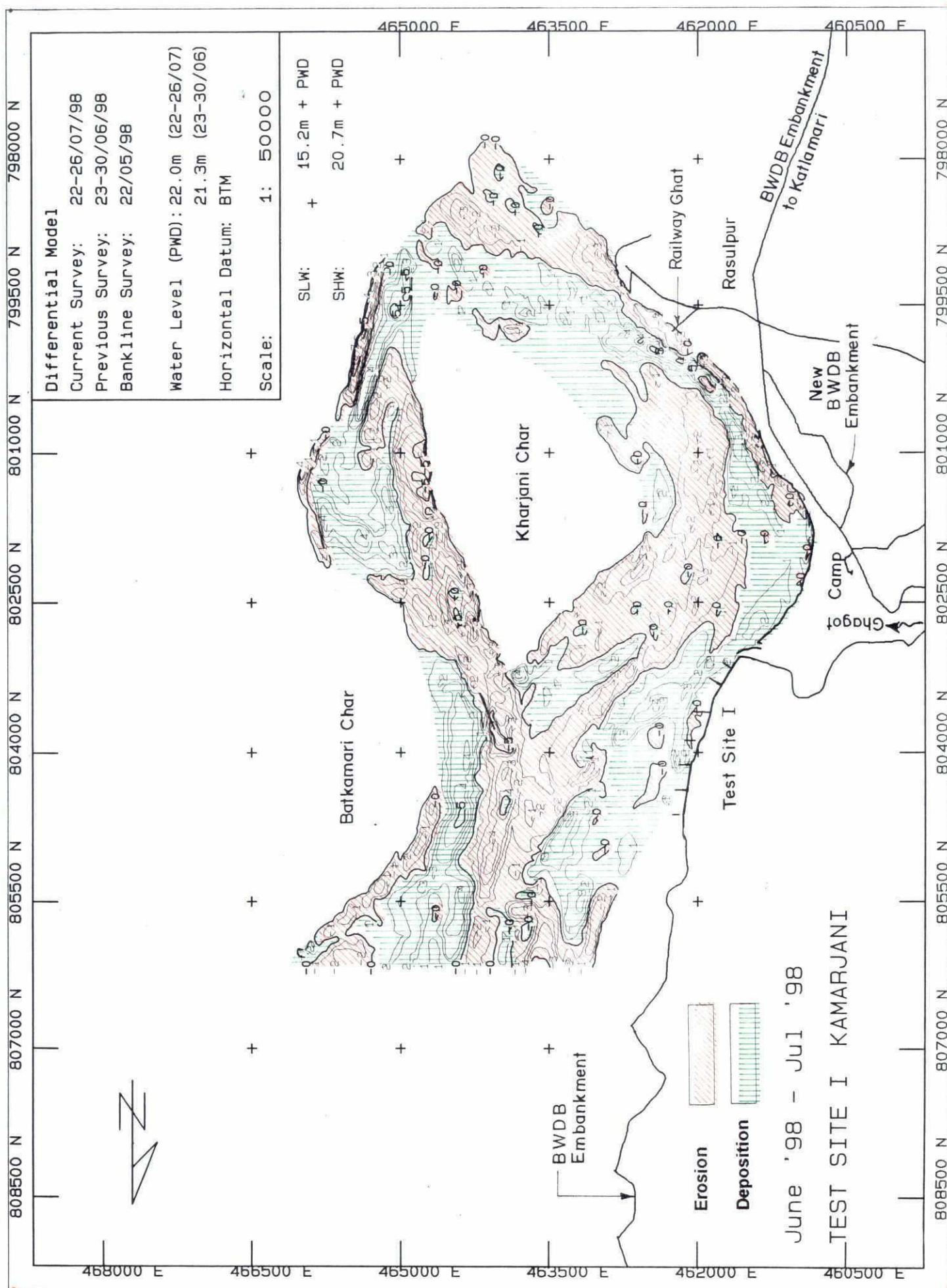




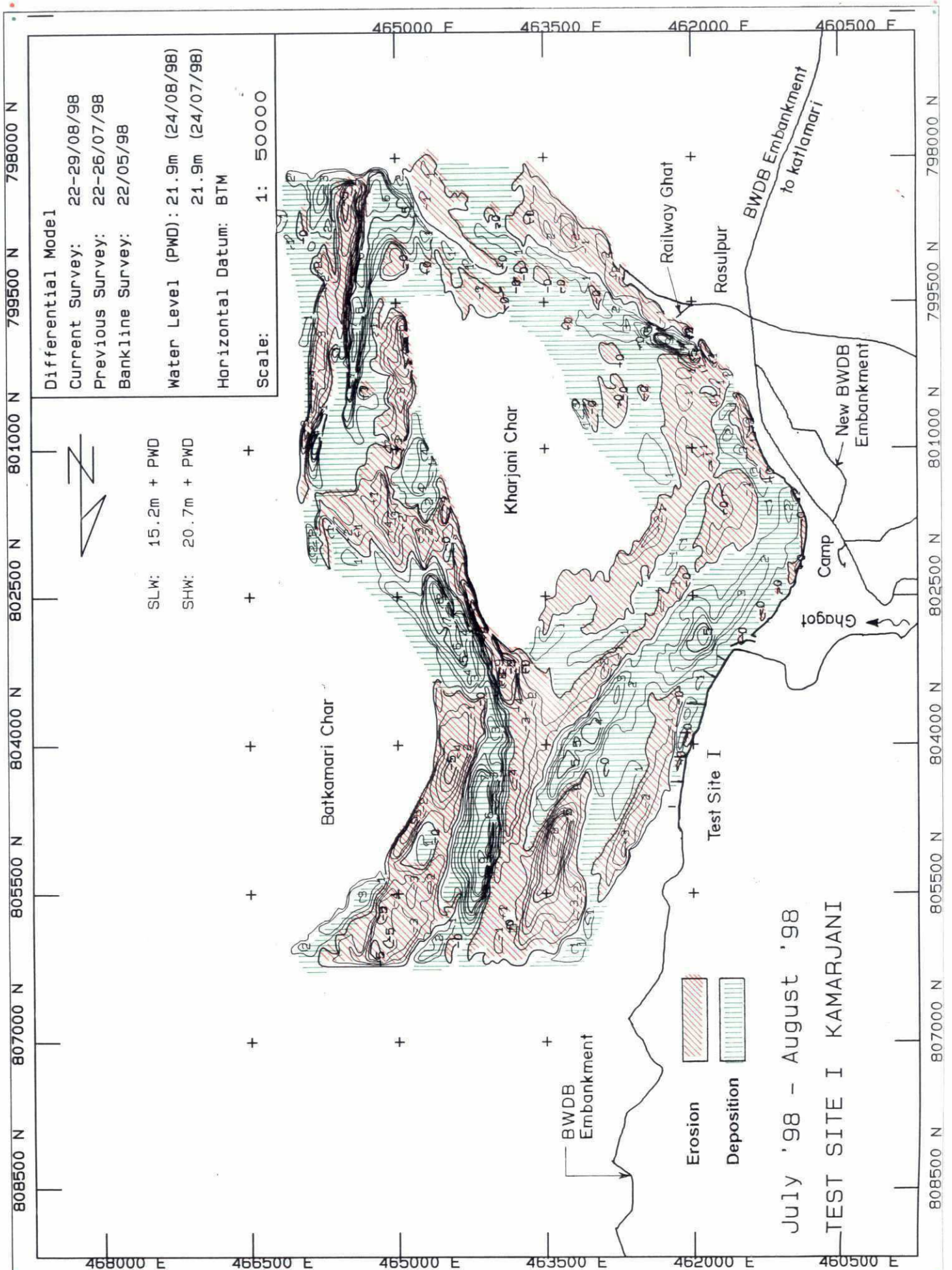
## **ANNEX C**

**FAP 21 / Test Site I**

- Differential Models

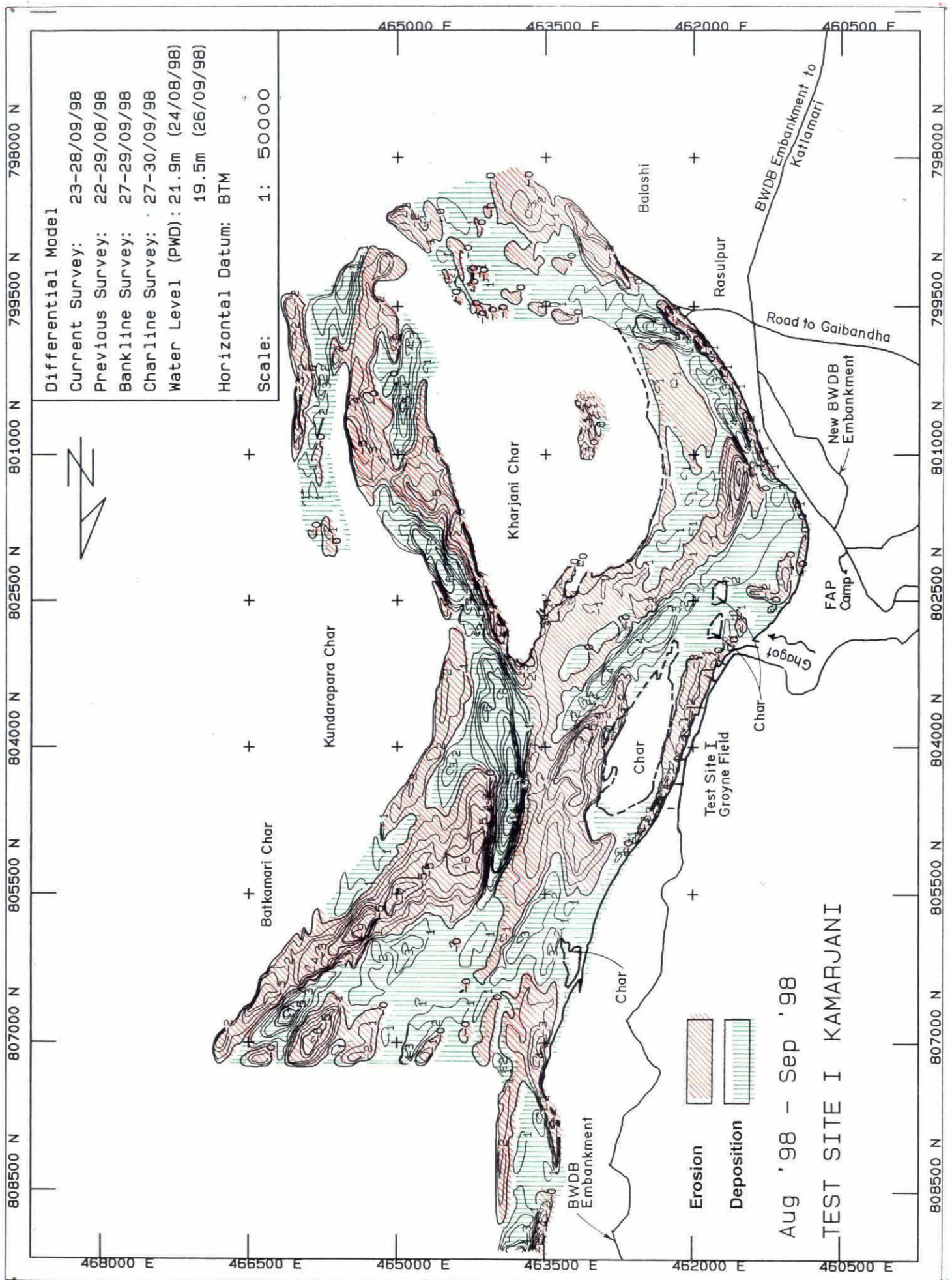






July '98 - August '98  
 TEST SITE I KAMARJANI



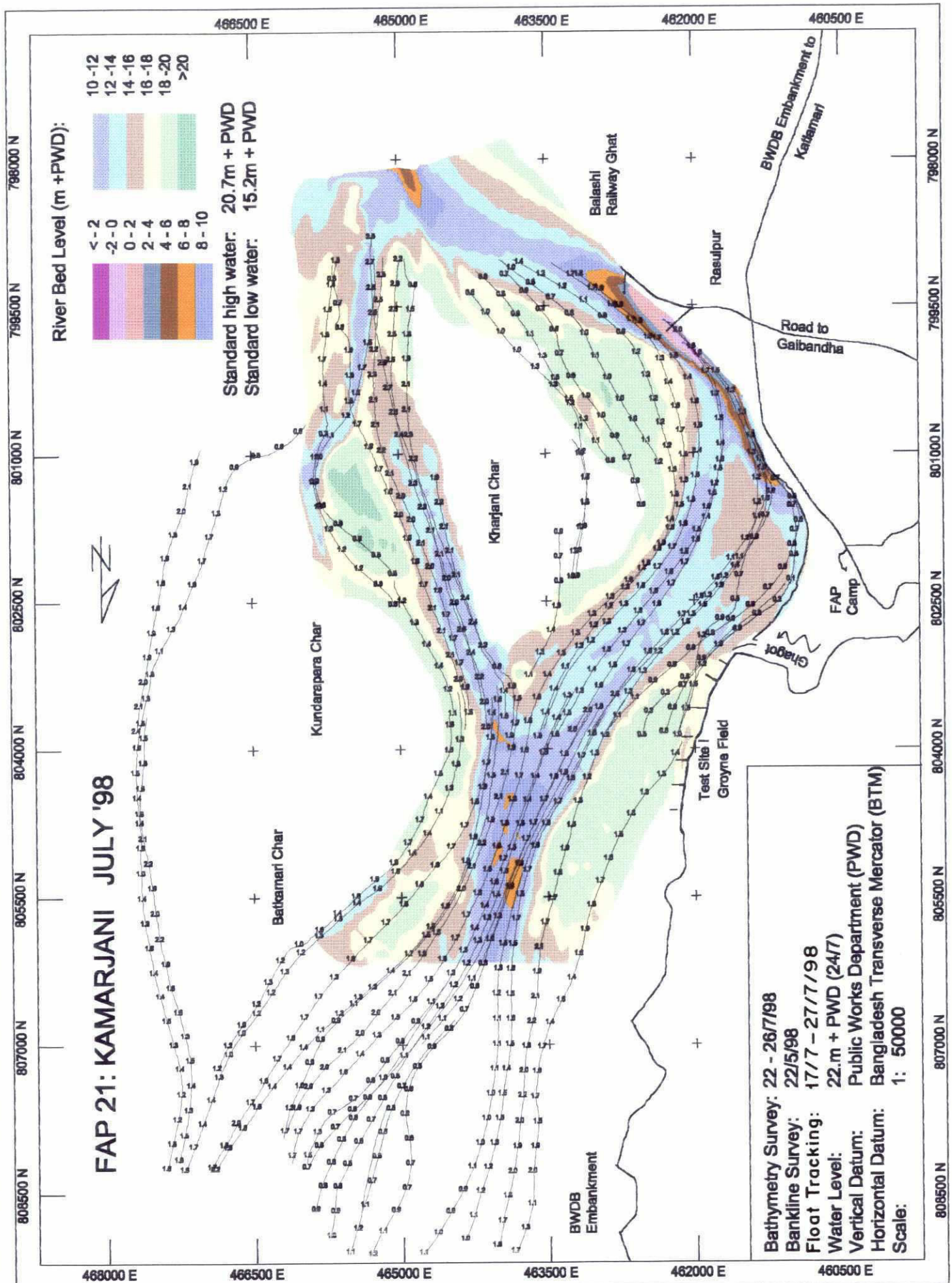


## ANNEX D

**FAP 21 / Test Site I**

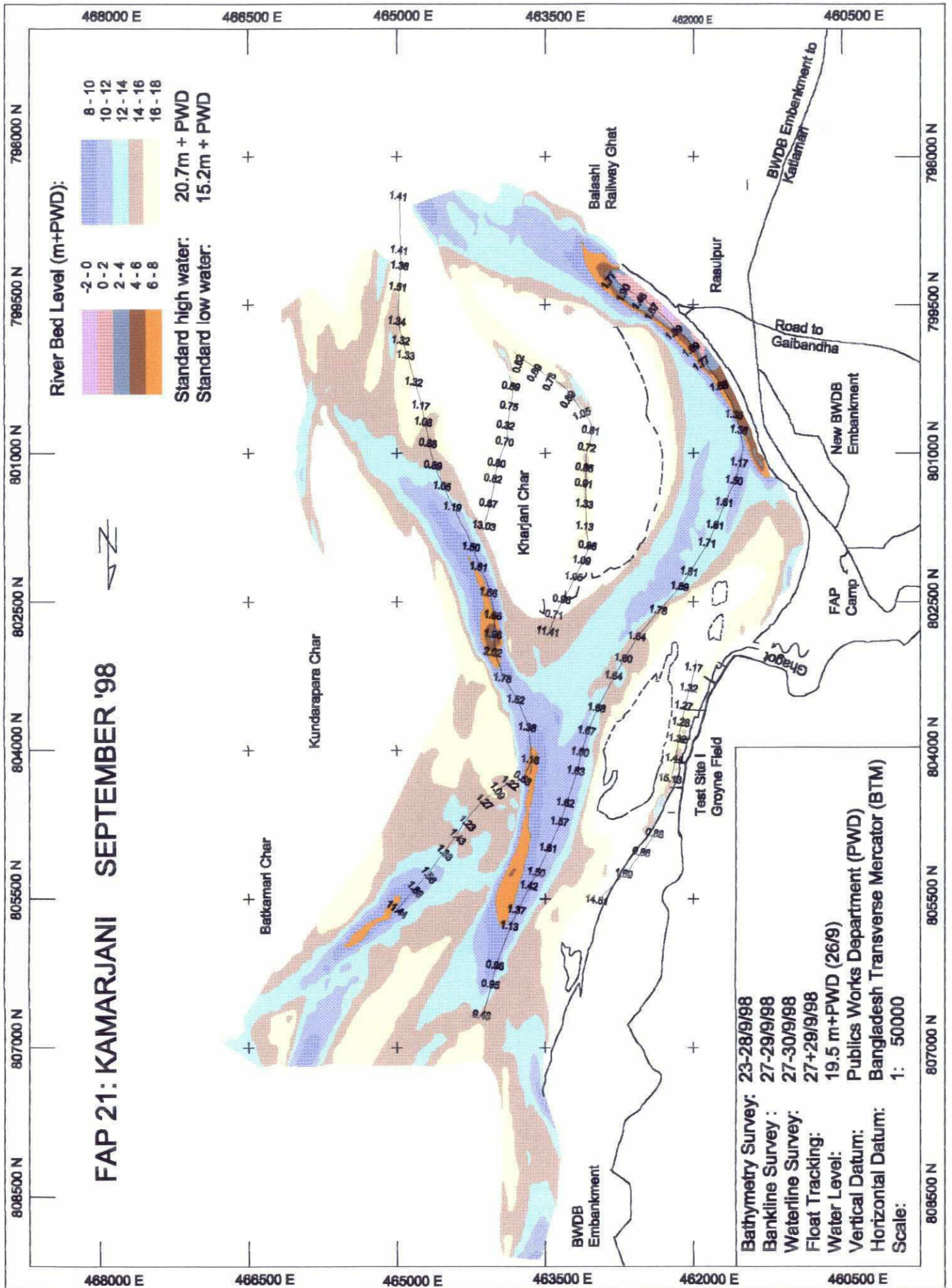
- Flow Velocities







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## ANNEX E



**FAP 21 / Test Site II**

- Water Level

**BANK PROTECTION TEST STRUCTURES - FAP 21**  
**WATER LEVEL AT BAHADURABAD TEST SITE**  
**MONTH : JULY 1998**

DAYS	T I M E			REMARKS
	8.00	13.00	17.00	
1	19.130	19.110	19.090	
2	19.090	19.090	19.090	
3	19.060	19.080	19.110	
4	19.150	19.180	19.210	
5	19.240	19.240	19.270	
6	19.300	19.320	19.320	
7	19.320	19.310	19.310	
8	19.350	19.360	19.390	
9	19.440	19.440	19.470	
10	19.450	19.490	19.490	
11	19.500	19.490	19.470	
12	19.450	19.440	19.470	
13	19.530	19.550	19.580	
14	19.690	19.640	19.630	
15	19.630	19.650	19.610	
16	19.560	19.560	19.530	
17	19.470	19.450	19.410	
18	19.340	19.330	19.310	
19	19.270	19.260	19.260	
20	19.340	19.350	19.350	
21	19.380	19.380	19.390	
22	19.410	19.420	19.460	
23	19.440	19.440	19.490	
24	19.520	19.540	19.560	
25	19.650	19.660	19.680	
26	19.710	19.720	19.710	
27	19.710	19.710	19.700	
28	19.660	19.660	19.660	
29	19.610	19.600	19.590	
30	19.520	19.520	19.440	
31	19.440	19.440	19.430	



**BANK PROTECTION TEST STRUCTURES - FAP 21**  
**WATER LEVEL AT BAHADURABAD TEST SITE**  
**MONTH : AUGUST 1998**

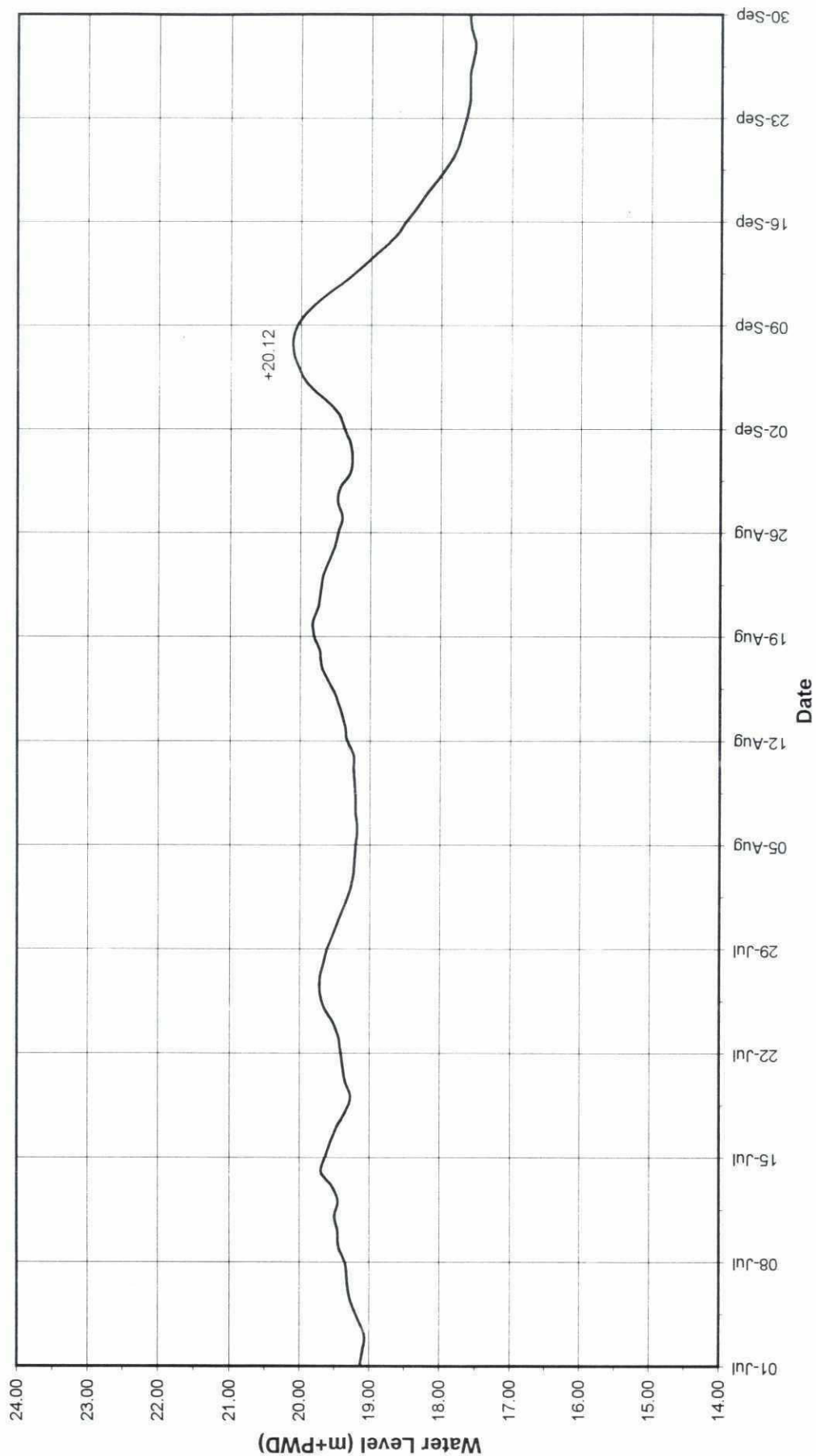
DAYS	T I M E			REMARKS
	8.00	13.00	17.00	
1	19.350	19.330	19.320	
2	19.280	19.270	19.250	
3	19.230	19.230	19.220	
4	19.220	19.210	19.230	
