FRERMIP
Flood and Riverbank Erosion Risk Management Investment Program

Bangladesh Water Development Board
Asian Development Bank

Flood and Riverbank Erosion Risk Management Investment Program – Project 1

ADB Loan 3138-BAN (SF)/GON Grant 0396 (EF)

Institutional Strengthening and Project Management Consultant (ISPMC)

QUARTERLY PROGRESS REPORT NO. 18

FOR

October-December 2019

Prepared by:

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FRERMIP
Flood and Riverbank Erosion Risk Management Investment Program

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XX March, 2020

To
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Project Director
Flood and Riverbank Erosion Risk Management Investment Program
152/3/B Bir Uttam, Kazi Nuruzzaman Road, Panthopath,
Firoz Tower, (12th Floor) Dhaka-1205, Bangladesh

Subject: **Submission of Quarterly Progress Report No. 18, October,to December 2019**

Reference: **As per Institutional Strengthening and Project Management Consultant Service Contract, Clause 9 (i).**

Dear Sir,

Please find enclosed Quarterly Progress Report No. 18 for the period October-December 2019 for "Flood and Riverbank Erosion Risk Management Investment Program (FRERMIP) – Project 1". This report has been prepared in close discussion with your office, using information available in the Revised (November 2018) Development Project Proforma and considering the Facility Administration Manual.

The quarterly progress report documents the status of project and progress made during the reporting quarter. When required, it identifies changes to the key assumptions and possible risks to project implementation. This report was prepared by ISPMC with contributions, assistance and cooperation of the Bangladesh Water Development Board (BWDB).

We look forward to further comments from BWDB, ADB and others on this report.

Yours sincerely,
JV Northwest Hydraulic Consultants – Euroconsult Mott MacDonald

Knut Oberhagemann
(Team Leader)

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ABBREVIATIONS AND ACRONYMS

AP	-	Affected Person
ADB	-	Asian Development Bank
ADP	-	Annual Development Program
BDPC	-	Bangladesh Disaster Preparedness Center
BDT	-	Bangladesh Taka
BDRCS	-	Bangladesh Red Crescent Society
BRM	-	Bangladesh Resident Mission
BWDB	-	Bangladesh Water Development Board
CbFRM	-	Community-based Flood Risk Management
CCL	-	Cash Compensation under Law
CDMU	-	Community Development Medical Unit
CEGIS	-	Center for Environmental and Geographic Information Services
CRO	-	Chief Resettlement Officer
CV	-	Community Volunteer
DG	-	Director General
DDM	-	Department of Disaster Management
DMC	-	Disaster Management Committee
DPP	-	Development Project Proforma
EKN	-	Embassy of the Kingdom of the Netherlands
EP	-	Entitled Person
FRERMIP	-	Flood and Riverbank Erosion Risk Management Investment Program
GAP	-	Gender Action Plan
GFM	-	Grout Filled Mattress
GOB	-	Government of Bangladesh
GON	-	Government of the Netherlands
ha	-	hectare
IMED	-	Implementation Monitoring and Evaluation Division
INGO	-	Implementing Non-Government Organization
ISPMC	-	Institutional Strengthening and Project Management Consultant
JLB-2	-	Jamuna Left Bank 2 Sub-Project
JRB-1	-	Jamuna Right Bank 1 Sub-Project
JMREMP	-	Jamuna-Meghna River Erosion Mitigation Project (2002-2011)
JVT	-	Joint Verification Team
km	-	Kilometer
LA	-	Land Acquisition
LAP	-	Land Acquisition Plan
MDIP	-	Meghna-Dhonagoda Irrigation Project (1977-1983)
Mil	-	Million (1,000,000)
MIS	-	Management Information Systems
MoDMR	-	Ministry of Disaster Management and Relief
MoWR	-	Ministry of Water Resources
O&M	-	Operation and Maintenance
PD	-	Project Director (BWDB)
PM	-	Project Manager (DDM)
PIRDP	-	Pabna Irrigation and Rural Development Project (1978-1992)
PLB-1	-	Padma Left Bank 1 Sub-Project
PMO	-	Project Management Office (BWDB)
PMU	-	Project Management Unit (DDM)

PPTA	-	Project Preparatory Technical Assistance
PVAT	-	Property Valuation Advisory Team
QPR	-	Quarterly Progress Report
SCME	-	Senior Community Mobilization Expert
SMO	-	Sub-Project Management Office
TN	-	Technical Note
ToR	-	Terms of Reference
ToT	-	Training of Trainers
UDMC	-	Upzilla Disaster Management Committee
USD	-	United States Dollars
VDP	-	Village Defense Party
VRDS	-	Voluntary Rural Development Society

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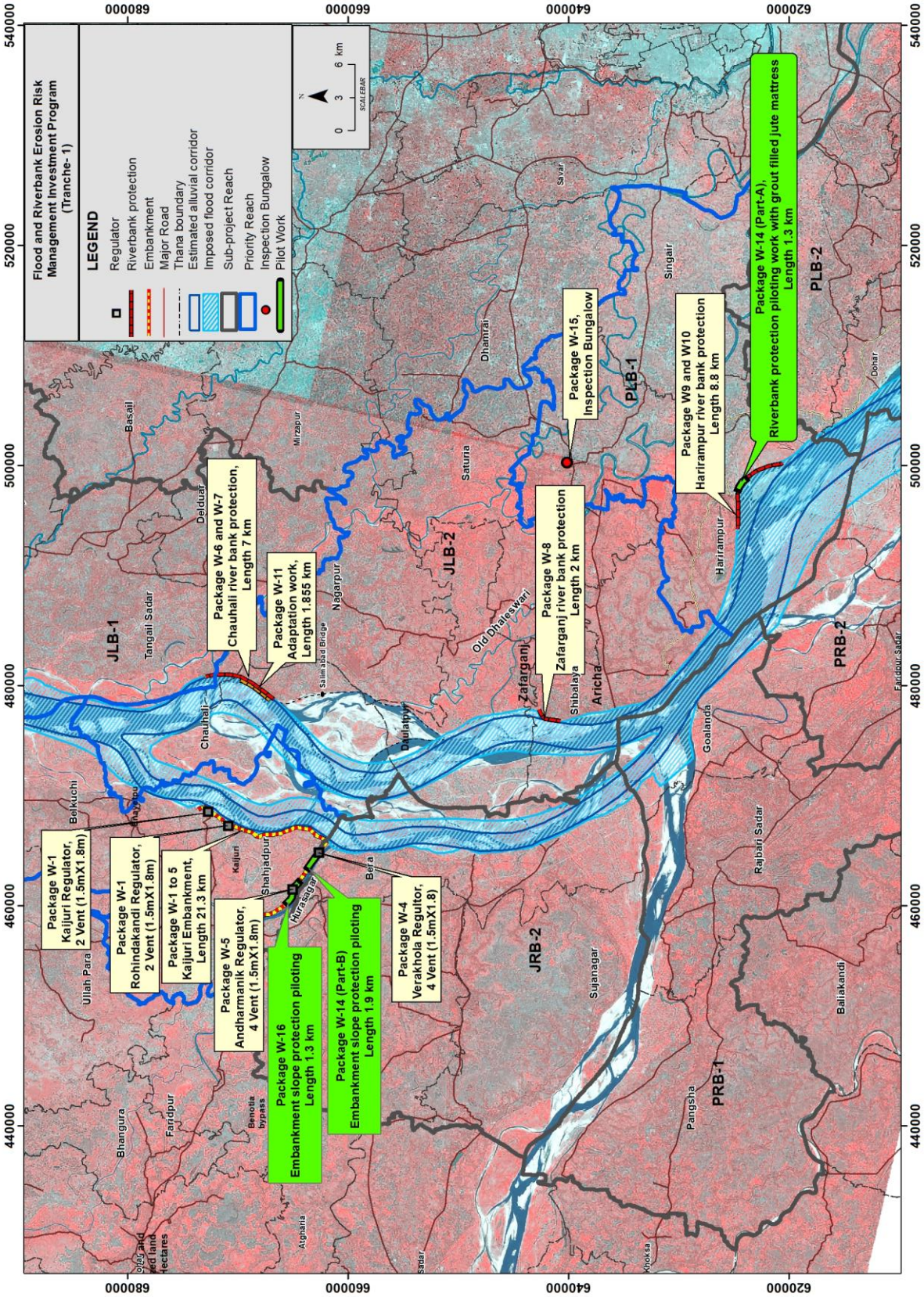

Figure 0-1 Index Map (Tranche-1)

Table 0-1 Project Progress at a glance

1.	Basic Data	
	ADB Loan Agreement Number	3138-BAN(SF)
	GON Grant Agreement Number	0396-BAN(EF)
	Project Name	Flood and Riverbank Erosion Risk Management Investment Program - Tranche 1
	Country	Bangladesh
	Borrower	People's Republic of Bangladesh
	Executing Agency	Bangladesh Water Development Board
	Implementing Agency	Department of Disaster Management

2. Financing Plan

Modality and Sources	Tranches ($ million)			Amount ($ million)
	I	II	III	
Government of Bangladesh (GOB)	23.3	45.3	34.8	103.4
Asian Development Bank (ADB)	65	100	90	255
Government of The Netherlands (GON)	15.3	0	0	15.3
Total	103.6	145.3	124.8	373.7

3. Milestones

Milestone	Date		
	Approval	Signing	Effectiveness
ADB Loan Agreement	2014 June 27	2014 August 14	2014 September 17

Milestone	Project		
	I	II	III
Estimated Completion Date	2020 June 30	2023 December 31	2024 August 31

Milestone	Date
Last ADB Review Mission	24-26 September 2019

4. Assets and Physical Progress

Proposed Project Assets	Goods	Services	Works	eXtra	Total	Available
Project Program Best Estimate (Tk Mil)	1360	1116	3609	2589	8674	8674

Primary Component	Secondary Component		Assigned Weight (%)	Progress	
				Actual (%)	Weighted (%)
1. Establishment & Recruitment	1.1	PMO Establishment and Staffing	2	100	2.00
	1.2	ISPMC Consultants Recruitment	2	100	2.00
	1.3	NGO Recruitment	2	100	2.00
2. Implementation; Tranche-1	2.1	Detailed Design	2	100	2.00
	2.2	Tender Documents Preparation	6	100	6.00
	2.3	Tendering and Contract Award	6	100	6.00
	2.4	Land Acquisition and Resettlement	8	97	7.76
	2.5	Project Management	6	89	5.34
	2.6	Physical Completion of Works	32	96	30.72
	2.7	Financial Disbursements	4	96	3.84
3. Knowledge Base & Capacity	3.1	Knowledge Base & Tech. Studies	4	95	3.80
	3.2	CBFRM Activities	6	100	6.00
	3.3	MIS Project Mgmt Module	4	85	3.40
4. River Study, Piloting & Master Plan	4.1	Long-term stabilization study	4	91	3.64
	4.2	Land Recovery / Piloting	2	71	1.42
5. Preparation; Project-2	5.1	Feasibility Study; Project-2	6	100	6.00
	5.2	Detailed Design; Project-2	4	100	4.00
Totals			**100**		**95.92**

5.	Financial Progress		
Financial Indicator	BDT Million	US$ Million	% of Total
Estimated Project Cost (Source: DPP Page 1)	8,674	108.43	100
PMO Expenditures	7,447	93.09	86
ADB and GON Disbursement	5,484	68.54	93
Total Reimbursement	5,171	64.64	88

*1 USD= 80 Taka (Source : Revised Devised Development Project Performa (Page-2)

1. INTRODUCTION

1.1 Background

The people in Bangladesh are often detrimentally affected by flooding and riverbank erosion along its four main rivers: Jamuna, Ganges, Padma and Meghna. Even though the erosion rates of floodplain land have reduced from nearly 5,000 hectares per year to less than 2,000 hectares (Figure 1-1), ten thousand people are affected annually.

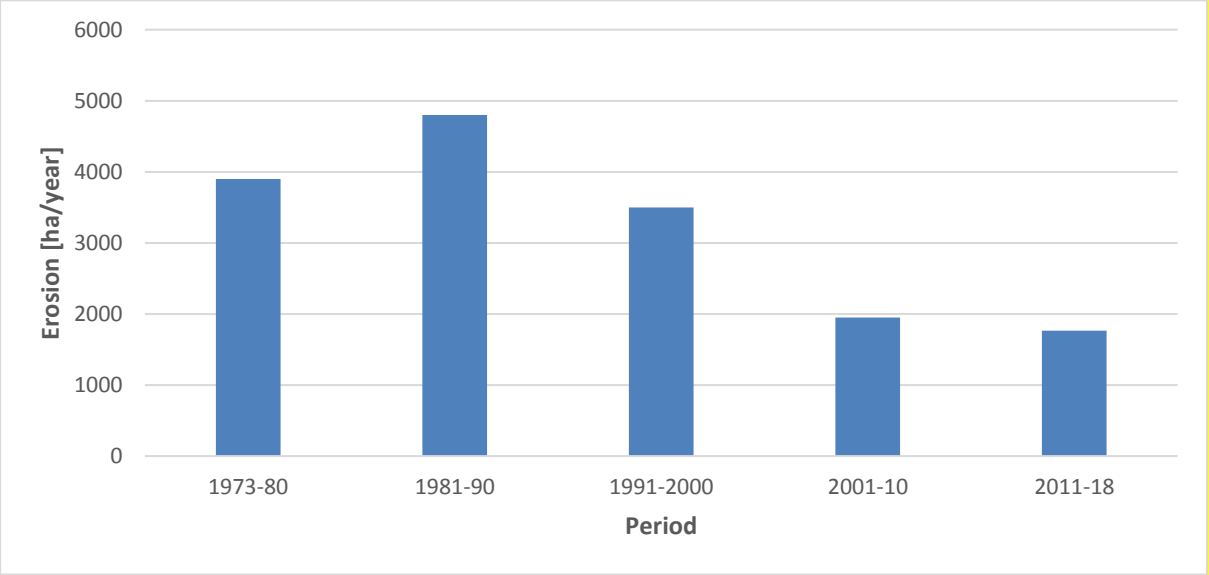

Figure 1-1 Decadal erosion rates of the Jamuna-Ganges-Padma River (Source: CEGIS 2019)

The risk associated with flooding and riverbank erosion increases with the growth of the population, and the high population density of Bangladesh restricts the scope for moving people away from disaster prone areas. Riverbank erosion increasingly threatens embankments required for flood protection, as the setback distances from the riverbank become increasingly smaller. The threat of flooding and riverbank erosion discourages investment and leads to lower economic growth in riverine areas. Effective riverbank erosion and flood protection management is essential for the economic growth and poverty reduction in affected areas.

The BWDB undertook the 'Jamuna-Meghna River Erosion Mitigation Project ' (JMREMP) with financial assistance from ADB in 2001, having the dual purpose to firstly mitigate riverbank erosion at the Pabna Irrigation and Rural Development Project (PIRDP) and the Meghna-Dhonagoda Irrigation Project (MDIP) through sustainable and cost-effective protective works; and secondly to develop a framework for a sustainable erosion risk management system to be applied elsewhere in the country. JMREMP has developed the concept of phased planning (based on erosion prediction, river surveys, and flexible fund allocations) and implementation to adapt to changing river condition known as adaptive management. The most important development of the project is a special method of construction of underwater revetment by dumping sand filled geo-textile bags from positioned barges. Between 2004 and 2011, this protection method was used along 17 km of the lower Jamuna River and some 11 km around the MDIP. Geobag revetments were incorporated into the 'Guideline for Riverbank Protection' approved by the BWDB in 2010. The Project Preparatory Technical Assistance (PPTA), implemented from 2012 to 2013, provides the key concept for FRERMIP and is documented in the Final Report,

Feasibility Study, 2013 (NHC, 2013). This initiative includes recovering floodplain land lost during the widening process which has persisted since the 1960s[1].The ADB Facility Administration Manual, June 2014 (ADB, 2014) is the key document prescribing the loan objectives and procedural details.

The loan for Project-1 of the Flood and Riverbank Erosion Risk Management Investment Program (FRERMIP) was signed on 14 August 2014, and the contract with the main consultant (ISPMC) was signed on 8 September 2015. The first 17.80 km of riverbank protection, concentrating on the critical underwater part, was completed during the dry season 2016/17. This first project lays the foundation for systematic river stabilization supported by FRERMIP over three successive projects to be implemented over a period of around ten years. The first project, scheduled to be completed in June 2020, will provide structural and non-structural flood and riverbank erosion risk management measures in three high priority sub-projects: Jamuna Left Bank 2 (JLB-2), Jamuna Right Bank 1 (JRB-1) and Padma Left Bank 1 (PLB-1); refer to ADB, 2014. Subsequent projects will extend the protected reaches with the goal to substantially stabilize the lower Jamuna and parts of the Padma River, based on an adaptive approach with designs adjusted to changing river conditions.

FRERMIP will contribute to providing a defined boundary between river and floodplain, and thus contribute to a more secure and improved livelihood for people living along the main rivers of Bangladesh, which will trigger faster economic growth and accelerate poverty reduction. The outcome of the program will be reduced flood and riverbank erosion risks in the targeted sub-project reaches.

1.2 The Project

The project has three funding partners including two international development partners: Asian Development Bank (ADB), Government of Netherlands (GON) plus the local counterpart: Government of Bangladesh (GoB).

The project scope and implementation arrangements have not fundamentally changed from those outlined in the ADB Report and Recommendation of the President **(**ADB, 2014**)**, except for the postponement of some activities due to the reduction of available loan financing. The anticipated outputs of the project are to provide:

1. flood and riverbank erosion risk mitigation functioning at priority river reaches
2. a strengthened institutional system for flood and riverbank erosion risk management

Under Project-1, nearly 17.80 km of riverbank protection and 21.30 km of flood embankments; refer to the Project Map(**Figure 0-1)** were implemented. Adding to that, 4.4 km of grout filled jute mattress pilot work is under implementation as wave protection at two project sites. Project outputs also include social and environmental safeguards; institutional, knowledge-base, capacity development; and community-based flood risk management activities.

The project will result in an improved knowledge base and enhanced institutional capacity in sustainable asset management, and better strategic management of the main rivers. The project will actively promote a sound and sustainable program management system which will facilitate the implementation process. Table 0-1 placed at the beginning of the report, provides a summary of project information including salient reference data, estimates of project assets, plus physical and

[1] ADB 2014. Report and Recommendation of the President to the Board of Directors, Proposed Multitranche Financing Facility, People's Republic of Bangladesh: Flood and Riverbank Erosion Risk Management Investment Program, June.

financial progress indicators, in Bangladesh Taka (BDT), US dollars (USD) and percent completion. The project has been extended until June 2020 to complete the activities, namely, the embankment construction and pilot works including monitoring during the 2019 flood season. The ADB has approved the extension of one-year on 15 November 2018. After the first revision of the Development Project Proforma (DPP), approved on 15 June 2017, the Project Management Office (PMO) has revised the DPP as second time, which was approved on 1st November 2018. The revised DPP, amongst others, increases the budget for land acquisition and resettlement to complete the embankment works, without increasing the overall amount. The 2nd revised DPP also excluded work packages W-12 and W-13 and service packages S-03, S-05 and S-07. A first zero-cost Variation Order for the ISPMC S01 package was accepted on 27 July 2017, a second zero cost variation, extending the consulting services to May 2019, was signed on 10 June 2018. The 3rd zero cost variation for consultancy service was approved on 23 March 2019. 4th variation was approved on 15 December 2019 and it extends the consultancy services until April 2020.

The PMO is expecting that the modified Project outputs (Appendix-A, Table A-5) can be fully achieved by 30 June 2020.

1.3 Overall Progress

Project-1 successfully completed or substantially completed its core activities, of:

(i) the construction of riverbank protection, during the dry season 2014/15, completed during the 2016/17 dry season with a total length of 17.80 km, and

(ii) the construction of 21.3 km of flood embankment and 4 regulators, contracted during the dry season 2017/18 and substantially constructed during the dry season 2018/19, with minor finishing works expectd to be completed during the following quarter.

While the underwater protection has performed very well, despite deep scouring to, in places, 28 m below the low water level and 25 m below the original apron setting level, a number of surficial failures occurred at the Chauhali site, mostly after placing the final wave protection in 2017. Initial repair and adaptation works were conducted during the 2018 dry season for a total length of some 3.8 km under existing work packages as well as a dedicated adaptation package. No further damages were observed in the adapted areas during the course of the 2018 and 2019 flood seasons. Only the downstream end section of the works was damaged after the river scoured to - 33m+PWD or 11 m below design scour level in 24 September 2018. No adaptation works were required for Harirampur and Zafarganj riverbank protection as no major erosion or river deepening occurred at these sites.

Over the years, geotextile bag revetments have been built at a stable cost level for around USD 3 million or BDT 24 Crore per kilometer in 2018 prices (Figure 1-2). It is noteworthy that only the works built at Kaijuri between 2009 and 2011, which were some 40% below this average construction cost, shows some damages, while the rest is performing well. Overall, geotextile bag revetments appear to be the most cost-effective and sustainable solution built till date, even below spur cost, historically considered more cost effective than continuous revetment works. Riverbank protection advances have been documented widely, including a number of memos and reports authored by the ISPMC FRERMIP. A list of memos produced by ISPMC is attached in Appendix-I.

The construction of 21.30 km embankment from Kaijuri to Verakhola including 4 regulators started on 15 February 2018 for contract packages W-01 to W-05. Average progress of these packages (W1 to W5) is 92[2]%. Construction activities are expected to be completed in early 2020.

[2] Source IMED 03/2003, ADP: 2019-20 Quarter-2, D

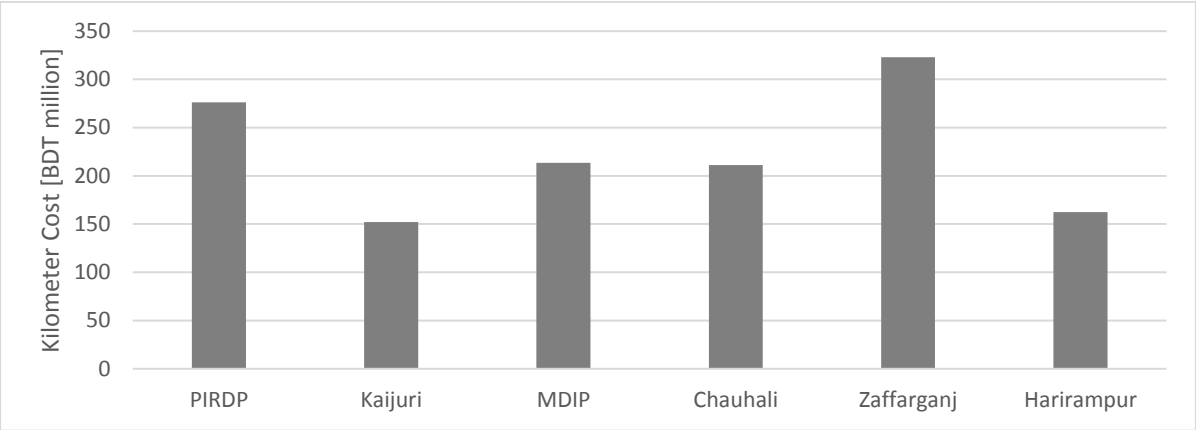

Figure 1-2 Kilometer cost of geotextile bag revetments implemented in Bangladesh (in 2018 prices)

There were three sites selected for the implementation of jute grout-filled mattress pilot works. Two were as embankment slope protection at Kaijuri and one was as riverbank wave protection at Harirampur. These three sites were implemented under two work packages: W14 and W16. Under package W14, the contractor completed the grout fill mattress work at Harirampur riverbank and a 200m section remains at Kaijuri embankment adjacent to the regulator where the embankment has not been completed. Cummulative progress of this package is 95% with the contract scheduled to end in March 2020.

Package W16 was awarded on 17 September 2019 and consisted of survey and construction works. The contractor mobilized for the survey works in early October and completed the surveys on 23rd November. The contractor mobilized for the grout-filled jute mattress works at the end of December 2019 with grouting works expected to commence at the beginning of January 2020. Overall progress of this package is 15%.

The overall weighted project progress is presented in Table 0-1 and shows that, compared with the total estimated projected cost, the physical progress is 96%, PMO expenditure is 86% and ADB (plus GON) disbursement is 73.6%. The following Table 1-1 shows the relative comparison between the total project cost, ADB loan amount and the comparative percentage progress.

Table 1-1 Comparative Project Cost and ADB Disbursement Progress (until 31 December 2019)

Total Project Cost (BDT Million)	Total Project Aid (ADB and GoN) (BDT Million)	ADB and GoN Disbursement Progress compared to the total cost (%)	ADB and GoN Disbursement Progress compared to the Aid amount (%)
8674.44	5907.49	73.6	93

1.4 This Report

Quarterly Progress Report No. 18 covers the period 01 October 2019 to 31 December 2019. The report describes activities carried out during the quarter, which included: multi-beam surveys, single beam echosounder surveys, float track and ADCP surveys, mobilization of contractors for grout-filled jute mattress erosion protection and embankment construction and land acquisition for the approach channels to regulators in the Koijuri embankment. In addition, ISPMC prepared the "*Lower Jamuna*

2019 Morphological Analysis" and "Geotechnical review of riverbank protection at Upstream Chauhali" which are included in Appendix K and Appendix L respectively.

2. PROJECT ACTIVITIES

2.1 Introduction

The BWDB FRERMIP Project Management Office (PMO) started functioning in April 2014. In 2014/15 was initially engaged in preconstruction and procurement activities, and since November 2015 with construction activities at three sites (through two Sub-Project Management Offices (SMOs) at Tangail and Manikganj). After the riverbank construction was completed in 2016/17 adaptation works was implemented at Chauhali in 2017/18 and the Koijuri embankment construction started at which point a third Sub-Project Management Office in Koitala was activated. During the 2018/19 dry season, construction work largely related to the Koijuri embankment and pilot works. The PMU DDM has implemented the CbFRM sub-component from 30 August 2018 until 30 June 2019.

The Joint Venture of Northwest Hydraulic Consultants (nhc) and Euroconsult Mott Macdonald (EMM) is working as Institutional Strengthening and Project Management Consultant (ISPMC) since 8th September 2015 and has completed numerous activities including: prepared the Project Inception and Mid-Term reports, a number of technical memos, summary study team and feasibility report for tranche 2; supported overall project management and capacity building activities; advised on design, construction and resettlement activities during implementation; prepared management support tools including data bases; provided regular quarterly progress reports; and prepared the terms of reference for several supporting studies. The status of implementation activities in the reporting quarter is discussed in the following sections, and summaries and detailed tables are provided in Appendix-A and Appendix-B respectively.

Table 2-1 provides the status of annual ADP expenditures. The completion of the embankments at Koijuri as well as the grout-filled jute mattresspilot works will complete the Tranche-1 construction activities and are expected in March 2020. The PMO expects to spend the remaining fund allocation within June 2020.

Table 2-1 Annual ADP allocation and disbursement (in BDT million)

Fiscal Year	ADP/RADP/RADP Reallocation	Actual expenditure	Percentage of Budget Utilization
2014/15	311.20	217.78	66.20/70.00
2015/16	2108.20	2074.34	90.33/98.39
2016/17	2290.80	2246.11	86.26/98.05
2017/18	1331.50	1106.21	40.65/80.08
2018/19	1676.30*	1633.77	81.16/97.46
2019/20	1007.0		-

*Up to December 2019, Fiscal Year Ongoing; Source: IMED Report 05/2003

2.2 PROJECT ASSET IMPLEMENTATION

2.2.1 Introduction

Tables A-1 and A-2 (Appendix A) show the type, number and total cost of the project according to the 2nd revised DPP. The cost of the 21.30 km of embankment (plus associated structures) is BDT 1,202.943

million, as per awarded contract (Table A-5). The 17.8 km of riverbank revetment cost BDT 1,863 million (work contracts), plus BDT 1,054 million for geo-bags (supply contracts). In line with the 2nd revised DPP (September 2018) the best estimate of the final cost for all project assets currently amounts to BDT 8,674.44 million (Goods BDT 1,360.26 million, Services BDT 1,116.08 million and Works BDT 3,609.24 million, plus BDT 2,588.86 million of additional assets included in the DPP, primarily for land acquisition) (source, PMO December 2019). The total estimated expenditure will vary due to contract variations which are currently under preparation.

Using cross-link tables that connect these category items (and Asset Types) with other financial indicators, it is possible to produce tables which show project progress based on ADB Financial Categories (Table A-3) or DPP Components (Table A-4 and A-5). Table A.2 and Table A.5 shows the detail breakdown of RDPP budget estimation.

2.2.2 Bidding Activities

All bidding activities under the FRERMIP project were completed in the last quarter. Bidding details are provided in Table B-2 (Appendix-B).

2.2.3 Design Activities

The design work for Tranche-1 is complete with the exception of minor modifications proposed to the second pilot work contract which were under discussion with BWDB Design Circle II.

2.2.4 Implementation Activities

In this quarter there were no significant construction activities and the contractors for the embankment and pilot works remobilized only in December 2019 after the flood season. The following work contracts are complete or under implementation:

Table 2-2 Summary of Implementation activities – up to 31 December 2019

Contract	Locations	Start date	Completion date	Contract Amount in Lac	Amount paid in Lac	Percent completed
W-01 to W-05	Kaijuri	05-03-18 27-02-18 08-03-18	05-01-20 02-12-19 31-12-19	12029.43	10304.3	91.4
W-6 & W-7	Chauhali	25-10-15	15-04-18	8895.6	8293.58	100
W-8	Zaffarganj	20-02-16	20-01-18	4850.00	4668.69	100
W-9 & W 10	Harirampur	15-01-16	09-02-18	5705.15	5673.15	100
W-11	Chauhali	20-03-18	31-01-19	670.119	639.4695	100
W-14	Pilot	16-09-18	30-06-19	3197.69	2872.12	95
W-15	Inspection Bungalow	10-06-18	31-05-19	70.452	67.15	95

W-16	Pilot	17-09-19	16-03-2020	1232.2		15

Details of the ongoing contract works are:

Construction work of the embankments under contract packages W-01/2016-17 to W-05/2016-17 started again in mid-December after the flood season. The individual progress of each of the packages from W1 to W5 are 92%, 93%, 90%, 90% and 92% respectively. The remaining works are the repair of raincuts, provision of clay cladding and vetiver grass and completion of the regulators including the installation of gates and excavation of approach channels. To complete the embankment work all the embankments construction work package, W01 to W05 has variation on December.

Under pilot works package W-14/2017-18, the contractor has re-mobilized to complete the 200m adjacent to the regulator under package W-04/2016-17 that could not be completed before the 2019 flood season but works cannot begin as the embankment in this section is still incomplete.

The W-16/2018-19 pilot works package started on 17 Sep 2019 with surveys including bathymetric and flow velocity surveys. The contractor began mobilizing for the grout-filled jute mattress component of the works in mid December and casting is expected to start in the first week of April 2020.

2.3 OTHER PROJECT ACTIVITIES

Other project activities that are documented in the following sections include:

1. Supporting Service studies
2. Environmental Management
3. Resettlement Services
4. Gender and Development
5. Community-based Flood Risk Management
6. Capacity Building
7. Data Inventory Development
8. River Study
9. Feasibility Study for Tranche-2 Project
10. ISPMC performance compliance with ToR

2.3.1 Supporting Service Studies

The project comprises four service contracts for supporting Project activities. The status of the four ongoing supporting services are summarized in Table 2-3.

Table 2-3 Supporting Service Studies

Pkg.	Service Name	Present Status
S-01	Institutional Strengthening and Project Management Consultant (ISPMC)	The ISPMC signed a contract with BWDB on 08 September 2015,and their work is estimated to be around 85 % complete. After the 4th variation approved on 12 December 2019, contract extended from December 2019 to April 2020.

S-02	Resettlement Plan Implementation	The Resettlement INGO signed a contract with BWDB on 16-Mar-2016, and their work is estimated to be 96 percent complete. Details are provided in Section 2.3.3.
S-04	NGO Service for Community based Flood Risk Management (DDM)	The contract was signed on 30 August 2018 with implementation starting on 01 September, 2018. The contract has ended in 30 June 2019. More details are provided in Section 2.3.5.
S-06	Erosion Prediction	CEGIS has completed the contracted work under this project in April, 2018.

2.3.2 Environmental Management

The National Environmental Specialist visited embankment packages W-03,W-04 and W-05 on 21 December 2019 with Mr Jahangir Alam, Executive Engineer PMO, FRERMIP and Mr Md Al Amin, Sub Assistant Engineer/Sectional Officer Bera. The semi-annual environmental monitoring report is expected to be finalized in early January 2020.

2.3.3 Resettlement Services

There was some progress in resettlement service during this quarter as summarized in Table 2-4 showng increased satus of compensations in all sites except Harirampur.

Table 2-4 Summary of Resettlement Grant Received by the AP

Sl No	Location of Intervention with sub-reaches	Upazilla/ District	Type of Loss	Approved by PVAT & JVT	No. of APs & CPR Title/ Non-title/Tenants					Affected Households		Status of Compensation	
					Title	Non Title	Tenants	CPR	Total	Male	Female	Cumulative up to Dec 2019	
												CCL	Resettlement Grant
1	Embankment (Koijuri to Hurasagor) incl. 4 regulators in JRB-1	Shajadpur of Sirajgonj and Bera of Pabna	Residence & Business structure, Business loss,	JVT on Squatters done on 30/08/2017	949	1305	56	12	2322[3]	2081	229	84% CCL payment for structure holders done & 88% CCL	2124 EPs received Resettlement Grant
2	Riverbank protection work at Chauhali JLB-2	Chauhali of Sirajgonj; Nagorpur& Sadar of Tangail	Residence & Business structure, Business loss, Agriculture plot	Approved by JVT	176	14	00	01	191	179	11	89% CCL payment done at Tangail part. 64% CCL payment done at Sirajganj part	Resettlement Grant among 52 EPs on 16/07/17 Replacement Cost (RC) for 36 APs

3	Riverbank protection work at Zafargonj JLB-2 (1.4 Km)	Shibaloy of Manikganj	Residence & Business structure ,Business loss, Agriculture plot	Approved by JVT	38	40	12		90[4]	77	13	61% CCL payment done	Resettlement Grant distributed among 90 EPs and replacement cost for 8 Aps
4	Riverbank protection work at Zaforgonj JLB-2 (0.6 km)	Shibaloy,Manikganj	Residence & Business structure ,Business loss, Agriculture plot	Approved by JVT	26				26	22	04	80% CCL payment done	Resettlement Grant distributed among 26 EPs
5	Riverbank protection work at Hariramp ur PLB-1	Harirampur , Manikganj	Residence & Business structure,Business loss, Agriculture plot	Not Done	66	13		02	81	72	07	Not yet started	Not yet started
	Total				1255	1372	68	15	2710			2956	

2.3.4 Gender and Development

There was little progress in gender and development during this quarter. The progress report is compiled as per approved revised GAP which is provided in Appendix F.

2.3.5 Community-based Flood Risk Management (CbFRM)

All the CbFRM components were successfully completed before this quarter.

2.3.6 Capacity building

In this quarter no capacity development took place. Table 2-5 summarises the total number of trainings so far conducted.

Table 2-5 Capacity Building Progress as per RDPP (2nd Revised)

Item	Total	Completed	Pending
A. Local Training	7	6	1
B. Overseas Training/Study Tour	9	6	3
Total	16	12	4

2.3.7 MIS Development Activities

No additional survey data was added to the database in this quarter.

A current summary list of all surveys in the River Survey (2297) and ADCP (259) database is presented in Appendix - H.

2.3.8 River Study

Significant progress was made on the 37 Supplementary Annexes (SAs) during the reporting quarter. E1 and E2 were formatted and submitted to the PMO in this quarter (Letter reference: ISPMC-FRERMIP-650, Dated 20 October 2019).

In total 2 Annexes (F3 and H4) were technically completed. Draft reports were completed for 2 Supplementary Annexes (D1 and D2). Report formatting was completed for 9 Supplementary Annexes (C1, C2, C3, C4, C5, C6, H1, H2 and H3).

The individual status of all 37 Supplementary Annexes is available in Appendix-D.

2.3.9 Feasibility Study Design

The Tranche 2 feasibility report was approved during the last quarter. Now the Consultant is preparing the Tranche 2 documents including updating the EIA report following BWDB comments.

2.3.10 ISPMC Performance Compliance with ToR

So far, the ISPMC has complied with the terms and conditions defined in the Terms of Reference (ToR) of the consultancy contract. Appendix-E presents a detailed summary of the ISPMC performance so far in accordance with the tasks defined in the ToR of the consultancy contract.

3. ADMINISTRATIVE ARRANGEMENTS

3.1 Establishment of Project Offices

The PMO and ISPMC offices are fully operational. The project management team of the ISPMC and the BWDB PMO Office are both located in the Firoz Tower, 152/3/B Bir Uttam, Kazi Nuruzzaman Road (Green Road), Dhaka-1205; on the 12th and 7th floor respectively.

While the PMO and the three SMOs are understaffed, the present staff strength is sufficient to complete the remaining works. The following tables show the current staff employment status compared to the approved setup.

Table 3-1 PMO-FRERMIP Staffing

Post Name	No. of Posts in the approved setup	Currently appointed in the post	Vacant post
Project Director	1	1	0
Superintending Engineer	2	1	1
Executive Engineer	4	1	3
System Analyst	1	0	1
Sub-Divisional Engineer	2	0	2
Assistant Engineer	2	2	0
Assistant Director	1	1	0
Accounts Officer	1	1	0
Accounts Assistant	1	1	0
Data Entry Operator	2	0	2
Driver	2	2	0
Guard	2	2	0
MLSS	4	3	1
Total	**25**	**15**	**9**

Table 3-2 SMO-Koitola Staffing

Post Name	No. of Posts in the approved setup	Currently appointed in the post	Vacant Post
Executive Engineer	1	1	0
Sub-Divisional Engineer	1	1 (additional charge)	0
Assistant Engineer	1	0	1
Sub-Assistant Engineer	3	3	0
Accounts Assistant	1	0	1
Data Entry Operator	1	0	1
Revenue Surveyor	1	0	1
Work Assistant	3	1	2
Guard	2	2	0
MLSS	1	1	0
Total	**15**	**9**	**6**

Table 3-3 SMO-Tangail Staffing

Post Name	No. of Posts in the approved setup	Currently appointed in the post	Vacant Post
Executive Engineer	1	1	0
Sub-Divisional Engineer	1	1	0
Assistant Engineer	1	0	1
Sub-Assistant Engineer	2	1	1
Accounts Assistant	1	1	0
Data Entry Operator	1	1	0
Revenue Surveyor	1	1	0
Work Assistant	2	1	1
Guard	1	1	0
MLSS	2	2	0
Total	**13**	**10**	**3**

Table 3-4 SMO-Manikganj Staffing

Post Name	No. of Posts in the approved setup	Currently appointed in the post	Vacant Post
Executive Engineer	1	1	0
Sub-Divisional Engineer	2	1	1
Assistant Engineer	1	1	0
Sub-Assistant Engineer	3	2	1
Accounts Assistant	1	1	0
Data Entry Operator	1	1	0
Revenue Surveyor	1	1	0
Work Assistant	3	3	0
Guard	1	0	1
MLSS	2	2	0
Total	**16**	**13**	**3**

Appendix-C Utilization of Consultant Person-Months details the man-months spent by all international and national specialists to the end of the reporting period.

3.2 Compliance with Loan and Grant Agreement Covenants

Schedule 5 of the FRERMIP Loan Agreement (Ref. 6) contains a set of 32 specific covenants to be followed during project implementation. These 30 covenants are documented in Appendix-G, together with a column for compliance, and a column that provides evidence to support the compliance value.

3.3 Important Events During This Quarter

- 24-26 September 2019 – ADB review mission to Kaijuri, Chauhali and Zaffarganj,
- 03 November 2019 - Contract variation signed for Package W-01/2016-17, W-02/2016-17 and W-03/2016-17
- 05 November 2019 - Contract variation signed for Package W-04/2016-17 and W-05/2016-17
- 26 November 2019 – Pilot works performance meeting between Proserve Ltd, ISPMC and Design Circle II
- 15 December 2019 - Contract variation signed for Package S-01

4. FINANCIAL ARRANGEMENTS

4.1 Statements of Expenditure

Using the project implementation database, and with help from the PMO- FRERMIP, the ISPMC generate reports on project financial progress including: all ADB (and GON) disbursements (deposits) to the project, PMO- FRERMIP expenditures paid to contractors and suppliers, and all reimbursement bill applications approved by ADB.

Table A-5 shows cumulative totals up to 31 December for progress, expenses and reimbursements, for all DPP categories. This table also includes the 2018/19 fiscal targets (and fiscal progress) as defined in the provisional ADP (Annual Development Program).

PMO- FRERMIP expenditures by individual contract are provided in Table B-4. Only the total expenditure values are exactly correct. The individual developing values have been calculated using total expenditure values and the percent distribution by financial component.

Reimbursement values (BDT) are also summarized by ADB Financial Category (Table A-3), and by DPP Component (Table A-4 and A-5).

5. ISSUES FOR DISCUSSION AND AGREEMENT

Following the identification of ran cuts and rat holes during site inspections, the Contractors were advised on the appropriate method of repair including layerwise compacting of material to prevent zones of weakness.

The Study team has conducted a review of three river stabilization concepts/plans prepared in 2019 for finalizing the FRERMIP river stabilization plan. The final document is expected during the following quarter.

6. REFERENCES

CEGIS 2019. Prediction of Riverbank erosion along the Jamuna. The Ganges and the Padma rivers in 2019" Table E.1, Page xii.

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ADB, 2012: Involuntary Resettlement Safeguards, A Planning and Implementation Good Practice Sourcebook – Draft Working Document, Asian Development Bank, 2012 November

ADB, 2014: Facility Administration Manual, Bangladesh: Multi-Project Financing Facility - Flood and Riverbank Erosion Risk Management Investment Program, 2014 June

ADB, 2014: Loan Agreement, Flood and Riverbank Erosion Risk Management Investment Program - Project 1, between People's Republic of Bangladesh and Asian Development Bank, 2014 August 14

ADB, 2014: Report and Recommendation of the President to the Board of Directors, Proposed Multi-Project Financing Facility People's Republic of Bangladesh: Flood and Riverbank Erosion Risk Management Investment Program, 2014 June

BWDB 2015: Contract for Consultancy Services (Time Based) for Institutional Strengthening and Project Management Consultant (ISPMC) between Bangladesh Water Development Board and Northwest Hydraulic Consultants Ltd. Joint Venture with Euroconsult Mott Macdonald, September 2015

BWDB 2019: Implementation Monitoring and Evaluation Division Report (IMED 05/2003), Implementation Monitoring and Evaluation Division, Ministry of Planning, Government of the People's Republic of Bangladesh, June 2019

BWDB, 2018: Revised Development Project Proforma/Proposal on Flood and Riverbank Erosion Risk Management Investment Program (Tranche-1) (2nd Revised), Bangladesh Water Development Board, Ministry of Water Resources, Government of the People's Republic of Bangladesh, November 2018

ISPMC, 2016: Flood and Riverbank Erosion Risk Management Investment Program (FRERMIP) Project-1, Inception Report, 2016 March

NHC, 2013: Project Preparatory Technical Assistance 8054 BAN, Main River Flood and Bank Erosion Risk Management Program, Main Report, 2013 December

Appendices

Appendix-A Work Program Summaries

Table A-1 Project Program Summary

Component	Asset Type	Units	Quantity (Units) BWDB	DDM	MAN	KOI	TAN	Totals
A: Civil Works								
A1: Embankment & Regulator Works	New: Embank	km	0.0	0.0	0.0	12.5	0.0	**12.5**
	Cons/ReCon: Embank	km	0.0	0.0	0.0	8.8	0.0	**8.8**
	New: Insp.Banglow	BDTM	0.0	0.0	7.8	0.0	0.0	**7.8**
	New: Regulator	Nos.	0.0	0.0	0.0	4.0	0.0	**4.0**
A2: Riverbank Prot Works	New: Revetment	km	0.0	0.0	10.8	0.0	7.0	**17.8**
A3: Emerg & Adaptation	Emerg: AdpRivProt	BDTM	0.0	0.0	0.0	0.0	67.0	**67.0**
A4: Pilot Land Recovery	New: RivTrnWrk	BDTM	330.0	0.0	0.0	146.0	0.0	**476.0**
B: Materials								
B1: Geotextile, Riverbank Prot.Works	Procure: GeoBag	Mil Nos.	0.0	0.0	3.2	0.0	1.5	**4.6**
B2: Geotextile, Adaptation	Procure: AdpGeoBag	Mil Nos.	0.0	0.0	1.3	0.0	0.0	**1.3**
C: Vehicles & Equipment								
C1: Vehicles/Transport	Procure: Veh/Trans	Nos.	15.0	0.0	0.0	0.0	0.0	**15.0**
C2: Office Equipment	Procure: Equip	BDTM	4.4	0.0	0.0	0.0	0.0	**4.4**
C3: Survey Equipment	Procure: Equip	BDTM	6.7	0.0	0.0	0.0	0.0	**6.7**
C4: DDM Office Eqpt	Procure: Equip	BDTM	0.0	0.5	0.0	0.0	0.0	**0.5**
D: Consulting/NGO Services								
D1: ISPM; Consultant Serv.	Service: 1 Impl.Consult	BDTM	387.0	0.0	0.0	0.0	0.0	**387.0**
	Service: 2 River.Stabil	BDTM	461.0	0.0	0.0	0.0	0.0	**461.0**
	Service: 3 Feasi.Study	BDTM	170.0	0.0	0.0	0.0	0.0	**170.0**
D2: INGO BWDB	Service: Resettle.S	BDTM	16.2	0.0	0.0	0.0	0.0	**16.2**
D3: INGO DDM	Service: CbFRM	BDTM	0.0	50.5	0.0	0.0	0.0	**50.5**
D4: Survey & Investigation	Service: Eros.Pred	BDTM	28.9	0.0	0.0	0.0	0.0	**28.9**
E: Capacity Development								
E1: BWDB Training & Study	Service: Training	BDTM	76.9	0.0	0.0	0.0	0.0	**76.9**
F: Land Acqn & Resettle								
F1: Land Acquisition	Compensate: Land.Acqu	BDTM	2,083.	0.0	0.0	0.0	0.0	**2,083.0**
F2: Resettle Benefits	Compensate: Resettle.B	BDTM	90.0	0.0	0.0	0.0	0.0	**90.0**
G: Program Management								
G1: Staff Salaries BWDB	Service: Prog.Mngt	BDTM	83.7	0.0	0.0	0.0	0.0	**83.7**
G2: Honorarium Allowance	Service: Honor.Allow	BDTM	0.8	0.0	0.0	0.0	0.0	**0.8**
G3: Office Opns BWDB	Service: Prog.Mngt	BDTM	32.3	0.0	0.0	0.0	0.0	**32.3**
G4: Office Opns DDM	Service: Prog.Mngt	BDTM	0.0	2.1	0.0	0.0	0.0	**2.1**
G5: BWDB Surveys	Service: Land/Riv.Surv	BDTM	8.0	0.0	0.0	0.0	0.0	**8.0**
X: Misc. Costs								
X1: Misc. Costs	Misc. Costs: CD&VAT	BDTM	12.1	0.0	0.0	0.0	0.0	**12.1**
	Misc. Costs: Service Charge	BDTM	199.2	0.0	0.0	0.0	0.0	**199.2**

Abreviations:
DDM - Department of Disaster Managment
MAN - Manikganj WD Division, BWDB (SMO-FRERMIP)
KOI - Koitola WD Division, BWDB (SMO-FRERMIP)
TAN - Tangail WD Division, BWDB (SMO-FRERMIP)

The unit BDTM refers to an estimated cost of Bangladesh Taka 1 Million.

