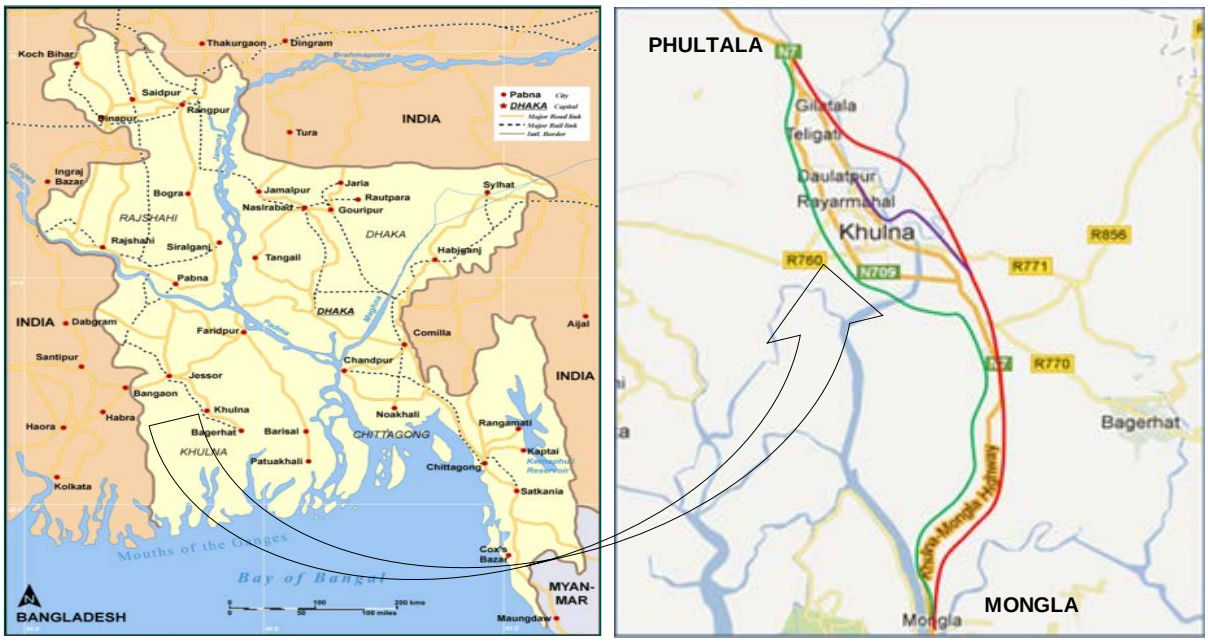
GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH,
BANGLADESH RAILWAY, CRB, CHITTAGONG

Detailed Feasibility Study & Safeguard Policy Study, Detailed Engineering & Bidding Services and Construction Supervision Services etc. for the Purpose of Construction of KHULNA - MONGLA PORT RAIL LINE

FINAL REPORT OF FEASIBILITY STUDY
VOLUME I - MAIN REPORT



JUNE – 2013

CONSULTING
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EXECUTIVE SUMMARY

ES 1 INTRODUCTION

The Government of Bangladesh has taken up a project to construct of a Broad Gauge (BG) rail link from the city of Khulna to Mongla Port under Line of Credit of USD 1 billion by Government of India. Bangladesh Railway has initiated the work for development of the proposed rail link with appointment of Consultant to undertake feasibility study, detailed design and construction supervision of about 60 km broad gauge railway line.

Presently, the Mongla Port is connected with the Inland Waterway and Highway, but do not have any connectivity with the Bangladesh Railways (BR) Network. This rail link will provide connectivity to Mongla Port with the existing railway network of BR which will eventually lead to establish regional and sub-regional railway connectivity.

ES 2 CONSULTING SERVICES &TERMS OF REFERENCE

A contract for consulting services was made on 14th June, 2012 between Consulting Engineers Group Ltd. in Joint Venture Association with Nippon Koei Pvt. Ltd. and Bangladesh Railway for Consultancy Services for this Project. This contract bears the approval no. GOILOC-134[7] of EXIM Bank (India) which was communicated vide Bank's letter no. GOILOC-134/12/1413 dated Oct 1, 2012. The Bangladesh Railway communicated with the Consultant for commencement of services vide letter No: ENC/P/AGT/K-M/01, dated 03/10/2012. The Consultant commenced its services from 5th November 2012.

The consultancy services will be performed in the following three phases.

a) Phase-I: Detailed Feasibility Study and Safeguard Policy Studies,
b) Phase-II: Detailed Engineering Design and Bidding Services, and
c) Phase-III: Construction Supervision Services for the purpose of construction of Khulna-Mongla Port BG Rail Line.

Completion date of assignment for Phase-I is 5 months from date of commencement; for Phase –II it is 3 months from start date of assignment under Phase-II, and for Phase-III it is 24 months from start date of assignment under Phase-III.

The main objective of consultancy is to conduct a Feasibility Study and Safeguard Policy Study (Environmental & Social Impact Analysis and Resettlement Plan) for the

construction of Broad Gauge (BG) railway link between Khulna and Mongla Port. The study includes to determine economic and financial viability of the project, fixing suitable alignment including detail design for rail line, bridges, stations, yards, signalling, etc. including construction supervision services

The broad Scope of Work under the Feasibility Stage (Phase-I) is as follows.

- Review Available Data and Records
- Reconnaissance Survey
- Identification and Assessment of Alternative Alignments
- Preliminary Topographic Survey
- Identifying Technical Solutions for Rail Link Construction
- Traffic Studies and Forecasting
- Preliminary Hydrological and Morphological Studies
- Preliminary Cost and Benefits
- Economic and Financial Analysis
- Environmental Services
- Social and Resettlement Services

The present report pertains to Phase-I.

ES 3 FINAL REPORT OF FEASIBILITY STUDY

Structure of the Report

As part of the Scope of Work and Reporting Requirements for Phase-I of the consulting assignment, the Final Report of Feasibility Study consists of the following four volumes. While Volume I and Volume II are part of the main report, Volume III and Volume IV are self-contained reports.

- Volume I – Main Report
- Volume II – Drawings
- Volume-III: Environmental Report
- Volume-IV: Social and Resettlement Report

The Final Report of Feasibility Study (Volume I) consists of 13 chapters. Chapter 1, Chapter 2 & Chapter 3 provides introduction to project and consulting services, describes the methodology adopted for the Feasibility Study, and gives the socio-economic setting of Bangladesh and the project area. In Chapter 4 & Chapter 5, the various surveys and investigations performed at project location has been elaborated along with the steps that were followed to identify the best alternative alignment. The traffic estimates and its forecasts for the proposed rail line have been described in

Chapter 6. Engineering aspects such as design standards & specifications, conceptual design of the rail line, bridges, stations, etc., their cost estimates related to the project, have been dealt in Chapter 7, Chapter 8 and Chapter 9. The economic analysis for the alignments and the financial analysis for the selected alignment are presented in Chapter 10 & Chapter 11. Finally, the investment & financial plan, along with the recommendations are made in Chapter 12 & Chapter 13.

ES 4 PRELIMINARY SURVEYS & INVESTIGATIONS

The preliminary surveys relating to engineering, traffic, environmental and social & resettlement were conducted to obtain desired data/ information from the project area that will form a basis in alignment study. The various preliminary surveys conducted for the feasibility of proposed rail route are listed below:

- Preliminary Topographic Survey
- Hydrological and Morphological Study
- Geotechnical Survey
- Material Survey
- Traffic Surveys
- Environmental Survey
- Social and Resettlement Survey

ES 5 ALTERNATIVE RAIL ALIGNMENTS

The purpose of the alignment study was to select the best suitable alignment for construction of the proposed rail link. The study was initiated through adopting a selection criterion, followed by field visits/ surveys aimed at obtaining maximum data and information for the alignment study.

The project area starting from Phultola Railway Station (start point) to Mongla Port was divided into two sections. In Section-1 a total of eight alignment options were considered in three directions and in Section-2 two alignment options were studied in two directions. The distribution of the alignments in the different directions and in the two sections is shown in the table below.

Table E1: Alignment Options

Section	Alignment Direction	Alignment Alternatives
Section 1	Eastern Alignment	Alignment A
		Alignment B
		Alignment C
		Alignment D
	Western Alignment	Alignment E
	Central Alignment	Alignment F
		Alignment G
		Alignment H
Section 2	East Side	Alignment A
	West Side	Alignment B

Considering the requirement of the Amendment No. 2 to the Request for Proposal (RFP), dated 30.04.2011, issued by Bangladesh Railways, the Consultant studied four alignment (A,B,C,D) options on the Eastern side to avoid Rupsha River. However, during preliminary survey it was observed that while avoiding river Rupsha, all these alignments on East Side will be passing through three major navigable rivers, viz., Bhairab, Atai and Atharobaki (River Bhairab is of the same class as Rupsha River, requiring navigational clearance of 60 feet). For crossing the three consecutive rivers, construction of high embankment for a considerable length of about 26 Km will be required.Finally combination of C and A option designated as modified option C was found the most suitable option on East Side and termed as Eastern Alignment.

The other four alignment options were considered in the following manner.

One option on the Western part was taken for studywhich will be passing through one major navigable river, viz., Rupsha River, requiring navigational clearance of 60 feet and termed as Western Alignment.

Other three options F, G and H on the Central part of the project area were studied. The alignment F and G will be passing through one major navigable river Rupsha. The option H will cross two navigable rivers, viz., Bhairab and Atharobaki. River Bhairab is of the same class as Rupsha River, requiring navigational clearance of 60 feet. Finally option H was found the most suitable option on Central part and termed as Central Alignment.

Based on the above preliminary study the most suitable alignment on each side viz., East West and Centre, were further studied and investigations were carried out to finalize the most suitable alignment.

A comparative analysis of the three Preliminary selected alignments one on each side (East, West and Central) is presented in the following table.

Table E2: Comparison of Selected Alignments

Attribute	Eastern Alignment	Western Alignment	Central Alignment
Length (Km)	59.60	60.40	49.2
Embankment Height/ Physical Obstruction	Major Issue	Not a Major Issue	Major Issue
Major Bridges	3 Nos.	1 No.	2 Nos.
Road Over Bridge	1 No.	---	---
Accessibility	Low	High	Moderate
Constructability	Difficult	Easier	Easy
Station Height	1 at Approx. 10 m ht.	All at Grade	All at Grade
Social Impact	Moderate	Low	High
Operating & Maintenance Cost	High	Low	Moderate
Serviceability	Low	High	High
Safety	Lower	High	Low
Land Constraint	Critical from Phultola to BADC Godown	Negligible	Critical (City Area on both side of Rupsha)
Approx. Construction Cost (Crore Taka)	2472.57	1895.51	2035.63
Social Cost including LA	442.76	480.01	512.20
Environmental Cost	2.05	2.06	1.75

Based on the above comparative study, the order of priority for the three alignments are as under.

1. Western Alignment (Alignment-E)
2. Eastern Alignment (modified Alignment-C)
3. Central Alignment (Alignment-H)

ES 6 PROJECT RAIL TRAFFIC

The Consultant has studied the present traffic flows along the proposed rail corridor, identified the major future projects from where the traffic offerings are possible and also studied the possibility of catering to the traffic linked to Nepal and Bhutan.

The sequence adopted for traffic assessment and its forecasts is listed as follows.

- Assessment of total traffic flows (freight and passenger) along the proposed rail corridor by existing mode of transport
- Diversion of the above traffic to the proposed rail link
- Potential traffic offerings to the project rail link from the proposed projects that

would come up in future

- Possibility of materializing of regional cargo in case of being routed through Mongla Port (traffic to and from Nepal and Bhutan)
- Traffic projects by using the growth rates and/ or the future expansion/ production plan of the industrial units and Mongla Port.

The passenger & freight traffic for the first year of railway operations (2016-17) and the horizon years are set out in the following tables.

Table E3: Freight Traffic

Alignment Option	Freight Traffic (Lac Ton)					
	2016-17		2019-20		2029-30	
	Tons	Ton-Km	Tons	Ton-Km	Tons	Ton-Km
Eastern Alignment (modified Alignment C)	63.63	17731	80.48	23034	169.72	51530
Western Alignment (Alignment E)	63.63	17731	80.48	23034	169.72	51530
Central Alignment (Alignment H)	63.63	17731	80.48	23034	169.72	51530

Table E4: Passenger Traffic

Alignment Option	Passenger Traffic Lac)					
	2016-17		2019-20		2029-30	
	Pass	Pass-Km	Pass	Pass-Km	Pass	Pass-Km
Eastern Alignment (modified Alignment C)	11.24	1343	14.16	1692	24.19	2890
Western Alignment (Alignment E)	17.51	1443	22.06	1818	37.67	3105
Central Alignment (Alignment H)	17.51	1443	22.06	1818	37.67	3105

ES 7 DESIGN STANDARD, SPECIFICATIONS & CONCEPTUAL DESIGN

Having identified the three alignments for further investigation and assessing the traffic for theses alignments, conceptual design for the alignments were prepared by following the applicable design standards and specifications.

In general, the Bangladesh Railway Specifications and Indian Railway Specifications IRS) were used. In the event of conflict between Bangladesh Railway (BR)/ Indian Railway Standards (IRS)and Indian Standards / Indian Road Congress Specifications, IRS Specifications was considered. International codes may be followed for the items

not covered in IRS/IS/IRC Specifications. The standards and specifications were considered for all the project items/ parameters such as tracks, bridges, stations, yards, crossings, right of way, geometrics, navigational clearing requirements, loadings, speed design life, signalling & telecommunications, etc.

The details of conceptual design are given in Chapter 8.

ES 8 INDICATIVE COST ESTIMATES

The construction work is expected to be completed in two years period, commencing from the financial year 2014-15. The construction cost estimates for the three alignments along with the phasing are set out in the following table.

Table E5: Construction Cost and Phasing

Alignment Option	Construction Cost (Lacs Taka)		
	2014-15	2015-16	Total
Eastern Alignment (modified Alignment C)	86540	160717	247257
Western Alignment (Alignment E)	66343	123208	189551
Central Alignment (Alignment H)	71247	132316	203563

The social & environmental costs related to the three alignments are given in the table below (the social & environmental costs estimates are for a corridor width of 100 meter, however, on an average the corridor width of about 50 meter would be required for the rail alignment, therefore the only 50% of the estimated cost is shown in the table).

Table E6: Social & Environmental Cost

Alignment Option	Social Cost (Lacs Taka)			Environmental Cost (Lacs Taka)		
	2014-15	2015-16	Total	2014-15	2015-16	Total
Eastern Alignment (modified Alignment C)	15496	28779	44276	72	133	205
Western Alignment (Alignment E)	16800	31201	48001	72	134	206
Central Alignment (Alignment H)	17928	33294	51222	61	113	175

ES 9 ECONOMIC ANALYSIS

The Consultant has followed the 'with' (i.e., project alternatives) and 'without' (i.e., base case or do minimum/ nothing) project approach, whereby the cost to the economy for moving a specified and projected volume of traffic by rail and competing modes road/ IWT would be estimated in both the 'with' and 'without' the project situations,

and compare theses costs to obtain the net benefit to the economy.

The resultin terms of Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and Benefit- Cost Ratio (B/C Ratio) of the economic analysis for the three alignments are presented in the following table. The minimum discount rate is considered at 15%, and it sets the minimum value for acceptance of EIRR.

Table E7: Results of Cost-Benefit Analysis

S. No.	Alignment	NPV (@15%) (Lac Taka)	EIRR (%)	B/C Ratio
1	Eastern Alignment (modified Alignment C)	1,547	15.10%	1.01
2	Western Alignment (Alignment E)	39,326	17.84%	1.26
3	Central Alignment (Alignment H)	28,387	16.94%	1.18

ES 10 FINANCIAL ANALYSIS

Financial analysis evaluates the financial returns of investments for the projects, and determines financial feasibility of the project based on the cost of the project and revenue estimates as per the traffic volume forecasts and the applicable fare and freight rates.

The resulting terms of Financial Internal Rate of Return (FIRR), Net Present Value (NPV) and Benefit- Cost Ration (B/C Ratio) of the financial analysis for the three alignments are presented in the following table. The minimum discount rate is considered at 15%, and it sets the minimum value for acceptance of FIRR.

Table E8: Results of Financial Analysis

S. No.	**Alignment**	**NPV (@15%) (Lac Taka)**	**FIRR (%)**	**B/C Ratio**
1	Eastern Alignment (modified Alignment C)	**5,607**	**15.32%**	**1.01**
2	Western Alignment (Alignment E)	**52,807**	**18.65%**	**1.14**
3	Central Alignment (Alignment H)	**43,764**	**17.80%**	**1.11**

ES 11 RECOMMENDATION AND CONCLUSION

Based on the results of the physical, environmental, social and economic analysis of the three alignments, it is inferred that:

a) Western Alignment is the most economically viable (EIRR **17.84%**) with least

social & environmental issues, hence it is the preferred alignment that would impart maximum benefit to the economy, both in percentage as well in quantity terms.

b) Though the economic returns of the Central Alignment (EIRR **16.94 %**%) is marginally higher than the Eastern Alignment (EIRR **15.93%**), but from the social impact perspective the Central Alignment will be difficult to implement.

c) Eastern Alignment is economically viable (EIRR **15.10%**) with moderate social impact, and can be implemented by meticulously addressing the issues relating to high embankment and accessibility to the site during construction.

Following the conditions specified in Terms of Reference (TOR), the Eastern Alignment (Modified Alignment C)is recommended.

Based on higher economic return and other project related issues, the Western Alignment (AlignmentE) is recommended.

The above recommendations are placed to Bangladesh Railway for taking decision on approval of the alignment through the Draft Final Report of Feasibility Study Volume I (Main Report) on May 2013.

ES 12 APPROVAL OF ALIGNMENT

Bangladesh Railway communicated to the Consultant the approval of alignment vide letter no. ENC/P/AGT/K-M/01 dated 03.06.2013. Among the various alternative options proposed by the Consultant, the Western Alignment has been approved. Consultant will carry out the detail engineering design & bidding services (Phase II) for this approved Western Alignment.

CHAPTER 1 INTRODUCTION

1.1 OVERVIEW

The Government of Bangladesh has embarked upon the construction of a Broad Gauge (BG) rail link from the city of Khulna to Mongla Port. It is basically the extension of the existing rail line serving Khulna, to the Mongla Port. Presently, the Mongla Port is connected with the Inland Waterway and Highway, but do not have any connectivity with the Bangladesh Railways (BR) Network. This link will provide connectivity to Mongla Port with the existing railway network of BR which will eventually lead to establish regional and sub-regional railway connectivity. It is well understood that with the linking up of Mongla Port with the BR rail network, and further to the neighbouring counties, viz, Nepal, Bhutan, and the North-East India, these countries/ regions falling in the hinterland of Mongla Port, can be served efficiently, and will benefit from international trade. At the same time, Mongla Port will be used efficiently to its existing capacity, with possibility for capacity expansion in future.

As part of their efforts for wider rail connectivity, Government of Bangladesh has taken up a project for construction of Padma multiple-bridge, including railway line, over the river Padma. The Padma railway link will have connectivity upto Bhanga under Phase-I which will be extended upto Jessore in Phase-II. Thus upon construction of Padma rail link,distance between Khulna and Dhaka by rail will be reduced to substantial extent.After implementation of the railway link between Mongla and Khulna under the present project, the Mongla Port will be connected with BR network and both the sea ports Chittagong and Mongla will be connected by rail link.

In the national perspective, at present, majority of export and import cargo are being handled at Chittagong Port, the main seaport of Bangladesh. For lessening the congestion at Chittagong seaport and development of other regions, efficient infrastructure facilities need to be provided at Mongla Port, the proposed rail line to the port is expected to fulfil the gap.

In the above context, to compliment the efforts of the Government of Bangladesh, the Government of India is providing Line of Credit of USD 1 billion (since reduced to USD 800 million) through Exim Bank of India to Government of Bangladesh. One of the components under this fund is development of rail link between Khulna and Mongla Port. BR will be the implementing agency for the proposed rail project.

1.2 PROJECT AREA

The project is located in Khulna Administrative Division. It is one of the seven administrative divisions in the Southern part of Bangladesh, close to Sunderban and Bay of Bengal, and lies on the banks of river Rupsha and Bhairab. Two districts (Khulna and Bagerhat) of Khulna Division are falling under this project area and which is further divided into seven Upazilla/ Thana as presented in Table 1.1. Nearly one third of Southern Khulna is covered by thick mangrove forest on muddy saline tidal banks namely Sunderban. Because of its strategic location of only 45 km from Mongla Port, Khulna is considered as a port city like Chittagong. The geographical location of Khulna and Mongla Port can be seen in the accompanyingmap

Table1.1: Administrative Setting of Khulna Division

Division	Districts	Upazilla/ Thana	
Khulna	Khulna	1.Phultala	3. Rupsha
		2. Dighalia	4. Terokhada
	Bagerhat	1. Fakirhat	3. Mongla
		2. Rampal	

1.3 CONSULTANCY SERVICES

Bangladesh Railways (BR) has initiated the work for development of the proposed rail link with the appointment of Consulting Engineers Group Ltd. in Joint Venture with Nippon Koei India Pvt. Ltd. (herein after Consultant) to undertake feasibility study, detailed design and construction supervision of about 60 km broad gauge railway line. The major component of the project is to construct broad gauge railway track. The Consultant is expected, inert alia, to finalise the proposed alignment in the course of its assignment. As part of the contractual agreement between the Consultant and BR, the present Final Report of Feasibility Study (Phase 1) is being submitted to BR.

A contract was made on 14th June, 2012 between Consultant and Bangladesh Railway for Consultancy Services for this Project. The contract bears the approval no. GOILOC-134[7] of EXIM Bank (India) which was communicated vide Bank's letter no. GOILOC-134/12/1413 dated Oct 1, 2012. The Bangladesh Railway communicated with the Consultant for commencement of services vide letter No: ENC/P/AGT/K-M/01, dated 03/10/2012.The Consultant commenced its services from 5th November 2012.

The consultancy services is to be performed in the following three phases.

Phase-I: Detailed Feasibility Study and Safeguard Policy Studies,

Phase-II: Detailed Engineering Design and Bidding Services, and

Phase-III: Construction Supervision Services for the purpose of construction of Khulna-Mongla Port BG Rail Line.

The present Final Report of Feasibility Report and the Safeguard Policy Study (SPS) is part of the submission requirement under Phase 1.

1.4 STUDY OBJECTIVE & SCOPE OF WORK

The objective and scope of consulting services of the project have been elaborated in the RFP document. The Consultant has thoroughly studied it, and the same forms the basis for the present Final Report & SPS. The objective and scope of consulting services as given in the RFP document has been summarised in the following sections.

1.4.1 Study objective

The main objective is to conduct a Feasibility Study and Safeguard Policy Study (Environmental & Social Impact Analysis and Resettlement Plan) for the construction of Broad Gauge (BG) railway link between Khulna and Mongla Port. The study includes to determine economic and financial viability of the project, fixing suitable alignment including detail design for rail line, bridges, stations, yards, signalling, etc. including construction supervision services.

The study will be conducted in three phases as set out below. The first two phases will includedetail feasibility study and safeguard aspects, the engineering design and preparation of tender documents. The third phase relates to construction supervision. The components for these three phases are highlighted in Table 1.2.

Table 1.2: Project Phases

Phase	Study Type	Study Components
Phase -I	Detailed Feasibility Study and Safeguard Policy Study	• Detailed Feasibility Study with Economic and Financial Analysis • Environmental Studies • Social and Resettlement Studies
Phase –II	Detailed Engineering Design & Preparation of Tender Documents	• Detailed Survey of the proposed route • Detailed Engineering Design of all Infrastructures including embankment, track, bridges & culverts, station buildings, platforms, approach road, foot over bridges, platform sheds yards, signalling, etc. • Detailed Cost Estimates • Preparation of Tender Documents • Providing Bidding Evaluation Assistance Services
Phase – III	Construction Supervision	• Supervision the Construction works as per drawing, design, BOQ etc. • Quality Control • Time and Cost Management

1.4.2 Scope of Consulting Services for Phase I

The tasks to be undertaken by the Consultant are summarised below.

Detailed Feasibility Study with Economic and Financial Analysis

i. Review of all available data and reports, etc.

ii. Assess the various alternative routes considering the critical factors and avoiding major identified impediments during field visits

iii. Identifying the various technical solutions for rail link construction and all others facilities deemed necessary for identifying the least time & cost solution

iv. Assessing the costs and benefits of various alternative routes of the project that is technically sound and economically & financially viable

v. Undertaking traffic studies based on traffic surveys, and do traffic forecasts for domestic and cross-border cargo by taking into account the current and future development scenarios(economy & transport network), and also considering other modes of transport (modal split)

vi. Carryout Hydrological and Morphological Study for fixation of the formation level of the railway track, opening of the bridges & culverts and design scour

&erosion protection in the vicinity of major bridges and river banks

vii. Conduct the Economic and Financial Analysis

viii. Prepare a suitable phased Investment Plan and Financial Plan

ix. Quantify the Financial and Economic Benefits of the proposed Investment Plan by including – (a) Implementation Schedule, (b) Schedule for Procurement of Goods and Services, and (c) Methodology for Project Benefit Monitoring.

Environmental Services

As a part of the Safeguard Policy Study for the construction of the proposed railway line the Consultant will conduct Environmental Impact Assessment (EIA) and prepare an Environment Management Plan (EMP) as per the EIA guideline of the Government of Bangladesh. The provision for implementing and recommendations of EIA shall be incorporated in the bid document and the environmental mitigation cost will be included in the cost estimates for the project. In addition to the preparation of the environmental reports, the Consultant will also assist Bangladesh Railway for getting environmental clearance from Department of Environment (DOE).

The following tasks will be performed for undertaking the Environmental Services..

i. Conducting I.E.E to identify moderate, major and significant impacts

ii. Conducting EIA and prepare EMP

Social and Resettlement Services

The Social and Resettlement Services is one of the components of Safeguard Policy Study. The following tasks shall be performed by the Consultant to complete this assignment.

iii. Conducting Social Impact Assessment (SIA) to establish resettlement and relocation cost.

iv. Based on SAI, prepare a Social Management Plan (SMP), Land Acquisition Plan

v. LA Planning and Resettlement Plan (RP) for Project Affected People (PAP).

vi. Assisting BR for engaging NGO for the implementation of SMP & RP.

1.4.3 Scope of Consultancy Services of Phase - II

On completion of the Phase –I, the Consultant will, as a part of Phase –II, conduct a detailed survey of the selected route, prepare detailed engineering design & drawings, workout detailed cost estimate, prepare bid documents and provide bid evaluation assistance services for construction of the proposed Broad Gauge Railway Link between

Khulna and Mongla Port. Basically the services will be in two parts – (a) Investigation Services and (b) Detailed Design, Plan, Drawings and Cost Estimates. This will be followed by preparation of bid documents and assistance in tender processing.

The following tasks shall be performed by the Consultant under the Phase –II.

i. Detailed survey of the selected route, following the specifications as laid down in the Engineering Code of Bangladesh Railway with deviations/modifications adopted in "Jamuna Bridge Railway Link Project".

ii. Detailed Engineering Design of all infrastructures including soil, hydrological, hydrographic, and seismic and foundation investigations (where necessary), preparation of detailed design, plan and drawings and prepare cost estimates and bill of quantities.

iii. Preparation of bid documents following the terms and condition of Indian Dollar Line Credit Agreement and incorporating comments from client and finalize bid documents.

iv. Providing support services during the bidding period, including holding a pre-bid meeting and site visit; assist in developing bid evaluation criteria and procedures, preparing bid evaluation report and finalization of the bid.

1.4.4 Scope of Consultancy Services of Phase - III

The scope for the phase includes construction supervision and monitoring of all contracts including environmental and social aspects. The specific tasks to be performed are listed below:

i. Contract administration and management

ii. Quality control, time and cost management

iii. Inspection of construction activities

iv. Testing of materials on-site and off-site (if required)

v. Review of contractor’s submittals, verification of progress and interim payment requests

vi. Determination of final construction quantities

vii. Preparation of Monthly Progress Report

viii. Maintenance of Record

ix. Contract/ works or goods acceptance and close of contract, issuance of completion certificates, etc.

x. Preparation of operation, maintenance and management manuals

xi. Assurance for proper demobilisation and restoration of the construction sites

after completion

xii. Carry out all obligations provided for the Engineer in Civil Works contracts

xiii. Monitor and support as necessary the implementation of EMP & RAP

xiv. Handling of construction disputes under the terms of the Contract

xv. Provide support to BR for coordination required to implement the works under the contract together with those works being financed by other agencies and by the Government of on its own

xvi. Commissioning of the works

1.5 STRUCTURE OF REPORT

As part of the Scope of Work and Reporting Requirements for Phase-I of the consulting assignment, the following volumes of reports are being submitted as a part of Final Report of Feasibility Study.

- Volume-I: Main Report
- Volume-II: Drawings
- Volume-III: Environmental Report
- Volume-IV: Social and Resettlement Report

The Final Report (Volume I) consists of the following 13 chapters. Chapter 1, Chapter 2 & Chapter 3 provides introduction to project and consulting services, describes the methodology adopted for the Feasibility Study, and gives the socio-economic setting of Bangladesh and the project area. In Chapter 4 & Chapter 5, the various surveys and investigations performed at project location has been elaborated along with the steps that were followed to identify the best alternative alignment. The traffic estimates and its forecasts for the proposed rail line have been described in Chapter 6. Engineering aspects such as design standards & specifications, conceptual design of the rail line, bridges, stations, etc., their cost estimates related to the project, have been dealt in Chapter 7, Chapter 8 and Chapter 9. The economic analysis for the alignments and the financial analysis for the selected alignment are presented in Chapter 10 & Chapter 11. Finally, the investment & financial plan, along with the recommendations are made in Chapter 12 & Chapter 13. The approval of the alignment by BR has also been discussed in Chapter 13.

Chapter 1: Introduction

Chapter 2: Methodology for Feasibility Study Report

Chapter 3: Socio-Economic Profile

Chapter 4: Preliminary Surveys and Investigations

Chapter 5: Alternative Alignments

Chapter 6: Traffic Estimation & Forecasts

Chapter 7: Design Standard and Specifications

Chapter 8: Conceptual Engineering Design

Chapter 9: Indicative Cost Estimates

Chapter 10: Economic Analysis

Chapter 11: Financial Analysis

Chapter 12: Investment and Financial Plan

Chapter 13: Recommendations and Conclusions

CHAPTER 2 METHODOLOGY FOR FEASIBILITY STUDY REPORT

2.1 GENERAL

Feasibility Study covers different aspects relating to data collection from primary surveys as well from secondary sources, investigations of the project area, identification of possible alignments for extending the existing Jessore- Khulna rail line to Mongla; conducting traffic surveys, studying engineering, social and environmental issues relating to the rail alignment options. The broad structure of the methodology adopted for the study is as presented in Chart 2.1, and the description of the same is provided in the following sections.

2.2 REVIEW AVAILABLE DATA AND RECORDS

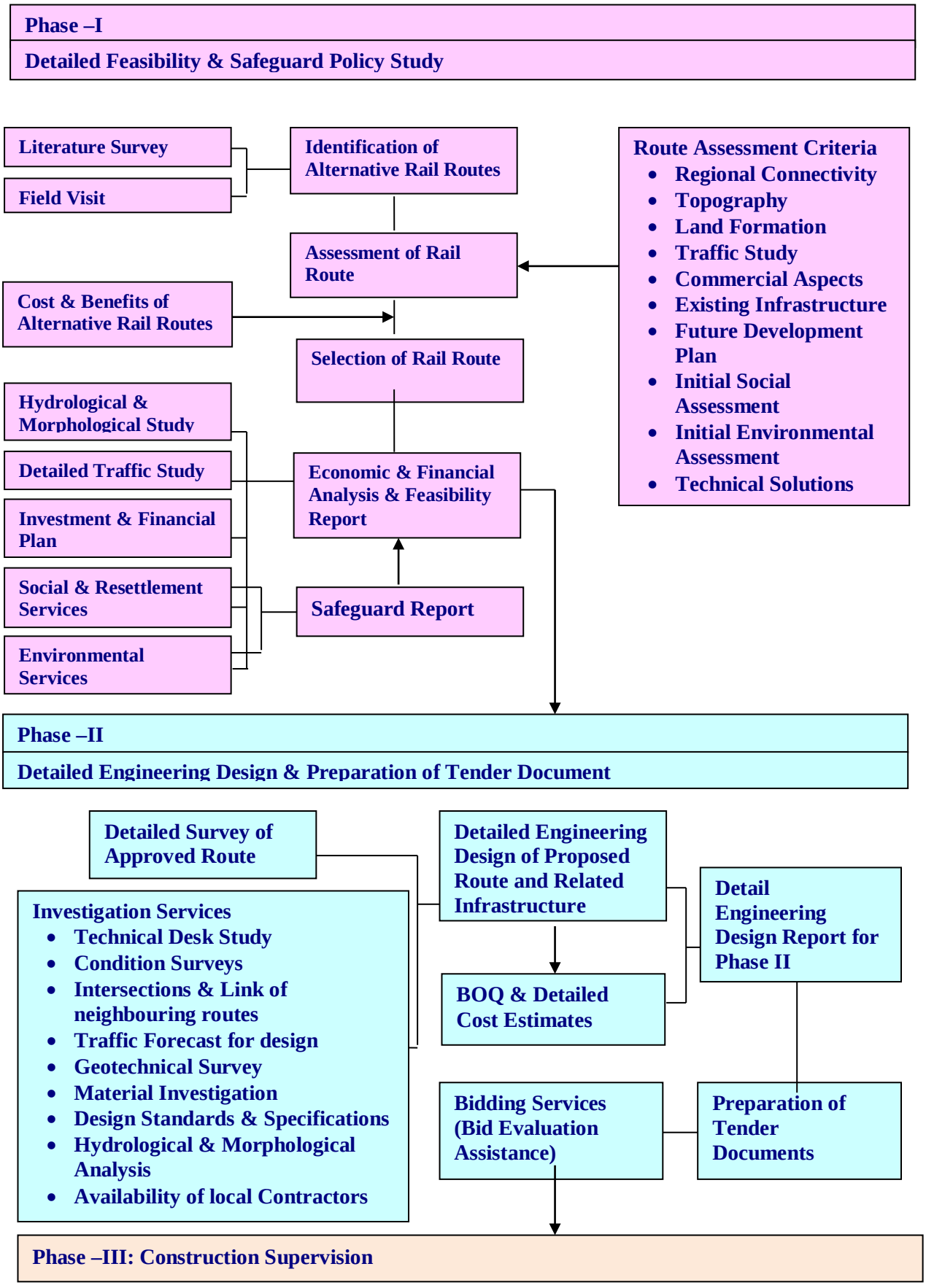
The Consultant reviewed all the available data and report relating to the study. All possible sources for data and reports were identified and contacted for gathering the same. Information received from agencies such as Bangladesh Railways, Port Authority, Inland Water Transport Authority, Roads and Highway Department, Khulna Development Authority, Water Resource Department and other related agencies were reviewed and incorporated in the study as required.

2.3 RECONNAISSANCE SURVEY AND FIELD VISITS

Initial joint site visit with senior members of the Consultant team and Railway Officers was made on 10th and 11th November, 2012 for site appreciation and reconnaissance survey for different possible alternatives for proposed rail route. It was informed by the Railway Officers that there was a preliminary study with tentative alignment also marked on Mouza Maps for this railway route around year 1968, conducted by Bangladesh Railway. Some initiatives were also taken for land acquisition.

The above initial visit was followed by a series of site visit and investigations by different experts of the Consultant team with a view to study the project area for identifying the possible alignment options, familiarising with the local conditions, identifying major constraints and collecting sufficient information for conducting preliminary surveys – topographic, hydrological, traffic, social and environmental – so that the desired inputs/ data can be obtained from these surveys so as to facilitate the study in selection of the best alignment alternative.

Chart 2.1:Flow Chart for Methodology



2.4 IDENTIFICATION AND ASSESSMENT OF ALTERNATIVE ALIGNMENTS

Based on the site visits and initial information on the study area the Consultant identified various alternative alignments for proposed railway link connecting Khulna and Mongla Port. The various factors such as topography, regional connectivity, available land information, traffic projections, social and environmental factors, Major River crossings, existing and proposed infrastructure facilities were studied through conducting surveys and detailed investigations.