5	19.200	19.200	19.200	
6	19.180	19.180	19.210	
7	19.200	19.200	19.200	
8	19.200	19.210	19.200	
9	19.220	19.220	19.240	
10	19.230	19.230	19.220	
11	19.230	19.240	19.240	
12	19.330	19.350	19.350	
13	19.360	19.360	19.410	
14	19.420	19.420	19.450	
15	19.490	19.500	19.540	
16	19.600	19.620	19.640	
17	19.700	19.710	19.720	
18	19.720	19.720	19.750	
19	19.810	19.820	19.830	
20	19.820	19.790	19.780	
21	19.740	19.740	19.710	
22	19.710	19.710	19.710	
23	19.680	19.670	19.650	
24	19.600	19.570	19.550	
25	19.510	19.500	19.500	
26	19.460	19.450	19.440	
27	19.400	19.430	19.430	
28	19.470	19.470	19.470	
29	19.440	19.390	19.390	
30	19.290	19.300	19.290	
31	19.260	19.260	19.250	

**BANK PROTECTION TEST STRUCTURES - FAP 21**  
**WATER LEVEL AT BAHADURABAD TEST SITE**  
**MONTH : SEPTEMBER 1998**

DAYS	T I M E			REMARKS
	8.00	13.00	17.00	
1	19.290	19.310	19.310	
2	19.380	19.390	19.390	
3	19.460	19.470	19.510	
4	19.660	19.740	19.740	
5	19.900	19.920	19.940	
6	20.020	20.020	20.040	
7	20.100	20.120	20.120	
8	20.120	20.120	20.110	
9	20.050	20.030	20.000	
10	19.880	19.820	19.800	
11	19.640	19.620	19.590	
12	19.360	19.320	19.280	
13	19.110	19.070	19.020	
14	18.870	18.850	18.790	
15	18.650	18.630	18.620	
16	18.500	18.480	18.430	
17	18.340	18.310	18.280	
18	18.190	18.160	18.130	
19	18.030	18.000	17.980	
20	17.880	17.880	17.860	
21	17.770	17.760	17.740	
22	17.710	17.700	17.690	
23	17.650	17.640	17.630	
24	17.610	17.610	17.600	
25	17.600	17.600	17.600	
26	17.600	17.600	17.500	
27	17.560	17.560	17.560	
28	17.530	17.540	17.540	
29	17.590	17.600	17.600	
30	17.610	17.610	17.580	



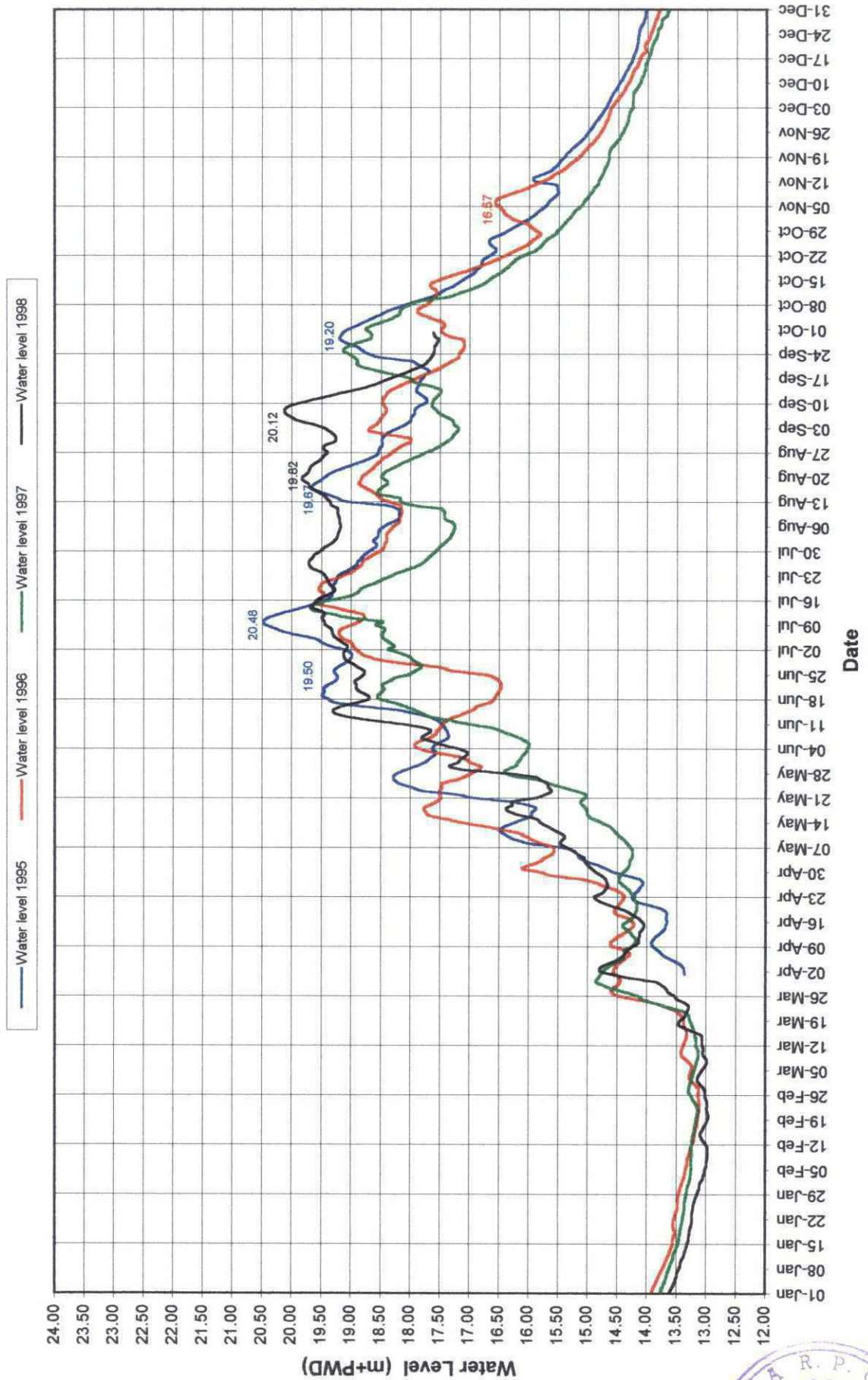
# **BANK PROTECTION TEST STRUCTURES - FAP 21** **WATER LEVEL AT BAHADURABAD TEST SITE** (July to September 1998)