Table A.2 - RDPP estimates of the project according to IMED Report					all values in BDT lacs	
Sl no	Category	GoB fund	Project Aid RPA			Total
			GOB	Special Account	DPA	
	(a) Revenue Cost					
1	Salary & allowances for support staffs	836.60	0.00	0.00	0.00	836.60
2	Honorarium Allowances	8.00	0.00	0.00	0.00	8.00
3	Resettlement Support Program	0.00	0.00	900.00	0.00	900.00
4	BWDB Capacity Development Program	46.13	0.00	722.75	0.00	768.88
5	Implementation Consultant	503.46	0.00	3369.36	0.00	3872.82
6	River Stabilization and Land Recovery	599.60	0.00	4012.71	0.00	4612.31
7	Feasibility Study of Tranche 2/3 Project	220.58	0.00	1476.16	0.00	1696.74
8	Resettlement Implementation Support	22.75	0.00	152.25	0.00	175.00
9	Community based Disaster Management Program (DDM)	65.78	0.00	440.12	0.00	505.90
10	Land/River Survey and Data Processing	10.40	0.00	69.60	0.00	80.00
11	Survey and Inverstigation/Data Processing	37.51	0.00	251.04	0.00	288.55
12	PMO Operational expenses	38.75	0.00	284.18	0.00	322.93
13	PIU-DDM Operational expenses	2.52	0.00	18.48	0.00	21.00
14	ADB loan interest during implmentation and service charge for Netherlands grant	0.00	0.00	0.00	1992.00	1992.00
15	Sub-total Revenue Component of (a)	2392.08	0.00	11696.65	1992.00	16080.73
	(b) Capital Component					
17	CD/VAT	120.74	0.00	0.00	0.00	120.74
18	Construction of Inspection banglow at Manikganj	7.04	0.00	71.17	0.00	78.21
19	Regulator/ Sluice (new construction 4 nos) in JRB subproject area	222.93	0.00	2254.08	0.00	2477.01
20	21.30 km embankment along the Right Bank of Jamuna and left bank of Baral-Hurasagar	859.72	1625.70	7067.00	0.00	9552.42
21	Riverbank Protective Works	2094.24	0.00	27110.10	0.00	29204.34
22	Adaptive Protection and Emergency Works	380.82	0.00	2874.53	0.00	3255.35
23	Land Recovery/ River training pilot works	421.11	0.00	4257.87	0.00	4678.98
24	Transport vehicles	334.11	0.00	15.37	0.00	349.48
25	Computer and office Equipment	2.09	0.00	41.54	0.00	43.63
26	Computer and office Equipment (DDM)	0.25	0.00	4.74	0.00	4.99
27	Survey equipment	3.37	0.00	64.10	0.00	67.47
28	Land acquisition (136.00 ha)	20831.09	0.00	0.00	0.00	20831.09
29	Sub-total revenue component (b)	25277.51	1625.70	43760.50	0.00	70663.71
	Sub total a+b	27669.59	1625.70	55457.15	1992.00	86744.44
30	**Physical contingency ©**	0.00	0.00	0.00	0.00	0.00
31	**Price Contingency (d)**	0.00	0.00	0.00	0.00	0.00
	Grand total (a+b+c+d)	**27669.59**	**1625.70**	**55457.15**	**1992.00**	**86744.44**

Table A-3 ADB Categories: Reimbursed Amount, by Development Partner

Component Code	Categories	Total Cost Est	Value of Physical Progress	PMO expenses	Reimbursed Amount		
					ADB	GON	Total
1	Works	3609	3222	3202.97	2665	261.3	2926.3
2	Materials	1312.8	1312.8	1312.9	1312.9	0	1312.9
3A	Vehicles-BWDB	34.9	34.5	34.9	1.5	0	1.5
3B	Equipment -BWDB	11.1	11.1	11.1	10.6	0	10.6
3C	Equipment -DDM	0.5	0.5	0.5	0.5	0	0.5
4	Resettlement	90	79.2	78.76	78.76	0	78.76
5	Training	76.9	63.8	64.15	60.14	0	60.14
6A	Consulting Services-Project Management BWDB	1018.2	868.2	833.09	156	568.64	725.06
6B	Consulting Services-INGO/ Erosion Prediction Services -BWDB	45.1	42.9	41.54	26.8	0	26.8
6C	Consulting Services-Project Management DDM	50.5	37.4	30	0	0	0
7A	Project Management - BWDB	32.29	30.6	24.7	21.7	0	21.7
7B	Project Management - DDM	2.1	1.5	1.53	0.4	0	0.4
8	Service Charge of ADB loan & GoN Grants	199.2	149.4	170	0	0	0
9	Unallocated	2191	1775.7	1641.28	6.6	0	6.6
	Grand Total	8674	7630	7447	4340	830	5171

Table A-4 RDPP Categories: Reimbursed Amount by Development Partners

Sl no	Economic Code	Category	PMO expenses	Reimbursed Amount – Until 31 Dec 2019		
		(a) Revenue Cost		ADB	GON	Total
1	3111201, 3111301, 3111325, 3111335	Salary for support staffs	**6.16**	**0**	**0**	**0**
2	3111332	Honorarium Allowances		**0**	**0**	**0**
3	3211103	Resettlement Support Program	**78.76**	**78.6**	**0**	**78.76**
4	3231101, 3231201	BWDB Capacity Development Program	**64.15**	**60.14**	**0**	**60.14**
5	325701	Implementation Consultant	**381.45**	**59**	**273**	**332.11**
6	325701	River Stabilization and Land Recovery	**321.23**	**67**	**213**	**279.53**
7	325701	Feasibility Study of Tranche 2/3 Project	**130.41**	**30**	**83**	**113.42**
8	325701	Resettlement Implementation Support	**12.28**	**10.66**	**0**	**10.66**
9	325701	Community based Disaster Management Program (DDM)	**30.00**	**26.09**	**0**	**26.09**
10	3257104	Land/River Survey and Data Processing	**7.48**	**6.6**	**0**	**6.6**
11	3257104	Survey and Investigation/Data Processing	**28.77**	**25.1**		**25.1**
12	3111302, 3111329, 3111332, 3111338, 3211119, 3211125, 3211128. 3211129, 3241101, 3243101, 3243102, 3255101, 3255105, 3256101, 3258104, 3258107, 3258129, 3258140, 3258129, 3255102, 3255104	PMO operational expenses	**24.73**	**21.3**	**0**	**21.73**
13	Same as PMO expenses	PIU-DDM Operational expenses	**1.54**	**1.32**		**1.32**
14	3221110, 3411101	ADB loan interest during implementation and service charge for Netherlands grant	**170.00**	**0**		**0**
15		Sub-total Revenue Component of (a)	**1256.96**	**385.81**	**568.64**	**955.46**
16		**(b) Capital Component**				
17						
18	3821104, 3821101	CD/VAT		**0**	**0**	**0**
19	4111201	Construction of Inspection bungalow at Manikganj	**6.72**	**6.11**	**0**	**6.11**
20	4111307	Regulator/Sluice gate in JRB1 subproject area	**212.12**	**193.18**	**0**	**193.18**
21	4111321	21.30 km embankment along the Right Bank of Jamuna and left bank of Baral-Hurasagar	**818.30**	**744.51**	**0**	**744.51**
22	4111321	Riverbank Protective Works	**2920.43**	**2711**	**0**	**2711**
23	4111321	Adaptive Protection and Emergency Works	**322.47**	**284.66**	**0**	**284.66**
24	4111321	Land Recovery/ River training pilot works	**287.20**	**0**	**261.35**	**261.35**
25	4112101	Transport vehicles	**34.94**	**4.1**	**0**	**4.1**
26	4112202, 4112310, 4113301	Computer and office Equipment	**4.40**	**4.2**	**0**	**4.2**
27	4112202, 4112310, 4113301	Computer and office Equipment (DDM)	**0.50**	**0.5**	**0**	**0.47**
28	4112304	Survey equipment	**6.70**	**6.4**	**0**	**6.4**
29	4141101	Land acquisition (136.00 ha)	**1576.80**	**0**	**0**	**0**
30		Sub-total revenue component (b)	**6190.58**	**3954.66**	**261.35**	**4215.98**
31		Sub total a+b	**7447.54**	**4340.47**	**829.99**	**5171.44**
32		**Physical contingency ©**	**0.00**	**0**		**0**
33		**Price Contingency (d)**	**0.00**			**0**
34		**Grand total (a+b+c+d)**	**7447**	**4340**	**830**	**5171**

Table A-5 DPP Categories: Financial and Physical Progress Indicator

Sl no	Economic Code	Category	Budget	Fiscal year 2019/20		Progress up to the month of December 2019	
				Financial	Physical %	Financial	Physical %
		(a) Revenue Cost	**RDPP**	**Provisional Target**			
1	3111201, 3111301, 3111325, 3111335	Salary for support staffs	**83.7**	**3.288**	**94.05**	**6.16**	**7.37**
2	3111332	Honorarium Allowances	**0.8**	**0.8**	**100**		
3	3211103	Resettlement Support Program	**90**	**0.9**	**12.48**	**78.76**	**87.52**
4	3231101, 3231201	BWDB Capacity Development Program	**76.9**	**10.097**	**16.73**	**64.15**	**83.44**
5	325701	Implementation Consultant	**387.3**	**10.13**	**2.69**	**381.45**	**98.02**
6	325701	River Stabilization and Land Recovery	**461.2**	**172.525**	**37.75**	**321.23**	**72.25**
7	325701	Feasibility Study of Tranche 2/3 Project	**169.7**	**45.246**	**26.87**	**130.41**	**83.13**
8	325701	Resettlement Implementation Support	**17.5**	**1.675**	**11**	**12.28**	**92.00**
9	325701	Community based Disaster Management Program (DDM)	**50.6**	**7.414**	**40.7**	**30.00**	**59.30**
10	3257104	Land/River Survey and Data Processing	**8**	**0.4**	**6.44**	**7.48**	**93.56**
11	3257104	Survey and Investigation/Data Processing	**28.9**			**28.77**	**100.00**
12	3111302, 3111329, 3111332, 3111338, 3211119, 3211125, 3211128. 3211129, 3241101, 3243101, 3243102, 3255101, 3255105, 3256101, 3258104, 3258107, 3258129, 3258140, 3258129, 3255102, 3255104	PMO operational expenses	**32.3**	**7.43**	**25.73**	**24.73**	**76.62**
13	Same as PMO expenses	PIU-DDM Operational expenses	**2.1**	**0.29**	**26.67**	**1.54**	**73.33**
14	3221110, 3411101	ADB loan interest during implementation and service charge for Netherlands grant	**199.2**	**29.2**	**14.66**	**170.00**	**85.34**
15		Sub-total Revenue Component of (a)	**1608.1**	**2975**	**24.76**	**1256.96**	**80.24**
16		**(b) Capital Component**					
17							
18	3821104, 3821101	CD/VAT	**12.1**	**10.1**	**100**		
19	4111201	Construction of Inspection bungalow at Manikganj	**7.8**	**2.33**	**22**	**6.72**	**95.00**
20	4111307	Regulator/Sluice gate in JRB1 subproject area	**247.7**	**35.4**	**11**	**212.12**	**95.00**
21	4111321	21.30 km embankment along the Right Bank of Jamuna and left bank of Baral-Hurasagar	**955.2**	**135.27**	**15**	**818.30**	**92.00**
22	4111321	Riverbank Protective Works	**2920.4**			**2920.43**	**100.00**
23	4111321	Adaptive Protection and Emergency Works	**325.5**			**322.47**	**100.00**
24	4111321	Land Recovery/ River training pilot works	**467.9**	**246.42**	**35.18**	**287.20**	**69.82**
25	4112101	Transport vehicles	**34.9**			**34.94**	**100.00**
26	4112202, 4112310, 4113301	Computer and office Equipment	**4.4**			**4.40**	**100.00**
27	4112202, 4112310, 4113301	Computer and office Equipment (DDM)	**0.5**			**0.50**	**100.00**
28	4112304	Survey equipment	**6.7**			**6.70**	**100.00**
29	4141101	Land acquisition (136.00 ha)	**2083.1**	**279.95**	**8**	**1576.80**	**94.00**
30		Sub-total revenue component (b)	**7066.4**	**709.5**	**2.53**	**6190.58**	**99.27**
31		Sub total a+b	**8674.4**	**1007**	**6.28**	**7447.54**	**95.92**
32		**Physical contingency ©**	**0**			**0.00**	
33		**Price Contingency (d)**	**0**			**0.00**	
34		**Grand total (a+b+c+d)**	**8674.4**	**1007**	**6.28**	**7447.54**	**95.92**

Appendix-B Work Program Details

Table B-1 Design Progress Details

Description	Total	Design Data Collection			Prog (%)		Remarks
		Surv	Hydraul	Geotech	Desn	Dwg	
Component A: Civil Works							
BWDB PMO							
New: RivTrnWrk: 330 BDTM: River Training Pilot Work: & Land Recovery		c	c	na	100	100	Desn. & Dwg. Complete
BWDB PMO Totals	*1*	*1*	*1*	*1*	*1*	*1*	
Koitola SMO							
Cons/ReCon: Embank: 4.8 km: Embankment Reconst. (4.8 km): Baghabari - Verakhola; km 12.5-17.3		c	c	na	100	100	Desn. & Dwg. Complete
Cons/ReCon: Embank: 4 km: Embankment Reconst. (4 km): Baghabari - Verakhola; km 17.3-21.3		c	c	na	100	100	Desn. & Dwg. Complete
New: Embank: 3.5 km: Embankment (3.5 km): Bhatpata - Gala; km 5-8.5		c	c	na	100	100	Desn. & Dwg. Complete
New: Embank: 5 km: Embankment (5 km): Kaijuri - Bhatpara; km 0-5		c	c	na	100	100	Desn. & Dwg. Complete
New: Embank: 4 km: Embankment (4 km): Gala - Verakhola; km 8.5-12.5		c	c	na	100	100	Desn. & Dwg. Complete
New: Regulator: 1 Nos.: Kaijuri Reg 2V 1.5x1.8m: Koijuri		c	c	c	100	100	Desn. & Dwg. Complete
New: Regulator: 1 Nos.: Rohindakandi Reg 2V 1.5x1.8m: Ruhindakandi		c	c	c	100	100	Desn. & Dwg. Complete
New: Regulator: 1 Nos.: Verakhola Reg 2V 1.5x1.8m: Verakhola		c	c	c	100	100	Desn. & Dwg. Complete
New: Regulator: 1 Nos.: Andhar Manik Reg 4V 1.5x1.8m: Andharmanik		c	c	c	100	100	Desn. & Dwg. Complete
New: RivTrnWrk: 146 BDTM: Piloting Work; Jute Mattress: Shahzadpur		c	c	c	100	100	Dwgs Complete
Koitola SMO Totals	*10*	*10*	*10*	*10*	*10*	*10*	
Manikganj SMO							
New: Insp.Banglow: 7.8 BDTM: Construction of Inspection Banglow		c	na	na	100	100	Desn. & Dwg. Complete
New: Revetment: 2 km: Revetment (2 km): Zaffarganj; km 6.1-8.1		c	c	na	100	100	Desn. & Dwg. Complete
New: Revetment: 3.6 km: Revetment (3.6 km): Harirampur; km 0-3.5		c	c	na	100	100	Desn. & Dwg. Complete
New: Revetment: 5.2 km: Revetment (5.2 km): Harirampur; km 3.5-7		c	c	na	100	100	Desn. & Dwg. Complete
Manikganj SMO Totals	*4*	*4*	*4*	*4*	*4*	*4*	
Tangail SMO							
New: Revetment: 2.5 km: Revetment (2.5 km): Chauhali; km 0- 2.5		c	c	na	100	100	Desn. & Dwg. Complete
New: Revetment: 4.5 km: Revetment (4.5 km): Chauhali; km 2.5-7.0		c	c	na	100	100	Desn. & Dwg. Complete
Emerg: AdpRivProt: 67 BDTM: Emergency/Adaptive 1: Riverbank Protection		c	c	na	100	100	Desn. & Dwg. Complete
Tangail SMO Totals	*3*	*3*	*3*	*3*	*3*	*3*	
Component Totals	*18*	18	18	18	18	18	

Legend:
n - not commenced c - completed
p - partially completed na - not applicable/required

Table B-2 Tender Progress Details

Project Code	Description	Dates: ISPMC ToR	ADB ToR	EoI Notice	EoI Received	BWDB EoI Eval	ADB EoI Eval	ADB Bid Doc	Tender Notice	Tender Received	Eval Comp	ADB Consur	Appr. Compl, Authority	Notif. Award
Goods; B: Materials														
G-01	Supply of Geobags; Chauhali &Sirajganj							26Dec14	31Dec14	19Feb15	04Aug15	29Apr15	07Jan15	01Jul15
G-02	Supply of Geobags; Zaffarganj, Harirampur & Manikganj							26Dec14	31Dec14	19Feb15	04Aug15	29Apr15	07Jan15	01Jul15
G-03	Supply of Geobags; Harirampur & Manikganj							19May15	19May15	06Jul15	08Dec15	27Aug15	22Sep15	27Sep15
G-04	Supply of Geobags; Chauhali, Harirampur, Koijuri & Benotia							13Sep16	27Sep16	14Nov16	19Dec16	20Jan17	31Jan17	12Feb17
Component Totals		*0*	*0*	*0*	*0*	*0*	*0*	*4*	*4*	*4*	*4*	*4*	*4*	*4*
Goods; C: Vehicles & Equipment														
G-05	2016 Supply of Jeep;							26Feb16	29Feb16	31Mar16	13Apr16	19Apr16	19Apr16	07Jun16
G-06.1	2015 Supply of Jeeps;								01Jun16	05Jun16	09Jun16	12Jun16	16Jun16	30Jun16
G-06.2	2016 Supply of Jeep;								10Mar16	24Mar16	14Apr16	21Apr16	28Apr16	05May16
G-06.3	2016 Supply of Motorcycles;								10Mar16	24Mar16	14Apr16	21Apr16	28Apr16	05May16
G-07.1	2015 Office Equipment; BWDB PMO								13Apr15	17May15				28May15
G-07.2	2016 Office Equipment; BWDB PMO							10Apr15	03Jan16	04Feb16	29Feb16	28Mar16	28Mar16	30Mar16
G-08	2016 Supply of Survey Equipments;							10Apr15	03Jan16	04Feb16	29Feb16	14Mar16	14Mar16	16Mar16
G-09	2017 Supply of Office Equip; DDM								01Jun17	08Jun17	08Jun17	15Jun17	22Jun17	22Jun17
Component Totals		*0*	*0*	*0*	*0*	*0*	*0*	*3*	*8*	*8*	*7*	*7*	*7*	*8*
Services; D: Consulting/NGO Services														
S-01	ISPMC;			23Oct14	15Dec14				01Apr15	01Jun15				08Sep15
S-02	Resettlement Impl.Support; Sirajganj, Tangail, Manikganj		22Apr15	09Jun15	09Jul15	24Aug15		22Oct15	11Nov15	10Dec15	11Jan16	04Mar16	15Mar16	16Mar16
S-04	Community Based Flood Risk Mngmt; DDM	30Sep15	01Mar16	28Mar16	26Apr16	27Mar17	23Oct17	23Oct17	12Nov17	17Dec17	05Aug18	28Aug18		30Aug18
S-06.1	2015 Erosion & Morphological Chg;								23Dec14	01Jan15				29Jan15
S-06.2	2016, 2017 & 2018 Erosion Prediction;		23Feb16						23Feb16	15Mar16	24Mar16	28Mar16	09May16	10May16
Component Totals		*1*	*3*	*3*	*3*	*2*	*1*	*2*	*5*	*5*	*3*	*3*	*3*	*5*
Works; A: Civil Works														
W-01	Embankment, & 2 Reg.; km 0-5							06Nov17	07Nov17	11Dec17	27Dec17	21Jan18	12Feb18	12Feb18
W-02	Embankment; km 5-8.5							06Nov17	07Nov17	11Dec17	27Dec17	21Jan18	23Jan18	29Jan18
W-03	Embankment; 8.5-12.5							06Nov17	07Nov17	11Dec17	27Dec17	21Jan18	23Jan18	29Jan18
W-04	Embankment & 1 Regulator; km 12.5-17.3							06Nov17	07Nov17	11Dec17	27Dec17	21Jan18	12Feb18	12Feb18
W-05	Embankment & 1 Regulator; km 17.3-21.3							06Nov17	07Nov17	11Dec17	27Dec17	29Jan18	20Feb18	22Feb18
W-06	Revetment; Jamuna at Chauhali, R1; km 0-2.5							30Mar15	04May15	08Jun15	28Jul15	14Aug15	22Sep15	23Sep15
W-07	Revetment; Jamuna at Chauhali, R2; km 2.5-7.0							30Mar15	04May15	08Jun15	28Jul15	14Aug15	22Sep15	23Sep15
W-08	Revetment; Jamuna at Zaffarganj, km 6.1-8.1							11May15	22Jun15	27Jul15	08Oct15	04Dec15	03Feb16	03Feb16
W-09	Revetment; Padma at Harirampur, R1; km 6.7-10.2							11May15	22Jun15	27Jul15	04Nov15	10Dec15	30Dec15	30Dec15
W-10	Revetment; Padma at Harirampur, R2; km 3.2-6.7							11May15	22Jun15	27Jul15	04Nov15	10Dec15	30Dec15	30Dec15
W-11	Emergency/Adaptive 1; Riverbank Protection							31Dec17	14Jan18	15Feb18	25Feb18	01Mar18	14Mar18	19Mar18
W-14	Piloting Work; Manikganj, Tangail, Sirajganj	04Oct17						21May18	21May18	25Jun18	28Jun18	30Jul18	29Aug18	30Aug18
W-15	Construction of Inspection Banglow; Manikgonj		05Apr18					15Apr18	15Apr18	17May18	29May18	07Jun18	11Jun18	11Jun18
W-16	Piloting Work; Shahzadpur							1Aug19	1Aug19	22Aug19		09Sep19	11Sep19	11Sep19
Component Totals		*1*	*1*	*0*	*0*	*0*	*0*	*13*	*13*	*13*	*13*	*13*	*13*	*13*
Project Totals		**2**	**4**	**3**	**3**	**2**	**1**	**22**	**30**	**30**	**27**	**27**	**26**	**30**

Abbreviations:

ADB - Asian Development Bank
BDT - Bangladesh Taka
Comp. - Completion
Concur. - Concurrence
Doc. - Document
Eval. - Evaluation
EoI - Expression of Interest
Notif. - Notification

Table B-3 Implementation Progress Details, by Contract

Contract Code	Description	Contractor	Best Estimate of Final Cost (BDT Mil)	Value of Cumulate Progress: during Mth% (%)	31-Dec-2019 Current Mth (%)	31-Dec-2019 Current Mth (BDT Mil)	31-Mar-2020 Next Mth (%)	31-Mar-2020 Next Mth (BDT Mil)	Remarks
Goods									
B: Materials									
G-01	Supply of Geobags: Chauhali &Sirajganj	BJ Geo-Textile	364.9	100	100	364.9	100	364.9	Financially Complete
G-02	Supply of Geobags: Zaffarganj, Harirampur & Manikganj	BJ Geo-Textile	472.6	100	100	472.6	100	472.6	Financially Complete
G-03	Supply of Geobags: Harirampur & Manikganj	DFL-DCTL(JV)	315.1	100	100	315.1	100	315.1	Financially Complete
G-04	Supply of Geobags: Chauhali, Harirampur, Koijuri & Benotia	DIRD	258.5	100	100	258.5	100	258.5	ImplementationComplete
Component Totals			***1,411.1***			***1,411.4***		***1,411.1***	
C: Vehicles & Equipment									
G-05	2016 Supply of Jeep:	Pacific Motors Ltd.	5.5	100	100	5.5	100	5.5	Implementation Complete
G-06.1	2015 Supply of Jeeps:	Progoti Industries	20.8	100	100	20.8	100	20.8	Implementation Complete
G-06.2	2016 Supply of Jeep:	Progoti Industries	6.9	100	100	6.9	100	6.9	Implementation Complete
G-06.3	2016 Supply of Motorcycles:	Atlas Bangladesh Ltd.	1.3	100	100	1.3	100	1.3	Implementation Complete
G-07.1	2015 Office Equipment: BWDB PMO	Logitech Computer Ltd.	2.2	100	100	2.2	100	2.2	Implementation Complete
G-07.2	2016 Office Equipment: BWDB PMO	Source & Service	2.2	100	100	2.2	100	2.2	Implementation Complete
G-08	2016 Supply of Survey Equipments	Logitech Computers Ltd.	6.7	100	100	6.7	100	6.7	Implementation Complete
G-09	2017 Supply of Office Equip: DDM	DDM	0.5	100	100	0.5	100	0.5	Implementation Complete
Component Totals			***46.1***			***46.1***		***46.1***	
Goods Totals			***1,457.2***			***1,457.2***		***1,457.2***	
Services									
D: Consulting/NGO Services									
S-01	ISPMC:	NHC (JV) Mott MacDonald	1,018.2	89	89	785.5	88	896.6	Satisfactory Progress
S-02	Resettlement Impl.Support: Sirajganj, Tangail, Manikganj	VRDS-HCL-JV	16.2	91	91	91	100	16.2	Implementation Ongoing
S-04	Community Based Flood Risk Mngmt: DDM	BDPC	37.4	100	100	22.1	100	37.4	Implementation Ongoing
S-06.1	2015 Erosion & Morphological Chg:	CEGIS	4.6	100	100	4.6	100	4.6	Implementation Complete
S-06.2	2016, 2017 & 2018 Erosion Prediction:	CEGIS	24.3	100	100	24.3	100	24.3	Implementation Complete
Component Totals			***1,100.7***			***850.5***		***979.1***	
Services Totals			***1,100.7***			***850.5***		***979.1***	
Works									
A: Civil Works									
W-01	Embankment, & 2 Reg.: km 0-5	Md. Moyenuddin (Bashi)-Gol	323.0	92	92	282.5	100	323.0	Satisfactory Progress
W-02	Embankment: km 5-8.5	Taher Brothers Ltd.-MA Ente	118.2	93	93	100.0	100	118.2	Construction Ongoing
W-03	Embankment: 8.5-12.5	Taher Brothers Ltd.-MA Ente	112.3	90	90	89.8	100	112.3	Construction Ongoing
W-04	Embankment & 1 Regulator: km 12.5-17.3	HB-SSECL (JV)	362.4	90	90	315.9	100	362.4	Construction Ongoing
W-05	Embankment & 1 Regulator: km 17.3-21.3	Md. Moyenuddin (Bashi)-Gol	287.1	92	92	242.0	100	287.1	Satisfactory Progress
W-06	Revetment: Jamuna at Chauhali, R1; km 0-2.5	I-J (JV)	444.4	100	100	422.1	100	422.1	Financially Complete
W-07	Revetment: Jamuna at Chauhali, R2; km 2.5-7.0	I-J (JV)	445.2	100	100	407.2	100	407.2	Financially Complete
W-08	Revetment: Jamuna at Zaffarganj, km 6.1-8.1	WEL-NZK-PTSL (JV)	485.0	100	100	466.9	100	466.9	Financially Complete
W-09	Revetment: Padma at Harirampur, R1; km 6.7-10.2	M.M.Builders & Engineers Lt	311.9	100	100	309.0	100	309.0	Financially Complete
W-10	Revetment: Padma at Harirampur, R2; km 3.2-6.7	M.M.Builders & Engineers Lt	258.5	100	100	258.3	100	258.3	Financially Complete
W-11	Emergency/Adaptive 1: Riverbank Protection	M/S. Hassan & Brothers	67.01	100	100	62.7	100	63.9	Construction Complete
W-14	Piloting Work: Manikganj, Tangail, Sirajganj	JV Khondoker Shaheen Ahm	319.7	95	95	303.6	100	287.2	Construction Ongoing
W-15	Construction of Inspection Banglow: Manikgonj	MS Builders	7.0	95	95	5.5	100	6.3	Construction Ongoing
W-16	Piloting Work: Shahzadpur		123.2	15	15	0.0	100	0.0	Construction Ongoing
Component Totals			***3,664.9***			***3,265.5***		***3,423.9***	
Works Totals			***3,664.9***			***3,226.5***		***3,423.9***	
Project Totals			***7630***			***5431.5***		***6271.3***	

Table B4 ADB & GON Disbursement Details (until 31 December)

ADB Disbursements
ADB Loan Account

Appl. No	Date	US$	Rate	BDT
WL001	09/Dec/2014	3,682,433.00	77.85	286,677,409.05
Wl007	17/Dec/2015	11,069,711.01	78.70	871,186,256.49
BW006	15/Oct/2015		77.80	
BW008	20/Dec/2015	1,198,478.59	78.70	94,320,265.03
BW013	30/Jun/2016	3,889,762.94	78.40	304,957,414.50
BW011	02/Oct/2016	1,627,548.73	78.40	127,599,820.43
BW017	27/Nov/2016	3,567,316.77	78.65	280,569,463.96
BW018	04/May/2017	10,263.46	78.40	804,655.17
BW020	02/May/2017	6,561,484.21	78.84	517,302,907.94
BW023	22/Jun/2017	1,746,397.55	78.84	137,685,982.91
BW029	06/Nov/2017	4,715,885.93	80.51	379,675,976.22
BW030	22/Dec/2017	1,148,309.32	80.51	92,450,383.35
BW034	12/Sep/2018	1,708,882.48	80.85	138,163,148.51
BW037	05/Dec/2018	3,546,512.56	80.85	286,735,541.67
BW042	19/Feb/2019	510,691.02	78.22	39,946,120.74
		44,983,677.57		**3,558,075,345.97**

Grant Imprest Account

Appl. No	Date	US$	Rate	BDT
WG002	09/Dec/2014	1,189,354.00	77.85	92,591,208.90
WG007	17/Dec/2015	20,651.00	78.70	1,625,233.70
WG008	04/Oct/2016	319,995.00	78.40	25,087,608.00
ED002	24/Nov/2016	43,392.97	78.63	3,411,989.23
ED006	24/Nov/2016	341,134.29	78.63	26,823,389.22
ED007	04/May/2017	58,422.77	78.40	4,580,345.17
ED008	02/May/2017	349,549.87	78.84	27,532,857.98
ED011	22/Jun/2017	160,051.52	78.84	12,618,462.00
ED015	10/Nov/2017	435,718.95	80.66	35,145,342.16
ED016	22/Dec/2017	218,279.52	77.58	17,647,898.88
ED019	08/Aug/2018	163,006.74	80.85	13,179,094.93
ED021	10/Oct/2018	164,795.19	80.85	13,323,691.11
ED024	19/Dec/2018	656,219.52	80.85	54,511,119.84
ED027	24/May/2019	1,090,542.52	83.95	91,549,128.14
ED030	11/Sep/2019	805,534.72	84.35	67,950,398.37
ED031	18/Nov/2019	833,894.02	84.63	70,571,212.35
		6,850,542.60		**558,148,979.98**

Reimbursement

Dir.Pay			ADB & GoN	
Appl. No.	**Date**	**Category**	**US$**	**(BDT)**
BW002	22/Sep/2015	2	355,602	27,665,835
BW003	22/Sep/2015	2	460,513	35,827,904

BW009/BW010	23/Feb/2016	6A	204,145	15,836,549
BW012/ED003	20/Mar/2016	6A	302,979	23,503,567
BW014	23/Jun/2016	5	95,517	7,488,568
BW015/ED004	29/Jun/2016	6A	374,096	29,020,474
BW016/ED005	29/Jun/2016	6A	306,512	23,777,655
BW019	20/Jan/2017	5	19,044	1,503,562
BW021/ED009	10/Mar/2017	6A	410,184	31,819,987
BW022/ED010	06/Apr/2017	6A	689,643	53,499,087
BW024	06/Jun/2017	5	92,993	7,497,996
BW025/ED012	07/Jun/2017	6A	290,620	22,544,814
BW026/ED013	22/Jun/2017	6A	199,295	15,460,289
BW027/ED014	06/Jul/2017	6A	74,843	5,805,907
BW028	06/Jul/2017	5	94,000	7,520,000
BW031/ED017	12/Jan/2018	6A	110,259	8,553,380
BW032	01/Feb/2018	5	52,910	4,232,857
BW033/ED018	26/Mar/2018	6A	485,343	37,650,472
BW035/ED020	08/Jun/2018	6A	409,309	31,752,167
BW036	18/Jul/2018	5	37,601	3,083,316
BW038	12/Oct/2018	5	15,246	1,250,199
BW039	17/Oct/2018	5	35,231	2,888,974
BW040/ED022	14/Nov/2018	6A	408,413	41,682,606
BW041/ED023	21/Nov/2018	6A	495,613	38,447,167
BW043	04/Jan/2019	5	23,359	1,915,422
BW045/ED026	30/May/2019	6A	220,448	17,101,271
BW046	05/Jul/2019	5	23,405	1,977,697
BW047/ED028	30/Jun/2019	6A	415,025	32,190,946
BW048/ED029	18/Jul/2019	6A	109,534	8,497,116
BW044				
BW001 (LC)	30/Oct/2019	2	8,687,840	657,998,236
Capitalization			1,967,102	161,302,351
Subtotal			17,466,624	1,359,296,370

Total Disbursement	
Currency	**ADB & GON**
BDT Mil	5,338
US$ Mil	68.47

Total Disbursement is the sum of the ADB Loan and Grant Imprest Account deposits, plus the total ADB & GoN Reimbursement amount.

Appendix-C

Table C-1 Utilization of Consultant Person-Months

No.	Position	Firm	Name	Person-Months - updated for month of December - 2019									
				VO-3	VO-4	Jul '19	Aug'19	Sep'19	Oct'19	Nov'19	Dec'19	Used	Balance VO-4
	MAIN TEAM - INTERNATIONAL												
I-1	Team Leader / River Mangement Specialist	NHC	Knut Oberhagemann	34.50	38.50	0.58	0.32	0.89	0.53	0.83	0.40	36.38	2.12
I-2	Institutional Development Specialist/	EMM	Robert A. van de Putte	2.51	2.51							2.51	0.00
I-3	Morphologist	DELTARES	Erik Mosselman	5.00	5.00	0.03	0.01			0.07		4.90	0.10
I-4	River Engineer	NHC	Bruce Walsh	5.23	5.90		0.08					5.21	0.69
I-5	Construction / Quality Control Engineer	EMM	Basistha Adhikari	0.87	0.78							0.87	-0.09
I-6	Flood Risk Management Specialist	NHC	Dave Burkholder	11.05	11.30							11.30	0.00
I-7	Social Development / Resettlement Specialist	EMM	Jean Louis Leterme	11.00	11.25							10.52	0.73
I-8	Economist	NHC	John D. M. Roe	2.40	2.90							1.92	0.98
	CRVA (Climate Risk and Vulnerability Assessment)											0.45	-0.45

I-9	Financial Management Specialist	EMM	J. Spurr	0.00	0.00							0.00	0.00
I-10	Hydrologist	NHC	Derek Stuart	7.90	7.90	0.02	0.001				0.003	7.90	0.00
I-11	Environmental Specialist	EMM	Wandert Benthem	4.20	4.60			0.05				3.52	1.08
I-12	Information and Data Management Specialist	NHC	Dave Burkholder	8.50	9.00	0.01		0.02	0.02	0.04	0.02	8.06	0.94
I-13	Unallocated Engineering Services	NHC	TBN										0.00
I-13-1	Int'l Construction Advisor-Engineer	NHC	Graeme Vass	3.00	**3.00**							3.00	0.00
I-13-2	Junior Engineer	NHC	Jesper Mathiesen	**17.15**	**21.02**	0.83	0.67	0.23	0.30	0.53	0.17	19.83	1.19
	CRVA (Climate Risk and Vulnerability Assessment)											0.36	-0.36
I-13-3b	Geotextile Specialist (Unallocated)	NHC	Michael Heibaum	**0.65**	**0.65**							0.65	0.00
I-13-3	Numerical Modeller	NHC	Angela Thompson	10.20	**11.33**				0.60	1.00	0.03	11.33	0.00
I-13-4	Unallocated Engineering Services	NHC	Seth Bryant	4.00	**4.00**							3.95	0.05
I-13-5	Unallocated Engineering Services	NHC	TBN/Brecht D'Haeyer	2.50	**2.50**							2.55	-0.05

I-13-6	**Unallocated Engineering Services**	**NHC**	**Yannik Gunther**		**0.50**				0.07	0.83		0.90	-0.40
I-16	Geotechnical/ Construction Engineer	EMM	Hiba Khan	13.00	**17.00**	0.31	0.17	0.39	0.29	0.73	0.60	13.00	4.00
I-14	Senior Geotechnical Engineer	NHC	Dr. Horst Kramer	1.20	1.10							1.04	0.06
I-15	River Engineer	NHC	Brad Hall	6.40	6.48							6.48	0.00
I-17	Water Resouurces Specialist	NHC	Marieke Niewaal	0.00	0.00							0.00	0.00
I-13	Design and Specification Engineer	EMM	John Prytherch	4.00	4.50	0.14			0.05		0.01	3.09	1.41
I-18	Geotecnical Engineer	EMM	James Gelder		0.50							0.00	0.50
			Totals	**155.26**	**172.22**	**1.92**	**1.25**	**1.58**	**1.86**	**4.03**	**1.23**	**132.39**	**12.50**
	Main Team National												
N-1	DTL / Flood & Erosion Risk Management Spec.	EMM	Sharif Al Kamal	42.00	46.00	0.05	0.50	0.64	0.73	0.79	0.32	43.90	2.10
N-2	Institutional / Capacity Development Specialist	RPMC	Dr. M. A. Qassem	9.86	9.86							9.86	0.00
N-3	River Engineer (Morphologist)	CEGIS	Dr. Maminul Haque Sarker	7.00	7.00	0.04		0.03		0.03	0.14	7.00	0.00
N-4	Community-based Flood Risk Mngt. Spec.	RPMC	Quazi Towfique Islam	38.0	38.0	0.18						37.27	0.73

N-5	Resettlement Specialist	EMM	Shireen Akhter/ **Begum S. Nahar**	16.50	16.50							16.45	0.05
N-6	Project Economist	RPMC	Amiul Islam	10.00	11.50							9.14	2.36
N-7	Procurement Specialist	RPMC	A. Abdullah Chowdhury / **Md Abdullah Sadeque**	1.90	1.89							1.89	0.00
N-8	Construction Engineer	RPMC	Mirza Harunar Rashid	33.94	34.90							34.94	-0.04
N-9	Financial Management Specialist	EMM	Md. Habibur Rahman **/Ektedar Rahman**	10.50	12.50	0.05	0.05	0.27	0.09		0.23	10.71	1.79
N-10-1	River Engineer Flood Management Infr.- 1	RPMC	Mukhlesuz zaman	13.74	13.74							13.74	0.00
N-10-2	River Engineer Flood Management Infr. -2	RPMC	Md. Motiur Rahman	18.00	18.00							18.01	-0.01
N-11	Social Development and Gender Specialist	EMM	Ruh Afza Ruhi/**Begum S. Nahar**	9.5	11.0							9.36	1.64

N-12	Environment Specialist	RPMC	Dr. Md. Nurul Islam/**Md. Amir Faisal**	18.0	18.5					0.23		16.79	1.71
N-13	Training Coordinator	EMM	Jahangir Kabir/ **Shameem Ahmed**	19.3	19.3							19.29	0.01
N-14	Information and Data Management Specialist	EMM	Asrafuzzamen	0.00	0.00							0.00	0.00
N-15	Hydraulic Structural Engineer	RPMC	Md. Dabir Uddin/**Aminul Haque Shah**	3.00	3.02							3.02	0.00
N-16	Road Engineer	RPMC	Zakir Hossain	4.21	4.21							4.21	0.00
N-17	Geotechnical Engineer / **Geotecnical Expert (Local)**	EMM	Md. Korban Ali / **Md. Shamsul Islam**	8.50	8.50							8.08	0.42
N-18-1	Site Engineer 1 (PRB-1)	RPMC	Md. Nurul Amin	41.00	44.00	0.62		0.20				40.88	3.12
N-18-2	Site Engineer 2 (JLB-2 Chauhali)	RPMC	KM Nazmul Haque/ **Ekram Sarder/ Mainul Islam**	14.50	14.24							14.24	0.00
N-18-3	Site Engineer 3 (JLB-2 Zaffarganj)	EMM	Md Faridul Alam/Moin Uddin/ AZM	35.00	40.00							34.98	5.02

			Abdullah /Ziaul Alam										
N-18-4	Site Engineers 4 (PLB-1 Harirampur)	EMM	Abdul Jalil/**Saiful Islam**	8.04	8.04							8.04	0.00
N-19	Surveyor	EMM	Osman Ghani	14.00	14.00	0.49		0.32				13.07	0.93
N-20	Unallocated Engineering Services	RPMC	TBN Mukhlesuz zaman	1.50	1.50							1.00	0.50
N-21	Morphologist	CEGIS	Sudipta Kumar Hore	5.00	5.00	0.53	0.11	0.12	0.03	0.08	0.13	5.00	0.00
												0.00	
			Totals	**382.99**	**401.20**	**1.96**	**0.66**	**1.58**	**0.85**	**1.13**	**0.82**	**380.87**	**20.33**

Table C-1 Utilization of Consultant Person-Months continued ...