2.5 IDENTIFYING TECHNICAL SOLUTIONS FOR RAIL LINK CONSTRUCTION

Apart from the selection of the rail alignment in the most effective manner, the Consultant, on the basis of data collected and available information, identified the viable and cost effective technical solutions for various components such as:

i. Rail embankment and track
ii. Bridges & elevated structures
iii. Signaling and operational facilities
iv. Buildings, Platforms and platform sheds
v. Approach Roads, foot over bridges. level crossings
vi. Station Yards & Siding
vii. Connectivity to Mongla Port, etc.

2.6 TRAFFIC STUDIES AND FORECASTING

The traffic on the new BG rail link was studied on the following accounts.

- Possibility of traffic diversion from the existing competing modes – Road and IWT
- Possibility of traffic diversion from the competing ports – Chittagong, Haldia/ Kolkata, etc.
- Increased / Induced traffic due to linking of Mongla Port and industries in the project area by BG rail network
- Increased traffic due to linking of Mongla Port with neighbouring countries/ land locked areas by BG rail network
- Generation of traffic due to setting up of already planned industries

The traffic (freight and passenger) were estimated on the basis of both primary surveys as well secondary data collection. The Consultant undertook Classified Traffic Volume

Counts (CTVC) and Origin – Destination (OD) Surveys at two locations on the Khulna - Mongla Highway (N7) to capture the traffic movement by road and the possibility of its diversion to proposed railway. For other modes of transport and port/ industry traffic, efforts were be made to get the traffic data through market survey (for industries) and by interacting with related agencies (BR, IWT Authority, Roads & Highway Department., Mongla Port Authority, etc.).

Traffic forecasts for next 20 years were made for domestic and cross-border cargo. It was based on the available data, past trends and the future development of the business activities. Development of traffic on competing modes of transport network and other infrastructure facilities likely to come in future were considered and the model share on the proposed Rail Link was assessed.

Efforts were made to identify the traffic demand for movement of major bulk commodities such as Fertilizer, Coal, Cement, Mineral Oil, etc.

2.7 PRELIMINARY TOPOGRAPHIC SURVEY

Preliminary topographic survey was carried for all the identified alignment options. The identified alignment options were plotted on Topographic Maps/ Google Maps and were verified on ground. Locations for various important points along the route were collected in terms of coordinates by GPS Instrument. Extent of development, any restricted area, historical places, river crossing locations, etc. were considered during study. The purpose of the preliminary survey was to establish probable alignments which will be further studied on the basis of technical and other parameters.

2.8 PRELIMINARY HYDROLOGICAL STUDY

Preliminary Hydrological and Morphological study of the area was conducted to assess the probable flood levels which in turn will decide the formation level at major bridges. Navigational clearances were maintained for bridges across major rivers as per requirement keeping in view the tidal fluctuations.

Information on high flood level (HFL), low water levels (LWL), standard water level (SWT), discharge, velocity with respect to high / low tides etc. were collected from available past records, local inquiries and visible signs on the structural components and embankments.

The purpose of the preliminary hydrology was to fairly decide the linear water way and other hydraulic parameters for bridges along the proposed alignment. The data on river depth for the four major rivers –Bhairab, Atai, Atharobaki and Rupsha (Photo 2.1 to Photo 2.4) - were collected at the probable bridge construction sites through manual method.

Photo 2.1: Bhairab River

Photo 2.2: Atharobaki River

Photo 2.3: Atai River

Photo 2.4: Rupsha River

2.9 ECONOMIC AND FINANCIAL ANALYSIS

The economic analysis was done for identified alignment alternatives and the best alternative with highest economic returns was recommended. Financial analysis was done for the recommended alternative.

2.9.1 Economic Analysis

Economic analysis wascarried out within the frame work of "With" and "Without" the project situation. For a given volume of projected traffic, the transportation cost (vehicle operating cost, value of time, accident, etc.) to the economy under the two situations mentioned above, was estimated for each year of the project analysis period of 20 years and 2 years construction period. The difference in transportation costs under the two situations was the net benefit to the economy. The net benefit stream for the project analysis period of 20 years (plus 2 years of construction) was discounted and the economic indicators such as Economic Internal Rate of Return (EIRR), Net Present Value (NPV), and Benefit – Cost ratio were worked out to ascertain the economic viability of the project.

The economic costs were estimated by converting the current financial costs by applying the standard conversion factor. At the terminal year (20^{th} year) of the project analysis period the residual/salvage value of the assets was duly accounted for in the

economic analysis.

2.9.2 Financial Analysis

The financial analysis has been performed from the point of view of the investing agency (in this case BR). The following costs to be incurred by BR were estimated.

- Construction cost of the new BG rail line and associated infrastructure
- Operations & maintenance cost of the above assets
- Operating cost of transportation by railway for moving goods and passengers

For the projected goods and passenger traffic, revenues were estimated by considering the prevailing "freight" and "fare" rates for the classified cargo groups and passenger classes.

A financial model for the project analysis period of 20 years (plus two years of construction) was prepared to estimate the project financial indicators such as Financial Internal Rate (FIRR), Net Present Value (NPV), and Benefit – Cost ratio, of the project. Based on the values of these indicators, the financial viability of the project was established.

2.9.3 Sensitivity Analysis

The robustness of the financial and economic viability of the project was further judged by conducting a sensitivity analysis whereby the cost and benefit/ revenue stream of the project were subjected to sensitivity cases to know the change in the economic and financial indicators under extreme probable cases.

2.10 ENVIRONMENTAL STUDY

As the part of environmental study, the Consultant hasidentified and collect the data from different sources, and undertaken all the necessary surveys to estimate the environmental impact and to quantify the same. The Consultant has started with the Initial Environmental Examination (IEE) for all the route alternatives. It will be followed by assessment of the impact due to the construction of the selected/ recommended railway alignment (after approval from BR), for which an Environment Impact Assessment (EIA) as per requirement of the Government of Bangladesh (GOB) will be conducted. The Consultant will prepare an Environment Management Plan (EMP) as per the EIA guideline of the GOB.

Consultant has conducted a preliminary study during feasibility stage. The detail EIA and EMP for the selected alignment will be submitted along with draft final report of detail design.

For an effective safeguard of the environment, the recommendations of EIA & the provision of EPM shall be incorporated in the Bid Document for project construction and the environmental cost estimates will be incorporated in the overall cost estimates of the project.

2.10.1 Surveys & Data Collection

The environmental study has been based on both primary and secondary information. During the IEE primary observation was made on all the route alternatives through field visit, key stakeholder consultations and key informant interviews. Secondary data was collected from different sources including published and unpublished literature, different databases, newspapers and the internet.

During the EIA stage more specific survey shall be conducted on both sides along the right-of-way of the selected rail alignment to prepare an inventory of all the features to be impacted due to the construction of the rail line.

2.10.2 Initial Environmental Examination

At the feasibility phase, the Consultant has initiated by conducting environmental scoping or an initial environmental examination for the alternative route alignments. It simply indicates whether or not there is an environmental concern and has identified for each alternative minor and significant impacts. It has not determined the extent of an effect, or whether an effect has actually occurred.

While conducting IEE the Consultant has carefully identified for each route alternatives the major environmental impact categories such as loss of farm/agricultural land, water bodies, flora & fauna, human habitation, aquatic life, social and cultural properties, pollution, navigation, irrigation, land erosion/ degradation, eco system, forest areas, etc.

A comparative summarised statement indicating the IEE of each alignment was prepared to rank the alignments according to the quantum of impact (in monetary terms). This formed the basis for incorporating the environmental impact, apart from the other factors, in selection of alignment.

2.11 SOCIAL AND RESETTLEMENT SERVICES

Consultant has conducted a preliminary study for all the alignment options during feasibility stage. The detailed Social Impact Assessment (SIA), Rehabilitation Plan (RP) and Land Acquisition Plan (LAP) for the selected alignment will be submitted along with draft final report of detail design. Social Impact Assessment study will provide necessary input for developing a Social Management Plan (SMP), Land Acquisition Plan (LAP) and Resettlement Plan (RP).

Every project has some impact on quality of life of the people in surrounding area/villages. The impact may be positive or negative. Both the aspect of the impact on quality of life has to be determined during feasibility stage of the project.

Team of trained investigators (the team) was assigned in the field the task of data collection on the properties and other social resources such as schools, cultural structures, religious places, public places, etc likely to be affected on each of the alignment alternatives. A comparative summarised statement indicating the initial social impact of each alignment was prepared to rank the alignments according to the quantum of impact (in monetary terms). This formed the basis for incorporating the social impact, apart from the other factors, in selection of alignment.

CHAPTER 3 SOCIO ECONOMIC PROFILE

3.1 GENERAL

The present chapter discusses the socio-economic profile of Bangladesh and the Project Influence Area (PIA). The data and analysis relating to the economic growth and development of Bangladesh and the PIA, as well as the future potential for economic development are the major aspects covered in the chapter.

The main purpose of the socio-economic profile analysis is to relate the economic development potential of an area to the demand for transport .In this regard, due to diverse economic potential of the different areas constituting the PIA, it was felt necessary to reflect this diversity in the transport demand analysis. The diversity in economic potential of the areas likely to be served by the proposed rail link was incorporated in the transport demand analysis by considering wider definition of PIA, and incorporating the national and regional level influence of the proposed rail link.

3.2 PROJECT INFLUENCE AREA (PIA)

The project is located in Khulna Administrative Division. It is one of the seven administrative divisions in the Southern part of Bangladesh, close to Sunderban and Bay of Bengal, and is located on the banks of river Rupsha, Bhairab and other rives. Nearly one third of Southern Khulna is covered by thick mangrove forest on muddy saline tidal banks namely Sunderbans. Because of its strategic location of only 45 km from Mongla Port, Khulna is considered as a port city like Chittagong.

Khulna is third largest city with a population of about 22 lac (2010 estimates for the Master Plan 2001 area consisting of Khulna City Corporation Area and Extended Area), and it projected to reach about 32 Lakhs by the year 2020. It covers an area of 223.36sq.km.

Since the proposed rail alignment will pass through Khulna Metropolitan Area, it is important to understand the ‘planned expansion’ of the city as envisaged in the Master Plan 2001 as well as the Khulna – Mongla Development Plan. Khulna City from its original position gradually extended towards northwest, and with the development of Khulna-Jessore road, the city started to grow along Khulna-Jessore corridor.Industrial Estate is at Shiromoni on about 511.29 acre land.Now, due to the availability of land, the city is gradually extending towards West and South-West (towards Satkhira), and with the construction of City Bypass Road the direction of spatial growth has moved towards the road.

It is felt that regional integration is very important for the growth and development of

Khulna city, particularly in the context of development strategy for the whole of South-West region of Bangladesh. In this regard the integration of Mongla Port and Noapara Industrial Township with Khulna is of prime importance, and the development of the project rail line along with the existing Rupsha Bridge and the proposed Khan Jahan Ali Airport are crucial for it.

3.3 ECONOMY

3.3.1 Country

Bangladesh is one of the largest deltas of the world with a total area of 147,570 sq. km. The population of the country (2010) was reported at about 142 million, making it one of the densely populated countries of the world (964 persons /sq kms. 2009-10).

The resilience and inherent strength of Bangladesh economy has been mainly due to its robust sectors such as agriculture, readymade garments and remittances. Bangladesh is one of world's largest producers of Rice (4th), Potato (11th), Mango (9th), Pineapple (16th), Tropical Fruit (5th), Onion (16th), Banana (17th), Jute (2nd), Tea (11th).

The Gross Domestic Product (GDP) of Bangladesh stands at US $ 113 billion (2011 estimates), with the per capita income being US $ 678. According to the International Monetary Fund (IMF), 2010, Bangladesh was ranked as the 44th largest economy in the world with gross domestic product of US$257 billion (purchasing power parity basis).

It has been observed that during the financial year (FY) 2001-2009, the GDP grew by a healthy 5.8 % per annum (including 6.3% per annum in the FY 2006-2009), accelerating by one percentage point compared to the previous decade.

Vision 2021 stipulates that Bangladesh will attain middle income status by 2021. However, in order to achieve this goal the government has set its economic growth target to 8% by 2015 and 10% by 2021. In order to fulfil this vision the manufacturing and service sectors are expected to play a central role. The strategy of the Government has been to facilitate a dynamic, vibrant, pro-export and competitive manufacturing sector that would eventually contribute some 30% to national income and be able to absorb 20% of the work force.

3.3.2 Project Area

Khulna is known as the city of shrimp as 75% of shrimp exported from Bangladesh are cultivated in the Khulna zone. A number of large and medium scale industrial units were set up in this district during the period of 1950-70. These industrials units are located mainly in present Khulna City Corporation and its adjacent areas. Khulna Newsprint Mills Ltd, Khulna Hardboard Mills Ltd, Khulna Textile Mills Ltd, Khulna Power Station and seventeen jute mills were established by the bank of Bhairab River.

Another important industrial unit –Khulna shipyard Ltd was established in 1957. But now, Khulna Newsprint Mills, Textile Mills and a number of jute mills have already been closed as per government decision. On the other hand, Khulna shipyard Ltd was handed over to Bangladesh Navy for running its operation.

3.4 TRANSPORT SYSTEM

Bangladesh, a densely populated country with an estimated population of 964 persons/sq km, has an extensive and diversified transport system comprising 1,03,536 km roads (20,948 km highways and 82,588 km rural roads), 2791 km railways, 24,000 km inland waterways, 2 seaports, maritime shipping, and civil aviation etc. The road transport by an order of magnitude in carriage of goods and passengers has apparently been playing the most dominant role. The modal share of passenger and freight traffic for road, rail and IWT has been estimated at 88%, 4%, 8% and 80%, 4%, 16% respectively for passenger modes and freight modes (World Bank 2007). The transport network map Bangladesh is presented as Figure 3.1

Figure 3.1 Bangladesh Transport Network

3.4.1 Road

The road sector comprises road infrastructure and transport services. While the ownership, provision and management of road infrastructure are with the government, the transport services i.e. bus for passengers and trucks for freight transport are mainly in the private sector.

The Roads and Highway Department (RHD) is responsible for planning, provision and maintenance of National, Regional and Feeder Road “A” Type roads. The total length of the road network under RHD during the period 2001 to 2011 is presented in Table 3.1. While the total length of the roads under RHD has remained more or less the same, the length of national/regional highways increased and that of feeder road “A” type

decreased; indicating upgrading from lower level roads to higher level and in turn increase in the length of better quality road. Further, about 86% of the RHD road length is paved. A total number of 4,507 bridges and 13,751 culverts are also under RHD control. RHD is currently operating about 153 ferry boats in 60 ferry ghats on its road network throughout the country.

Table3.1:Categories of Roads under RHD

Year	National Highway (km)	Regional Highway (km)	Feeder Road 'A' type (km)	Total (km)
2001	3086	1751	15962	20799
2002	3086	1751	15962	20799
2003	3086	1751	15962	20799
2004	3723	4832	13823	22378
2005	3570	4323	13678	21571
2006	3570	4323	13678	21571
2007	3570	4323	13678	21571
2008	3484	4128	13255	20865
2009	3478	4222	13248	20948
2010	3478	4222	13248	20948
2011	3492	4268	13280	21040

Source: Bangladesh Economic Review 2011

In the project area, the main connectivity to Mongla Port is by way of Khulna - Mongla Highway (N7) and a 2 lane bridge on Rupsha River, which is connected through Khulna City bypass road to the Khulna – Jessore highway. This is the only Highway which connects the Mongla Port from rest of country. The road network in the project area is shown as Figure 3.2

Figure 3.2: Project Area Road Network

The public transport system comprises of buses and micro buses that operates in the study area. There are large number of bus companies operating their buses from Sonadanga Bus Terminal to Dhaka and other districts like, Kushtia, Barisal, Patuakhali, Perojpur, Faridpur, Rangpur, Mymensing, Satkhira, Bagerhat, and Gopalganj.

The major traffic generating/ congestion centres in the study area are: (a) Boiro Bazar area and Sonadanga Bus Terminal in West; (b) Noapara, Fulbari Gate, Mohsin Intersection, and Doulatpur area in North; c)Gallamari Intersection in South; and (d) Rupsha Ghat and East Rupsha Bus Terminal in East.

3.4.2 Railway

Bangladesh Railway (BR) operates a total of 2,791 route km, comprising of Meter Gauge (MG) – 1,757 km (62.95%), Broad Gauge (BG) – 659 km (23.61%) and Dual Gauge (DG) – 375 km (13.44%). BR operates 443 stations, and under it there are 3,380 bridges, of which 2,903 are minor and 477 are major ones. In terms of traffic, about 64 million passengers and about 2.5 million tons of freight traffic was moved by the railways during the year 2010-11. The rail network map of Bangladesh is presented in Figure 3.3.

The BR is organized as two zones i.e. East Zone and West Zone. While East Zone has only MG (1222 km), West Zone has MG (535 km), BG (659 km) and DG (375 km). Because of the multi-gauge system, transport on BR involves transhipment at break of gauge points as well as at riverine points. Transhipment acts an impediment as it entails additional time and cost and places the rail mode in a cost disadvantage position relative to other competing modes.

Figure 3.3: Bangladesh Rail Network

With the completion of the 99 km new DG line over the Bangabandhu Bridge over Jamuna River connecting the East and West zones and rehabilitation and conversion of 245 km BG line from Jamtoil to Parbatipur to DG, the transhipment problems have eased out. Further improvement has been achieved after completion of the railway link between eastern side of Jamuna Bridge to Tarakandi conversion of MG track to DG track from Joydebpur to Dhaka. Further improvement is expected on completion of the railway link between western side of Jamuna Bridge to Bogra,

Passenger Traffic

Passenger traffic on BR has been increasing at an average rate of 7.8% in case of passengers carried and 11.20% in terms of passenger-km (PKM) performed over the last 6 years i.e. 2005-06 to 2010-11. The higher growth rate for P-km is mainly due to the fact that the average distance travelled by the passenger has increased from 99 km to 126 km during the seven year period (Table 3.2).Intercity trains carry 40.8% of total passengers but in terms of Passenger-km contribution of intercity trains is about 76%.

Table 3.2: Number of passenger carried, Passenger-km and Average Lead - BR

Year	No. of Passengers ('000)			Passenger-Km (000)			Average Lead (Km)		
	BG	MG	Total	BG	MG	Total	BG	MG	Total
2005-06	10855	33665	44520	989903	3397544	4387447	91	101	99
2006-07	11618	34306	45924	1067082	3518957	4586039	92	103	100
2007-08	13635	40306	53941	1370544	4238699	5609243	101	105	104
2008-09	14689	50470	65159	1652084	5148649	6800733	112	102	104
2009-10	14939	50852	65791	1737993	5566952	7304945	116	109	111
2010-11	14256	49426	63682	1884114	6167806	8051020	132	125	126

Source: Bangladesh Railway

Freight Traffic

The freight traffic in 2010-11 was 2554 thousand Metric Tons against 2714 thousand Metric Tons during 2009-10. Freight traffic, both in terms of tonnes and net ton-km (NTKM) has been registering a negative growth. It may be mentioned here that decreasing trend in BR freight traffic was not due to lack of sufficient traffic, but the constraints in providing adequate number of wagons and locomotives as well as creation of required line capacity, especially on Dhaka-Chittagong rail corridor. It is pertinent to mention here that BR is lifting only about 6% of the import/export traffic available at Chittagong port

Project Area - Railway

The project area falls under Bangladesh Western Railways. Khulna is the southern-most terminal station of the West Zone railway.Other railway stations within the study area are, Daulatpur, Bajerdanga and Noapara. Khulna has broad gauge railway line that runs

to northern region through Jessore, and is further linked with north-western districts like, Kushtia, Rajshahi, Natore Rangpur and Bogra and also the capital city via Bangabandhu Jamuna Bridge.

The Khulna railway has some spur and loop lines. One spur line runs along the industrial belt at Khalishpur. A loop line goes to the Daulatpur warehouse area. Another loop line goes to Maheshwarpasha CSD area. Except the CSD area lines all other spur and loop lines are currently abandoned. In the Eastern area the railway line between Khulna and Bagerhat was long abandoned.

Five express trains operate from Khulna (Table 3.3) 6 days a week to three destinations, while one express train operate seven days a week. Two trains each to Dhaka, Rajshahi and Saidpur Five mail train (Table 3.4) operate from Khulna seven days a week to destinations like, Chapai Nababganj, Parbatipur, Goalanda Ghat and Benepole. Besides, one commuter train

Table 3.3: Inter-city Trains from Khulna

Train No.	Name of the Train	Destination	Off Day
763	Chitra Express	Dhaka	Monday
761	Sagordari Express	Rajshahi	Monday
725	Sundarban Express	Dhaka	Friday
715	Kapotaksha Express	Rajshahi	Wednesday
727	Rupsha Express	Saidpur	Thursday
747	Simanta Express	Saidpur	No off day

Source: wwwrailway.gov.bd

Table 3.4: Mail Trains from Khulna

Train No.	Name of the Train	Destination	Off Day
15	Mohananda Express	Chapai Nabaganj	No
23	Rocket Express	Parbatipur	No
25	Nakshikantha Express	Goalando Ghat	No
53	Benapole Commuter	Benapole	NO

Source: wwwrailway.gov.bd

3.4.3 Inland Water Transport (IWT)

Bangladesh, as a riverine country with 24,000 km waterways, has a navigable network varying from 5968 km during the monsoon to 3865 km during the dry season. Its inland water transport (IWT) continues to be an important mode of transport not only in the inland movement of freight and passengers but also in the transportation of import and export items through the ports of Chittagong and Mongla. IWT network provides access to about 25% of the rural household in Bangladesh. It has a network of 11 inland ports, 303 secondary riverine stations, 374 landing points without infrastructure, 23 coastal stations and 5 ferry terminals.

BIWTC (Bangladesh Water Transport Corporation) and BIWTA (Bangladesh Water Transport Authority) are GOB organizations and BIWTC is the business operating arm.Bangladesh Inland Water Transport Authority (BIWTA) gives pilot age facilities to about 7,000 inland water vessels. It regulates the movement of about 2000 passenger launches and maintains 21 inland ports along with about 800 launch ghats including terminals.

The most important IWT route is from Chittagong to Narayanganj. The IWT system plays a significant role in cargo originating at or destined for Chittagong Port, and accounts for about 35% of the total cargo volume. Various commodities carried by IWT include petroleum products, grain, edible oils, and dry bulk products (e.g., fertilizers and clinker). IWT is the major carrier of petroleum products from Chittagong to the six Bangladesh Petroleum depots. The waterways carry about 30% of all freight traffic and about 16% of the passenger volume in Dhaka-Chittagong corridor. The details of traffic handled by BIWTA are shown in Table 3.5.

Table 3.5: IWT Operation by BIWTA

Year	No. of Passengers(million)				Cargo (Million Tones)
	By Motor Launch	By Steamer	By Ferry	Total	
2005-06	166.50	1.11	17.05	184.66	17.80
2006-07	177.62	0.94	17.84	196.40	20.50
2007-08	190.30	0.89	17.80	208.99	25.51
2008-09	199.80	0.80	17.33	217.93	26.77
2009-10	220.19	0.89	17.73	238.81	27.85

Due to longer transit time between Dhaka and Chittagong (20 hours), IWT is not a strong competitor in container transport. Further, there is lack of well-equipped and effective terminal facilities for transfer at either ends of the corridor. All this resulted in relatively insignificant container traffic on IWT.

Currently two major projects are under implementation by BIWTA. The projects are, in line with the GOB policy, are being implemented by private sector investors on a BOT and Lease Out basis. The projects are:

- Development of Inland Container Terminal at Khanpur, Narayangonj, and
- Development of Inland Container Terminal at Pangaon, Dhaka.

IWT Operations - Project Area

In the project area BIWTA River Ghat is the major waterway ghat, apart from it, there are more than two dozens of small ghats on the Bhairab-Rupsha and Kazibachha rivers that are used for passenger and goods movement.

Noapara, is a major trading centre of the region, and a large number of barges operate between Mongla and Noapara, everyday carrying import and export goods. The Bhairab-Rupsha River serves as the main waterway route. The river is very stable and navigable round the year. The draft in the river varies between 12 feet to 20 feet.

There are regular launch communication between Khulna and adjacent zila and upazila towns and important trading centres in the southern region. Launches operate in 12 routes every day from the Steamer Ghat. Besides, Rocket Steamer Service by IWTA operates one steamer everyday between Khulna and Dhaka. But lately, this service has become irregular due to scarcity of vessels. Cargo vessels also operate from Khulna to destinations, like, Noapara, Mongla, Dhaka, Chittagong, Barisal, and Narayanganj. Noapara, as a major trading centre of the region large number of barges operate between Mongla and Noapara everyday carrying import and export goods. The Bhairab-Rupsha River serves as the main waterway route. The river is very stable and navigable round the year.

Considering importance of Noapara as a business and industrial town and its waterway connection with Khulna and Mongla for transportation of goods, BIWTA has taken up a project to develop a river port on the Bhairab river at Noapara. IWTA is contemplating to build a guide wall and walkway along the river Bhairab in Noapara.

3.4.4 Ports & Harbours

There are two main sea ports in Bangladesh, viz, Chittagong Port and Mongla Port. Chittagong Port Authority (CPA) is a government agency of Bangladesh responsible for the management, maintenance and governance of the port, located in the city of Chittagong on the Karnaphuli River nine nautical miles from the shore of the Bay of Bengal of the Indian Ocean.

The Mongla Port Authority is responsible for operations, maintenance and development of the port, which is located on the south western part of the country at the confluence of Pussur River with Mongla Nulla approximately 71 nautical miles upstream of the Bay of Bengal.

Mongla Port provides facilities and services to the international shipping lines as well as inland water crafts. The maximum length of vessels that can enter into the port is 225 meter long. There are three types of berthing facilities – MPA operated berths, specialised private berths and berths for Inland Water Crafts. There are 28 vessels & crafts for various port operations, and the port has 58 cargo handling equipment. The port has cargo and container storage space along with 19 container handling equipment.

Major export and import cargo handled at the port are: (a) Exports – Jute & Jute Products, Frozen Cargo, and General Cargo; and (b) Imports – Clinker, Food grains, Fertilizers, Machinery, Gas, Flyash, Gypsum, Sugar and Car. During the year 2011-12

the port handled 234 vessels, 2.5 million tonnes of imported cargo and 0.4 million tonnes of exports. During the same period, about 0.25 million tonnes (30045 TEUs) container cargo was handled at the port.

Currently the Chittagong Port is operating close to capacity. Mongla is operating at about 40% of its capacity. Freight volumes for the two ports are indicated in Table 3.6.

Table 3.6: Cargo Traffic handled at Chittagong and Mongla Port.

Import/Export	2006-07	2007-08	2008-09	2009-10	2010-11
Chittagong Port ('000 Tons)					
Import	23,836	25,345	26,719	32,813	39,915
Export	3,289	3,601	3,764	4,188	4,978
Total	27,125	28,946	30,483	37,001	44,893
Mongla Port ('000 Tons)					
Import	662	518	930	1,502	2,530
Export	252	204	208	147	169
Total	914	722	1,138	1,649	2,699

Source: Chittagong and Mongla Port Authority

As may be seen Chittagong Port handled a total of 44.9 million tons of cargo during 2010-11, the corresponding figure for Mongla port was 2.7 million tons. The pattern is almost same for earlier years also. In other words, Chittagong port handles more than 94% of the seaborne international trade of Bangladesh. Further, at both the ports volume of imports are significantly high as compared to exports. In case of Chittagong port imports constitute 89% of total traffic handled in 2010-11. For Mongla port, the share of imports is 93% of the total traffic handled at the port. It is also observed that Mongla Port utilizes only 40% of its capacity (6.5 million tons).

One of the reason for low utilisation of capacity at Mongla Port can be absence of bulk transport system such as railway, as the IWT linked to the port has limited operational capacity in terms of distance (due to draft constraint it operates only till Naopara).

The on-going/ approved projects at Mongla Port are listed as follows.

- Procurement of Cargo Handling Equipment
- Dredging in the Harbour Area of Pussur Channel
- Procurement of Cutter Suction Dredger & Pilot Dispatch Boat
- Navigation Aids
- Dredging at the outer Bar in the Pussur Channel.
- Procurement of 6 nos. Dredgers and Ancillary Crafts & Accessories for Ministry of Water Resources & Ministry of Shipping (Mongla port-1 No.BIWTa-3 Nos. BWDS- nos.)

- Procurement of Container & Cargo Handling Equipment (1st Phase).
- Construction of shed for jute, jute goods & Fertilizer

3.4.5 Airways

Bangladesh has 3 international airports, 5 domestic airports and 7 STOL (Short Take-off and Landing) airports. The project area is connected with Dhaka by air via Jessore, about 56 km north of Khulna. Currently two private airlines each operate two flights each every day. The airlines operate small aircrafts with a carrying capacity of 40 to 60 passengers. There is a project to build a new airport at Foilahat in Mongla for a STOL service, which would be at 30 minute drive from both Khulna and Mongla Port area, whereas it takes about 2 hours from Khulna and about 3 hours from Mongla Port area to reach the present airport at Jessore.

3.4.6 Transport Modal Share

As expected in most of the developing countries, the growth in transport demand in Bangladesh has outpaced the growth of GDP. The growth in different modes of transportation has not been uniform thereby causing significant changes in share of different modes i.e. modal shares over a period of time. Modal share in passenger traffic for road, rail and IWT is 88%, 4% and 8% respectively. The same in 1985 was 64%, 20% and 16% respectively. Modal share in freight service is 80%, 4% and 16% respectively. The same in 1985 was 35%, 28% and 37% respectively.

It clearly indicates the increasing prominence of road transportation in passenger as well as freight services over the last 3 decades. The decrease in railway modal share is attributed mainly to the constraints in terms rolling stock, track condition, line capacity of Dhaka-Chittagong corridor and operational issues.

One of the major reasons for significant increase in the share of road transportation is the major investments in road sector. The inadequate investment/maintenance in the rail and IWT sector resulted in inadequate operational capacity and inefficiency which in turn led to less traffic volumes.

CHAPTER 4 PRELIMINARY SURVEYS AND INVESTIGATIONS

4.1 GENERAL

The primary objective of the preliminary survey is to get the desired information from the project area which will form a basis in alignment study. The various preliminary surveys conducted for the feasibility of proposed rail route has been described in brief subsequently.

4.2 SITE VISITS

Site visits were conducted by consultant's team time to time as per requirements and also with the BR officials. Meetings were also conducted with various govt. agencies to collect the data.

Available data of the project site were collected by consultant for preliminary study, which includes:-

- Topographical Survey Maps from Survey of Bangladesh
- Google earth images
- Traffic survey data from Roads and HighwaysDepartment.
- Petrol & Diesel sales data
- Information book 2011 of Bangladesh Railway
- Reference reports of the Rupsha Highway Bridge
- Meteorological data

4.3 PRELIMINARY TOPOGRAPHIC SURVEY

The objective of the preliminary survey is to get an overview of the proposed alternative alignments and to capture sufficient ground information which will help to finalise the route alignment. The important objects, ground slope, rivers, streams and canals along with the probable depth and width, stream course, flow direction, high points, low points, road crossings, embankment, utilities, nature of land (agriculture, shrimp pond, habitation, industrial, institution, protected area, or any other kind) mosques, graveyards or any other such objects which may affect the alignment were captured in a strip of 100m on either side of the centre line of the proposed routes with hand handle GPS instrument, digital distance measuring instrument or tape measurements. Ground levels at interval of approximately 100m along the preliminary alignments were also recorded by a level instrument or any other suitable instrument within a reasonable accuracy to enable earth work calculations.

Survey of Bangladesh BM reference was used in taking the levels.Locations of the Geodetic Control Points referred in preliminary survey are presented in Table 4.1.

Table 4.1: Locations of Geodetic Control Points

S. no.	ID No.	Height above MSL (m)	Location & Description
1	BM-5000	3.4051	The pillar is situated at the south-west corner of Damodor Secondary School's field and north-west corner of a pond. Village : Damodor, Upazila : Phultala, District : Khulna.
2	BM-1032	2.6218	The pillar is situated at 7m south from Khulna - Fakirhat Road and 12.8m north from north-east corner of the new school building. Village : Bailtan, Upazila : Fakirhat, District : Khulna.

The topography in the project area is flat land with no hills and vales.The levels mostly lie below 5m. The alignment on eastern side is crossing three major rivers (Bhairab, Atai and Atharobaki) and various other small stream/ canals/ waterways, etc. Along west, the alignment crosses one major river Rupsha and other small streams/ / canals/ waterways, etc. The central alignment will cross the river Bhairab and then follow the east alignment. It will also cross the river Atharobaki and other streams same as for east alignment.

Depth of water was also measured at proposed bridge site. The proposed bridge locations were critically reviewed by the consultant's team and all relevant information including details for approaches were collected.

The preliminary information gathered through this survey was used in deciding the embankment height for proposed railway line along with the bridges, stations, yards, etc. The output of the topographical survey is to:

- Transfer all the data digitally to process on computers
- Prepare alignment layouts showing start-end points, lengths, location of curves, etc.
- Show general physical features such as type of area, canals, roads,
- Prepare profile along the tentative centre line showing levels along with change.

4.4 HYDROLOGICAL AND MORPHOLOGICAL STUDY

Information regarding general topography, soil characteristics, rainfall data, tidal information, etc. were gathered and briefly described below. The information regarding width of river/ stream, bank levels, flow direction, high tide level, low tide level, etc.

were also gathered from concern authorities for estimating bridge parameters.

4.4.1 Topography and Land Form

The topography is flat land with no hills and vales. The land height lies within one meter above mean sea level (at the northern end of Sundarban) to above 15m at the north-west corner of the region (Ref. to Fig. 4.1). The tide limitation area (below 5m elevation) has been classified under Tidal flood plain. The materials carried by the tidal rivers are predominantly fine sand, thus narrow leeves of very fine sand and silt are formed and fine silt and clay are deposited in adjacent basins. The water receding from the land into the rivers at low tide erodes deep channels, so that the area is crossed by a network of tidal creeks and interconnected rivers. The project area comes within this Tidal flood plain.

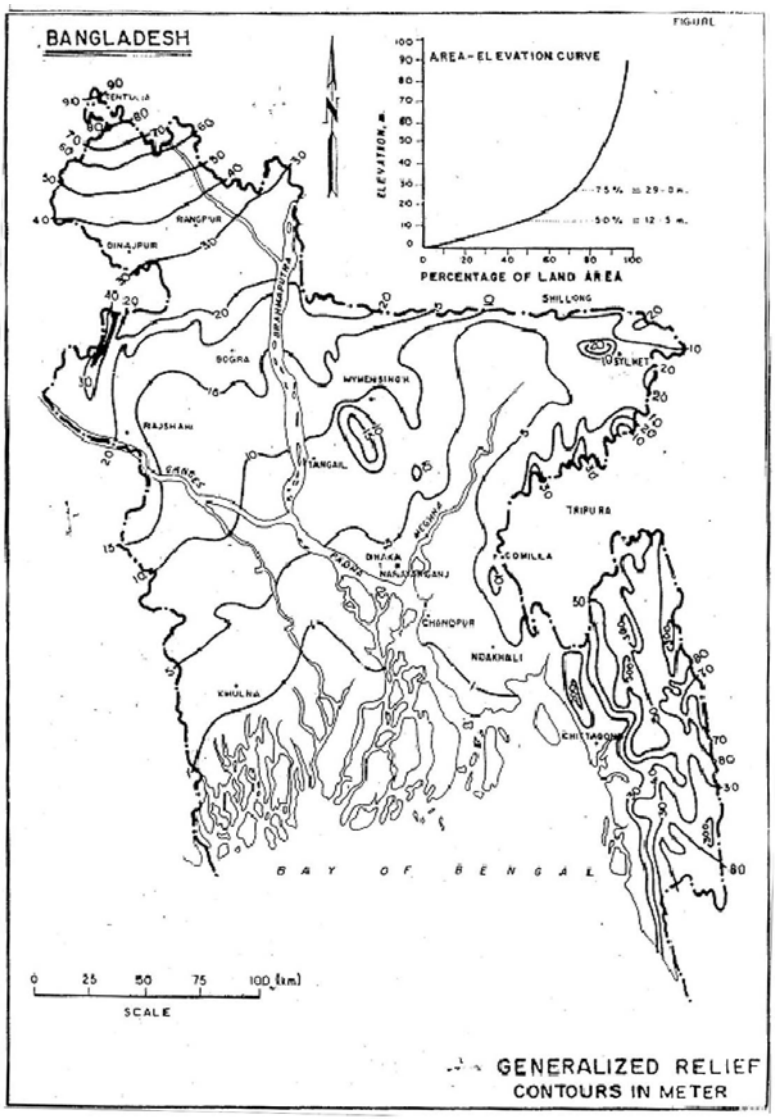


Figure 4.1: Generalised Relief Contours

4.4.2 Geology

Geologically Bangladesh forms the major part of Bengal Basin which is regarded as one of the more active tectonic regions of the world. The Bengal Basin located at the head of the Bay of Bengal is bordered on the west by the out cropping Pre-Cambrian rocks of the Indian Shield and on the north by the elevated Shillong block. The eastern margin of the Bengal basin is formed by the North-North-West, South-South-East and frontal south trending frontal fold zones of the neo-gene phase of the Indo-Burma orogeny. The surface geology of Bangladesh is covered almost entirely by quaternary Sediments with some exceptions in the north and eastern belts. The depth of sediment deposition is highest in the southern part and least in the northern edge

4.4.3 Soil

Bangladesh soil has been classified into 21 groups based on its formation background. The soils of the upper part of the project area come under the group (a) Calcareous Aluminium Soil and those of the tidal flood plain area come under (b) Calcareous Dark Grey Flood Plain Soils.The Characteristics of group (a) is stratified aluminium deposit, they are calcareous within up to 125 cm from surface, they are comprised of mainly sand and silt deposit. They undergo flooding almost every year, has the potential of being eroded or buried by this deposit.These soil are grey-dark to organic in nature. These types are predominant in the tidal and estuarine flood plain. They are also saline affected with low agriculture potential.