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

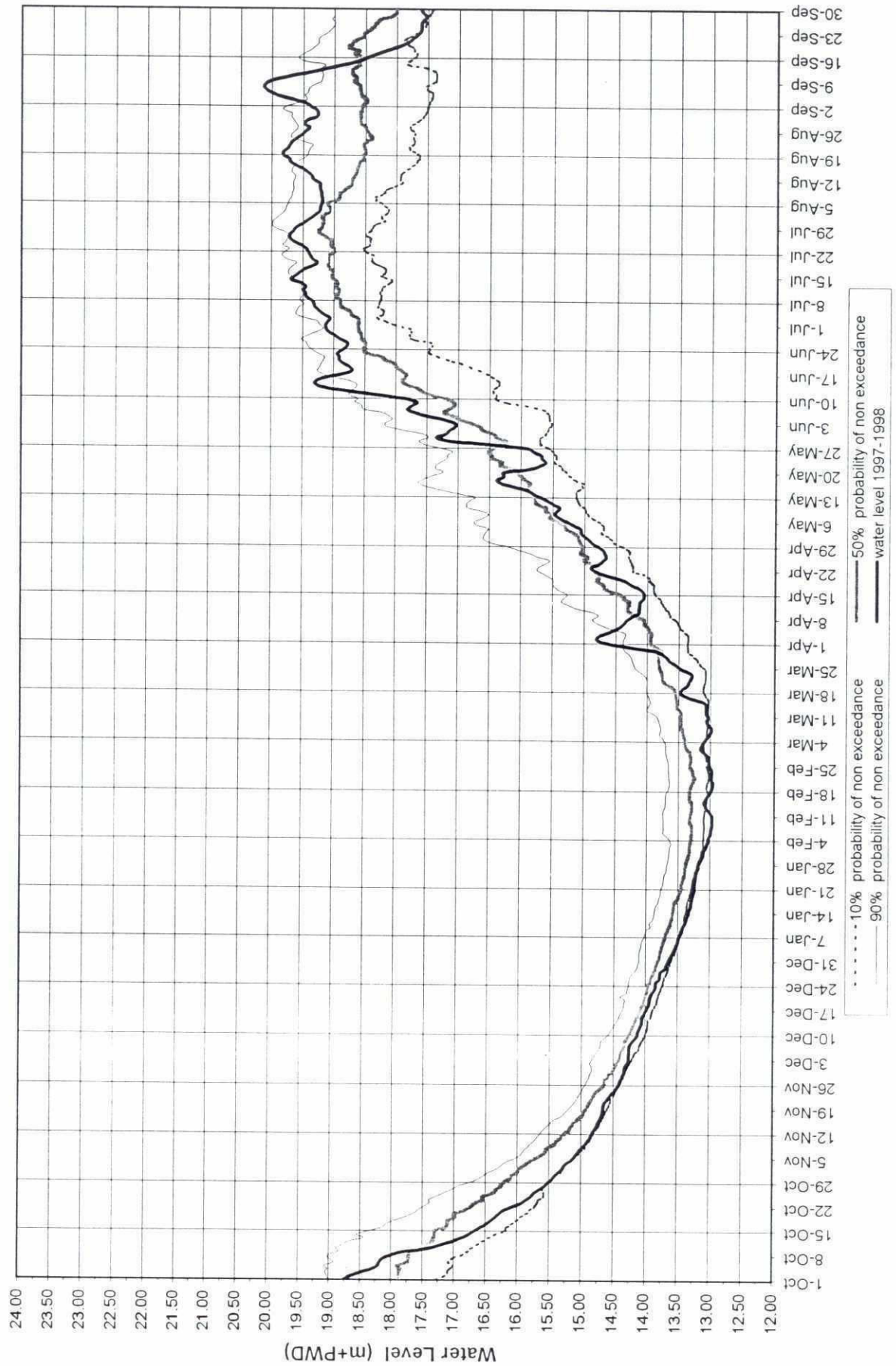




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BWDB Data: Period of Record 1962 ~ 1994

**BANK PROTECTION TEST STRUCTURES - FAP 21**  
**BWDB WATER LEVEL FREQUENCY CURVES VERSUS ACTUAL FAP 21 WATER LEVEL**  
**AT BAHADURABAD TEST SITE UP TO SEPTEMBER '98**

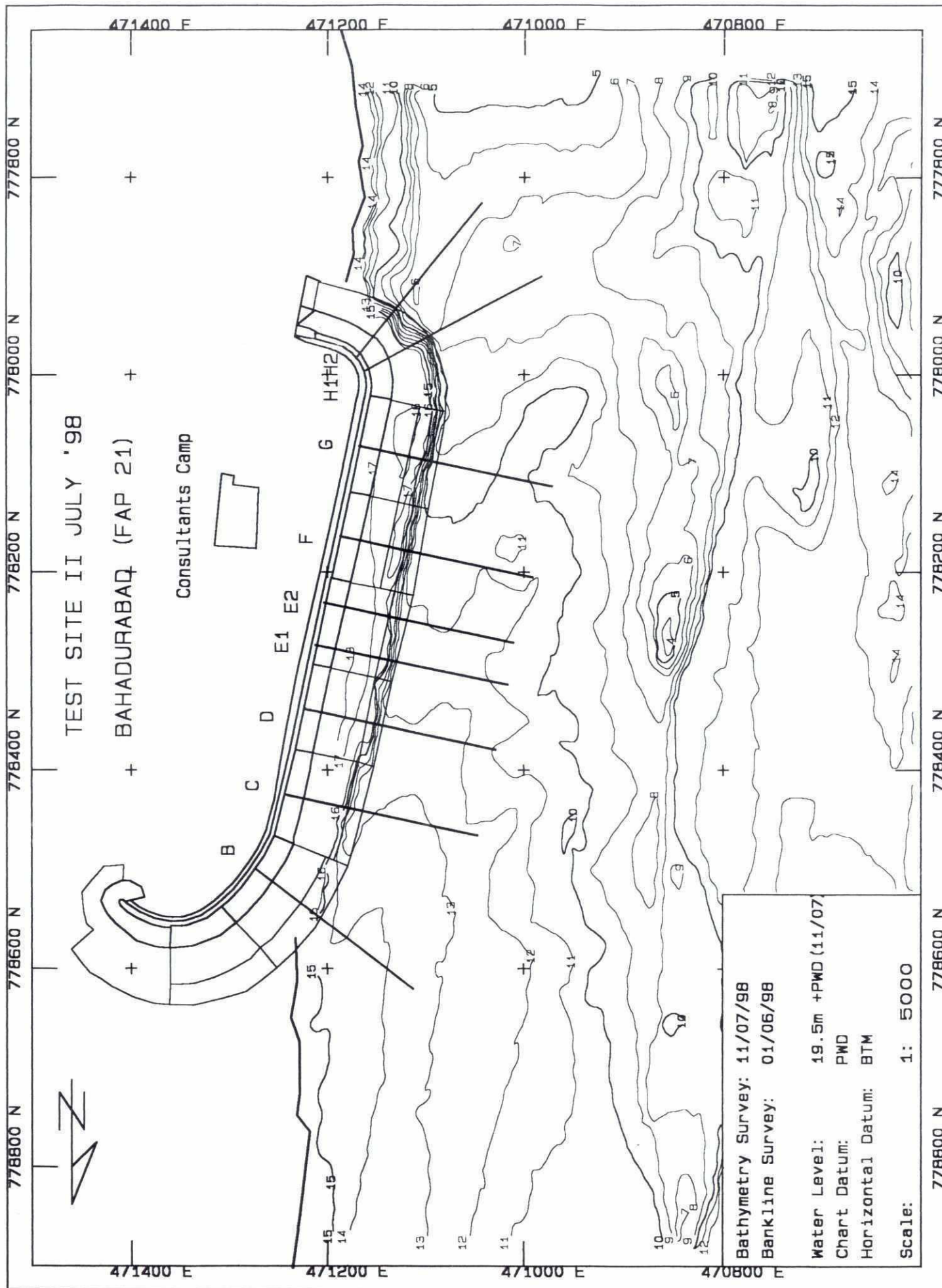


## **ANNEX F**

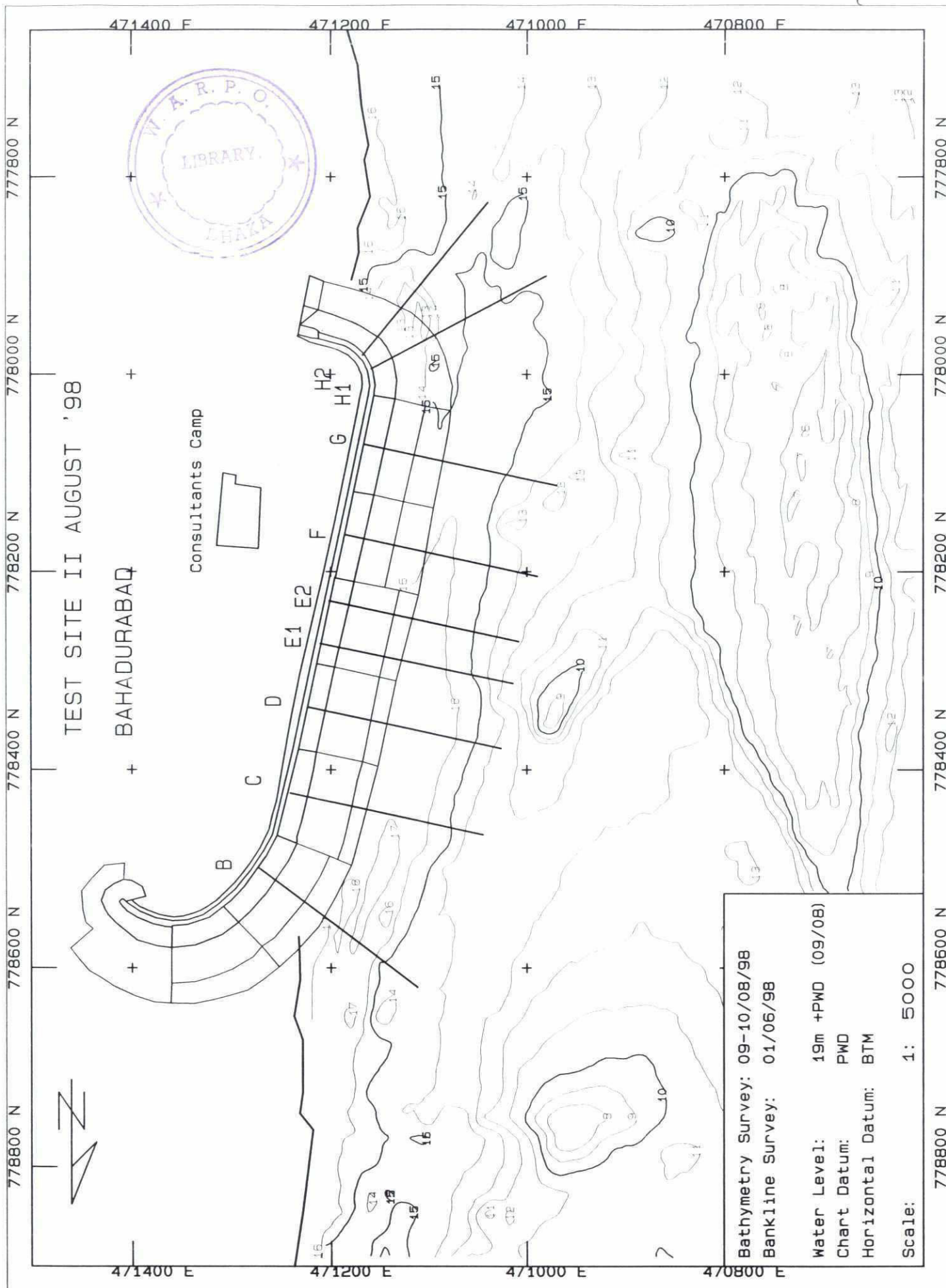
**FAP 21 / Test Site II**

- Bathymetric Survey





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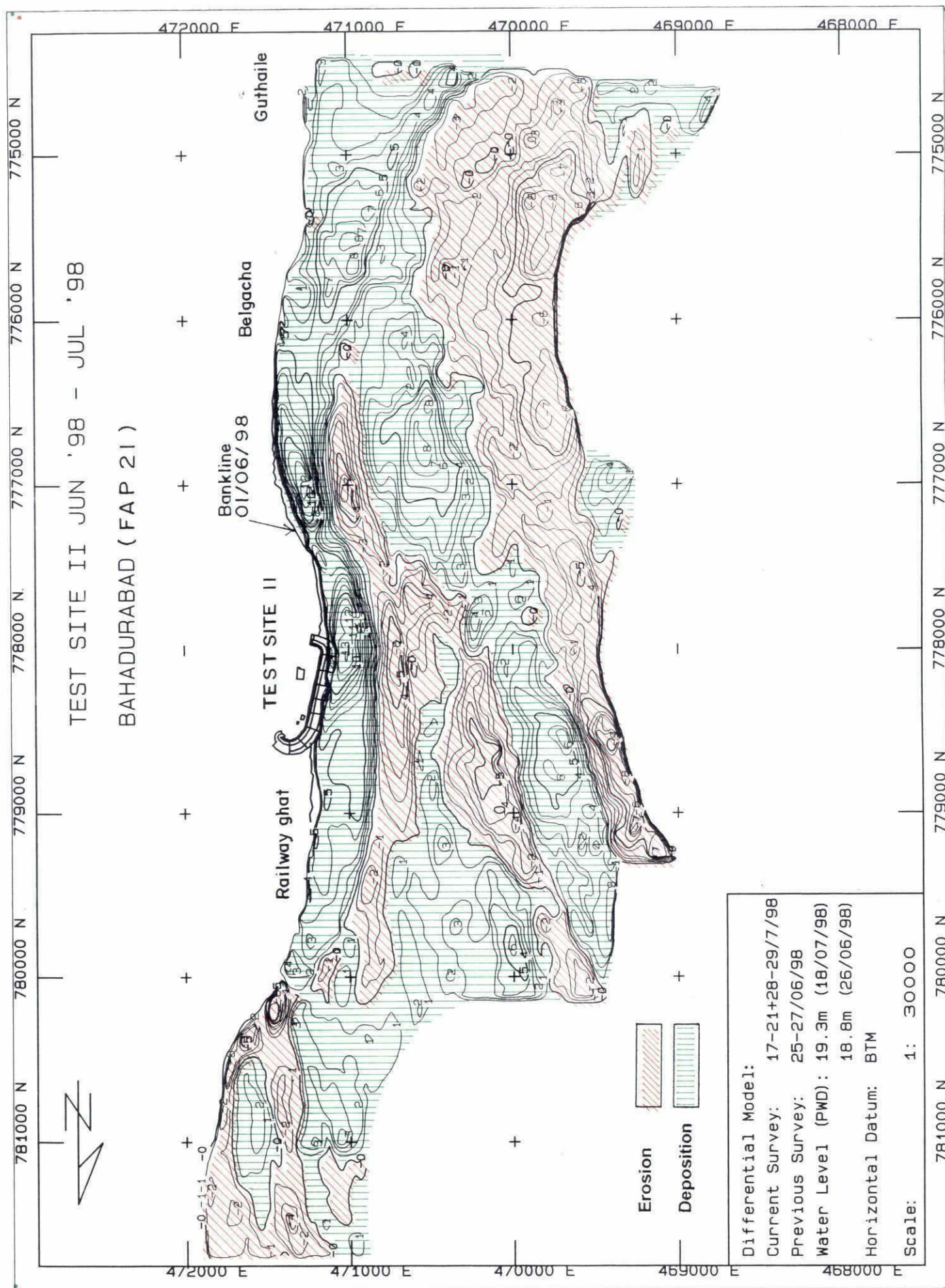