	RIVER STUDY TEAM - INTERNATIONAL												
IR-1	Task Leader / Flood & River Management Spec.	NHC	Carsten Stuab	10.98	10.98							10.98	0.00
IR-2	Institutional Development Specialist/**Capacity**	EMM	Robert A. van de Putte	0.50	0.50							0.50	0.00

	Development Specialist.												
IR-3	Morphologist	DELTARES	Sanjay Giri	6.50	6.50							6.17	0.33
IR-4	River Engineer (River Training)	NHC	Gerritt Klaassen	10.50	10.60							10.33	0.27
IR-5	Water Resources Management Specialist	DELTARES	W. J. Oliemans	2.80	2.95							2.76	0.19
IR-6	Economist	EMM	Alexander Mueller/ **John D.M. Roe**	2.30	2.47							2.47	0.00
	CRVA (Climate Risk and Vulnerability Assessment)											0.00	0.00
IR-7	Social / Regional Development Specialist	NHC	Mark Hopkins	6.37	6.37							6.15	0.22
IR-8	Environmental Specialist	EMM	Wandert Bentheim	4.00	4.10							4.01	0.09
IR-9	Hydrologist	NHC	Malcolm Leytham	3.80	3.65							2.92	0.73
	CRVA (Climate Risk and Vulnerability Assessment)											0.73	-0.73
IR-10	Climate Change Specialist	NHC	Mariza Costa-Cabral	2.05	2.05							1.98	0.07
	CRVA (Climate Risk and Vulnerability Assessment)											0.07	-0.07
IR-11	Dredging Specialist	NHC	Pieter Van Groen	2.11	2.11							2.11	0.00

IR-12	Urban & Master Planner	NHC	Dr. Douglas Webster	3.20	2.90							2.82	0.08
IR-13	Morphologist Modeller	DRS	Mohammed Yossef	1.40	1.40	0.01						1.38	0.02
IR-1	Sedimentologist	NHC	Dan Haught	1.40	1.42							1.42	0.00
IR-2	Geomorphologist	NHC	Andrew Nelson	1.50	1.75		0.003					1.64	0.11
IR-3	Community Development / Flood Management Specialist	EMM	Judith de Bruijne	0.18	0.18							0.18	0.00
IR-4	Report Editor	NHC	Dr.Sara Bennett,	2.00	2.00							0.53	1.47
IR-5	Report Publisher	NHC	Sabrina Asche	5.00	7.00	0.18	0.23	0.36	0.18		0.18	6.14	0.86
			Totals	**66.59**	**68.93**	**0.19**	**0.23**	**0.36**	**0.18**	**0.00**	**0.18**	**65.30**	**3.63**
			Grand Total International	**221.9**	**241.2**	**2.11**	**1.48**	**1.94**	**2.04**	**4.03**	**1.41**	**197.68**	**16.13**
	RIVER STUDY TEAM - NATIONAL												
NR-1	Water Resources Management Specialist	RPMC	G M Akram Hossain	9.92	9.92							9.92	0.00
NR-2	Flood Management Specialist	RPMC	Md. Makbul Hossain	7.51	7.55							7.55	0.00
NR-3	River Engineer (Morphologist)	CEGIS	Dr. Maminul Haque Sarker	4.00	4.00	0.06		0.11			0.03	4.00	0.00

NR-4	Economist	EMM	Dr. Shaker Ahmed	0.03	0.01							0.00	0.01
NR-5	Regional / Spatial Planner	RPMC	Dr. Shamim M Haque	3.37	3.37							3.37	0.00
NR-6	Institutional Development Specialist	RPMC	Dr. M. A. Qassem	3.94	3.94							3.94	0.00
NR-7	River Engineer	RPMC	Md. Motiur Rahman Jewel	11.7	11.7							11.70	0.00
NR-8	Hydrologist	EMM	Imdadul Haque Siddiqui	0.00	0.00							0.00	0.00
NR-9	Social Development and Gender Specialist	EMM	Ruh Afza Ruhi/**Begum S. Nahar**	4.00	4.00							3.99	0.01
NR-10	Environment / Climate Change Specialist	EMM	Md. Rakibul Haque/**Amir Faisal**	2.50	2.50							2.49	0.01
NR-11	Water Supply and Water Quality Specialist	EMM	Md. Mozammel Hossain/ **Dr. Khairul Bashar**	3.63	3.63							3.63	0.00
NR-12	Agriculture Specialist	RPMC	Dr Quazi Reasul Islam	3.34	3.34							3.34	0.00
NR-13	Fishery Specialist	RPMC	Dr. Md. S. Howlader	6.00	9.00			0.73	0.45	0.82		8.00	1.00

NR-14	Environmental Avisor	EMM	Dr. Alnun Nishat	0.50	0.30							0.18	0.12
												0.00	
			Totals	**60.44**	**63.26**	**0.06**	**-**	**0.84**	**0.45**	**0.82**	**0.03**	**62.12**	**1.14**
			Grand Total National	**443.43**	**464.46**	**2.0**	**0.7**	**2.4**	**1.3**	**2.0**	**0.9**	**351.88**	**21.47**

Appendix-D

Table D-1 Status of River Study Technical Notes

New Number	Title	Main Author(s)	Review/Approval	A Background information & Morphology	B Morphology - General	C Morphology - Bifurcations & Offtakes	D River Engineering	E Flood Risk Management	F River Stabilization Impacts	G Water Resources Management	H Land Use & Economic Benefits	Status
A1	Strategic Framework for River Stabilization & Development	DW	KO	x								Formating completed.
A2	Preliminary Regional Master Plan for the North-Central Zone	DW	KO	x								Formating completed.
A3	Strategic-Environmental and Social Assessement of River	WB	NCEA	x								In late-Dec, NCEA agreed to review report.
A4	Inland Navigation and Dredging	HK	KO	x								Formating completed.
B1	Holistic river morphology analysis for the Brahmaputra river system	MHS	CS/EM		x							Formating completed.
B2	Long term view of Brahmaputra/Jamuna channel planform	AN	EM		x							Formating completed.
B3	Cross-Section Analysis on Brahmaputra, Jamuna and Padma Rivers	MRJ	GJK		x							Formating completed.
B4	Char characteristics and dynamics – past and present conditions on basis of satellite imagery	MHS	GJK		x							Formating completed.
B5	Upper Meghna - present conditions and issues	JAA/MHS	CS		x							Formating completed.
C1	River bifurcations: Theory and model experience	EM	KO			x						Formating completed.
C2	Anabranching Channels of the Jamuna and Padma Rivers	MHS	CS			x						Formating completed.
C3	River bifurcations: Simplified numerical modelling	AT	SG/GJK			x						Formating completed.
C4	Reach 3 and bifurcation: numerical modelling	AT/SG	EM			x						Formating completed.

C5	Offtake and Flow Dynamics of the Major Rivers	MHS	CS			x						Formating completed.
C6	Offtakes part 2 Numerical model studies and generic guidelines	MY	EM			x						Formating completed.
D1	River Stabilization Plan -Technical Basis	GJK	KO				x					Review completion by end-Feb-2020.
D2	River stabilization of other main rivers	GJK/ BH/ EM	BH/GJ K				x					Review completion by end-Feb-2020.
D3	Earlier proposals and attempts for stabilization of Jamuna River (include capital dredging)	MZ/ BW/ JM	KO				x					Review completion by end-Feb-2020.
D4	Intermediate and final planform alternatives	MRJ /GJK	KO				x					Updated draft expected by end-Jan-2020.
D5	Feasible techniques and methods for riverbank protection and future channel narrowing	AN	BH				x					Revised Appendix Completed; 14-Feb-2019.
D6	Underwater Apron for Chandpur Confluence	MRJ /AT	SG				x					Completed
E1	Main river flood risk and management	Mho /DS	DS					x				Formating completed.
E2	Flooding numerical modelling	DS	BH					x				Formating completed.
F1	Long-term effects of river narrowing on water levels	EM	KO						x			Formating completed.
F2	Effects of sinuosity on channels and bars	MY	EM						x			Formating completed.
F3	River stabilization and Sediment Management	GJK	BH						x			Completed Sep-2019.
F4	Char Stabilization Impact Modelling	SB/G JK	EM						x			Formating completed.
F5	Impact of Earthquake Induced Sediment Supply Variability	EM/ AN	GJK/B H						x			Formating completed.
F6	Future conditions affecting flows	MCC	ML						x			Formating completed.
G1	Distributaries: Water resources preparation and baseline	WO/ ML	ML							x		Formating completed.
G2	Potential Impacts of Flow Augmentation and Study Needs	WO/ ML	EM							x		Formating completed.
H1	Socio-economic Aspects	MH/ SN	JLL						x			Formating completed.
H2	Environmental and social aspects of river stabilization: Remedial measures	WB/ MH	CS						x			Formating completed.
H3	Fisheries Impacts of FRERMIP and their	SH	CS/W B						x			Formating completed.

	Management: A Pre-project Status Review											
H4	Planning the Use of Stabilized and Reclaimed Land, Procedure and Issues	MH	CS								x	Completed
H5	Charland amelioration and agriculture development	QRI/ AC	AC								x	Completed; 10-June-2018
H6	Economic Assessment of River Stabilization	JR/A I	KO								x	Updated draft expected by end-Jan-2020.

Abbreviations:

AC = Alan Clark
AF = Amir Faisal
AI = Aminul Islam
AN = Andrew Nelson
AT = Angela Thompson
BH = Brad Hall
BW = Bruce Walsh
CS = Carsten Staub
NCEA = Netherlands Commission for Economic Assessment
DS = Derek Stuart
DW = Doug Webster
EM = Erik Mosselman
GJK = Gerrit Klaassen
HK = Hiba Khan
JAA = Jakia Akter
JLL = Jean Louis Leterme
JM = Jesper Mathiesen
JR = John Roe
KO = Knut Oberhagemann
MCC = Mariza Costa-Cabral
MH = Mark Hopkins
MHo = Makbul Hossain
MHS = Mamin H. Sarker
ML = Malcolm Leytham
MRJ = Motiur Rahman Jewel
MY = Mohamed Yossef
MZ = Mukhles uz Zaman
QRI = Qazi Reasul Islam
SB = Seth Bryant
SG = Sanjay Giri
SH = Shajahan Howlader
SN = Shamsun Nahar
WB = Wandert Bernthem
WO = William Oliemans

	Reports
0	**Annex Submitted**
0	**Formatting Reviewed**
26	**Formatted**
5	**Technically Complete**
6	**Draft Complete**
0	**Under Preparation**
#REF!	**Total**

Appendix-E

Table E 1 ISMPC performance compliance with TOR

Tasks by ToR	Tasks Done	Current Tasks	Future Tasks
Task-1: Supporting BWDB for institutional capacity strengthening of the holistic and strategic management of the main rivers	1 Inception Report, 16 Quarterly Progress Reports, 1 Mid-term Review Report, have been submitted.	The Quarterly Progress Report-18 for October-December 2019 quarter is under prepration	The Quarterly Progress Report-19 will be submitted as scheduled.
Task-2: Supporting BWDB and DDM for project implementation management of Tranche-1	1. Institutional capacity strengthening: From DPP Budget 12 Trainings and tours done.	1. Institutional capacity strengthening: From DPP Budget, 6 of 7 local trainings and 6 of 9 overseas trainings have been implemented.	1. Institutional capacity strengthening: From DPP Budget, 1 more local and 3 overseas trainings will be implemented in fiscal year 19/20.
	2. Data and knowledge base development for flood and river management: basic river survey database, project maintenance database, resettlement and socio- economic survey database for Tranche-2 Feasibility studies have been built.	2. Data and knowledge base development for flood and river management: the river survey database is being populated and prepared for hand- over to BWDB. One BWDB official has been trained on database over a number of weeks to ensure more effictive handover. The project monitoring database is currently being used by the ISPMC to generate quarterly progress reports and assist the PMO.	2. Data and knowledge base development for flood and river management: river survey database will be fully populated and handed over to the BWDB.

	3. Support BWDB for supervising physical works: Supervising for Riverbank protection works at three sites since October 2015. The ISPMC submitted 6 construction completion report.	3. The supervising of embankment construction works is currently ongoing.	ISPMC will finish supervising the embankment construction works and the river training pilot works and will submit construction completion reports accordingly.
	4. Support DDM for implementing Community-based Flood Risk Management: Implementation NGO has been contracted in August 2018 with the help of ISPMC expert	4. The INGO has finished implementing their contract assigned.	The ISPMC will evaluate the final report
Task-3: Supporting BWDB for preparation of Tranche-2, including verification of site selections, feasibility studies, preparation of loan approval documents meeting requirements for the government and ADB.	1. Site Selection Report submitted in May 2017	Final Feasibility Report is approved. ADB evaluation of safeguard documents ongoing.	Updated EIA will be submitted based on comments followed by the Department of Environment approval of the Environmental Impact Assessment (EIA) and approval of the DPP through ECNEC.
	2. Technical and social field surveys completed in December 2017		
	3. Basic Structural design complete in March 2018		
	4. Design of non-structural activities completed in March 2018		
	5. Safeguard, gender and poverty assessment completed in March 2018		
	6. Project economic assessment		

	was updated with the final feasibility report in March 2019.		
Task-4: A long-term strategic river stabilization plan study for the Jamuna, Padma and Lower Meghna rivers covering from the Indian border to the estuary (by the river study task team)	Strategic framework on long-term river stabilization plan was presented in a workshop on December 2016. It was submitted on May 2017 and recommended to the Technical Advisory Committee on September 2017.	4 main reports are being finalized.	4 main reports with necessary annexes will be submitted
Task-5: A preliminary master plan study for river management of the Jamuna- Padma-Lower Meghna.	Draft regional plan has been submitted in September 2018 (part of Task-4)	Final regional master plan is under preparation.	Final regional master plan to be submitted
Task-6: Development, implementation support, and monitoring of land recovery/river training piloting schemes, including piloting using building with nature concept (by the river study task team)	ISPMC has assisted PMO, BWDB on preparing technical specifications and bid documents for implementing grout-filled jute mattress as riverbank protection works as a part of river training piloting schemes for first contract. The work package on pilot works has started in March 2019.	The contractor has completed Harirampur and Shahjadpur (W14) grout filled jute mattress construction except roughly 200m left due to the embankment not being complete at this site. The second pilot works contract (W16) for a further 1.3 km of jute mattress is in progress.	Some design modifications for the additional 1.3km of grout mattress may be proposed following site visits to the damaged areas once the flood waters recede. No land recovery could be implemented under W14 due to local government objections
Task-7: Hydraulic and morphological analyses for the Jamuna-Meghna and Jamuna-Padma-Ganges confluences (by the river study task team)	Strategic framework on long-term river stabilization plan was presented in workshop on December 2016. It was submitted on May 2017 and recommended by the Technical Advisory Committee on September 2017.	4 main reports are being finalized.	4 main reports with necessary annexes will be submitted in December 2019.

Appendix-F

Revised Gender Action Plan

Quarterly Progress Report on Revised Gender Action Plan (GAP) Implementation Monitoring

Flood and Riverbank Erosion Risk Management Investment Program (Tranche-1)

Project Title : Flood and Riverbank Erosion Risk Management Investment Program (Tranche-1)

Date of Update : 01/01/2020 **Submission Date:** 06/01/2020 -

Agency : Bangladesh Water Development Board (BWDB)

Timeframe : April 2014 to June 2020

Gender Category : EGM

Project Impact (from PAM) : The expected impact of the investment program will be improved livelihoods of people in the project area along the main rivers of Bangladesh.

Project Outcome (from DPP log frame) : The outcome of the program will be reduced flood and riverbank erosion risks in the Subproject reaches

Whether there is a Gender Action Plan : Yes

Is there a Gender Specialist : A Gender Specialist worked (intermittent basis) in Institutional Strengthening and Project Management Consultant (ISPMC). Presently the Gender specialist has utilized all her man-months. An Executive Engineer of PMO is appointed as Gender Focal Point. He is working for GAP implementation till date.

If not, how gender mainstreaming is supported ? N/A

Output/Activities	Indicators and Targets	Progress in this Quarter (01 Oct 2019 – 31 Dec 2019)	Cumulative Progress (up to 31 Dec 2019)	Remarks/Comments
Output I: Flood and Riverbank Erosion Risk Mitigation Functioning at Priority Reaches				
A1 Construction of riverbank protection structures using appropriate technology and methods A1-2 Rehabilitation/construction of embankments				
- Ensure women benefit from employment in construction - Ensure gender-related aspect of labor standard including equal wage for women and men for equal work - Ensure occupational health and safety, safe water supply, sanitation is in place (incl. separate toilets)	1. Specific condition included contractors' bidding document whereby 5% unskilled labor opportunities be given to women.	No significant construction activities this quarter	A total of 2469 female labours (8% of total) out of total 28687 labour worked in construction sites till date.	All the ongoing contract packages W-01 to 05 , W-14 and W-16 work packages are revised and as per revised contract agreement Contractors are now appointing min 5 % females as unskilled labors.
	2. Orientation sessions targeting 45 SMO staffs (at least one orientation in each SMO) i.e. SDE, Section Officers, surveyors and contractors' site manager, site engineer and supervisors to verify and ensure that conditions are met	-	One training session covering three courses on "Gender Awareness Training for SMO's engineers and contractor's staff" for work package W-04 and W-05 was held on 21 December 2018 at XEN office, Koitola. Three courses on "Orientation session to verify and ensure that Core Labor Standard conditions are met for SMOs Engineers and Contractors Staff" have been held at the Koitola work site for work packages W-01, W-02 & W-03 on 22 December 2018 at XEN office, Koitola. During these sessions 1 XEN, 1 SDE, 2 Section Officers, 5 site managers, 5 site supervisors, 3 site engineers of Koitola SMO were present. Out of total 78	There are 3 SMOs under the project. But presently work site is running only at Koitola SMO. The training sessions held for Contract Packages No. W-01 to 05 under Koitola SMO.

Output/Activities	Indicators and Targets	Progress in this Quarter (01 Oct 2019 – 31 Dec 2019)	Cumulative Progress (up to 31 Dec 2019)	Remarks/Comments
			participants 6 were female.	
	3. Provisions for either separate toilets for women or arrangements for use of facilities in nearby communities and/or households	In 7 places of 7 contract packages separate toilet for women built at running work sites.	7 Separate toilets for women in 7 Contract Packages (W-01 to 05 & W-14,W-16) along with arrangements for use of facilities in nearby communities and/or household have been provided till date at running work sites.	-
	4. Sex-disaggregated information in field monitoring quarterly reports and contractors' compliance reports	Sex-disaggregated data collection is on-going till this quarter.	Sex-disaggregated data collection is on-going till date.	-
A2 Formulating Community Disaster Management Units				
- Form 40 Community Disaster Management Units (CDMUs) - Develop a community flood risk assessment and community risk reduction plan	5. CDMUs (40) -consisting of 15 male and female volunteers/each-established with minimum 33% units led by women (baseline=0).	-	Out of 40 CDMUs, 39 CDMUs consist of total 15 volunteers which include both male and female members and the rest 01 CDMU consists of 20 volunteers. Out of total 605 volunteers, females are 244 (40.33%) nos. 100% CDMUs are led by women as Leader/Deputy Leader.	CbFRM component implementation started from 1 September 2018 and completed on 30 June 2019.
	6. ***Community Flood Risk Assessment*** prepared identifying: (i) risks for women, men, children and vulnerable groups; and (ii) disaster response mechanism	-	40 Community Risk Assessments were conducted in 40 identified CDMUs, identifying: (i) risks for vulnerable groups i.e. women, children, elderly, disabled and other, and (ii) disaster response mechanism related to flood and	***Community Flood Risk Assessment*** were introduced in ***Community based Disaster Preparedness Plan (CDPP)*** at page 2.

Output/Activities	Indicators and Targets	Progress in this Quarter (01 Oct 2019 – 31 Dec 2019)	Cumulative Progress (up to 31 Dec 2019)	Remarks/Comments
	related to flood and erosion warning;		early erosion/disaster warning.	
	7. ***Community Risk Reduction Plan*** 20 plans prepared for 40 Units through participation of women volunteers specifying roles, provisions for women and men in terms of disaster preparedness at HH and community level; (iii) risk reduction measures	-	40 plans were prepared in 40 CDMUs through participation of male and female volunteers, specifying roles, provisions for women and men in terms of disaster preparedness at HH and community level. In each of these planning processes, 30-35 community people participated among which at least 27 were female (90%) and they participated as representative from their household/family. iii) the risk reduction measures included but not limited to: - Dissemination of flood early warning in local context using local reference points - Raising awareness among vulnerable communities - Installation of flood markers - Linkage between relevant govt. officials and vulnerable community - Raising household plinth, tube-wells and latrines	***Community Risk Reduction Plan*** was named as ***Community based Disaster Preparedness Plan (CDPP)*** in the ToR of signed Contract with DDM.

Output/Activities	Indicators and Targets	Progress in this Quarter (01 Oct 2019 – 31 Dec 2019)	Cumulative Progress (up to 31 Dec 2019)	Remarks/Comments
			- Storing dry foods, medicine and fuel Assisting flood affected people to evacuate in flood shelters, particularly women, children, elderly and people with disabilities	
	8. 60 locations identified and build community flood markers for flood warning information	-	114 densely populated locations were identified in the vicinity of the rivers and canals. In these identified locations, a total of 114 flood marker posts were installed which are easily identifiable by men, women and children as flood warning information.	-
A3 Formulating Community Disaster Management Units				
- Initiate community-based flood warning dissemination procedures building on indigenous techniques - Disseminate regular warning messages in relevant to local context/language in line with national warning	9. 50% of the units have flood warning mechanisms [Source: end-line beneficiary survey]	-	Trained 604 male and female volunteers from 40 CDMUs to follow flood warning procedure and disseminate warnings by- i. using local language; ii. using mosque mikes; iii. using megaphone from local Union Parishad; iv. using local reference point to explain danger level Introduced flood-warning mechanisms to the community people through 100% units, which are yet to be tested during flood cycle between July to August 2019 or next.	National warning may not reach communities as the warning are not relevant to the local contexts. ***End-line Beneficiary Survey*** was not conducted as it was not included in the ToR of the Contract Agreement signed with DDM.

Output/Activities	Indicators and Targets	Progress in this Quarter (01 Oct 2019 – 31 Dec 2019)	Cumulative Progress (up to 31 Dec 2019)	Remarks/Comments
network	10.20 knowledge events held [Target: 100 women]	-	A total of 7,260 knowledge events i.e. courtyard sessions were conducted by all 605 female and male volunteers to share knowledge and practices on flood warning mechanism in local context. Representatives from 60,000 beneficiary households participated while almost 45,000 (=>75%) women were present.	-
	11.50% of households, including low-income households, and poor women living on the embankment participate have increased resilience through preventive measures at household level [Source: end-line beneficiary survey].	-	100% of the 60,000 identified beneficiary households, including low-income households, and poor women living on the embankment participate have increased resilience through preventive measures at household level.	***End-line Beneficiary Survey*** was not conducted as it was not included in the ToR of the Contract Agreement signed with DDM.
A4 Construction of Resettlement Areas with Basic Infrastructure and Facilities				
- Ensure effective consultation with women in the affected areas and maintain sex disaggregated data on Project Affected Persons (PAPs) along with	12.Full compensation for 100% women PAPs as per RP entitlement	- Total 41 EPs received CCL through DC office. Among them 2 are women (100% women Eps paid).	Total 2336 out of 2720 Aps received resettlement grant/benefit and replacement cost. Among them 211 are women (100% women PAPs paid). Total 3657 out of 4256 EPS received CCL through DC Office. Among them 104 are women	-

Output/Activities	Indicators and Targets	Progress in this Quarter (01 Oct 2019 – 31 Dec 2019)	Cumulative Progress (up to 31 Dec 2019)	Remarks/Comments
entitlement benefits, as per Resettlement Plan (RP) - Ensure that gender issues are considered when planning resettlement villages and community facilities			(100% women Eps paid).	
	13.33% women involved in planning meetings	-	Total 324 planning meetings were held till date where more than 16200 persons attended and out of which female are more than 9072 nos (=>56%).	Gender Issues were considered while forming resettlement villages and communities.
Output II: Strengthened Institutional Systems for Flood and Riverbank Erosion Risk Management				
A5 Capacity Enhancement of BWDB				
- Integrate a gender-specific module in the BWDB training - Build capacity of female staff in BWDB	14.10% women in training programs	A gender specific module has been kept and is under implementation in the BWDB training programs.	40 % women (16 out of 40) have participated in the Gender specific training held in March 2019.	-
	15.- Provide 3 training (1 in BWDB HQ, 1 in design office and 1 in 3 SMOs) to at least 60 women staff in BWDB on working as women in BWDB – Challenges and issues		Total 5 training program held. Total 132 participants attended out of which 57 participants were female (43.18%) On 16 April 2019, "Updation of specifications of geotextile' training was held where 13 female engineers from BWDB design wing out of 40 participants were participated.	-In November 2018, "training/ orientation session for SMOs" was held where all staff of site offices attended. Out of 14 participants 2 (14.29%) were female. -In June 2017, 1 (one) Gender specific course has been held for building capacity of female staff in BWDB HQ. Out of 32 participants, 25 (78.13%) were female. The main discussions were Importance of gender in

Output/Activities	Indicators and Targets	Progress in this Quarter (01 Oct 2019 – 31 Dec 2019)	Cumulative Progress (up to 31 Dec 2019)	Remarks/Comments
				water management project and concept of gender with government's commitment. ADB's Gender Specialist attended as resource person in this workshop. -In October 2017, "Training for River Survey Database" was held, where 1 participant was female out of 6 (16.67%). -In March 2019, one gender specific training was held in Design Office, BWDB. In total of 40 participants including 16 (40%) females attended - On 16 April 2019, "Updation of specifications of geotextile' training was held where 13 (32.50%) female engineers from BWDB design wing out of 40 participated.
Output III: Program Management Systems Operational				
A6: Implementation Management				
- Establish MIS system with sex disaggregated data base for project reporting	16. - Identify gender indicators, incorporate in monitoring system and ensure regular reporting of progress of GAP implementation	Regular reporting of progress of GAP implementation identifying gender indicators are in progress. Sex disaggregated data being used till Quarterly Project Progress Report No. 18 (October-December 2019).	Regular reporting of progress of GAP implementation identifying gender indicators and incorporating in regular monitoring system are being done regularly till date.	Establishment of MIS system was dropped during the 1st revision of project DPP.

Appendix-G

Table G 1 Compliance status with Loan and Grant Agreement Covenants

Sl.No.	Covenant Description	Comply[2]	Evidence to Support Claim
Implementation Arrangements			
1	Project is implemented in accordance FAM.	Yes	All Environmental, Social and Financial provisions outlined in the FAM are being satisfactorily implemented.
2	PMO, SMOs and PMU shall employ sufficient and experienced staff.	No No	• BWDB: on average, the PMO has only 55% of Senior Staff as specified in DPP. • DDM: PMU only has only 2 staff, and the Project Manager is on additional charges.
3	PMO, SMOs and PMU staff shall remain for a reasonable period of time.	Yes No	• BWDB: PD stayed for over 4 years. new PD has been in role for more than two years • DDM: had 3 Project Managers in 2.5 years
4	The PMO PD shall have a rank not less than a Superintending Engineer.	Yes	PMO both PDs had rank of Superintending Engineer.
5	BWDB shall establish a CE River Management office responsible for flood and riverbank erosion risk management.	Yes	On 22-Nov-2017, BWDB established the office of CE River Management, and appointed a Chief Engineer.
Counterpart Support			
6	If Borrower cannot avail of the proceeds of the Grant, the Borrower shall find an alternative source of funding.	Yes	No problem has occurred in availing Grant money.
7	The Borrower shall reimburse BWDB for any taxes and duties imposed for Goods, Works and Consulting Services.	Yes	Typically, taxes and duties are being reimbursed by the Borrower as per their portion of each Loan Category.
Selection of Subproject areas			
8	BWDB shall ensure that Subprojects are selected in accordance with FFA Schedule 4.	Yes	All 3 selected Subprojects are included in the approved Project-1 Feasibility Study completed in Dec-2013.
Environment			
9	Project facilities comply with environmental safeguards, laws and regulations, EARF, EIA/EMP, and reported upon in Monitoring Reports.	Yes	EIA approved, EMP being implemented, SESA drafted, and Quarterly and Semi-Annual Monitoring Reports submitted. These reports document satisfactory compliance with environmental safeguards.
Land Acquisition and Involuntary Resettlement			

10	BWDB shall ensure that all land and all rights-of-way are available to contractors in a timely manner.	No	Contractors' work have not been delayed due to land acquisition issues for riverbank protection Delays are ongoing for embankment works and land for regulator channels has not yet been aquired
	(a,b,c&d) Land acquisition and resettlement comply with applicable laws, Involuntary Resettlement Safeguards, RF, and RP.	No Yes	Riverbank Protection: land acquisition done after construction, due to severe erosion potential and local public demand. A Corrective Action Plan is currently being implemented. Embankment: land acquisition and resettlement processes have been properly followed.
11	BWDB shall ensure that there is no physical or economic displacement until:		
	(a) compensation and other entitlements have been provided to affected people	Yes	• Refer to Sl.No. 10 above. However, compensation process is now actively ongoing for embankment.
	(b) a comprehensive income and livelihood restoration program has been established	No	• Not yet started. ToR for Livelihood Support Study sent to ADB for concurrence in May 2016.
Indigenous Peoples			
12	BWDB shall ensure that the Project does not have any indigenous peoples' impacts.	Yes	No indigenous people affected by project.
Human and Financial Resources to Implement Safeguards Requirements			
13	BWDB shall fully implement the EMPs and the RPs.	Yes	EMPs included in all Civil Work contracts, and an INGO is actively engaged to develop all RPs. Monitoring results are regularly being reported.
Safeguards			
14	BWDB shall ensure that all Works contracts require contractors to:		
	(a) comply with EIA, EMP and RP; and Safeguards Monitoring Report actions	Yes	Covered in 'Technical Specifications' under Section 2. Environmental Management Plan and Safety at the Site.
	(b) include a budget for environmental and social measures	Yes	Included in Bill of Quantities, Bill No. 02: Environmental Management Works.
	(c) provide written notice of unanticipated environmental, resettlement or indigenous peoples' risks	No	No special clause found to provide written notice of unanticipated environmental, resettlement or indigenous peoples' risks. Clause to be added to all 5 pending embankment contracts.

	(d) adequately record pre-Work condition of roads, agricultural land and infrastructure	No	No special clause found requiring contractors to record pre-work condition in riverbank protection contracts. Embankment contracts contain clause 2.2.2 in the technical specifications requiring access roads to be inspected for appropriateness before use. There is no mention of agricultural land or infrastructure.
	(e) fully reinstate pathways, other local infrastructure, and agricultural land pre-Work condition	Yes	Adequately covered in Section 2. 'Environmental Management Plan and Safety at the Site' of the Technical Specifications.
Safeguards Monitoring and Reporting			
15	BWDB shall:		
	(a) submit semi-annual Safeguards Monitoring Reports to ADB	Yes	ISPMC submit Monitoring Reports on quarterly and bi-annual basis on environmental and social issues.
	(b) promptly document any unanticipated environmental and social risks and impacts	Yes Yes	Environmental: No serious unanticipated risks or impacts have occurred. Social: Resettlement Issues documented in QPR.
	(c) within 6 months, engage external experts to verify information regarding land acquisition and involuntary resettlement	No	The bid document has been received and evaluated, short-listing completed, and negotiations are ongoing for External Expert. Contract award is expected by early Feb-2018.
	(d) promptly report any breach of compliance with EMP or RP	Yes Yes	Environment: Non-compliances reports are submitted by ISPMC. A joint ISPMC/ PMO inspection took place in July 2019 Social: Resettlement Issues documented in QPR.
Prohibited List of Investments			
16	BWDB shall ensure that Loan or Grant funds are not used for prohibited investment activities.	Yes	Accounting procedures are being rigorously maintained by PMO and no evidence of misuse has been found.
Labour Standards			
17	All civil works contracts require contractors to:		
	(a) comply with labour standards, labor laws and applicable health and safety principles	Yes	Covered in 'Conditions of Contracts for Construction', under Section: 6. Staff and Labour.
	(b) eliminate discrimination between men and women for work of equal value	Yes	Adequately covered in 'Conditions of Contracts for Construction', under clause: 6.24 NonDiscrimination and Equal Opportunity.

	(c) eliminate child labour, and forced or compulsory labour; and allow freedom of association	Yes	Covered in 'Conditions of Contracts for Construction', under clause: 6.21 Child Labour.
	(d) maximize employment of local poor and disadvantaged persons	No	No special clause found to employ local poor and disadvantaged person.
	(e) disseminate information on sexually transmittable infections and HIV/AIDS	Yes	Covered in 'Conditions of Contracts for Construction', under clause: 6.7 'Health and Safety'.
	(f) implement applicable provisions of GAP	Yes	No special clause found related to provisions of GAP in the contract documents. Requirements e.g. for a minimum % of women labourers were followed by the embankment contractors
Gender and Development			
18	BWDB shall implement the GAP, and monitor and report on key gender outcome and output targets.	Yes	GAP outcomes and outputs are being documented in QPR.
Quality Assurance			
19	Engage external experts to inspect and store results of completed riverbank protection works using accurate surveying equipment.	Yes	ISPMC performs a rigorous and regular Flood Monitoring Program including Multi-Beam EchoSounder surveys which are currently ongoing under package W16. Scuba diving investigations were also conducted for riverbank protection.
Panel of Experts			
20	BWDB shall engage experts to analyze project implementation constraints, and advise on remedial measures.	Yes	There has been four Technical Advisory Committee (TAC) Meetings to review Project technical issues and make recommendations. A Technical Committee was also formed by BWDB to investigate slope failures at Chauhali.
Inter-agency Coordination			
21	BWDB shall timely notify all relevant agencies of their riverbank protection works.	Yes	ISPMC has one Specialist permanently deputed to DDM, who updates PM PMU on project activities.
Operation and Maintenance of Project Facilities			
22	Ensure that:		
	(a) BWDB inspect and maintains all Works rehabilitated according to O&M plans	Yes	ISPMC performs a rigorous Flood Monitoring Program to identify status of Riverbank Protection Works.

	(b) BWDB submits annual budgets to MoWR for O&M works according to the plans	Yes	Provisional 2017/18 ADP funding for Adaptive Protection and Emergency work is BDT 89 million; other funding also available.
	(c) Borrower allocates adequate resources for BWDB to carry out O&M works	Yes	Funding for 2017/18 Emergency/Adaptive work is expected to be around BDT 160 million. Koitola riverbank protection transferred to O&M Division in Dec-2017.
23	BWDB shall maintain adequate stockpiles of geo-textile bags for emergency riverbank protection works and repairs.	No	Geobag stockpiles are present at Tangail however there are no stockpiles remaining at Bera or Manikganj
24	BWDB shall provide local communities with land use rights for embankment to promote livestock grazing and tree cultivation.	No	Construction work of embankments not yet started. However, Social Forestry is mentioned in the CbFRM Support Services INGO Contract.
Road Map and Policy and Institutional Reforms			
25	BWDB shall implement timely institutional reform actions identified under Investment Program policy framework.	Yes	Refer to Sl.No. 5 reply regarding the establishment of CE River Management office.
Policy Dialogue and Coordination with Development Partners			
26	BWDB shall keep ADB informed of discussions with government and quasi-government bodies responsible for water sector development.	Yes	This is being done through periodic ADB Missions, and regular discussions and correspondence between PMO and ADB BRM.
Governance and Corruption			
27	BWDB shall comply with ADB's Anticorruption Policy and cooperate with any investigations.	Yes	No evidence of corruption in dealing with any project activities have been reported or found.
28	BWDB shall include anticorruption provisions in contracts, allowing ADB to audit records of contractors, suppliers, and consultants.	Yes	Covered in the 'Conditions of Contracts for Construction' Section, under clause: 15.6 Corrupt and Fraudulent Practices.
29	BWDB shall announce all business opportunities on their websites, including participating bidders, winning bidders and contract award amounts.	Yes	Adequate contract information is available on: www.bwdb.gov.bd/index.php/site/live_tender
30	Borrower shall periodically inspect financial activities related to the procurement of Goods, Works and Consulting Services.	Yes	Foreign Aided Project Audit Directorate (FAPAD) audits carried out on a annual basis.

Notes: 1. Implementation Arrangement Covenants are defined in Loan Agreement Schedule 5.

2. Valid Comply answers include: Yes, No or na (non-applicable)

Appendix-H

Table H 1 Status of Local Trainings, PMO-FRERMIP

Name of Training	Trainees	Number	Unit	Status	Time	Executing Agency
River Engineering	20	2	Course	Complete	Apriil 2016	BUET
River Trainig Techniques	20	2	Course	Complete	February 2017	BUET
Riverbank Protection	20	1	Course	Complete	July 2018	BUET
Topographical, Morphological & Hydrometric Survey and Data Collection	10	1	Course	Complete	January-February 2019	IWM
Land Acquisition and Resettlement Management Course	15	1	Course	Complete	January 2019	CEGIS
Environmental Impact Assessment	15	1	Course	Complete	October 2018	CEGIS
Capacity Building for DDM	15	2	LS	Pending	-	-

Table H 2 Status of Overseas Training/Study Tour, PMO-FRERMIP

Name of Training/Course	Number	Trainees	Unit	Status	Time	Place
River Morphodynamics and Erosion Protection Practices	1	8	Course	Complete	September-October, 2016	UNESCO-IHE, Netherlands
River Morphodynamics and River Training Techniques	1	8	Course	Complete	June-July, 2017	UNESCO-IHE, Netherlands
Study of the Management of Yellow and Yangtse River and Flood and Erosion Protection Works	1	5	Tour	Complete	August, 2016	Renmin University,China
Missisipi River Management and Alied Erosion Protection Work	1	10	Tour	Complete	October, 2017	USA and Canada
Geofabrics Geotextile Factory and the Coastal Protection Works	1	10	Tour	Complete	July, 2018	Australia
Application of Geotextile on Innovative Interventions and Experience Sharing	1	10	Tour	Complete	September 2018	The Netherlands and Germany
Study Tour-2	1	5	Tour	Pending	-	-
Study Tour-3	1	8	Tour	Pending	-	-
Study Tour-4	1	8	Tour	Pending	-	-

Table H 3 Implementation Progress of Training Activities by ISPMC

Sl.	Description	Completed				Date				Remarks
		No. of Courses	No. of Trainees							
			M	F	Total	FY 15-16	FY 16-17	FY 17-	FY 18-19	
ISPMC Line Item-1: Workshops, Training and Seminars (Provisional Sum)										
A.	**Workshops**									
1	Workshop on Draft Inception Report	1	83	40	123	09-Dec-2015				Pan Pacific Sonargaon, Dhaka
2	River Stabilization and Preliminary Master Plan	1	99	41	140		07-Dec-2016			Pan Pacific Sonargaon, Dhaka
3	National Stakeholder Workshop on the River Stabilization Plan	1	170	80	250			29-Nov-2017		Hotel Radisson, Dhaka
	Sub Total	**3**	**352**	**161**	**513**					
B.	**Training:**									
1	Training on Environmental Management at 3 sites	3	30	0	30	26-28 Apr-2016				Chauhali, Harirampur &
2	Training on International River Stability	1	90	20	110		08-Dec-16			Level-4 of WAPDA Building
3	Training for Task Force on Sand-filled Geotextile Bags	1	24	0	24		22-Dec-16			Level-4 of WAPDA Building
4	Training: Gender Awareness for BWDB Engineers	1	31	41	32			31-Jul-17	20 Mar-19	BWDB Design Office Conference Room
5	Training: Gender Awareness for SMO Engineers and Contractors	7	32	3	35				21-22-Dec-2018	XEN office, Koitola
6	Training: River survey database management training and on the job training	6	5	1	6				Oct-2018	ISPMC office
7	Updation of specifications of geotextile	1	27	13	40				16 April, 2019	BWDB Design office conference room
	Sub Total	**20**	**215**	**62**	**277**					
C.	**Conferences & Discussions**									
1	International Conference on Scour and Erosion	1	3	0	3		12-15 Sep-2016			Oxford University, UK With the DG, BWDB & PD, FRERMIP
2	International Large Rivers Conference	1	3	0	3		17-22 Apr-2017			Delhi, India with solely ISPMC
3	a) Round Table Discussion: River Management	1	20	0	20	28-Mar-16				Pan Pacific, Sonargaon
	b) Round Table Discussion: Presentation from the DG,	1	20	0	20	25-May-16				Lake Castle, Gulshan
	c) Round Table Discussion: Capacity Development	1	30	0	30		28-Oct-16			Pan Pacific Sonargaon
	Sub Total	**5**	**76**	**0**	**76**					
	ISPMC Totals	**22**	**635**	**225**	**860**					

Appendix-I

Table I 1

Bathymetric Survey Summary

Project	Surveys	End Date	Start Date
Bazar Station Groyne	16	12-Jul-2014	17-Jun-1998
Betil Spur	10	20-Sep-2014	26-Oct-2002
Chandan Baisha Groyne	5	26-Nov-2011	05-Jul-2002
Chandpur	6	01-Aug-2003	01-May-2001
Chauhali	26	26-Oct-2019	04-May-2016
East Guide Bun	10	25-Jul-2004	11-Apr-2004
Enayetpur Spur	28	05-Oct-2018	26-Oct-2002
Ganges	4	19-Oct-2001	19-Oct-2001
Harirampur	12	03-Nov-2019	15-Jun-2012
Hasnapara Spur	1	30-Jul-2002	30-Jul-2002
Kalitola Groyne	56	28-Oct-2016	04-Sep-2001
Koijuri	10	05-Nov-2019	23-Nov-2004
Lower Jamuna Full River	9	22-Sep-2019	15-Sep-2015
Mathuapara Groyne	66	08-Aug-2016	23-Dec-1998
MDIP	8	15-Jan-2009	23-Aug-2006
Meghal Spur	25	31-Jul-2016	01-Sep-2001
PIRDP	109	06-Nov-2019	30-Apr-1992
Ranigram Sirajganj	443	04-Nov-2019	30-May-1998
RBIP	1	27-Aug-2013	27-Aug-2013
Sailbari Revetment	11	17-Oct-2003	08-Sep-2001
Sailbari Revetment Down	23	13-Jul-2016	02-Oct-1998
Sailbari Revetment Up	43	13-Jul-2016	02-Oct-1998
Sariakandi Groyne	45	08-Aug-2016	29-Oct-2001
Simla Spur	13	11-Sep-2016	26-Oct-2003
Sirajganj Full River	81	11-Sep-2016	17-Jun-1998
Sirajganj Hard Point	1057	20-Dec-2016	06-May-1998
Subagacha Spur	9	04-Jul-2013	01-Sep-2001
West Guide Bund	160	20-Jul-2009	13-Apr-2004
Zaffarganj	10	28-Jul-2019	19-Jul-2016
Total	**2297**		

Table I 2 ADCP (Velocity) Survey Summary

Project	Transects	End Date	Start Date
Bachamara Zafarganj	12	26-Aug-2017	05-Aug-2016
Char Salimabad	11	26-Aug-2017	01-Aug-2017
Chauhali Down	22	22-Dec-2017	05-Aug-2016
Chauhali Middle	14	22-Dec-2017	05-Aug-2016
Chauhali Up	23	22-Dec-2017	06-Aug-2016
Enayetpur	20	22-Dec-2017	15-Oct-2016
Ganges	15	27-Aug-2017	06-Aug-2016
Harirampur Down	12	08-Aug-2017	07-Aug-2016
Harirampur Middle	13	08-Aug-2017	07-Aug-2016
Harirampur Up	21	19-Aug-2017	07-Aug-2016
Hurasagar	12	22-Dec-2017	01-Aug-2017
Jamuna Bridge Down	16	25-Aug-2017	04-Aug-2016
Mahespur	2	15-Oct-2016	15-Oct-2016
Nagarbari	15	26-Aug-2017	05-Aug-2016
Paturia	12	27-Aug-2017	18-Oct-2016
Sthal Chauhali	13	25-Aug-2017	15-Oct-2016
Zafarganj	26	21-Oct-2016	08-Aug-2016
Total	**259**		

Appendix-J

List of Memos

Sl. No.	Memo Subject	Memo No.	Memo Date
1	Implementation Design of the Riverbank protection at Chauhali	ISPMC- FRERMIP-18 /80	29-Oct-2015, updated 03-Feb-2016
2	First quality checking of geobag delivery, contract G1	ISPMC- FRERMIP- 028	16-Nov-2015
3	Design of underwater works at Harirampur	ISPMC- FRERMIP-073	28-Jan-2016
4	Design Guidance for Zaffarganj	ISPMC- FRERMIP-079	02-Feb-2016
5	Use of resources for 1 km of riverbank protection works at Kaijuri	ISPMC- FRERMIP- 154	02-Jun-2016
6	Geotechnical stability of JRB-1 embankment	ISPMC- FRERMIP-427	22-Nov-2017
7	Savings in Concrete Blocks at Chauhali and Zaffarganj	ISPMC- FRERMIP-243	03-Nov-2016
8	Memo on Pilot Works	ISPMC- FRERMIP-0264	15 Dec-2016
9	Slope failure during construction of permanent wave protection at Chauhali	ISPMC- FRERMIP- 0314	23-Feb-2017
10	Draft memo on site monitoring from 2015 to 2017	ISPMC- FRERMIP-316	02-Mar-2017
11	Background memo and bidding document for pilot works involving grout-filled jute mattresses	ISPMC- FRERMIP- 408	04-Oct-2017
12	Updated guideline for riverbank protection: additional investigations on the stability of geotextile bags	ISPMC- FRERMIP-469	08-Mar-2018
13	Adaptation works summary of Chauhali April 2018	ISPMC- FRERMIP-487	12-Apr-2018
14	Submission of Site Monitoring Report 2017	ISPMC- FRERMIP-495	09-May-2018
15	Background on launching aprons – follow up of discussions with the design office.	ISPMC- FRERMIP-517	18-Jul-2018
16	Review of bank protection design and bank failures in Chauhali By ISPMC for Chauhali committee	ISPMC- FRERMIP-522	31-Jul-2018
17	Assessment of slope failure at Chauhali	ISPMC- FRERMIP- 534	27-Sep-2018
18	Updated memo about the downstream failure at Chauhali	ISPMC- FRERMIP-557	29-Nov-2018
19	Pilot works site visit report	ISPMC- FRERMIP- 581	12-Feb-2019
20	Review of clay cladding requirements for Kaijuri embankment	ISPMC- FRERMIP-583	17-Feb-2019
21	Proposed changes to grout mattress design	ISMPC-FRERMIP-595	11-March-2019
22	Analysis of erosion of the Upstream end of main protective work of Chauhali in February 2019 and future recommendations	ISPMC-FRERMIP 596	13- March-2019
23	Current status of riverbank protection at Zafarganj and Harirampur.	ISPMC-FRERMIP-626	17-Jul-19
24	Status of Riverbanks and Riverbank protection at Benotia, Chauhali, Harirampur and Zafarganj	ISPMC-FRERMIP-630	8-Aug-19

Appendix-K
Lower Jamuna 2019 Morphological Analysis

Author: Angela Thompson
November 28th, 2019

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Executive summary

Since 2016 the Lower Jamuna has been studied extensively, utilizing satellite images and morphological modelling. After every flood season the analysis and models have been updated using the most recent bathymetry. To this end, a better understanding of the behaviour of the Lower Jamuna has been developed, enabling more accurate predictions of future changes and helping to plan future works.

Several conclusions have been drawn from the most recent analysis (performed in the fall 2019). The most important developments are the rapidly altering morphological conditions at the major bifurcation of the Lower Jamuna, which threatens its stability. The floodplains (chars) along both of the upstream banks of the bifurcation were formed and stabilized during the period from 1998-2011 (depicted in Figure A). The area was rather dynamic before 1998. During the last few years significant erosion has been occurring along both banks just upstream of the major bifurcation. The width of the upstream reach has increased by approximately 1.5 km since 2011. At present, the deep channels continue to migrate towards the banks. The right bank in particular appears to be vulnerable to bank erosion given the upstream deep-channel pattern, which has a meandering form (as seen in the bathymetry data depicted in Figure 7) that may develop further. The erosion of these banks and chars would have devastating consequences for the bifurcation and downstream branches. Particularly, unfavorable flow conditions such as a combination of low flows (that causes migration of deep channels and erosion of bank toes) and high flows (that causes overland flow leading to weakening or even collapse of the chars). Consequently, it is rather critical that these banks and chars be protected against further erosion as soon as possible, especially the right bank of the bifurcation.