4.4.4 Climate

Bangladesh is situated in tropical regionand its climate is mainly controlled by summer and winter circulation of wind. Because of these circulation systems, Bangladesh is a scene of perpetual battle-ground among three air streams of different thermodynamic characteristics. The elements of climate are Rainfall, Temperature, Wind flow and Humidity. Topographic conditions modify the distribution of rainfall.As the project is located in the south-west part of Bangladesh, the climate condition of the zone and related climate data are relevant for design consideration.

4.4.4.1 Rainfall

Extensive studies were conducted during the period 1983 to 1995 for water resources assessment of Bangladesh in connection with regional water resources planning and water resources Master Plan of Bangladesh. These studies are sources of secondary data on rainfall. Table 4.2 shows results of mean annual rainfall pertaining to the project area.

Table 4.2: Mean Rainfall in mm.

Station Name	30 year Mean (MPO) for 1951-81	Mean for 1901-30	Mean for 1931-60	Mean for 1961-90	Mean for Dry years 1957	Mean for Wettest year 1988
Khulna	1800	1700	1760	1790	1340	2280
Bagerhat	1825	1740	1790	1840	1400	2340
Narail	1770	1680	1735	1755	1375	2300

Table 4.3 shows the mean monthly distribution of rain fall in mm averaged out for five years 2001-05 for the project area, Khulna.

Table 4.3: Mean Monthly Rainfall of the Project Area in mm for Years 2001-05.

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Khulna	19	44	64	87	212	376	322	271	244	119	83	01	1842

i.	Means of 5 years total rains	1842 - mm	= 100%
ii.	Pre-monsoon (April-May) total	299 - mm	= 16.23%
iii.	Monsoon rains (June-September)	1213 - mm	= 65.85%
iv.	4. Autumn months (October-November)	202 - mm	= 10.97%
v.	5. Dry months (December-March)	128 - mm	= 6.95%

Recent trend of Rainfall

In order to understand the recent trend of rainfall, data of recent years have been collected from primary and secondary sources of data (Bangladesh Metrological Department and Statistical year books). Fourteen years annual total rainfall of nearby stations of the project area are presented in Table 4.4.

Table 4.4:Annual Total Rainfall around Project area in Recent Years

Station Name	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Khulna	1312	2416	1922	1780	1418	1921	1754	1224	1954	1159	1961	1471	1817	1994
Jessore	1573	2099	2059	1805	1344	1687	1587	1333	1714	1260	1397	1752	1537	1490

(Rainfall in mm)

One mean annual Isohyetal map of the south-west area of Bangladesh is presented as Figure 4.2 for a ready reference.

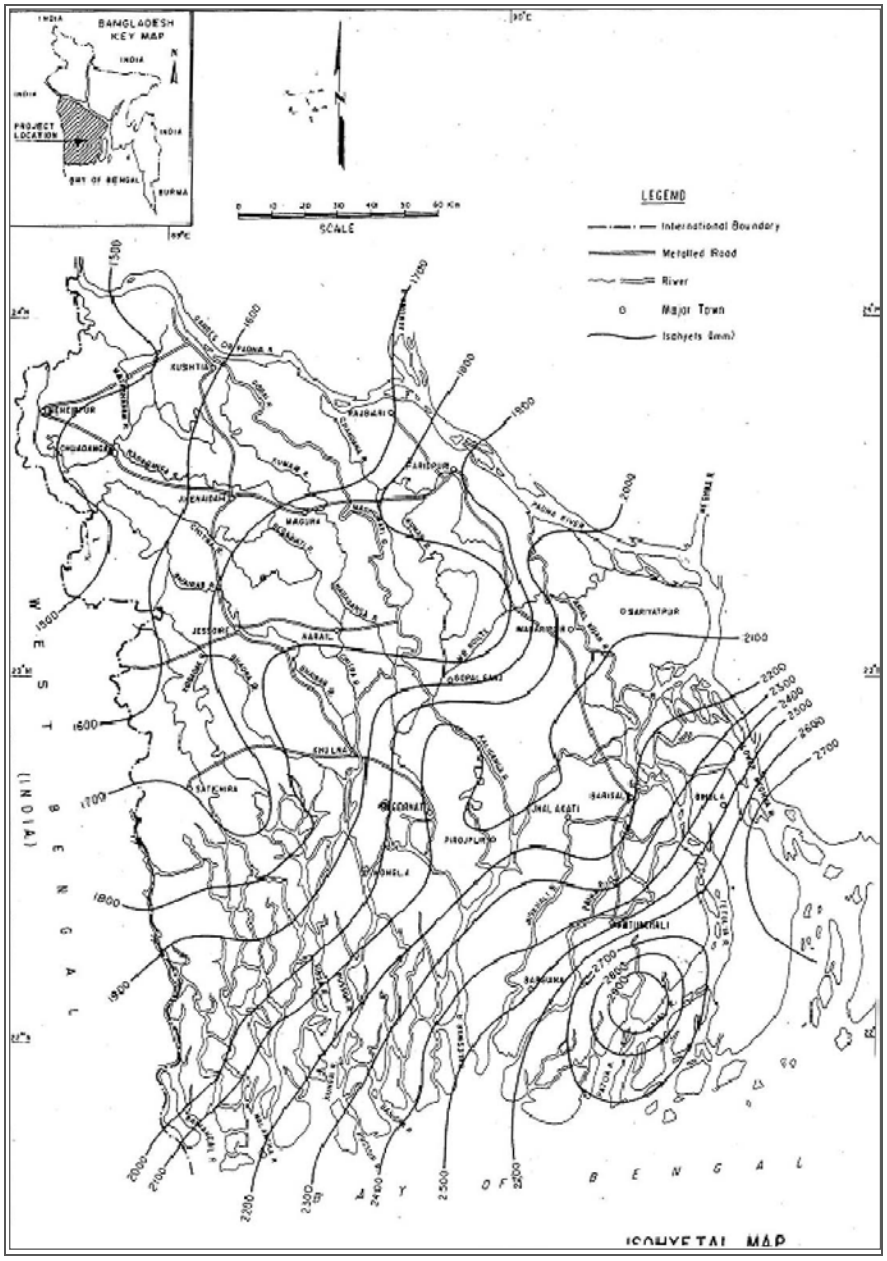


Figure 4.2: Mean Annual Isohyetal map for south-west area of Bangladesh

4.4.4.2 Temperature

Information on temperature is required for design purposes. Temperature data is collected by the Bangladesh Metrological Department (BMD). These are reported as daily bulletin and compiled by the department and by the Bangladesh Statistical Bureau. Monthly maximum and minimum temperatures of stations close to the project area are presented in Table 4.5. The hottest months are April & May, coldest month is January.

Table 4.5: Mean Monthly Temperature of the Project Area

Station Name		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Khulna	Max.	25.7	29.8	32.4	34.5	34.8	32.6	32.2	32.4	32.9	32.9	30.2	27.1
	Min.	11.3	16.8	20.3	24.4	25.5	26.3	26.5	26.7	26.1	24.8	20.1	14.5
Jessore	Max.	25.0	29.0	32.7	34.4	35.6	33.3	33.5	33.2	33.0	32.9	30.5	27.1
	Min.	10.6	14.9	19.1	23.4	25.1	26.1	26.4	26.3	25.6	23.7	18.7	13.0

Source: Bangladesh Meteorological Department (BMD) & Bangladesh Bureau of Statistics(BBS).

4.4.4.3 Humidity

Humidity or presence of moisture is an element of climate. The nearest stations, where humidity records are available are Jessore and Khulna. Table 4.6 shows mean monthly relative humidity (%) by station (mean of 9 years).

Table 4.6: Mean Monthly Relative Humidity (%) of the Project Area.

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Khulna	83	78	73	79	80	83	88	88	86	85	84	81
Jessore	82	78	74	77	78	83	87	87	86	85	81	79
Satkhira	82	79	77	80	78	82	87	87	87	86	84	79

Source: Bangladesh Meteorological Department (BMD) & Bangladesh Bureau of Statistics (BBS)

4.4.4.4 Wind Speed

There are two types of wind – the Prevailing wind and the Cyclonic wind. The prevailing wind speed and direction varies from season to season or month to month. Its magnitude is limited and is not harmful (may vary 5 km/hr. to 20 km/hr.).The cyclonic wind is very high. The Bangladesh Coast has been experiencing cyclones with the speed of hurricane from time immemorial. This is caused due to deep depression forming in the Indian Ocean between latitude 10N to 15N.The depressions intensify and proceed with a rotary wind towards the north to north-west and enter the funnel shaped Bay of Bengal. It ultimately when reaches the Indian or Bangladesh Coast hit them with a speed varying from 80 km/hr. to over 200 km/hr. When the cyclonic wind reaches the shallow water zone of the coast, wave surge is generated which with a height varying from 2 - 6m hit the land area, inundates the coastal belt. Sometimes the damage due to surge wave is very high. It washes out the roads, embankment, cropland, trees, homesteads, human life and cattle are destroyed. The impact of the surge-wave is felt up to 100 km inland along the Meghna estuary and other estuaries west of it.

The impact of the cyclones in the project area is felt in the form of high speed wind associated with copious rains and inclement weather for 2 - 3 days and sudden rise of

water level in the rivers.

In addition to the above, during summer months (March - May) north - westerly high speed cyclones often hit local areas. These are called nor'westers or Kalboishakhi. They also cause considerable damage to homesteads, standing crops and vegetation. Sometimes it is associated with hail and thunder. The destruction over which area it blows is very high, but the area of destruction is limited over a small area.

4.4.5 Hydrology of the Project Area

Study of hydrology comprises study of river system of the area, hydro-metric measurements and analysis of data for an acceptable long period.

4.4.5.1 The River System

The Ganges (Ganga) is the prime river of the area. This river separates the south-west area of Bangladesh from the rest of the country. Ganges enters Bangladesh from the Indian state of West Bengal in the district of Chapai-Nawabganj and flows in a south-easterly direction up to Goalundo where it unites with the Brahmaputra-Jamuna River. The combined channel takes the name Padma River and flows further south-east to unite with the Meghna near Chandpur. The combined flow channel from Chandpur to sea is known as lower Meghna River. The Ganges used to empty into the Bay of Bengal through a good number of distributaries. From west to east they are the Bhagirathi, Churni, Jolangi, Bhairab, Mathabhanga, Gorai, Chandana and Arial Khan. Before 1780 there was no link of the Ganges with the Brahmaputra. Therefore, all flow of the Ganges used to pass through the distributary channels mentioned above and their sub-distributories, froming a network in the south-west Ganges delta. The rivers Bhagirathi, Churni and Jolangi lie in the West Bengal (India). In the Bangladesh part lie the rest of the channels. The main channels areBhairab (Upper), Mathabhanga, Gorai, Arial Khan and Halifux Cut. Fig. 4.3 shows river system of the area with project location and hydrometric stations of the concerned rivers.

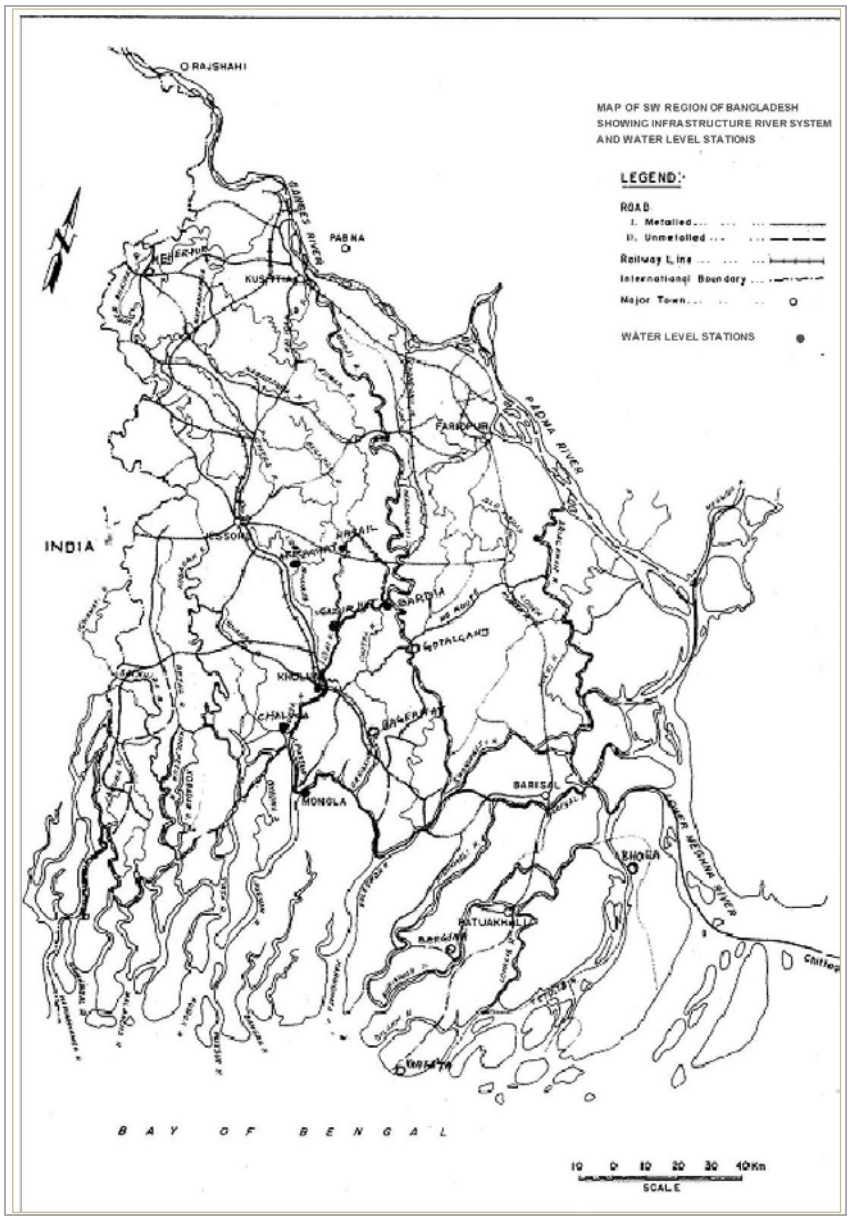


Figure 4.3: River System

4.4.5.2 The Project Concerned Rivers

The Project concerned rivers are – the lower Bhairab,-Atai-Nabaganga, Atharabanki and the Rupsha-Passur. The Rupsha-Passur is the name of the Channel below the confluence of lower Bhairab-Atai-Nabaganga.

4.4.5.3 Hydrological Data Collection

Bangladesh water Development Board maintains a network of hydro-metric measurement stations throughout Bangladesh. Of these, stream-flow, and water levels are the main items. Stream-flow is measured only in the non-tidal areas, water level is measured five times a day for non-tidal areas and for tidal areas in addition to five times, daily highest and lowest water levels are also recorded. The hydrology department of Bangladesh Water Development Board (BWDB) is actually responsible

for data collection, processing, computerisation and data bank management. Primary source of data is the data bank of hydrology. The map presented in Fig. 4.3 for the river system of southwest area of Bangladesh alsoshows hydrometric data collection locations.

As no stream-flow data is available, water level data of the stations listed in Table 4.7 have been collected from the hydrology data-bank.

Table 4.7: List of Water Level Data Collected

Sl. No.	Name of River	Name of Station with no.	Data Specification	Data Period
1.	Lower Bhairab	30 Afraghat	Annual highest & lowest	1970 - 2010
2.	Rupsha-Passur	241 Khulna	--- do ---	--- do ---
3.	Rupsha-Passur	243 Chalna	--- do ---	--- do ---
4.	Rupsha-Passur	244 Mongla	--- do ---	--- do ---
5.	Chitra	561 Narail	--- do ---	--- do ---
6.	Chitra	219 Gazirhat	--- do ---	--- do ---

4.4.5.4 Stream-flow

There is no stream flow data available for the channel in the project area. However, for design consideration of the bridges, stream flow will be determined with an alternative approach from the hydraulic properties of the cross-sections after detailed survey. In this connection it may be mentioned that at highest water level in a tidal channel the velocity tends to zero and therefore, discharges is also zero. In actual observation it has been established that peak velocity and peak discharge occur at a drop level during falling tide. This water level and discharge may be referred to as the dominant discharge of the tidal channel which determines its regime and morphology.

4.4.5.5 Estimation of Design Water Levels

The methodology and approach is to compute design water levels of the channels at or near to the proposed bridge sites as per the alignments. Since the water level gauges are located in the channels but not exactly near the bridge crossings, to arrive at water level of the bridge site slope correction has to be applied to find out the water levels at the bridge site.

In the statistical distribution analysis Normal or Pearson Type-III distribution are considered as more relevant for natural events. Log normal and Gumbel extreme value give higher results and they are used for comparison and assessment. In the present

case, there is no or little upland flow; the main variation is due to tidal oscillation in the channels. For Bangladesh context, the experts opined for acceptance of Pearson Type - III. Since there is impending danger of Sea Level Rise in the future, Gumbel Ev1 results have been adopted for design water level computation.

The methodology involves establishment of slope of the channels for the segments where the bridge is to be built and apply slope correction to arrive at the water level with respect to the nearby water level gauge. The slope of the river Lower Bhairab has been established considering the water levels of Afraghat and Khulna. The distances between the stations have been measured along the channels from Google Map on Computer Screen. The locations of the crossing points (bridge points) have been also identified on Google Map and their distances measured from the reference gauge station. Thus applying slope correction the water levels at the bridge points have been determined.

The water levels at the bridge points on Atai and Atharobaki channels have been designed on the same procedure considering the slope of the respective channels with respect to reference gauge stations

The results of fixing water level at bridge points are shown in Table 4.8.

Table4.8: Design Water Levels at Proposed Bridge Points & Navigation Clearances

Bridge Location		Distance from Khulna Gauge Station (km)	100 year RI Khulna WL mPWD (EV1)	Slope Correction Applied (m)	100 year Water Level at Bridge Point (mPWD)	Standard High Water Level (mPWD)	Class of Route	Horizontal Clearance (m)	Vertical Clearance (m)
Option ID	River Name								
East Alignment									
Option - C	Bhairab (lower)	13.62	4.18	+ 0.109	4.29	3.89	Class I	76.22	18.30
Option - C	Atai	8.13	4.18	+ 0.065	4.25	3.84	Class II	76.22	12.20
Option - C	Atharobaki	12.29	4.18	+ 0.099	4.28	3.87	Class III	30.48	7.62
West Alignment									
Option - E	Rupsha (Lower Bhairab)	5.30	4.18	+ 0.027	4.21	3.80	Class I	76.22	18.30
Central Alignment									
Option - H	Rupsha (Lower Bhairab)	7.20	4.18	+ 0.037	4.22	3.81	Class I	76.22	18.30
Option - H	Atharobaki	4.89	4.18	+ 0.039	4.22	3.81	Class III	30.48	7.62

4.4.5.6 Tidal Prism

A study of water level profile along Passur - Rupsha - Bhairab indicates a 'tidal prism' formation during the rising tide. From the water level profileshown in Figure 4.4 it is seen the water level at Mongla is higher than that of Khulna during high water stage. Again water level of Afraghat is higher than Khulna. This is possible due to time lag of tidal flow and ebbing process.

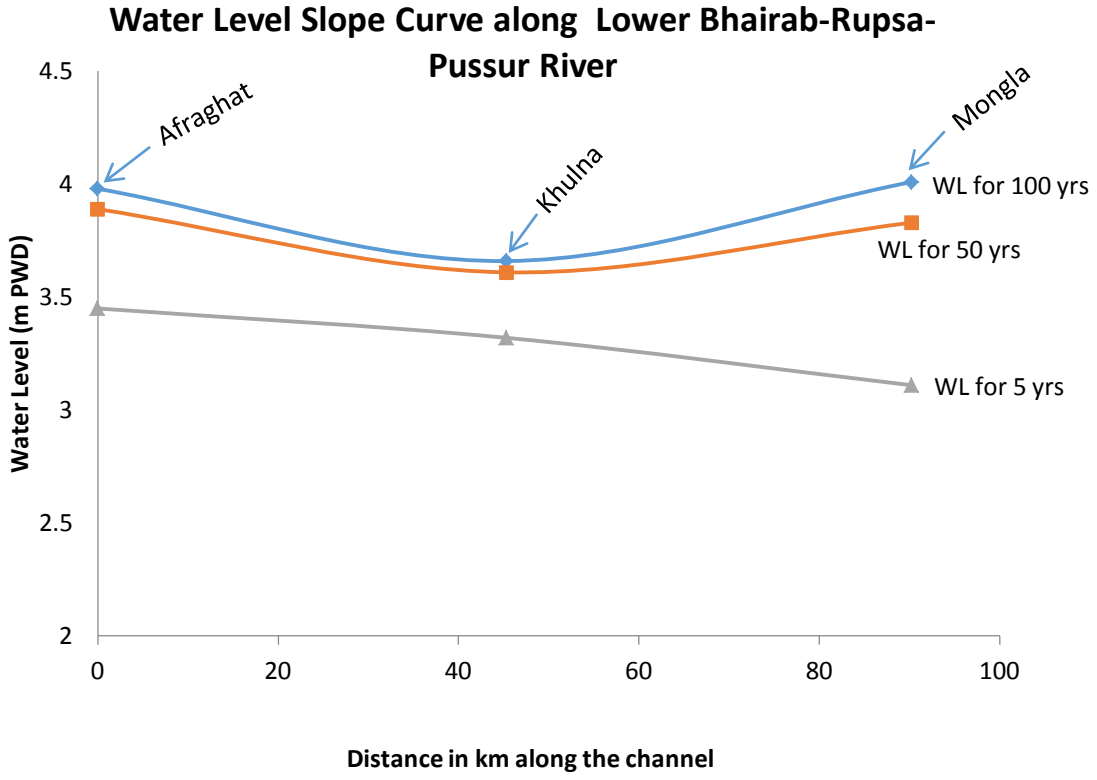


Figure 4.4:Water Level Profile during rising Tide

One tidal oscillation curve (13 hr. 30 m. duration) is shown in Figure 4.5to have an impression of tidal variation near Khulna City in the Bhairab river.

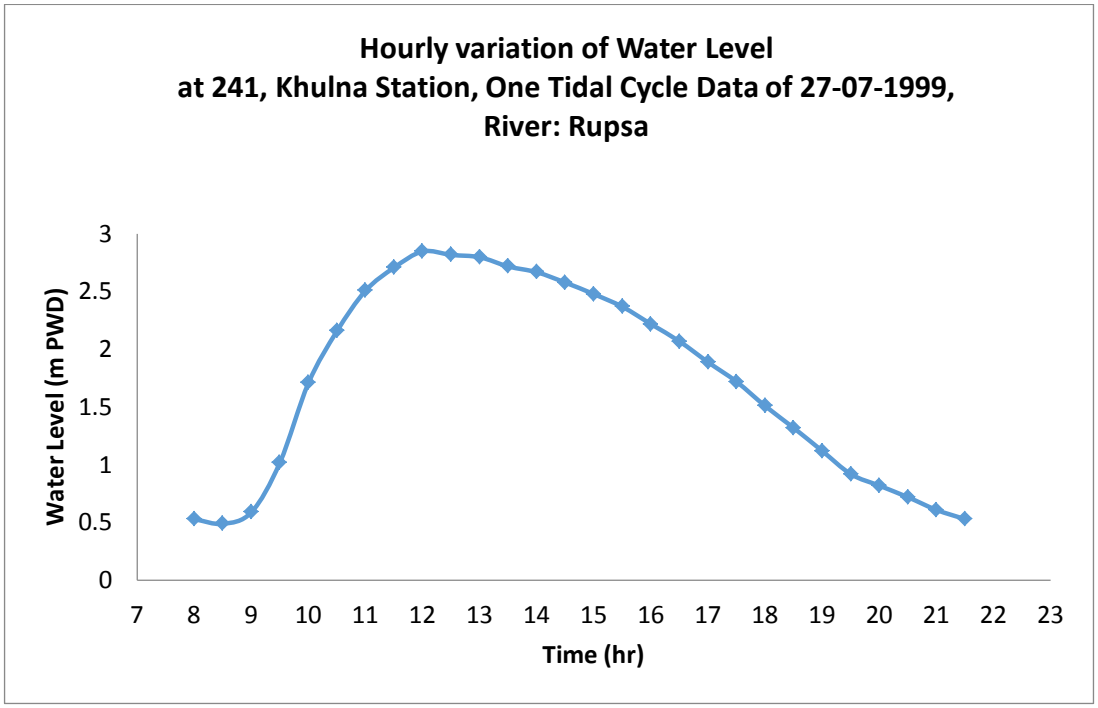


Figure 4.5: Tidal Oscillation Curve

4.4.5.7 Navigation Clearance of Bridges

The lower Bhairab river upto Noapara Inland river port is an important water way route. Mainly cargo vessels of various categories use this water way to transport cargoes from Mongla Port to Khulna and Noapara Ports. Fixation of navigation clearance on lower Bhairab is therefore an important issue. The concerned authority (Bangladesh Inland Water Transport Authority) was approached for the purpose to get the vertical and horizontal clearances of the rivers on the bridge crossing points.Table 4.8 also shows the class of river, horizontal and vertical clearance for different river crossings.

4.4.5.8 Tide Salinity and Water Quality

All rivers in the south-west region are tidal. Tide is semi-diurnal in Bangladesh Coast which means two high waters and two low waters are experienced in these rivers in about 24 hours time. The maximum tidal amplitude near Khulna is near about 3m. In the further upstream it diminishes.

The river water is highly saline during the dry months (Jan. - May). Its magnitude sometimes is more than 25,000 micro-mhos/cm. During monsoon, this salinity drops to tolerable limit (below 500 micro-mhos).

Ground water availability in Khulna area is very meagre. In the upper strata it is saline and unfit for any use. In the deeper strata (beyond 1,000 ft.) some potable water is available. The top soil of Khulna and Bagerhat area is also saline and agriculture potential is limited

4.4.6 Morphological Characteristics of the Rivers

4.4.6.1 General

The morphological study comprise study of the channel type, variability of the cross-section and its type, suspended load and bed load and their grain size, variability of flows, shifting of the thalweg line, bed and bank erosion with rise and fall of the water levels.

The Morphological Characteristics of a river/channel is very much linked with its origin, land topography, basin characteristics, soil character, land slope etc. The project area is located in the south-west part of Bangladesh which is more specifically called the lower Gangetic Delta. This delta land is the outcome of sediment deposit of millions of years of sediment carried by the river Ganges/Ganga. There occurred a remarkable change in this part of Ganges delta when the Brahmaputra changed its course from the old Brahmaputra to its present course Jamuna, uniting with the Ganges near Goalundo. Between the years 1780-1820 the main flow of Brahmaputra started flowing through the Jamuna channel. This impact of this great change manifested in declining flow through the distributories of the Ganges – namely the Bhagirathi, Churni, Jalangi, Bhairab and Mathabhanga, and opening up of the Gorai - Madhumati river. Source: On recent changes in Gangetic Delta – by Morgan and Mc. Intire - 1953.

With the passage of time, the off-takes of the distributaries got silted up and remained cut-off from the parent river. The branches of these distributaries which formed a network of rivers in the districts of Nadia (Kushtia), Jessore and Khulna started deteriorating. However, these rivers were getting flood flows of the Ganges during high flow season and also carrying generated run-offs from the basin areas.

The ultimate outfall of these distributaries and sub-distributaries was the Bay of Bengal, they branched up or joined with other rivers and entered the tidal zone. Thus the lower part of these rivers are tidal estuaries which is a big factor in determining their regime and morphology.

The Khulna - Mongla Rail Link is going to cross the river Lower Bhairab, Atai, Atharobaki and Rupsha. Therefore, the morphological study will be limited to these rivers only

4.4.6.2 Data Collection

For an exhaustive study of river morphology, past and present study data like, river cross sections, sediment transport, discharge, velocity profile, thalweg movement, bank movement, depth-width ratio, bed and bank scour etc. are required. But very little data on the subject of the past is available, except some rivers survey of Rupsha Bridge Construction – 1999 and hydrographic charts (Navigation available depths) of the

concerned channels. The preliminary cross-section survey of the channelswas carried out at the purposes of Bridge site to supplement the study. The other relevant information are the physical verification of the channels and sites, local interviews, identification of problem sites and expert opinion.

4.4.6.3 Tidal Channel Regime

It has been already mentioned that the project rivers have little upland flow except during the rainy season. Therefore, these rivers are active channels due to tidal penetration and ebbing upto the limit of tangible tidal amplitude. Tidal estuary and channels morphology is different from those of non-tidal channels with varying discharges from the head waters. The maximum tidal inflow occur during and near about the full moon and new moon phases of the lunar cycles. The incoming tidal flow velocity is always less than the ebb tide velocity for obvious reasons. During spring tide the water may spill over bank and may go into valley storage. The return flow volume during ebbing, therefore, flows with a greater velocity with greater impact on the channel bed and banks. In the course of its lower reach, if any contributory channel enters, the channel geometry changes causing its widening or deepening or the both.

The project concerned rivers are continuing in their present status for nearly two centuries except some man made interference. In the year 1900 one short link canal joined (Halifax Cut) the Madhumati with Atai. Which led to flow substantial amount of Madhumati flow into the Atai - Lower Bhairab - Rupsha - Passur system. Since 1976 due to Ganges flow diversion the Gorai - Madhumati is not getting any Ganges flow during the dry months (January - May). The Government of Bangladesh have plans to build Barrage on the Ganges in the near future. But this water will be utilized for irrigation and other priority purposes. Very little water is likely to go into the Gorai - Madhumati - Atai - Bhairab system. Therefore, the present tidal regime of the project river have little or no scope of change.

4.4.6.4 Stability of the Present Channels

The present state of the channels is the results of centuries of tide and ebb flows. The channels are oriented in a north - south direction joining the Bay of Bengal in the south. There is no meander or serious bend in the reach, so that, the lower Bhairab and Atai may be termed as straight channels. The Atharobaki is a cross channel linking the Madhumati with the Lower Bhairab (Rupsha). The later one has several bends/loops, and its link with Madhumati is very often get cut-off due to siltation.

Sedimentation: The channels in the area are oriented north-south linking the Bay of Bengal in the south. In the Sundarban area there are some cross-channels also. The coastal water of the Bay has high sediment content which penetrates through the estuaries during the rising tide. It penetrates deep inland & comes to its upper limit

(5melevation is the approximate limit).

At the end of the high tide for certain duration the water remains in a stagnant state. Silts drop in the no flow zone which can be noticed as a common feature in the tidal rivers. When there was no polder, siltation used to drop in the far-flung low areas. But sediment is now dropping in the channels especially in the upper limit of the tide penetration.

River Bank Stability: The river banks are seen to be stable in the upper limit of the tidal zone. Minor bank erosion is however noticed at places due to impact of wave generated by high speed mechanised vessels. Rain-cuts and tidal water back flow during ebbing also cause some erosion at places. Thus it can be said the river banks are stable. The main cause of stability is the soil texture. The soils of the bed and banks are composed of silty clay to clay which has less erosive character.

The maximum flow velocity near Khulna gauge station has been measured as 1.70m/sec during ebbing at the midstream. Flow velocity in the lower Bhairab is expected to be less than the above velocity. Rigorous bank protection at the bridge location may not be required. But during and after construction of the bridge piers scour around the piers and downstream is expected which may require protection measure.

Bank Migration: The rivers lower Bhairab, Atai and Atharobanki has been classified as tidal oscillating internal rivers. During wet season they receive some generated flow from the catchment area no doubt, but they do not behave like non-tidal rivers, where high water stage prevails for months. Flood season in these channels are not that much perceptible. No data is available to co-relate bank movement but local interview establish that bank migration is negligible for these channels.

4.5 GEOTECHNICAL SURVEY

Preliminary geotechnical investigations are required to assess the subsurface properties of soil. It is also desirable to study the earlier work done for nearby structures if available in the project area. Consultant has referred the Draft Feasibility Report for the Rupsha Highway Bridge on Khulna bypass which is situated close to proposed west alignment option. Preliminary assessment of the soil properties has been made on the basis of the preliminary geotechnical investigations conducted along the proposed routes and available data in the referred report.

Khulna city has been raised and developed by the process of siltation from a network of rivers. The referred report reveals that thereexists a layer of very soft to soft silty and clayey soils with thickness varying from 7 to 10m. Loose to medium dense sandy soil with N-value less than 30 was encountered beneath the soft cohesive soils. In the vicinity of the Rupsha river, relative density of the sandy soil increases with depth and

the layer changes to a dense sandy layer. A layer underlying the dense sandy soil layer consists of dense to very dense sandy soil and medium stiff to very stiff and clayey soils. The silty and clayey soils predominate at Rupsha river. A total thickness of this layer is approximately 25m. Very dense sandy soil layer underlies the above discussed heterogeneous deposits. Surface of this layer lies betweenPWD-48m and PWD-51m at the Rupsha river. This layer forms a competent bearing stratum for the deep foundations.

There will be three major bridges over river Bhairab, Atai, Atharobakialong the proposed east alignment option, one major bridge over river Rupsha along the proposed west alignment option and two major bridges over river Rupsha, Atharobaki along central alignment option. The detailed geotechnical investigations will be conducted along the approved final route.

4.5.1 Seismic Information

Based on the severity of earthquakes, Bangladesh has been divided into three seismic zones namely Zone 1, Zone 2 and Zone 3, which have seismic zoning coefficient, Z of 0.075, 0.15 and 0.25 respectively (BNBC-1993).According to this zoning, the project site at Khulna is situated in Zone 1.

4.5.2 Field Exploration

Preliminary geotechnical investigations were conducted through drilling bore holes in the project area along the proposed alignments to have some representative samples. The location of boreholes are shown in Figure 4.6. GPS Coordinates of the borehole points are shown in Table 4.9.