## ANNEX G

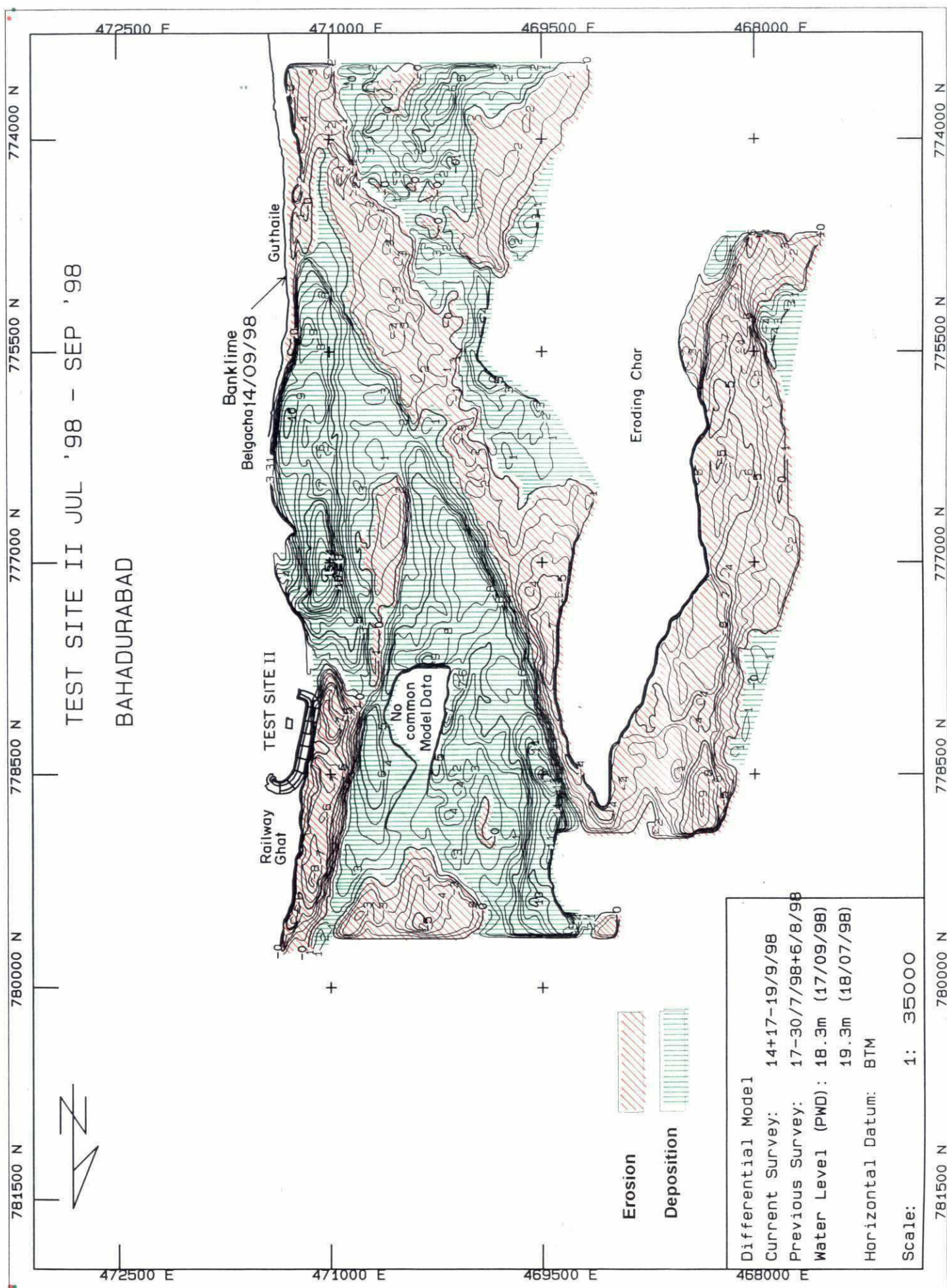


FAP 21 / Test Site II

- Differential Model









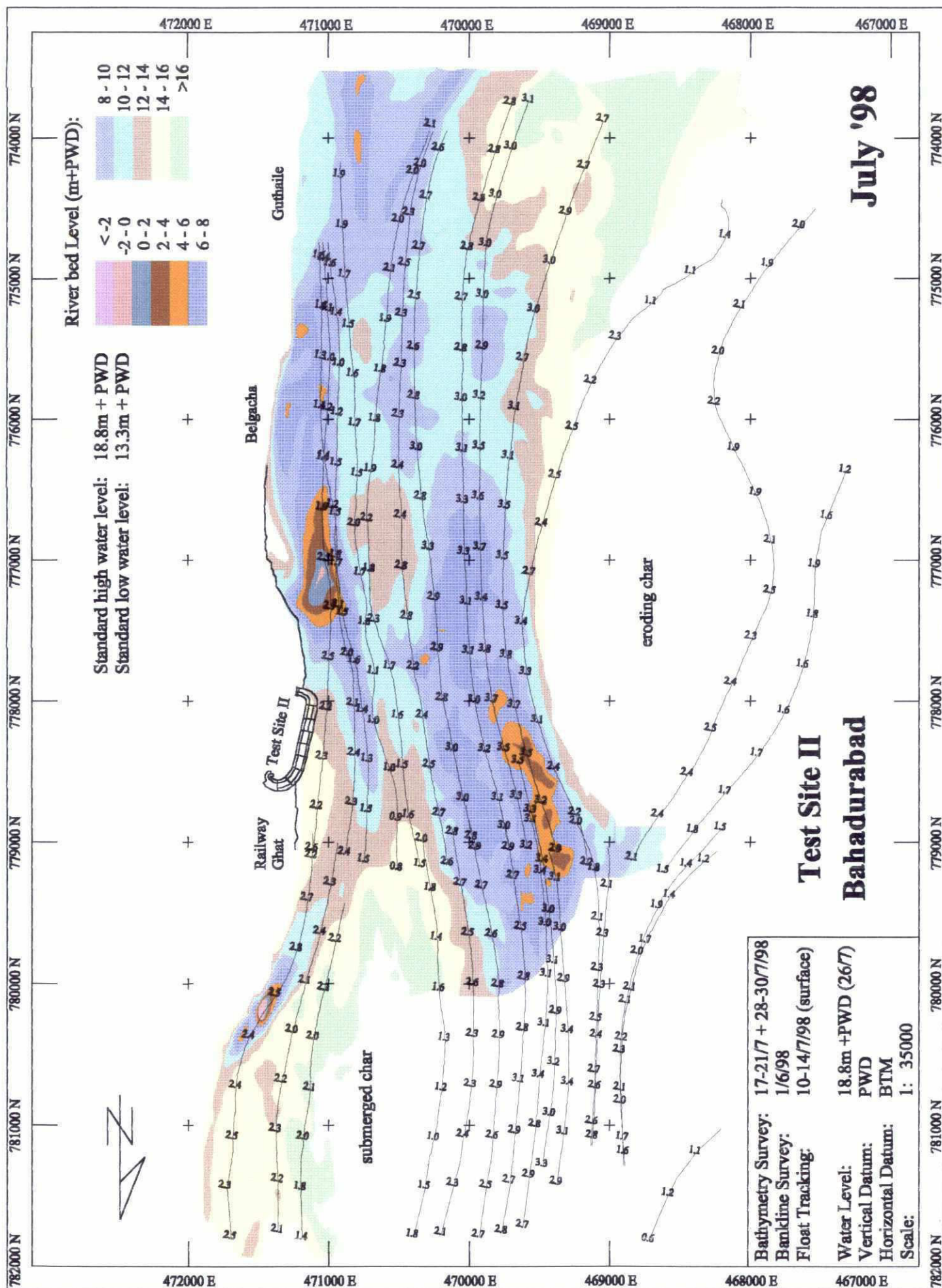
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## **ANNEX H**

**FAP 21 / Test Site II**

- Flow Velocities

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## ANNEX I

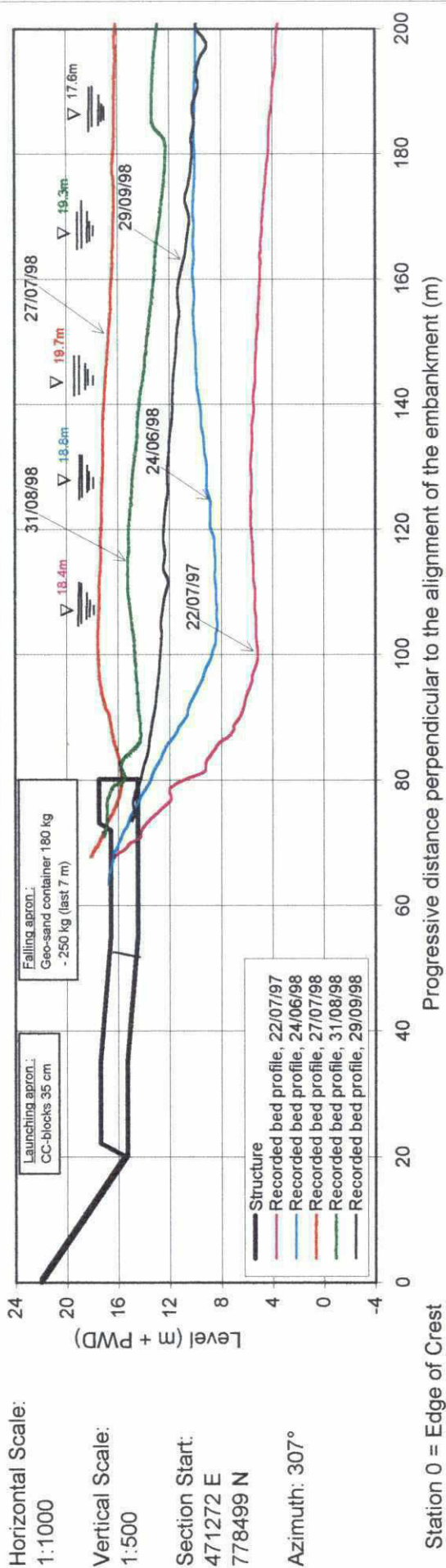


**FAP 21 / Test Site II**

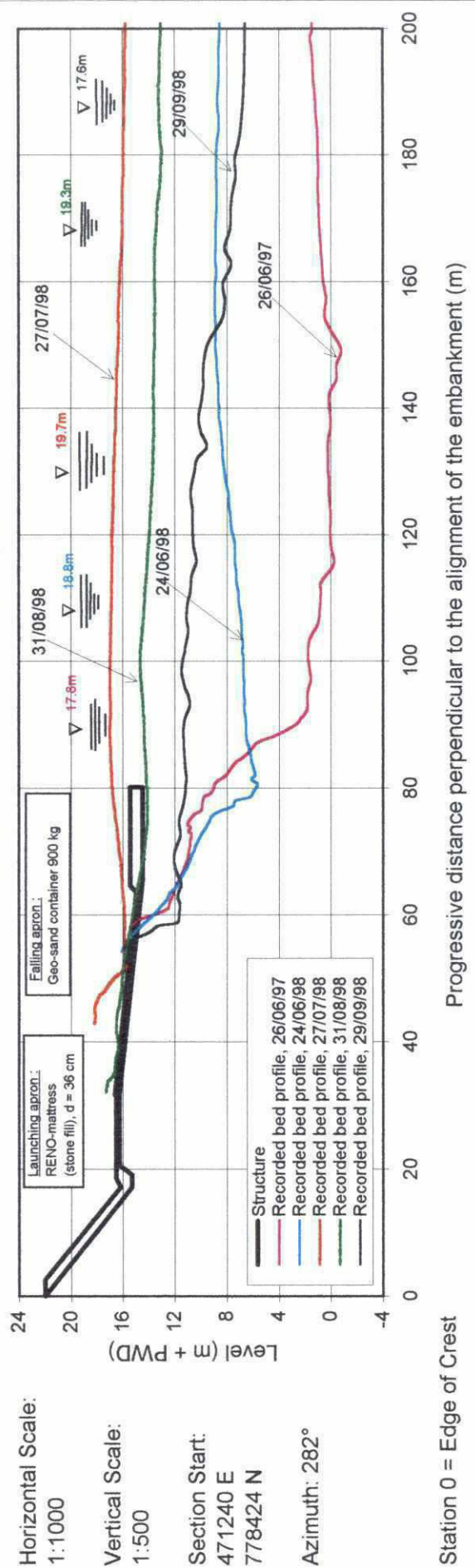
- Cross Section end of September 1998

## BAHADURABAD (FAP 21) - TEST SITE II

### Cross-Section B, July '97 to September '98



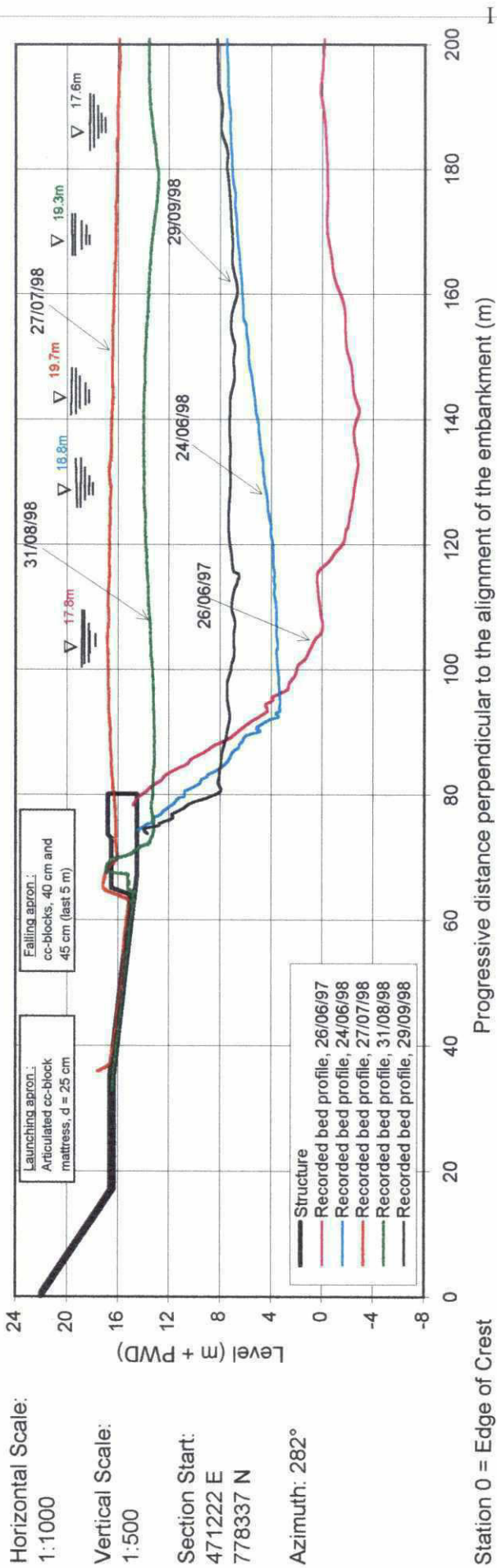
### Cross-Section C, June '97 to September '98