These changes including the deep-channel dynamics and bank erosion at the bifurcations, appear to be causing problems in the downstream branches as well. For example, banks are actively eroding downstream of Enayetpur and along Benotia at the right branch, while the deep-channel pattern is significantly changing in the left branch forming a cut-off channel and abandoning the channel along the Chauhali bend Additionally, there is bank erosion along the Solimabad channel despite the fact that the channel appears to be decaying due to the majority of the left branch discharge flowing through the Chauhali cut-off (especially during low flows). However, this creates relatively favourable conditions for closing the Solimabad channel. If channel closure structures that significantly reduce flow velocities are successfully constructed large scale bank protection within the channel will be unnecessary.

The modelling has also looked at the effects of dredging for the planned works. Dredging activities can impact downstream sections of the river. They should be planned carefully. The model results suggest that dredging a deep channel along the left bank of the bifurcation (for the construction of bank protection structures to deeper scour depths) could possibly direct flow away from the recently formed cut off towards the stabilized outer bend of Chauhali.

Figure B shows the banks which are vulnerable to bank erosion in the Lower Jamuna.

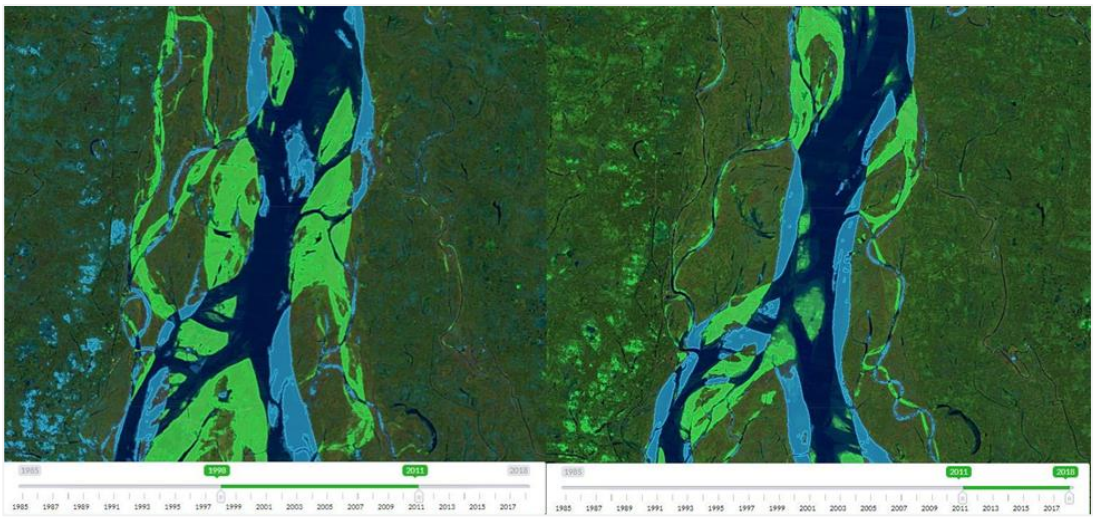


Figure A: Morphological development at the major bifurcation during 1998-2011 (left image) and 2011-2018 (right image), quantified by Aqua Monitor (Green: sedimentation, light blue: erosion, dark blue: no change). The banks have been eroded even more during 2019, which is not included in the image analysis.

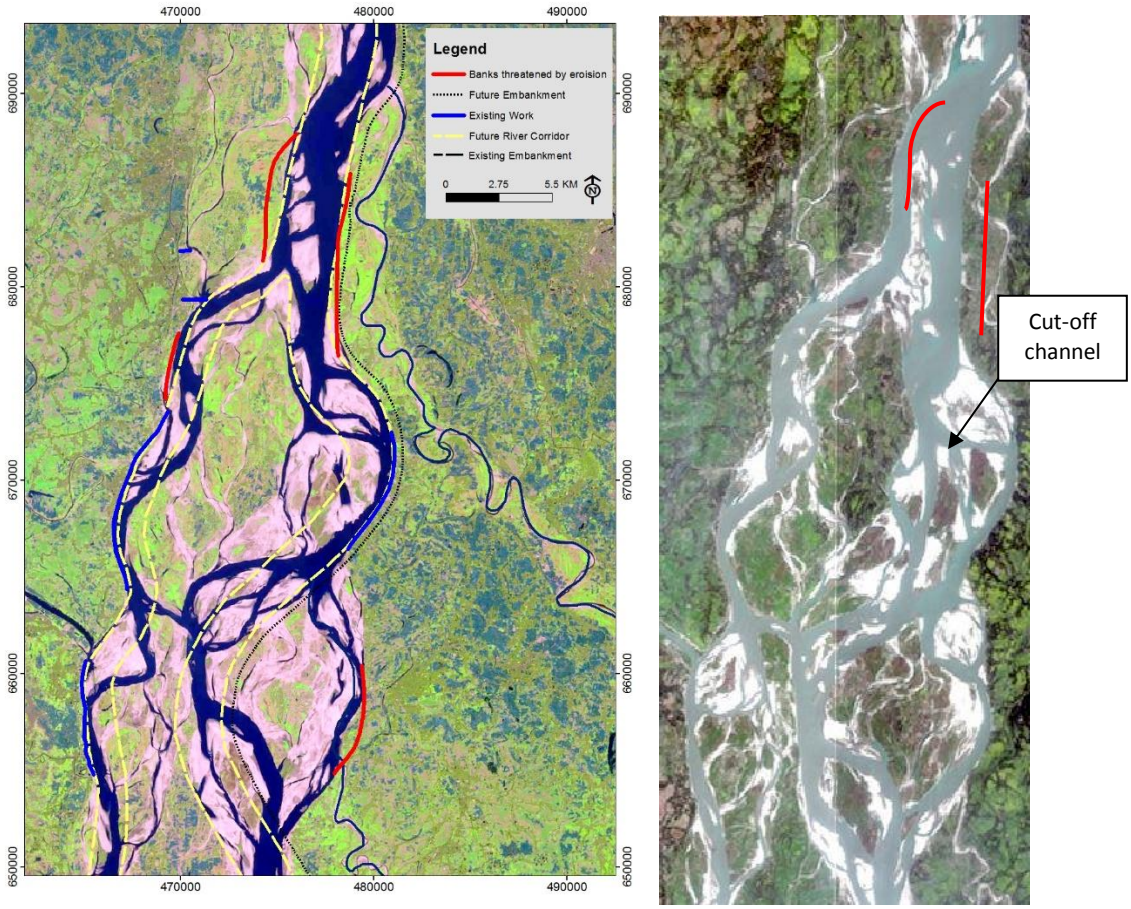


Figure B: The banks which are vulnerable to bank erosion in the Lower Jamuna (satellite image from 2018 (left) and January 2020 (right)).

1 Introduction

Because of the fine but heavy sediment load in the Lower Jamuna the morphological situation is ever changing from year to year. Within this unstable environment channel developments occur rapidly, and banks can erode laterally at rates upwards of 1 km/year. As there are several river training works planned under the Flood and Riverbank Erosion Risk Management Implementation Program (FRERMIP), the current morphological situation must be understood to ensure that the planned works are still relevant and likely to succeed. This report will first summarize the morphological analyses from 2016 to 2018 and modelling exercises done during FRERMIP. The validation of the 2019 model with updated geometry will then be presented. Next, the report will assess the current morphological situation. Finally, the report will describe the predictions for the future morphological developments for the next two years (until 2021), including an assessment of the proposed works for FRERMIP Tranche 2.

2 Summary of past morphological analyses and numerical modelling

Since 2016 there have been annual morphological analysis and monitoring of the Lower Jamuna, accompanied by numerical modelling. The morphological analysis has been done using Deltares Aqua Monitor, Google Earth satellite image analysis, bathymetric data, site visits and 2D morphological modelling using Delft3D. The finding from these activities can be found in Supplementary Annex C-4 Reach 3 and Bifurcation Numerical Modelling (NHC and EMM 2019b) and the Feasibility Report, Design Report Annex 5 (NHC and EMM 2019a). Some of the main finding from these reports are summarized below.

2.1 Morphological findings

Listed are some main findings regarding the general morphology of the Lower Jamuna, which have been presented in the reports mentioned above:

- Dredging exercises, particularly those triggering the formation of new channel which instigates large amounts of erosion and sedimentation, can cause downstream instabilities. Additional sediment can deposit as bars, widening channels and causing bank erosion.
- Likewise, bank erosion can cause instability to downstream sections of the river because of the added sediment load and formation of sandbars. Preventing bank erosion is key to stabilizing the Lower Jamuna.
- Deep channel propagation is prominent in lower flows, while sand bar movement largely occurs during higher flows.
- Deep channel migration is a key factor for bifurcation dynamics.
- The main bifurcation has been dynamically stable since at least 1994. The right branch was in an enlarging phase from 2003 to 2012 while the left branch was in a declining phase (before the Capital Pilot Dredging Project). From 2013 to 2017 the left branch has been in an enlarging phase and the right branch has been in a declining phase (after the Capital Pilot Dredging Project). This may have occurred because of the Capital Pilot Dredging Project, in combination with natural oscillations of enlarging and declining anabranches.
- From 2011-2015 there were erosional trends in the Lower Jamuna. From 2015-2017 there were sedimentation trends in the Lower Jamuna.
- The right branch is beginning to carry more discharge during lower flows (probably due to deep channel developments towards the right branch). To prevent the enlarging of the right branch the banks and chars must be protected.

2.2 Notes on the numerical model

The model of the Lower Jamuna spans from just downstream of the Jamuna Bridge to just upstream of the Jamuna- Ganges confluence at Aricha. The general sediment transfer formula has been used in

the models, with parameters derived from the FAP24 studies. Some of the main findings regarding the numerical modelling of the Lower Jamuna:

- The trends in erosion and sedimentation (ex. deep channel migration) are captured by the model; however, the model tends to underestimate the quantity of reach averaged erosion and sedimentation. This could also possibly be due to the interpolation of measured data on to the computation grid.
- Bank erosion is not accurately replicated by the model. Locations at risk of bank erosion have been identified by close proximity of the deep channels to the banks.
- The model does not properly represent the non-erodible area along existing riverbank protection structures because of the relatively low resolution of the model.
- Deep channels near banks are not well represented in the model because the failure to include bank erosion, low model resolution and failure to capture the effects of armoured revetments.
- The model has a 2-year prediction capability in the current study.
- Tributaries and distributaries along the Lower Jamuna have not been included in the model (including the Hurasager and the Old Dalishwari) because of their relatively small discharges.
- Generally, meso scale deep channel and bar migration are captured well by the model; however, specific details such as depths of anabranches and secondary channels have a degree of uncertainty to them.
- For all the results presented in this report, no morphological factor has been used, meaning that the rate of morphological changes is not artificially accelerated.

3 Validation of model

3.1 2018 model: morphology

The model was used in 2018 to predict what would happen during the 2019 flood. These predictions which were made are summarized below:

- If there is a lower flood the deep channels will most likely be less pronounced, and bar movement will slow.
- Sedimentation will occur in front of the central char at the bifurcation.
- River banks upstream of the bifurcation (particularly the left bank) are vulnerable to erosion.

A comparison of the predicted September 2019 bed levels to the measured September 2019 bed levels can be seen in Figure 1. Some deep channel developments and sedimentation trends have been captured by the model; for example, the sedimentation that has deposited upstream of the central char. Also correctly identified is the less pronounced deep channels after lower floods. The 2019 flood had one high peak, with a very short duration (Figure 2). The general erosion and sedimentation trends were not correctly identified by the model (Table 1). The sedimentation in the upstream was not correctly estimated, likely because of the equilibrium boundary conditions upstream. Consequently, there was less sedimentation in the downstream left branch than what has been measured. Table 1 also shows how dependent the results are on the modelled flood, which is impossible to predict.

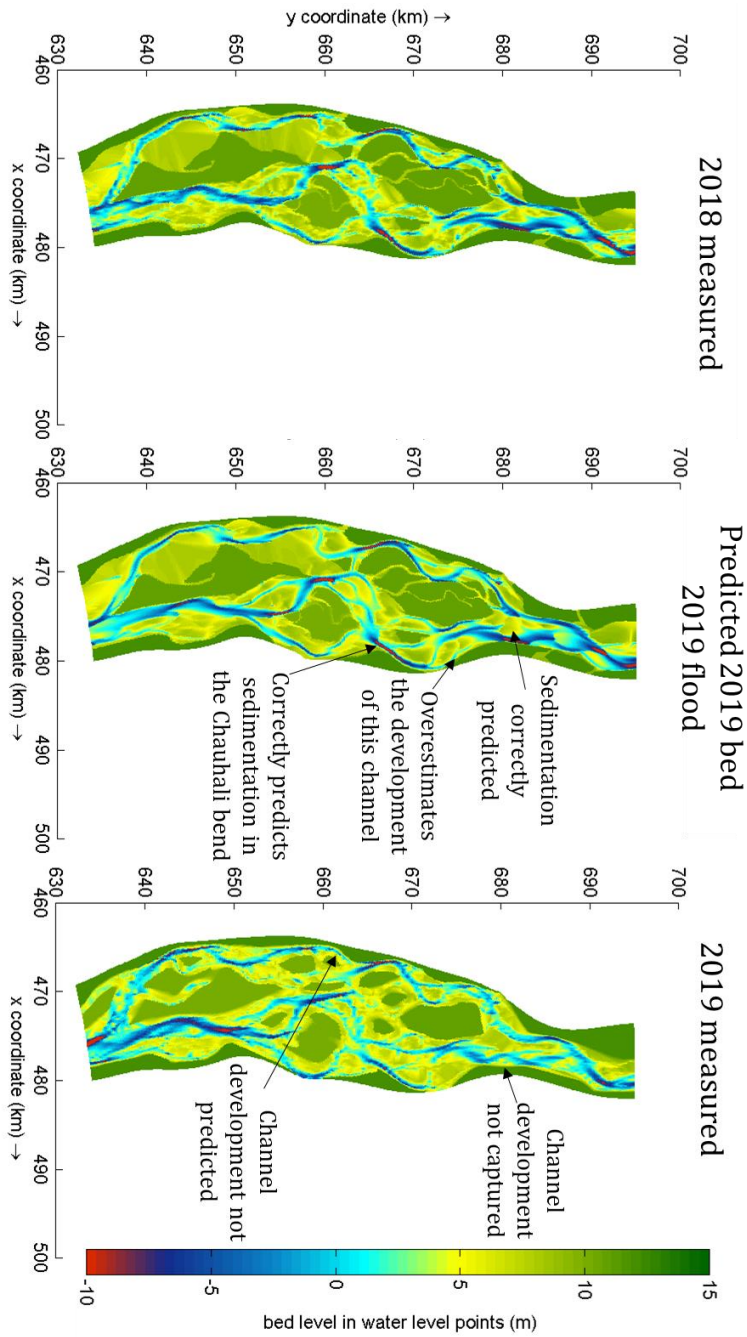


Figure 3: Comparison of the predicted bed levels (using the 2019 flood boundary conditions) and the actual bed levels (north is orientated to the right)

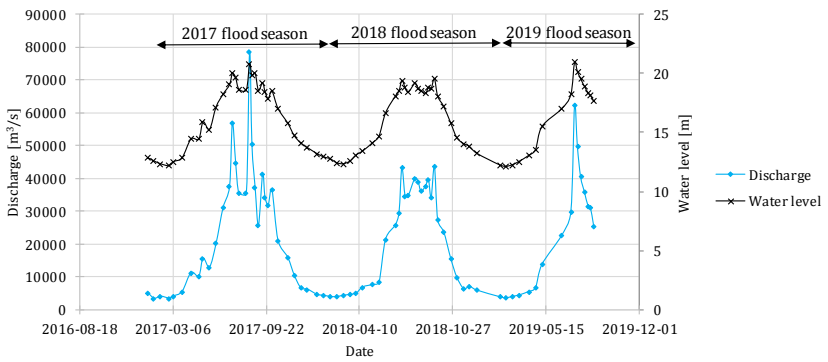


Figure 4: Discharge and water level at Bahadurabad

Table 5: Difference in average interpolated bed levels (cm) (bed levels measured in autumn of each year)

	Period	Right branch	Left branch	Upstream
Measured	2016-2017	94	78	-75
Computed	2016-2017	2- 3	2-3	<-15
Measured	2018-2019	-64	-93	65
Computed (2019 flood)	2018-2019	14	-17	-4

3.2 2019 steady models: flow division and velocity distribution

Bed levels, float track velocities as well as, various ADCP discharge measurements were collected in the Lower Jamuna from September 19th- 23rd, 2019. This survey was performed by the IWM. The measurements have been compared to steady models results without morphological updates. **Error! Reference source not found.** shows the comparison of the modelled depth average velocity with the surface velocity measured by float tracks. The model appears to recreate the flow velocities and the areas of flow concentrations well. Comparisons between the discharges and water levels can be seen in **Error! Reference source not found.**. The model simulates the discharge distribution reasonably well, apart from the mid channel connection (cross section 8 in **Error! Reference source not found.**), where the model underestimates the discharge by ~1000 m^3/s (62% error).

The model predicts the mid channel connection flows from right branch to left branch in lower flows but flows from left branch to right branch when flows reach approximately bankfull discharge. ADCP measurements at the cross section show flow going from right branch to left branch at an upstream total discharge of ~36,000 m^3/s. Field observations of exposed bars in the mid-channel connection that have been eroding, shows steep banks at both ends indicating flow does go in both directions through the channel (field trip was on November 22nd, 2019).

The discharge at the downstream boundary of the model, Aricha, has not been measured; therefore, the water level has been acquired from the Aricha BWDB gauge station (SW50.6) on September 18th, 2019 (8.53 m). A comparison of the measured water levels of this survey and those from BWDB can be seen in **Error! Reference source not found.**. The survey company has explained that their water level measurements at Sirajganj (SW49) have been consistently 0.2 m lower than the BWDB station data. They have not compared their previously surveyed water levels at Aricha to the levels recorded by BWDB. The BWDB water level at Aricha is higher than the upstream surveyed water levels from the IWM. Additionally, the surveyed water level shows the water level increases at the mid point of the right branch of the Lower Jamuna. These discrepancies have not been resolved; consequently, there are uncertainties in the surveyed water levels shown in **Error! Reference source not found.**.

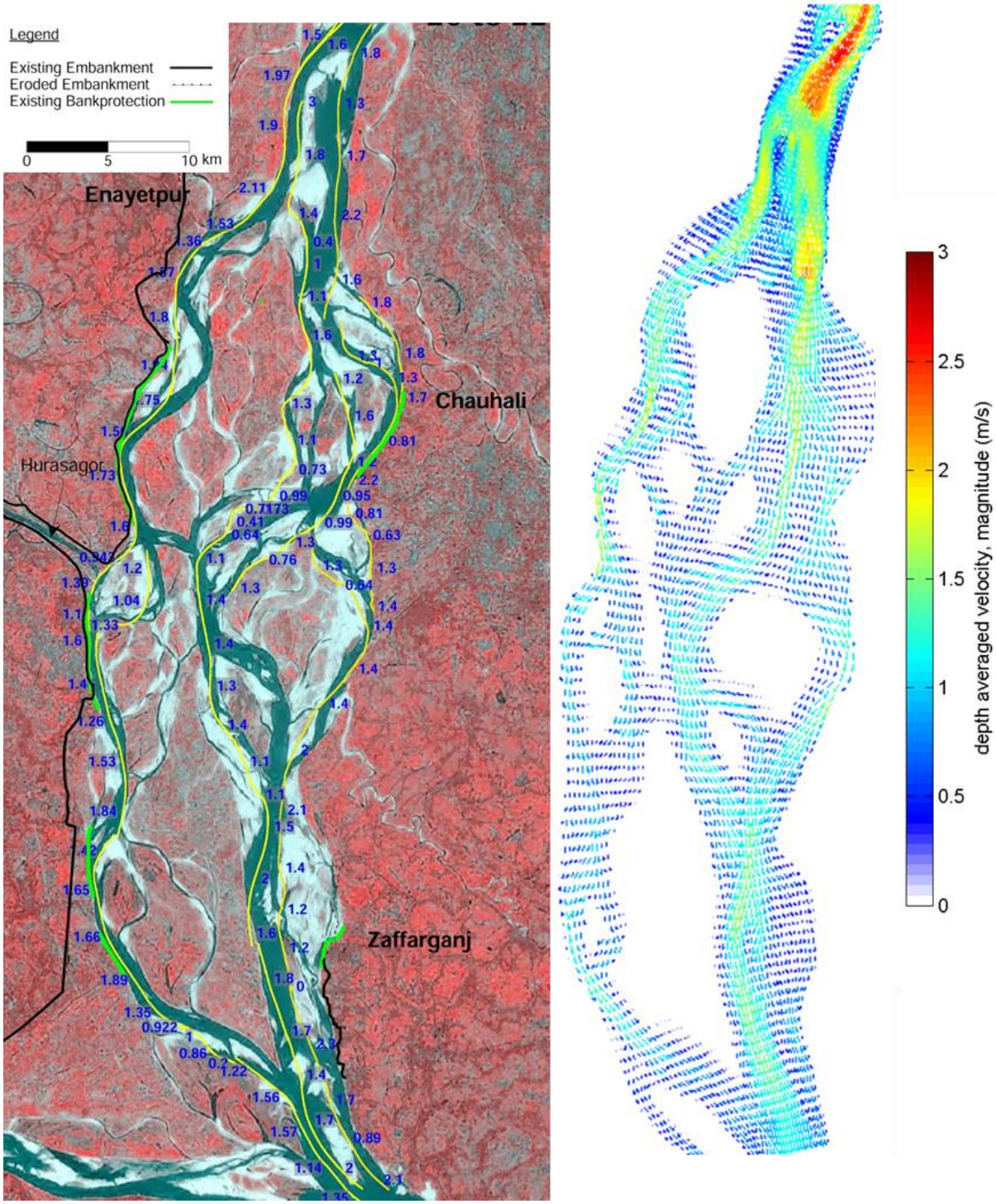


Figure 5: Float track velocity measurements (m/s) (left) and computed depth averaged velocities (right) (satellite image from January 2019)

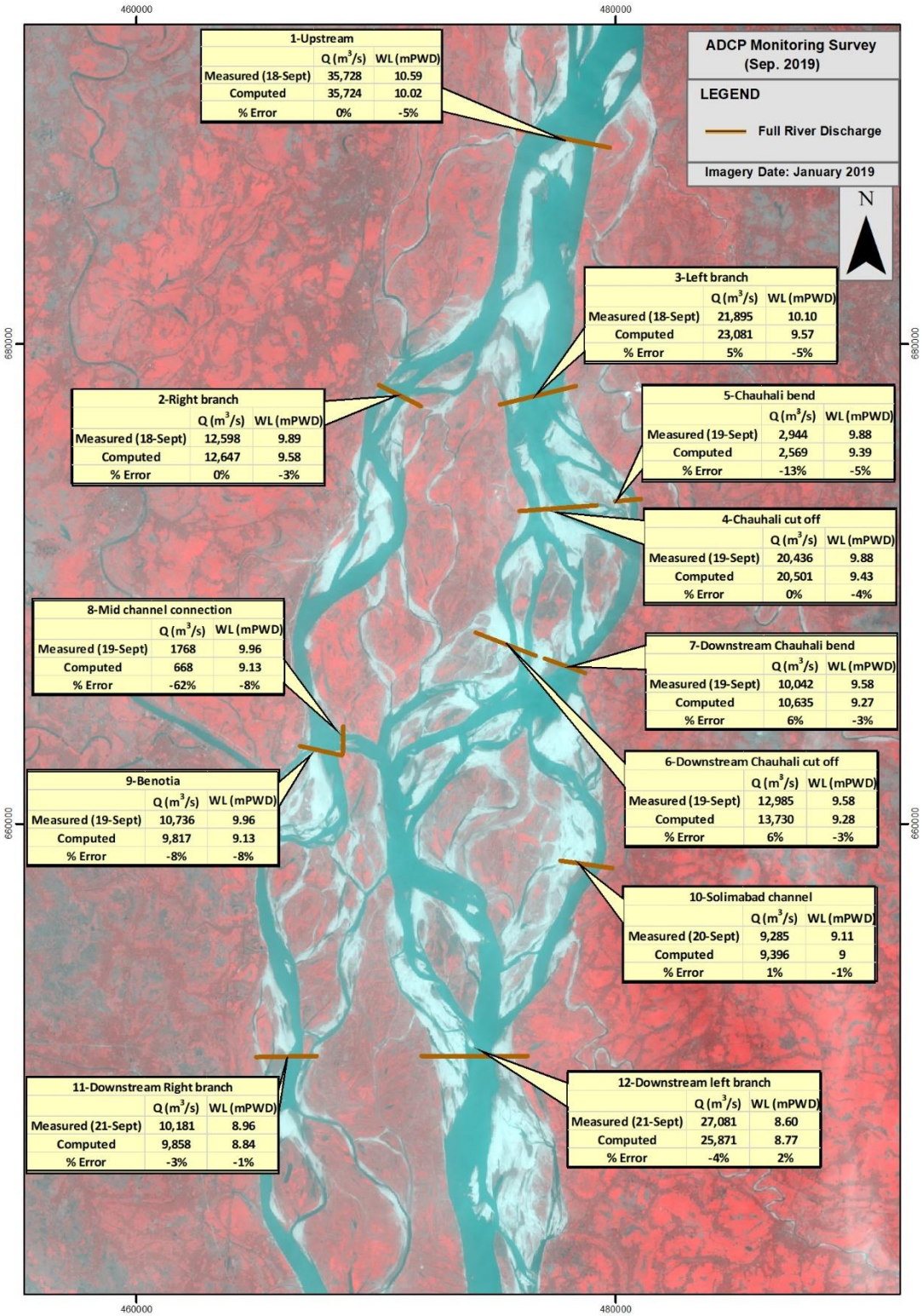


Figure 6: Comparison of measured and modelled discharges and water levels

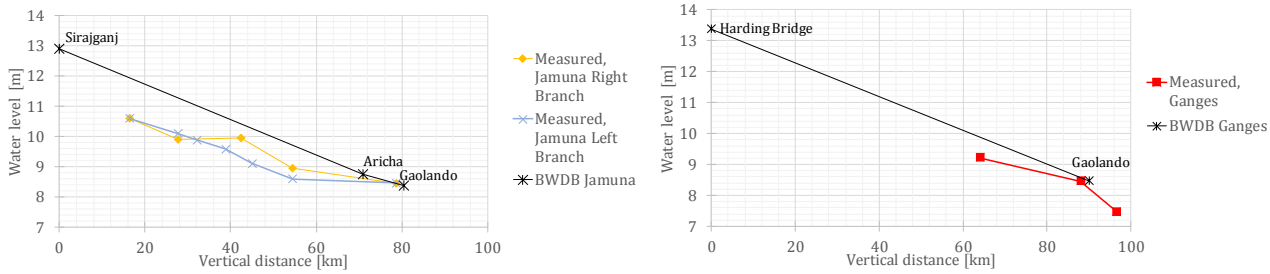


Figure 7: Comparison of measured water levels by the current survey with those done by BWDB (BWDB values are taken on Sept 20th and Sept 21st, 2019 for the Jamuna and the Ganges stations respectively. Locations of BWDB stations are approximated)

4 2019 developments

4.1 Observations

Erosion and sedimentation trends from 2016 to 2018 can be seen in **Error! Reference source not found.** including developments like the Chauhali cut off. Additionally, the declining of the left branch (more sedimentation) and enlarging of the right branch (more erosion) can be seen. As previously mentioned, the Lower Jamuna has been under a general accretion trend from 2015-17. This general trend has continued during the 2017 flood, with large amounts of sediment being deposited (**Error! Reference source not found.**). The bed levels surveyed in 2019 show a deepening of the right branch and the downstream portion of the left branch (**Error! Reference source not found.**). A deep channel has developed close to the right bank upstream of the bifurcation. This deep channel will likely cause bank erosion.

Along with showing the average bed levels for the entire Lower Jamuna, ***Error! Reference source not found.*** shows the average bed levels of the bifurcation and the Solimabad channel for selected years. Average bed levels upstream of the bifurcation have increased, likely because of the sedimentation that has occurred just upstream of the central char, while average bed level in the Solimabad channel has decreased since 2017.

Error! Reference source not found. shows the bank line shifts around Benotia. The bank line has shifted by ~100 m since 2010. This cut off channel does not seem to be deepening significantly; however, the main channel has a large cut off ratio (1.5) and this Benotia channel will likely develop (**Error! Reference source not found.**). The bank will not likely experience heavy erosion because the existing bank protection upstream will fix the approach channel of the bend. That being said, points along the existing embankment has a set back distance ~100 m, and so small amounts of bank erosion could cause embankment breaches.

Table 6: Average bed levels from samples [m] (values pre 2019 from NHC and EMM 2019a) (bed levels are measured in the autumn of each year)

Year	2011	2012	2016	2017	2018	2019
Entire Lower Jamuna	3.52	-	2.02	4.06	2.22	2.09
Upstream of the bifurcation	3.18	3.85	2.47	1.71	0.82	2.29
Solimabad channel	-	-	3.69	5.33	4.46	2.78

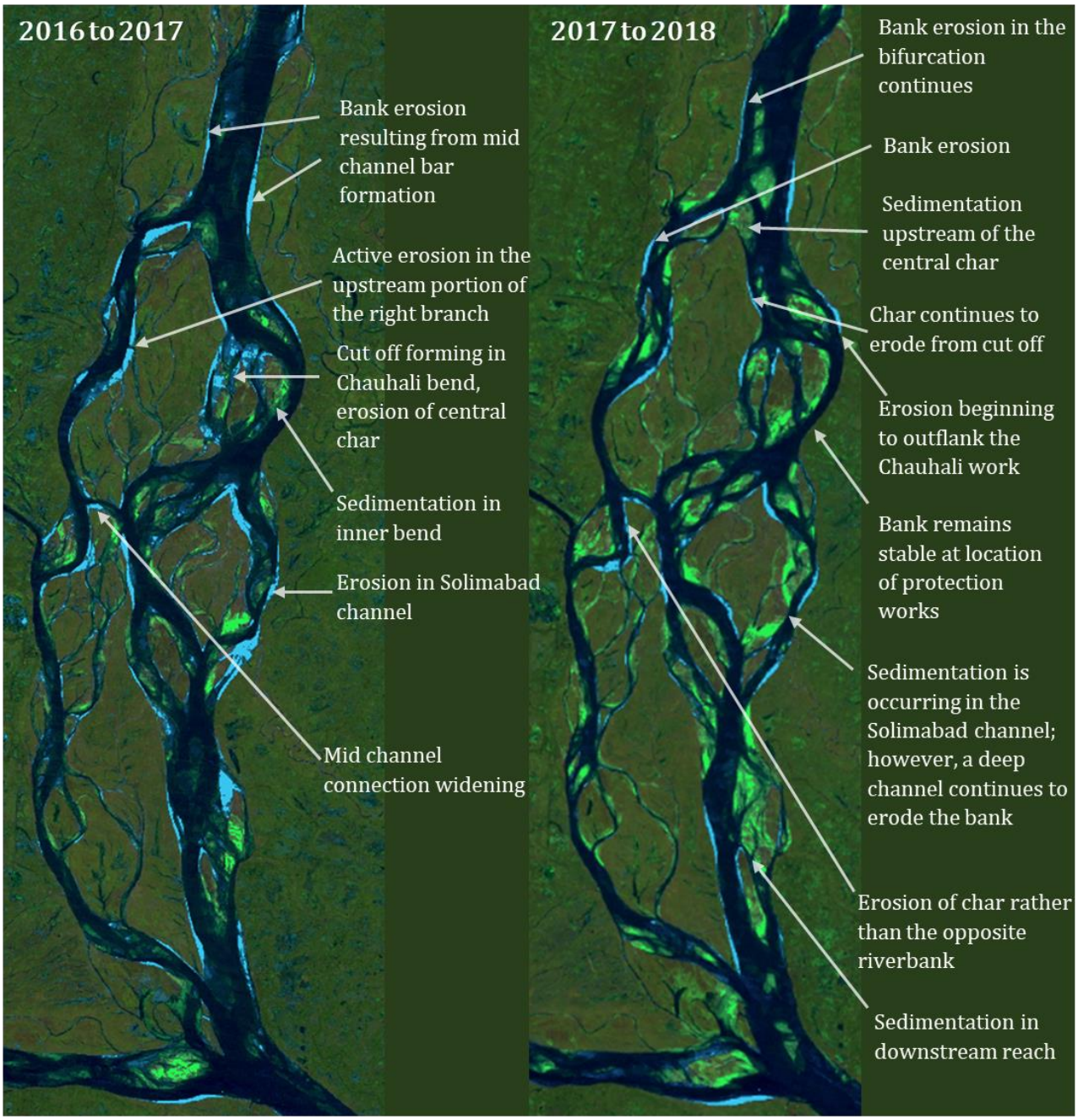


Figure 8: Erosion and sedimentation trends in the Lower Jamuna from 2016 to 2018 (green area shows areas of new land and blue areas show areas of new water) (Satellite images are taken near the start of each year)

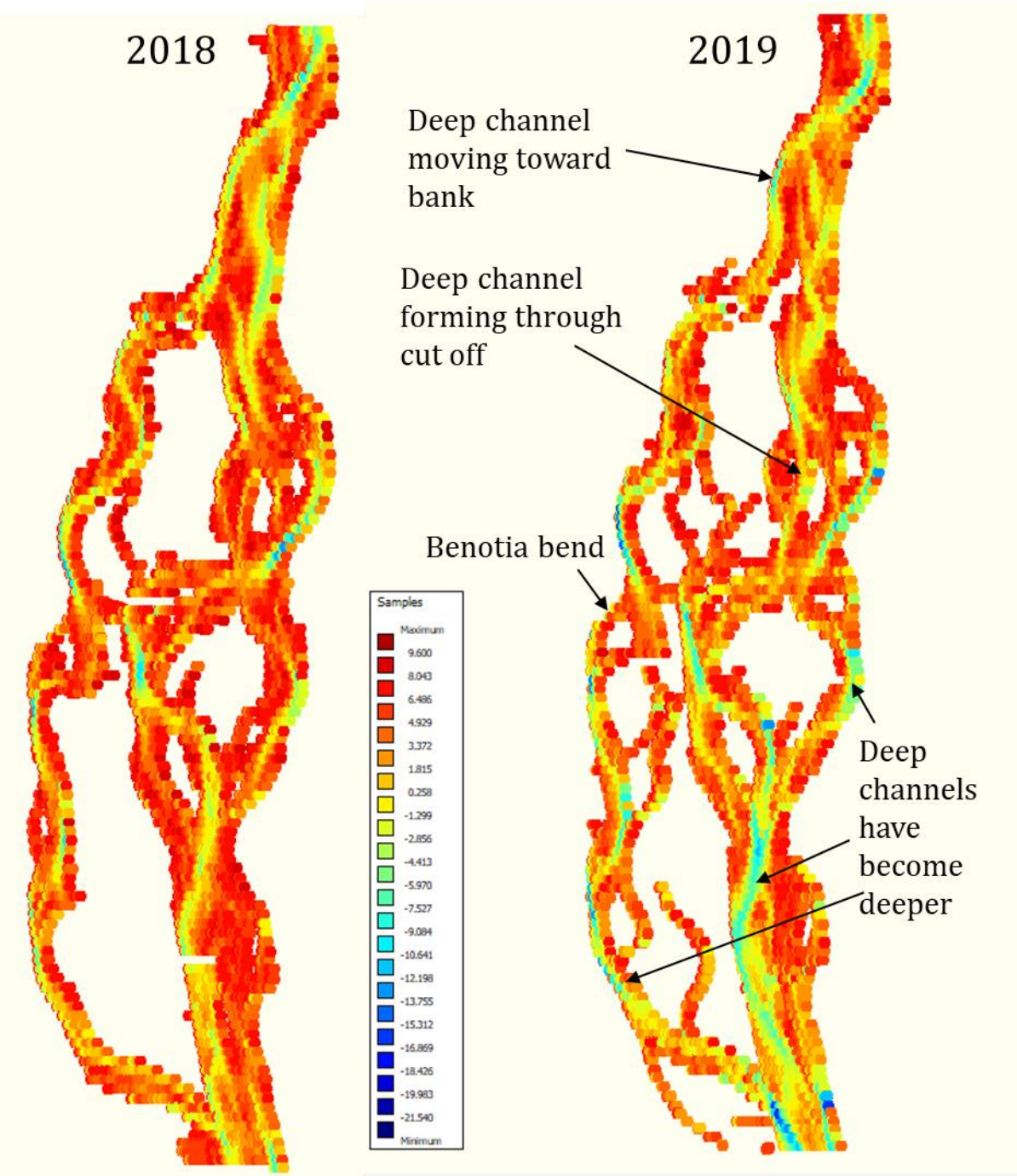


Figure 9: Survey data from September 2018 and 2019 of the Lower Jamuna

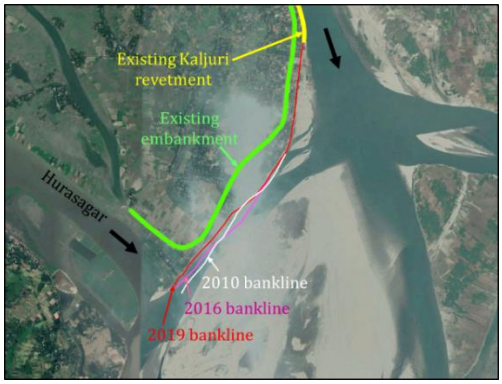


Figure 10: Bankline shifts around Benotia (2019 bank line was from a January satellite image) (Google Earth)

4.2 Steady hydraulic model results

Several scenarios with steady discharge (and no morphological updates) have been modelled. The boundary conditions, shown in **Error! Reference source not found.**, have been chosen to represent a number of different flow scenarios (see **Error! Reference source not found.** for the flood frequency discharges). **Error! Reference source not found.** shows the discharge distribution between the channels for 2016, 2018 and 2019. A number of observations can be made from the discharge division. First, the cut off at Chauahli has begun to take the majority of the left branch flow. There has not been an increase in discharge flowing through the cut off since 2018. The outer bend at Chauhali is almost dry during low discharge. The right branch is taking more flow. The Solimabad channel has overall decrease in flow conveyance during low flows since 2016 (with little change since 2018). This may correlate with the large bar at the upstream end of the Solimabad channel in addition to the development of the Chauhali cut off. The large portion of discharge that flows through the cut off rather than around the Chauhali bend circumnavigates around the Solimabad channel rather than through it (Figure 10). Lastly, Figure 9 shows that there is an increase in flow exchange during low flows in the downstream portion of the branches. Although this could partly be caused by artifacts from the prescribed char heights, which have not been surveyed.

Table 7: Steady model boundary conditions

Upstream discharge [m^3/s]	Downstream water level [m]	Discharge characteristic
3700	2.56	Low, steady flow
39,400	9.22	Approximately bank full
74,200	9.39	Rising flood 1 in ~5-year discharge
109,000	10.50	100-year flood scenario

Table 8: Flood frequency for the Jamuna (NHC and Fichtner 2015)

Return period (years)	Annual exceedance probability (%)	Discharge (m^3/s)
500	0.2	126,000
200	0.5	116,000
100	1	109,000
50	2	102,000
20	5	92,200
10	10	84,700
5	20	76,800
2	50	65,100

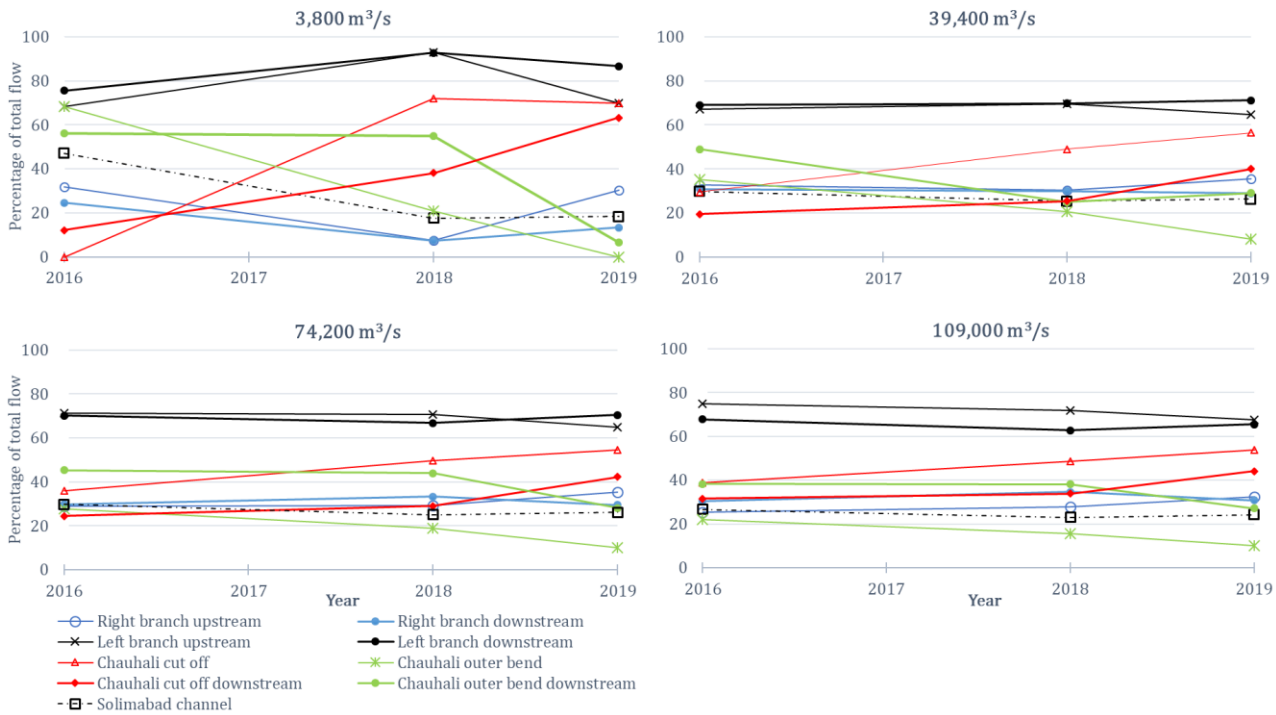


Figure 11: Discharge distribution in the channels of the Lower Jamuna at various steady discharges

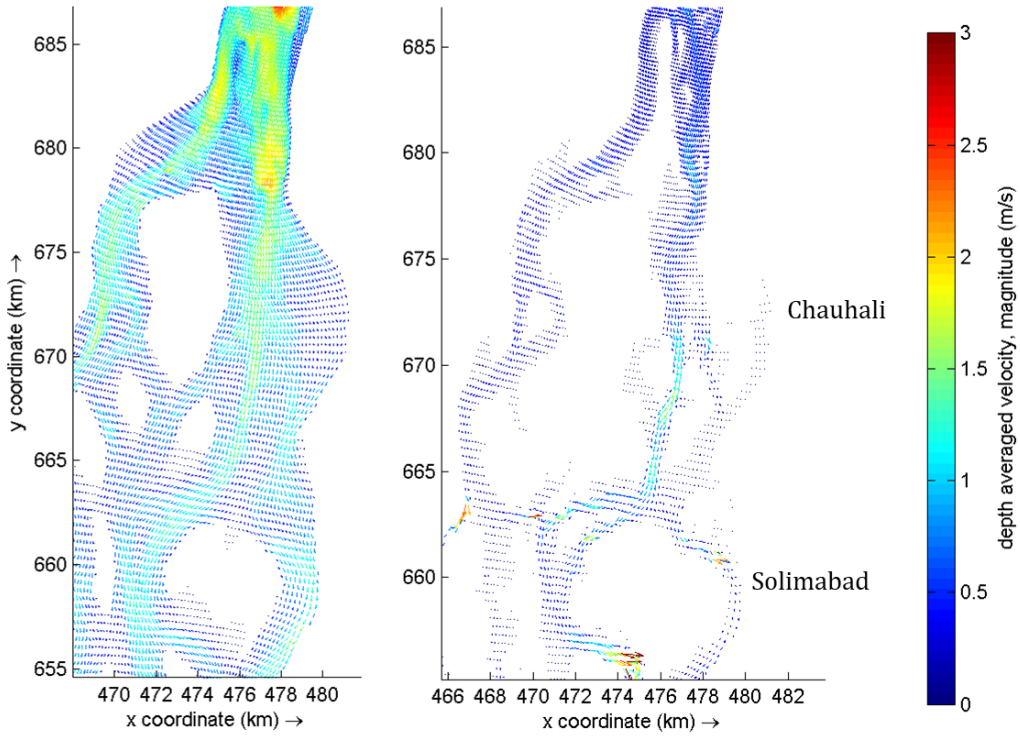


Figure 12: Velocity vectors in the upper portion of the left branch with bank full discharge

4.3 Locations that are at risk of erosion

Based on the above observations, there are several major locations in the Lower Jamuna that are at risk of bank erosion and mitigation measures are necessary:

- Downstream of Enayetpur (~4 km)
    - This reach is being protected by the BWDB (Chief Engineer Rajshahi)
- Right bank of the bifurcation (~7 km)
    - BWDB is planning to prepare a project to protect this reach
- Left bank of the bifurcation (~11 km)
- Right bank of the Solimabad channel (~6.5 km)
- In right branch at Benotia, upstream of the Hurasagar (~3 km)
    - While unlikely to have extensive erosion here, the small setback distance for the parallel embankment causes a high risk of embankment failure from erosion

5 Future developments and potential intervention work

5.1 Proposed intervention works

The Feasibility Report (FRERMIP 2019) has proposed a number of works for Tranche 2. The works effecting the river planform are listed below as well as some notes on the proposed works considering the observations described in Section 4.