Table 4.9: Coordinates of Borehole locations

Bore Hole ID	Chainage (km)	Location Name	Easting	Northing
East Alignment				
EBH 1	3+500	Shiromoni	756382	2536304
EBH 2	10+025	Panigati	761885	2534046
EBH 3	13+800	Laskarpur	763750	2532620
EBH 4	23+400	Alaipur	769976	2523820
EBH 5	24+300	Shamontosena	769725	2523309
EBH 6	35+000	Chulkathi Bazar	772440	2513118
EBH 7	55+100	Digraj Apabari	766433	2495472
West Alignment				
WBH 1	9+125	Arongghata	755275	2531383
WBH 2	22+575	Putimaari	762730	2520831
WBH 3	27+400	Narayankhali	766744	2518483
WBH 4	45+500	Bhaga	771429	2503525

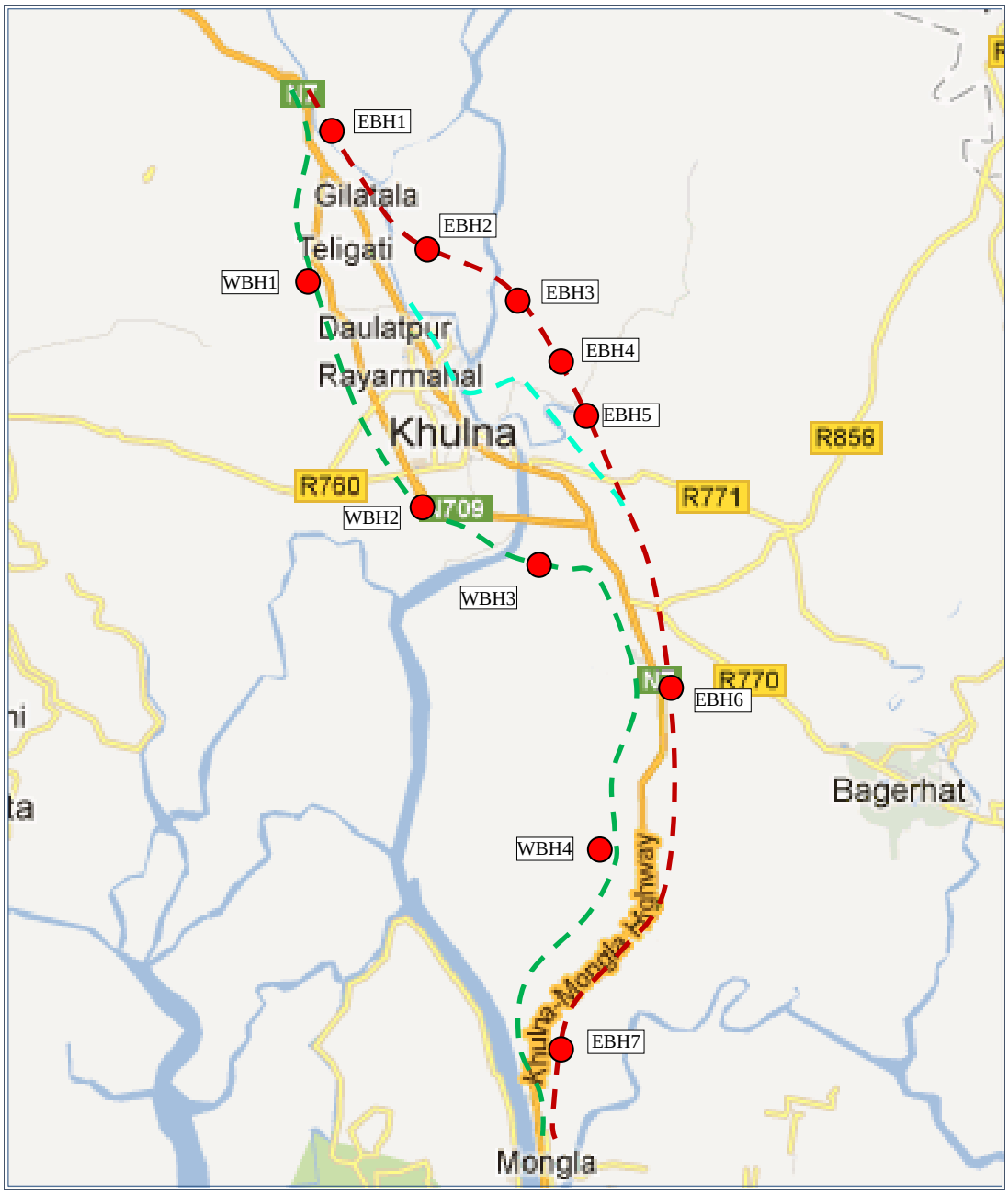


Figure 4.6: Location plan of bore holes

Standard penetration tests wereconducted in all the boreholes at 1.5m intervals upto a depth ranging from 10 to 20m. The disturbed and undisturbed samples were visually examined in the laboratory and the required classification and identification tests were done in the laboratory on the representative samples.

4.5.3 Field Exploration Findings

4.5.3.1 East Alignment

Seven numbers of boreholes were drilled along the East Alignment. The bore log data

are presented at Appendix 4.1, the findings are summarized below.

The SPT N- Value at km 3+500 and 10+000 varies from 2 to 7 for a depth up to 20m. It indicates the soil is poor from ground level to 20m depth. The type of soil is very soft to soft clay with traces of fine sand, medium plastic in upper layers and soft to medium stiff in lower layers.

At chainage km 13+800 the soil is mostly soft clay with fine sand SPT N- value up to 10m depth is only 5 and at 20m depth it is 6. It indicates that there is no hard stratum in this location.

At chainage km 23+400 there is hard strata at depth 12m with SPT N- value 53 and at 10.5m it is 35 and at 7.5m the value is 9.But up to 6m the N-value is from 2 to 4.The top 6m the soil is mainly soft silt medium plastic. At depth 7.5m to 12m the soil is non-plastic with fine sand and silt.

At chainage km 24+300, the SPT N-value at 5m depth is 4, at 10m it is 13 and at 15m the value is 17. It indicates that the soil at top 5m layer is poor, the bottom soil is better. The top layer is soft clay, trace fine sand with medium plastic. The layer below 7m the soil is medium fine sand trace silt & mica and non-plastic.

At chainage km 35+400 the soil is better at depth 4.5m and SPT N- value at this location is 20. But at depth 9.5m the SPT N- value is 13. The layer at 3m depth the N-value is 16. Soil is non-plastic with fine sand, trace of mica and silt.

At km 55+100, the N- value is 2 up to 5m and at depth 10m the value is 15, at 13.5m the N-value is 21 and at 18m depth the value is only 9.The soil is mostly fine sand with little silt trace of mica.

4.5.3.2 West Alignment

Four numbers of boreholes were drilled along the West Alignment. The bore log data are presented at Appendix 4.1, the findings are summarized below.

At chainage km 9+100 SPT N- value is 2 to 3 only up to 7.5m depth, 7 at 13m depth, and 15 at 20m depth. The Soil is mainly organic with trace of fine sand in the top layer and medium plastic. In the bottom, the soil is fine sand trace silt and mica with medium and non–plastic.

At chainage 22+575 SPT N-value is 2 to 3 up to 5m depth, 6 at 14m depth and 15 at 20m depth. It indicates that soil is very poor up to 5m depth and poor up to 14m depth. The soil is blackish organic clay with high plasticity. The bottom layer is medium dense fine sand, some silt, trace mica and non-plastic.

At chainage 27+400, SPT N-value is 2 to 3 up to 5m depth, then the value increase at

10m where the value is 11. But the value then decreases 5 to 7 up to 18m depth. It indicates that the soil is very poor and blackish soft organic clay up to 5m depth.

At chainage km 45+500, SPT value is up to 12m depth from 1 to 2 only and at depth 15m the value is 15.It indicates that the top layer up to 12m the soil is very poor with soft clay trace silt of sand medium plastic. Below 13.5m the soil is little better with respect to top layer with fine sand, trace silt & mica and non-plastic.

4.5.3.3 Central Alignment

The central alignment passes through Khulna railway station and then after crossing Rupsha river, it follows the east alignment. Hence the exploratory findings for centre alignment beyond chainage 17+000 may be treated same as those for east alignment.

4.6 MATERIAL SURVEY

Various kind of material will be required for construction of the proposed rail link. To identify potential sources of material for construction, preliminary survey for the followingmaterialswas carried out in terms of their likely sources, their availability and suitability.

Embankment Filling

Dredged sand from the river bed Bhairab, Rupsha, Atai, Atharbaki,Pussur rivers may be used for construction of core layer of embankment and clayey soil from borrow area or outside may be used for cover layer, shoulder and slopes for stability of the embankment. All embankment fill material will comply with the Specification. In this region CBR of dredged sand is more than 6% and plasticity Index is less than 6%which are suitable for embankment fill.

Blanket

Material for blanket are dredged sand, Sylhet sand which are available in source country and stone chips may be imported from India.

Ballast

This may be imported from India. Pakur stone is available in India near Bangladesh-India Border site. It will conform to the requirements relevant Indian Standards.

Cement

The cement is available in country source.

Structural Steel

The structural steel for superstructure and material for steel casing for piles will be imported from India.

Reinforcing Steel

This will be available from source country or may be imported from India.

Prestress Strand

The Prestress strand& ancillaries for pre-stressing will be imported from India.

Coarse Aggregate

This may be imported from India. Pakur stone is available in India near Bangladesh-India Border site.

Fine Aggregate

This is available in source country at Sylhet.

Local Sand

Local sand is available in source country located near project area. Local sand will be used for plaster work, brick work etc.

Bentonite

The bentonite required for piling works will be imported from India

Geo-textile

This will be supplied from country source or may be imported from India.

Bricks

These are locally available. Quality should be ensured through testing as per Specification.

Rail Track Material

All type of rail track material like Rails, Fish plates, Dog Spikes, Hook Bolt, Bearing Plates for Bridges, Steel Sleeper, Wooden Sleeper, different parts of Steel Bridges etc. may be imported from India. Pre-stress Concrete Sleeper may be supplied from source country or may also be imported from India. All track materials will be purchased from RDSO approved vender.

4.7 ENVIRONMENT SURVEY

Preliminary environmental survey was conducted for the various possible routes identified to estimate the environmental impact.During the EIA stage more specific survey shall be conducted.

The environmental study will rely on both primary and secondary information. Primary observations were made on all the route alternatives through field visit, key stakeholder consultations and key informant interviews. Secondary data were also collected from different sources including published and unpublished literature, different databases, newspapers and the internet.

The amount of carbon emission and carbon sequestration has been estimated based on the existing standard methodology (used by the British Rail), however there may be some deviation when actual measurements / data are taken/collected for the final alignment.

The eastern alignment (three alternative routes) mostly traverses through a rural setup comprising of agricultural land and low-lying wetlands. There are however no protected or ecologically critical areas of national importance but these wetlands and low lying areas are the backbones for the sustenance of local natural ecosystem and ecological services. The importance of these diverse habitats and their importance in the local context has to be recognized while planning/designing and finalizing the railway alignment.

The central alignment runs through the already built up and physically altered area and presumably will have little impact but care has to be taken in the area between Bhairab – Atharobaki Rivers and Lakpur to provide ample structures to facilitate the natural drainage patterns with little obstruction to the migratory routes between the river and floodplain, spawning grounds of the aquatic fauna particularly fishes.

The western alignment runs through an area that is developing fast and the alignment ROW needs to be identified at the earliest since delay in the alignment ROW identification may create future problems for the railway line. Some important natural drainage canals, tidal in nature, exist here that demands extra care in identifying locations and numbers of drainage structures.

Major heads for the environmental costs have been identified but not estimated. A summary of the environmental parameters along various alternative alignments is presented in Table 4.10 for section-I (Phultola/Daulatpur to Katakhali) and Table 4.11 for section-II (Katakhali to Mongla). The preliminary assessment was made in a project corridor width of 100m on along the proposed route for the purpose of comparison which will likely to reduce during detail study as the actual corridor width will be less (about 50% of it).

Table 4.10:Summary of Environmental Parameters along alternative Alignments - Section I (Phultola/Daulatpur – Katakhali)

Alignment	Start Point	Length (km) (estimated)	Total Number of Trees (Approx.) within 100 m corridor		Monetary Value of Trees (average 2.5 cft @Tk.150/cft (crore)	Carbon Sequestration tCO2 (average 1.5 tons/tree) @ US$25/ton	Estimated Carbon Emission (single trip Phultola to Katakhali), kg		Ponds/ Ditches/ Fish Ponds		Land Use Types (Agri/Fallow/ Homestead/ Wetland, etc)
			LEFT	RIGHT			Goods Train	Passenger Train	LEFT	RIGHT	
A	Fultala	30.90	24,600	24,300	1.84	73,350 tCO2 = USD1,833,750	315	207	342	264	homesteads, roads, schools, mosques, agricultural land, fish farms, ponds, orchards, ditches, canals, betel leaf, horticultural, commercial markets/shops, industries
B	Phultola	32.20	21,500	16,500	1.43	57,000 tCO2 = USD1,425,000	328	216	246	180	homesteads, roads, schools, mosques, agricultural land, fish farms, ponds, crab farms, ditches, canals, betel leaf, commercial markets/shops, industries
C	Phultola	33.10	15,500	12,800	1.06	42,450 tCO2 = US$1,061,250	337	222	184	226	homesteads, roads, schools, mosques, agricultural land, fish farms, ponds, crab farms, ditches, canals, betel leaf, commercial markets/shops, industries
D	Phultola	29.85	18,300	25,100	1.63	65,100 tCO2 = US$1,627,500	304	200	215	256	homesteads, roads, schools, mosques, agricultural land, fish farms, ponds, crab farms, ditches, canals, betel leaf, commercial markets/shops, industries

Alignment	Start Point	Length (km) (estimated)	Total Number of Trees (Approx.) within 100 m corridor		Monetary Value of Trees (average 2.5 cft @Tk.150/cft (crore)	Carbon Sequestration tCO2 (average 1.5 tons/tree) @ US$25/ton	Estimated Carbon Emission (single trip Phultola to Katakhali), kg		Ponds/ Ditches/ Fish Ponds		Land Use Types (Agri/Fallow/ Homestead/ Wetland, etc)
			LEFT	RIGHT			Goods Train	Passenger Train	LEFT	RIGHT	
East Alignment New Alignment C1 (Alignment C + A)	Phultola	31.70	12,050	13,050	0.94	37,650 tCO2 = US$941,250	314	206	244	293	homesteads, roads, schools, mosques, agricultural land, Sports Institution, Firing range, water treatment plant (under construction), jute mill, gas line, high voltage electric line, fish farms, ponds, ditches, canals, betel leaf, commercial markets/shops, industries
West Alignment	Khulna By-pass (Atra-Afil Gate)	32.40	10,225	15,200	0.96	38,137.5 tCO2 = US$953,437.5	333	219	105	400	homesteads, roads, schools, mosques, agricultural land, Sports Institution, Firing range, water treatment plant (under construction), jute mill, gas line, high voltage electric line, fish farms, ponds, ditches, canals, betel leaf, commercial markets/shops, industries
Central Alignment	Daulatpur	21.30	3,500	5,500	0.34	13,500 tCO2 = US$337,500.00	204	133	65	83	markets, commercial area, schools, college, horticulture gardens, agri-land, graveyard, homesteads, national highway, brick kilns, coconut/betel leaf-nut gardens, ditches, ponds, bamboo groves, fish processing industry, Abashon-Harijon Colony, temple, mosques, shrine, saw mills,

Table 4.11:Summary of Environmental Parameters along alternative Alignments - Section-II (Katakhali to Mongla)

Start/End Point	Total Length (km) (Section I & II) (estimated)	Length Section II (km) (estimated)	Total Number of Trees (Approx.) within 100 m corridor		Monetary Value of Trees (average 2.5 cft @Tk.150/cft (crore)	Carbon Sequestration tCO2 (average 1.5 tons/tree) @ $25/ton	Estimated Carbon Emission (single trip Katakhali to Mongla Port)		Ponds/ Ditches/ Fish Ponds		Land Use Types (Agri/Fallow/ Homestead/ Wetland, etc)	
			LEFT (estimated)	RIGHT (estimated)			Goods Train (kg/trip)	Passenger Train (kg/trip)	LEFT	RIGHT	LEFT	RIGHT
East Alignment (east of National Highway - N7)	59.6	27.90	48,200	34,575	3.15	124162.50 tons = USD3,104,062.50	276	182	375	245	homesteads, roads, schools, mosques, agricultural land, fish farms, ponds, crab farms, ditches, canals, betel leaf, commercial markets/shops, industries	homesteads, mosques, agricultural land, fish farms, ponds, burrowpits, crab farms, betel leaf, ditches, canals, commercial markets/shops, industries
West Alignment (west of National Highway - N7)	60.4	28.00	48,200	34,575	3.15	124162.50 tons = USD3,104,062.50	277	182	375	245	homesteads, roads, schools, mosques, agricultural land, fish farms, ponds, crab farms, ditches, canals, betel leaf, commercial markets/shops, industries	homesteads, mosques, agricultural land, fish farms, ponds, burrowpits, crab farms, betel leaf, ditches, canals, commercial markets/shops, industries

4.8 SOCIAL AND RESETTLEMENT SURVEY

Social Impact Assessment study will provide necessary input for developing a Social Management Plan (SMP), Land Acquisition Plan (LA Plan) and Resettlement Plan (RP). The objective of the SIA study is to understand the socio-economic impact on affected habitation along the alignment and develop a Resettlement Plan (RP) for the Project Affected People (PAP). The preliminary study has reflected the existing socio-economic profiles of the population along the preliminary alignments (east, central and west) through the preliminary survey. The detail survey of the agreed alignment will provide necessary information for identification of the base line social dimensions of the people and formulate plans to restore the quality of life after implementation of the project. The study will develop database for current situation and record the probable impacts of the intervention as perceived by the people themselves. The study will also identify all the possible impacts of the proposed project in advance, plan mitigation measures so that the required actions can be started well before the implementation begins.

Consultant conducted the preliminary study of all alignments from east, central and west side during feasibility stage. The detail SIA, RP and LA plan for the selected alignment will be submitted along with draft final report of detail design.

A summary of the preliminary social assessment along various alternative alignments (east, central and west) is presented in Table 4.12 for section-I (Phultola/Daulatpur to Katakhali) and Table 4.13 for section-II (Katakhali to Mongla Port).The combined summary for Phultola to Mongla section is presented in Table 4.14. The preliminary assessment was made in a project corridor width of 100m along the proposed alignments for the purpose of comparison which will likely to be reduced during detail study as the actual corridor width will be much less (about 50% of it). The preliminary study has been conducted through social methods like transect walk, detail counting of infrastructure, land size and accumulation of pricing of the land and infrastructure as well as analysis of educational, religious and economic hubs (markets, shops and local bazaar etc.).

Table 4.12: Summary of the preliminary social assessment along alternative Alignments - Section I (Phultola/Daulatpur – Katakhali)

Alignments	Number of habitations [including Bazaar areas]	Length of Habitation (Km) [Including bazaar]	Total Number of Structures in the Habitation (Approx.) Within 100 meter corridor		Total Value of Structure and land (crore)		Total Replacement Cost (crore) approximately	Length of Forest (Tree/ Green Canopy) (Km)		CPRs Within 50 meter corridor	Religious Structure Within 30 meter corridor	Land Use (Agri/Barren Grassland/submergence/irrigation network/Plateau)
			L	R	Structure	Land		L	R	L/R		
A	Approximately 11	11.05	1417	651	81.01	503	611.2 (108.2 for infrastructures)	12.47	12.15	94% private land	Masjid-7 Mandir-4 Grave-1	Houses, shops, railway land, Agro- irrigation, beel, vegetation
			2068		584.01						12	
B	6	6.21	448	315	30.82	428.5	472.9 (44.4 for infrastructures)	4.55	5.1	96% private land	Masjid-5 Mandir-2	Agro-irrigation, three beel- wetland, vegetation,
			763		459.32						7	
C	13	16.40	1865	1223	157.17	295.3	506.45 (211.15 for infrastructures)	13.05	12.58	15% railway land, rest is private	Masjid-9 Mandir-4 Grave yard-2 Madrassa - 3	Less wetland and more railway land than any other alignments
			3088		450.47						18	
D	5	7.36	1491	1352	98.75	479.43	974.8	6.65	6.49	95% private land	Masjid-6 Madrasa-1 Grave yard-1	Agro-irrigation, three beel, vegetation
			2843		578.18						8	
E	6	5.34	1417	651	86.1	447.88	577.48 (129.6 is for the infrastructures)	6.5	7.32	95% private land	Mosque and madrassa – 2 Mandir – 2 Graveyard - 4	High voltage electric line, firing range, gas line, Wetland, Dakatia beel,
			2068		533.98						8	
Central alignment	14	10.35	2824	2634	167.35	423.74	645.34 (221.6 is only for infrastructure)	7.9	9.3	81% are private lands		Private houses, industries, government offices, shops, markets
			5458		591.09						24	

Table 4.13: Summary of the preliminary social assessment along alternative Alignments - Section II (Katakhali to Mongla)

Alignments	Number of habitations [including Bazaar areas]	Length of Habitation (Km) [Including bazaar]	Total Number of Structures in the Habitation (Approximately) Within 100 meter corridor	Total Value of Structure and land (crore)		Total Replacement Cost (crore) approximately	Length of Forest (Tree/ Green Canopy) (Km)	CPRs Within 50 meter corridor East/West	Religious Structure Within 30 meter corridor	Land Use (Agri/Barren Grassland/submergence/irrigation network/Plateau)
				Structure	Land					
East	Approximately 6	3.4	1663 (mostly shops in the bazaars)	52.69	319.6	379.06 (59.46 for infrastructures)	2.79	At least 15 meter R&H land (rest is private land and water bodies/ghers)	Masjid-4 Mandir-2 Madrassa-1	Water bodies, gher, industry, port area, Bazaar, petrol pumps,
				372.29					7	
West	6	4.4	1188 (mostly shops in the bazaars)	50.25	313.4	382.54 (69.14 for infrastructures)	2.99	At least 15 meter R&H land (rest is private land)	Masjid-2 Mandir-2 Madrassa-1	Water bodies, gher, industry, port area, Bazaar, navy area,
				363.65					5	

Table 4.14: Summary Total of the preliminary social assessment along alternative Alignments - Section I+II (Phultola/Daulatpur to Mongla)

Alignments	Number of habitations [including Bazaar areas]	Length of Habitation (Km) [Including bazaar]	Total Number of Structures in the Habitation (Approximately) Within 100 meter corridor	Total Value of Structure and land (crore)		Total Replacement Cost (crore) approximately	Length of Forest (Tree/ Green Canopy) (Km)	CPRs Within 50 meter corridor	Religious Structure Within 30 meter corridor	Land Use (Agri/Barren Grassland/submergence/irrigation network/Plateau)
				Structure	Land			East/West		
East	Approximately 19	19.8	4751 (mostly shops in the bazaars)	209.86	612.9	885.51 (270.61 for infrastructures)	15.37	At least 15 meter R&H land (rest is private land and water bodies/ghers)	25	Water bodies, gher, industry, port area, Bazaar, petrol pumps,
				822.76						
West	12	9.74	3256 (mostly shops in the bazaars and semi-pucca houses)	156.35	761.28	960.02 (198.74 for infrastructures)	10.31	At least 15 meter R&H land (rest is private land) at section 2	13	Water bodies, gher, industry, port area, Bazaar, navy area, High voltage line. Gas pipeline, Firing Zone of Army
				917.63						
Central	20	13.75	7121	220.04	783.34	1024.44 (281.06 is for infrastructure)	10.69	private land and water bodies/ghers)	31	Water bodies, gher, industry, port area, Bazaar, petrol pumps
				1003.38						

CHAPTER 5 ALTERNATIVE ALIGNMENTS

5.1 GENERAL

The proposed rail alignment from Khulna to Mongla will be a new alignment starting from the existing railway station at Phultola. In this chapter the Consultant has followed a systematic approach for selection of various route alternatives that can start from the above starting point to Mongla Port. The process was initiated through adopting a selection criterion, followed with field visits aimed towards investigations and obtaining the GPS coordinates of the alignments. These initial field visits helped the Consultant in identifying the take-off point for the new alignment from the existing Phultola-Khulna rail section and identifying probable alignment options.

The next step was to conduct preliminary surveys of all the probable alignments with a view to gather data and information that would be sufficient to do a comparative assessment of alternate alignments and relative priorities of those alternate alignments on the basis of technical, social, environmental and costs considerations.

It is observed that moving downwards (in south direction towards Mongla Port) the new alignment can pass through the Khulna City (Central Direction) or avoid congested city area by moving either in East or West directions beyond the city limits. All these options were studied and three alignment alternatives (one in each direction) were selected for further study and then were subjected to economic analysis for selection of the most suitable alignment considering all aspects.

The present chapter details with the study of one of the most suitable alignments on each of the three directions, and the selection of most suitable alignment among these three alternative alignments is discussed in the chapter on economic analysis. The framework for selection of the alignment is presented in the following section.

It may be emphasised that the Amendment No. 2 to the Request for Proposal (RFP), dated 30.04.2011, issued by Bangladesh Railways, says *"Assess the various rail routes avoiding construction of the new railway bridge over Rupsha river considering the regional connectivity, topography, land formation, traffic forecast, commercial aspects, and existing infrastructures of the area and future development plan and schemes of the Government in the area. Conduct preliminary surveys of all alternative routes and suggest the suitable route among proposed routes''*.

Considering the requirement of the RFP, the Consultant studied four alignments of the eastern side (with respect to the existing Phultola-Khulna rail line) and found one of the alignments most suitable on the Eastern side of Phultola - Khulna rail line.

However, during preliminary survey it was observed that while avoiding river Rupsha,

the alignment on the east side will have to pass through three major navigable rivers (one of the rivers the Bhairab is of the same class as that of Rusha River, requiring horizontal navigational clearance of 250 feet and vertical navigational clearence of 60 feet), needing construction of high embankment for a considerable length. Therefor the Consultant considered additional alternatives on western and central sides of the existing Phultola - Khulna rail line.

5.2 FRAMEWORK FOR SELECTION OF ALIGNMENT

The whole project area staring from Phultola Railway Station (start point) to Mongla Port was divided into two sections:

d) Section 1: From Phultola to Katakhali; and

e) Section 2: From Katakhali to Mongla Port

Section 1:

The alignment was studied for three directions - Eastern Alignment (from Phultola towards east direction), Western Alignment (from Phultola towards west direction) and Central Alignment (from Daulatpur towards Khulna City), and. Within each of the three directions, one or more alignment alternatives were studied, as indicated below:

f) Eastern Alignment – four alignment alternatives

- Alignment A
- Alignment B
- Alignment C
- Alignment D

g) Western Alignment – one alignment

- Alignment E

h) Central Alignment – three alignment alternatives

- Alignment F
- Alignment G
- Alignment H

Section 2:

In Section 2, the alignment was studied for two directions - Alignment A (from Katakhali to Mongla Port on the eastern side along the National Highway - N7) and the Alignment B (from Katakhali to Mongla Port on the western side along the National Highway - N7)

The above alignments are discussed in detail in the subsequent sections and are

summarised in Table 5.1.

Table 5.1: Alignment Alternatives

Section	Alignment Direction	Alignment Alternatives
Section 1	Eastern Alignment	Alignment A
		Alignment B
		Alignment C
		Alignment D
	Western Alignment	Alignment E
	Central Alignment	Alignment F
		Alignment G
		Alignment H
Section 2	East Side	Alignment A
	West Side	Alignment B

For the selection of the most suitable alignment for the project (complete alignment from Phultola to Mongla Port), one of the most suitable alignments from the three alternate alignments of Section 1 was selected and to this selected alignment one of the two alignment of Section 2 was added as per the suitability to obtain the complete alignment from Phultola to Mongla Port.

For example, if the alignment from Section 1 approached Katakhali in east or west direction, then the corresponding alignment (Section 2) in east or west side was added to the approaching alignment to avoid crossing the National Highway (N7), not much difference on account of technical and cost considerations were observed between the two alignments of Section 2.

5.3 SELECTION CRITERIA

Studying a new alignment possess a major challenge for fixing the take-off point and the route to be followed that is reflected in achieving ‘cost minimisation’ and ‘benefit optimisation’ under a given technical parameters and addressing the safe guard issues. There are various parameters (technical, commercial, social, environmental, etc.) that need to be carefully factored while deciding a new alignment, otherwise it would result either in initial higher capital investment in construction of the rail line or incur higher recurring cost in operation and maintenance of the rail route.

The selection criteria adopted for identification of alternative alignments considers all the important factors influencing a rail alignment, and the same is described in the subsequent sections of this chapter, and is summarised below.

- Connectivity
- Topography & Land Form

- Hydrology & Morphology
- Commercial Aspects
- Existing Infrastructures of the Area
- Future Development Plan
- Safety & Aesthetic Aspects

5.4 FIELD INVESTIGATIONS

To arrive at a set of alternative alignments and further investigations, three main field visits were undertaken by Consultant's team - one visit before submitting the Inception Report and two others after the submission. This was followed by preliminary surveys – physical, engineering, social and environmental. The details on investigations and surveys have already been discussed in the previous chapter, and its results were used for identifying & studying the alignments. However, the following main aspects studied during field investigations, are worth mentioning.

5.4.1 Start Point for Alignment

For deciding the start point, factors such as availability of railway station and sufficient land area without or with minimum habitation and structures were of prime concern. In addition to these factors, on the eastern side, due to the presence ofclass one navigable river (Bhairab) close to the existing rail line it became necessary that the location of the starting point to be at a sufficient distance from riverto negotiate the applicable ruling gradient to cross the river. All these possibilities were investigated by Consultant's team and the possible start-point for the alignment alternatives was found suitable at Phultola Railway Station, from where the proposed new alignment can branch-off towards Mongla Port, either in west, east or central direction.

5.4.2 Possibility of using Abandoned Lines

The possibility of using the abandoned rail line was investigated with a view to maximize the use of the railway land. There are two abandoned lines on the east side of the study area, and the Consultant explored the possibility of using these lines.

a) Rupsha East–Bagerhat (branch line closed on 16th August 1997) Rail Line: Bagerhat is on the eastern side of Khulna. This abandoned rail line starts from Khulna Station till the western bank of river Rupsha, where it terminates and again starts from the eastern bank of river Rupsha to Bagerhat. This line cannot be used as it moves towards Bagerhat which is on the eastern side of Khulna, whereas Mongla Port is located south of Khulna. Also, in order to connect it to Khulna or for that matter to the existing Khulna–Jessore rail line, a bridge over Rupsha River will have to be constructed with its approaches passing through build-up areas of Khulna City, necessitating major resettlement and rehabilitation

of people and structures.

b) Abandoned BADC Rail Line: There is an abandoned rail line branching-off the existing rail line near Shiromoni (Photo 5.1) and connecting Bangladesh Agriculture Development Corporation (BADC) fertiliser godown at the west bank of river Bhairab. The right-of-way of this abandoned line (Photo 5.2) can be used in case the alignment works out to be economical through the eastern side of Khulna.

Photo 5.1: Branch-off Point at Shiromoni

Photo 5.2: Abandoned Rly Line leading to BADC Godown from Shiromoni

5.4.3 Mongla Port Area

The officials of Mongla Port Authority (MPA) discussed with the Consultant's team about their need for railway line, sidings, containers yards, stacking yards, etc. and assured their full cooperation in providing the relevant documents/ maps needed for the study. The Consultant team and the officials of MPA visited the areas in-and-around the port to identifying the possible rail alignment options with a view to integrate the proposed Khulna - Mongla Port rail link with port operations as well as to meet the requirements of the industries in the port area.

5.5 ALIGNMENT DIRECTION

The proposed Khulna-Mongla new rail alignment is basically an extension of the existing Jessore-Khulna broad gauge (BG) rail line in the north-south direction, with an option to pass through the city or bypass it. Thus the directional issue was the first and foremost aspect that was studied during the field investigation. The rail alignment from Khulna towards Mongla Port can take one of the three possible directions – towards east, west or center, and reach a common point near the Highway N7 at Katakhali (south of Khulna). From Katakhali to Mongla Port the alignment can run parallel to N7 on western or eastern side of the highway.

In order to incorporate the directional aspect in the study of alignment, the following

three exhaustive directions were considered.

a) Central Direction (towards Khulna from Phultola): The new rail route can follow the existing rail alignment till Khulna Railway Station, and then pass through the city built-up areas before crossing Rupsha River (which is on the south of Khulna City). In this option there are two major hurdles – i) passing through city would pose a major problem for land acquisition and rehabilitation of people and structure; and ii) immediately after the city the alignment will have to cross Rupsha River (Class I) for which the navigational clearance of at least 60 feet will be required, and considering an acceptable gradient, a high embankment (from ground level to 70 feet considering structure height) of about 5 km length (on both sides of the river) will have to be built, which will not only increase the width of land required (ranging from about 100 feet to 300 feet) but also virtually divide the city in the area starting from a location near Khulna Railway Station to the north bank of Rupsha River. Similar situation will be encountered even if the alignment is considered towards east or west direction from a point close to Khulna Railway Station.

b) East Direction (towards east side of existing Phultola-Khulna rail line): The new alignment can branch-off from the existing rail line at a location between Phultola and Shiromoni towards left (east direction) and cross three rivers - Bhairab (Class-I), Atai (Class-II), and Athrobaki (Class-III)– before narrowing down to Katakhali and further to Mongla Port. In this option the main points to be considered are – i) crossing three rivers at a considerable height (60 feet, 40 feet and 25 feet height vertical clearances respectively for the navigational rivers Bhairab, Atai and Athrobaki); ii) high embankment (ranging from ground level to 60 feet, 40 feet and 25 feet height) for about 26 km length from the take-off point (on the existing rail line) to a point after crossing Athrobaki River); iii) presence of wet land in the area bounded by Atai and Athrobaki rivers; and iv) problem of accessibility to the site during construction phase; v) difficult for daily passengers between Mongla and Khulna to reach Khulna City due to lack of road connectivity. In this direction the Consultant has considered four alignment options.

c) West Direction (towards west side of existing Phultola-Khulna rail line): The new alignment can branch-off from the existing rail line at a location between Phultola and Shiromoni towards right (west direction) and move along the existing Khulna City Bypass and after crossing Rupsha River, proceeds towards Katakhali and further to Mongla Port. In case of this alignment options the major issues are – i) crossing Rupsha River (Class-I) with an navigational clearance of 60 feet; and ii) it has been given to understand that Khulna city is expanding towards west and south-west, and construction of rail line would constraint the city development in terms of mobility of people and would involve crossing roads connecting the city

core or otherwise, it is important that the rail alignment should be in accordance with the future spatial developmental plan of Khulna Development Authority (KDA). In this direction the Consultant has considered one alignment option.

d) From Katakhali to Mongla the probable alignment can be on either side along the National Highway (N7)- i.e, on the east side of N7 (Alignment A) and on west side of N7 (Alignment B). The alignment will go through sparsely populated area, passing through typical tidal deltaic coastal deposit which may contain patches of very soft compressible soil. Special care has to be taken for the treatment of this type of problematic soil.

5.6 POSSIBLE ALIGNMENT ALTERNATIVES

5.6.1 Over View

After giving due consideration to the available data & records, opinions received from experts, BR officials, Mongla Port Authority Officials as well as the local residents, it was decided to divide the whole alignment (for the purpose of the study) into two sections, coinciding with the geographical spread of the identified alignment options. Accordingly, Section-1 was considered from Phultola to Katakhali and Section-2 was considered from Katakhali to Mongla Port. The alignment options along with the two sections are shown in Fig 5.1.

A total of eight possible alternate alignments for rail routes were explored under Section-1. These alternative alignments are named as Alignment-A, Alignment-B, Alignment-C, Alignment-D, Alignment–E, Alignment–F, Alignment-G and Alignment-H. While Alignment-A to Alignment-D are on the eastern side, Alignment-E is on the western side and Alignment-F to Alignment-H are on central direction.

Within Section-2 the two possible alternate alignments are: Option-A, on the eastern side of Khulna-Mongla Highway (N7) and Option-B, on the western side. The preferred alignments will be a combination of the best alignments of Section -1 and Section -2. Thus, after selecting the alignment in Section -1 and Section-2, both will be combined to form a whole alignment for detailed investigation and further studies

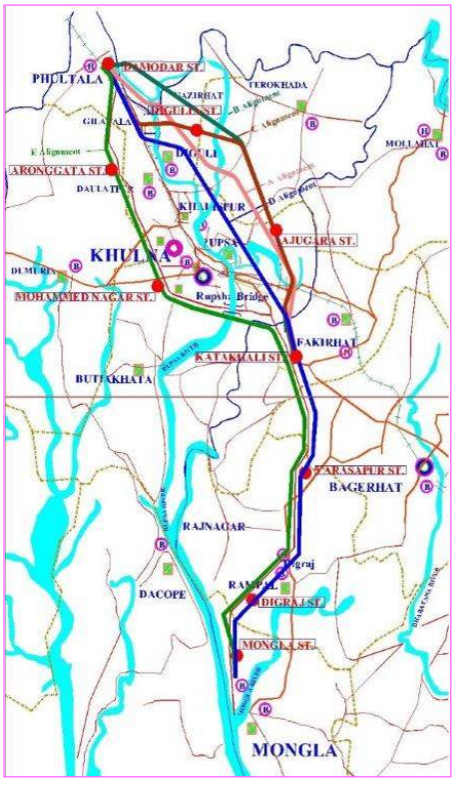


Fig 5.1: Alignment Options

5.6.2 Section 1 –Eastern Alignment

Alignment-A: Starts from the Phultola and passes through the locations - Pather Bazaar Level Crossing, Stand Gate, Gabtoli, Shiromoni, 2 No Bihari Colony, Gilatala, Purbapara, Barakpur Union Complex, Uttorpara, Digholia, Brommogati, Bativita, Hazigram, Shenhati, Bashurmar Kheyaghat, Lashkarpur, Bipro Ajogara, Shamontoshena, Lokhpur, and ends at Fakirhat. The alignment Option is depicted in Fig 5.2.