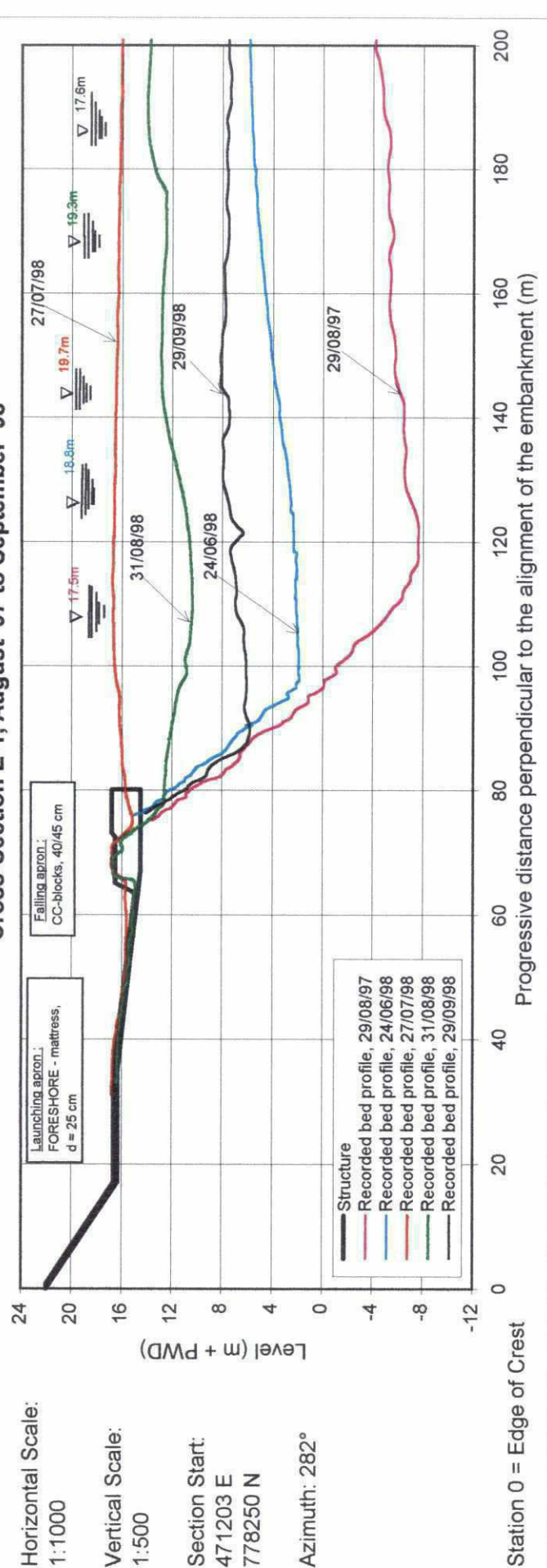


# BAHADURABAD (FAP 21) - TEST SITE II

Cross-Section D, June '97 to September '98

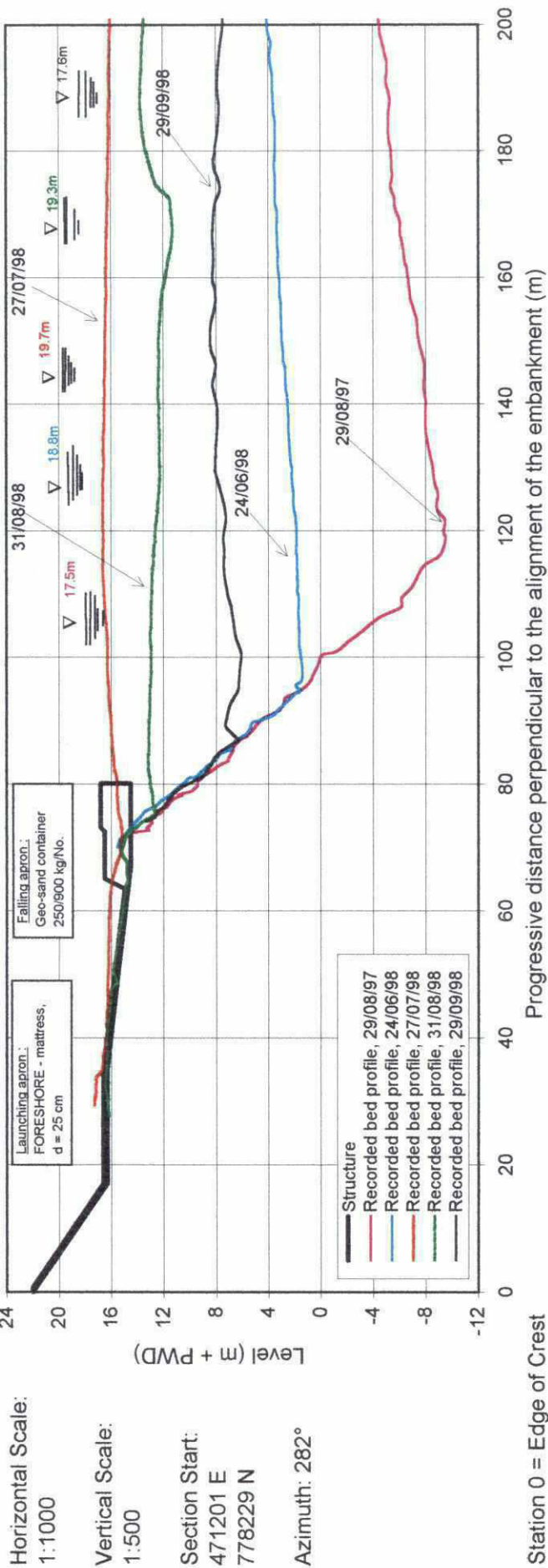


Cross-Section E-1, August '97 to September '98

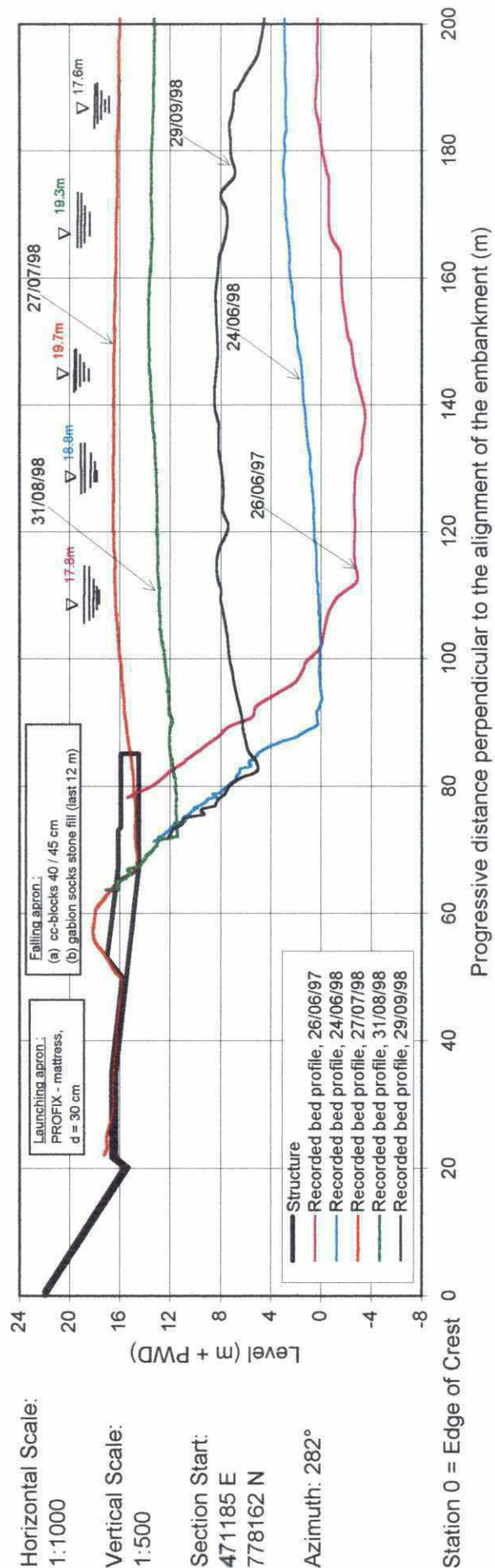


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# Cross-Section E-2, August '97 to September '98



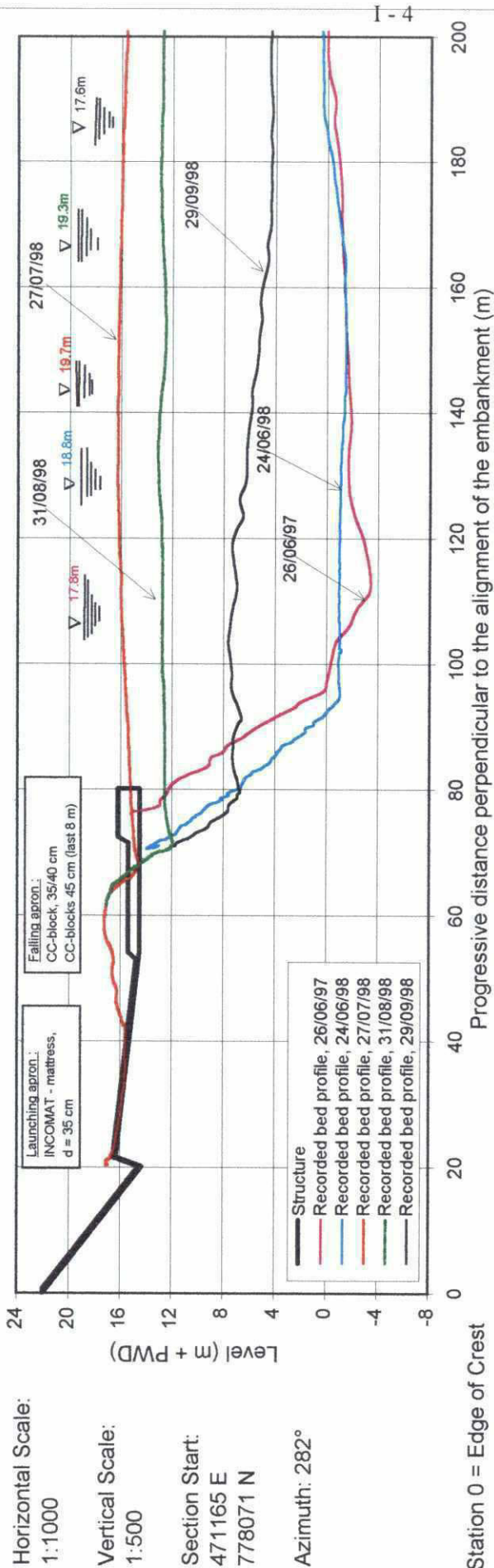
# Cross-Section F, June '97 to September '98



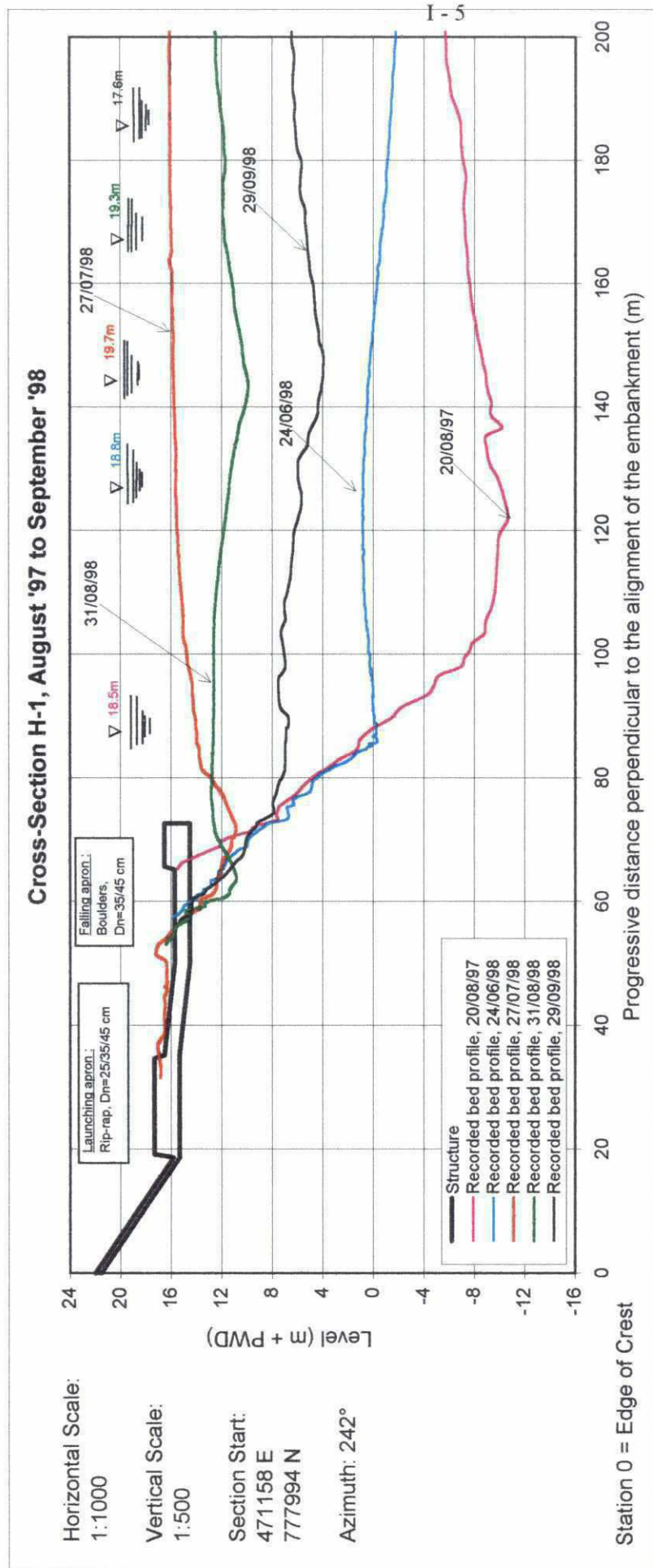


# BAHADURABAD (FAP 21) - TEST SITE II

Cross-Section G, June '97 to September '98



## BAHADURABAD (FAP 21) - TEST SITE II

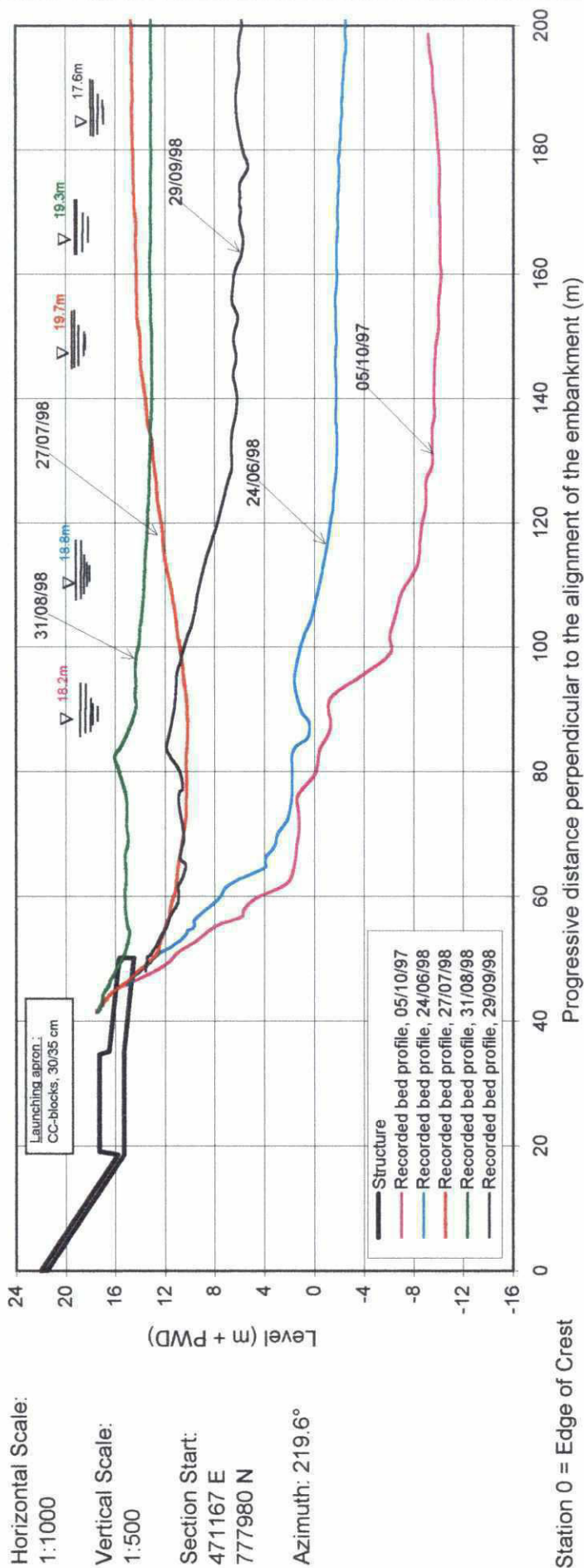


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# BAHADURABAD (FAP 21) - TEST SITE II