A. Riverbank protection at Benotia (upstream of Hurasagar River) in the Jamuna right branch (3 km)
    - Downstream continuation of Kalijuri riverbank protection
B. Sediment choking in Solimabad channel
    - While this is a large channel, the closure of it would allow for a large portion of land to be reclaimed. Since the Solimabad channel does not appear to be widening appreciably this could be an ideal time to attempt to close the channel.
C. Riverbank protection upstream of Chauhali on the left bank extending upstream of the bifurcation point (12 km)
    - There is erosion along this stretch upstream of the bifurcation point, as well as directedly upstream of the exiting Chauhali work. There is a large bar at the inner bend of this section which is not under immediate threat of erosion.
D. Precautionary riverbank protection in Solimabad channel on the left bank (10.5 km)
    - While there is erosion in the Solimabad channel, the protection of the banks seems to be redundant if the channel is to be closed successfully with a closure dam.

Bank protection is also critically required on the right bank at and upstream of the bifurcation. The works reviewed for Tranche 2 are listed below. Details are provided on how they have been included in analysis and model. It should be noted that because of instability of the natural slopes which have been protected during Tranche 1, dredging is recommended to achieve more stable, flatter bank slopes where soil is weaker.

1) Riverbank protection on the right bank of the bifurcation (new work not suggesting in the Feasibility Report for Tranche 2)
    - The work would consist of ~7 km of anti-erosion works on the right bank at the bifurcation
    - The work would consist of geobag revetments with ~50 m underwater apron
    - For bank stability, 1V:6H bank slopes would be dredged. The slopes would extend to ~10-15 m below low water level.
2) Riverbank protection on the left bank of the bifurcation (Work C)
    - The work would consist of ~14 km of anti-erosion works extending the existing Chauhali protection upstream past the bifurcation.
    - The work would consist of geobag revetments with ~50 m underwater apron

- For bank stability, 1V:6H bank slopes would be dredged. The slopes would extend to ~10-15 m below low water level.
- Because the entire stretch of riverbank is not under threat of immediate erosion, the construction could be phased in order to protect the more vulnerable portion upstream of the bifurcation first and directly upstream of the exiting Chauhali work in the outflanking section. A second phase of the work could protect the remain connecting section, where there is currently a large bar and little flow. The entire length of riverbank protection could be under threat of erosion if the river moves eastward again, away from the cut-off that has formed.
- Currently there are geobags protecting a short reach of bank upstream of Chauhali. The slope is protected but it is unknown is there is a geobag apron underwater.

3) Closure of the Solimabad channel (Work B)
    - The work would consist of a closure dam on the upstream end of the Solimabad channel.
    - The closure dam would be constructed from dredged sand from the river. The sand would be removed from the main channel. The dredged channel would be oriented to encourage the flow to bypass the Solimabad channel.
    - The left portion of the dam would be constructed to floodplain level with a ~40 m crest width. This portion would be ~2700 m in length. The total required dredged construction material would be ~750,000 m^3. (Note: This crest width is estimated. Previous closure dams have failed in the Jamuna because of inadequate crest width (NHC and EMM 2019))
    - Along the right side of the Solimabad channel where a deep channel resides the dam will be built ~1 m below low water level to allow limited amounts of flow to pass through the channel, transporting sand into the channel for deposition, preventing extreme water level differences and drying of the Old Daliswari.
    - The closure dam would not have an armoured surface and would therefore be able to erode.
    - Building a successful closure dam would depend on the production of sand being able to exceed the losses of sand due to scour.

Because of project scheduling, future work will not be constructed until the dry season of 2020/21. A flood season model has been run using the 2019 bathymetry in order to predict the bathymetric conditions that will be relevant for the potential works. Using the bathymetry predicted by the model for the dry season of 2020, the proposed work has been reviewed, focussing on how the river responds to the interventions. Using a predicted bathymetry adds uncertainty to the results.

5.2 Modelled flood

Flood characteristics have large impacts on morphological developments. Peak discharge, duration of high flows as well as the raise and fall rate of the flood raises all impact how the deep channels propagate, and sand bars develop. Two floods have been modelled, a high flood (**Error! Reference source not found.**) and a low flood (**Error! Reference source not found.**). The high flood has a relatively high peak discharge around 80,000 m^3/s, which correlates to a 10-year return period, while the low flood peak of just over 40,000 m^3/s correlates to a <2-year return period (**Error! Reference source not found.**). The models start in September because the bathymetry data has been collected in September.

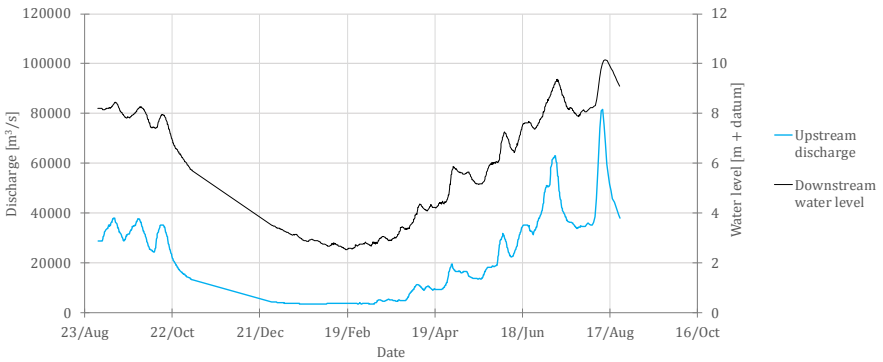


Figure 13: Boundary conditions for a high flood (2017 flood)

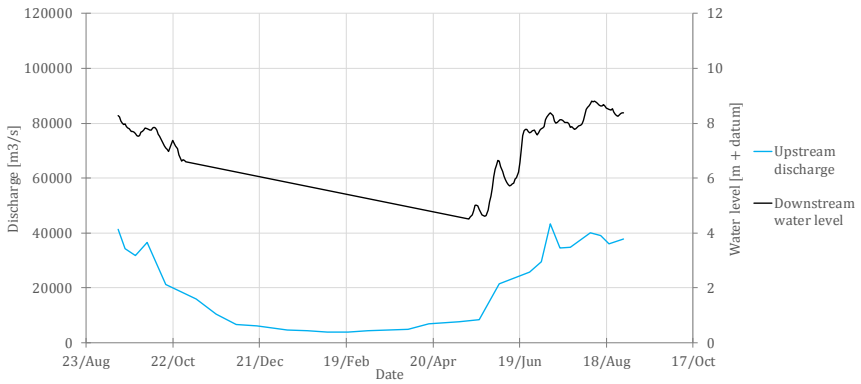


Figure 14: Boundary conditions for a low flood (2018 flood)

5.3 Morphological developments without interventions

The bed levels after two sequential high floods are shown in **Error! Reference source not found.**. It appears that the bank erosion upstream of the bifurcation will become severe, especially along the right bank. The upstream deep channel flows from the left bank towards the right, pushing the flow up against the right bank just before the bifurcation point. There is a general erosion trend predicted for the approach channel of the bifurcation. The newly deposited sediment at the central char will likely begin to erode.

There is an overall sedimentation trend predicted for the downstream branches, more so in the left branch. The model predicts that there will be sedimentation in the upstream portion of the Chauhali branch and the Chauhali cut off will continue to develop. The model predicts that the right branch will continue to enlarge, taking more flow, especially in the dry season. At the inlet of right branch, the point bar appears to be getting larger, which is eroding a deep channel. This deep channel would likely cause erosion of the central char (**Error! Reference source not found.**). During the two floods the offtake of the right branch appears to begin to be orientated in more of an outer bend scenario, which appears to lead to less sediment laden water flowing through the branch (**Error! Reference source not found.**). This development could lead to widening of the channel.

The model also predicts a deep channel propagating through the mid channel connection. This channel appears to flow from the right branch to the left during lower flows and vice versa during higher flows. ADCP measurements in November 2019 show that more flow goes through the mid channel connection than the downstream right branch channel (however, there are some uncertainties with this data, and it should be looked into further). In the right branch beside this mid channel connection, Benotia, the near bank bed levels do not appear to be deepening (**Error! Reference source not found.**).

Overall erosional trends are also predicted in the Solimabad channel; however, the channel does not appear to be taking more flow (**Error! Reference source not found.**). The floods which have been run are higher floods, and sothese results are dramatic developments.

Bank erosion has been added to the model manually by cutting back the banks in erosion prone locations and adding an equivalent amount of sediment into the river beside the bank erosion location. This has been done on both sides of the bifurcation, in the Solimabad channel and on the first outer bend of the right branch. A high flood has been modeled with and without bank erosion. The comparison of cumulative discharge and bed load transport through various cross sections can be seen in **Error! Reference source not found.** and **Error! Reference source not found.** respectively. As shown in the tables, it appears that the added sediment caused from the bank erosion on the right bank at the bifurcation has deposited at the inlet of the right branch, causing less flow, but more sediment into the branch. This would cause morphological instabilities in the branch. The flow that is diverted from the right branch flows through the cut off at Chauhali. The sediment that has been added to the Solimabad channel reduced flow into the channel.

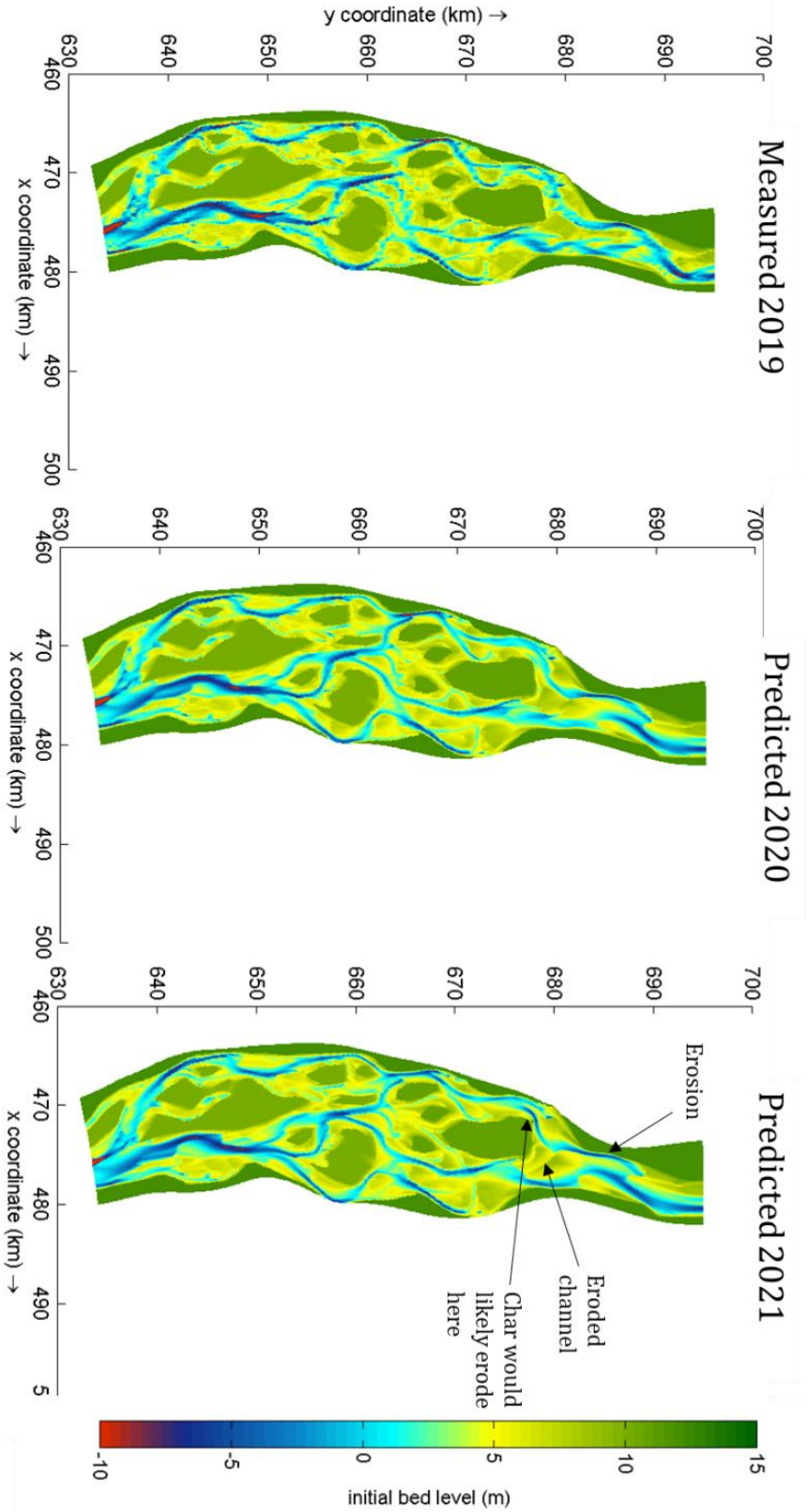


Figure 15: Bed levels of the Lower Jamuna with 2 years of high floods (no intervention works included) (North is to the right)

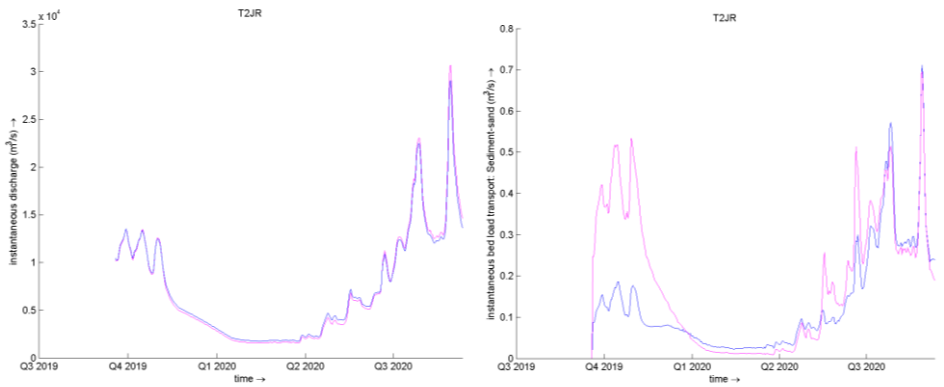


Figure 16: Instantaneous discharge (right) and instantaneous bed load transport (left) through the right branch during the first year high flood (blue) and the second year high flood (pink) (cross section location is shown in Error! Reference source not found.**)**

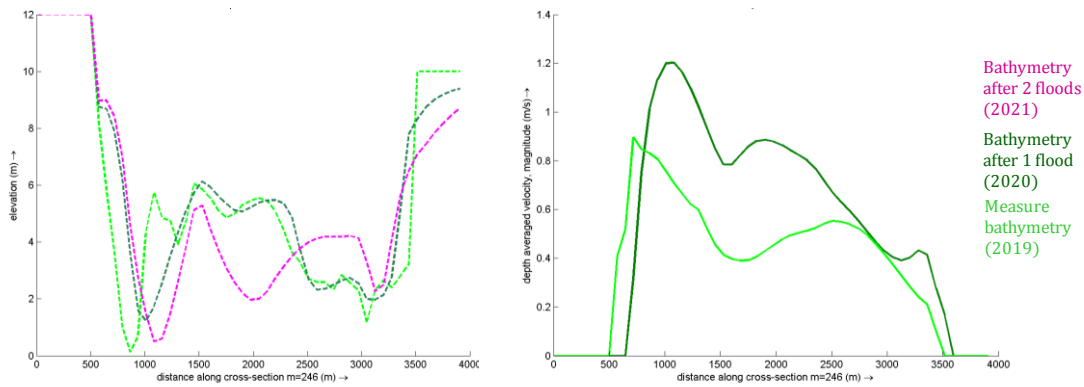


Figure 17: Bed levels (left) and depth averaged velocity (total discharge ~34,000 m³/s) (right) for the cross section at Benotia (right bank is on the left) (cross section location is shown in Error! Reference source not found.**)**

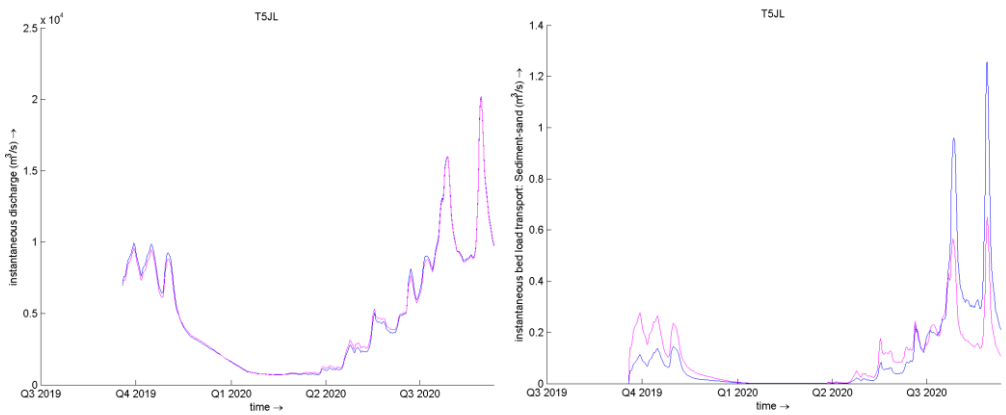


Figure 18: Instantaneous discharge (right) and instantaneous bed load transport (left) through the Solimabad channel during the first year high flood (blue) and the second year high flood (pink) (cross section location is shown in Error! Reference source not found.**)**

Table 9: Effects of bank erosion on the cumulative discharge (measured in km³) that moves through certain cross sections during the modelled 2021 flood season (cross section locations are shown in Error! Reference source not found.**)**

	With bank erosion	No bank erosion

Right branch	206	223
Left branch	397	379
Chauhali cut off	371	354
Chauhali outer bend	27	25
Downstream Chauhali cut off	274	264
Solimabad channel	140	153

Table 10: Effects of bank erosion on the cumulative bed load transport (measured in m^3) that moves through certain cross sections during the modelled 2021 flood season (cross sections locations are shown in Error! Reference source not found.**)**

	With bank erosion	No bank erosion
Right branch	1,685,151	1,652,386
Left branch	19,153,646	15,113,811
Chauhali cut off	9,178,969	6,651,514
Chauhali outer bend	95,407	88,191
Downstream Chauhali cut off	6,545,761	6,060,960
Solimabad channel	1,472,202	3,182,972

5.4 Morphological developments with interventions

Interventions include the upstream bank protection with dredging and the Solimabad closure dam. **Error! Reference source not found.** shows the initial works and the bed levels after different flood seasons. Comparison of the cumulative sedimentation and erosion in the left branch can be seen in **Error! Reference source not found.** and values of the cumulative discharge and bed load transport for the intervention works can be seen in **Error! Reference source not found.** and **Error! Reference source not found.** respectively.

Upstream dredging for the bifurcation bank protection is useful for several reasons. First, it would provide a higher factor of safety for the bank slope. Field observations have shown that revetment works all along the Jamuna and Padma rivers often have geotechnical failures when there is significant attack of the river on the bank. Second, the dredged channel would bring flow back to the outer Chauhali bend. This would be an ideal development because of the communities on the old central char that are being eroded as a result of the cut off. Additionally, more flow moving through the cut off may lead to undesirable widening of the right branch. The dredged channel does lead to less flow moving through the Chauhali cut off and less flow in the right branch (**Error! Reference source not found.** and **Error! Reference source not found.**). The Chauhali dredged channel brings flow into the upper Chauhali bend, which would otherwise be dry. This is especially important during the draw down of the flood from October to December when erosion rates are high.

A main concern of the dredged channel would remain open and continue to bring flow back through the Chauhali bend. The Capital Dredging project dredged a 200 m channel upstream of the Jamuna Bridge which widened to 700m (NHC and EMM 2019a); however, an unfavourably placed dredged channel can also easily fill by the river. Currently, there is a channel along the entire Chauhali bend, but it is shallow at the upstream end. It may develop with the help of dredging because of the deep channel downstream at Chauhali which attracts flow during the draw down of the flood when the river's self dredging ability is the highest. The model shows that the dredged channel does develop and remain open during a flood season (**Error! Reference source not found.**); however, sedimentation does occur at the upstream portion of the left branch (an inner bend), which may fill up the dredged channel (**Error! Reference source not found.**). Sedimentation at this location has also been seen in the field. The dredged channel on the right bank has remained open, because there is still high flow attack along this bank.

The closure dam creates favourable morphological developments in the Solimabad channel. While a deep channel does develop at the closure dam in the overtopping section, there is no erosion in the downstream channel (**Error! Reference source not found.**). Solimabad closure dam slows velocities in the channel in both the dry season and the flood season which would prevent bank erosion downstream in the channel (**Error! Reference source not found.**). The velocities over opening in the Solimabad closure dam reach ~2.5-3 m/s during the flood season and fall to ~0.5-1 m/s during the dry season.

Since the model does not capture dry cell erosion, the closure dam at flood plain level would erode more than what is predicted by the model, likely causing the adjacent deep channel to be shallower. Even if the closure dam erodes, studies have shown that bars move ~ 2 km/flood season on average (NHC and EMM 2019b) and so the added sediment would remain in the channel.

The numerical models were also used to determine whether the upstream dredging will cause unfavourable changes for closing the Solimabad channel. **Error! Reference source not found.** and **Error! Reference source not found.** show that the dredging work does not lead to significantly more flow going into the Solimabad channel possibly because the cut off still carries a significant amount of the flow. The Solimabad closure dam reduces the flow through the channel and increase sedimentation. Average bed levels in Solimabad channel are predicted to increase by ~30 cm during the 2021 flood season with work (without work it is expected to remain constant).

The model shows that the Solimabad closure channel creates backwater effects in the upper section of the Lower Jamuna, particularly the left branch (**Error! Reference source not found.**). The backwater effect is increased with the upstream dredging because of the extra flow that is drawn into the left branch. This may lead to more flow in the right branch. This backwater effect is also seen in the low flood scenario. This backwater effect will impact the river for a short period of time before the river adjusts.

The intervention works would decrease the flow through the mid channel connection (**Error! Reference source not found.**). Longer bifurcations are more stable (NHC and EMM 2019b) and so preventing this connection from widening would be favourable for the overall stability of the Lower Jamuna. The reduction in flow that moves through this channel is likely resulting from the backwater effect that is caused from the closure of the Solimabad channel.

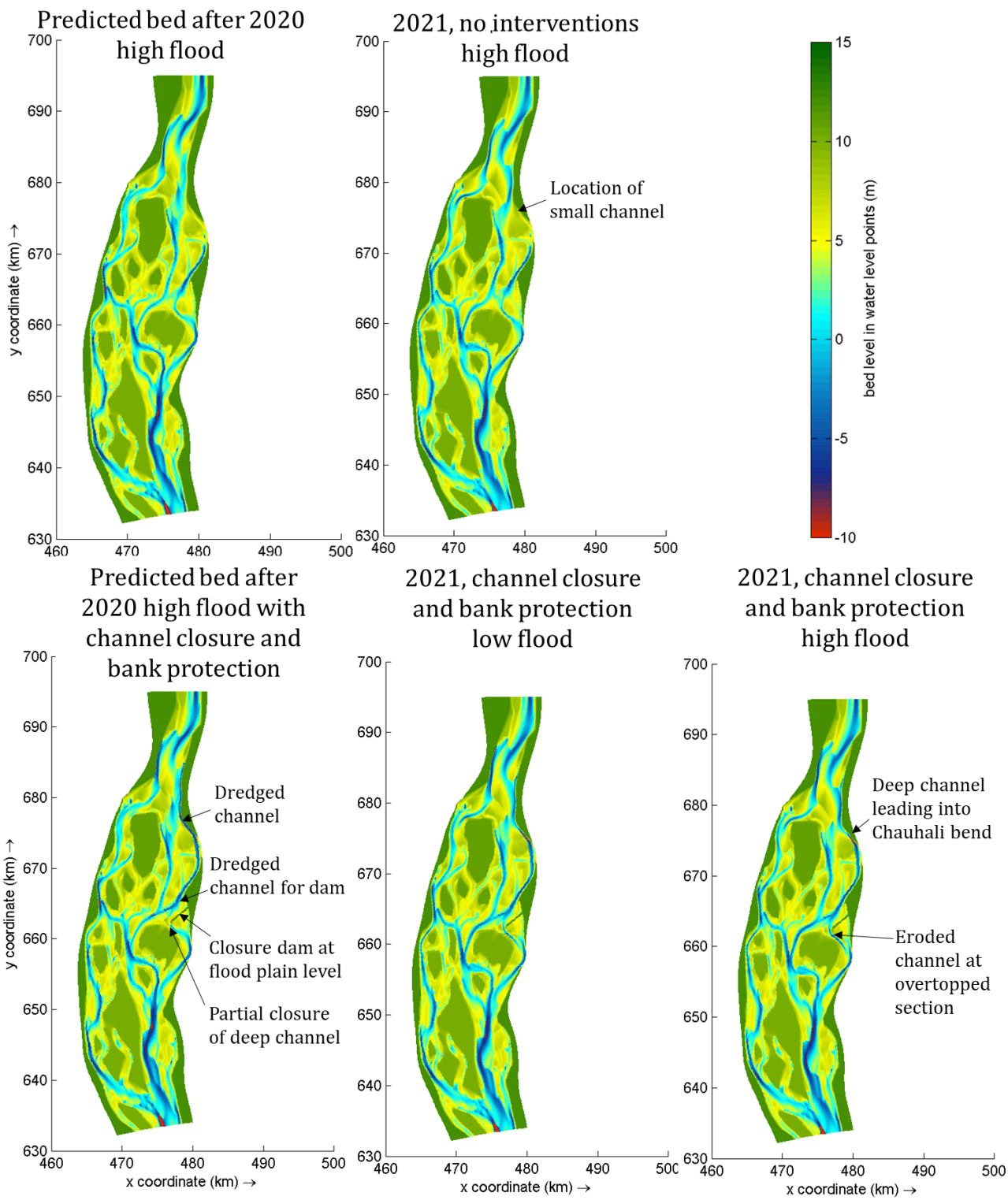


Figure 19: Bed levels with all interventions

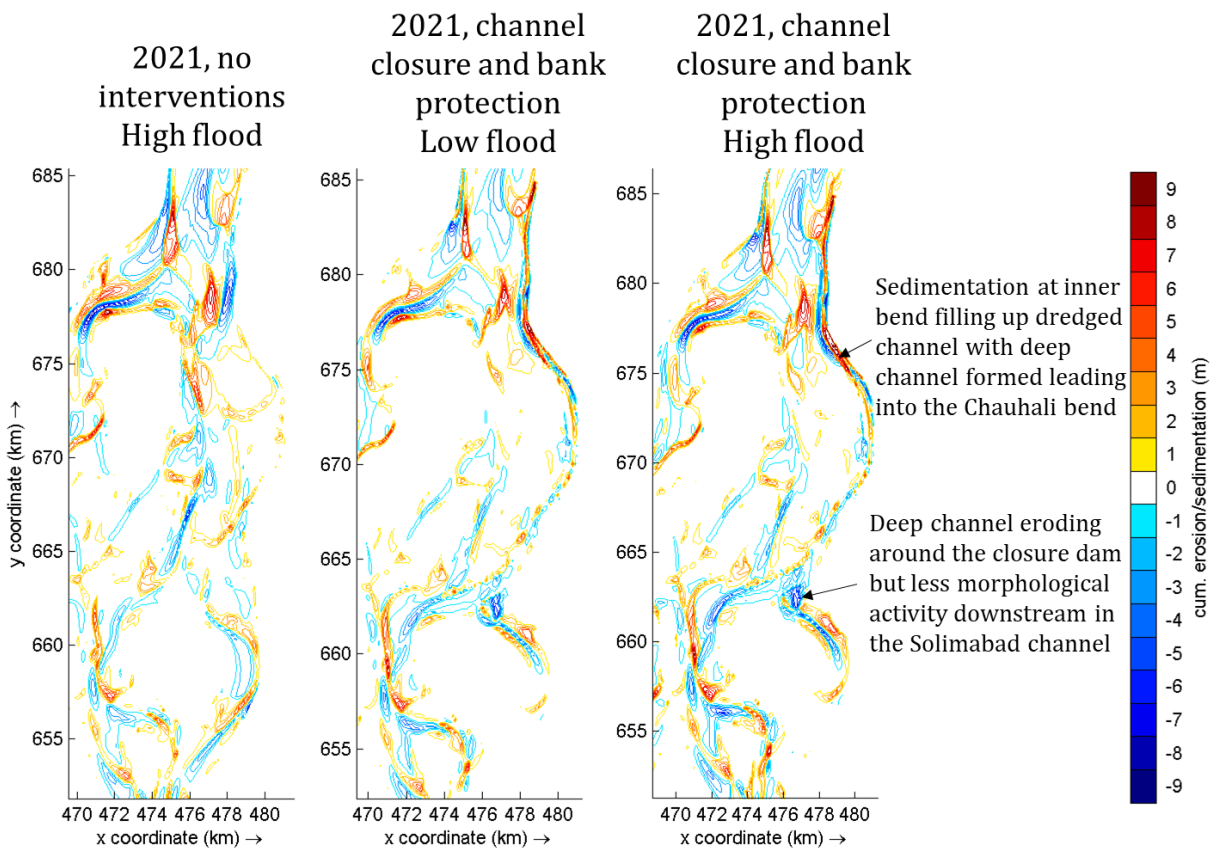


Figure 20: Cumulative erosion and sedimentation in the left branch with and without intervention works

Table 11: Effects of intervention works on the cumulative discharge (measured in km^3) that moves through certain cross sections in the modelled 2021 high flood season (cross section locations are shown in Error! Reference source not found.**)**

	No interventions	Channel closure	Channel closure and bank protection
Right branch	223	225	207
Left branch	379	377	396
Chauhali cut off	354	351	255
Chauhali outer bend	25	25	140
Downstream Chauhali cut off	264	268	232
Solimabad channel	153	96	97

Table 12: Effects of intervention works on the cumulative bed load transport (measured in m^3) that moves through certain cross sections in the modelled 2021 high flood season (cross section locations are shown in Error! Reference source not found.**)**

	No interventions	Channel closure	Channel closure and bank protection
Right branch	1,652,386	5,729,892	4,670,766
Left branch	15,113,811	14,245,664	9,741,263
Chauhali cut off	6,651,514	6,050,615	2,605,461
Chauhali outer bend	88,191	77,338	772,913
Downstream Chauhali cut off	6,060,960	5,883,325	4,101,195
Solimabad channel	3,182,972	1,437,101	1,455,101

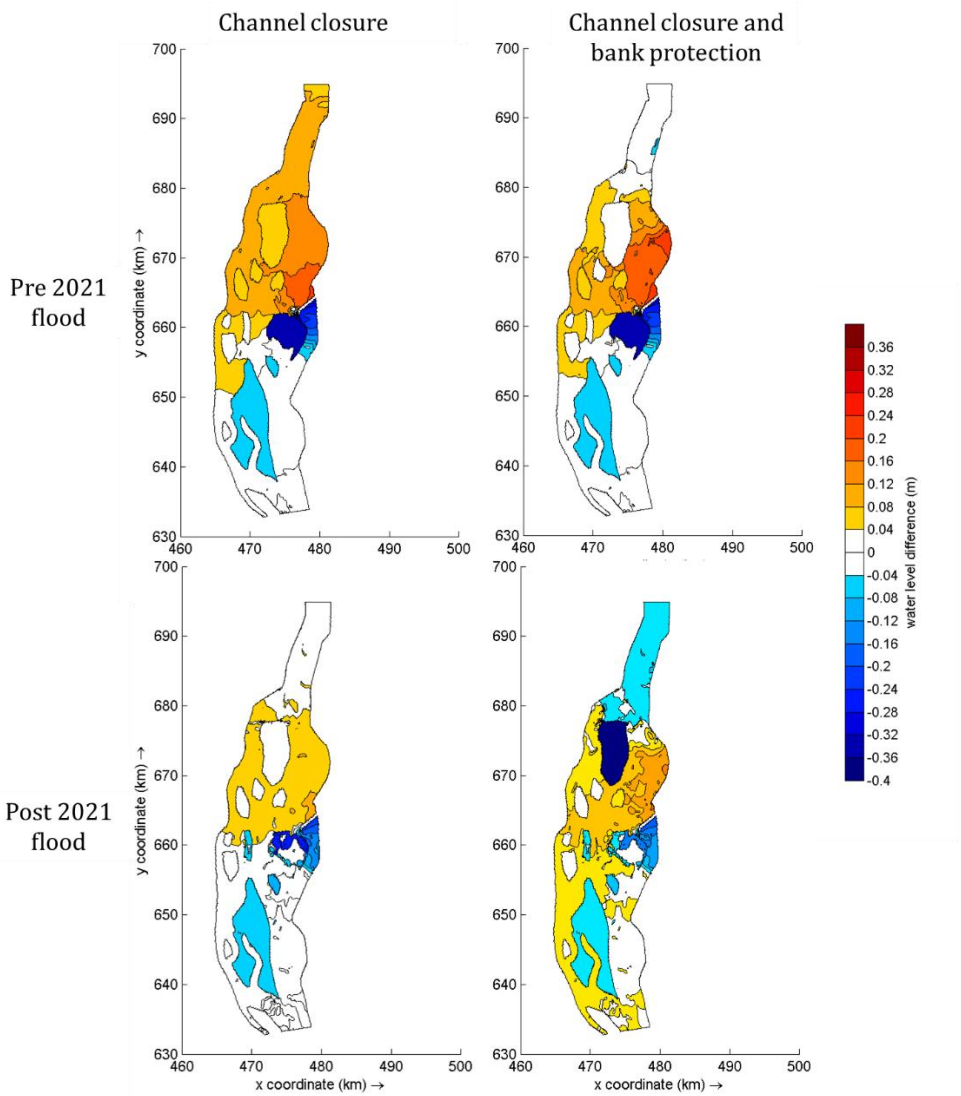


Figure 21: Water level difference compared to model with no intervention works

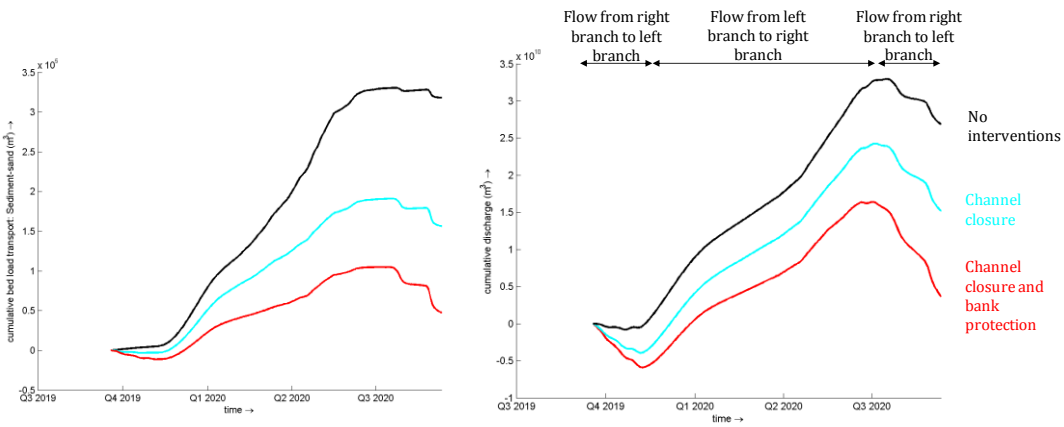


Figure 22: Effect of intervention works on mid-channel connection

5.5 Dredging capabilities

Dredging volumes are limited by dredging capabilities. At the bifurcation, the dredging volumes could be reduced by dredging only the shallow sections along the left bank (**Error! Reference source not found.**). The required dredged volumes for the lowering of the apron elevation for bank

protection (**Error! Reference source not found.**) are shown in **Error! Reference source not found.**. By using dredging to lower the constructed apron, the factor of safety of the revetment increases. The values in **Error! Reference source not found.** do not include over dredging required because of inaccuracies and scour reduction. Scour reduction is the reduction of the river's self scouring ability because of the increase in the wet cross section. A medium sized dredger can dredge 1.5 Mm^3 in 2 months (approximately half the length of time dredging is possible in the Jamuna). Five medium sized dredgers would be required to dredge the 13 Mm^3 of sand in one dry season. The dredged spoils could be used for embankment construction. Additionally, the Solimabad channel closure would call for another ~3 Mm^3 of dredged sand requiring one more medium sized dredger. Backfill could be a problem for the upstream dredged channel and further dredging could be required, especially at the upstream bend along the left bank. Further dredging would be required in subsequent years for the Solimabad closure dam to completely close the channel.

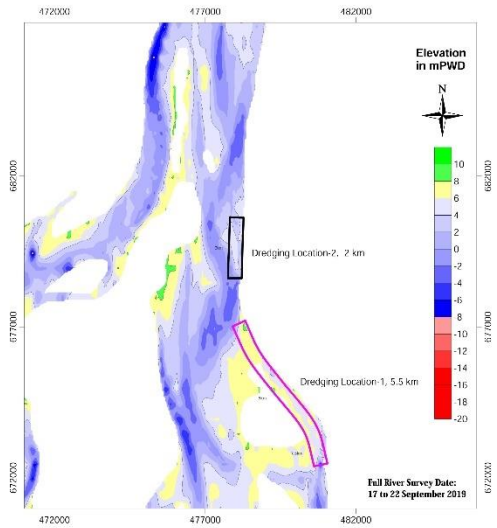


Figure 23: Dredging locations along left bank of the bifurcation

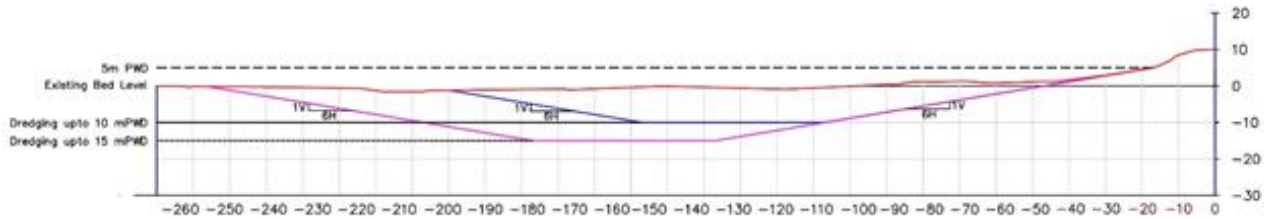


Figure 24: Dredged channel for bank protection, shown reaching -15 mPWD (pink) and -10 mPWD (blue)

Table 13: Dredged volumes required (in m^3) (based on September 2019 bed levels)

	5.5 km	7.0 km
Dredge to -10 mPWD	13 million	16 million
Dredge to -15 mPWD	20 million	26 million

6 Concluding remarks

Conclusions from the result are listed below. These results pertaining to the planned works should be revisited next year in order to assess the situation using updated bathymetry after the 2020 flood season. Details such as the connection of the Old Dalashwari in two places along the left branch at the bifurcation should also be considered.

- The right branch appears to continue to increase in conveyance, particularly for low flows. Bank protection at the bifurcation is critical for stabilization of the branches. Further enlargement of the right branch may be spurred on by the Chauhali cut off development and bank erosion of the right bank of the bifurcation. Stabilization of the Lower Jamuna is dependent on the stabilization of the banks at the bifurcation.
- The mid channel connection (east of the Hurasagar mouth, see **Error! Reference source not found.**) is developing. Flow travels in both directions through this channel depending on the discharge.
- The cut off at Chauhali continues to enlarge; however, a channel remains along the bank and could possibly develop with the help of dredging.
- The Solimabad channel is not enlarging. This would be a good time to attempt to close the channel. The Solimabad closure dam would prevent bank erosion downstream. Bank protection would not need to be built in the channel in a successful closure dam is built.
- An upstream dredged channel appears to increase flow along the Chauhali bend, but the risk of infill of the channel should be closely evaluated. This could be a development that could be studied with higher resolution, local models.
- Morphological developments in the Lower Jamuna occur quickly, and consequently, delays in project timelines can cause planned works to become irrelevant and makes larger scaled planning difficult.
- At Benotia there is a risk of the embankment eroding, but the location will not be under extreme erosion attack from the river and so lighter protection of the bank may be adequate.

Improvements in modelling results could be obtained if there was refinement of surveyed bathymetry data (this is limited by the time it takes to survey the river; however, smaller local models can be built) and if a number of modelling parameters, for example the slope stability factor was calibrated using a large set of data. Additional improvements could be made if the elevation of the chars and floodplain were measured and included in the simulations. Certain phenomenon could be studied, such as the 2019 flood having lower water levels compared to the 2017 flood, despite having higher peak discharges. This may possibly be the result of floodplain flow; however, to capture this correct elevation of floodplain and char elevations is necessary. As well, inclusion of bank protection structures would improve the model results, especially if dredging is involved.

7 References

NHC and EMM, 2019a. Feasibility study, Design Report Annex 5 Appendix F. Prepared for the Bangladesh Water Development Board for the Flood and Riverbank Erosion Risk Management Investment Program.

NHC and EMM, 2019b. River Stabilization and Development Supplementary Annex C4: Reach 3 and bifurcation: numerical modelling. Prepared for the Bangladesh Water Development Board for the Flood and Riverbank Erosion Risk Management Investment Program.

NHC and EMM, 2019c. River Stabilization and Development Supplementary Annex A4: Inland Navigation- Past, present and future expectation. Prepared for the Bangladesh Water Development Board for the Flood and Riverbank Erosion Risk Management Investment Program.

NHC and Fichtner, 2015. River bank improvement program, Annex 2 Vol 2 Hydrology and flood assessment. Prepared for the Government of the People's Republic of Bangladesh Ministry of Water Resources.

Appendix-L
Geotechnical Review of Riverbank Protection at Upstream Chauhali (Draft)

1 Introduction

Bangladesh Water Development Board (BWDB) under the Ministry of Water Resources, Government of Bangladesh, has undertaken a project entitled "Flood and Riverbank Erosion Risk Management Investment Program (FRERMIP) Project 1" with the financial assistance of Asian Development Bank (ADB) and the Government of the Netherlands. BWDB has engaged the Joint Venture of NHC, Canada and Euroconsult Mott MacDonald, The Netherlands in association with Deltares NL, RPMC CEGIS for the consultancy services (ISPMC) of the Project.
This technical note has been prepared by the ISPMC and discusses the geotechnical analysis carried out for the design of the riverbank protection works which were implemented under Tranche 1 at the left bank of the Jamuna river at Chauhali and the design changes that are proposed at the upstream site in Tranche 2 as shown in Figure 1-1 below.

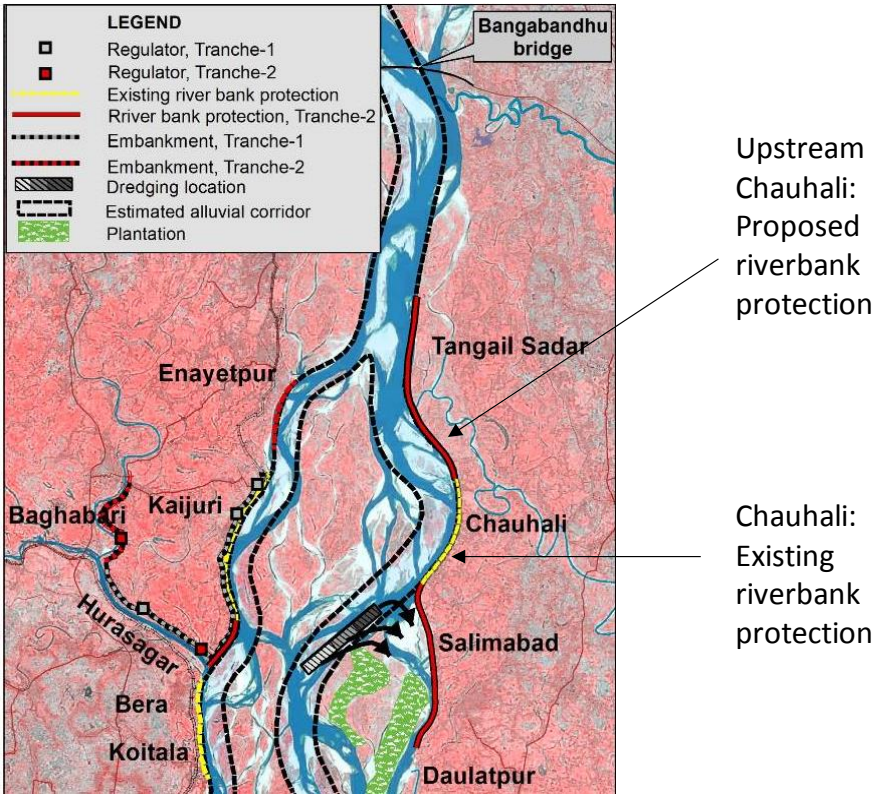


Figure 1-1 Location plan of existing and proposed riverbank protection works

2 Context

Bangladesh is one of the largest deltaic environments in the world with large unstable rivers capable of eroding hundreds of metres of bankline per year. Satellite image-based riverbank erosion analysis since 1973 indicates that up to over 5,000 hectares of floodplain land have been lost annually,

affecting an estimated over 55,000 people[5]. Over the last two decades, during the beginning of the 21st century, erosion rates have declined to approximately 2,000 ha per year annually. Two main factors contribute to this decline: (i) the sediment wave triggered by the Great Assam earthquake in 1950 has largely passed the country, and (ii) increasing investment into riverbank protection has reduced the vulnerable length of banklines.

Riverbank protection creates a boundary between the highly erodible floodplain soils and the river and consists of two distinct types of protection as follows:

- Upper Slope Protection – This protection sits largely above the low water level (usually during the dry season from November to April) and primarily resists wave loading, the majority of which occurs during the flood season (June – September). This slope treatment has typically consisted of individual pre-cast concrete blocks as per Figure 2-2 but also has included grout filled mattresses and sand-filled geotextile bags (geobags)
- Lower Slope Protection – This protection lies below the low water level to resist river erosion. Due to the large theoretical scour depths of the river (more than 30m) and high dredging costs, it is necessary to use launching aprons because they are capable of reaching greater depths at a lower construction cost. The process of launching was described by Inglis in 1949 through the sketches in Figure 2-1 below. These show the slope scouring and the protective elements being undercut and subsequently 'launching' to greater depths until they cover the slope in a maximum of 1 layer thickness.