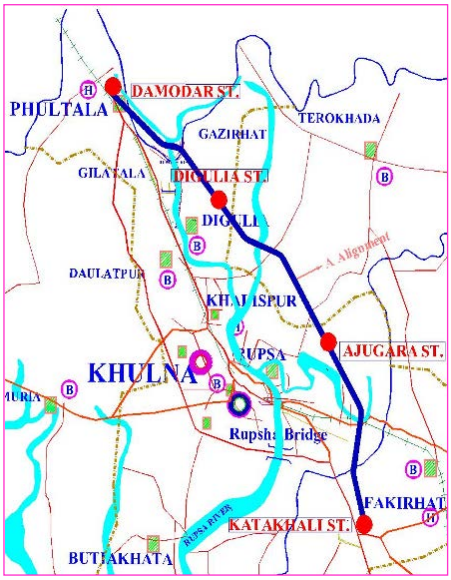


Fig 5.2: Alignment Option A (Section -1)

After take-off the alignment crosses National Highway (N7) and moves along Bhairab River and crosses Bhairab River after its (river) junction with River Madhumati. The stretch from N7 to the river bank has industrial structures that may require acquisition.

After crossing Bhairab, the alignment passes through agricultural area and crosses rivers Atai and Athrobaki. The patch of land between Atai and Athrobaki has been observed to be wet land, requiring detailed investigation. After crossing Athrobaki, the alignment moves towards south, crosses Bagerhat Highway (near Katakhali), the end point of Section I.

Alignment -B: The option starts from the rail line at Phultola old rail station and passes through Mashiali, Shiromoni, Baroipara, Nondon Protab, Kamargati Kheyaghat, Patgati Kheyaghat, Bhabanipur Palpara, Baijipara Ajogara, Rustam Ajogara, Shamontoshena, Naihati, Baburbarir More, Lokhpur and ends at Fakirhat. The alignment Option is depicted in Fig 5.3.

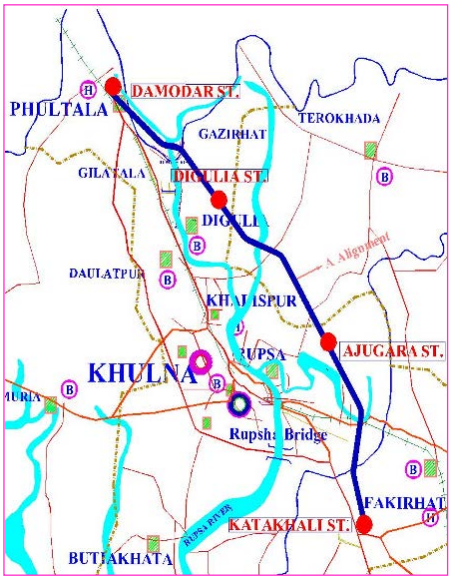


Fig 5.3: Alignment Option B (Section -1)

Thus, Alignment B starts from the same take-off point as Alignment A with a shift in north-east direction to avoid the industrial structure between the N7 and Bhairab River. However due to the shifting of alignment it will be required to cross one additional river (Madhumati), apart from the three rivers mentioned in Alignment A. Also at the take-off point, the course of river Bhairab is close to the land that will not allow sufficient distance for the train to negotiate the acceptable gradient, and therefore the take-off point will be required to shift further north by about 4 km, increase the length of the alignment.

After crossing rivers Bhairab and Atai, Alignment B meets the alignment discussed in Option A at a point (Ajogara) before Athrobaki River, after that it follows the alignment same as that of Option A.

Alignment -C: Starts from Phultola and passes through Shiromoni along abandoned railway line, BADC Godown, Bhairab River, Mominmpur/ Hazigram, Digholia (beside Atai River) and Parhazigram/ Shyamnagar, Shamontoshena, Lokhpur, and ends at Fakirhat (Katakhali). The alignment Option is depicted in Fig 5.4.

Fig 5.4: Alignment Option C (Section -1)

Thus, Alignment C starts from the same take-off point as in Alignment A & Alignment B, and moves along the existing rail line up to the point near Shiromoni where the abandoned BADC line meets the existing line. From this point the alignment follows the abondant rail line up to BADC godown on the west bank of river Bhairab. It then crosses the river and meets Alignment B after crossing river Atai. Beyond this point it follows alignment described in Alignment B.

Alignment-D: Starts from Jabdipur, Shiromoni (on the rail line), and passes through Mirerdanga Kheyaghat, Naptighat, Morol Bazaar Digholia, Border of Brommogati and Digholia, Bkandorbill, Mostofipara, Lutfarer Bottala, Bipro Ajogara (beside Atai river), Nishipur (on the sluice gate), Abdullarmor Shrifaltala, Beltala Rupsha, (beside Atharobaki River), Jahirer Bottala, Naihati (beside old Karmopur Rail Station), Tilok Rupsha, Katakhali. The alignment Option is depicted in Fig 5.5.

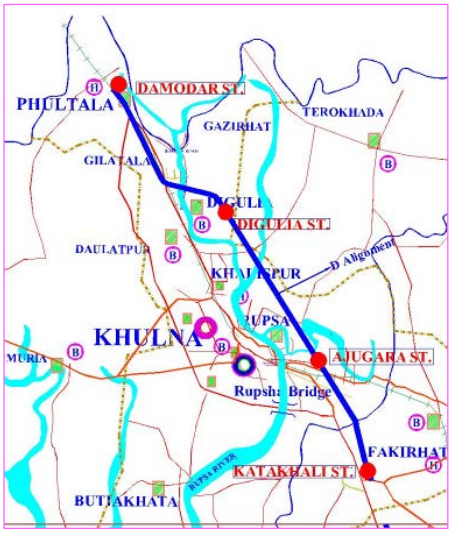


Fig 5.5: Alignment Option D (Section -1)

The alignment follows the existing line and moves towards east at a point near Mirerdanga and crosses river Bhairab. After which it crosses rivers Atai and Athrobaki and meets Katakhali via Ajogara.

The alignment passes through the industries and may require rehabilitation. It crosses river Athrobaki through an area which may be susceptible to flooding/ erosion

5.6.3 Section 1 –Western Alignment

Alignment-E: The alignment option is on the western side, and starts before the intersection of National Highway (N-7) and Khulna City Bypass Road (N-709). Then, it moves along the bypass (on western side) passes through places, viz., back ofFire Service Station, BKSP, Baitus-salam Mosque, Aronghata Bypass More, Lata Bypass More, Aksar-er More, Akman-er More, Mostafar More, Zero Point, Sachibunia Bishho Road–er More, Near to Rupsha Bridge to Lokhpur and Katakhali. The alignment Option is depicted in Fig 5.6.

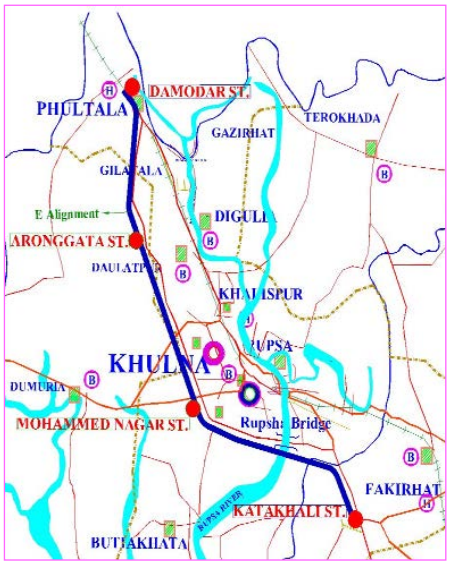


Fig 5.6: Alignment Option E (Section -1)

The alignment crosses two busy regional roads and other roads. Since Khulna city is expected to expand towards west direction, in future the development of infrastructure and other facilities may be obstructed by the alignment. The alignment shall have to cross canals/ rivers before reaching Rupsha River. The areas close to Rupsha River have habitation, requiring either replacement or moving the alignment (in west direction) by about 1.5 kmdownstreamof the location of existing road bridge over River Rupsha.

5.6.4 Section 1–Central Alignment

Khulna Station about 2.5 Km from Crossing Point of Rupsha River, which is a Class I river, requiring a navigational clearance of 60 feet. Therefor the train will have to gain a height of about 70 feet before cross Rupsha River, for which a length of about 5 km would be needed to negotiate the proposed bridge height, necessitating the start-point to move beyond Khulna Station by 2.5 Km. For all the three central alignment the Khulna Station cannot be the start-point, as it may require raising at least by 30 feet or demolishing, which is not recommended. The start–point can be at a station more than 3 km north of Khulna Station, for which, the existing station at Daulatpur (about 7 km from Khulna Station) can be considered, or otherwise a new station would have to be constructed, for which availability of land will be difficult and would increase the project cost.

Fig 5.7: Alignment Option F (Section -1)

Alignment-F and Alignment-G: Both the alignment can start from Dhaulatpur Station and by-pass Khulna Station at an elevation. After which the alignments pass through congested city area. Alignment-F passes through dense built-up area near Khulna Railway Station, Khulna Bazar, Jail Khana Road and crosses Rupsha River near Ferry Ghat (about 3.0 Km upstream stream of the existing road bridge over Rupsha River).

Fig 5.8: Alignment Option G (Section -1)

Alignment-G turns towards east and runs along Rupsha River and crosses the river at the same point as that of Alignment-F. Before crossing Rupsha both the alignments will have to move almost parallel to the river, which will cause major design constraint for construction of rail bridge over the river. The Alignment F and Alignment G are shown in Fig 5.7 and Fig 5.8 respectively.

Alignment-H: This alignmentstarts at Daulatpur Station and turns in east direction before Khulna Station. After this, it crosses two rivers – Bhairab (Class I) & Atharobaki (Class III), before joining the common path of Alignment-C and Alignment-A (discussed earlier under Eastern Alignment). For this alignment also, due to it being close to the river, design constraint for construction of bridge over Bhairab River is expected. As compared to the above two alignments, this alignment will have to cross two rivers, but would avoid passing through highly congested city area. The Alignment H is shown in Fig 5.9.

Fig 5.9: Alignment Option H (Section -1)

5.6.5 Section 2 – East Alignment

Alignment-A: Itpasses through **eastern side** of Khulna-Mongla Highway (N-7) through Katakhali, Chulkati Bazaar, Votabunia, Bharosapur Bus Stand, Tetulia, Gobai, Digraj Bazaar, Balurmath and Mongla Port Area. The alignment Option is shown in Fig 5.10.

There are some of habitation, market places and industry along the route that would need bypassing to avoid acquisition and rehabilitation. Also the alignment will have to avoid as much as possible the fish ponds along the route.

Fig 5.10: Alignment Option A (Section -2)

In the vicinity of Mongla Port the alignment will cross N7 after the port housing colony and enter the loading/ unloading yard (Mongla Port Yard) for handling the export/ import cargo. There are some of industrial units alongside the port area; the cargo handling requirement of these units will be met by providing separate siding facilities.

5.6.6 Section 2 –West Alignment

Alignment-B: Itpasses through **western side** of Khulna-Mongla Highway (N-7) through Katakhali, Chulkati Bazaar, Votabunia, Bharosapur Bus Stand, Tetulia, Gobai, Digraj Bazaar, Balurmath and Port Area. The alignment Option is shown in Fig 5.11

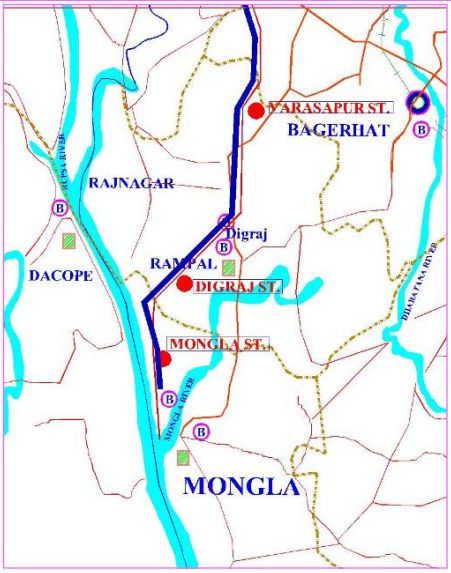


Fig 5.11: Alignment Option B (Section -2)

The alignment runs parallel to Alignment-A. Along this alignment there are relatively less habitation than Alignment-A. However the other features such as fish ponds, canals, etc. may be close to that of Alignment-A. Along this route, before entering the proposed Mongla Port Yard, there is Naval Base and a cluster of industries, close to the port.

At the Naval Base there is only about 10 meter space available between the Naval Base and N7. Thus the options for the alignment to continue on the western side are:

- To acquire land from Naval Base
- To shift N7 towards east at the Naval Base location by about 100 meters (behind PH Pump House).

Under the above arrangement the alignment can continue on the west side and also serve industrial units (by providing siding, service road and level crossings) before entering the port. In the event of the above two options being not available, the only option would be to divert the alignment before Naval Base to the east side of N7 and thereafter follow the alignment as described for Alignment A

On the basis of the above options, preliminary survey has been conducted to obtain the necessary data and information on the alignments.

5.7 BASIS FOR COMPARISON OF ALIGNMENTS

In the earlier chapter, the results of the preliminary survey were discussed for the alignment options considered in Section -1 and Section-2. On the basis of the data obtained for these options, comparison was made to select the options based on cost and technical parameters associated with the alignments. The factors listed in Table 5.2 were given due consideration for comparing the alignments.

Table 5.2: Factors Considered for Comparison of Alignments

Sl. No.	Factors	Remarks
1	Obligatory and Controlling Points	Important towns, economic activities, villages; avoiding locations where river width is more, avoiding areas liable to flooding
2	Length of Alignment	As far as possible, alignments followed shortest route by duly considering the other factors such as intermediate obstructions, steep gradients, suitable bridge sites (it may become necessary to deviate from the shortest route to connect obligatory point where the points are traffic generating and places of importance)
3	Bridges	Bridge sites were selected where width of river is less and alignment crosses the river at right angle; firm bank for abutment of foundation (suitable bridge site may require deviation of alignment from straight path to form curves before and after the crossing of the river)
4	Culverts	Geometry of alignment is selected in a way to minimize number of culverts for cross drainage works
5	Level Crossing	Efforts were made to minimise level crossings and design them right angle to the highway
6	Quantity of Earth Work	Minimising quantity of earth work and maintain free board margin above high flood levels.
7	Geometrics	• Due consideration are given for factors such as gradient, speed, loadings and method of traction followed, etc. • Ruling gradient and minimum permissible radius of curve is considered • Curves should be of ~~maximum possible~~required radii • Use of curve is avoided on approaches and at stations as well as on bridges • The effect of rise and fall of ground were given due consideration while proposing the alignment. • Steeper gradients were avoided
8	Approach Road	Availability of approach road that can facilitate transportation of materials for the construction were also considered
9	Station Location	Alignment is chosen so as to have space available for station area out-side habitation where levelled and open space should is available
10	Social Aspects	• Minimising rehabilitation and resettlement issues • Avoiding pucca and semi-pucca structures • Maximum utilisation of available railway land • Avoiding private and cultivable land • Avoiding land used for economic activity • Considering stakeholders view point • Avoiding places of worship and burial land
11	Environmental Aspects	• Minimising tree cutting and avoiding rare species • Avoiding forest area and ecologically sensitive areas • Avoiding places of cultural heritages, community resources (water, ponds, well, etc.

5.8 SELECTION OF ALIGNMENT

Based on the survey results, the Consultant has performed a comparative analysis of all the alignment options to find out best possible rail-route that would be cost-effective as well as technically, socially and environmentally viable. For selection of alignment due consideration was given to the requirement of the RFP for the present study as well to the factors that were encountered during the course of the study. Accordingly, one alignment from each of the directions - west, east and central – was selected. The three alignments were further considered for economic analysis to ascertain their economic viability as well as to prioritise the three alignment options. The three selected alignments are summarised in Table 5.3.

Table 5.3: Summary of Selected Alignments

Attribute	Eastern Alignment	Western Alignment	Central Alignment
Length (Km)	59.60	60.40	49.2
Embankment Height/ Physical Obstruction	Major Issue	Not a Major Issue	Major Issue
Major Bridges	3 Nos.	1 Nos.	2 Nos.
Road Over Bridge	1 No.	---	---
Accessibility	Low	High	Moderate
Constructability	Difficult	Easier	Easy
Station Height	1 at Approx. 10 m ht.	All at Grade	All at Grade
Social Impact	Moderate	Low	High
Operating & Maintenance Cost	High	Low	Moderate
Serviceability	Low	High	High
Safety	Lower	High	Low
Land Constraint	Critical from Phultola to BADC Godown	Negligible	Critical (City Area on both side of Rupsha)
Approx. Construction Cost (Crore Taka)	2472.57	1895.51	2035.63
Social Cost including LA	442.76	480.01	512.20
Environmental Cost	2.05	2.06	1.75

Based on the above comparative study, the order of priority for the three alignments are as under.

1. Western Alignment (Alignment-E)
2. Eastern Alignment (modified Alignment-C)
3. Central Alignment (Alignment-H)

CHAPTER 6 TRAFFIC ESTIMATION AND FORECASTS

6.1 INTRODUCTION

The present chapter relates to the assessment of traffic that is likely to patronize the proposed Khulna-Mongla rail line in the event of its becoming operationalized. The Consultant has studied the present traffic flows along the proposed rail corridor, identified the major future projects from where the traffic offerings are possible and also studied the possibility of catering to the traffic linked to Nepal and Bhutan.

Sufficient volume of traffic is one of the preconditions for implementation and sustainable operations of a railway project. To assess the volume of traffic to be carried by the railway after implementation of the project, it is necessary to assess existing volume of traffic by different modes of transportation. As the proposed railway line is a new one, there exists no railway traffic and as such the need for surveying existing traffic by railway from Mongla to other parts of the country does not exists. However, existing traffic by Road and Waterways to and from Mongla were surveyed to estimate its volume, nature, routes and possible diversion to the proposed new rail link. It has been assessed that daily average goods carried from Mongla to different parts of the country is roughly 7000 Metric Ton (MT), i.e., adding up to an annual traffic of approximately 2.50 Million MT. Likewise, daily average number of passengers carried by bus from Mongla to different parts of the country is roughly 5600, i.e., annual passenger traffic is approximately 2.04 Million.

In the following sections a detail account of traffic assessment and its forecasts has been presented. The sequence adopted for the same is listed as follows.

- Assessment of total traffic flows (freight and passenger) along the proposed rail corridor by existing mode of transport
- Diversion of the above traffic to the proposed rail link
- Potential traffic offerings to the project rail link from the proposed projects that would come up in future
- Possibility of materializing of regional cargo in case of being routed through Mongla Port (traffic to and from Nepal and Bhutan)
- Traffic forecasts by using the growth rates and/ or the future expansion/ production plan of the industrial units and Mongla Port.

The assessment of traffic flows along the proposed rail corridor was based on - both the data collected through primary traffic surveys by the Consultant, as well as, from secondary sources. The traffic surveys were conducted on the existing National Highway (N7), and the data so collected were supplemented through the data collected from the secondary sources. The secondary sources for traffic data were – previous

reports, Mongla Port Authority (MPA), Bangladesh Inland Water Transport Authority (BIWTA), Bangladesh Inland Water Transport Corporation (BIWTC), Bangladesh Road Transport Authority (BRTA), Bangladesh Road Transport Corporation (BRTC), Road and Highway Department (RHD), Khulna Development Authority (KDA), Customs Authority, Petrobangla, Bangladesh Petroleum Corporation (BPC), Ministry of Industries & Commerce, Power Development Board; different industries located around Khulna, Mongla and Noapara; Bangladesh Railways, and Railway stations falling on Khulna –Jessore rail section; and local entities and traders.

6.2 TRAFFIC DATA FROM SECONDARY SOURCES

Road traffic data on Khulna-Mongla Highway were collected from different sources such as Rupsha Bridge Toll Plaza, Mongla Bus Terminal, Khulna Truck Association and Study Report on the Construction of Rupsha Bridge.

6.2.1 Rupsha Bridge Toll Plaza

The road traffic volume over Rupsha Bridge on both directions was collected for a period of 6 months, May 2012 to October 2012. Traffic from Khulna direction after crossing the bridge moves in three directions: Dhaka, Bagerhat and Mongla. Similarly traffic to Khulna comes from Dhaka, Bagerhat and Mongla. A summary of volume of traffic over Rupsha Bridge on both directions is shown in Table 6.1.

Table 6.1: Class wise Daily Average Traffic on Rupsha Toll Bridge

Class	Category	No of vehicles		Total
		From Khulna	To Khulna	
Class 1	Motor Cycle	863	843	1706
Class 2	Baby taxi/ Mishuk// Tempo	194	194	388
Class 3	Car/ Jeep/ Station Wagon	179	174	353
Class 4	Maxi/ Micro/ Pick-up/ Pick up van	445	419	1217
Class 5	Coaster/ Tractor/ Mini Bus/ Mini truck	309	315	624
Class 6	Truck/Covered Truck(2/3 Axle); Bus	419	425	844
Class 7	Tractor with Trailer/ Construction Equipment; Class	2	15	3
Class-8	Trailer Truck/ Long Truck	4	35	7
Class 9	Free Class	171	162	333
Total	All Classes	2585	2535	5120

Source: Rupsha Toll Bridge at Khulna

6.2.2 Mongla Bus Terminal

Mongla town is separated from Mongla Port area by a river. It was observed that from 0600 hrs. to 1800hrs, on an average after every 6 minutes a boat arrives at Kheya Ghat

from Mongla town and each boat carries on an average 25 passengers. Thus, the number of passengers arriving at bus stand from Mongla town during 0600 hrs to 1800 hrs.is about 3000 persons. Mentionable that the Bus Stand is adjacent to the Kheya Ghat. During night frequency of boat is much less and is 25% to 30% of the day time. So, number of passengers arriving during night is 900. In a day the number of passengers arriving at bus stand from other side of the river from Mongla town is about 3900. In addition to it, about 700 passengers get generated from Mongla Port area and 1000 from other areas located in between Mongla Port to Katakhali. It is estimated that on an average 5600 passengers are using Khulna- Mongla Highway daily in each direction. Of this passenger traffic, on an average, about 1120 (20%) go to Dhaka, 3360 (60%) to Khulna and onwards and 1120 (20%) to different destinations up to Khulna (Roadside Passengers).

6.2.3 Study Report on Construction of Rupsha Bridge

As per the study, based on the results of regression analysis, number of vehicles by type in the year 2015 has been projected as shown in Table 6.2.

Table 6.2: Vehicle Ownership by Type

Year	Motorcycle	Auto-rickshaw	Car	Bus	Trucks	All Vehicles
1989/90	125,000	30,200	92,650	25,000	37,200	310050
1990/91	138,750	32,616	97,943	26,750	39,512	**335,571**
1991/92	150,171	36,796	101,806	28,820	40,752	358,345
1992/93	158,588	40,114	103,511	30,444	41,632	374,289
1993/94	165,360	43,863	106,634	32,335	42,723	390,915
1994/95	173,167	53,851	111,392	35,601	44,691	418,702
1995/96	182,035	68,039	119,020	38,156	48,175	455,425
1997/98	236,000	99,000	141,000	51,000	57,000	584,000
1999/2000	267,000	121,000	155,000	58,000	63,000	664,000
2004/2005	414,000	222,000	221,000	95,000	90,000	1,041,000
2009/2010	506,000	286,000	263,000	117,000	107,000	1,279,000
2014/2015	614,000	360,000	312,000	144,000	127,000	1,558,000

Before construction of the bridge on Rupsha River, the Rupsha Ferry Service which existed on National Highway No. 7, and operated under jurisdiction of the Roads and Highway Department (RHD), was so congested that two ferries were operated simultaneously during peak hours.

6.2.4 Roads & Highways Department

The Roads & Highways Department (RHD) of Bangladesh carry out Classified Traffic Count survey on regular basis at identified locations on National Highways and other roads. The Consultant obtained the traffic data available with RHD for two locations on

the Khulna – Mongla section of National Highway (N7). The two locations are: (a) at Chalk Katha (Katakhali where N7 intersects with road R770 near Digraj) and (b) Lockpur at Kudir Battala (intersection with N 709) - Katakhali (intersection with R770). The vehicle-wise traffic figures in terms of Average Annual Daily Traffic (AADT) at these two locations are set out in Table 6.3 and Table 6.4, respectively.

Table 6.3: Traffic Count (AADT) at Chalk Katha

Vehicle	2004	2007	2008	2009	2011
Truck -Heavy	2	36	54	89	89
Truck - Medium	302	827	596	621	821
Truck - Small	42	383	233	76	371
Bus - Large	51	380	334	37	37
Bus - Medium	332	353	274	323	246
Bus - Micro	58	172	237	80	111
Utility	37	144	212	58	1099
Car	73	179	198	94	153
Auto rickshaw	89	272	371	584	10
Motorbike	292	588	482	816	573
Bi-cycle	973	843	572	587	335
Cycle Rickshaw	1694	898	760	817	482
MT	1278	3334	2991	2778	3510
NMT	2667	1741	1332	1404	817

Source: RHD, Bangladesh

Table 6.4: Traffic Count (AADT) at Lockpur

Vehicle	2004	2007	2008	2009
Truck -Heavy	5	38	169	50
Truck - Medium	534	785	417	939
Truck - Small	155	357	218	470
Bus - Large	322	617	94	545
Bus - Medium	777	556	284	415
Bus - Micro	189	200	120	314
Utility	194	165	66	78
Car	241	213	138	234
Auto rickshaw	392	221	291	533
Motorbike	592	842	816	1170
Bi-cycle	1643	1042	861	741
Cycle Rickshaw	1608	1218	934	1083
Cart	8	0	0	0
MT	3401	3994	2613	4748
NMT	3259	2260	1795	1824

Source: RHD, Bangladesh

The yearly traffic count data is an important basis for knowing the growth rates for the categories of vehicles moving in the project area. However, as is evident from the above two tables there is much variance in the yearly figures of the vehicles, and therefore cannot form the basis for estimating the growth rates.

6.2.5 Mongla Port Traffic

At Present port is handling about 2.5 million tons of cargo. The Annual handling capacity is 6.5 million tons. The major imports are food grain, fertilizer, clinker, machinery, gas, fly ash, gypsum, sugar and car. In terms of exports the main commodities are jute & jute goods, frozen cargo and general cargo. During the period 2003-04 to 2011-12, the number of vessels, cargo and containers handled at the port is set out in Table 6.5.

It may be observed from the table and the attached charts that:

a) predominantly Mongla Port handles import cargo;

b) the percentage share of exports to total tonnage handled at the port was less than 30% and off-late (since 2008-09) the share of exports has been declining and observed to be 5% - 6% during the last two years;

c) marked difference in imports and exports from the port indicates un-even cargo flows “from and to’’ the port;

d) the share of container traffic (in terms of tonnage) to the total traffic handled ranged from 8% to 17%;

e) the trend in exports and container traffic handled at the port is observed to be similar, indicating the dependency of container traffic on exports rather than both exports and imports at the port;

Turnaround time of the non- container vessels calling at the port ranged from 3.75 days to 5.95 days, while for container vessel the turnaround time is about 2 days. The traffic linked to Mongla Port would be one of the major sources of traffic to the project rail link, and the operation of train on the proposed rail link would be greatly influenced by the offerings from the port as well as the pattern of exports and imports cargo movement from/ to the port.

Table 6.5: Mongla Port Traffic

Year	Vessel	Cargo Handled (000 MT)		Containers Handled	
		Import	Export	TEUs	(MT)
2003-04	170	1179	316	27,148	1,95,663
2004-05	144	1254	222	25,649	1,86,859
2005-06	131	1215	268	25,571	1,73,423
2006-07	110	662	252	25,342	1,68,352
2007-08	93	518	204	20,885	1,45,774
2008-09	140	930	208	21,201	1,42,377
2009-10	153	1502	147	20,651	1,44,250
2010-11	302	2530	166	27,123	2,11,430
2011-12	234	2482	137	30,045	2,51,327

Source: Mongla Port Authority (MPA)

6.2.6 Inland Water Transport Traffic

The Consultants team visited Bangladesh Inland Water Transport Authority (BIWTA) and Bangladesh Inland Water Transport Corporation (BIWTC) offices at Khulna. Both the offices confirmed that no Government water transport vessel carry any passenger or goods between Khulna and Mongla. The main reason is insufficient navigation depth of the rivers. However, steamer and launch of private ownership run from and to Khulna, particulars of which are shown in Table 6.6.

Table 6.6: Steamer and launch of private ownership run from and to Khulna

Sl. No.	Vessels	Carrying Capacity (No. of Passengers)	Route
1	M.L. Al-Madina-2	147	Khulna-Madinabad
2	M.L. Bagdad	171	Khulna-Madinabad
3	M.V. Mohammadi	306	Khulna-Madinabad
4	M.V.Riad Express	404	Khulna-Madinabad
5	M.V. Faria Sadia	171	Khulna-Jorsingh
6	M.V. Momin Khan	404	Khulna-Munshigonj
7	M.V. Al-Madina-1	291	Khulna-Munshigonj
8	M.V. Muhuri Nafi	612	Khulna-Nil Dumur
9	M.V. Water King-8	602	Khulna-Nil Dumur
	Total	3100	

It was reported that about 3100 passengers leave Khulna daily by water ways. The majority of the passenger movement by water ways is from Khulna is to Madinabad and

Nil Dumur. It was also observed that no passenger vessel move from Mongla after the closure of Mongla- Ghosiakali canal due to insufficient navigation depth. However, small passenger launches and speed boats ply to Sunderban for tourists.

In the year 2011-12, in terms of movement of cargo by Inland Water Transport (IWT), it was gathered from Mongla Port Authority (MPA) statistics that 22, 54,844 MT of import and 1, 02,985 MT of export goods were carried by private vessel operators from and to Mongla Port.

Thus from the above observations it is inferred that IWT services between Mongla Port and Khulna (and beyond) is only for goods traffic, and therefore, the diversion of traffic from IWT to the proposed rail link can be expected for only goods traffic and not for passenger traffic.

6.3 TRAFFIC SURVEY

Traffic survey for the road traffic on Khulna-Mongla National Highway (N7) was conducted at two locations- Lokpur / Kudir Battala and Digraj / Chalk Katha, coinciding with the locations adopted by RHD. At these locations, the vehicles moving on both the directions were counted manually (Classified Vehicle Count) continuously for 5 days in 2 shifts daily (0800hrs to 2000 hrs. and 2000 hrs. to 0800 hrs.) by specially trained enumerators. Along with the vehicle counts on both the locations, Origin-Destination (O-D) survey was conducted for three days in order to obtain the flow pattern of the vehicles plying on N7.

6.3.1 Classified Vehicle Count Survey

Survey Location: Lockpur / Kudir Battala

Summary of Classified Vehicle Count at Lockpur / Kudir Battala in terms of Average Daily Traffic (ADT) in both the directions is set out shown in Table 6.7.

Table6.7: Summary of Classified Vehicle Count (ADT) at Lokpur / Kudir Battala

Heavy Truck	Medium Truck	Small Truck	Large Bus	Mini Bus	Micro Bus	Car	Other MT*	Total MT	Total NMT
119	1104	236	308	633	687	459	3878	7424	2721

Source: Consultant Survey

** MT = Motorised Transport, 'Other MT' = Other Motorised Transport such as Utility, CNG/Auto-Rickshaw and Motor-Cycles, and 'NMT' = Non-motorised Transport such as bi-cycle, Rickshaw/van and push cart/animal cart*

Survey Location: Digraj / Chalk Katha

Summary of Classified Vehicle Count at Digraj / Chalk Katha in terms of Average

Daily Traffic (ADT) in both the directions is set out shown in Table 6.8.

Table 6.8: Summary of Classified Vehicle Count (ADT) at Digraj / Chalk Katha

Heavy Truck	Medium Truck	Small Truck	Large Bus	Mini Bus	Micro Bus	Car	Other MT*	Total MT	Total NMT
142	542	91	54	277	203	176	2566	4051	2233

Source: Consultant Survey

** MT = Motorised Transport, 'Other MT' = Other Motorised Transport such as Utility, CNG/Auto-Rickshaw and Motor-Cycles, and 'NMT' = Non-motorised Transport such as bi-cycle, Rickshaw/van and push cart/animal cart*

6.3.2 Observations on Classified Traffic Count Survey

- Traffic volume at Digraj / Chalk Katha is much lesser than that at Lokpur / Kudir Battala. It may be noted that Lokpur / Kudir Battala is situated before Katakhali towards Mongla and includes traffic flows of 3 directions: Dhaka, Bagerhat and Mongla. On the other hand at Digraj / Chalk Katha is situated after Katakhali towards Mongla and includes traffic of Mongla direction only.
- Total number of all types of trucks at Digraj / Chalk Katha is about 53% of the same at Lokpur / Kudir Battala. Total number of all types of buses at Lokpur / Kudir Battala is 33% of the same at Lokpur / Kudir Battala.
- Daily average goods carried from Mongla area to different parts of the country is roughly 5000 MT
- Daily average number of passengers carried by bus from Mongla to different parts of the country is about 5600. On an average 1120 passengers move towards Dhaka, 3360 to Khulna and 1120 to different destinations up to Khulna.

6.3.3 Originating-Destination (O-D) Survey

Summary of O-D survey for goods traffic is presented in Table 6.9. The survey was conducted continuously for three days on Khulna-Mongla National Highway at the same two locations where the Classified Vehicle Count was organised. The survey was confined to buses and trucks. It reveals the origin/ destinations of passengers and goods moving on the highway; their distances, fare and freight; and commodities carried.

Table 6.9: Summary of O-D Survey of Goods Traffic from and to Mongla

Main Destinations	Distance From Mongla	Average Travel Time (hr-mt)	Average Freight (Medium Truck (TK.)	Commodities and Average Tons Carried (MT)	Avg. Ton-Km Rate (Tk.)
Khulna	50	1-30	3500	Small truck Rice-3, Gas Cylinder-1 Pipe-2, Fish-2 Paper-2 MT, Jute-4 Cement-6, Oil-3 Medium Truck Rice-10, Timber-12, Gas Cylinder-12, Fish-4, Cement-17, Supari-15, Oil-11, Jute-10 Large Truck Rice-25, Timber-18, Cement-30, Brick-16, Oil-17, Jute-10, Fuel-15, Gas Cylinder-17	Food grain-2.50 Cement-3.25 Jute-5.50, Oil-4.40 Fuel-10.00 Timber-3.80 Gas Cylinder-8.00 Fish-16.00 Brick-9.00 Supari-5.00
Daulatpur	55	1-45	4000		
Noapara	75	2-30	4500		
Jessore	109	3-00	5000		
Chuadanga	180	6-00	8000		
Ishwardi	260	8-00	10000		
Santahar	340	10-00	12000		
Saedpur	450	16-00	14000		
Dinajpur	484	17-00	16000		
Thakurgaon	520	18-00	17000		
Rangpur	450	16-00	13500		
Bogra	345	10-00	11500		
Rajbari	180	6-00	8000		
Faridpur	205	7-00	9000		
Barisal	150	4-00	6000		
Takerhat	100	2-30	5000		
Rajshahi	227	7-00	9000		
Chapai-Nawabgonj	260	8-00	10000		
Kustia	201	5-00	8500		
Pabna	250	6-00	9000		
Gopalgonj	70	2-00	4500		
Patuakhali	260	7-00	10000		
Madaripur	140	3-00	6000		

In case of passenger traffic about 10% of buses were surveyed. Through the survey the information such as origin and destination, travel time, capacity, actual number of passengers carried, reason for choice of the route, willingness to travel by railway and reason, were collected.