## Cross-Section H-2, October '97 to September '98



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## **ANNEX K**

**FAP 22 / Test Site I**

- Water Level



**RIVER TRAINING TEST STRUCTURES - FAP 22**  
**WATER LEVEL AT KATLAMARI TEST SITE**  
**MONTH : JULY 1998**

DAYS	T I M E			REMARKS
	8.00	13.00	17.00	
1	19.910	19.910	19.910	
2	19.890	19.880	19.880	
3	19.900	19.910	19.930	
4	20.020	20.040	20.050	
5	20.100	20.100	20.110	
6	20.150	20.150	20.160	
7	20.150	20.150	20.170	
8	20.220	20.230	20.250	
9	20.340	20.370	20.370	
10	20.400	20.400	20.400	
11	20.410	20.400	20.400	
12	20.390	20.390	20.410	
13	20.460	20.480	20.510	
14	20.600	20.620	20.620	
15	20.630	20.620	20.610	
16	20.560	20.540	20.520	
17	20.420	20.390	20.360	
18	20.280	20.260	20.240	
19	20.170	20.150	20.150	
20	20.240	20.260	20.280	
21	20.310	20.310	20.320	
22	20.370	20.370	20.380	
23	20.400	20.420	20.430	
24	20.470	20.490	20.520	
25	20.620	20.660	20.680	
26	20.700	20.700	20.700	
27	20.700	20.680	20.660	
28	20.600	20.590	20.580	
29	20.530	20.510	20.480	
30	20.350	20.340	20.300	
31	20.210	20.190	20.180	

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**RIVER TRAINING TEST STRUCTURES - FAP 22**  
**WATER LEVEL AT KATLAMARI TEST SITE**  
**MONTH : AUGUST 1998**

DAYS	T I M E			REMARKS
	8.00	13.00	17.00	
1	20.090	20.080	20.050	
2	20.020	20.020	20.020	
3	20.010	20.010	20.010	
4	20.010	20.010	20.010	
5	20.010	20.010	20.010	
6	20.030	20.030	20.030	
7	20.040	20.050	20.050	
8	20.030	20.030	20.030	
9	20.040	20.050	20.050	
10	20.060	20.060	20.070	
11	20.090	20.090	20.090	
12	20.210	20.220	20.240	
13	20.260	20.260	20.280	
14	20.310	20.330	20.340	
15	20.400	20.410	20.430	
16	20.490	20.510	20.540	
17	20.620	20.650	20.660	
18	20.680	20.710	20.720	
19	20.800	20.800	20.810	
20	20.810	20.790	20.760	
21	20.700	20.690	20.700	
22	20.710	20.700	20.700	
23	20.650	20.630	20.610	
24	20.520	20.490	20.470	
25	20.400	20.390	20.380	
26	20.330	20.310	20.290	
27	20.270	20.280	20.290	
28	20.330	20.330	20.320	
29	20.250	20.220	20.200	
30	20.120	20.110	20.110	
31	20.070	20.070	20.070	

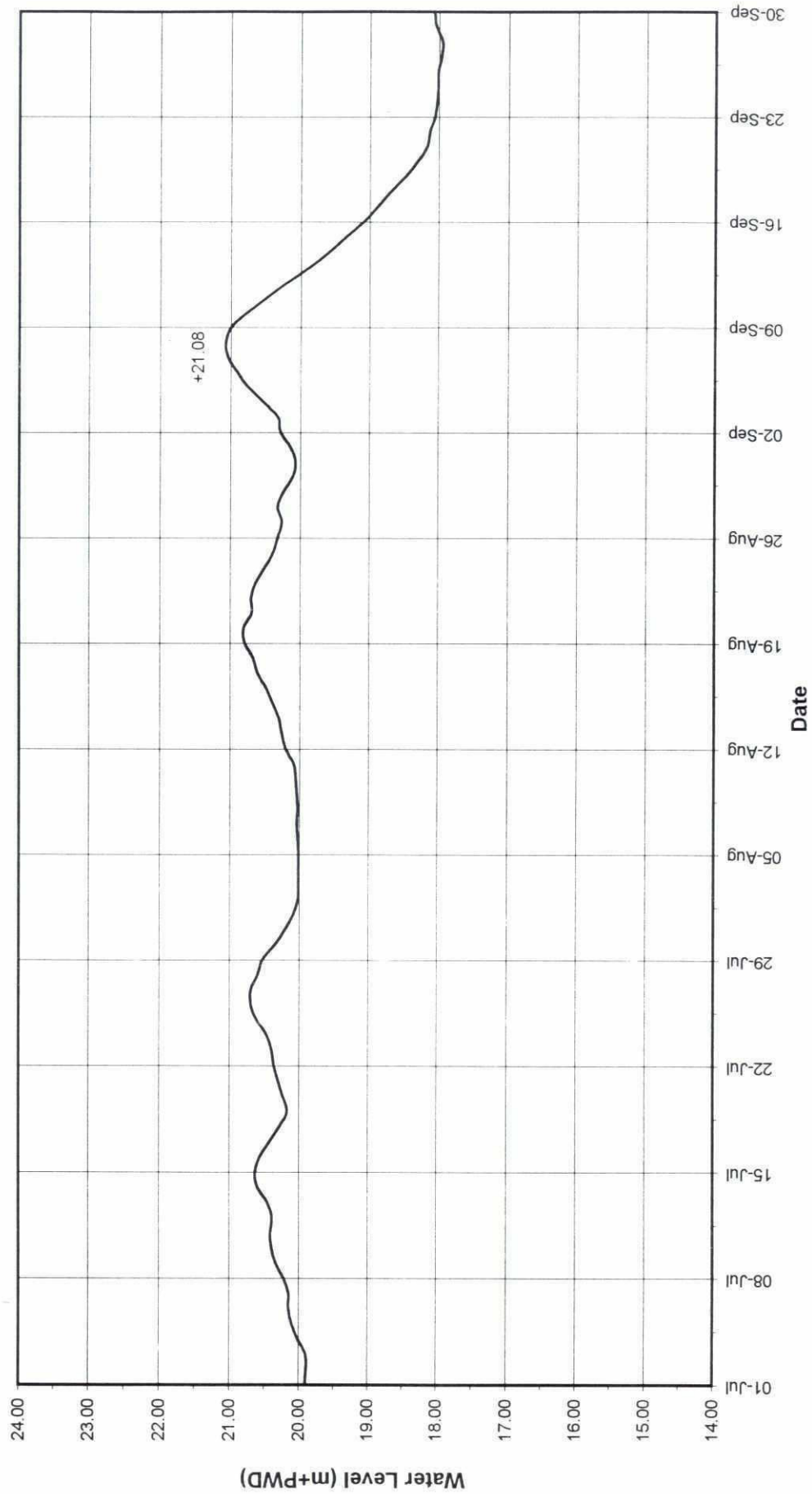
**RIVER TRAINING TEST STRUCTURES - FAP 22**  
**WATER LEVEL AT KATLAMARI TEST SITE**  
**MONTH : SEPTEMBER 1998**

DAYS	TIME			REMARKS
	8.00	13.00	17.00	
1	20.150	20.170	20.190	
2	20.290	20.290	20.290	
3	20.330	20.360	20.380	
4	20.540	20.600	20.630	
5	20.760	20.780	20.810	
6	20.910	20.930	20.950	
7	21.050	21.060	21.070	
8	21.080	21.080	21.080	
9	21.000	20.970	20.930	
10	20.760	20.720	20.670	
11	20.480	20.420	20.380	
12	20.180	20.130	20.080	
13	19.870	19.820	19.780	
14	19.590	19.540	19.500	
15	19.350	19.270	19.240	
16	19.090	19.050	19.020	
17	18.890	18.870	18.840	
18	18.700	18.660	18.620	
19	18.490	18.460	18.430	
20	18.320	18.310	18.290	
21	18.180	18.160	18.140	
22	18.140	18.120	18.110	
23	18.060	18.060	18.060	
24	18.030	18.010	18.000	
25	18.020	18.020	18.030	
26	18.020	18.010	18.010	
27	17.970	17.950	17.960	
28	17.960	17.970	17.970	
29	18.050	18.070	18.080	
30	18.080	18.060	18.050	

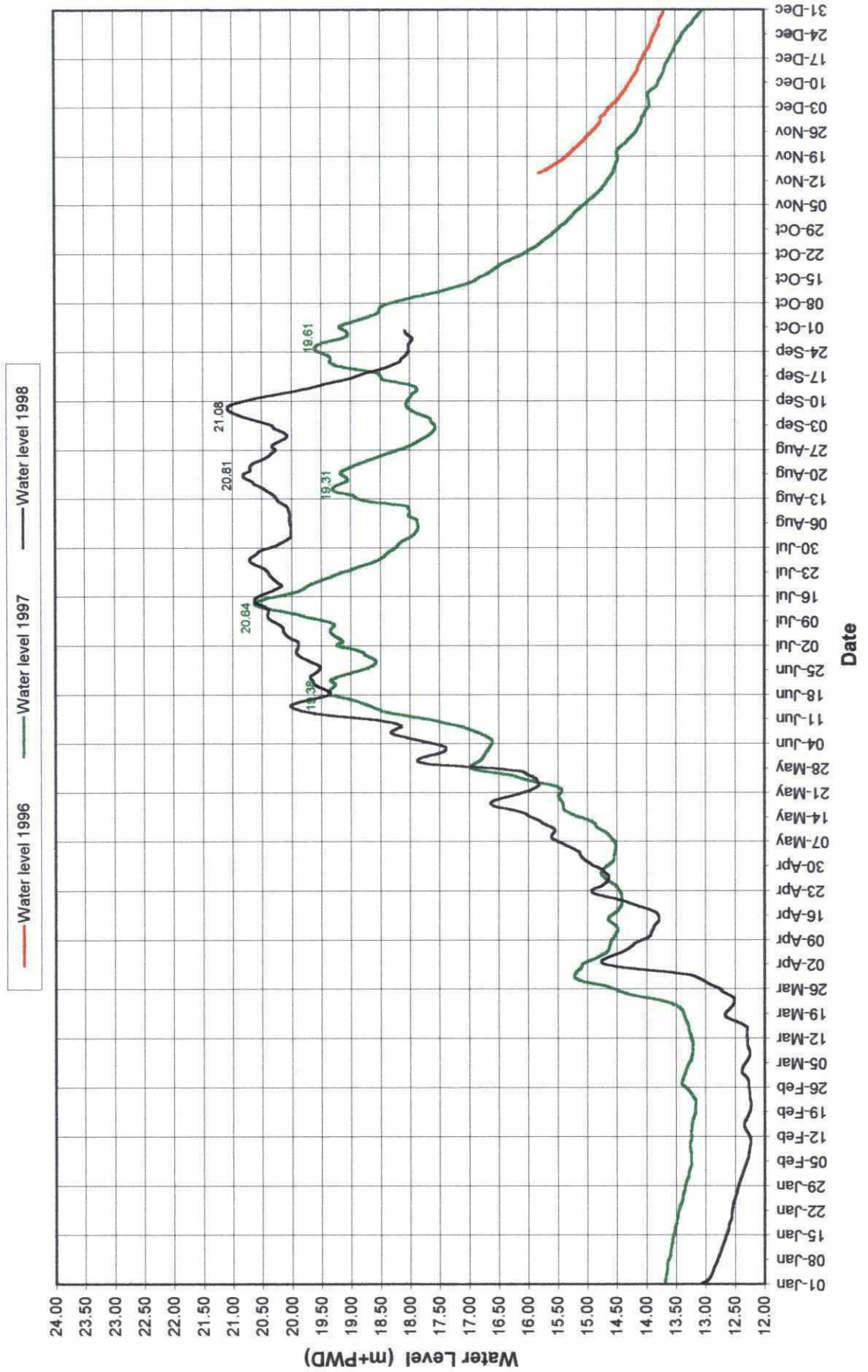


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**RIVER TRAINING TEST STRUCTURES - FAP 22**  
**WATER LEVEL AT KATLAMARI TEST SITE**  
(July to September 1998)