[5] FRERMIP River Study Technical Note 2: Holistic River Morphology Analysis for the Brahmaputra River System

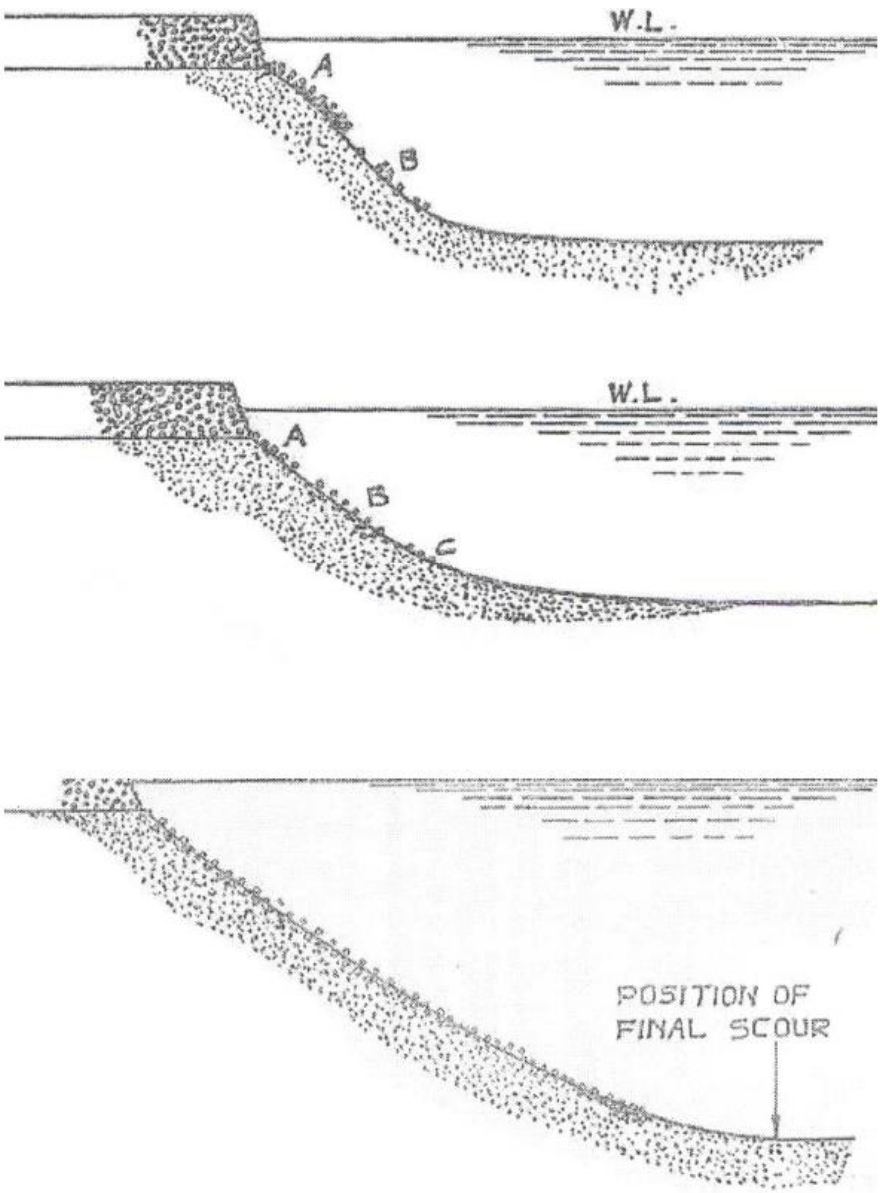


Figure 2-1 Launching process of protective elements to design / final scour level ((Inglis, 1949)

Traditionally these falling elements have been either rock, geobags or concrete blocks. Recently combinations of geobags and concrete blocks have also been proposed (River Research Institute, 2016). Extensive applications and model testing have shown that geobag aprons launch at approximately a 1V: 2H slope in a single layer and that further material must be dumped on launched slopes to prevent winnowing failure through any gaps in the launched elements. This additional dumping is referred to as adaptation works and allows stable construction to greater depth. One layer launching behavior has also been observed for tests in combinations of geobags and concrete blocks (River Research Institute, 2016).

Figure 2-2 Upper Slope Protection (left = concrete block revetment, right = grout mattress)

The riverbank protection at Chauhali was constructed from 2014 to 2016 and consisted of concrete block wave protection with underwater slope protection and a falling apron of geobags. Following a series of failures of the upper slope, a revised riverbank protection design was proposed by the BWDB to provide a more robust protection by using an equal volume of concrete blocks underlain by geobags as the falling apron (see Figure 2-4). This is designed to launch to the full scour depth without adaptation works (River Research Institute, 2016). No changes were made to the upper slope which remains as a concrete block revetment at 1V : 3H and therefore this note also aims to review the stability of this slope and propose an alternative gradient if necessary.

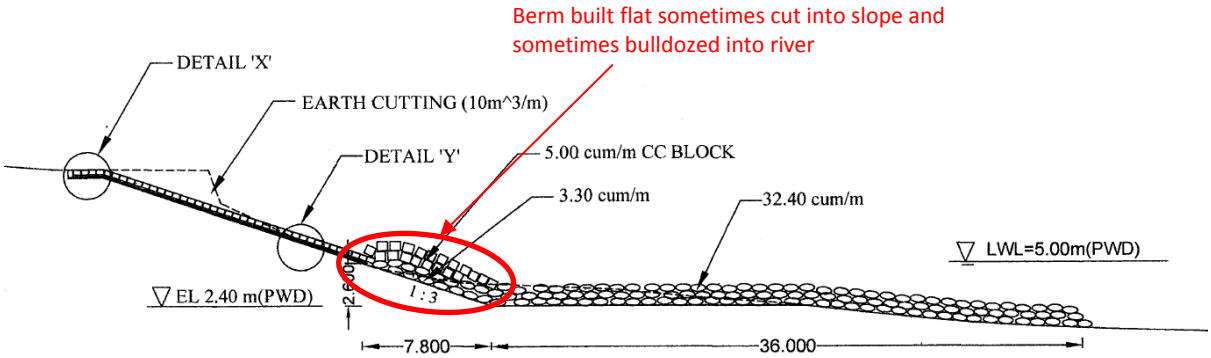


Figure 2-3 Original Design under Tranche 1 (Berm was built flat following design changes during implementation)

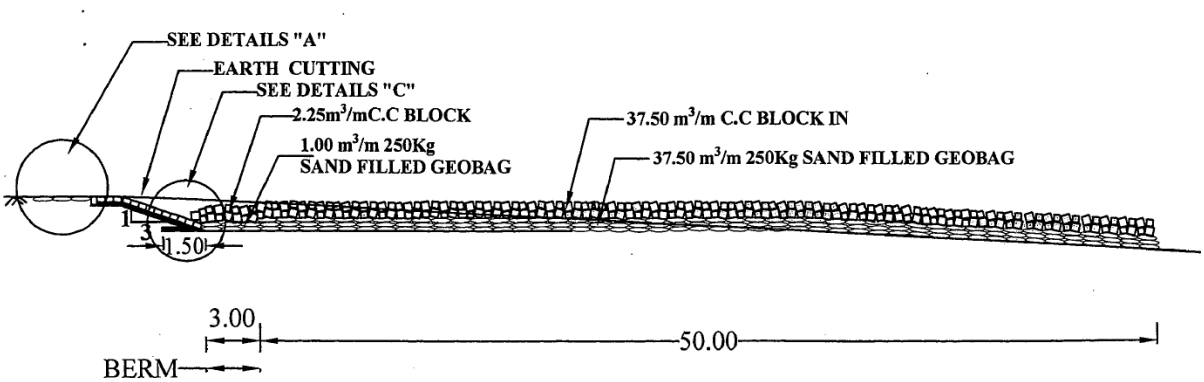


Figure 2-4 Updated BWDB Design for Tranche 2

The model study carried out by the RRI (River Research Institute, 2016) showed that a 1:1 mix of concrete blocks and geobags launched at a slope of 1V: 1.9H and in single layers comprising strips of

each element type i.e. geobags and concrete blocks clumped together in distinct regions as shown in Figure 2-5 below.

Figure 2-5 Graded element launching behavior in strips (River Research Institute, 2016)

Geotechnical investigations were carried out following the upper slope failures at Chauhali. This data is used to evaluate the global geotechnical slope stability of this new design to reduce the chance of geotechnical failure in the future. It can also be used to optimize the design approach of riverbank protection in Bangladesh, which typically does not include geotechnical investigations nor considers geotechnical stability.

Numerous failures were noted in Chauhali under the FREMRIP project in addition to others in recently built BWDB work along the Jamuna river. Anecdotally these are known to occur in the first 1-3 years following construction after which there are usually very few or no failures. Therefore, constructing the upper slope or wave protection out of geobags in the temporary case and replacing these with hard protection after a number of years may be a more durable design philosophy in addition to changing the slope gradient as necessary.

3 Standards Used and Sources of Data

The geotechnical slope stability analysis of different design options for riverbank protection at Upstream Chauhali under FRERMIP Tranche 2 was carried out using Geostudio (Geostudio Limited, 2019). This numerical analysis software includes limit equilibrium stability analysis and seven finite element applications for modelling geotechnical and earth science problems. Limit equilibrium analysis considers the point at which the limit of stability after which it will become unstable or fail. For slope stability analysis, the limit equilibrium (Morgenstern-Price) Method is used and nominal cohesion (up to 1 kPa) is included where necessary to prevent model instability. This method is more accurate than the Modified Bishop method in cohesionless and granular soils which are more likely to fail in sheet failure.

Slip optimization has also been used to model non-circular slip failure. The optimization process divides the critical slip surface into a number of straight-line segments which are individually modified through an iterative procedure based upon the Monte Carlo method to evaluate the potential for a lower factor of safety.

Geotechnical parameters are based on data from the geotechnical investigation carried out in February 2018 by Prosoil Ltd where possible.

The calculation of the maximum scour depth of the launching apron is based on the guidelines given in ‘Guidelines for Riverbank Protection’, BWDB 2010 and field experience from the Chauhali riverbank protection constructed under Tranche 1 of the project.

4 Factor of Safety

In order to assess the geotechnical safety of the proposed riverbank protection against different geotechnical failure mechanisms, analyses consider a minimum required factor of safety which must be met. This factor of safety represents the ratio between the driving forces (that may otherwise lead to failure) and the resisting forces (which provide resistance to prevent failure from occurring).

$$Factor\ of\ Safety\ (FOS) = \frac{Resisting\ Forces}{Driving\ Forces}$$

The required safety factor for normal/ frequent loading conditions is 1.5. For temporary loading, such as earthquake loading, the factor of safety of 1.25 may be accepted according to the Design Guidelines for Riverbank Protection (Bangladesh Water Development Board, 2010). Where possible, these standards have been evaluated against the International Levee Handbook (CIRIA, 2013) as presented in Table 5-1. As the application of seismic loads in a pseudo-static way is not fully representative of the dynamic loading it is recommended that further study is carried out to determine other important factors including the liquefaction potential and displacement calculations to quantify seismic risk. Therefore, there are no recommended factors of safety for pseudo-static seismic vulnerability calculations in the Levee Handbook. In the absence of such displacement calculations and at this initial design stage it is recommended that a safety factor of greater than 1.1 is used for this conservative representation of the earthquake loading subject to future detailed design. This is lower than the BWDB recommended value (Bangladesh Water Development Board, 2010) but in line with international best practice.

A summary of the required safety factors based on the BWDB Design Guidelines and international best practice is summarised in Table 5-1 below.

5 Load Cases

For this analysis, five load cases have been modelled, 3 of these relate to the stability of the upper slope (the slope which largely sits above low water level) while 2 relate to the launched slope (launched elements below low water level). The launched slope analysis does not consider anything in the top 2m of soil which has launched and therefore by definition has a limit equilibrium of 1 and therefore looks at the global check of the whole underlying slope and the ultimate limit state.

As the upper and lower slopes are geotechnically separated by a large apron of dumped geobags, the stability of the upper slope was found to be independent of the lower slope and so the upper and launched slope stability is assessed separately. The independence of the two slopes can be shown through the modelling of a large surcharge equivalent to 4m of concrete blocks placed on the slope. The factor of safety found for the lower slope with and without concrete blocks is the same in both cases when the surcharge is more than 5m from the edge of the slope.

The berm plays a significant role in the stability of the riverbank protection with the most stable case being a berm which is a minimum of 5m wide and which is excavated into the existing consolidated riverbank soils as shown in Figure 5-1 below. Figure 5-2 and Figure 5-3 show less stable cases where there is no defined berm or where the berm consists of temporary geobag protection and soil that is bulldozed into the river and upon which concrete blocks are dumped as was the case in some sections of the Tranche 1 Chauhali riverbank protection. This loose material is subject to erosion and collapse resulting in gaps in protection and associated upper slope instability.

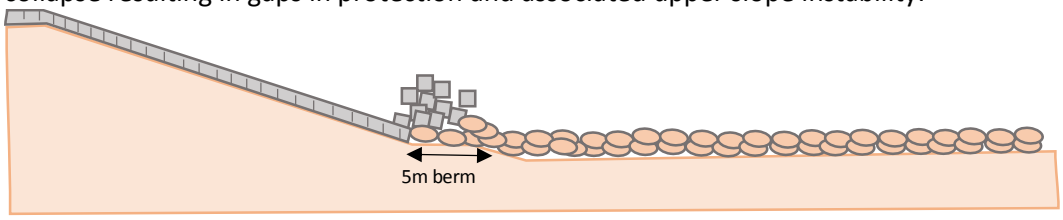


Figure 5-1 Most stable: 5m berm built into existing riverbank

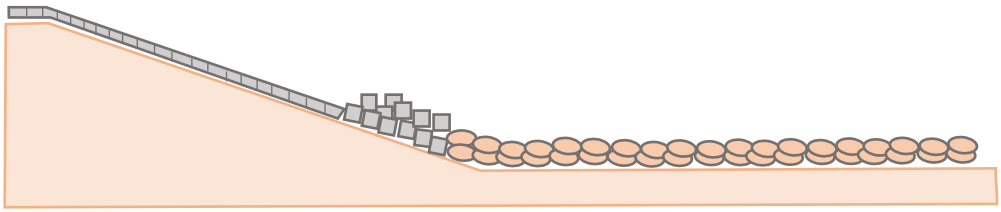


Figure 5-2 Less stable: No defined berm between upper and lower slope protection

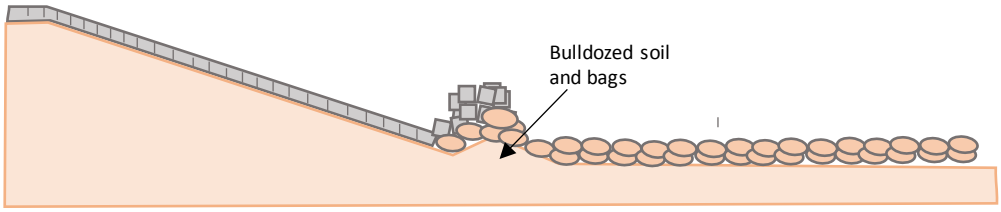
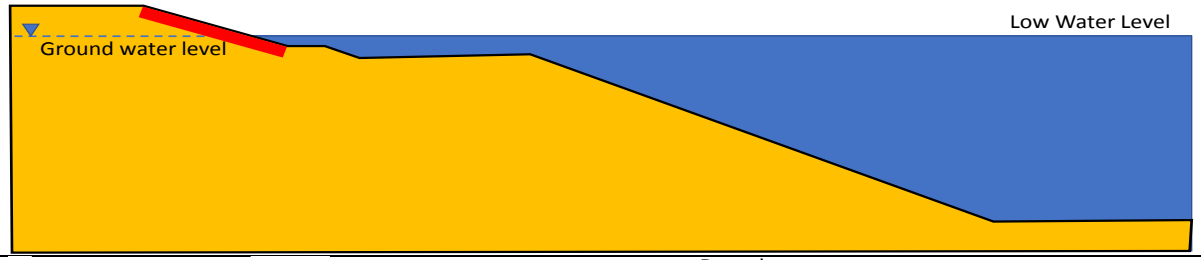
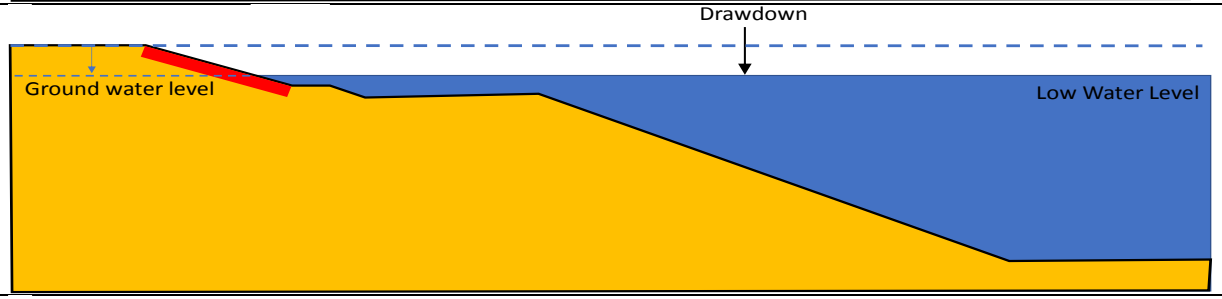
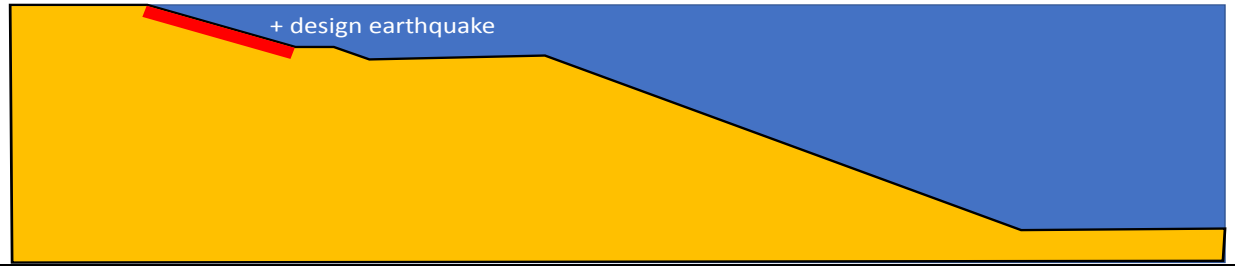
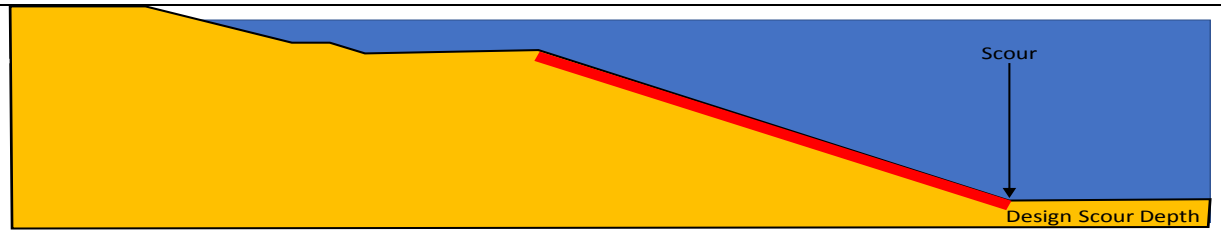
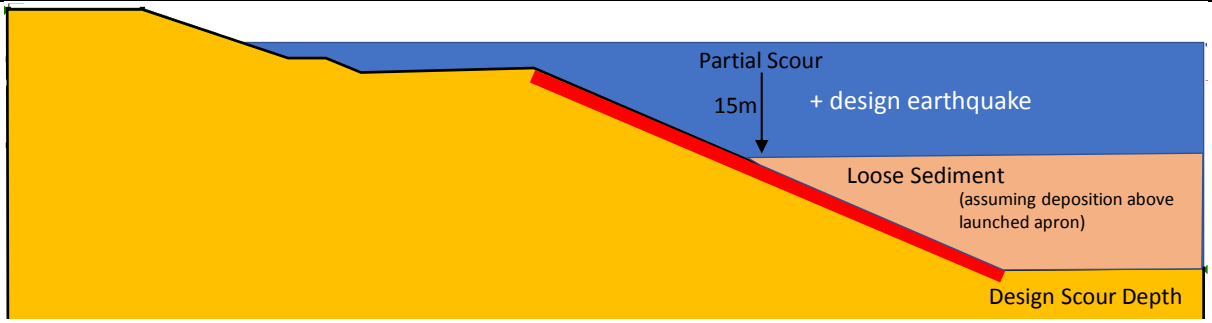


Figure 5-3 Less stable: Bulldozed soil and geobags forming berm on riverside and vulnerable to erosion and associated upper slope instability

Table 5-1 Load cases modelled

Load case	Slope stability	Sketch (Red line shows slope assessed for stability)	Description	Required Factor of Safety (BWDB 2010)	Required Factor of Safety (CIRIA, 2013)
1	Upper slope		Design low water level in the river and the ground water table at the same level	1.5	1.4 – 1.5
2	Upper slope		Rapid assuming a drawdown rate of 0.6m per day (flood plain saturated)	1.5	1.2 – 1.4
3	Upper slope		Impact of design earthquake (see Section 8.3) at bankfull water level.	1.25	n/a – deformation limited to 1 ft vertical settlement and 3ft horizontal

4	Lower slope		Design flood level and the permanent loads on the fully launched lower slope.	1.5	1.5
5	Lower slope		Design earthquake (see Section 8.3 with 15m scour and sediment deposition on launched slope).	1.25	n/a – deformation limited to 1 ft vertical settlement and 3ft horizontal

6 Analysed Concepts: 'Adaptive Approach' and BWDB 'No Regret Approach'

The geometry for the options considered a fully developed case in which the launching apron has launched to the full design scour depth as follows:

- The adaptive approach (Option 1) design scour depth was calculated using Lacey's theory to be -27m PWD (32m below low water level) at Upstream Chauhali which is to form a part of the Tranche 2 works. A launching of 15m in the first season is considered to mimic actual conditions found at Chauhali in one flood season as a conservative scenario. For reference, the design launching before adaptation works should be carried out is 10m.

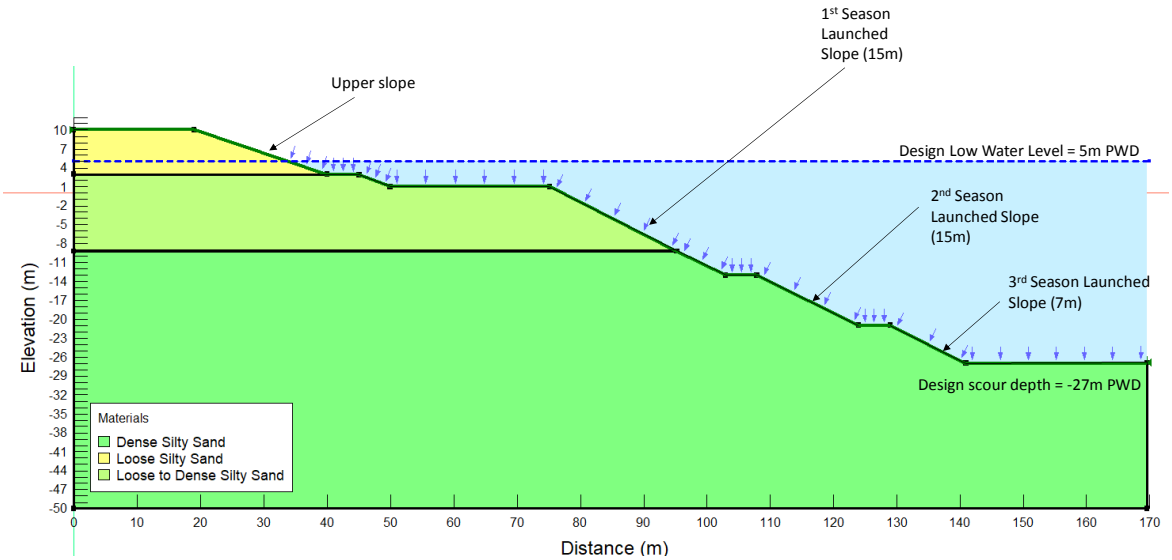


Figure 6-1 Option 1: 'Adaptive Approach' Geometry

- Option 2, the BWDB 'No Regret Approach' follows the Water Development Board Design Office Proposal. No design report nor design calculations were made available, and consequently the maximum scour depth was taken to be the same as for option 1 as agreed by the SE Design in the meeting on 16th October 2018.

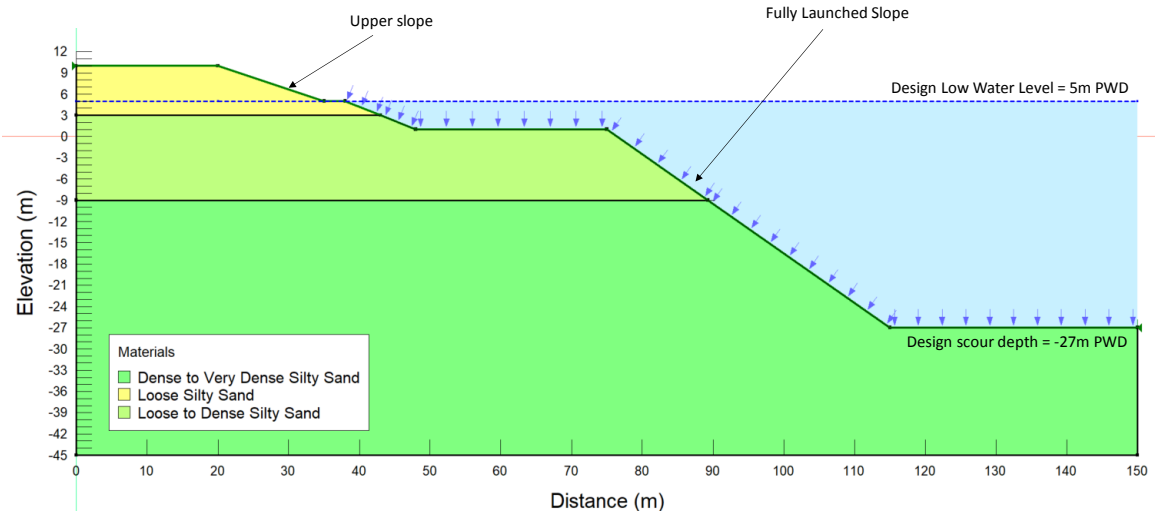


Figure 6-2 Option 2: 'No Regret Approach' Geometry

7 Material parameters

7.1 Friction Angle

The angle of friction has been taken from an average of the SPT N-60 values as determined following field SPT testing using the equations given in the Bangladesh National Building Code and verified using the guidance in British Standard 8002-1994 Section 2.2.4. In addition to being corrected to find N-60 from the N values measured in the field, an additional correction factor is used to account for the negative excess pore water pressure during driving (Craig, 2004).
The unit weight has been approximated based on the range of unit weights given in British Standard 8002-1994 Table 1. Further details about the geotechnical investigation and assumed geotechnical parameters is given in Appendix B.
The summary of material properties used is tabulated below.
Table 7-1: Selected soil properties chart

Depth (m PWD)	Layer Name	Unit Weight, (kN/m^3)	Angle of Friction, φ	Cohesion (kPa)*
3 to 10	In-situ Loose Silty Sand	18	28	0.25
-9 to 3	In-situ Loose to Dense Silty Sand	19.5	30	0.5 - 1.0
-50 to -9	In-situ Dense to Very Dense Silty Sand	20.0	32 - 36	0.5 – 1.0

* Cohesion was used to prevent instability in the modelling where necessary. For all design options except Option 2, the maximum value was 0.5 kPa. For Option 2, the maximum value was 1.0 kPa.

7.2 Volumetric Water Content

The volumetric water content function is estimated using the internal GeoStudio estimation algorithm based upon the grain size data found during the geotechnical investigations in 2018. This method was developed by Aubertin el al for use with basic material parameters but it is important that the final design is based on measured material properties as opposed to estimated ones (Aubertin, et al., 2003).
The values used in this estimation are as follows:

- D10 = 0.001
- D60 = 0.045

8 Design actions and reactions

Only geotechnical stability against slope failure is evaluated. The analysis therefore does not consider other factors such erosion or toe scour which is often considered the most frequent cause of failure of riprap and “also for a wide variety of protection techniques” (US Army Corps of Engineers, 1991) and therefore cannot capture the complexity of the full dynamic river environment. A summary of the most important loads on the works is presented below.

8.1 Soil loading

The dead load of the embankments is taken from the Unit Weights of soils as outlined in Appendix A. No surcharge loads either from the riverbank protection on the upper slope or the underwater scour protection elements were considered in the analysis. While the weight of these may provide some confinement to the slope, they will also reduce the permeability and therefore the effect of these

cannot be verified. In the case of underwater scour protection elements, these are not uniform following launching.
Major geological loads, for example large horizontal loads from stresses locked up in the geological strata are not anticipated in alluvial soils.

8.2 Water

Loads due to the weight or pressure of water are distinct from the effects of pore water pressure on material strength (through the principle of effective stress). The cases considering the design low water level (as set by the Bangladesh Water Development Board at 5 mPWD) and the bankful water levels (10 m PWD) have been considered in the analyses.
For the drawdown case, a maximum drawdown rate of 0.6m per day is based upon water level monitoring data along the Jamuna river (Bangladesh Water Development Board, 2003-2019). The maximum drawdown observed at monitoring stations at either Sirajganj (approx. 38km upstream of the site) and Aricha (approx. 30km downstream of the site) was 1.2m per day in 2009 as shown in Figure 8-1 below however this is significantly above the rest of the data and so is considered an outlier. For this reason, it is recommended that a safety factor of > 1 is acceptable for this load case. A sensitivity analysis of this using SEEP-W and assumed hydraulic parameters was also carried out and found that this assumption leads to a conservative safety analysis.

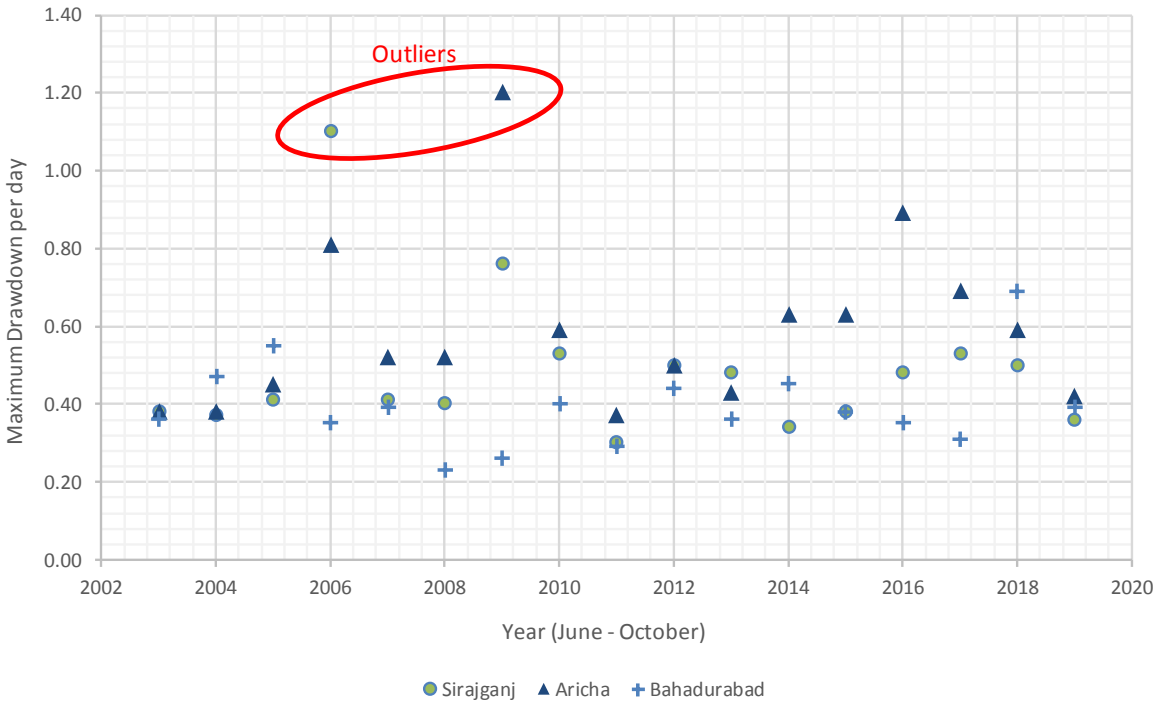


Figure 8-1 Maximum drawdown per year (observed in Sirajganj, Aricha and Bahadurabad monitoring stations, June to October)

8.3 Seismic

Bangladesh is a seismically active area. According to the Bangladesh National Building Codes (BNBC 2015) which classifies the country into 4 seismic zones. Each zone has a zone coefficient (Z) which gives an indication of the Maximum Considered Earthquake (MCE) on very stiff soil/ rock for a 2% probability of exceedance within a period of 50 years (see Figure 8-2). The riverbank protection constructed and proposed in Tranches 1 and 2 are situated in seismic zone 2 with an approximate peak ground acceleration (PGA) of:

Z = 0.2 g

In accordance with the BNBC 2015 code, the design basis earthquake (DBE) ground motion is selected at a ground shaking level that is 2/3 of the Maximum Considered Earthquake.

DBE = 0.13 g = 1.308 m/s

Following this, the pseudo static coefficient was obtained by multiplying by 0.5 in accordance with Eurocode 8 (CEN, 2005) and Hynes-Griffin Franklin 1984 (Hynes, et al., 1984). This gives the resulting pseudo-static coefficient or OBE as outlined in Table 8-1. As an approximation, the horizontal coefficient is assumed to be 50% of the vertical coefficient and to be acting against the self-weight of the soil.

Table 8-1: Proposed Seismic Parameters for Design

Location	Division	Zone factor for MCE	Zone Factor for DBE	Pseudo Static Coefficient for Design for OBE
Chauhali / Chauhali Upstream Riverbank Protection	Manikganj	0.2 g	2/3 * 0.2 = 0.13	0.5*0.13 = 0.06g

Figure 8-2 Seismic Zoning Map from Bangladesh National Building Codes (2015)

International best practice allows for both the pseudo-static and displacement approaches. SP117A from the California Geological Survey (California Geological Survey, 2008) use the pseudo-static analysis as a conservative screening analysis and the recommended value of seismic coefficient is based on a displacement level. It was chosen to adopt a pseudo-static approach.

During a pseudo static analysis, the horizontal pseudo-static force has a larger influence on the Factor of Saftety than the vertical pseudo-static force, as F_h reduces the resisting force and increases the driving force. Thus, the analysis is done for the horizontal pseudo static forces only.
For the seismic loading case, to provide a more realistic case than assuming the slope is fully launched with no sedimentation at the time of an earthquake, a launched depth equivalent to the first year of launching after construction is assumed. Any material between this depth and the maximum theoretical scour depth is assumed to be loose material that was deposited after full launching of the slope as shown in the timeline in Figure 8-3.
An analysis of the launched slopes at Chauhali riverbank protection constructed under Tranche 1 of the Flood and Riverbank Erosion Risk Management Investment Program showed that the maximum scour depth observed in the first year at Chauhali in 2016 was approximately 15m. For this reason, a scour depth of 15m below apron setting level is assumed as an approximate uncovered launched slope length for the seismic load case.

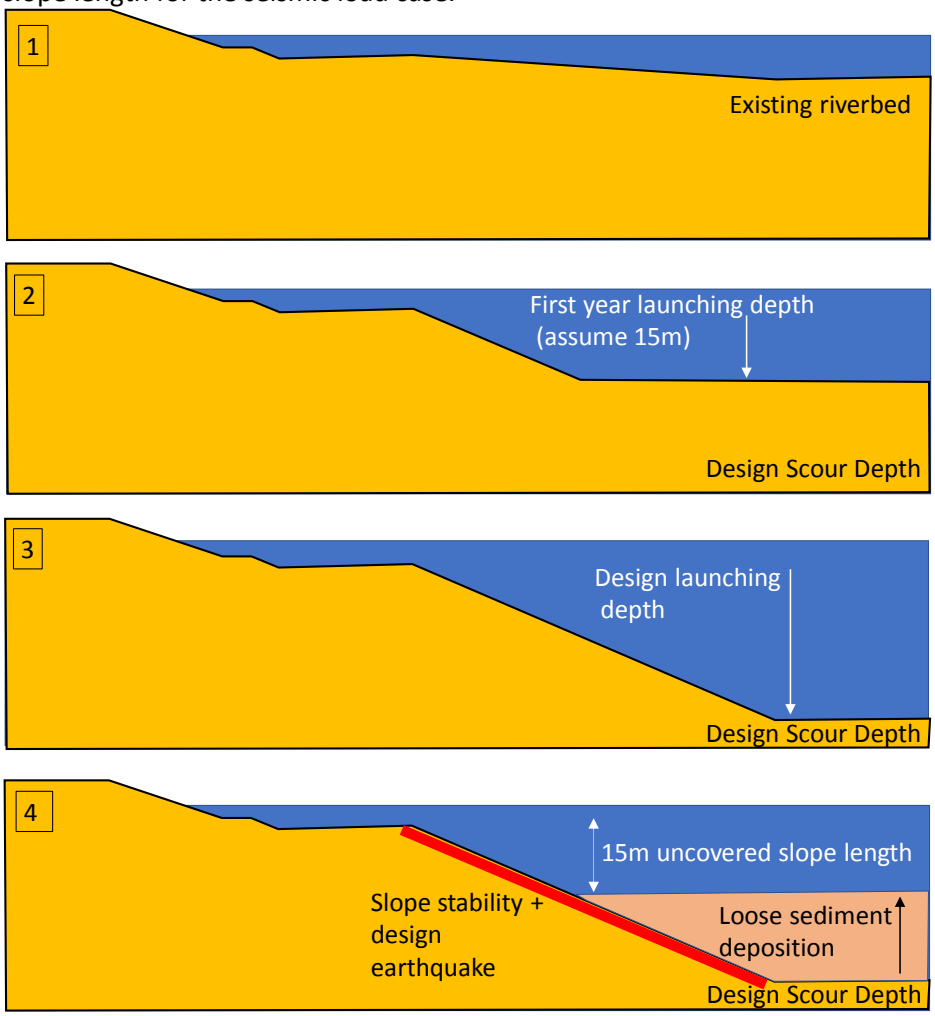


Figure 8-3 Assumed launched slope geometry during seismic loading timeline

8.4 Liquefaction

Other seismic hazards like liquefaction should also be considered for the shallower soils up to 20m in depth. Liquefaction is a process by which non-cohesive or granular sediments below the water table temporarily loose, totally or to a significant degree, their strength when subjected to strong ground shaking during an earthquake. Typically, saturated, poorly graded, loose, granular deposits are most susceptible to liquefaction.
The potential consequences of liquefaction include:

- slope instability (e.g. flow failures and lateral spreading);
- loss or reduction of bearing capacity;
- excessive settlement;

It is recommended that a liquefaction assessment is performed with detailed ground investigation information. Lateral spreading i.e. the lateral movement of gently sloping ground in shallow unconsolidated soils with collapsed settlements in the region of 200 to 300mm will be an issue at the DBE that could not be captured in this analysis.

8.5 Flow Slides

Fitchner et al characterized flow slides of newly deposited char material as common in Bangladesh and associated with fine-grained, poorly graded and loose sand. The slides were generally found to start at the toe of the slope and progress upwards. The likelihood of flow slides is exacerbated by the presence of mica particles even for sands with a higher relative density then is typical for liquefying sands. (JV Ficthner Nhc, 2015). They discussed that these could be caused by factors including rapid dredging or scouring, waves heavy rains, rapid lowering of the river level or apron launching. For dredging or scouring, they noted based on experience at the Jamuna bridge that the inclination of the slope can also play a role. The only possibilities to prevent static flow slides are slow dredging and flat slopes and they found at the Padma bridge that slopes of 1V: 6H were sufficiently shallow to be resistant to flow slides.

8.6 External

External loads are loads imposed on the ground/structure by structures, surcharges, anchorages and other sources. These were not considered during this analysis.

8.7 Temporal e.g erosion and launching

As geobags launch to provide on average a 1-layer coverage, it is essential that adaptation works are carried out to increase the coverage of protective elements following launching and prevent winnowing failure. The effect of erosion at the toe or winnowing failure causing steepening of the launched slopes was not considered and represents a significant risk to the stability of the works. It was found during the Jamuna-Meghna River Erosion Mitigation Project (JMREMP) in 2007 that 3 layers of geobags (2 additional layers placed following launching) were sufficient to prevent winnowing failure occurring underwater by showing through multibeam echosounder surveys that launched slopes with 3 layers of geobags did not steepen over time (see Figure 8-4).

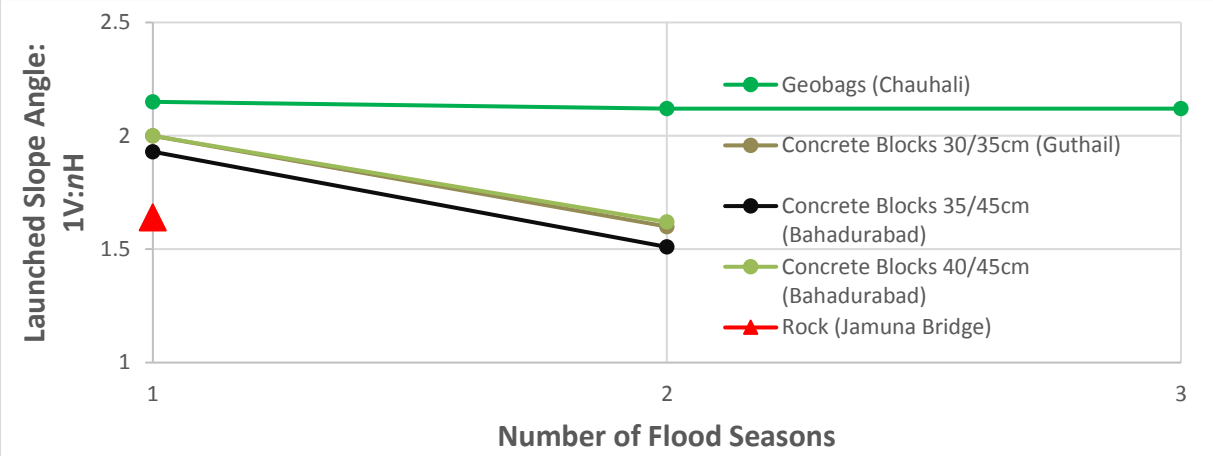


Figure 8-4 Slope angles of launched aprons after multiple attacks

Concrete blocks are more prone to winnowing failure as through the larger void spaces forming in between launched elements and therefore the factors of safety calculated are only valid for the first flood season, after which they are likely to reduce. Details on winnowing can be found in (Diggelmann, 2007) and (Oberhagemann, et al., 2008)
Geometries analysed assume that elements have already launched at the design slope of 1V: 2H and does not consider instabilities caused by the launching process. Following launching it is assumed that the geobags are at or close to their angle of repose and therefore shallow slips relating to the geobag launching are not considered. Instead the global analysis assumes a minimum slip depth of 2m with a sensitivity analysis presented in Appendix A below.

9 Analysis

A summary of the types of analysis carried out is shown in Table 9-1 below.

Table 9-1 Summary of analyses carried out

Reference	Type of Run	Run summary	Geometry	Load Case
1	Sensitivity	To review effect of modifying permeability	1: Adaptive Approach	2: Drawdown
2	Sensitivity	To review effect of varying minimum slip depth	1: Adaptive Approach 2: BWDB No Regret	4: Launched slope stability
3	Sensitivity	To review validity of conservative selected soil strength	1: Adaptive Approach 2: BWDB No Regret	4: Launched slope stability
4	Final	Full analysis	1: Adaptive Approach 2: BWDB No Regret	1: Upper slope stability 2: Upper slope drawdown 3: Upper slope earthquake 4: Launched slope 5: Launched

				slope with earthquake
5	Final - modified	Alternative geometries	3: 20m Dredging 4: 15m Dredging 5: 10m Dredging	3: Upper slope earthquake 4: Launched slope 5: Launched slope with earthquake

10 Sensitivity, Validation and Verification

Sensitivity was carried out for Options 1 and 2 as per the table below. The detailed results of the sensitivity analysis are presented in Appendix C below. The effect of slip depth and soil friction angle were found to be small while the effect of reducing permeability in the upper slope drawdown case was significant. Silt lenses of lower permeability are known to be present in the area and may not have been picked up in the geotechnical investigation and these have the potential to reduce the factor of safety by 43% compared to the higher permeability material found (see Table 10-1). This is particularly important as detailed geotechnical investigation is often not carried out prior to the design of riverbank protection and this could be the leading cause of the upper slope failures observed across all riverbank protection implemented on the Jamuna river to date.

Table 10-1 Summary of sensitivity analyses carried out

Ref.	Parameter	Load Case	Defined Parameter	Values tested	Comments	Effect on Factor of Safety
1	Permeability	2 – Drawdown on the upper slope	1 E-6 m/s (Based on grain size found in geotechnical investigation)	5 E -6, 1 E-6, 1 E-8 m/s	Based upon the USCS guidance for minimum and maximum values in silty sand	43% variation between minimum and maximum USCS permeability value
2	Minimum slip depth	4 – Launched slope stability	2m	1m, 2m, 3m and 4m	Top layer of geobags is at or close to angle of repose following launching so shallow slips do not need to be considered	4.7 % variation found for a 3 metre increase in slip depth
3	Soil friction angle	4 – Launched slope stability	See Table 7-1 (Based on geotechnical	Phi + 0.5, phi + 1.0 and phi +		3.1 – 3.3% variation found for a

			investigation)	1.5		1.5 degree increase in friction angle

11 Results

11.1 Upper Slope (Load Cases 1, 2 and 3)

The review of the upper slope results will be included in the revision of this document.