- The main destinations by bus from Mongla and time taken were: Rupsha-1hr., Khulna-1hr.10mts, Barisal-5hrs, Takerhat-3 hrs 30 mts, Dhaka-7hrs, Kustia-8 hrs, Chittagong-16 hrs, Netrokona-16 hrs.
- 90% of the passengers opined that they will shift to the railway as the journey is safe and comfortable. However the constraint indicated by the passengers were: (i) Khulna bound passengers will travel up to Zero-Point (Katakhali) as it will

take much time to reach Khulna by rail via Phultola/Shiromoni; (ii) Dhaka bound passengers will avail railway if it goes over Padma Bridge, and they would use railway via Jamuna Bridge if intercity train is introduced with running time less than11 hrs. with reasonable fare.

6.4 TRAFFIC STUDY – BANGLADESH RAILWAYS

In this section the Consultant has studied the passenger and freight traffic aspects relating to Bangladesh Railways (BR). While studying the BR traffic, the crucial factors to be considered for the traffic estimates for the project rail traffic have been identified and ascertained in terms of their applicability to the project rail line.

6.4.1 Passenger Traffic – Bangladesh Railways

The present operations Bangladesh Railway is passenger oriented. The passenger traffic in terms of number of passenger carried and pass-km are presented in Table 6.10.

Table 6.10: Bangladesh Railways - Passenger Carried and Passenger- Km

Year	No. of Passengers ('000)			Passenger-Km (000)				
	BG	MG	Total	BG	MG	Total	Intercity	Others
2004-05	10167	32237	42254	843070	3321063	4164133	3018996	1145137
2005-06	10855	33665	44520	989903	3397544	4387447	3202836	1184611
2006-07	11618	34306	45924	1067082	3518957	4586039	3347808	1238231
2007-08	13635	40306	53941	1370544	4238699	5609243	4030214	1579029
2008-09	14689	50470	65159	1652084	5148649	6800733	5074191	1726542
2009-10	14939	50852	65791	1737993	5566952	7304945	5427949	1876996
2010-11	14256	49426	63682	1884114	6167806	8051020	6088440	1962588
Growth Rate (%)			8.4%			11.2%	12.47%	7.80%

As shown in the above table, the average growth of number of passengers for the period 2004-05 to 2010-11 is 8.40% and the growth in passenger-km for the same period is 11.20%. An important aspect of the BR passenger traffic is that in 2010-11 intercity trains carried 40.8% of total passengers but in terms of passenger-km contribution of intercity trains is about 76%.

6.4.2 Goods Traffic – Bangladesh Railways

The freight traffic carried by BR during the period 2005-06 to 2010-11 is presented in Table 6.11.

As can be seen from table the freight traffic, both in terms of tons carried and ton-km movement has registered a negative growth in the period 2006-07 to 2010-11. In the case of freight tons, the traffic declined from 3.06 million tons in 2005-06 to 2.55 million tons in 2010-11; the corresponding figures for ton-km being 820 million in 2005-06 and 692 million in 2010-11. This decline in traffic resulted in an average

annual growth rate of -2.6% for 'tons carried' and -3% for ton-km. It may be mentioned here that decreasing trend in BR freight traffic was not due to lack of sufficient traffic, but due to inadequate number of wagons and locomotives as well as line capacity constraints, especially on Dhaka-Chittagong rail corridor. It is pertinent to mention here that BR is able to move only about 6% of the import/export traffic handled at Chittagong Port.

Table 6.11: Bangladesh Railways – Freight Traffic

Year	Freight Tons carried ('000)			Net Ton-km ('000)		
	East Zone	West Zone	Total System	East Zone	West Zone	Total System
2005-06	1440	2212	3057	425642	394844	820486
2006-07	1431	2001	2967	424270	351305	775575
2007-08	1348	2600	3282	403323	466268	869591
2008-09	1391	2067	3010	425042	375117	800159
2009-10	1187	1969	2714	357584	352480	710064
2010-11	1247	1787	2554	373750	318890	692640
Average Growth (%)			-2.6%			-3.0%

6.4.3 Commodity-wise Traffic Analysis – Bangladesh Railway

Table 6.12 presents commodity-wise tonnage carried during the period 2006-07 to 2010-11. It may be observed that 59% of the freight traffic carried by BR is accounted by 8 bulk commodities and about 23% is accounted by container traffic. All the commodities (including container movement), except for Fuel Oil and Fertilizers, have registered negative growth rates during the period 2006-07 to 2010-11. However, during the same period, the movement of fuel oil and fertilisers has been increasing at a rate of 5.31% and 7.27% respectively. These two commodities are also the prospective offerings that can patronize the project rail link with Mongla Port being the source.

Table 6.12: BangladeshRailway – Major Commodity Movement

('000' Tons)

Commodity	2006-07		2007-08		2008-09		2009-10		2010-11		Growth Rate (%)
	Ton	%	Ton	%	Ton	%	Ton	%	Ton	%	
Container	574	19.35	652	19.86	613	20.37	548	19.90	579	22.67	-1.56%
Fuel Oil	422	14.22	418	12.74	549	18.27	521	19.20	493	19.30	5.31%
Wheat	257	18.66	324	09.89	349	11.59	299	11.02	259	10.14	-0.65%
Vegetable Oil	338	11.39	199	06.06	314	10.43	274	10.00	225	8.81	-4.94%
Kerosene Oil	5	0.17	254	2.01	242	08.04	232	08.55	215	8.42	-5.42%
Fertilizer	158	5.33	179	7.74	228	7.57	220	8.11	205	8.03	7.27%
Marble& Stone	269	9.07	n.a	-	117	3.89	110	4.02	100	3.92	-7.85%
All Other Commodities	944	31.81	1256	41.70	598	19.84	510	18.80	478	18.71	-22.62%
Total	2967	100	3282	100	3010	100	2714	100	2554	100	

The above analysis leads to the fact that despite the Bangladesh economy growing in the range 5% to 6.5% during the period 2006 – 2011, the movement of bulk commodities by railway has declined, except for few commodities. World over it is an established fact that over certain lead/ distance, railway has a competitive edge over road transport for movement of bulk commodities, which does not seem to be happening in case of Bangladesh Railways (BR). The reasons for it could be many, and are beyond the scope of the present study. However, the proposed Khulna-Mongla Port rail link would be a part of BR network and there are possibilities that the movement of commodities on this rail link can be influenced by the conditions prevailing on the rest of the BR network. In this regard the Consultant has further studied the movement of bulk commodities by railway and to ascertain the possibilities of movement of these commodities on the project rail link.

6.4.3.1 Food Grains - Bangladesh Railway

Bangladesh is a net importer of essential food grains, primarily rice and wheat. Some food grains are imported by government, but the majority is imported by the private sector. Almost all the private sector and donor imports move by inland waterways to distribution depots or directly by road, however, the imports by the government is moved by rail. Import figures of food grains via Chittagong and Mongla Port for the last 7 years are shown in Table 6.13.

Table 6.13: Food Grain Import at Chittagong and Mongla Ports

('000 MT)

Port	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Chittagong	1179	1757	1966	2053	3068	3338	4717
Mongla	75	35	20	32	66	18	504
Total	1254	1792	1986	2085	3134	3356	5221
Yearly Increase	-	13%	11%	5%	50%	7%	55%
Carried by BR		693	525	925	513	441	389
Rail Share		38%	26%	44%	16%	13%	7.5%

Source: Year Book 2011, Bangladesh Bureau of Statistics (BBS)

The compound growth rate of food grain imports at the two ports during the last 7 years (2004-05 to 2010-11) is about 21%.

6.4.3.2 Fertilizer - Bangladesh Railway

The overall requirement for fertilizer in Bangladesh is 2.6 million tons per year. Most of the fertilizer is used in the north-west of the country that can be easily accessed from Mongla Port through the proposed rail link. It is observed that state-owned Bangladesh Chemical Industries Corporation (BCIC) has 6 plants, and produces 1.8 million tons and the privately-owned Karnafuli Fertiliser Company (KAFCO) can supply 0.3 million

tons from its export production. Import requirements are therefore currently 0.5 million tons, which mainly comes in through Chittagong Port and smaller quantity through Mongla Port. All imports are bagged and arrive in 10,000 – 15,000 ton parcels. All BCIC and KAFCO production is distributed by IWT or locally by road.

Demand for fertilizer is currently growing at 2% per year. However the BCIC plants are old, under-utilised, and their production is gradually reducing. This according to industry sources may lead to higher imports. Import figures of fertilizer through Chittagong and Mongla ports for the last 7 years are set out in Table 6.14. The compound annual growth rate of fertiliser imports at the two ports during the last 7 years (2004-05 to 2010-11) is about 12%.

Table 6.14: Fertilizer Import at Chittagong and Mongla Ports

('000 MT)

Port	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Chittagong	1318	1235	1246	1168	946	1604	1894
Mongla	-	-	58	190	338	449	1001
Total	1318	1235	1304	1358	1284	2053	2895
Yearly Increase		-6%	6%	4%	-5%	60%	41%
Carried by BR		240	158	179	228	220	205
Rail Share		19%	12%	13%	18%	11%	7%

6.4.3.3 Container Traffic – Bangladesh Railways

Container traffic into and out of Bangladesh is being handled at Chittagong and Mongla port. In case of container traffic, imports exceed exports. Imports are mostly (about 75%) in 20' (feet) containers and surplus 20' containers are shipped out empty. Conversely exports consist largely of ready-made garments (RMG) and frozen fish, which require 40' dry and reefer containers, so some empty 40' containers are imported to meet this demand.

At least 75% of all container traffic is destined to or originates from the greater Dhaka region. An Inland Container Depot (ICD) has been constructed on railway land adjacent to Kamlanpur station in the center of Dhaka. The ICD has an annual average capacity of around 90, 000 to 100,000 TEUs (Ton Equivalent Units). Another new ICD is under process of construction at Dhirashram near Dhaka with the same capacity. Volume of container traffic handled at Chittagong and Mongla Port is shown in Table 6.15. The compound annual growth rate of containers at Chittagong and Mongla Port during the last 5years (2006-07 to 2010-11) was about 9.78% and 4.44%, respectively.

Table 6.15: Container Traffic - Chittagong and Mongla Port

Import/Export	2006-07	2007-08	2008-09	2009-10	2010-11
Chittagong Port ('000)					
Import TEUs	455	518	478	613	680
Tons	6,115	7499	8170	9377	10400
Export TEUs*	458	510	550	600	690
Tons	2,798	3144	3227	3563	4095
Total TEUs	913	1028	1028	1213	1370
Tons	8913	10647	11397	12940	14495
Annual Increase		19.41%	7.08%	13.54%	12%
Mongla Port ('000)					
Import TEUs	12.7	10.6	10.4	10.3	13.7
Tons	-	-	-	-	73.4
Export TEUs*	12.6	10.3	10.8	10.4	13.4
Tons	-	-	-	-	138.0
Total TEUs	25.3	20.9	21.2	20.11	27.1
Tons	168.4	145.8	142.4	144.3	211.4
Annual Increase		-13.6%	-2%	1.5%	46%

** including empties*

6.4.3.4 Mineral Oil Traffic - Bangladesh Railway

Bangladesh government stated policy is to substitute oil imports through increased use of natural gas which is widely available in Bangladesh. The government is also seeking to develop coal mining both for domestic consumption and power supply. However, rental power plants continue to be a major source of oil consumption.

In the year 2010-11 Bangladesh imported some 1.4 million tons of crude oil, all of which was refined and distributed from the refineries located in Chittagong Port area. It also imported about 3.5 million tons of refined oil. Year wise import of refined oil and crude oil is shown in Table 6.16.

Table 6.16: Imports of Crude & POL

Year	**Quantity ('000 Ton)**			
	Crude	**Annual Increase**	**POL**	**Annual Increase**
2005-06	1253	-	2381	-
2006-07	1211	-3.35%	2536	6.51%
2007-08	1242	2.56%	2228	-12.15%
2008-09	861	-30.68%	2508	12.57%
2009-10	1181	37.17%	2729	8.81%
2010-11	1405	18.97%	3490	27.89%
Yearly Growth Rate (%)	3.7%		6.4%	

Source: Year Book 2011, Bangladesh Railway

In terms of transportation, it has been observed that about 80% of POL is moved by inland waterways, some of which is moved to Khulna for onward transit by rail to the areas served by Western Zone railway network. BR carried 549000, 521000 and 493000 tons of POL in 2008-09, 2009-10 and 2010-11 respectively. The decline in tonnage cam attributed mainly to shortage of locomotive and line capacity constraints. Therefore, in the short term the growth of this traffic on BR network is expected to be negligible or remain static.

6.5 TRAFFIC ESTIMATE & FORECAST FOR PROJECT RAIL LINE

The objective of the forecast is to estimate the demand for passenger and freight traffic by rail on the proposed new railway line after completion of the project. The exercise on traffic estimation includes present traffic volumes and traffic forecasts for passengers and cargos to be carried by rail in future, taking into account the current and future development of trade, future change in the overall transport network and development of facilities by BR. Demand for railway traffic was estimated taking into consideration the project area in particular and the whole system of Bangladesh Railway in general.

The project is for construction of new rail line and therefore at present there is no traffic that can be projected for the future years. However, with the introduction of rail services in the project area it expected that the traffic from the existing modes – Road and IWT – will divert to the project railway and also some additional traffic by way of induced traffic (the traffic that would realize mainly due to the operation of the proposed rail services).

The traffic estimation for the new rail line has been made on following accounts.

- Diversion of traffic presently being carried by IWT and Roads
- Diversion of traffic for Nepal and Bhutan from Kolkata / Haldia ports
- Diversion of traffic from Chittagong Port
- Coal traffic linked to the proposed Thermal Power Plant at Rampal.
- Induced traffic due to availability of better transport facility (in this case the proposed rail link) in the project area

6.5.1 Passenger Traffic Estimates and Forecasts for the Project

Present passenger traffic from Mongla towards Khulna direction is only by road transport. To ascertain present volume of passenger, Traffic Survey was conducted on Khulna –Mongla highway which has been discussed in detail earlier in this chapter. The study was also supported by secondary data collected from Rupsha Bridge Toll Plaza, Mongla Bus Stand, BIWTA, BIWTC, BRTA, BRTC, KDA etc.

While from the traffic survey and other sources of data discussed above the traffic

volumes were estimated, from O-D survey the origin and destination of the vehicles were ascertained. This helped the Consultant to estimate the potential traffic (out of the total road traffic) that can patronize the proposed rail line, and thus, in other words, divert to the proposed rail line from road transport. From the passenger traffic survey it was revealed that most of the people traveling by bus are willing to avail railway after the project.

As per O-D survey daily average number of passengers carried by bus from Mongla to different parts of the country and vice versa, is about 11200 and the origin/ destination points are Khulna, Dhaka and Roadside (i.e., different origins/ destinations falling within the Khulna to Mongla section). The details of passenger traffic estimates for base year 2012-13, for the proposed rail line, are set out in Table 6.17.

Table 6.17: Project Rail – Passenger Traffic Estimates (Base Year: 2012-13)

(in 000)

Road Section	Average Daily Passenger	Diversion to Rail	Annual Rail Traffic
Western Alignment & Central			
Mongla - Khulna	6800	30%	744.6
Mongla - Dhaka	2200	40%	321.2
Mongla - Roadside	2200	40%	321.2
Total	11200		1387.0
Eastern Alignment			
Mongla - Khulna	6800	10%	248.2
Mongla - Dhaka	2200	40%	321.2
Mongla - Roadside	2200	40%	321.2
Total	11200		890.60

The base year traffic (year 2012-13) given in the above table was projected for a time horizon of 30 years from the expected start year (2016-17) of the rail operations. Based on the traffic studies, the growth in passenger traffic has been projected by considering the growth rates presented in Table 6.18 and the passenger traffic forecasts for the period 2016-17 to 2040-41, for the three routes: Mongla-Khulna, Mongla-Dhaka and Mongla-Roadside are set out in Table 6.19. The average rail distance from Mongla Port to Khulna, Dhaka and Road Side has been taken as 65 Km, 241 Km and 40 Km respectively.

Table 6.18: Growth Rates for Passenger Traffic

Period	Growth Rate
2012-13 to 2016-17	6%
2017-18 to 2019-20	8%
2020-21 to 2024-25	6%
2025-26 to 2029-30	5%
2029-30 to 2040-41	4%

Table 6.19: Passenger Traffic Forecasts for Project Rail Line

(Lac Passengers)

Year	Mongla - Khulna		Mongla - Dhaka	Mongla - Roadside	Total
Western & Central Alignment					
2016-17	9.40		4.06	4.06	17.51
2019-20	11.84		5.11	5.11	22.06
2024-25	15.85		6.84	6.84	29.52
2029-30	20.23		8.72	8.72	37.67
2035-36	25.59		11.04	11.04	47.67
Eastern Alignment					
2016-17	3.13		4.06	4.06	11.24
2019-20	3.95		5.11	5.11	14.16
2024-25	5.28		6.84	6.84	18.95
2029-30	6.74		8.72	8.72	24.19
2035-36	8.53		11.04	11.04	30.61

6.5.2 Freight Traffic Estimates and Forecasts for the Project

Freight traffic estimation and forecasts have been made for the potential traffic form the point of view of their serviceability by railway in general and their availability in the project area in particular. The freight traffic considered is discussed in detail in the subsequent sections. The diversion of these traffic to the proposed rail line is based on the assumption that for the project the supply of rolling stock by BR would not be a constraint and the handling capacity at Mongla Port will be adequately enhanced to cater to the increased traffic.

6.5.2.1 Food Grains - Project Railway

Food grains is imported at Mongla Port and carried by IWT and by road transport. The food grain imports at Mongla Port during the period 2007-08 to 2011-12 are presented in Table 6.20.

Table 6.20: Mongla Port - Food Grain Imports, Modal Share and Destinations

Commodity	Import Quantity(MT)					Modal Share (MT) 2011-12	
	2007-08	2008-09	2009-10	2010-11	2011-12	IWT	Road
Wheat	8595	52422	168657	146884	186160	186160	
Rice	23367	13655	7783	356863	100889	50000	50889
Total	31962	66077	176440	503747	287049	236180	50889
Modal Share (%)						82%	18%

It may be observed that the imports of food grains increased steadily up to 2010-11, and then there was a fall in 2011-12. However, import of wheat increased while import of rice came down to almost 35%. This is due to high production of rice in Bangladesh almost achieving self-sufficiency. However, considering population growth and all other factors the food grain scenario is expected to vary in successive years. Based on the figures given in the above table, the annual compound growth rate of food grains imports works out to 64%, which cannot be considered as sustainable and for long term forecast a growth rate of 6% upto year 2019-20 and thereafter 5% has been assumed.

It is seen from the above table that 82% of the imported food grain at Mongla Port was carried by IWT and 18% by road. At the national level the rail modal share in transportation of imported food grain in 2005-06 and 2007-08 was 38% and 44% respectively. However it came down to 7.55% in 2010-11 due to constraint in supply wagon as per demand. Thus, for the purpose of this study a share of 40% for project rail line has been considered till the year 2019-20 and after that the same is taken as 60% on the consideration that with handling facilities being created at Mongla Port and the share of railway will increase.

6.5.2.2 Fertilizer - Project Railway

The imports of fertilizers at Mongla port in bulk and non-bulk is given in Table 6.21.

Table 6.21: Fertilizer import particulars via Mongla Port

Fertilizer	Import Quantity(MT)				
	2007-08	2008-09	2009-10	2010-11	2011-12
Bulk	-	76383	122558	324479	488340
Break -bulk	190499	262241	326785	676660	529114
Total	190499	338624	449343	1001139	1017454
Present Modal Share - IWT (85%) and Road (15%)					

It is observed that the import of fertilisers at the port has been increasing rapidly almost at 41% annual growth rate. However, considering the present trend of agricultural development and local production of fertiliser, it is assumed that the annual growth of fertilisers to be 6%. Further the growth rate is expected to moderate to 5% after 2019-20.

At the national level, rail modal share in transportation of imported fertilizer in 2008-09 was about 18%. However it came down to 7% in 2010-11 due to constraint in supply wagons. Thus in the present context it is assumed that initially (till 2019-20) the share of railways would be 20%, and thereafter increasing to 30%.

6.5.2.3 Container Traffic - Project Railway

At present Mongla Port handles less than 2% of containers handled by Chittagong Port, therefore there is considerable scope for increase in container from linked to the port in case railway facility is created and other constrain relating to the BR system is addressed. All cargo imported by containers are de-stuffed at jetty and sent to destinations mainly by road. Even after Mongla Port is connected with railway, containers cannot be moved from Mongla Port to Dhaka until Padma Bridge is constructed with railway link, however, for the present analysis it is assumed that Padma Bridge will be commissioned by the year 2016-17. The container traffic at Mongla Port is set out in Table 6.22.

Table 6.22: Container Traffic at Mongla Port

(in 000)

Import/Export	2006-07	2007-08	2008-09	2009-10	2010-11
Import TEUs	12.7	10.6	10.4	10.3	13.7
Tons	-	-	-	-	73.4
Export TEUs*	12.6	10.3	10.8	10.4	13.4
Tons	-	-	-	-	138.0
Total TEUs	25.3	20.9	21.2	20.11	27.1
Tons	168.4	145.8	142.4	144.3	211.4

The annual compound growth rate of container traffic has been observed at 4.44% during the period 2006-07 to 2010-11. Assuming that by the year 2016-17 (opening year of project rail link), Padma Bridge is constructed, the container traffic at the port will to grow at (5%), and after it the growth rate is expected to increase to 8% in initial years (upto 2019-20) and reduce to 6% by 2024-25 and thereafter continue to grow at5% till 2035-36.

The modal share of rail in the container traffic is expected to be 40% in the year 2016-17, increasing to 50% by 2019-20 and after that stabilizing at 60%.

After Mongla-Dhaka rail connection for freight traffic, a considerable portion of

imported container traffic is also likely to be diverted to Mongla Port from Chittagong Port which has not been considered in import growth assumption. Diversion of imported container traffic from Chittagong to Mongla port has been considered separately and discussed later.

6.5.2.4 Clinker - Project Railway

Other traffic imported via Mongla Port is Clinker, General Cargo, Fly ash, Gypsum, Salt, Slag, Machinery and Motor Vehicles. Among these, Clinker considered as bulk commodity, can be carried by railway, the others being imported in small quantities and served by road transport. In 2011-12, import of clinker was 887414 MT. It is assumed that the imports of clinker to grow at about 6% upto 2019-20 and at 5% thereafter, and the share of railway would be 25% till 2019-20 and 30% thereafter.

6.5.2.5 Export Traffic - Project Railway

From Mongla Port Jute, Jute Goods, Break-Bulk Goods, Container, Frozen Cargo, Clay Tiles, Betel Nut, Bone Grist etc. are the main export commodities. Of these, the container traffic has already been included in the previous section, the other prospective commodities, viz., Jute, Jute Goods and Break-Bulk goods have been considered as rail traffic. The estimates for this traffic (Table 6.23) and the likely modal share are discussed in the following section.

Table 6.23: Jute & Jute Goods & Break-bulk Goods

Commodity	Export Quantity (MT)					Modal Share (MT) - 2011-12	
	2007-08	2008-09	2009-10	2010-11	2011-12	IWT	Road
Jute & Jute Goods	154247	161079	133241	148883	149782	132782	139759
Break-Bulk Goods	50887	59056	71060	150789	128023	7042	5761

On the basis of the export figures given in the above table it can be observed that the quantum of “jute and jute goods” exports have been marginally varying over the years with a negative growth rate of 1.4%. For the purpose of the present study the growth rate has been assumed at 2%. It is further observed that about 89% of the commodity moves by IWT. Therefore the modal share for the project railway is considered 20% in the year 2016-17, increasing to 30% by 2019-20 and after that stabilizing at 30%.

In case of break-bulk goods, the annual growth in exports from the port has been observed to be 27.86% during the period 2007-08 to 2011-12. In 2011-12, 10% of break-bulk goods moved to the port for export of which 5.5% by IWT and 4% by road.

It is assumed that the exports of break-bulk goods will grow at 7% till 2019-20 and thereafter the rate will be 6%. The modal share for railways is considered as 20%.

6.5.2.6 Petroleum Oil & Liquefied Petroleum Gas (LPG) Traffic - Project Railway

Presently no petroleum oil is being imported through Mongla Port either in crude or refined form. There is no refinery or oil storage at Mongla. Thus there is no possibility of importing crude oil till refinery is constructed at Mongla. On enquiry with Bangladesh Petroleum Corporation (BPC) it was stated that petroleum oil reservoir of capacity 1 lac ton is under process of construction for storage of imported refined petroleum and will be operated by 3 oil companies, viz., Padma, Megna and Jamuna. Another storage for LPG of capacity also 1 lac ton is being constructed under MOI (Mongla Oil Installation) project. Construction of both the installations is expected to be completed within 3 years from now. So, BR will have the opportunity to capture POL and LPG traffic from Mongla Port after completion of the Khulna-Mongla Rail Line Project.

The petroleum oil & LPG sales data for Bangladesh during the period 2001-02 to 2011-12 is presented in Table 6.24. The yearly compound growth in sales of petroleum oil & LPG was observed at 3.28% and 5.02% respectively.

Table 6.24: Petroleum Oil & LPG Sales

(Ton)

Year	Petroleum Oil	LPG
2001-02	3209593	20167
2002-03	3309261	22275
2003-04	3550697	23144
2004-05	3680984	20513
2005-06	3672602	22298
2006-07	3488057	16770
2007-08	3548375	14802
2008-09	3280605	10575
2009-10	3664425	16566
2010-11	4784024	21294
2011-12	5091858	20729

Source: Bangladesh Petroleum Corporation Website

As per the records on division-wise sales of petroleum products, Dhaka, Khulna and Rajshahi divisions, close to Mongla Port, account for about 70% of the total sales. Considering the location of these divisions, the movement by rail to Khulna and Rajshahi & Rangpur divisions and about 40% of Dhaka Division, can be economical

(distance wise) from Mongla Port vis-à-vis Chittagong Port. On this account the sales of the share works out to about 40% of the total share. Thus in the event of the storage capacity of 1 lakh tons each for petroleum oil & LPG being created at Mongla Port, the daily sales requirements of about 7,0000 tons (based on sales figures for 2011-12) for these divisions (40% for Dhaka Division) can be met by rail movement.

In terms of modal share, except for Khulna City, the distance from Mongla Port area to the divisions would be sufficiently long for movement of petroleum oil and LPG, and therefore railway operations will have edge over road transport. Also, beyond Noapara, IWT operations is not expected due to limited available water stretch as well as it would involve multiple handling/ transhipment, making the transportation cost by IWT costlier. The estimated quantities for petroleum oil and LPG (based on 2011-12 figures of 5091858 ton for Petroleum Oil and 20729 ton for LPG) and the railway share is shown in Table 6.25.

Table 6.25: Petroleum Oil & LPG Traffic (2011-12 base)

Division	Potential % Diversion	Petroleum Oil (MT)	LPG (MT)	Rail Share (%)
Dhaka	15%	773962	3151	60%
Rajshahi & Rangpur	7.5%	384690	1566	80%
Khulna	17%	865616	3524	50%

In terms of yearly growth in imports of petroleum oil it has been observed to be at 6.4% at Chittagong Port (the only port of import for petroleum oil). Thus, for the present analysis, the growth rate for imports has been kept around the figure as has been observed in the past for Chittagong Port. On this basis, the growth rate has been assumed at 5% till 2019-20 and thereafter, it is kept at 4%.

It is assumed that by the year 2016-17 (first year of operation), the petroleum oil and LPG storage capacity will be completed at Mongla Port area and the traffic related to it shall be available for transportation.

6.5.2.7 Coal Traffic - Project Railway

In the project area at Rampal (near Mongla Port) a 1320 mega-watt (MW) thermal power plant is being planned, and it is likely that coal for the power plant can move through the project rail line. In this regard the consultant had discussions with Mining Division officials of Petrobangla, and the summary of the same is as follows.

- Bangladesh has a reserve of 3 billion tons of coal of which 10% is mineable.
- Bara Pukuria coal mine has the capacity to extract 1 million ton per year and is

being operated at full capacity. Of this quantity, 0.6 million ton is being supplied to the local 125x2 MW thermal power plant and the rest to local brick fields, steel mills and tea gardens. Another thermal power plant of 125x2 MW capacities is under construction, coal for which will be taken from this mine. The coal from Bara Pukuria is not expected to move on project rail line.

- Extraction of coal from Fulbari coal mine has not yet been started. It has a capacity of 15 million tons per year. As per the agreement with Asia Energy, 80% coal is planned to be exported from Mongla Port and 20% will be locally consumed and method of extraction will be open cast mining. Based on the discussions it is expected that the coal movement from Fulbari to Mongla Port can be around 0.50 million tons in the initial period (2016-17 to 2019-20), thereafter 2.0 million ton upto 2024-25 and 3.0 million tons till the project analysis period.
- The proposed 1320 MW thermal power plant at Rampal, planned for commissioning by 2016, will require in total about 2.90 million ton (considering the coal consumption norm of 6.674 ton per mega-watt of electricity production and 330 operating days) coal annually in phased manner, either through imports or from domestic sources. Since the coal from Fulbari is expected in near future, it can meet the requirements of the thermal plant. It is assumed that 0.725 million ton of coal will be moved by the railway to the plant by 2016-17, increasing to 1.45 million ton by 2019-20, 2.175 million ton by 2022-23 and thereafter stabilizing at 2.9 million tons after 2024-25.

6.5.2.8 Diversion of Container Traffic from Chittagong Port - Project Railway

The handling cost at Chittagong Port is high and operational issues such as causing delays to vessels, congestion, etc. make it less attractive. By linking Mongla Port with the BR rail network it is expected that movement of container traffic up to Dhaka and other ICDs to be developed in future in Dhaka area (after construction of Padma Bridge), or even to other destinations will be economical as compared to the movement from Chittagong Port. As soon as Dhaka will be connected with Mongla Port by rail line fit for freight traffic, the container carrying ships at present calling at Chittagong Port are likely to touch Mongla Port for quick discharge and lesser turn-around time.

In 2010-11 the imports container traffic was 10.4 million tons and that of exports was 4.09 million ton. During the traffic study the possibility of diversion of container traffic from Chittagong Port to Mongla was discussed and it was understood that with the linking of Mongla Port by railway, some of the container traffic can divert to Mongla port. At present the container handled at Mongla Port is less than 2% of that being handled at Chittagong Port. Therefore the diversion of container traffic to Mongla Port seems to be possible on account of operational benefits as the distance to Dhaka from Mongla Port vis-à-vis Chittagong Port is shorter.

It is assumed that a conservative volume of 5% of the container handled at Chittagong Port can be get diverted in the event of the port being connected by railway. The diversion percentage is assumed to increase to 6% by 2019-20. It is further assumed that this share of container traffic to grow at 5% to 6% per annum in future.

6.5.2.9 Traffic Diversion from Industries in Mongla Port Area - Project Railway

There are 5 cement factories along the side of Khulna –Mongla Highway with annual production capacity ranging from 1Lac to 10 Lacs MT, and having a total approximate production capacity of 3.2 million ton per year. Presently, in absence of railway, the entire production is being carried by road to different parts of the country. After consultation with the concerned factory officials and other stakeholders it was gathered that about 0.40 million tons of cement produced in these factories can be carried by railway to different stations in North Bengal, Khulna Division and Faridpur district.

Besides cement factories, there are as many as 15 different industries relating to LPG, Petroleum Product, Edible Oil and Gas Cylinder with approximate annual production capacity of 1.8 million tons. About 0.20 million tons of this traffic can likely be carried annually by railway from Mongla area to an average distance of 250 km to different stations in North Bengal, Khulna Division, Faridpur district and Barisal division

Thus the total traffic linked to local industry is expected to be about 0.60 million tons (year 2012-13 basis). The annual growth of local industry related traffic is expected to be at 6% till 2016-17, there after it is considered at 5% beyond 2019-20.

6.5.2.10 Diversion of Nepal and Bhutan Traffic - Project Railway

At present, import/export traffic for Nepal and Bhutan is being carried through Kolkata Port which is already over-burdened and congested. If Transit Protocol/Agreement (through Bangladesh) is executed and Mongla Port is connected with Railway, there is ample opportunity to carry this traffic by BR from Mongla Port to Indian stations at borders with Nepal and Bhutan. Imported Urea (fertilizer) is being carried from Noapara station to Nepal with special permission from India time to time through Rohanpur-Singabad. For example, in recent past, the transportation of 18000 MT out of contract amount 25000 MT is already completed by Desh Trading Company and another consignment of 25000 MT is awaiting execution. After discussion with Mongla Port Authority Officials, Business Community of Noapara, concerned Railway Officials and stakeholders, it was assessed that annual 0.80 mil. MT of Nepal Traffic can be carried via Mongla Port in 2016-17 with an annual growth of about 6%. This traffic to be carried by railway is expected to be about 75% via Rohanpur-Singabad and 25% via Birol-Radikapur. It is expected that conversion of Parbatipur-Birol section into Broad Gauge will be completed by 2016-17.

Similarly, the volume of traffic for Bhutan would be approximately 0.20 million ton in 2016-17 with a future annual growth of 6%. This traffic may go to Bhutan via Burimari with transhipment at Santahar or Parbatipur from BG to MG.

6.5.2.11 Induced Traffic - Project Railway

Induced traffic can be defined as 'additional' traffic that may accrue to the project rail link as a result of addition to the transport capacity in the project area and choice to the users. It takes some time (after completion of the works) for the induced traffic to accrue and it lasts for some specific time period, till the time the users find it attractive to travel more on account of perceived savings in travel cost/ time.

The estimation and forecast of induced traffic is a difficult exercise. While consulting with stakeholders, the consultants came to know that quite a good number of industries would be willing to take advantage of the rail link, and are likely to be established units by the side of Khulna- Mongla Highway (the proposed rail line will run parallel to the Highway in the stretch starting from Katakhali to Mongla) after Mongla Port is connected with railway.

In case of passenger traffic, the travel frequency is expected to increase, in particular between Mongla town and Khulna City due the availability of additional and safe mode of transport by way of the proposed rail link.

The induced traffic estimates for passenger and freight traffic is assumed to be 10% of the respective traffic estimates and would accrue after one year (i.e by 2017-18) of the start of train operations (2016-17). It will grow at about 5% for next 3 years and then stabilize.

6.5.3 Summary of Project Railway Traffic

The traffic forecasts for the project rail line is summarised in Table 6.26.

Table 6.26: Summary of Traffic Forecasts – Project Railway

(in 000)

Traffic Direction	Commodity	2016-17	2019-20	2024-25	2029-30	2035-36
Imports/ Inward	Food Grain	154	183	350	447	599
	Fertilisers	272	324	621	792	1062
	Container -Mongla	60	95	153	195	261
	Container - Chittagong Port	737	853	1371	1834	2602
	Petroleum Oil	1465	1695	2063	2510	3176
	LPG	6	7	9	11	15
	Clinker	280	334	511	652	874
	Nepal Cargo	800	953	1275	1706	2420
	Bhutan Cargo	200	238	319	427	605
	Mongla Industrial Area	757	902	1151	1470	1969
	Total	4732	5585	7822	10044	13583
Exports/ Outwards	Jute & Jute Goods	33	53	58	64	72
	Break-bulk -Exports	34	41	55	74	104
	Container -Mongla	60	95	153	195	261
	Container - Chittagong Port	280	324	520	696	987
	Coal	1225	1950	4175	5900	5900
	Total	1632	2463	4961	6928	7325
	Grand Total	6363	8048	12783	16972	20908

6.6 TRAIN OPERATION & LINE CAPACITY - PROJECT RAILWAY

6.6.1 Passenger trains - Project Railway

6.6.1.1 Inter City (IC) Trains from /and to Mongla - Project Railway

It is observed that an intercity train carry about 900 passengers. Though presently 2 pairs of intercity trains run between Khulna-Dhaka, they are unable to fulfil the present demand. There exists a hidden demand for Dhaka bound passengers from Khulna, Noapara, Jessore and other road side stations. Usually, all the seats of an IC train are not allotted from the originating station. Depending on demand, about 30% to 50% seats are allotted from the originating station and the rest from other road side stations. As such, Dhaka bound IC train from Mongla may pick up 450 passengers from Mongla and rest from Phultala, Noapara, Jessore and other stoppages. Based on the passenger traffic forecast for the proposed rail line, it is estimated that 2 pairs of IC trains can run between Mongla and Dhaka with almost full capacity. However, initially one pair of IC train may be introduced between Mongla and Dhaka. Another pair may be introduced later on observing the performance and demand situation.