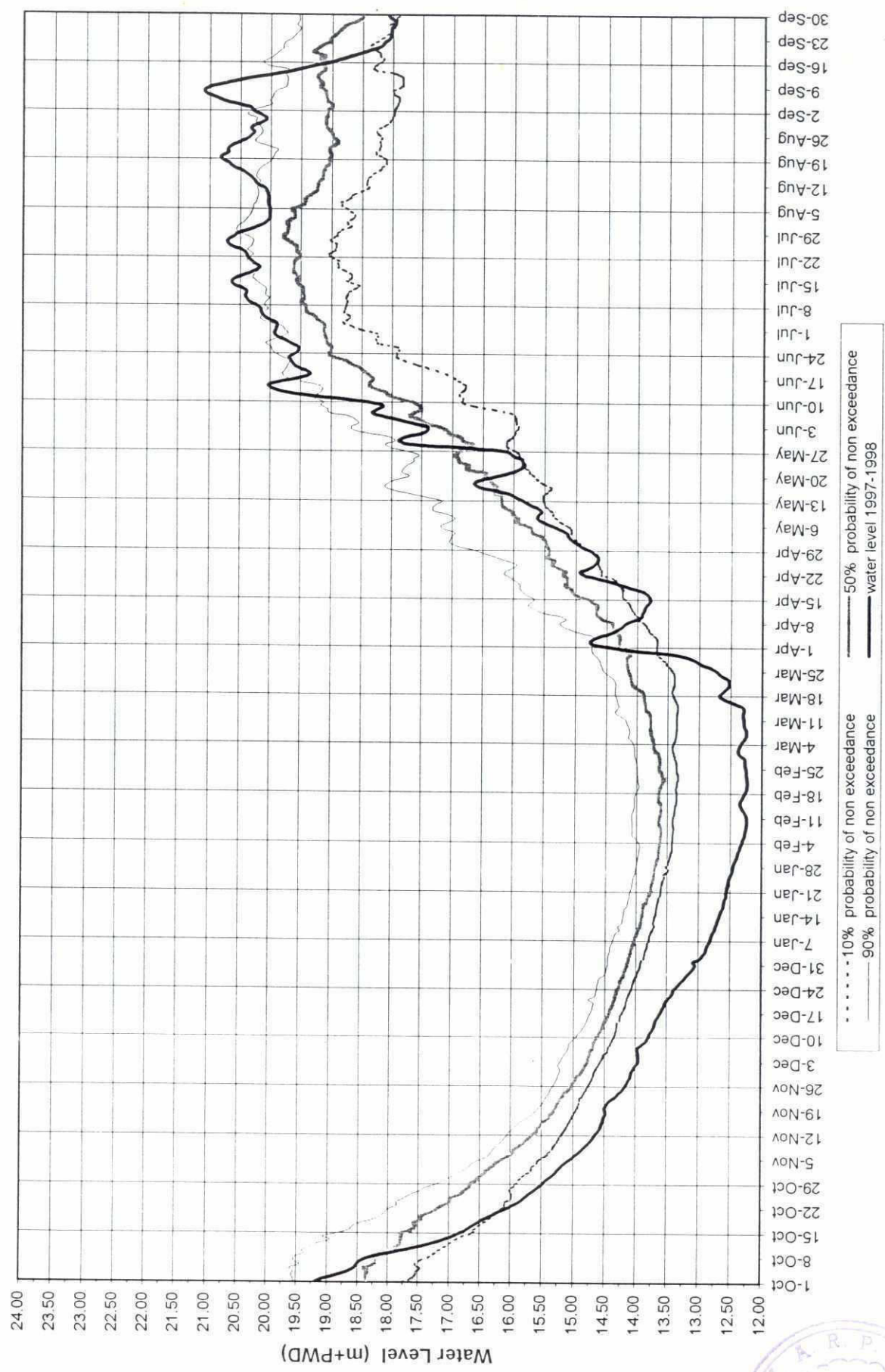


# **RIVER TRAINING TEST STRUCTURE - FAP 22** **WATER LEVEL AT KATLAMARI TEST SITE** **(January to December)**



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RIVER TRAINING TEST STRUCTURE - FAP 22  
ESTIMATED FROM BAHADURABAD WATER LEVEL FREQUENCY CURVES VERSUS  
ACTUAL FAP 22 WATER LEVEL AT KATLAMARI TEST SITE UP TO SEPTEMBER '98