11.2 Lower Slope (Load cases 4 and 5)

The results of the analysis are summarized in Figure 11-1 below and show that neither option can achieve the minimum factor of safety requirement for 1.5 on the launched slope in the normal case with the slope at the fully launched theoretical scour depth. Option 1 reaches the minimum requirement for the factor of safety in the earthquake load case of 1.1 in accordance with international best practice but does not reach the BWDB recommended safety factor of 1.25.

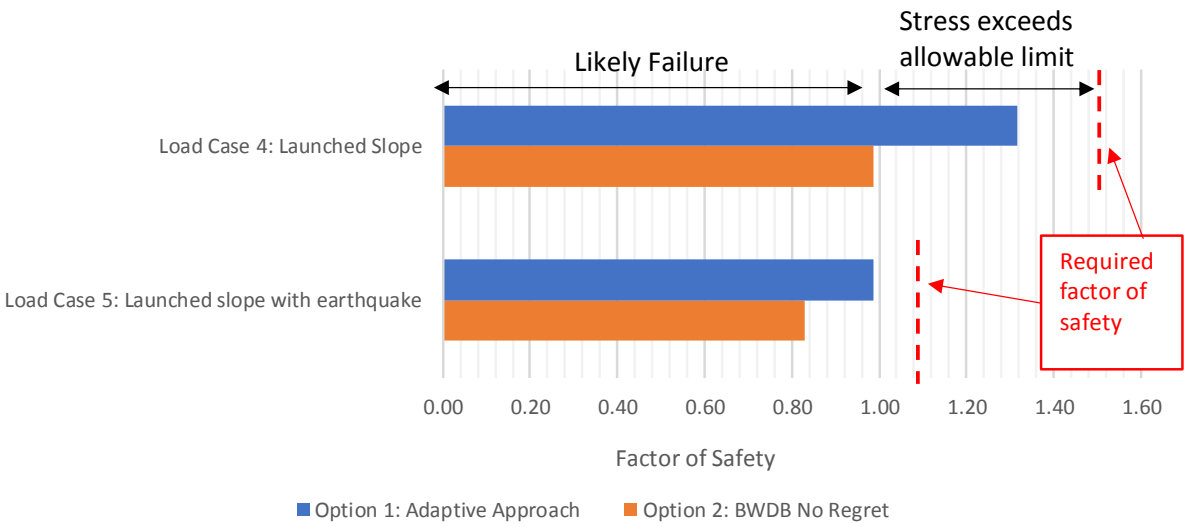


Figure 11-1 Results for analysis of Options 1 and 2

11.2.1 Improvement through dredging

The reasons that the Adaptive Approach has a higher factor of safety than the BWDB No Regret option are:

1) A reduced launched slope length because the maximum scour depth is made up of 3 individual slopes which are a maximum of 15m in height (compared to a maximum of 28m height for the BWDB No Regret slope) - Figure 11-2
2) The lower slopes are founded on more consolidated and therefore stronger material increasing their factors of safety

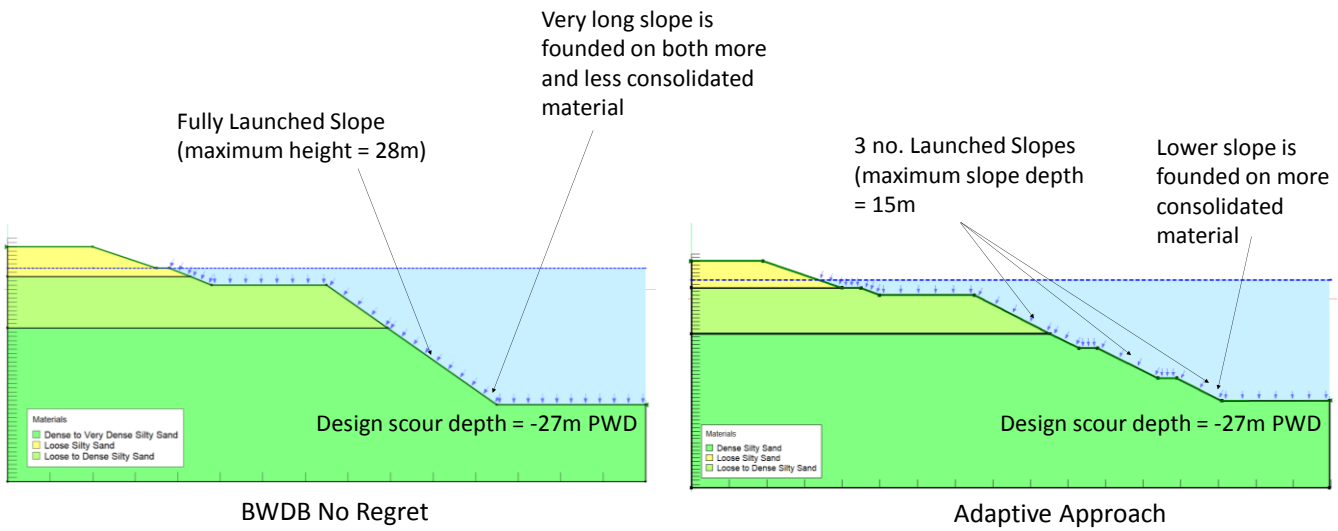


Figure 11-2 Comparison of BWDB No Regret and Adaptive Approach launched slopes

An alternative approach to increase the factor of safety is to deepen the apron setting level through dredging. In addition to reducing the launched slope height by the height of material dredged, this results in the launched slope being founded on more consolidated soil thereby increasing its factor of safety.

11.2.1.1 Geometry

The geometries analysed for the cases where dredging is used are as follows:

- For option A, it is assumed that dredging is carried out to achieve a 1V: 6H slope down to the apron setting level at 20m below the design low water level (-15 m PWD). This is based upon using a larger dredger such as those used during the construction of the Padma bridge which were able to dredge to a depth of 25m.

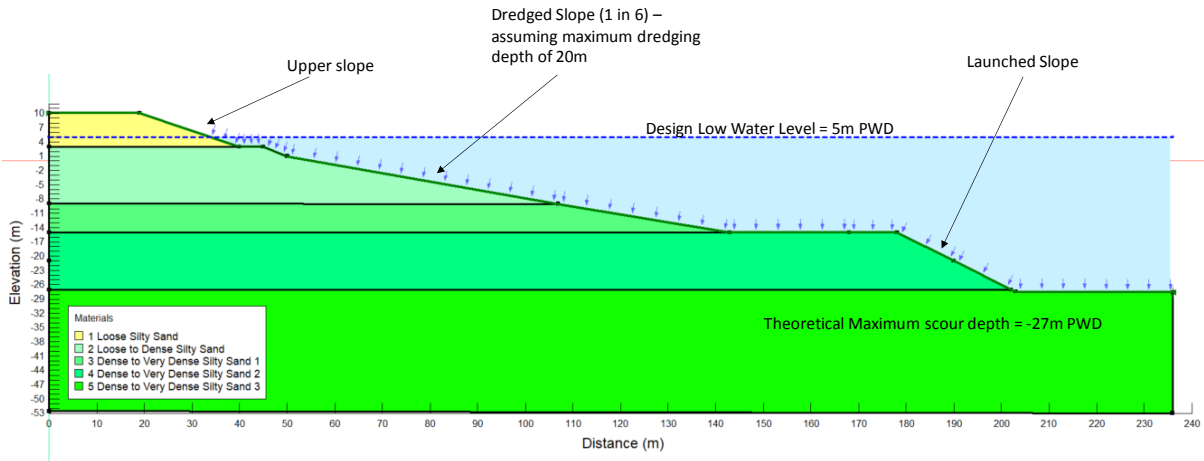


Figure 11-3 Option A Geometry

- For option B, it is assumed that dredging is carried out to achieve a 1V: 6H slope down to the apron setting level at 15m below the design low water level (-10m PWD). It is known that the Bangladesh Water Development Board currently operate approximately 25 dredgers, the largest with a maximum dredging depth of 18m.

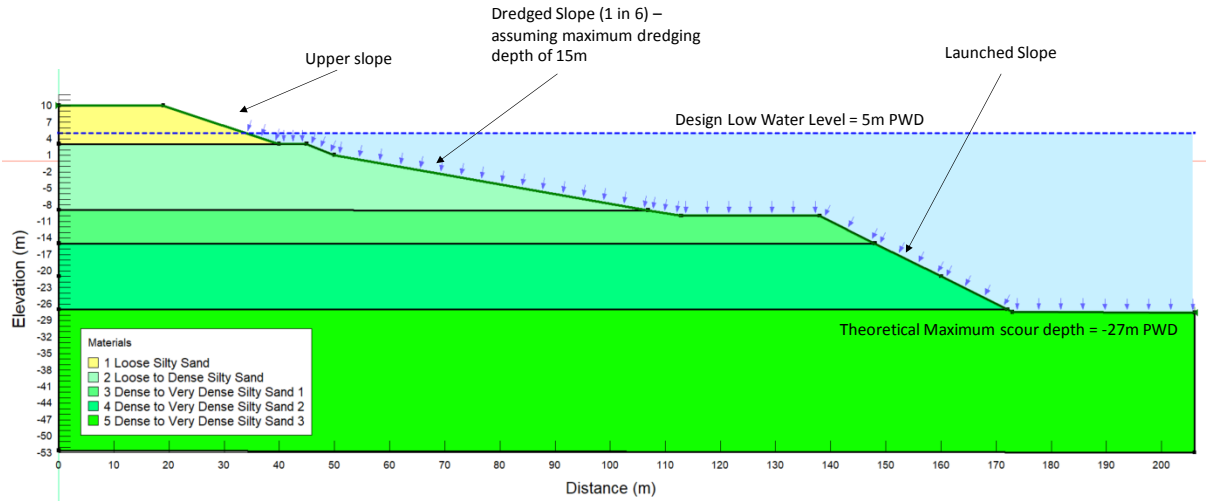


Figure 11-4 Option B Geometry

- For option C, it is assumed that dredging is carried out to achieve a 1V: 6H slope down to the apron setting level at 10m below the design low water level (-5 m PWD). This is based upon using a smaller BWDB dredger with a lower depth capacity as a comparison.

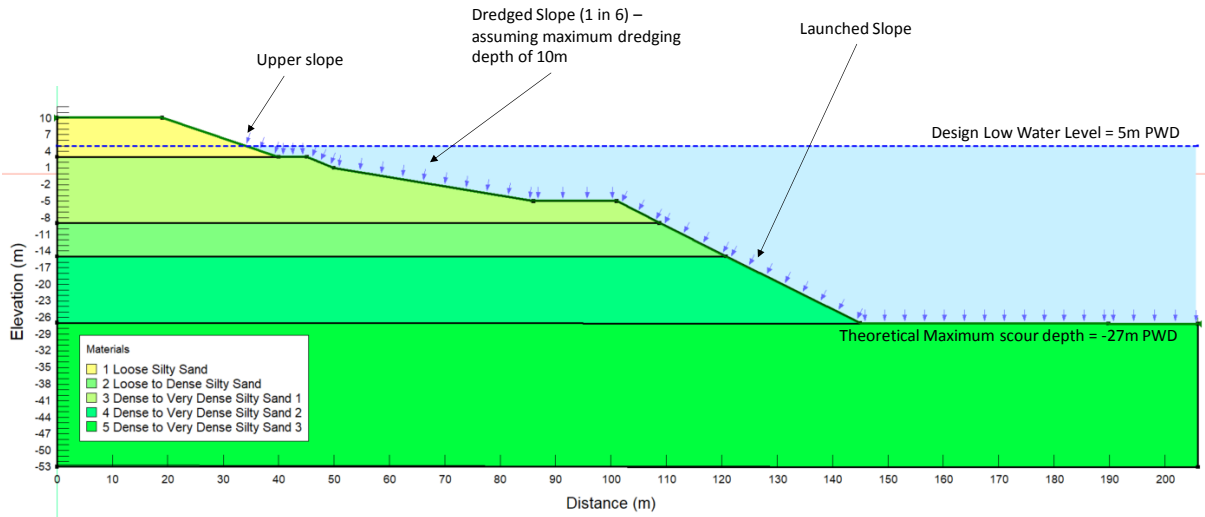


Figure 11-5 Option C Geometry

As expected, the results show that the deeper the dredging, the higher the factor of safety of the launched slope as shown in Figure 11-6 below. All dredging depth options exceed the minimum required factor of safety in the earthquake loading case with while only Options A (20m dredging) and Option B (15m dredging) exceeding the minimum factor of safety for the launched slope to the design scour level.

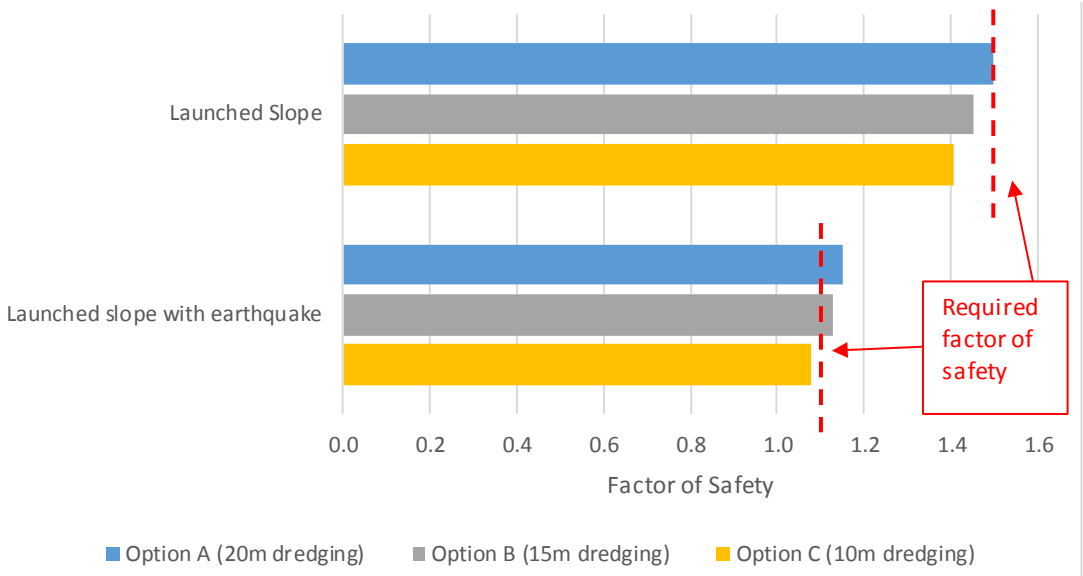


Figure 11-6 Factors of safety for launched slope assuming load case 4 (launched slope) and load case 5 (launched slope with sedimentation and earthquake loading)

11.2.1.2 Volumes and Costs

Figure 11-7 below shows how the factors of safety vary for all the load cases and geometries analysed. This shows that the underwater slope is where the majority of the differences arise with 66% variation between the highest and lowest factors of safety for the Launched slope (load case 4).

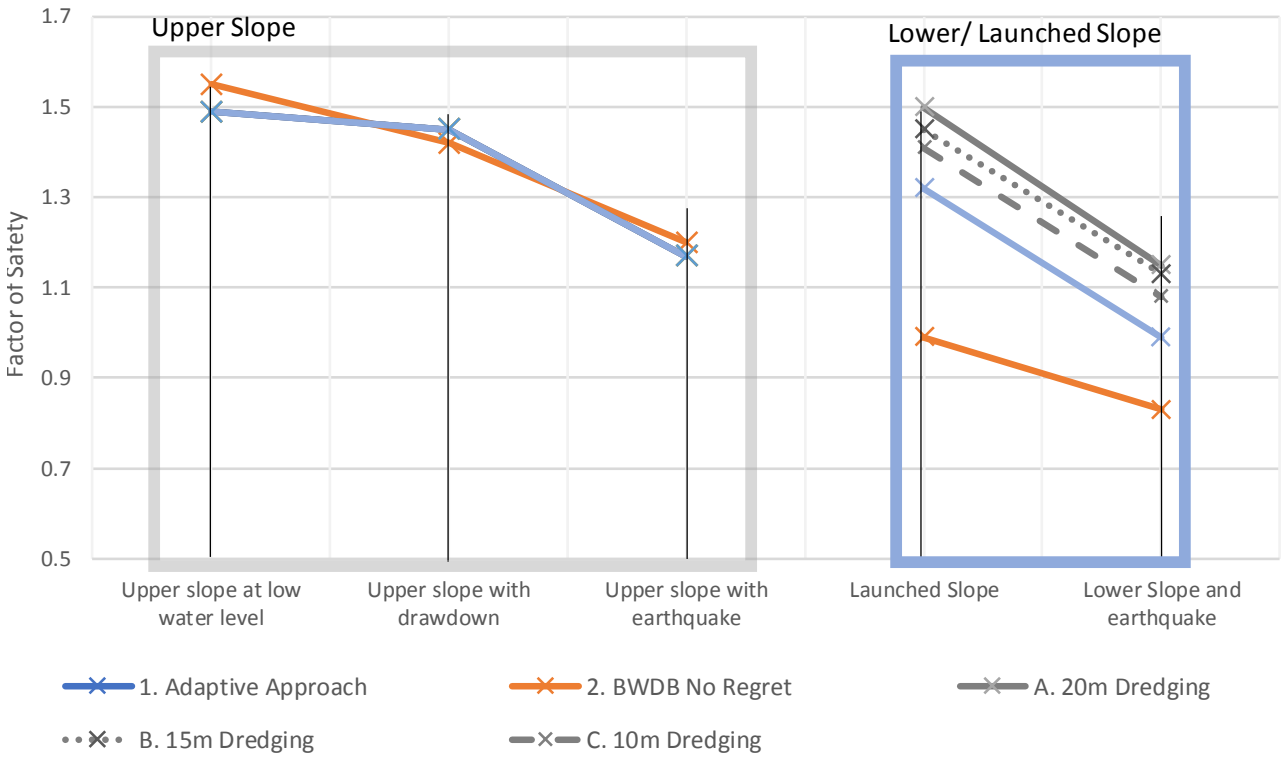


Figure 11-7 Summary of factors of safety for all geometries and load cases analysed

The next step is therefore to consider the cost of the different options and determine the trade-off between this and the factors of safety achieved for the lower slope load cases.

The approximate capital costs for the underwater elements of each of the geometries analysed is presented in Table 11-1 below. These do not include mobilisation or environmental management costs. For the costing, the BWDB 2018/2019 schedule of rates from the Dhaka/ Pabna / Mymensingh Operation and Maintenance Departments were used. The dredging rate of approximately 132 BDT/ m^3 for the lowest dredging depth of 10m was increased for 15 and 20m dredging depth to 250 BDT / m^3 to account for the use of larger dredgers. 10m dredging depth corresponds to the existing smaller dredgers used by the BWDB and the Bangladesh Inland Water Transport Authority which have a maximum dredging depth of 12m and range from 18” to 20” cutter suction dredgers.

Table 11-1 Approximate costs of different options analysed (lower slope only)

Geometry	Approximate cost of underwater works per km (million USD)
1. Adaptive Approach	1.37
2. BWDB ‘No Regret’ Approach	7.76
3. 20m Dredging Depth*	9.69
4. 15m Dredging Depth*	6.49
5. 10m Dredging Depth**	2.57

* Dredging cost as per market rate = BDT 250/ m^3 including mobilisation
** Dredging cost as per BWDB 2018/2019 Schedule of Rates = BDT 132 / m^3 including mobilisation

Figure 11-8 and Figure 11-9 below show the factors of safety achieved against the cost. By comparing the Adaptive Approach (Option 1) to the other options, it can be seen that the BWDB No Regret option achieves a lower factor of safety but is almost 6 times the price. Although Option A (20m dredging) has a safety factor of 1.5 compared to the 1.32 achieved by the Adaptive Approach, it is more than 6 times the price. Therefore, Option C perhaps represents much better value in increasing the factor of safety to 1.4 which is within the requirement of the International Levee Handbook (CIRIA, 2013) whilst costing 85% more. Option C also has the added benefit that it does not rely on adaptation work which can be subject to delays in implementation and diversion of funds once the initial capital constructions works are complete.

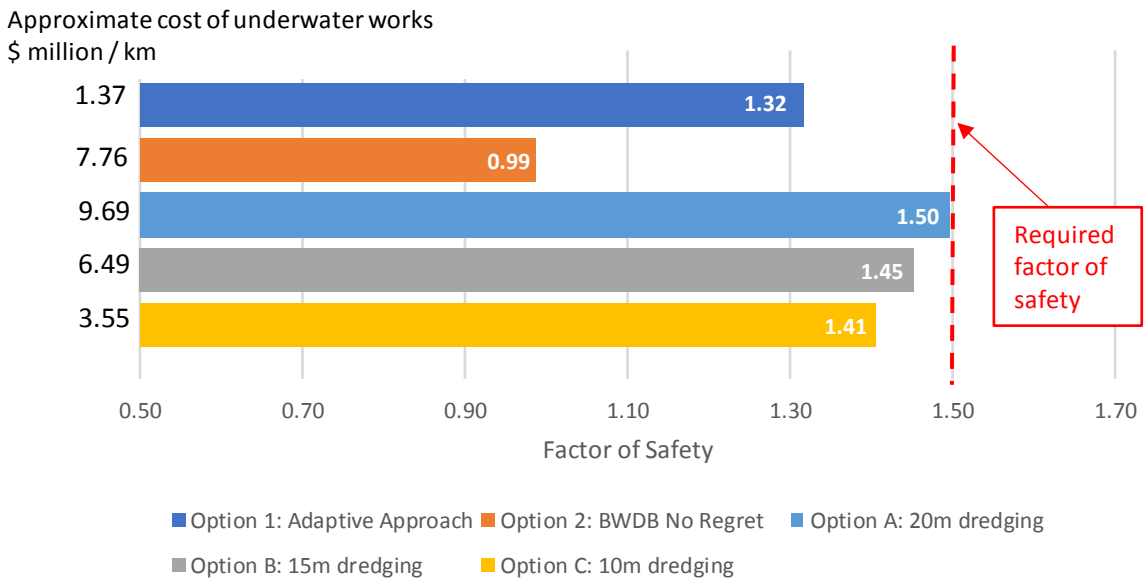


Figure 11-8 Summary of launched slope stability for all Load Case 4: Fully Launched Underwater Slope

Figure 11-9 shows the increases in factors of safety achieved for load case 5 by the dredging options. This shows that Option C is just below the requirement of a factor of safety of 1.1. However, in reality even Options A and B (20m and 10m dredging) will be subject to liquefaction and lateral spreading in an earthquake and lateral spreading will govern rather than the geotechnical slope stability analysed. Dredging deeper to the more consolidated soils will reduce the susceptibility of the launched slope to failure compared to the Adaptive Approach and so a marked improvement in stability is still likely for Option C.

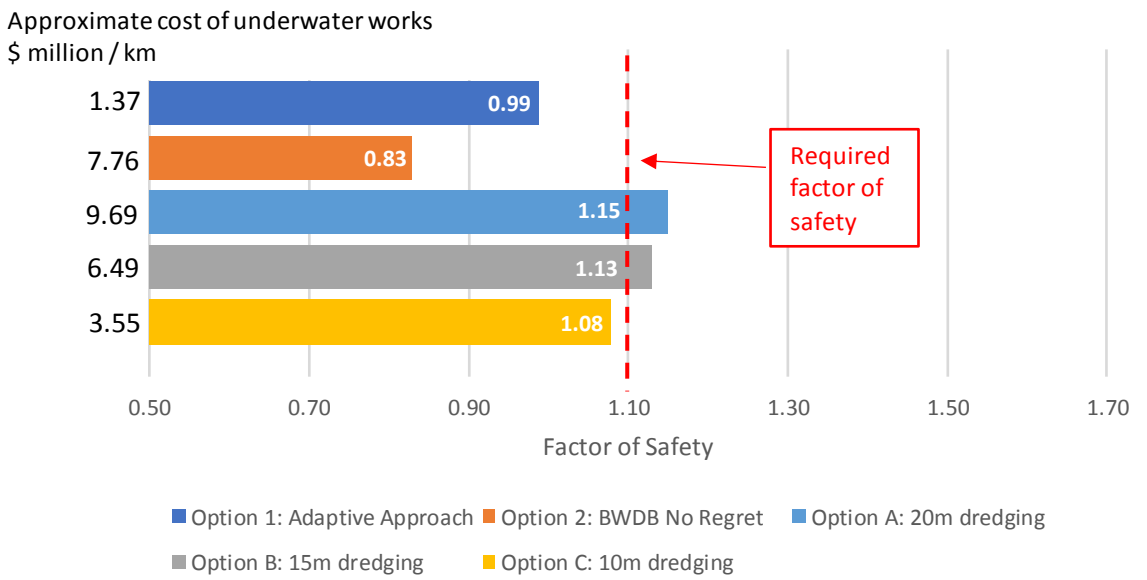
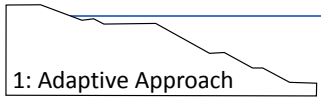
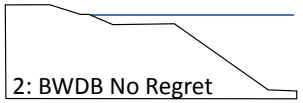
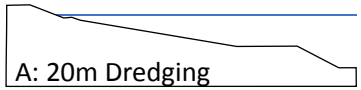
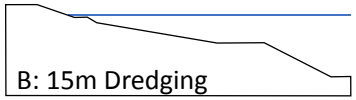


Figure 11-9 Summary of launched slope stability for all Load Case 5: Underwater slope with design earthquake

11.3 Summary of results

Option / Load case	 1: Adaptive Approach	 2: BWDB No Regret	 A: 20m Dredging	 B: 15m Dredging	C: 10m Dredging
1	TBC	TBC	As Option 1 Adaptive Approach		
2	TBC	TBC	As Option 1 Adaptive Approach		
3	TBC	TBC	As Option 1 Adaptive Approach		
4	1.32	0.99	1.50	1.45	1.41
5	0.99	0.83	1.15	1.13	1.08

12 Conclusions

Although the bank protection systems analysed are highly dynamic subject to seismic forces and lateral spreading, and erosion which are highly variable and likely to govern, global geotechnical stability still remains a factor in the overall stability. The upper slope is largely subject to wave loading and current flows and is geotechnically separate to the launched slope where the individual elements 'launch' to the river's theoretical maximum scour depth. Therefore, the conclusions for each are discussed separately below.

12.1 Upper slope

Conclusions relating to the upper slope will be included in the updated version of this docment

12.2 Launched slope

The launched slope analysis considers only the first year of launching to maximum theoretical scour depth. It does not consider the long-term steepening of the slopes which would occur without adaptation works because the elements launch in a single layer which would reduce the factor of safety in all cases. This effect would be greater for concrete blocks rather than geobags because of the large pore spaces between different elements.
For the launched slope, the No Regret option is the most expensive but has the lowest global factor of safety under full launching (load case 4) and achieves a factor of safety of just 0.83 in the seismic load case. However, lateral spreading of the slopes would be the governing factor in an earthquake and is likely to reduce the factor of safety further. Whilst the Adaptive Approach is the least expensive option, it reaches a factor of safety of 1.3 in load case 4 and so cannot achieve the 1.5 requirement in the BWDB Design Guidelines.
Dredging of the underwater slopes results in a greater distance between the upper slope and the launched slope therefore reducing the risk of deep-seated slip failures or flow slides in the launched slope affecting the upper slope. Dredging also allows greater factors of safety to be achieved as follows:

- Option A (20m dredging) has a factor of safety of 1.50 but the cost of underwater components is prohibitive at more than 7 times the cost of the Adaptive Approach
- Option B (15m dredging) has a factor of safety of 1.45 but the underwater works are 4.7 times the cost of the Adaptive Approach
- Option C (10m dredging) has a factor of safety of 1.41 but the underwater works are 160% more expensive than the Adaptive Approach

15m and 10m dredging options provide the best compromise between increasing the factor of safety while remaining below the cost of the BWDB No regret option. They also ensure dredging depths are more achievable by dredgers in Bangladesh (up to 18m dredging capacity would be required to achieve 15m dredging depth below design low water level during the construction season). From a cost perspective, 10m dredging provides a comparable safety factor to 15m dredging whilst being only 55% of the cost and therefore could be the better option for the riverbank protection built on the flood plain such as at Upstream Chauhali. Although riverbank protection on the char has not been considered here, the SPT values found there can be significantly lower than at the riverbank (a minimum SPT value of 11 was found during the geotechnical investigations at the Salura char which is opposite the upstream Chauhali site where a minimum SPT of 16 was found). In these cases, it is more likely that the 15m dredging depth would provide a better trade off between factor of safety and the minimum SPT of 21 at Salura char is more comparable to 23 at Upstream Chauhali).

Additionally, deeper dredging can help to attract flow thereby serving a hydrological purpose as well as increasing the geotechnical factor of safety.
The behavior of the slopes in the seismic case could was approximated through a pseudo-static analysis however this cannot provide an accurate picture of the seismic response and so displacement calculations should be carried out in addition to an analysis of the effect of liquefaction and related effects. Option B (15m dredging) has the benefit of exceeding the required 1.1 factor of safety in the pseudo-static case while option C has an FoS of 1.08. Both the Adaptive Approach and the BWDB No Regret Options fall significantly below the 1.1 requirement.

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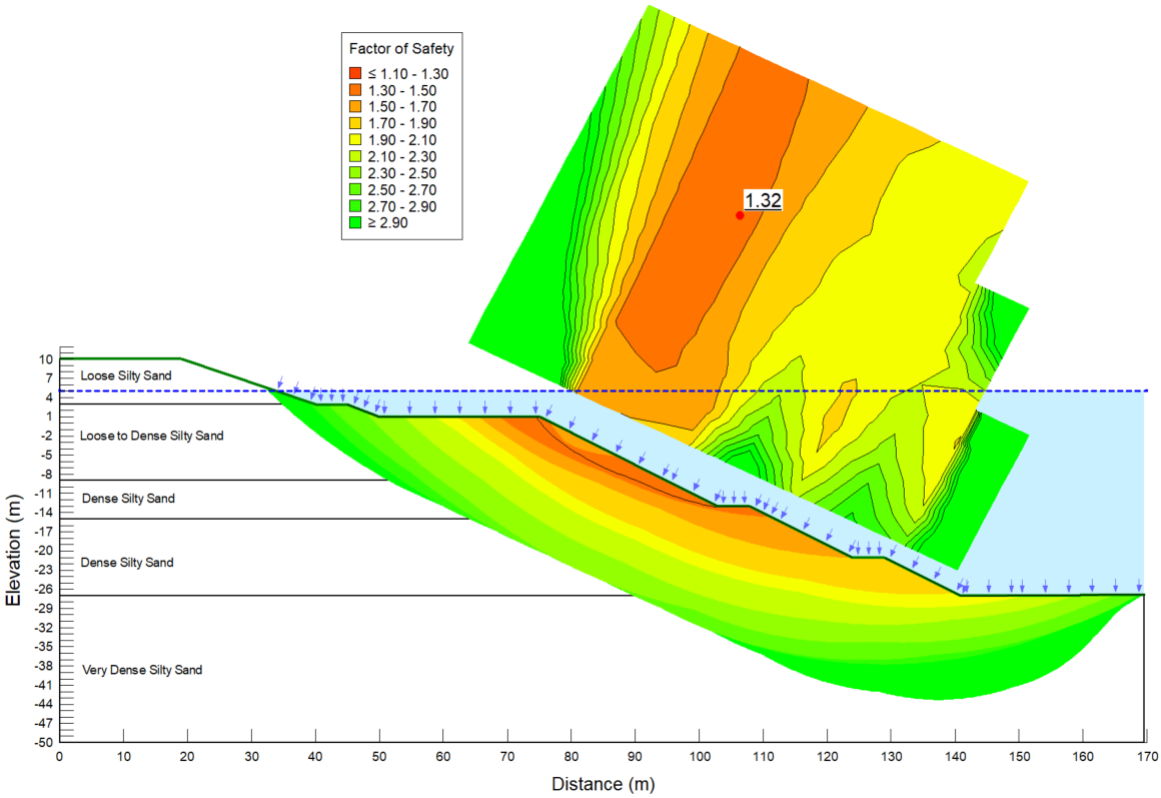
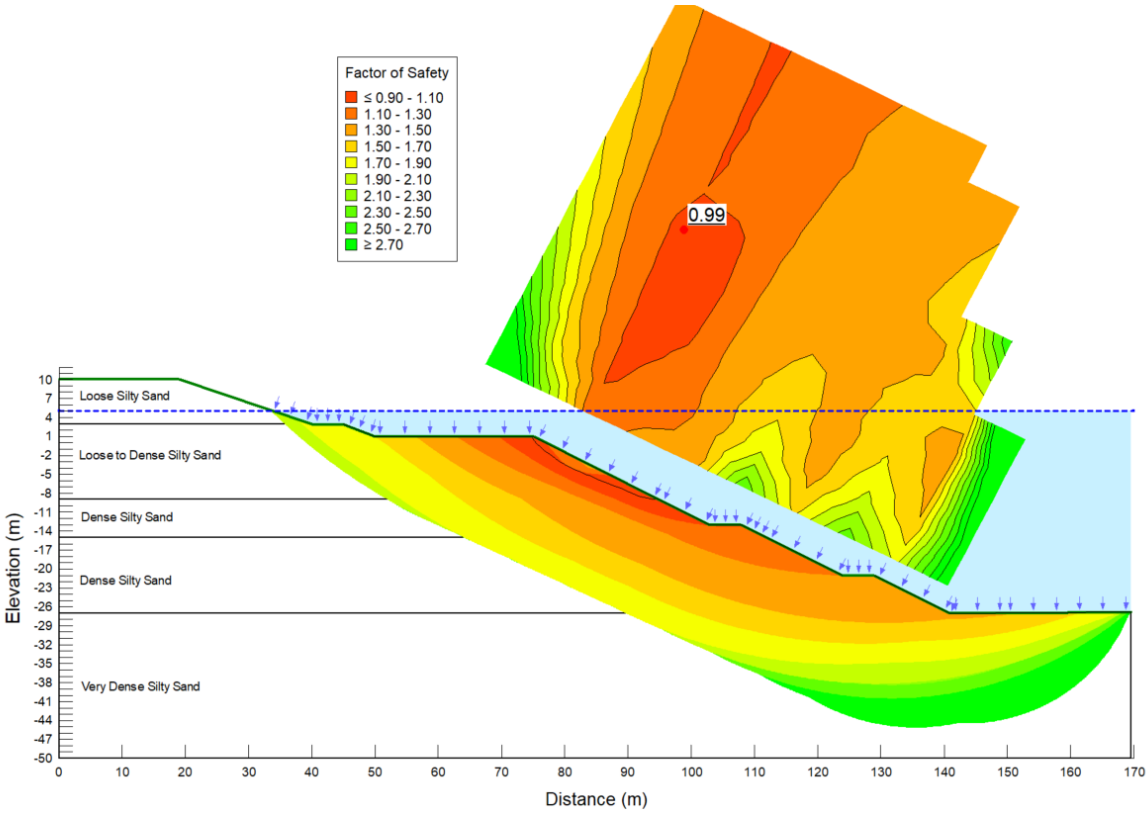
Appendix A – Results

Geometry Option 1

Load case 4 – Launched slope (normal loading)

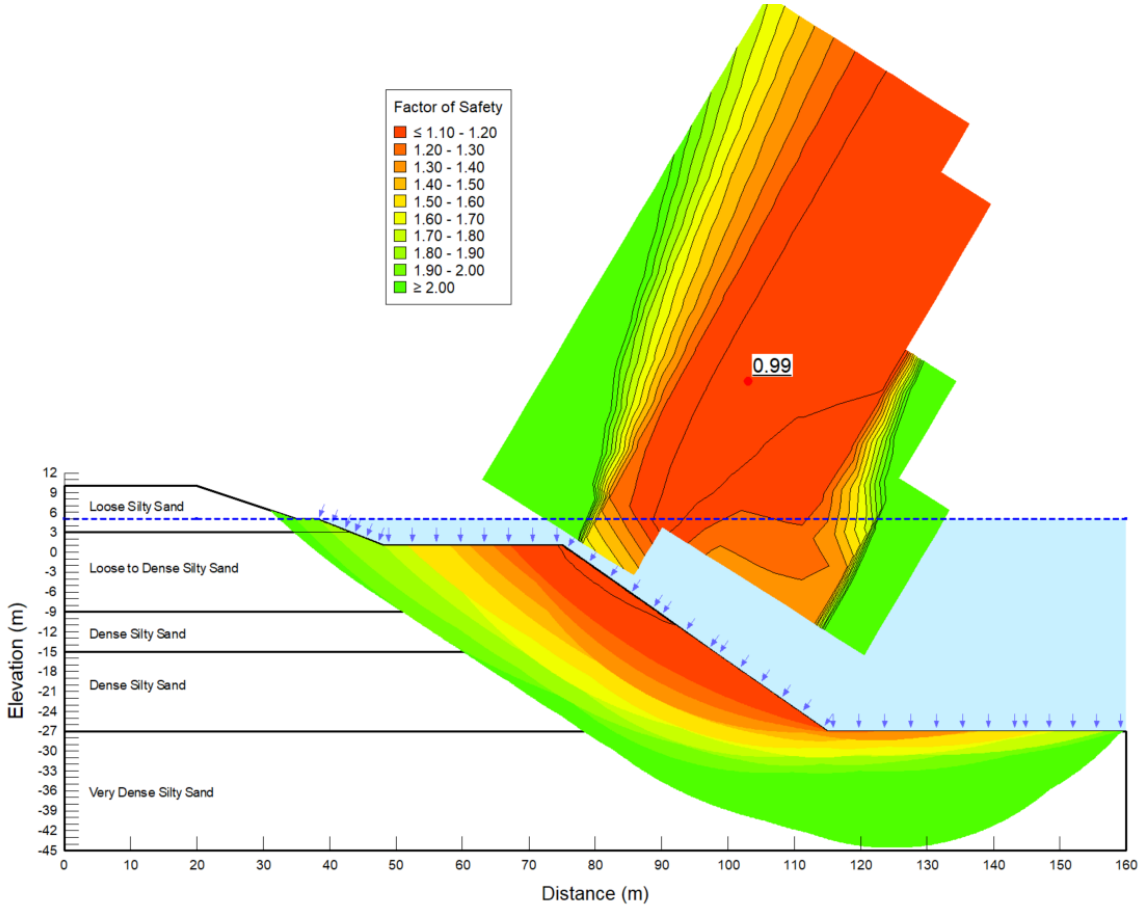


Load case 5 – Launched slope with earthquake + sedimentation

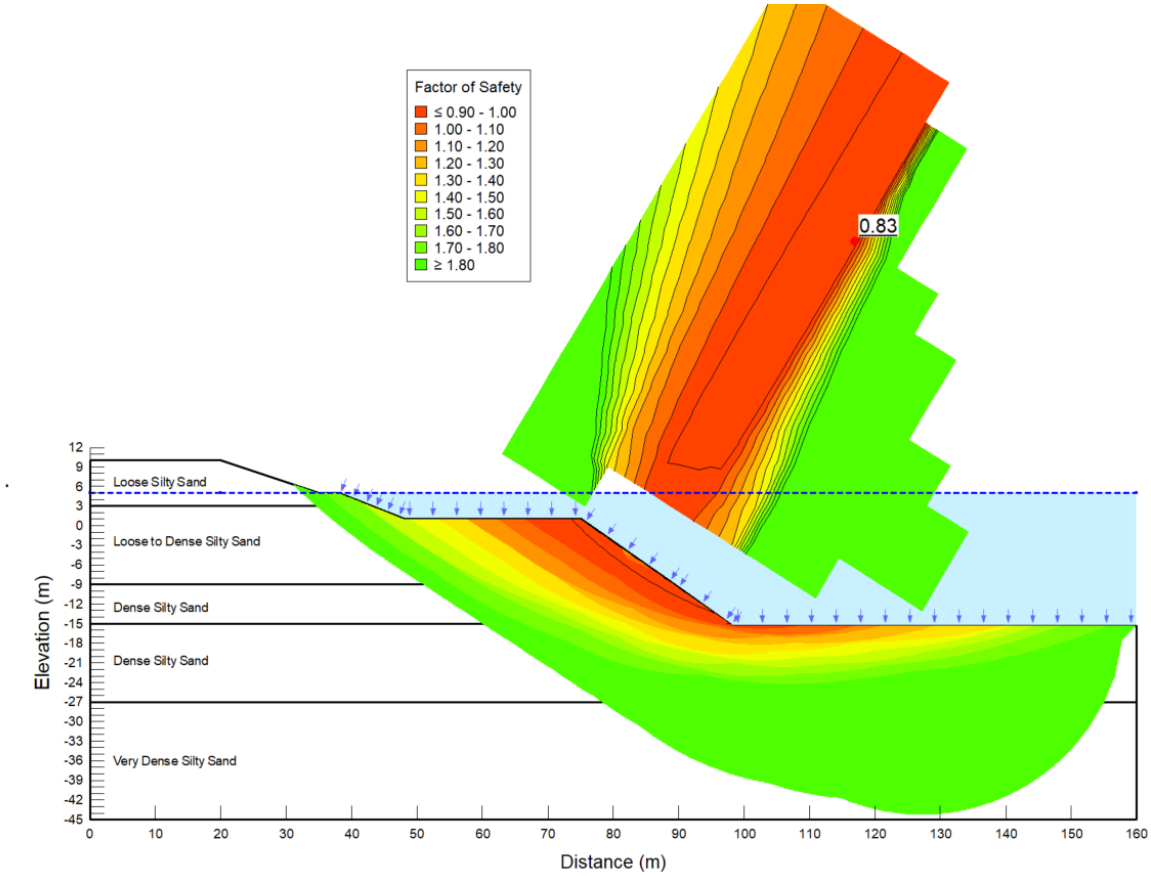


Geometry Option 2

Load case 4 – Launched slope (normal loading)

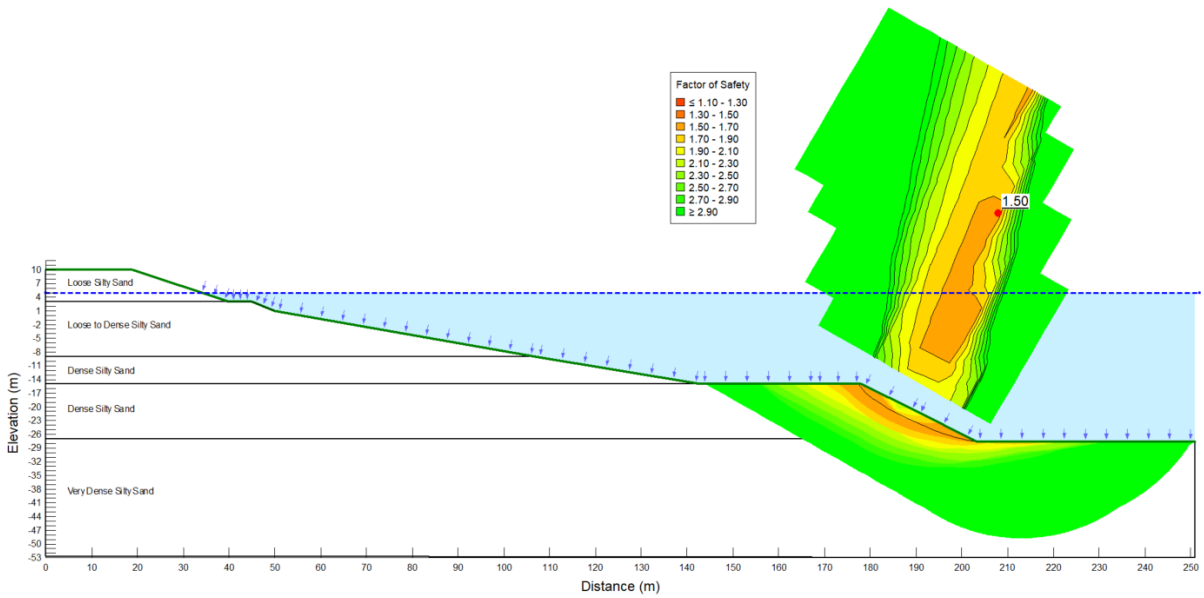


Load case 5 – Launched slope with earthquake + sedimentation

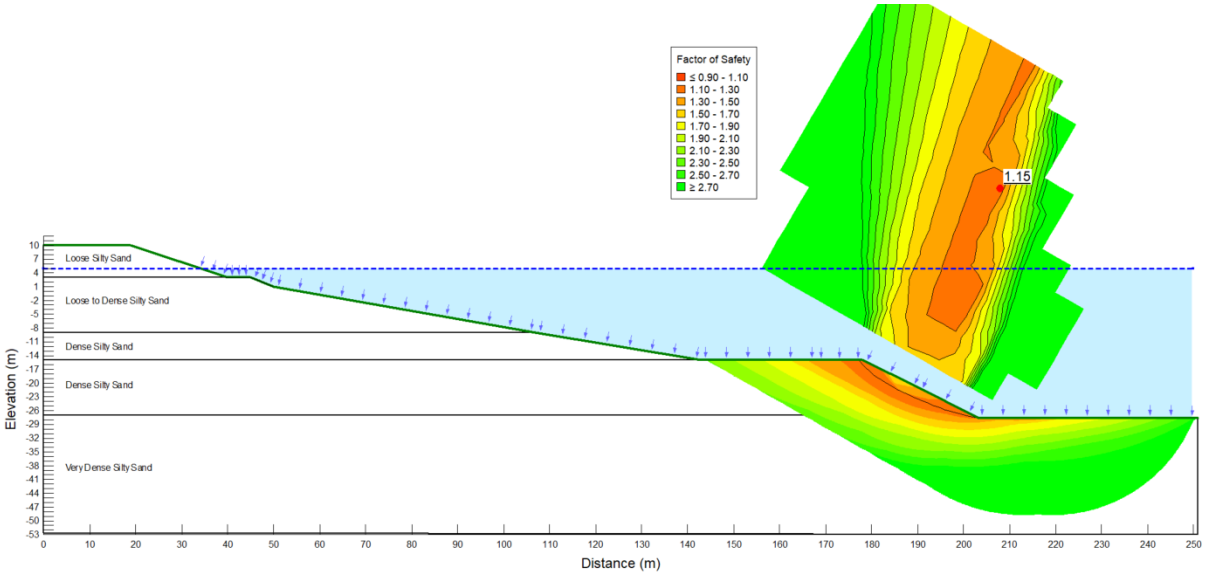


Geometry Option A

Load case 4 – Launched slope (normal loading)