Presently 2 pairs of IC trains run between Khulna-Rajshahi with almost full occupancy. A portion of the passengers coming from Mongla to Khulna presently by road go to Rajshshi or stations en-route Rajshahi. Keeping in view the growth of passenger traffic, 1 pair of IC train between Mongla and Rajshahi may be introduced within 5 years of operation after completion of the project.

6.6.1.2 Passenger /Commuter Trains - Project Railway

It is estimated that introduction of 1 pair of passenger train with parcel carrying facility between Mongla and Parbatipur may be possible in the second year of operation after completion of the project.

To fulfil the demand of 1000 Khulna bound and 450 roadside passengers, 6 pairs of Commuter Trains each having an average capacity of 500 may run between Khulna and Mongla daily. It is estimated that 3 pairs of commuter train between Khulna-Mongla can be operated within 5 years of operation.

6.6.2 Freight Trains - Project Railway

The estimated freight traffic that is likely to patronize the project railway has been summarized above in section Table 6.26. . The commodity wise and origin-destination wise traffic for the first year of operation(2016-17) is presented in Table 6.27.

Table 6.27: Commodity-wise and by Origin-Destination – Traffic (2016-17)

Commodity	Origin	Destination	Quantity (000 Ton)	Rail Distance (Km)	Ton-Km (000)
A - Traffic Movement: From Mongla towards North Direction (Up-traffic)					
Food grain	Mongla Port	Noapara	15	70	1078
	Mongla Port	Jessore	8	97	743
	Mongla Port	Chuadanga	15	179	2754
	Mongla Port	Ishwardi	15	246	3772
	Mongla Port	Santahar	23	324	7466
	Mongla Port	Parbatipur	15	420	6452
	Mongla Port	Saidpur	15	435	6684
	Mongla Port	Domar	8	471	3621
	Mongla Port	Faridpur	15	260	3995
	Mongla Port	Modhukhali	8	245	1882
	Mongla Port	Bhanga-	15	161	2474
		Total	154		40921

Fertilizer	Mongla Port	Noapara	27	70	1910
	Mongla Port	Jessore	14	97	1317
	Mongla Port	Chuadanga	27	179	4880
	Mongla Port	Ishwardi	27	246	6685
	Mongla Port	Rajshahi	27	304	8276
	Mongla Port	Santahar	27	324	8822
	Mongla Port	Parbatipur	27	420	11435
	Mongla Port	Saidpur	14	435	5923
	Mongla Port	Faridpur	27	260	7080
	Mongla Port	Modhukhali	27	245	6672
	Mongla Port	Bhanga	27	161	4384
		Total	272		67383
Container Imports	Mongla Port	Dhaka	60	241	14556
Container (Diverted - CP)	Mongla Port	Dhaka	737	241	177674
		Total	737		177674
Petroleum Oil	Mongla Port Area	Dhaka	564	241	136033
	Mongla Port Area	Rajshahi	374	304	113719
	Mongla Port Area	Khulna	526	65	34195
		Total	1465		283947
LPG	Mongla Port Area	Dhaka	2	241	554
	Mongla Port Area	Rajshahi	2	304	463
	Mongla Port Area	Khulna	2	65	139
		Total	6		1156
Clinker	Mongla Port	Noapara	93	70	6548
	Mongla Port	Singia	93	41	3828
	Mongla Port	Bhanga	93	161	15031
		Total	280		25407
Traffic for Nepal	Mongla Port	Rohanpur	560	367	205520
	Mongla Port	Birol	240	460	110400
		Total	800		315920
Traffic for Bhutan	Mongla Port	Burimari	200	575.2	115040
		Total	200		115040
Industrial Traffic	Mongla Port Area	Bogra	189	364	68931
	Mongla Port Area	Khulna	189	68	12877
	Mongla Port Area	Jessore	189	97	18369
	Mongla Port Area	Faridpur	189	260	49237
		Total	757		149414
Total - A (Up-traffic)			**4732**		**1191419**

B -Traffic Movement: Towards Mongla From North Direction (Down-traffic)					
Jute & Jute Product	Navaran	Mongla Port	4	81	325
	Jessore	Mongla Port	4	97	386
	Chuadanga	Mongla Port	3	179	613
	Kustia	Mongla Port	4	182	726
	Rajbari	Mongla Port	4	238	951
	Faridpur	Mongla Port	4	260	1038
	Khulna	Mongla Port	4	65	236
	Daulatpur	Mongla Port	4	60	218
	Noapara	Mongla Port	1	70	85
	Sirajgonj	Mongla Port	1	284	344
		Total	33		4922
Break-Bulk Goods	Noapara	Mongla Port	8	70	589
	Jessore	Mongla Port	3	97	270
	Chuadanga	Mongla Port	3	179	501
	Kustia	Mongla Port	6	182	1018
	Rajbari	Mongla Port	8	238	1999
	Faridpur	Mongla Port	6	260	1454
		Total	34		5831
Container	Dhaka	Mongla Port	60	241	14556
Container (Diverted - CP)	Dhaka	Mongla Port	280	241	67392
		Total	280		67392
Coal Traffic	Fulbari		500	395	197500
	Rampal		725	402	291450
	Total		1225		488950
Total - B (Down-traffic)			1632		581651
Total - A + B			6363		1773070

A further analysis of the above commodity movement between the same origin-destination points as well as the type of movement (container, tank wagons, normal wagons, etc.), the number of goods trains for the year 2016-17 were estimated. Likewise, based on the number of passengers for the year 2016-17 the number of passenger trains were estimated. The estimated goods and passenger trains were projected for future years by considering the traffic forecasts mentioned earlier in this chapter, for goods and passengers. The norms considered for estimating goods and passenger trains are presented in Table 6.28.

Table 6.28 : Norms Adopted for Estimating Number of Trains

Goods Trains	Container	Wagon
No. of Wagons/ Container per train	60	60
Ton Carried	8	24
Passenger Trains	IC Trains	Commuter Trains
Number of Passengers	900	500

The number of goods and passenger trains projections are set out in Table 6.29.

Table 6.29: Project Goods & Passenger Trains Each Way

Year	Pass	Freight	Total
2016-17	3.81	12.20	16.01
2019-20	4.80	14.43	19.23
2020-21	5.39	17.01	22.41
2021-22	5.72	17.92	23.64
2022-23	6.06	18.88	24.94
20 23-24	6.42	19.90	26.32
2024-25	6.74	20.97	27.39
2029-30	8.20	27.20	27.20

6.6.3 Line Capacity

Sectional (Line) Capacity of a single line section may be calculated by using the American Modification of Scott's formula which is as follows:

C= [1440/ (T1+T2+2t)] x Y, where C is the Sectional Capacity (pair of trains);

1440-Number of minutes in a day;

T1 +T2 are the interval between two successive opposing slowest trains in the most critical block section including acceleration and deceleration;

2t is the block operating time for two opposing trains (8 min); and

Y is the efficiency factor which is usually taken as 0.80.

Jessore – Khulna Section

Line capacity should be calculated keeping in view the critical section of the entire route. In Khulna-Parbatipur route, line capacity of Khulna-Jessore section is the least. After completion of the project, most of the new trains will run over this section. Let us calculate the line capacity of this section and see how many new trains it can accommodate without increasing the present line capacity.

Daulatpur-Phultola is the longest block section and the distance is 9.69 Km. As take off point starts at Phulatola, it should be considered a block section between two stations in Phultala Jessore section. Dhaka bound trains are likely to run via Singia and Bhanga in future. So, we are to choose the critical block section between Phultola and Singia. As such Bezerdanga-Noapara block section having a distance of 8.20 Km is to be considered to find out the line capacity of this section.

Goods trains are the slowest trains. In Working Time Table-48 of BR, booked speed of Through Goods Trains (KP/PK) has been shown 45 km/hr. which may be considered to calculate Line Capacity.

T1=60/45x8.20+2=13 min; Similarly T2=13 min (2mts for acceleration and deceleration)

Sectional Capacity C= [1440/ (13+13+8)] x0.80=34 trains in each direction.

Line capacity shown in WTT-48 is 20 trains in each direction which is less the calculated one. They might have considered non-vacuumed goods trains with much less speed.

Phultola -Mongla Section:

i. East Alignment: The longest block section in East Alignment is 11.4 Km between stations Varasapur and Digraj. T1=60/45x11.4+2=17min. Similarly T2=17min. C=[1440/ (17+17+8)] x0.80=27 trains in each direction.

ii. West Alignment: The longest block section in West Alignment is 14.2 Km between stations Mohhammad Nagar and Katakhali. T1=60/45x14.2+2=21min. Similarly T2=21min. C=[1440/ (21+21+8)] x0.80=23 trains in each direction.

iii. Central Alignment: The longest block section in Central Alignment is 20.1Km between stations Daulatpur and Katakhali. T1=60/45x20.1+2=27min. Similarly T2=27min. C=[1440/ (27+27+8)] x0.80=18 trains in each direction.

The Central Alignment option has not been considered due to high social impact, and thus do not form the part of line capacity analysis.

Considering the line capacity to be 34 trains each way and 11 number of trains moving each way on Jessore – Khulna rail section, the net available capacity on the existing rail line will be for about 23 trains each way, same as the minimum capacity of the new alignment being studied. The future scenario (considering the projected number of trains) for line capacity has been set out in Table 6.30.

Table 6.30: Future Line Capacity Scenario on Jessore- Khulna Rail Section

Year	Total Trains Projected	Existing Trains	Section Capacity	Capacity Scenario
2016-17	16.01	11	34	6.99
2019-20	19.23	11	34	3.77
2020-21	22.41	11	34	0.59
2021-22	23.64	11	34	-0.64
2022-23	24.94	11	34	-1.94
20 23-24	26.32	11	34	-3.32
2024-25	27.71	11	34	-4.71
2029-30	35.40	11	34	-12.40

It may be observed from the above table that the line capacity of the Jessore-Khulna rail section will be surpassed in the year 2021-22. The measures for capacity enhancement of the section will have to be initiated in advance, and the capacity of the section can be increased by about 10 to 12 trains each way, that is expected to allow the movement of the projected trains till 2029-30.

CHAPTER 7 DESIGN STANDARDS AND SPECIFICATIONS

7.1 GENERAL

In general, the Bangladesh Railway Specifications and Indian Railway Specifications will be used. When there is a conflict between Bangladesh Railway (BR)/ Indian Railway Standards (IRS)and Indian Standards / Indian Road Congress Specifications, Bangladesh Railway Specifications will govern.International codes and practices may be followed for items not covered in BRS/IRS/IS/IRC Specifications.

7.2 RIGHT OF WAY

It is proposed to have a minimum 30m Right of Way (ROW) for the rail route in general and 50m at Stations for a length of 1km. The proposed ROW at high embankment in bridge approaches will vary from 30m to 80m depending upon the height of embankment.

7.3 TRACK

The track will be designed for single track broad gauge. Parameters to be followed are stated in the articles below.

7.3.1 Speed

The track shall be designed for a maximum speed of 120 kmph for passenger trains and the booked speed of 60 kmph for goods train. If there is any necessity for restrictions of speed due to curvature limitations, regulatory signals need to be provided.

7.3.2 Loading

The track shall be designed for axel load of 25 T and shall conform to BroadGauge 25 ton loading standards.

7.3.3 Geometric Parameters

The geometric parameters shown in Table 7.1 will be used for design of the track.

Table 7.1: Geometric Parameters

Maximum design speed	120 kmph
Maximum degree of curve for main line	2 degree
Maximum degree of curve for siding	7 degree
Maximum cant to be provided	165 mm
Maximum permissible cant excess	100 mm
Maximum permissible cant deficiency	100 mm
Cant gradient	1 in 1000
Ruling gradient In straight sections In curved sections	 1 in 200 1 in 250
Maximum rate of change of cant	55 mm/sec

7.3.4 Track

The track standards shall be as shown in Table 7.2.

Table 7.2: Track Standards

Gauge	Broad Gauge
Rails	90A
Track for main line	LWR track
Track for siding & loop lines	SWR track
Sleepers	PC
Sleeper density for LWR track	1660/km
Sleeper demsity for SWR track	1540/km
Fastening	Elastic Fastening
Ballast cushion	300mm
Points and crossings for passenger lines	1 in 12
Points and crossings for goods and marshalling yard lines	1 in 8.5
Clear standing lengh fouling mark to fouling mark	725m

7.3.5 Codes and Specifications for Track

i. Bangladesh Railway Way& Works Manual

ii. RDSO guidelines for embankment construction for heavy axle loads.

iii. Bangladesh Railways Schedule of Dimensions for BG & MG

iv. Indian Railway Permanent Way Manual

7.4 BRIDGES

7.4.1 General

The bridges will be designed as per relevant standards and specifications. Some of the design parameters are discussed below.

7.4.2 Climatic Conditions

- Maximum Temperature: 42°C
- Minimum Temperature: 10°C
- Terrain Category: Open Terrain with scattered obstruction (Cat 2)
- Seismic Zone: Seismic Acceleration A:0.075 Zone I, In accordance with National Building Code, Bangladesh

7.4.3 Deck Type and Vertical Clearance for Through Girders

For Steel through Girders - Non ballasted open type deck, Live load directly acting on stringers. Minimum vertical clearance above rail level shall be kept not less than 5.87mspecified as per RDSO.

For Steel Composite I-Girder, ballasted deck with conventional concrete sleeper track-Live load transferred through composite RCC Deck Slab.

7.4.4 Navigation Requirement

Navigation Clearance of rivers in Bangladesh is controlled by Bangladesh Inland Water Transport Authority (BIWTA). The required Navigation Clearances of the rivers the Bhairab, the Atai and the Atharobaki were communicated by BIWTA's letter No.18.765.045.00.00.0010.2010/528 dated 15-1-2013 addressed to Engineering-in-Chief/ Project Director of this Project, Bangladesh Railway. Those are stated below

Bhairab Bridge:

- Navigation Clearance required.
- Horizontal : 76.22 m.
- Vertical : 18.29 m from SHWL

Atai Bridge:

- Navigation Clearance required.
- Horizontal : 76.22 m.
- Vertical : 12.19 m from SHWL

Atharobaki Bridge:

- Navigation Clearance required.
- Horizontal : 30.48 m.
- Vertical : 7.62 m from SHWL

Rupsha Bridge:

The following Navigation Clearances will be adopted as per the Navigation Clearances of existing Highway Bridge over Rupsha following BIWTA's requirement.

- Navigation Clearance required.
- Horizontal : 76.22 m.
- Vertical : 18.29 m from SHWL

7.4.5 Loading

The Bridges shall be designed for Axel load of 25 T and shall conform to Broad Gauge 25 Ton loading 2008 as per IRS Bridge Rules.

7.4.6 Design Speed

The Bridge shall be designed for speed of 120 kmph for passenger trains as per IRS Bridge rules.

7.4.7 Design Life

Design life of Bridge shall be considered as 100 years. Fatigue life as provided for in IRS Steel Bridge Code shall be ascertained.

The structural design shall ensure sufficient durability, considering the structural details of which they form part as well as the effects of the environment to which they may be exposed. Bridge components such as bearings and other parts requiring frequent inspection shall be designed such that they are easy forinspection. Provision shall be made to ensure easy access and adequate level of safety during inspection and maintenance operations. Adequate gap between ends of girders shall be maintained to allow for expansion & contraction.

All parts of the structure shall either be accessible for inspection or completely closed.

The design of member sections shall be made in such a way that the required inspection and maintenance of the structure are kept to minimum and the effects of maintenance on the operation of the bridge are low.

For reducing the maintenance, the steel structure will be provided with protective coating by metallising with sprayed aluminium as given in the Appendix VII of IRS -

131 - 2001 followed by the painting as per painting schedule given as per clause no. 39.2.1 of IRS - B1

7.4.8 Bearings

Rocker and roller bearings are envisaged to be provided under the steel through girders. For Steel Semi-through Girder (Br 29) and Steel Plate Girders (Br 1 A) Sliding Bearings shall be provided. For bridges with Composite Girder Elastomeric bearings shall be provided.

7.4.9 Methods of Erection of Steel Through Girders

Cantilever method of erection is envisaged for Steel Through Girders super structure of spans raging from 45m to 105m and girders shall be designed accordingly. Incremental launching method of erection is envisaged for Steel Through Girders of spans less than 45m.These are the general methodologies adopted for these kind of bridges, however detail erection methodology will be made at the time of detail design.

The design of superstructure will be done for service condition and the structure will be checked for the construction conditions.

7.4.10 Codes and Specifications for Bridges

Following is a list of important Codes which are proposed to be used for the design of the bridges

i. Indian Railway Bridge Rules,- Revised – 1964

ii. IRS: Steel Bridge Code adopted 1951

iii. IRS :Welded Bridge Code for Steel Bridges, adopted 1972

iv. Indian Railways of Dimensions for Broad Gauge, 2044

v. Indian Railways Bridge Manual 1998

vi. IRS: Fabrication and Erection of Steel Girder Bridges & LocomotiveTurntables (B1-2001)

vii. IS:1024 – 1999 Use of Welding in Bridges and Structures subject to Dynamic Loading – Code of Practice – Second Revision (Reaffirmed 1998)

viii. IS 1261 – 1959- Seam Welding in Mild Steel (Reaffirmed 1998)

ix. IS 1367 – Technical Supply Conditions for Threaded Steel Fasteners

x. IS:9595:1996 – Metal Are Welding of Carbon and Carbon Manganese Steels – Recommendations (1st Rev)

xi. Is;3502:1994- Steel Chequered Plates – Specifications (2nd Rev)

xii. IS:7205-1974 – Safety Code for Erection of Structural steel work (Fifth

Reprint, July 2001)

xiii. IS 7215 – 1974 – Tolerances for Fabrication of Structures (Reaffirmed 1995, Sixth Reprint July,1997)

xiv. IS; 814- 1991 – Covered Electrodes for Manual Metal Arc Welding (Fifth Revision)

xv. IS: 1323-1982 – Oxy-acetylene Welding for Structural Work in Mild Steel (Second Revision)

xvi. IS: 432 – Mild Steel, Medium Tensile Steel Bars and Hard Drawn Steel (Part I)-1982 Wire for Concrete Reinforcement: Part 1 Mild Steel and Medium tensile Steel Bars (Part II) – 1982 Wire for Concrete Reinforcement: Part II Hard Drawn Steel Wire (Third Revision)

xvii. IRS concrete Bridge Code

xviii. IS: 456 : Plain and reinforced concrete

xix. Indian Railway Standard (IRS) Bridge Substructure and foundations code – code of practice for the design of the Substructure and foundation of Bridges adopted 1936,IRS Sub - Substructure & foundation Code

xx. IS 2911 Pt I Pt IV – Pile foundations

xxi. IRC 6 – Standard Specifications and Codes of Practice for Road Bridges-Section – II – Loads and Stresses – Seismic Provisions of this Standard are to be adopted for the bridge design.

xxii. IS: 875 – Code of Practice for Design loads – Wind loads (Second Revision)

xxiii. IS: 1893- Criteria for Earthquake Design of Structures; (Part 1) 2002 1 General Provision and Buildings (Fifth Revision)

xxiv. SP 6 (10 – Structural Steel Sections – Handbook

xxv. IS: 3757 – 1985 – High Strength Bolts

xxvi. IS:6623 – 1985 - High Strength Nuts

xxvii. IS 1148- 1982 – Specification for Hot Rolled Rivet Bars (up to 40mm dia) for Structural Purposes (Third Revision)

xxviii. IS: 1149 – 1982 High Tensile Steel Rivet Bars for Structural Purposes (Third Revision)

xxix. IS:1929- 1982 – Hot Forged Steel Rivets for Hot Closing (12 to 36mm dia) (Reaffirmed 1996)

xxx. IS 800: 2007 – Code of Practice for General Construction in Steel (Second Revision)

xxxi. IS : 2062 – 2006 – Hot Rolled Low, Medium and High Tensile Structural

Steel (Sixth Revision)

xxxii. IS:7215-1974 – Tolerances for Fabrication of steel Structures (Reaffirmed 1995, Sixth Reprint July , 1997)

7.4.11 Loads

Following loads shall be considered in the design.

i. Self-Weight

ii. Superimposed Dead Loads (SIDL) :

iii. Live Load : BG 25 ton as per IRS Bridge Rules

iv. Live Load : Footpath

v. Coefficient of Dynamic Augment Impact (CDA) on Live Load

vi. Horizontal train Live Load- Tractive Efforts and Braking Force BG 25 ton asper IRS Bridge Rules

vii. Transverse Horizontal Force (Raking Force)

viii. Forces Due To Eccentricity (ballasted deck bridges)

ix. Centrifugal Force (Br No 28)

x. Derailment load

xi. Wind Load

xii. Seismic forces (Zone III of IS 1893,Zone IIIof Bangladesh, Importance Factor1.5 for Bhairab, Atai, Atharobaki and Rupsha and 1.2 for other bridges)

xiii. Hydrodynamic forces based on hydrological studies

xiv. Scour assessment based on hydrological studies.

xv. Earth pressure and LL surcharge on abutments and returns

xvi. Buoyancy Effect (B)

xvii. Barge Impact Force for Bridges over River Bhairab, Atai, Atharobaki and Rupsha

7.5 RAILWAY STATION AND YARDS

Railway stations shall be provided as B-class station. Approximate building area for the station shall be 350 sqm. The various facilities provided at stations shall cover the following:

- Booking Counter
- Porch

- Space for Passengers
- Waiting Lounge
- Waiting Room
- Toilets
- Parcel Booking Office
- SM room
- ASM Room
- Relay & Battery Room
- Store

Platformof size 400mx 9m with overhead shed for a size 30mx9m will also be provided.

There will be two loop lines (one on each side of main line) at each station. Marshalling yard will be provided at Mongla Port with six loop lines (three on each side of the siding line). The Mongla Port loading and unloading yard will have two loop lines (one on each side of the siding line). There will also be sick line with shed and other repairing facilities near marshalling yard for minor repairs of the rolling stock & others.

7.6 LEVEL CROSSINGS

As per Bangladesh Railway, the level crossings are specified into Special, A, B, C and D class based on the volume of traffic. All level crossings, except D class, are manned. The proposed railway line will cross various category of roads. Manned level crossings will be provided at the crossing of Highway (N-7) and Regional roads. Unmanned crossing will be provided at other minor roads.

7.7 SIGNALLING AND TELECOMMUNICATION

It is proposed to have seven new block stations in the Khulna-Mongla section for east and west alignment options. The existing originating station at Phultola also have been taken into consideration and converted to a junction station in planning for Signalling and Telecommunication of the route as a whole.

7.7.1 Signalling

The proposed rail section will be provided with non-interlocked signalling and the block working will be done through Tablet/ Token block instrument. Minimum safety measures will be provided with ‘Hand plunger key locks” at the points, operated manually through tumbler switches. Following Manual and Rules of BR will be used for signalling works.

i. Signalling Manual of Bangladesh Railways.

ii. General & Subsidiary Rules of Bangladesh Railways

7.7.2 Telecommunication

In the line of the Railways existing Telecommunication system, new telecommunication facilities have to be developed along the proposed new track alignment for interconnection of all stations, level crossings and other facilities in the section. The following types of communication facilities will be needed.

i. Block Communication

ii. Train Control Communication

iii. General Purpose Communication

iv. Signalling Protection System at Level Crossings

CHAPTER 8 CONCEPTUAL DESIGNS

8.1 GENERAL

The alternative alignment options the rail route has already been discussed in Chapter-5. The length of the route along east, west and central alignments are 59.6 km, 60.4 km and 49.2 km respectively.Phultola will be the take-off point for eastern and western alignments and Daulatpur for the central alignment. The terminal point will be at Mongla near Port.

On eastern side there are three major bridges which are across the rivers Bhairab, Atai and Atharobaki. On western side, there is one major bridge across river Rupsha. On central side, the alignment will cross the rivers Bhairab and Atharobaki.

8.2 ALIGNMENT

The preliminary alignment design was carried out taking provisions of the geometric requirements. All the horizontal curves on main line will be of 2 degreeor less except one location near Sheromoni due to limited availability of space.

At this stage, the alignment has been drawn in AutoCAD. At detail design stage Civil3D or MX will be used for alignment design. The proposed alignment plan for each alternate route has been prepared and presented in a separate drawing volume.

8.3 EMBANKMENT

The height of embankment will primarily be governed by existing topography of the area, flood levels in the vicinity, requirements of the rail levels at bridge locations, navigational requirements and permissible longitudinal gradients. The embankment formation level shall be minimum 0.45m above the highest flood level so that the rail top will be more than 1m high above highest flood level

Considering to the type of soil encountered, the maximum height of embankment will be restricted to 12m. A side slope of 1V:2H will be maintained. A 2m to 2.5m wide benching/ berm shall be provided for embankment height more than 6m. Side slopes shall be protected by grass turfing.

Ground for embankment fill will be prepared by removing top organic and unsuitable layer including loose deposits and refilled by sand layer with FM not less than 0.5. The refilling shall be done in layers not exceeding 150mm thickness with 97% compaction.

Dredged sand from the river bed Bhairab, Rupsha, Atai, Atharobakiand Pussur rivers may be used for construction of core layer of embankment.Clayey soil from borrow area

oroutside may be used for cover layer, shoulder and slopes for stability of the embankment. All embankment fill material will comply with the Standard Specification. CBR of dredged sand is more than 6% in the region and Plasticity Index is less than 6% and is suitable for embankment fill.Embankment fill material should be of CBR not less than 4%. Embankment shall be prepared in layers not exceeding 150mm with 97% compaction. 600m thick top layer of the embankment fill just below the sand blanket shall be compacted to 98% in four layers each of 150mm thick.

Blanket of 600mm thickness will be provided and designed with dredged sand,coarse sand and stone chips having CBR value greater than 25% and will be compacted to 98% in four layers each layer each of 150mm thick. The Blanket material should generally conform to following specification:

i. It should be coarse, granular and well graded.

ii. Skip graded material is not permitted.

iii. Fines (particles of size less than 75 micron): 3% to 5%

iv. Uniformity Coefficient Cu>4(preferably >7)

v. Coefficient of Curvature Cc should be within 1 & 3.

vi. The material for blanket shall be well-graded sandy gravel or crushed rock within the envelope.

8.4 TRACK

The track shall be as per relevant provisions of the Broad Gauge. Ballasted track with Pre-stress Concrete sleepers on earthen embankment and non-ballasted open track on major bridge locations over Bhairab, Atai, Atharobaki and Rupsha rivers will be provided.

8.5 RAILWAY STATIONS

Railway stations shall be provided with basic facilities as per requirements. Following will be the stations on different alignments.

S.no.	East	West	Central
1	Phultola	Phultola	-
2	Digulia	Aronggata	-
3	Ajogara	Mohammed Nagar	Daulatpur
4	Katakhali	Katakhali	Katakhali
5	Bharoshapur	Bharoshapur	Bharoshapur
6	Digraj	Digraj	Digraj
7	Mongla	Mongla	Mongla

8.6 BRIDGE

Consultants propose to proceed with conceptualization and preliminary design of the project infrastructures on the basis of the site visits, preliminary survey and some highway bridge data which has become available particularly for the Rupsha Bridge and its approach road (Khulna Bypass). The major Bridges on Rupsha, Bhairab,Atai and Atharobaki rivers happen to be the most critical part of the assignment. The Consultants are of the opinion that this will give the requisite head start to the assignment.

As sequel to the site visit, preliminary survey and scrutiny of available data and understanding the requirements of the project the Consultants have been able to arrive at some broad conclusions with reference to conceptualization of the above mentioned four major Bridges and the track alignment along the approaches of the entire alignment.

On eastern alignment option there are three major bridges which are across the rivers Bhairab, Atai and Atharobaki. On western alignment option, there is one major bridge across river Rupsha. On central option, the alignment will cross the rivers Bhairab and Atharobaki. All these rivers are navigational rivers. The basis of the required Navigational Clearances of the above mentioned four rivers was statedin Chapter 7.

The central span has been provided to meet the requirements of navigational horizontal and vertical clearances and stated in Table 8.1 below.

Table 8.1: Navigational Requirement as per BITWA

S.no.	River	Class	Horizontal Clearance	Vertical Clearance
1	Bhairab	A	250’ (76.22m)	60’ (18.29m)
2	Atai	B	250’ (76.22m)	40’ (12.19m)
3	Atharobaki	C	100’ (30.45m)	25’ (7.62m)
4	Rupsha	A	250’ (76.22m)	60’ (18.29m)

Though the length of main bridge will be governed by river width and other hydrological parameters, the approach bridge has to be provided for a considerable length to avoid the high embankments. The maximum embankment height has been restricted to 12m and beyond this height, viaduct spans has been provided. The rail top level will be SHWL + vertical clearance + distance from bottom of girder to top of rail.

8.6.1 Span Arrangement

Bhairab Bridge (East Alignment)

After accommodating width of pile capsand keeping required minimum horizontal clearance of 76.22m, one span of 102.4m at centre and two spans of 47.85m on each side of central span will be provided to have main bridge of length2@47.85+ 1@102.4+

2@47.85 = 293.80m. The bridge length on upside approach will be 90@20.2 = 1818 m and on downside approach will be 130@20.2 = 2626 m.

Atai Bridge (East Alignment)

After accommodating clearance for pile capsand keepingrequired minimum horizontal clearance of 76.22m, one span of 102.4m at centre and one span of 47.85m on each side of central span will be provided to have main bridge of length 1@47.85 + 1@102.4 + 1@47.85 =198.10m. The bridge length on upside approach will be 37@20.2 = 747.4 m and on downside approach will be 56@20.2 = 1131.2 m.

AtharobakiBridge (East Alignment)

After accommodating clearance for pile capsand keepingrequired minimum horizontal clearance of 30.48m, three spans of 47.85 m at centre and one span of 20.2m on each side of central span will be provided to have main bridge of length 1@20.2+ 3@47.85+ 1@20.2= 183.95m. The bridge length on upside approach will be 2@20.2 = 40.4 m and on downside approach will be 2@20.2 = 40.4 m.

Rupsha Bridge (West Alignment)

After accommodating clearance for pile capsand keepingrequired minimum horizontal clearance of 76.22m,one spans of 79.6 m at each end and three span of 102.4m at centre will be provided to have main bridge length of 1@79.6+ 5@102.4 + 1@79.6 = 671.2m..These span lengths will be almost similar to those span lengths of existing highway bridge at Rupsha on Khulna bypass. The bridge length on upside approach will be 110@20.2 = 2222 m and on downside approach will be 110@20.2 = 2222 m.

BhairabBridge (Central Alignment)

After accommodating clearance for pile capsand keepingrequired minimum horizontal clearance of 76.22m,one spans of 79.6 m at each end and three span of 102.4m at centrewill be provided to have main bridge of length 1@79.6+ 3@102.4+ 1@79.6= 466.4m. The bridge length on upside approach will be 195@20.2 = 3939 m and on downside approach will be 117@20.2 = 2363.4 m.

AtharobakiBridge (Central Alignment)

After accommodating clearance for pile caps and keepingrequired minimum horizontal clearance of 30.48m, three spans of 47.85 m at centre and one span of 20.2m on each side of central span will be provided to have main bridge of length 1@20.2+ 3@47.85+ 1@20.2= 183.95m. The bridge length on upside approach will be 2@20.2 = 40.4 m and on downside approach will be 2@20.2 = 40.4 m.

A summary of the levels and span arrangements for the proposed major bridges is presented in Table 8.2.

Table 8.2: Levels and Span arrangements for Major Bridges

S. no.	River	SHWL as per PWD	SHWL as per SOB	Rail top level	River Width	Span Arrangment		
						Main Bridge	Approach Up	Approach Down
East Alignment								
1	Bhairab	3.89	3.43	23.72	210	2*47.85+1*102.4+2*47.85 = 293.8 m	90*20.2 = 1818 m	130*20.2 = 2626 m
2	Atai	3.84	3.38	17.57	190	1*47.85+1*102.4+1*47.85 = 198.1 m	37*20.2 = 747.4 m	56*20.2 = 1131.2 m
3	Atharobaki	3.87	3.41	12.68	145	1*20.2+3*47.85+1*20.2 = 183.95 m	2*20.2 = 40.4 m	2*20.2 = 40.4 m
West Alignment								
1	Rupsha	3.80	3.34	23.63	520	1*79.6+5*102.4+1*79.6 = 671.2 m	110*20.2 = 2222.0 m	110*20.2 = 2222.0 m
Central Alignment								
1	Bhairab	3.81	3.35	23.67	340	1*79.6+3*102.4+1*79.6 = 466.4 m	195*20.2 = 3939.0 m	117*20.2 = 2363.4 m
2	Atharobaki	3.81	3.35	12.68	170	1*20.2+3*47.85+1*20.2 = 183.95 m	2*20.2 = 40.4 m	2*20.2 = 40.4 m

Note : Approach UP is towards Phultola side and Approach Down is towards Mongla side

8.6.2 Super Structure

Provision of pre-stressed concrete deck could have been one of the alternatives. However, with the depth of superstructure of the order of 12 m and the need to maintain the vertical navigational clearances, the rail level on the proposed bridge will get raised by approximately 30 m and will require excessive length of approach bridge to limit the embankment height around 12m. Thus the choice of the type of superstructure gets limited to Steel Through Girders. Thus for spans greater than 30m, Steel Through Girders are proposed. For spans 20 to 30m, composite super structure (steel plate girder with concrete deck) is proposed.

8.6.3 Substructure:

The substructure of the bridge shall be RCC piers which could be wall type or Twin Circular, which will be analysed during detail design.

8.6.4 Foundation

The choice of foundations is between Pile foundations and Well/Caisson foundations. In view of the preliminary studies done and the reference bridge details available in the project area (Rupsha) Consultant propose cast in-situ RCC piles which is considered to be the most suitable type of foundation in this case.

8.7 SIGNALLING AND TELECOMMUNICATION

The proposed rail link will be a branch line section and will take off from the existing Jessore- Khulna railway line at Phultola station for East and West alignment options and at Daulatpur for Central alignment option. Therefore the signalling& telecommunication and block working system of the proposed new link should have the similarity and conformity with the existing working system of the area as well other branch line sections of Bangladesh Railway.

8.7.1 Signalling

The method of train operation of Bangladesh Railway is based on the Absolute Block System working where the entire line is divided alternately into station sections and block sections. Under the system stations are provided with signalling to receive and dispatch of trains where only precedence and crossing can be arranged. The movement of trains between stations uses the Absolute Block working principle and permission for movement from one station to the other is granted through the cooperation of the two stations. No signalling is provided in between the stations i.e. in block section. Most of the branch line sections of Bangladesh Railway operate on the same principle.

The branch line sections of Bangladesh Railway are mostly provided with non-

interlocked signalling and the block workings are done through Tablet /Token block instrument. Minimum safety measures are provided with 'Hand plunger Key locks' at the points, operated manually through tumbler switches. Lower quadrant mechanical semaphore signal operated through lever or winch were in use in the branch line stations. But due to frequent theft and vandalism of mechanical gears of semaphore signal Bangladesh Railway gradually replacing them with two aspect colour light non-interlocked signal.

Jessore – Khulna line has 10 block stations which are provided with requisite signalling, block working and telecommunication facilities for regulating and controlling the movement of trains. Out of the 10 block stations Rupdia, Singia, Chengutia, Noapara, Bezerdanga, Doulatpur and Khulna stations are equipped with standard I Double wire interlocking while Jessore, Phultola and Khulna Jn stations are provided with non-interlocked signal. The Khulna Jn. has colour light non-interlocked signals and the rest two have mechanical semaphore signals

The consultant team have studied various options for the proposed link. In almost all the options it has been proposed to take off the new link from existing Phultola station of Jessore - Khulna section for east and west alignment options. The length of the new link would be approximately 60 km. There will be six new block stations in the proposed link in addition to Phultola station which will be modified and extended as junction station. The new block stations will have two loops in each station.