Estimated from Bahadurabad Water Level Frequency Curves

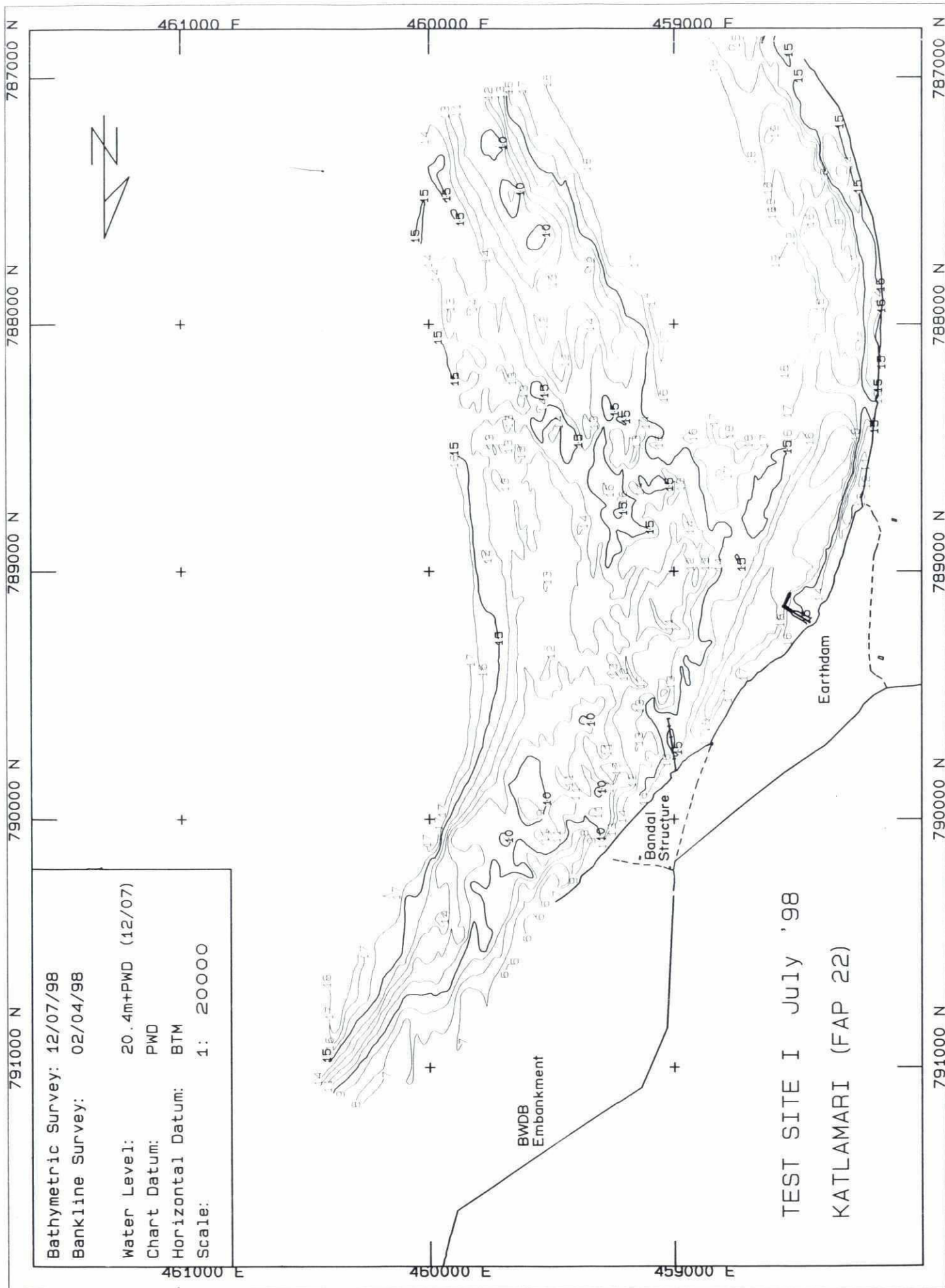




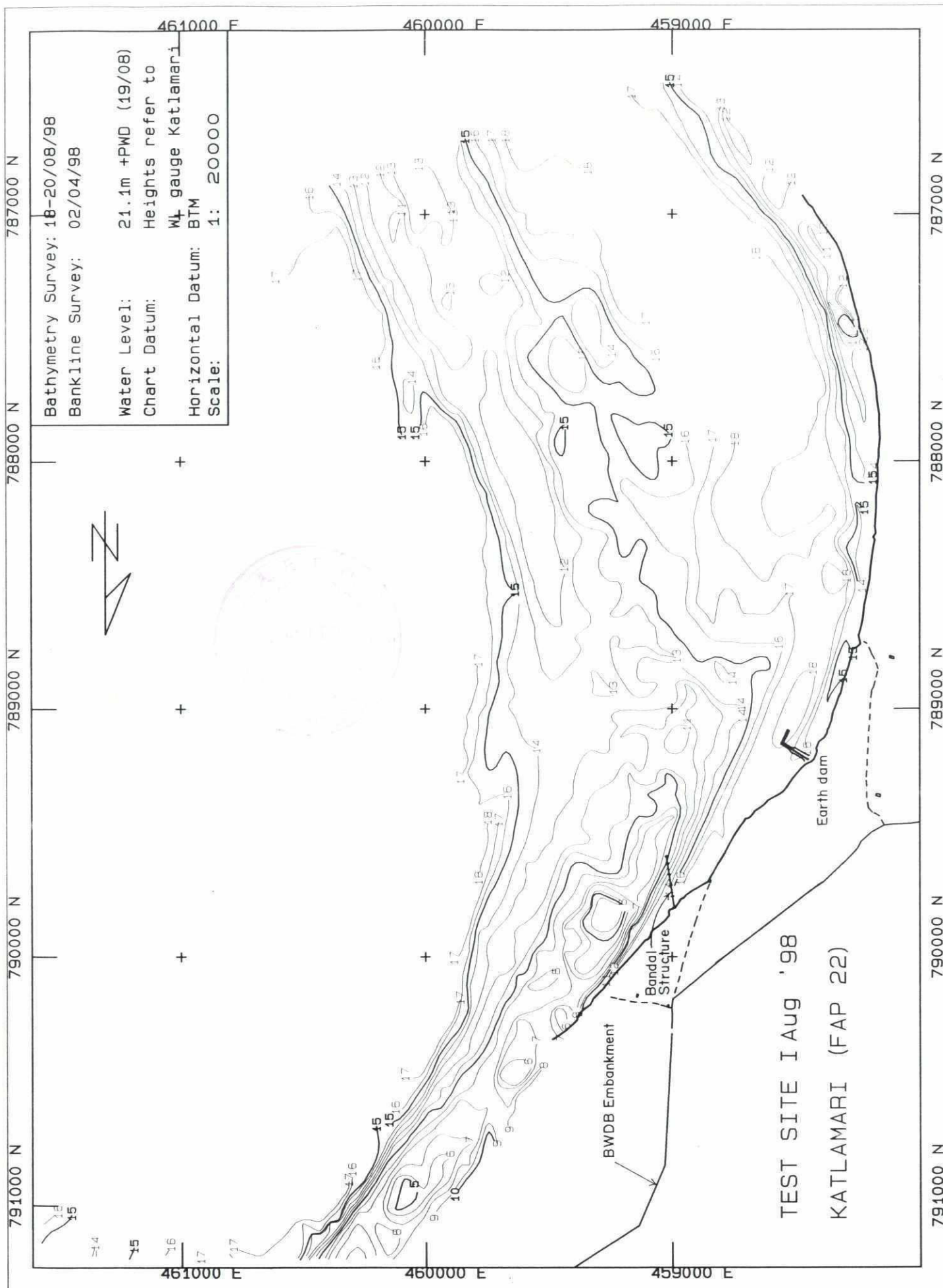
## ANNEX L

**FAP 22 / Test Site I**

- Bathymetric Survey

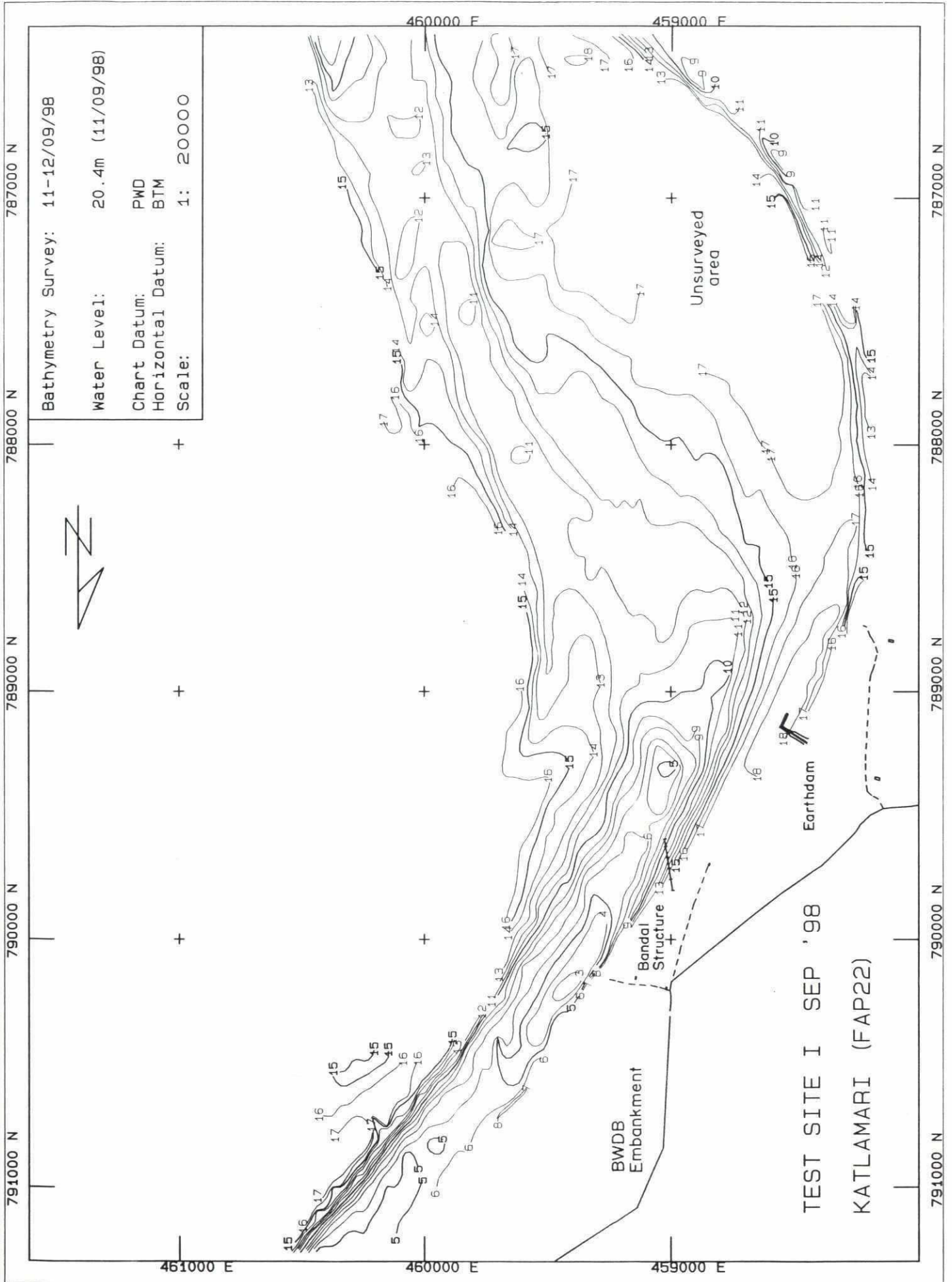


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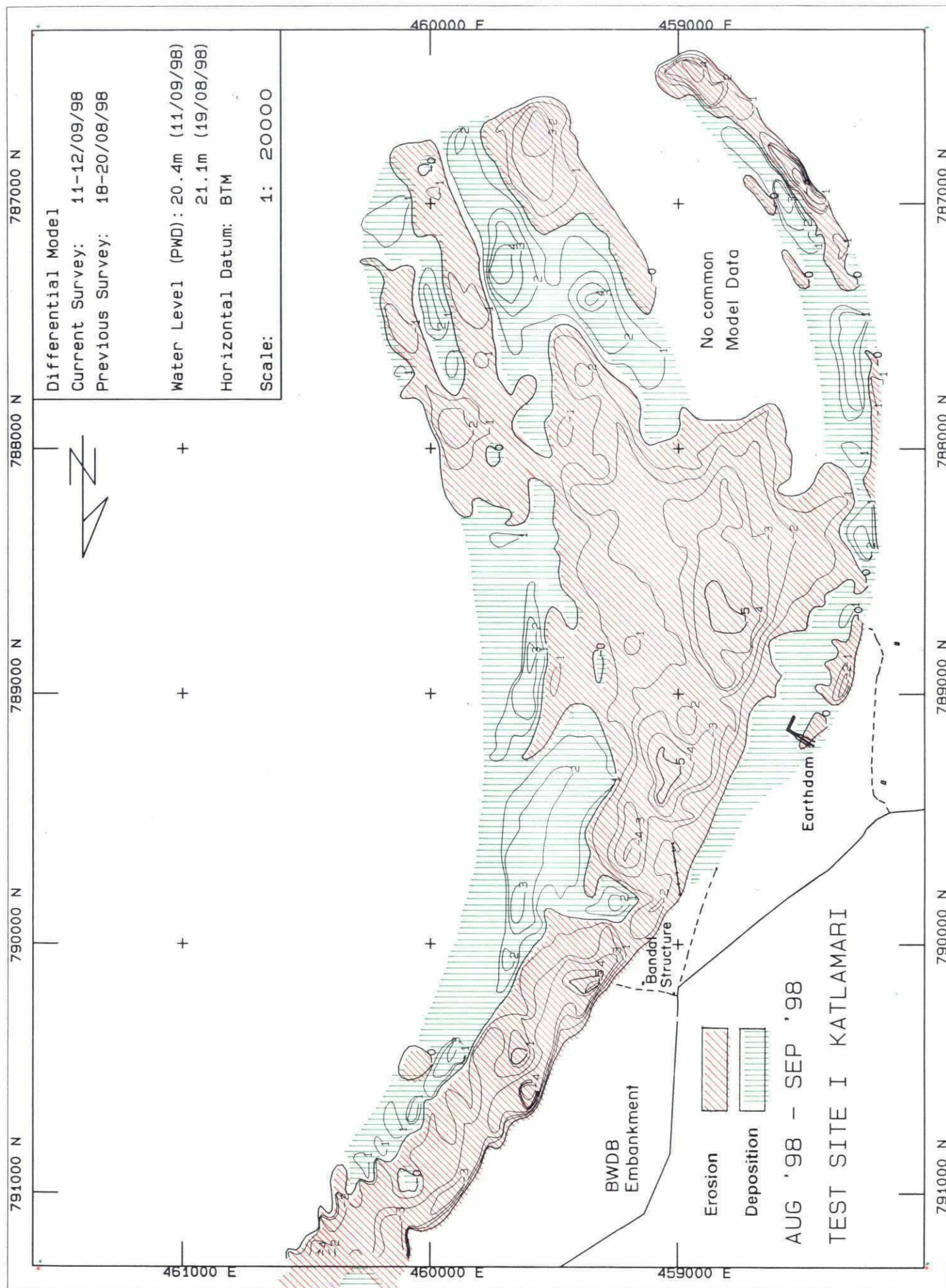
## ANNEX M

**FAP 22 / Test Site II**

- Differential Models







## ANNEX N



**FAP 22 / Test Site II**

- Water Level

**RIVER TRAINING TEST STRUCTURES - FAP 22**  
**WATER LEVEL AT KUNDARAPARA TEST SITE**  
**MONTH : JULY 1998**

DAYS	T I M E			REMARKS
	8.00	13.00	17.00	
1	21.400	21.390	21.390	
2	21.380	21.380	21.370	
3	21.310	21.410	21.420	
4	21.490	21.510	21.520	
5	21.570	21.570	21.580	
6	21.610	21.610	21.610	
7	21.600	21.610	21.620	
8	21.670	21.700	21.720	
9	21.820	21.840	21.850	
10	21.860	21.860	21.850	
11	21.840	21.830	21.820	
12	21.790	21.800	21.810	
13	21.880	21.910	21.950	
14	22.010	22.020	22.010	
15	22.000	22.010	21.990	
16	21.930	21.900	21.880	
17	21.810	21.770	21.740	
18	21.660	21.640	21.620	
19	21.580	21.550	21.560	
20	21.660	21.680	21.690	
21	21.710	21.700	21.700	
22	21.750	21.760	21.780	
23	21.790	21.810	21.830	
24	21.870	21.890	21.930	
25	22.030	22.050	22.070	
26	22.080	22.080	22.080	
27	22.070	22.050	22.030	
28	21.970	21.950	21.940	
29	21.890	21.850	21.820	
30	21.710	21.680	21.650	
31	21.570	21.560	21.540	



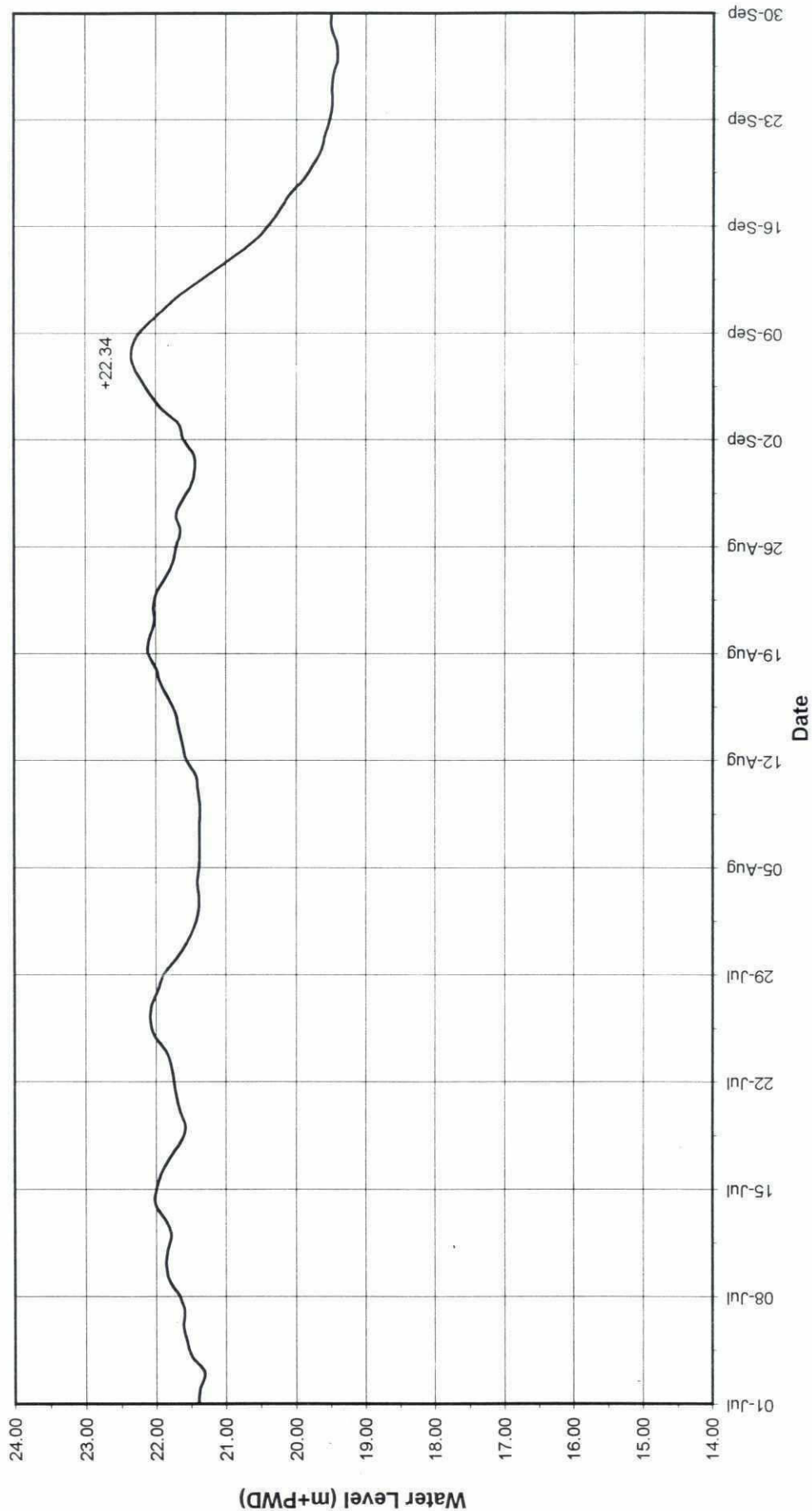
**RIVER TRAINING TEST STRUCTURES - FAP 22**  
**WATER LEVEL AT KUNDARAPARA TEST SITE**  
**MONTH : AUGUST 1998**

DAYS	T I M E			REMARKS
	8.00	13.00	17.00	
1	21.460	21.440	21.430	
2	21.400	21.400	21.400	
3	21.390	21.390	21.400	
4	21.410	21.410	21.410	
5	21.390	21.380	21.370	
6	21.380	21.390	21.390	
7	21.380	21.380	21.380	
8	21.380	21.380	21.380	
9	21.370	21.380	21.390	
10	21.400	21.410	21.420	
11	21.430	21.430	21.440	
12	21.570	21.580	21.590	
13	21.620	21.620	21.630	
14	21.670	21.680	21.690	
15	21.720	21.730	21.750	
16	21.820	21.850	21.880	
17	21.930	21.950	21.970	
18	22.000	22.020	22.040	
19	22.110	22.110	22.110	
20	22.090	22.080	22.060	
21	22.020	22.020	22.030	
22	22.040	22.030	22.030	
23	21.990	21.960	21.930	
24	21.860	21.830	21.820	
25	21.760	21.750	21.750	
26	21.710	21.680	21.660	
27	21.650	21.660	21.670	
28	21.710	21.690	21.680	
29	21.620	21.580	21.560	
30	21.500	21.500	21.490	
31	21.450	21.450	21.460	

**RIVER TRAINING TEST STRUCTURES - FAP 22**  
**WATER LEVEL AT KUNDARAPARA TEST SITE**  
**MONTH : SEPTEMBER 1998**

DAYS	T I M E			REMARKS
	8.00	13.00	17.00	
1	21.460	21.540	21.560	
2	21.610	21.620	21.630	
3	21.670	21.700	21.530	
4	21.920	21.960	22.000	
5	22.090	22.110	22.130	
6	22.220	22.230	22.250	
7	22.330	22.340	22.350	
8	22.340	22.330	22.320	
9	22.230	22.200	22.160	
10	22.210	21.970	21.930	
11	21.780	21.710	21.650	
12	21.690	21.430	21.370	
13	21.890	21.120	21.060	
14	20.890	20.820	20.760	
15	20.600	20.530	20.480	
16	20.500	20.360	20.330	
17	20.240	20.220	20.190	
18	20.100	20.060	20.030	
19	19.900	19.870	19.860	
20	19.760	19.750	19.720	
21	19.640	19.620	19.610	
22	19.590	19.580	19.570	
23	19.520	19.520	19.510	
24	19.480	19.480	19.480	
25	19.490	19.490	19.490	
26	19.570	19.460	19.450	
27	19.410	19.410	19.430	
28	19.420	19.440	19.450	
29	19.500	19.520	19.530	
30	19.500	19.480	19.470	

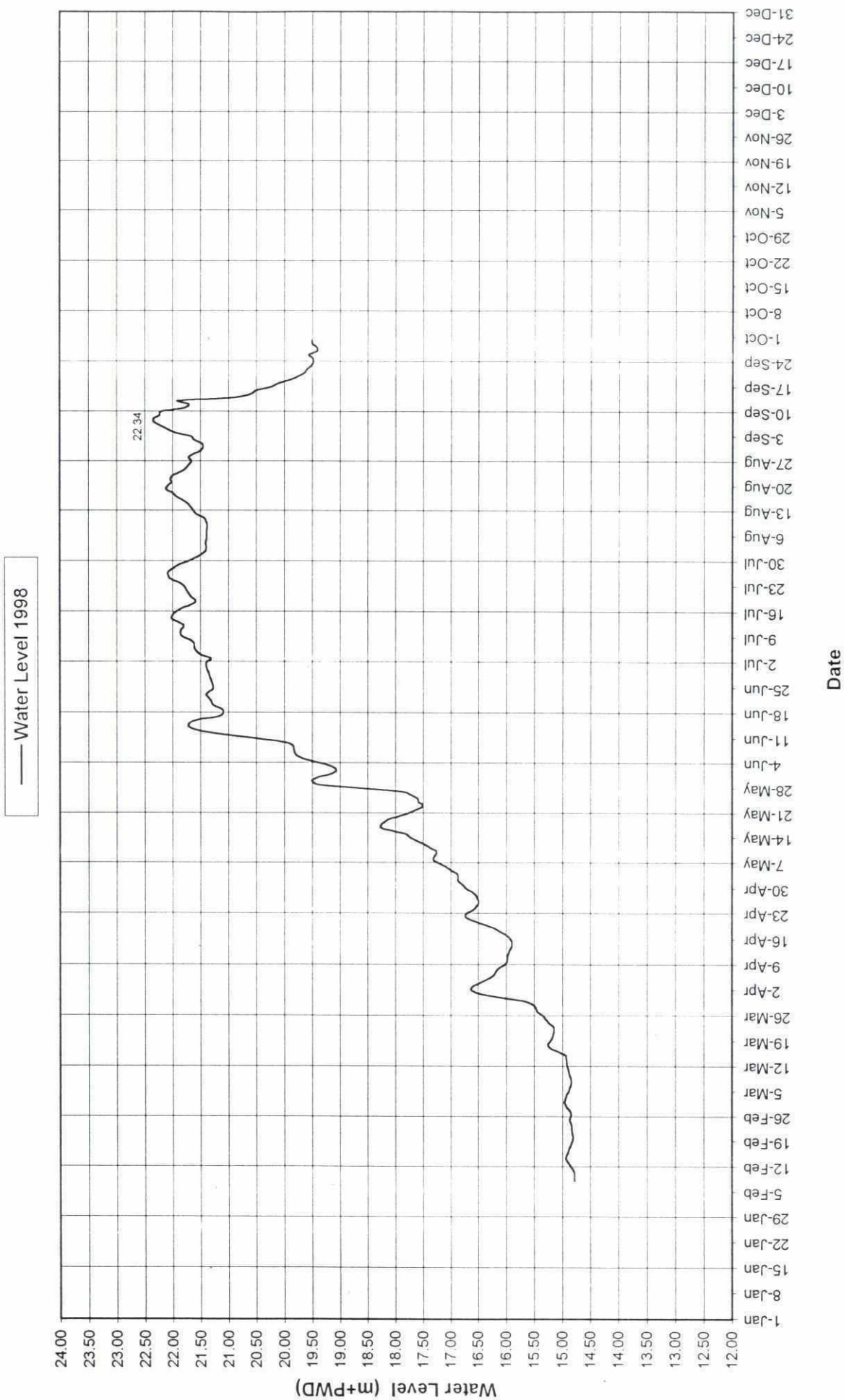
# RIVER TRAINING TEST STRUCTURES - FAP 22 WATER LEVEL AT KUNDARAPARA TEST SITE (July to September 1998)



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# RIVER TRAINING TEST STRUCTURE - FAP 22 WATER LEVEL AT KUNDARAPARA SITE (January to December)



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# RIVER TRAINING TEST STRUCTURES - FAP 22 BWDB WATER LEVEL FREQUENCY CURVES VERSUS ACTUAL FAP 22 WATER LEVEL AT KAMARJANI TEST SITE UP TO SEPTEMBER '98