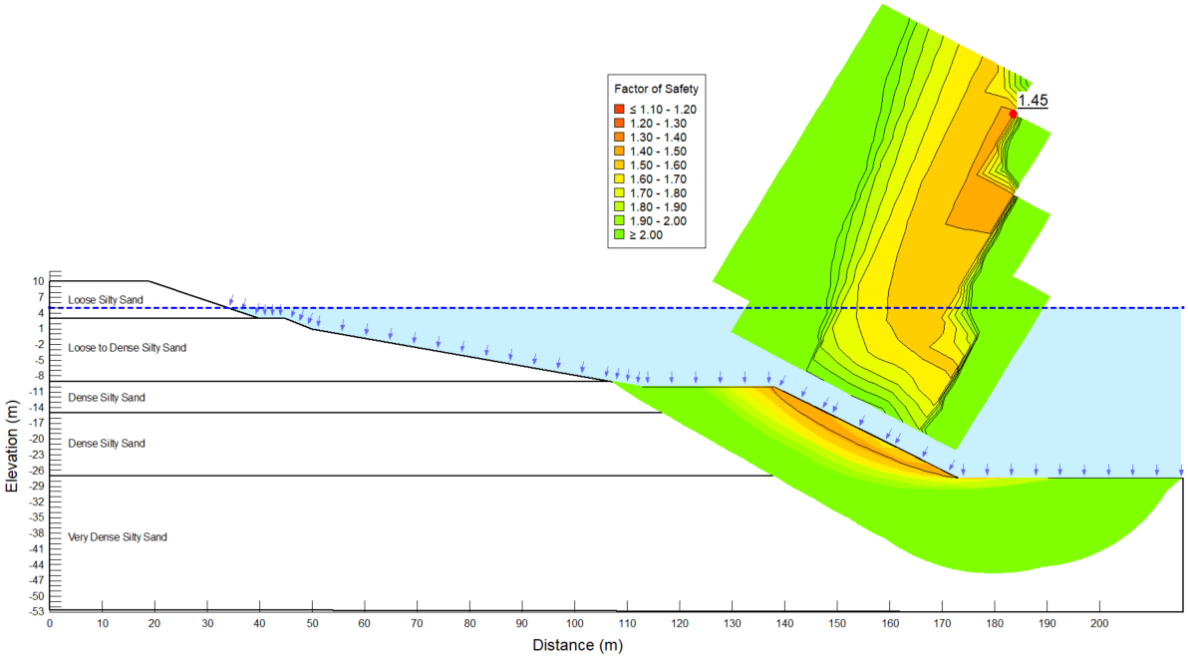


Load case 5 – Launched slope with earthquake + sedimentation

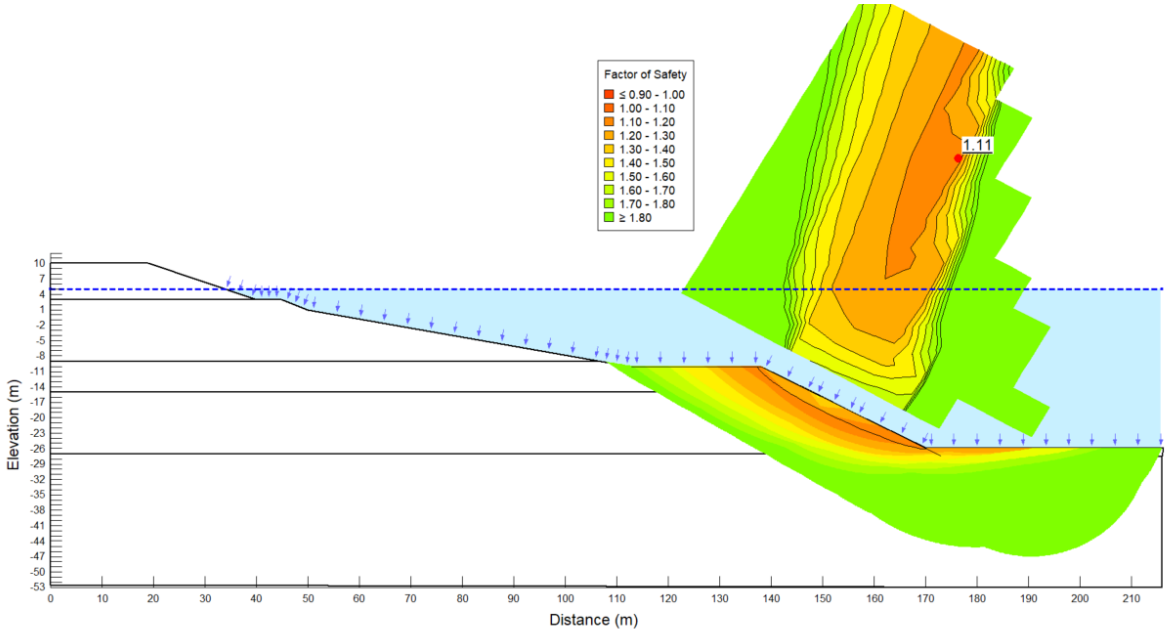


Geometry Option B

Load case 4 – Launched slope (normal loading)

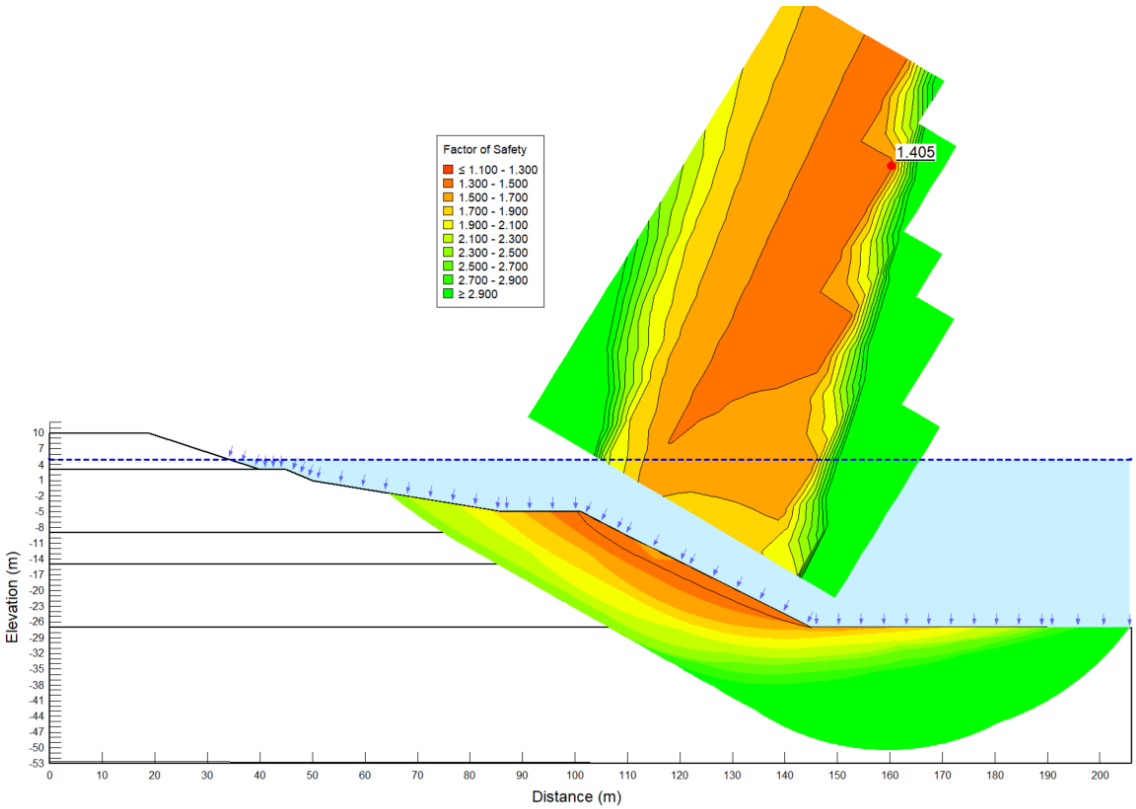


Load case 5 – Launched slope with earthquake + sedimentation

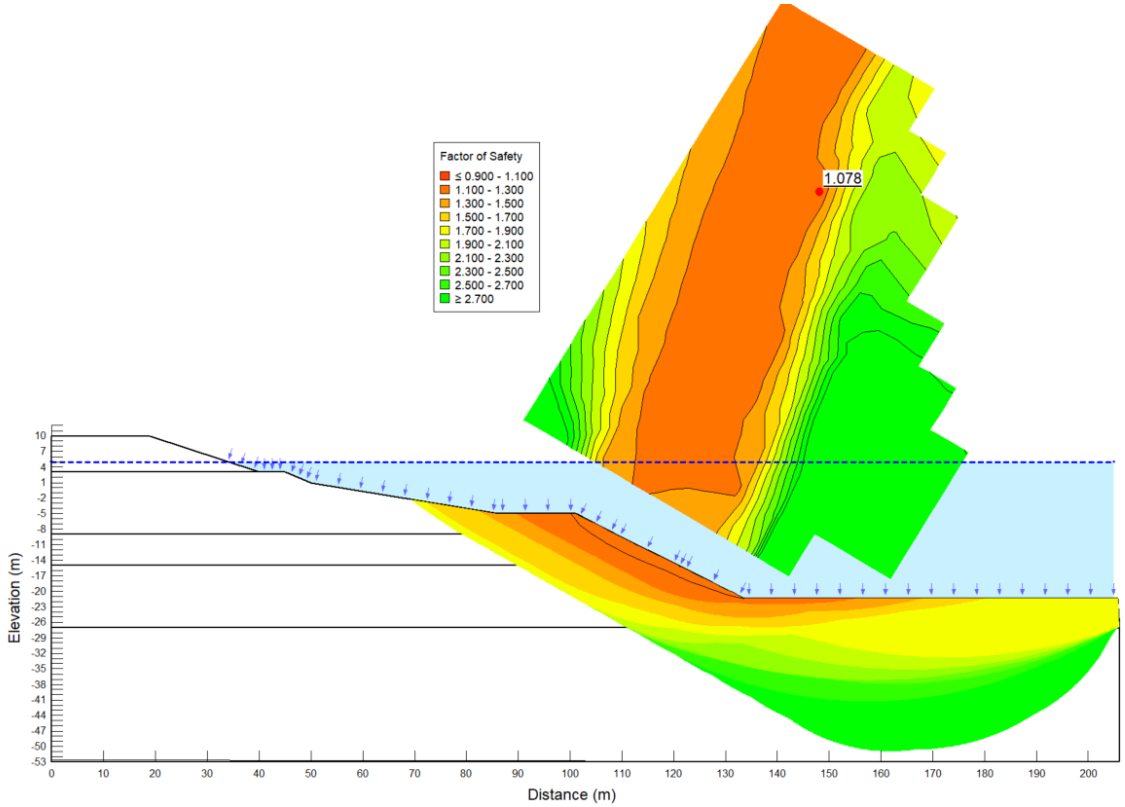


Geometry Option C

Load case 4 – Launched slope (normal loading)



Load case 5 – Launched slope with earthquake + sedimentation


Factor of Safety
≤ 0.900 - 1.100
1.100 - 1.300
1.300 - 1.500
1.500 - 1.700
1.700 - 1.900
1.900 - 2.100
2.100 - 2.300
2.300 - 2.500
2.500 - 2.700
≥ 2.700
1.078
Elevation (m)
Distance (m)

Appendix B – Review of Geotechnical Data

The geotechnical investigation carried out in 2018 consists of 4 no. boreholes in the footprint of the proposed riverbank protection at Upstream Chauhali (Boreholes 12, 13, 15 and 16) as shown in Figure 0-1 below.

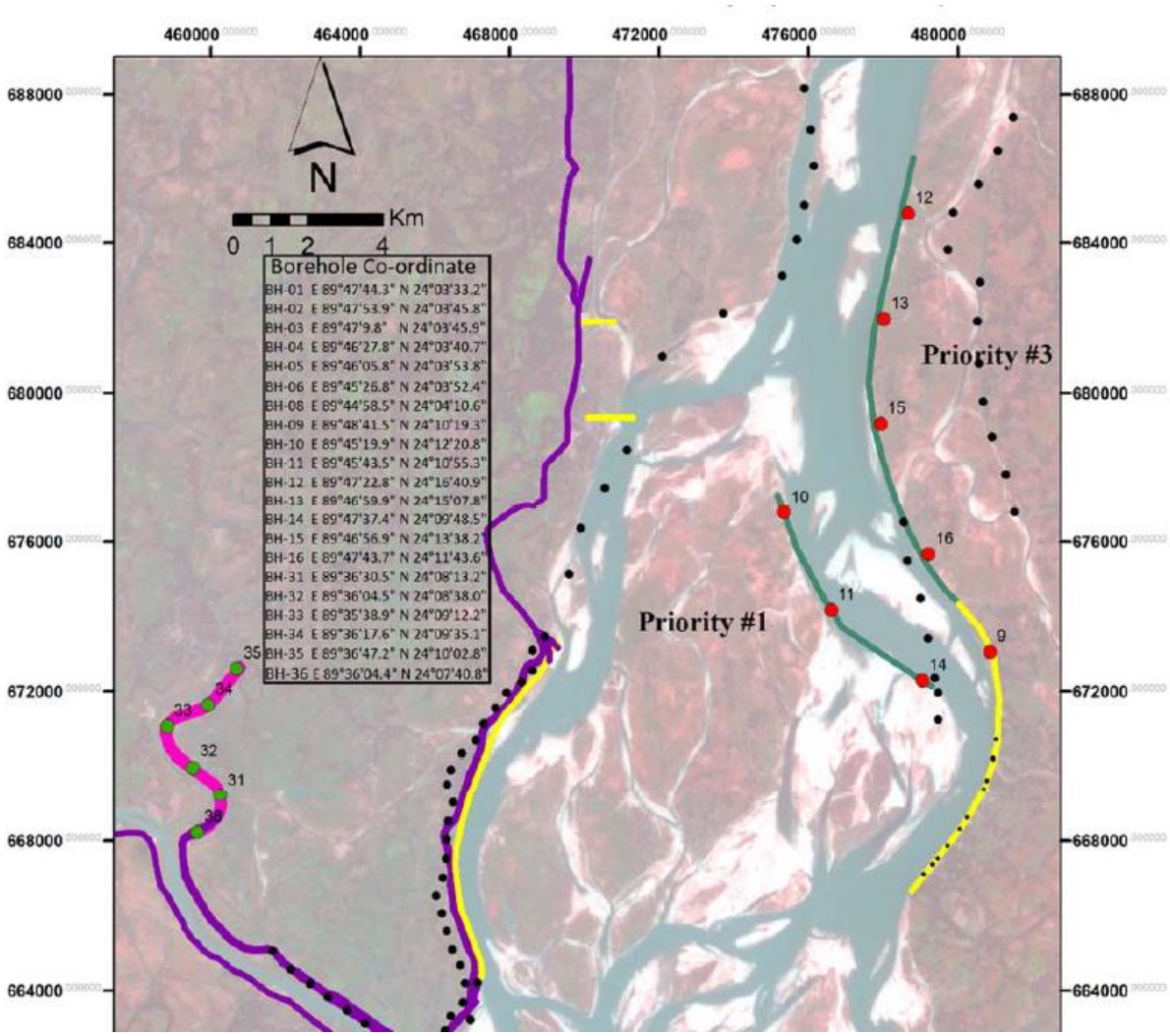


Figure 0-1 Layout of geotechnical investigation carried out in 2018

A summary of the ground conditions found in each of these boreholes is presented in the tables below:

BH 12

Depth (m)	Soil Type	Range of SPTs
0.0-6.0	Gray 7.5YR (5/1), loose to medium dense, Low Plasticity Silt with Sand, ML.	5 – 13
6.0-9.0	Gray 7.5YR (5/1), medium dense, Silty Micaceous Sand, SM.	15 – 19
9.0- 40.95	Gray 7.5YR (6/1), dense to very dense, Poorly Graded Silty Sand, SP-SM.	18 – 50

BH 13

Depth (m)	Soil Type	Range of SPTs
0.0-6.0	Light Gray 7.5YR (7/1), loose, Low Plasticity Silt with Sand, ML.	4 – 7
6.0-40.95	Gray 7.5YR (5/1), medium dense to very dense, Poorly Graded Silty Sand, SP-SM.	13 – 50

BH 15

Depth (m)	Soil Type	Range of SPTs
0.0-16.5	Gray 7.5YR (5/1), medium dense to dense, Poorly Graded Silty Sand, SP-SM.	9 – 18
16.5-40.95	Gray 7.5YR (5/1), dense to very dense, Poorly Graded Silty Sand, SP-SM.	20 - 50

BH 16

Depth (m)	Soil Type	Range of SPTs
0.0-16.5	Gray 7.5YR (5/1), loose to dense, Low Plasticity Silt with Sand, ML.	3 – 26
16.5-24.0	Brown 7.5YR (5/2), dense to very dense, Silty Micaceous Sand, SM.	24 – 37
24.0-28.5	Gray 7.5YR (6/1), very dense, Silty Sand, SM.	47 – 33
28.5-31.5	Brown 7.5YR (5/2), very dense, Silty Micaceous Sand, SM.	36 - 34
31.5-34.5	Gray 7.5YR (5/1), very dense, Poorly Graded Silty Sand, SP-SM.	50
34.5-37.5	Brown 7.5YR (5/2), very dense, Poorly Graded Silty Sand, SP-SM. (trace mica)	41 - 43
37.5-40.95	Light gray 10YR (7/1), very dense, Poorly Graded Silty Sand, SP-SM.	39 - 50

The relationship between the in-situ SPT N value and the phi value for the analysis is taken from the Bangladesh National Building Code 2015 (equation 6.D.5) as follows:

$$\emptyset° = 27 + 0.3\ (N_1)_{60}$$

The hammer efficiency was reported as 60%, rod length was 10m and the borehole diameter was less than 115mm therefore a correction factor of 1 has been applied to the N values to calculate the N_{60}.

The N_{60} value is subsequently corrected for the increased resistance due to negative excess pore water pressure set up during driving and unable to dissipate immediately as recommended in equation 8.13 in Craig's Soil Mechanics, 7th Edition:

$$N' = 15 + \frac{1}{2}(N - 15)$$

The results are also compared to the typical properties given in the following table based on the soil descriptions in the geotechnical investigation.

Table 6.D.6: Penetration Resistance and Soil Properties on the Basis of SPT (Cohesionless Soil: Fairly reliable)

N-value	Soil Condition	Relative Density, D_r	Angle of internal friction, ϕ
0 - 4	Very loose	0 – 15%	< 28°
4 - 10	Loose	15 – 35%	28° – 30°
10 - 30	Medium	35 – 65%	30° – 36°
30 - 50	Dense	65 – 85%	36° – 42°
> 50	Very Dense	> 85%	> 42°

Table 6.D.7: Penetration Resistance and Soil Properties on the Basis of SPT (Cohesive Soil)

N- value	Consistency	UC Strength (q_u), kN/m²
0 - 2	Very soft	< 25
2 - 4	Soft	25 - 50
4 - 8	Medium	50 - 100
8 - 15	Stiff	100 – 200

The ground model used for the modelling is based upon the worst-case ground conditions encountered in boreholes 12 and 13. Borehole 13 is found to be the worst case and contains loose, low plasticity silt with sand followed by medium dense, poorly graded sand. The geotechnical investigation noted trace mica in a number of the soil layers, therefore the lower and therefore more conservative value of the soil friction angle has been assumed for each soil layer. This mica will also increase the likelihood of soil liquefaction during an earthquake in the upper layers of soil.

The subsequent approximations of the soil friction angle are compared to those that would be used in international best practice i.e. the Peck, Hanson and Thornburn curve (1953) which was approximated by Wolff in 1989 as:

$$\emptyset° = 27 + 0.3\ (N_1)_{60} - 0.00054N^2$$

The table below shows that the relationship between the BNBC recommended design parameters and those from Peck, Hanson and Thorburn in addition to the selected phi value used in the analysis.

Table 0-1 Summary of approximations of phi values relating to BH 12 and BH 13

Depth	SPT N from BH 12	SPT N from BH 13	Average SPT N	Borehole 13			Borehole 12		Min phi	Max phi	Selected phi
				N'	BNBC phi	Peck, Hanson and Thornburn phi	N'	BNBC phi			
0 – 6	4.7	4.0	4.4	4.0	28.2	27.8	4.7	28.4	28.2	28.4	28.0
6 – 15	14	11.5	12.8	11.5	30.5	29.9	14.0	31.2	30.5	31.2	30.0
15 - 21	27.5	21.0	24.3	18.0	32.4	31.8	21.3	33.4	32.4	33.4	32.0

21 – 27	34.5	30.8	32.6	22.9	33.9	33.2	24.8	34.4	33.9	34.4	34.0
27 – 33	45.25	35.0	40.1	25.0	34.5	33.8	30.1	36.0	34.5	36.0	34.0
33 - 50	49.2	49.3	49.3	32.2	36.6	35.9	32.1	36.6	36.6	36.6	36.0

A summary of the final soil parameters selected for use in the Geostudio Slope-W model is presented in the table below.

Strata	Top Depth (m bgl)	Base Depth (m bgl)	Thickness (m)	Angle of friction proposed (equivalent to SPT)
Loose Silty Sand Light Gray 7.5 YR, loose low plasticity silt with sand M/L [Silty sand encountered in borehole BH 16].	0.00	6	7 (including 1m of fill above ground level)	28
Loose to Dense Silty Sand Light Gray 7.5 YR, loose to dense low plasticity silt with sand M/L [Micaceous sand encountered in BH 12]	6	15	8	30
Dense to Very Dense Silty Sand Light Gray 7.5 YR, dense to very dense low plasticity silt with sand M/L [Micaceous sand encountered in BH 16]	15	50	36	32 - 26

For future optimisations of the design, using parameters derived from Boreholes 15 and 16, also located within the proposed upstream Chauhali riverbank protection, could result in a second type of design, particularly for the upper (above low water level) slope.

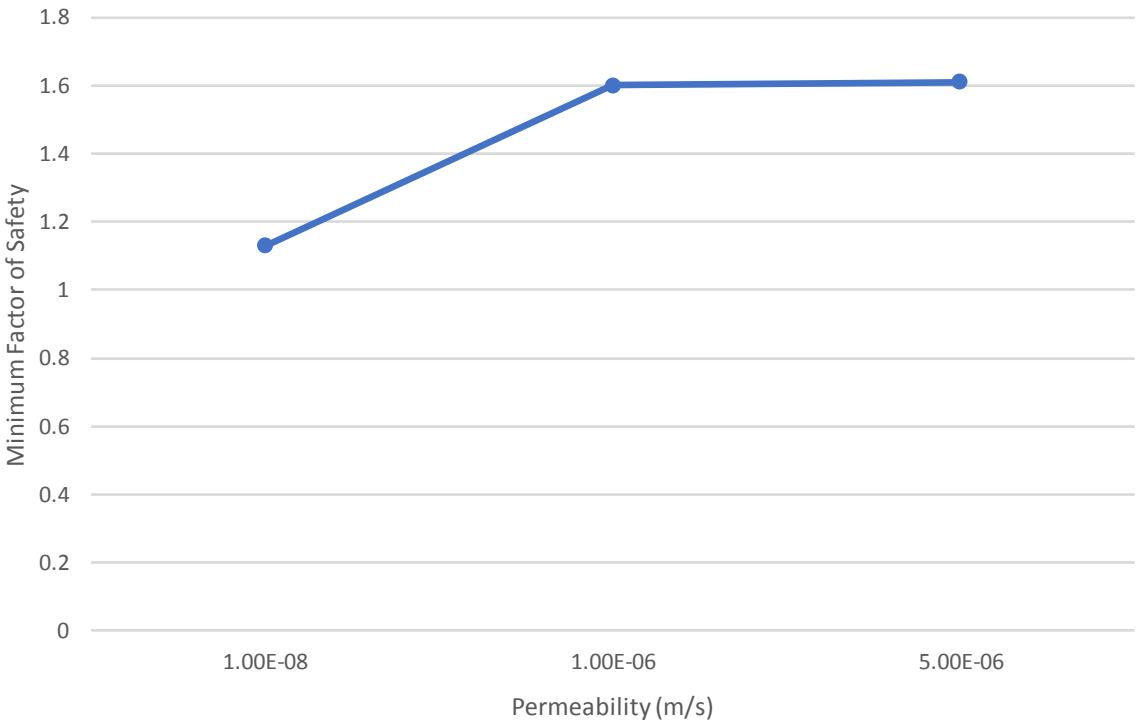
Appendix C - Sensitivity Analyses

13.1.1 Permeability / Hydraulic Conductivity

Seep-W was used to carry out a drawdown analysis assuming a drawdown rate of 0.6m per day.
No in-situ permeability testing was carried out during the geotechnical investigations in the area and so the estimation of permeability is based on Hazen's law as follows:

$$K = C\ (D_{10})^2$$

This results in an assumed permeability of 1 x 10-6 for the d10 of 0.0001m found in the upper 3m of soil in boreholes 12 and 13.
A sensitivity analysis was carried out on the effect of permeability on the safety factor against drawdown using a SEEP-W (seepage) model in conjunction with a SLOPE-W model (slope stability) for geometry case 3 with a 1V : 3H above water slope. The higher and lower values for permeability used in the analysis came from the USCS classification for silty sand as 5 x 10^-6 to 1 x 10-8 m/s. As expected, the FOS found in the analysis was very sensitive to the permeability of the material ranging from 1.03 to 1.52 for the higher and lower permeability materials respectively.

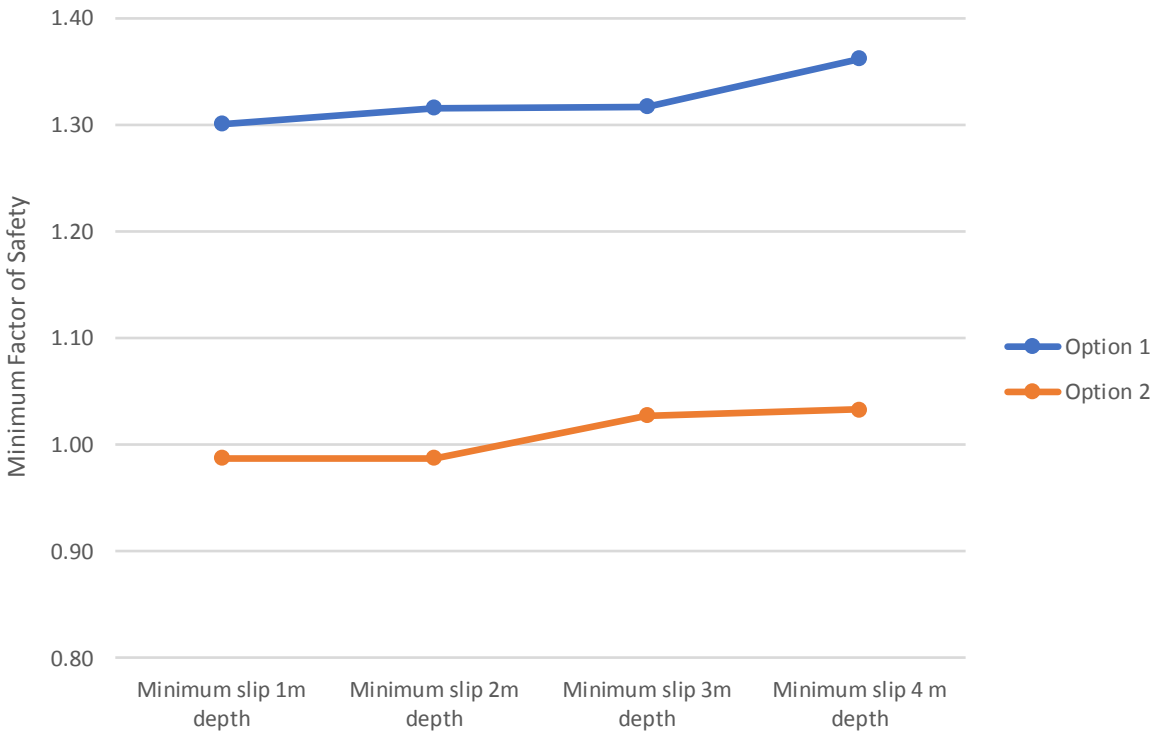


13.1.2 Volumetric Water Content

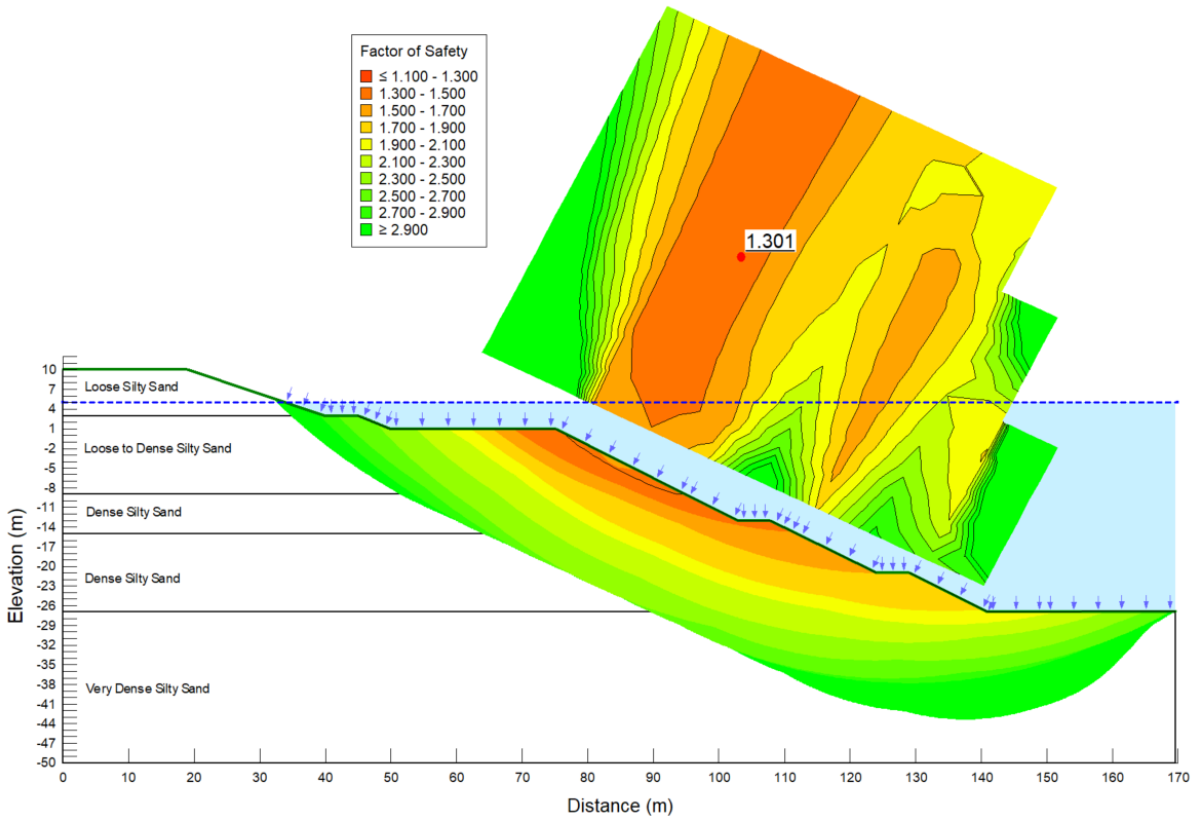
No sensitivity has been carried out on the volumetric water content however this will be completed for the future revision of this document.

13.1.3 Minimum Slip Circle Depth

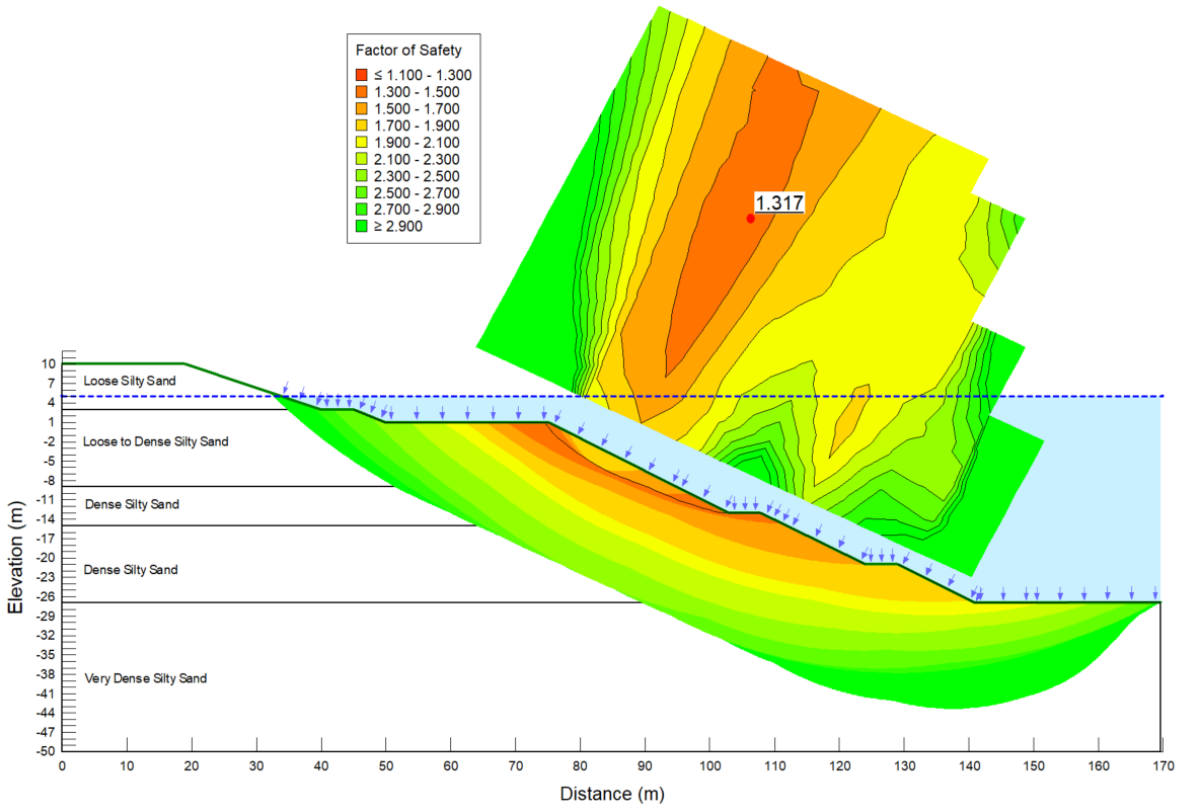
The minimum slip circle depth



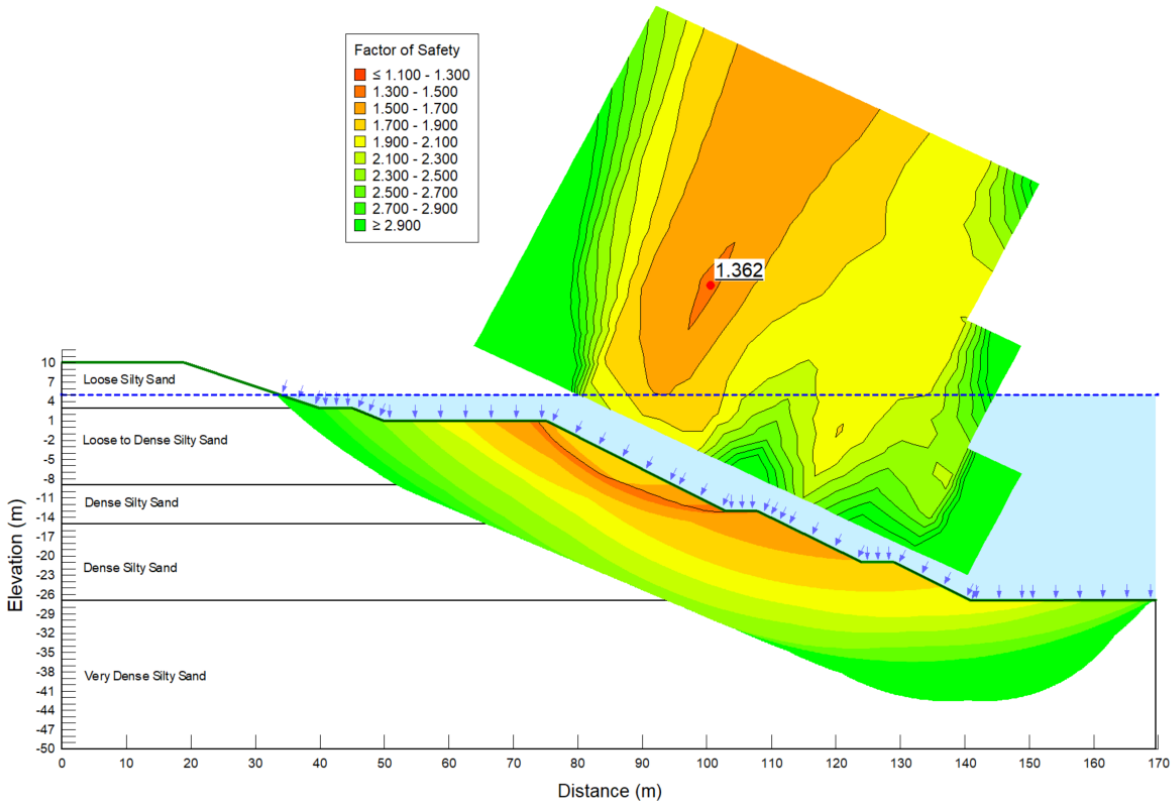
1m slip depth launched slope



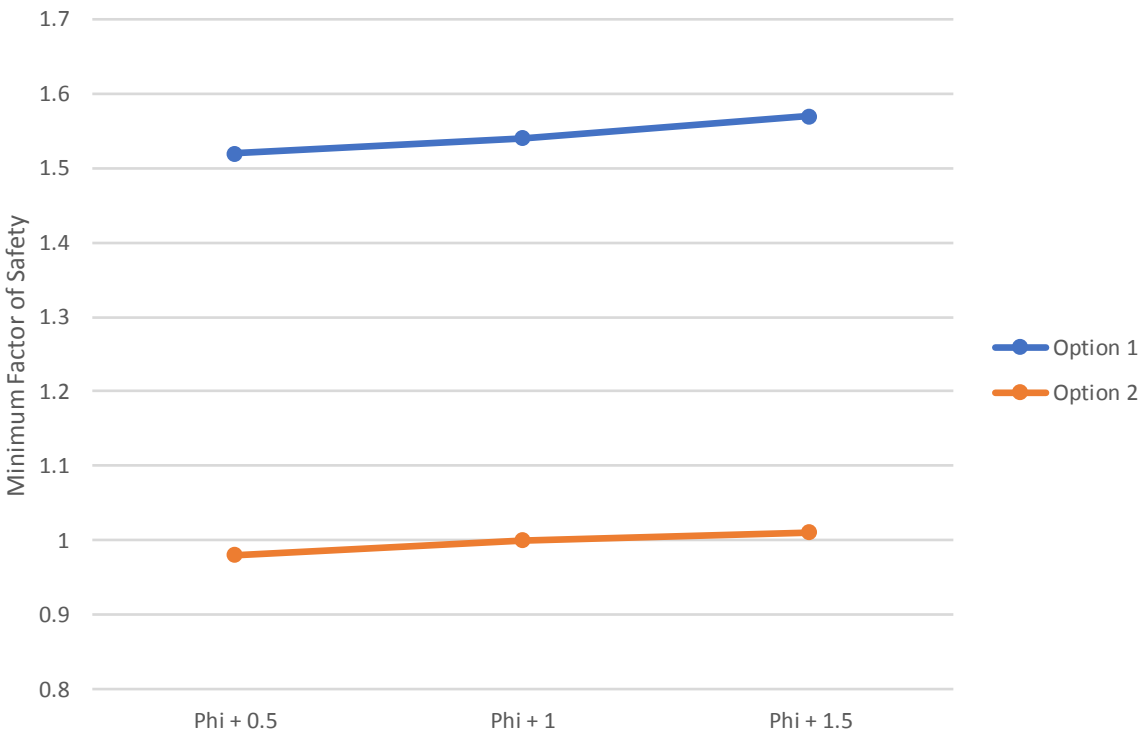
3m slip depth



4m slip depth

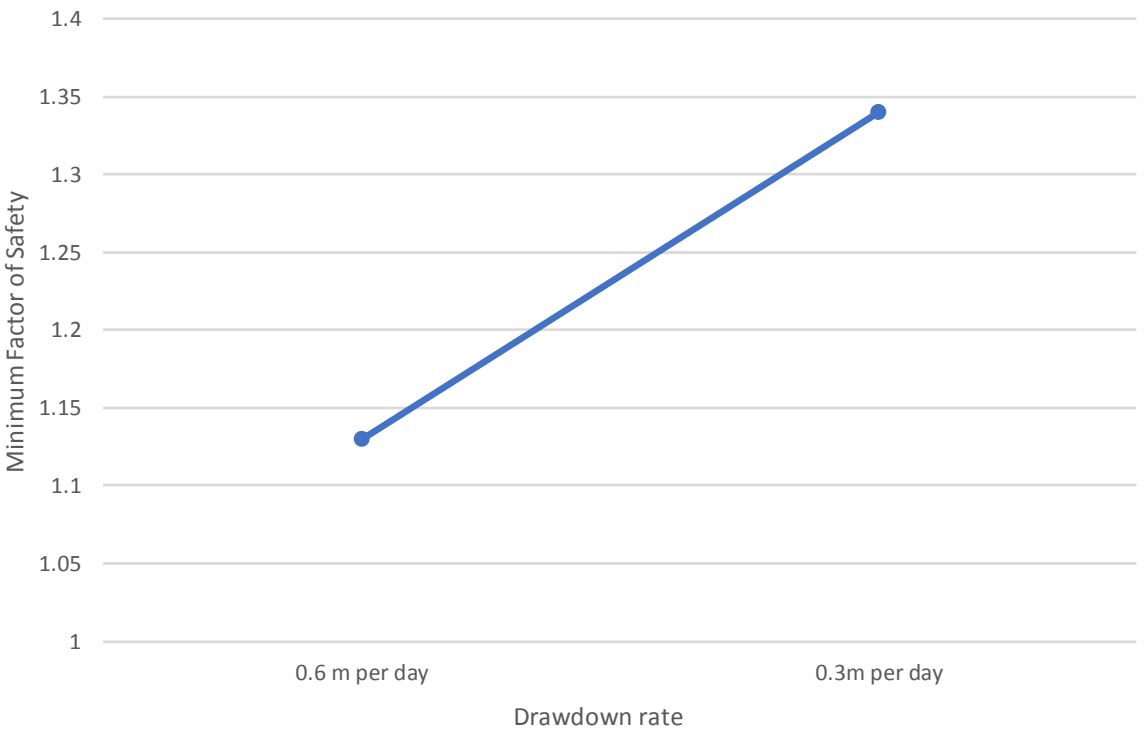


13.1.4 Friction Angle



13.1.5 Rate of Drawdown

Modifying the rate of drawdown from 0.6m to 0.3m per day was found to have a significant effect on the factor of safety, increasing from 1.13 to 1.34 in the option 1 minimum permeability case.



Appendix-M

Photos

Figure M1 ADB Mission 24 September 2019 inspecting the new embankment near Kaijuri, Sirajganj Division

Figure M2 ADB mission, Interaction with local stakeholders , 24 September 2019

Figure M3 Kaijuri embankment with partially completed vetiver coverage, 24 September 2019

Figure M4 BWDB emergency works at Benotia to secure the Kaijuri embankment, 24 September 2019

Figure M5 ADB mission, inspection of grout-filled jute mattress, pilot tested for the first time in Bangladesh, 24 September 2019

Figure M6 ADB mission, inspection of vetiver plantation to protect the embankment slope against rain-cuts, 24 September 2019

Figure M7 ADB mission, discussion with community-based disaster risk management volunteers, 25 September 2019

Figure M8 ADB mission, visit of Chauhali, 25 September 2019

Figure M9 ADB mission, visit to Jaffarganj school building at the riverbank, 26 September 2019

Figure M10 Harirampur, grout-filled jute mattress with measurement devices, 13 September 2019

Figure M11 Harirampur, grout-filled jute mattress, localized failure with measurement devices (red), 13 September 2019

Figure M12 Harirampur, temporary wave protection with geobags forming an organic bankline, 13 September 2019

Figure M13 Chauhali, upstream outflanking with emergency protection, 22 November 2019

Figure M14 Chauhali, upstream temporary wave protection after three floods, 22 November 2019

Figure M15 Chauhali, upstream permanent wave protection, 22 November 2019

Figure M16 Chauhali, stable repaired section after initial slippage in 2017, 22 November 2019

Figure M17 Kajuiri embankment, grout-filled jute mattress after 2019 flood, 22 November 2019

Figure M18 PIRDP, JMREMP riverbank protection after 15 flood seasons, 23 November 2019

Figure M19 PIRDP, downstream end of JMREMP protection built in 2004, after 15 yeas in service, 23 November 2019

Figure M20 Harirampur, grout-filled jute mattress after first flood season, 24 November 2019

Figure M21 Harirampur, localized failure of grout-filled jute mattress, 23 November 2019

Figure M22 Padma Bridge river training on dredged 1V:6H slope, 23 November 2019

Figure M23 Environmental Compliance Inspection meeting at site with representatives of SMO, ISPMC and Contractor at W-04 (21 December 2019)

Figure M24 Tube well with\ protection at W-04

Figure M25 Safety warning signboard displayed at site at W-05

Figure M26 Nurse at W-05

Figure M27 First aid box with required items at W-04

Figure M28 Kitchen with C.I sheet roofing and enclosure at W-03