8.7.2 Telecommunication

Most of the sections in Bangladesh Railways are provided with composite optical fibre cum copper cable as the telecommunication backbone. The composite cable comprising one pair Optical Fibre (OF) and 10 pair copper conductors in a single tube was laid along the section in 1987-88. The OF cable is terminated at major stations only for the purpose of regeneration and Drop/Insert of channels. Intermediate stations have no OF drop/insert facility. Copper cable is terminated at every station and some pairs are used directly for interconnection between neighbouring stations for block transmission and block telephone facilities.

At present, the section Poradhaha-Khulna is provided with 2 (two) pairs optical fibre for Telephone & control and 10 pair of copper conductors for block operations. For the proposed new link it is suggested to provide this section with similar 2 (two) pair optical fibre (OF) & 10 pairs of copper conductors.

The new telecommunication facilities, in line the existing Telecommunication system of Railways, shall be developed along the proposed new track alignment for interconnection of all stations, level crossings and other facilities in the section. The following types of communication facilities will be needed.

(a) Block Communication

At each station there has to be independent communication links with stations on either side for block working and block telephone purposes. Two pairs of copper wire are proposed to connect the block instruments and the block telephones on either side.

(b) Train Control Communication

A dedicated communication link will be established from the train control office situated at Paksey Railway Division with all new stations of the new link for train control purposes.

(c) General Purpose Communication

Dial up digital telephone connection will be provided at each station, marshalling yard and supervisory personnel for general purpose communication. The telephones will be connected to the nearest telephone exchange(Paksey) of BR using copper and optical fibre cable combination.

The telecommunication facilities will be developed so as to be compatible and interoperable with existing network and system on either side of the new rail link.BR's entire telecommunication network (optical fibre and copper conductors) is being maintained by Grameenphone under a contract agreement. But this is new line and going to be constructed as per Railways requirement, so the cost for telecommunication and its maintenance will be borne by Bangladesh Railway.

(d) Signalling Protection System at Level Crossings

According to BR's operational practice, any level crossing (LC) situated within station limits is protected by station signalling. Train movements are allowed only when closure and locking of the gate barriers against road traffic are proved in the signalling system. At some stations, facilities are also available for initiating approach warning and flashing signals for road traffic. Protection arrangements at LCs outside station limits (out-station LCs) are independent localized systems. Important out-station LCs requires signalling arrangements for both rail and road traffic and approach warning system for road users.

In the section between Phultola to Mongla the busy level crossings will have to be provided with proper signalling safety protection system and telecommunication facilities. So it is proposed to provide approach warning and interlocking for the busy and important level crossings of Special Class and 'A' Class, whereas telephone facilities will be provided at all ' B' Class level crossings to communicate with the adjacent stations about train movements. One pair of copper cables will be laid for the purpose. These are all localized communication.

CHAPTER 9 INDICATIVE COST ESTIMATES

9.1 GENERAL

This chapter describes the indicative cost estimates for the construction of broad gauge single line track for different alterative alignments from Khulna to Mongla section.

9.2 METHODOLOGY

The quantity of earth work in embankment is worked out as per preliminary topographic survey and typical cross sections proposed. Indicative unit cost estimates are prepared for varying heights of embankment, track, stations and other components to calculate the total cost. Indicative costs for bridges of different span lengths are taken on the basis of cost of similar bridges of other projects currently under implementation and the consultant's experience. Similar approach was followed in estimating indicative costs for track and other infrastructures of this project.The salient features of the project for three alternative alignments are given in Table 9.1. The indicative cost estimates for the construction of proposed rail route along alternative alignment options East, West and Central are given in Table 9.2, Table 9.3 and Table 9.4 respectively. The Social and Environmental costsare provided in Table 9.5.

Table 9.1: Salient features of the project

S.no.	Item	East	West	Central
1	Length of Track (km)	59.60	60.40	49.20
2	Length of Major Bridge, main bridge (km)	0.68	0.67	0.47
3	Length of Viaduct Bridge in Approaches (km)	6.40	3.23	6.46
4	Length of Minor Bridges (km)	0.33	0.44	0.29
5	Length of Track Embankment (km)	52.19	56.06	41.98
6	No. of Stations	7	7	5

Table 9.2: Abstract of ConstructionCost Estimates for East Alignment

S.no.	Item	Cost (Lacs BDT)
1	Construction of Embankment	27405.76
2	Major Bridges including approach bridge	138034.60
3	Minor Bridges including Culverts	14432.60
4	Road Over Bridge	20000.00
5	Construction of Track	38753.82
6	Stations	3542.18
7	Signaling	490.70
8	Telecommunication	1058.40
9	Contractor's Mobilisation & Construction of Facilities	3538.61
	Total Civil Cost (Lacs BDT)	**247256.66**
	Total Civil Cost (Crores BDT)	**2472.57**

Table 9.3: Abstract of Construction Cost Estimates for West Alignment

S.no.	Item	Cost (Lacs BDT)
1	Construction of Embankment	16431.48
2	Major Bridges including approach bridge	110872.00
3	Minor Bridges including Culverts	14816.20
4	Construction of Track	38917.44
5	Stations	3542.18
6	Signaling	490.70
7	Telecommunication	1058.40
8	Contractor's Mobilisation & Construction of Facilities	3423.03
	Total Civil Cost (Lacs BDT)	**189551.42**
	Total Civil Cost (Crores BDT)	**1895.51**

Table 9.4: Abstract of Construction Cost Estimates for Central Alignment

S.no.	Item	Cost (Lacs BDT)
1	Construction of Embankment	13863.71
2	Major Bridges including approach bridge	139003.20
3	Minor Bridges including Culverts	10662.10
4	Construction of Track	32974.24
5	Stations	2530.13
5	Signaling	350.50
6	Telecommunication	756.00
7	Contractor's Mobilisation & Construction of Facilities	3423.03
	Total Civil Cost (Lacs BDT)	**203562.90**
	Total Civil Cost (Crores BDT)	**2035.63**

Table 9.5: Abstract of Social and Environmental Cost Estimates

S.no.	Item	Cost (Crores BDT)		
		East Alignment	West Alignment	Central Alignment
1	Land Acquisition Cost	307.45	380.64	341.67
2	Infrastructures Cost	135.31	99.37	140.53
3	Environmental Cost	2.05	2.06	1.75
	Total Cost (Lacs BDT)	**444.81**	**480.01**	**513.95**

CHAPTER 10 ECONOMIC ANALYSIS

10.1 INTRODUCTION

The present chapter attempts at estimating the economic feasibility of the three alignment options discussed in Chapter 5 (Alignment Study) of this report. For this exercise, the inputs relates to the construction and maintenance cost of the proposed rail line, operating costs and the value of time to the transport users. The constructions costs for the different alignment options has been estimated in Chapter 9. All the cost inputs required for estimating the operating cost and value of time were collected by the Consultants.

10.2 FRAMEWORK FOR ECONOMIC ANALYSIS

The Consultant has followed the 'with' (i.e., project alternatives) and 'without' (i.e., base case or do minimum/ nothing) project approach, whereby the cost to the economy for moving a specified and projected volume of traffic by rail and competing modes road/ IWT would be estimated in both the 'with' and 'without' the project situations, and compare theses costs to obtain the net benefit to the economy. The frame-work adopted for economic analysis is presented in Table 10.1.

Table 10.1: Frame-work for Economic Analysis

Cost Item	'Without' the Project case (Project Benefit)	'With' the Project Case (Project Cost)
Capital Cost	-	Construction cost (including cost of land) of improvement/ upgrading/ strengthening etc. of the road
Environmental Cost	-	Cost towards mitigation of adverse environment effect as result of construction activities
Social Cost	-	Cost towards social rehabilitation of the displaced/ effected population, structure etc.
Maintenance Cost	-	Exiting maintenance cost norms related to Western Railway modified for the new rail link
Operating Cost	Operating cost of truck/ Bus/ IWT	Operating cost of railway on broad gauge line (Western Zone)
Value of Time	Estimates of the time value of the projected passengers and goods traffic in transit by truck/ Bus/ IWT	Estimates of the time value of the projected passengers and goods traffic in transit by railway
Increase in income of Mongla Port	For Nepal and Bhutan realted exports/ impots diverted from Kolkota Port will lead to the increase in net income of Mongal Port	

The project cost and benefits have been estimated for the project analysis period of 32 years with 2 years of construction period (2014-15 to 2015-16) and 30 years of operating period, starting from 2016-17. At the terminal year of the analysis period a residual/ salvage value of project facilities is calculated 10% . The social discount rate for the purpose of working out net present value (NPV) is taken at 15% (as defined in the terms of reference for the present study). This is the rate reflecting the premium on 'decision to invest today' vis-à-vis 'saving it for future consumption'.

Constant base year (Yr. 2012-13) prices are used for economic evaluation. All the costs and figures given in the chapter are at market prices. Since the project costs such as civil structures, rails, consumables, etc., are based on the market prices, these costs have been converted into economic costs by applying appropriate factors established for resource costs. For this, all the costs items (under 'with' and 'without' project cases) estimated at base year prices are adjusted for transfer payments such as taxes, duties and subsidies on materials and equipment. Standard conversion factor (SCF) of 0.80 for has been used for converting the cost estimates at market prices to economic prices.

In order to adjudge the economic strength of the selected alignment alternatives and to identify its robustness, sensitivity analysis of the selected alignment has been carried out under the adverse situation of cost and benefits. Through the sensitivity analysis the changes in the project EIRR/ NPV is estimated and compared to the minimum acceptable criteria.

10.3 ALIGNMENT ALTERNATIVES

The alignment alternatives were studied in detail in Chapter 5 of this report. As discussed in that chapter, alignment options were studied for three directions – East, West and Central – and were named, respectively, as Eastern Alignment, Western Alignment and Central Alignment. Within Eastern Alignment, four alternatives were studied and Alignment C (modified) was selected, like-wise in Central Alignment three options were studied and Alignment H was selected, and for Western Alignment only one alignment (Alignment E) was considered. In this chapter, economic analysis of the selected 3 alignments (Table 10.2) has been carried out to further select the best alignment.

Table 10.2: Alignments Considered for Economic Analysis

S. No.	Alignment	Length (Km)
1.	Eastern Alignment (modified Alignment C)	59.6
2.	Western Alignment (Alignment E)	60.4
3.	Central Alignment (Alignment H)	49.2

10.4 TRAFFIC

The passenger and freight traffic for the 3 selected alignments are discussed in detail in Chapter 6. For estimating the revenue, the traffic figures given in Annexure 6.1 for the 3 alignments have been considered and the same is summarised in Table 10.3 and Table 10.4 respectively for freight and passenger traffic.

Table 10.3: Selected Alignments – Freight Traffic

Alignment Option	Freight Traffic (Lac Ton)					
	2016-17		2019-20		2029-30	
	Tons	Ton-Km	Tons	Ton-Km	Tons	Ton-Km
Eastern Alignment (modified Alignment C)	63.63	17731	80.48	23034	169.72	51530
Western Alignment (Alignment E)	63.63	17731	80.48	23034	169.72	51530
Central Alignment (Alignment H)	63.63	17731	80.48	23034	169.72	51530

Table 10.4: Selected Alignments – Passenger Traffic

Alignment Option	Passenger Traffic Lac)					
	2016-17		2019-20		2029-30	
	Pass	Pass-Km	Pass	Pass-Km	Pass	Pass-Km
Eastern Alignment (modified Alignment C)	11.24	1343	14.16	1692	24.19	2890
Western Alignment (Alignment E)	17.51	1443	22.06	1818	37.67	3105
Central Alignment (Alignment H)	17.51	1443	22.06	1818	37.67	3105

10.5 COST ESTIMATES OF ALTERNATE ALIGNMENTS

10.5.1 Construction Cost

The construction cost estimates are given in Chapter 9 and it also includes physical and price contingencies. These cost estimates are at market prices and include taxes and duties as applicable for the various items constituting the cost. The same has been converted to economic cost using the standard conversion factor of 0.80.

The construction work is expected to be completed in two years period, commencing from the financial year 2014-15. The construction cost estimates for the 3 alignments along with the phasing are set out in Table 10.5.

Table 10.5: Construction Cost and Phasing

Alignment Option	Construction Cost (Lacs Taka)		
	2014-15	2015-16	Total
Eastern Alignment (modified Alignment C)	86540	160717	247257
Western Alignment (Alignment E)	66343	123208	189551
Central Alignment (Alignment H)	71247	132316	203563

10.5.2 Social & Environmental Cost

In addition to the above construction costs, the social & environmental costs related to the 3 alignments have also been added while performing the economic analysis. As explained in earlier chapter the social & environmental costs were estimated for a corridor width of 100 meter, however, on an average the corridor width of about 50 meter would be required for the rail alignment, therefore for the purpose of the economic analysis only 50% of the social and environmental costs has been considered. The costs for the three alignment options are set out in Table 10.6.

Table 10.6: Social & Environmental Cost

Alignment Option	Social Cost (Lacs Taka)			Environmental Cost (Lacs Taka)		
	2014-15	2015-16	Total	2014-15	2015-16	Total
Eastern Alignment (modified Alignment C)	15496	28779	44276	72	133	205
Western Alignment (Alignment E)	16800	31201	48001	72	134	206
Central Alignment (Alignment H)	17928	33294	51222	61	113	175

10.5.3 Operations & Maintenance Cost

The operating cost of railway operations and the competing modes - road (trucks & buses) and IWT - have been worked out on the basis of data from available from different sources.

Railway operation cost is based on the Railway Costing Profile 2010-12 published by Bangladesh Railway. The operating cost includes working expenses, depreciation and interest. For the purpose of the present study since the investment on track and other facilities have been accounted for in the capital cost (construction cost), only the working expenses have been considered, and the same has been updated to the year 2012-13 by considering an average price increase of 6.5% per annum. The figures are presented in Table 10.7.

Table 10.7: Railway Operating Cost

Item	Unit	2010-11	2012-13
Normal Freight Wagon	Taka Per Ton -Km	1.2134	1.376269
Containers/ Tank Wagons*	Taka Per Ton -Km	-	2.064403
Passengers	Taka Per Pass- Km	1.131	1.282808

** estimated by increasing the operating cost of freight wagon by 50%*

For working out the road vehicle operating costs the basis is the RHD Road User Cost, Annual Report for 2004-05. These cost figures have been updated by using the average price increase of 6.5% per annum and the same are presented in Table 10.8.

Table 10.8: **Road Vehicle Operating Cost**

Item	Taka per V-Km	Taka per TKm/ Pass Km	Taka per TKm/ Pass Km
	2003-04	2003-04	2012-13
Truck	15.75	1.75	3.08
Bus	20.01	0.80	1.41
Containers*			4.62
Tank*			6.17

** Operating cost of Containers is estimated by increasing the operating cost of truck by 50% and that for Tankers by 100%*

In case of IWT per ton-km unit cost was considered as Taka 0.67 per ton-km in the year 2007 (Source: Revival of Inland Water Transport: Options and Strategies, World Bank, 2007). It has been update to the year 2012-13 by considering an average price escalation of 6.5% per annum, which works out to Taka 0.90 per ton-km.

The maintenance cost of tracks and bridges has been considered as 2% of the construction cost.

10.6 ECONOMIC BENEFIT OF RAIL ALIGNMENT

The proposed rail link will connect Mongla Port, the second largest port in Bangladesh, and will also provide additional transport system in the project area. At present the project area, including Mongla Port, is served by road transport and limited IWT services. Thus the rail link is expected to remove the mass transport related constraint in the project area and facilitate movement of goods and people at relatively faster speed and at cheaper cost, resulting in savings in transportation cost and transit time for goods and passenger movement.

The main benefits of the proposed rail alignment considered for economic evolution are:

a) **Savings in operating cost of movement in goods and passenger traffic diverted to railway from road/ IWT modes:** Based on the diverted-traffic estimates in Chapter 6, the ton-km/ pass-km unit operating costs by railway, road and IWT and the distance for movement of the diverted commodities/ passengers, the savings in operating costs have been estimated for each of the years of the project analysis period (2016-17 to 2045-46)

b) **Savings in time for goods and passengers diverted to railway:** The passenger traffic is expected to divert from road transport to railway and the goods traffic will divert from road transport as well as IWT. It has been observed that due to traffic conditions and the prevalence of road side developments, the average speed of vehicles is about 40 km per hour for buses and 30 km per hour for trucks. For IWT movement the average speed has been considered as 10 km per hour. In case of the proposed railway operation, the rail line is being designed for a speed of 120 km per hour for passenger trains and 80 km per hour for goods trains. However, the average speed is expected to be lower and for the present purpose, the average speed for passenger trains is considered at 60 km per hour and for freight train as 40 km per hour. The savings time have been estimated for each of the years of the project analysis period (2016-17 to 2045-46). The value of time for passengers is estimated at Taka 22.94 per passenger per hour and for goods in transit at Taka 0.86 per ton per hour.

   Income to Bangladesh due to Nepal and Bhutan traffic: At present the export-import cargo linked to these two countries are mainly routed through India. As a result of Mongla Port being connected with the BR network, due to expected savings in distance and transportation cost, this traffic is expected to divert to Mongla Port. It would result in additional income to Mongla Port and hence to the economy. The net income to Mongla Port will be benefit to the economy. The income and expenditure statistics for the last 3 years (2010-11, 2011-12 and 2012-13, up to September 2012) for the port depicts that the average revenue (per ton) accrued to the port was Taka 340.85 per ton and the average net income was 21.44% of the revenue generation.

   Similarly, additional revenue is also expected for BR for moving this cargo from Mongla Port to border. It is observed that the BR is incurring net loss in its overall operations. However, for this specific movement, a 20% of the revenue has been considered as net income to BR.

   Thus the total net benefit to Bangladesh economy will be the summation of the above three steams of net income likely to accrue to: Mongla Port, BR and Truckers. The savings on account of Nepal and Bhutan traffic has been estimated for each of the years of the project analysis period (2016-17 to 2045-46).

c) Benefit from induced traffic: As a part of overall traffic for the proposed rail link, the induced traffic has been estimated in Chapter 6. The economic benefit on account of induced traffic has been considered as per the standard practice by considering 50% of the cost of movement by rail for each of the years of the project analysis period (2016-17 to 2045-46).

10.7 COST – BENEFIT ANALYSIS OF ALIGNMENTS

The cost –benefit analysis for the 3 alignments has been performed on the basis of the cost and benefits of the alignments discussed in earlier sections of this chapter. As mentioned earlier, the project analysis period has been considered from the year 2016-17 (first year of railway operation) to 2045-66 and for the 2 years of construction period (2014-15 and 2015-16).

The results of the cost-benefit analysis are summarised in Table 10.9 and the details for the 3 alignments are presented as Appendix 10.1 to Appendix 10.3.

Table 10.9: Results of Cost-Benefit Analysis

S. No.	Alignment	NPV (@15%) (Lac Taka)	EIRR (%)	B/C Ratio
1	Eastern Alignment (modified Alignment C)	1,547	15.10%	1.01
2	Western Alignment (Alignment E)	39,326	17.84%	1.26
3	Central Alignment (Alignment H)	28,387	16.94%	1.18

It may be observed from the above table that the economic internal rate of return (EIRR) for the alignment viz., Western Alignment, Central Alignment and the Eastern Alignment is 17.84%, 16.94% and 15.10% respectively. The EIRR for the Western Alignment is the highest at 17.84% with the net present value at 15% discount rate (NPV) being **39,326** Lac Taka.

10.8 SENSITIVITY ANALYSIS

Sensitivity analysis is carried out with a view to judge the robustness of results of the cost-benefit of the alignments. by assessing the impact of the variations in cost and benefits on the estimated EIRR, NPC and B/C ratio for the alignment.

Normally, the crucial parameters impacting the cost – benefit results are cost-overrun and time-overrun related to the project implementation aspect. The other important parameter is the decrease in estimated traffic that results in the decrease in benefits of the project. The possibility of adverse change in these three parameters has been studied by the Consultants, and accordingly the expected change in their values have been assessed and incorporated in the sensitivity analysis.

The sensitivity cases incorporated in the analysis are as follows.

- Increase in construction cost by 10%
- Decrease in project benefits by 10%
- Increase in construction cost by 10% and decrease in benefits by 10% (combined effect)
- Delay in accrual of benefits by 1 year

The results of sensitivity analysis for the 3 alignments is are summarised in Table 10.10.

Table 10.10: Results of Sensitivity Analysis

S. No.	Alignment	NPV (@15% (Lac Taka)	EIRR (%)
A.	**Eastern Alignment (modified Alignment C)**		
1	Increase in construction cost by 10%	(-)17,04	14.03%
2	Decrease in project benefits by 10%	(-)17,159	13.92%
3	Combined Effect of above (1) & (2)	(-)35,711	12.92%
4	Delay in accrual of benefits by 1 year	(-)23,690	13.61%
B.	**Western Alignment (Alignment E)**		
1	Increase in construction cost by 10%	24,206	16.62%
2	Decrease in project benefits by 10%	20,273	16.50%
3	Combined Effect of above (1) & (2)	5,153	15.35%
4	Delay in accrual of benefits by 1 year	13,622	15.93%
C.	**Central Alignment (Alignment H)**		
1	Increase in construction cost by 10%	12,173	15.77%
2	Decrease in project benefits by 10%	9,334	15.65%
3	Combined Effect of above (1) & (2)	(-)6,880	14.56%
4	Delay in accrual of benefits by 1 year	2,683	15.17%

The results of sensitivity analysis indicate that the EIRR of the Western Alignment remains above the minimum discount rate criteria of 15% and that of Eastern Alignment remains below the criteria.

10.9 ECONOMIC ANALYSIS RESULT

The cost-benefit analysis of the three alignments suggests that all the three alignments are found to be economically viable as their EIRR is above the minimum discount rate of 15%. Eastern Alignment is most sensitive to the Sensitivity analysis. Western Alignment has the highest EIRR (17.84%) and also meets the sensitivity criteria, is the preferred alignment that would impart maximum benefit to the economy, both in percentage as well in quantity terms.

It may be mentioned that the addendum to RFP specifies that the rail alignment over river Rupsha should be avoided. Out of the three options considered for economic analysis, the Western Alignment crosses Rupsha. The reason for including this alignment in the present study has been explained in the chapter on Alternative Alignment and the results of economic analysis indicate it to have the highest EIRR value.

The EIRRs of the other two alignment options that do not cross river Rupsha, are close to each other, but from the social impact perspective the Central Alignment will be difficult to implement, therefore the Eastern Alignment along with Western Alignment are the two options that need consideration of Bangladesh Railway for approving any one of these.

CHAPTER 11 FINANCIAL ANALYSIS

11.1 11.0 GENERAL

The exercise relating to Financial Analysis attempts to evaluate the financial soundness of the proposed investment in the project rail line and associated facilities. It essentially evaluates the financial returns of investments for the projects, and determines financial feasibility of the project based the cost of the project and revenue estimates as per the traffic volume forecasts and the applicable fare and freight rates.

All the costs (cash outflows) and revenues (cash inflows) of the projects are estimated at 2012-13 prices and are projected for future years based on anticipated traffic (passenger and freight). The cost of the project is based on Consultants estimates given in the previous chapters and the fare and freight rates considered are the ones being levied by BR. The discount cash flow (DCF) method is used for financial evaluation, and the financial feasibility is determined based on the financial internal rate of returns (FIRR) of the project. As specified in the terms of reference for the present study, a discount rate of 15% has been used for financial analysis.

11.2 ASSUMPTIONS

The financial analysis is based on certain general assumptions that are explained in the following sub-sections.

Financial Analysis Period:The project analysis period is taken as 32 years with 2 years of construction period (2014-15 to 2015-16) and 30 years of operating period, starting from 2016-17.

Price Basis:All the costs and revenue items are estimated at constant 2012-13 prices. The passenger fare and freight rates are the ones as applicable for the year 2012-13.

Residual Value:The residual/ salvage value of project facilities is considered at 10%. The project analysis period is considered as 30 years the residual/ salvage value has been duly accounted as negative values in the terminal year of the analysis period.

Discount Rate: The minimum discount rate criteria specified in the RFP is 15%, the same has been used for estimating the net present value of the net benefit of the project. It has also been considered as the cut-off value for acceptance of financial rate of return (FIRR).

Construction Period: 2 years (2014-15 & 2015-16)

11.3 ALIGNMENT

In the previous chapter on Economic Analysis the cost-benefit analysis for three alignments was undertaken and the two alternatives were found to be suitable for consideration of Bangladesh Railways. In the present chapter the financial analysis of all the three alignments, viz., the Western Alignment, Eastern Alignmentand Central Alignment, has been undertaken to assess the financial returns of the alignments.

11.4 CONSTRUCTION COSTS OF THE ALIGNMENT

The cost of the project includes construction costs, physical and price contingencies, operation and maintenance costs. These costs are at market prices and include taxes and duties as applicable for the various items constituting the cost.

The construction cost for Western Alignment (Alignment E), Central Alignment and Eastern Alignment (modified Alignment C) for the proposed Khulna - Mongla rail line has been estimated by the Consultant as 189551 Lac Taka, 203563 Lac Taka and 247257 Lac Taka, respectively. The construction work is expected to be completed in two years period, commencing from the financial year 2014-15. The construction cost of the two alignments along with the phasingare set out in Table 11.1.

Table 11.1:Construction Cost and Phasing

Alignment Option	Construction Cost (Lacs Taka)		
	2014-15	2015-16	Total
Eastern Alignment (modified Alignment C)	86540	160717	247257
Western Alignment (Alignment E)	66343	123208	189551
Central Alignment (Alignment H)	71247	132316	203563

11.5 OPERATIONS & MAINTENANCE COST

The operating cost of railway operations was estimated in the previous chapter (Economic Analysis) and the same has been used for financial analysis.

11.6 TRAFFIC

The passenger and freight traffic for the two alignments are discussed in detail in Chapter 6. For estimating the revenue, the traffic figures in ton-km and passenger-km were considered for each year of the analysis period (2016-17 to 2045-46). Summary of the freight and passenger traffic is given in Table 11.2 and Table 11.3.

Table 11.2: Selected Alignments – Freight Traffic

Alignment Option	Freight Traffic (Lac Ton)					
	2016-17		2019-20		2029-30	
	Tons	Ton-Km	Tons	Ton-Km	Tons	Ton-Km
Eastern Alignment (modified Alignment C)	63.63	17731	80.48	23034	169.72	51530
Western Alignment (Alignment E)	63.63	17731	80.48	23034	169.72	51530
Central Alignment (Alignment H)	63.63	17731	80.48	23034	169.72	51530

Table 11.3: Selected Alignments – Passenger Traffic

Alignment Option	Passenger Traffic Lac)					
	2016-17		2019-20		2029-30	
	Pass	Pass-Km	Pass	Pass-Km	Pass	Pass-Km
Eastern Alignment (modified Alignment C)	11.24	1343	14.16	1692	24.19	2890
Western Alignment (Alignment E)	17.51	1443	22.06	1818	37.67	3105
Central Alignment (Alignment H)	17.51	1443	22.06	1818	37.67	3105

11.7 REVENUE ESTIMATES

The current freight rates used by Bangladesh Railways as applicable for the distance slabs and commodity classification were applied to the freight traffic forecast figures to estimate the freight related revenues. For estimating the revenue for passenger traffic an average fare of Taka 0.58 per passenger-km was considered.

The details of freight revenue estimates for the year 2016-17 are presented in Table 11.4. On similar lines, the freight revenue for the remaining years of the analysis period was estimated.

In addition to the revenues from freight and passenger operations, other miscellaneous revenue on account of income from optical fibre, advertisement, etc. has been considered as 5% of the total revenue.

Table 11.4: Freight Revenues – 2016-17

Commodity	Origin	Destination	Quantity (000 Ton)	Rail Distance (Km)	Ton-Km (000)	Revenue (000 Taka)
A - Traffic Movement: From Mongla towards North Direction (Up-traffic)						
Food grain	Mongla Port	Noapara	15	70	1078	5302
	Mongla Port	Jessore	8	97	743	2766
	Mongla Port	Chuadanga	15	179	2754	5993
	Mongla Port	Ishwardi	15	246	3772	6914
	Mongla Port	Santahar	23	324	7466	12446
	Mongla Port	Parbatipur	15	420	6452	9450
	Mongla Port	Saidpur	15	435	6684	9450
	Mongla Port	Domar	8	471	3621	5071
	Mongla Port	Faridpur	15	260	3995	7375
	Mongla Port	Modhukhali	8	245	1882	3457
	Mongla Port	Bhanga-	15	161	2474	5993
		Total	154		40921	74217
Fertilizer	Mongla Port	Noapara	27	70	1910	9395
	Mongla Port	Jessore	14	97	1317	4902
	Mongla Port	Chuadanga	27	179	4880	10620
	Mongla Port	Ishwardi	27	246	6685	12254
	Mongla Port	Rajshahi	27	304	8276	13480
	Mongla Port	Santahar	27	324	8822	14705
	Mongla Port	Parbatipur	27	420	11435	16783
	Mongla Port	Saidpur	14	435	5923	8374
	Mongla Port	Faridpur	27	260	7080	13071
	Mongla Port	Modhukhali	27	245	6672	20705
	Mongla Port	Bhanga	27	161	4384	10620
		Total	272		67383	134910
Container Imports	Mongla Port	Dhaka	60	241	14556	68267
Container (Diverted - CP)	Mongla Port	Dhaka	737	241	177674	833293
		Total	737		177674	833293
Petroleum Oil	Mongla Port Area	Dhaka	564	241	136033	338723
	Mongla Port Area	Rajshahi	374	304	113719	246769
	Mongla Port Area	Khulna	526	65	34195	235947
		Total	1465		283947	821440
LPG	Mongla Port Area	Dhaka	2	241	554	1999
	Mongla Port Area	Rajshahi	2	304	463	1509
	Mongla Port Area	Khulna	2	65	139	931
		Total	6		1156	0
Clinker	Mongla Port	Noapara	93	70	6548	30809
	Mongla Port	Singia	93	41	3828	28008
	Mongla Port	Bhanga	93	161	15031	35011
		Total	280		25407	93828

Traffic for Nepal	Mongla Port	Rohanpur	560	367	205520	326777
	Mongla Port	Birol	240	460	110400	158976
		Total	800		315920	485753
Traffic for Bhutan	Mongla Port	Burimari	200	575.2	115040	165658
		Total	200		115040	165658
Industrial Traffic	Mongla Port Area	Bogra	189	364	68931	124766
	Mongla Port Area	Khulna	189	68	12877	68121
	Mongla Port Area	Jessore	189	97	18369	71088
	Mongla Port Area	Faridpur	189	260	49237	107828
		Total	757		149414	371803
Total - A (Up-traffic)			4732		1191419	3049168
B -Traffic Movement: Towards Mongla From North Direction (Down-traffic)						
Jute & Jute Product	Navaran	Mongla Port	4	81	325	1497
	Jessore	Mongla Port	4	97	386	1552
	Chuadanga	Mongla Port	3	179	613	1748
	Kustia	Mongla Port	4	182	726	2033
	Rajbari	Mongla Port	4	238	951	2339
	Faridpur	Mongla Port	4	260	1038	2512
	Khulna	Mongla Port	4	65	236	1309
	Daulatpur	Mongla Port	4	60	218	1309
	Noapara	Mongla Port	1	70	85	456
	Sirajgonj	Mongla Port	1	284	344	780
		Total	33		4922	15534
Break-Bulk Goods	Noapara	Mongla Port	8	70	589	2901
	Jessore	Mongla Port	3	97	270	1003
	Chuadanga	Mongla Port	3	179	501	1093
	Kustia	Mongla Port	6	182	1018	2178
	Rajbari	Mongla Port	8	238	1999	3778
	Faridpur	Mongla Port	6	260	1454	2691
		Total	34		5831	13643
Container	Dhaka	Mongla Port	60	241	14556	68267
Container (Diverted - CP)	Dhaka	Mongla Port	280	241	67392	316070
		Total	280		67392	316070
Coal Traffic	Fulbari		500	395	197500	321925
	Rampal		725	402	291450	466320
	Total		1225		488950	788245
Total - B (Down-traffic)			1632		581651	1201759
Total - A + B			6363		1773070	4250926

The revenue estimates for passenger traffic is summarised in Table 11.5

Table 11.5: Summary of Passenger Revenue

Year	Revenue (Lac Taka)	
	Western & Central Alignment	Eastern Alignment
2016-17	803	778
2019-20	1182	980
2024-25	1612	1311
2029-30	2077	1673
2035-36	2653	2117

11.8 FINANCIAL ANALYSIS

The results of the financial analysis are presented in Table 11.6 and the details of the project cost and revenues for the analysis period are presented in Appendix 11.1 Appendix 11.2 and Appendix 11.3, respectively, for Eastern Alignment,Western Alignment and Central Alignment.

Table 11.6: Results of Financial Analysis

S. No.	Alignment	NPV (@15%) (Lac Taka)	FIRR (%)	B/C Ratio
1	Eastern Alignment (modified Alignment C)	5,607	15.32%	1.01
2	Western Alignment (Alignment E)	52,807	18.65%	1.14
3	Cental Alignment (Alignment H)	43,764	17.80%	1.11

11.9 SENSITIVITY ANALYSIS

The financial analysis undertaken in the previous section is based on cost estimates prepared by the project engineers, and the revenues are based on certain assumptions as explained earlier in this chapter. Any change in the cost estimates or projectedrevenues would alter the project FIRR, NPV and B/C ratio. The extent of these changes can be ascertained through resorting to sensitivity analysis.

The following sensitivity cases were considered and their impact on the project financial results was assessed.

- Increase in construction cost by 10%
- Decrease in projectedrevenue by 10%
- Increase in capital cost by 10% and decrease in projected revenue by 10%

(combined effect)

- Delay in accrual of benefits by 1 year

The results of sensitivity analysis for the Eastern Alignment and Western Alignment are summarised in Table 11.7.

Table 11.7: Results of Sensitivity Analysis

S. No.	Alignment	NPV (@15% (Lac Taka)	FIRR (%)
A	**Eastern Alignment (modified Alignment C)**		
1	Increase in construction cost by 10%	(-)14,070	14.26%
2	Decrease in project benefits by 10%	(-)37,078	12.80%
3	Combined Effect of above (1) & (2)	(-)56,756	11.87%
4	Delay in accrual of benefits by 1 year	(-)51,913	12.35%
B	**Western Alignment (Alignment E)**		
1	Increase in construction cost by 10%	37,722	17.42%
2	Decrease in project benefits by 10%	9,988	15.73%
3	Combined Effect of above (1) & (2)	(-)5,098	14.66%
4	Delay in accrual of benefits by 1 year	(-)4,895	14.70%
C	**Central Alignment (Alignment H)**		
1	Increase in construction cost by 10%	27,564	16.64%
2	Decrease in project benefits by 10%	945	15.06%
3	Combined Effect of above (1) & (2)	(-) 15,256	14.05%
4	Delay in accrual of benefits by 1 year	(-) 13,938	14.21%

11.10 FINANCIAL ANALYSIS RESULT

The results of the financial analysis indicate that both the alignments are financially viable as their FIRRs are more than the minimum discount criteria of 15%. Western Alignment is financial more viable than Central Alignment and Eastern Alignment. The FIRR and NPV (@ 15%) of Western Alignment is 18.65% and 52807 Lac Taka. The same for Eastern Alignment and Central Alignment is estimated,respectively, at 15.32% & 5607 Lac Taka and 17.80% & 43,764 Lac Taka.

CHAPTER 12 INVESTMENT &FINANCIAL PLAN

12.1 INTRODUCTION

The Investment Plan and Financial Plan includes the project implementation schedule, procurement schedule and framework for project benefit monitoring. It is evident from the present study that the project would entail large investment and have major investment components requiring specific technology and construction method. Given a tight time-frame for project completion, it would require judicious and logical planning and packaging of the project components so as to implement concurrently, as far as possible, the major works item.

The overall implementation of the projectconsiders the prevailing local conditions, geographical & physical constraints, and other factors typical to the project area. It also considers the applicability of available construction methods and technological aspects to meet the specifications of the project.The proposed implementation schedule assumes that the project is implemented as per the suggested planning and framework.

12.2 CONSTRUCTION PACKAGES

The construction period indicated in the RFP is 24 months; therefore procurement and construction schedule is to be planned for parallel works. Considering the constructability aspect and project area conditions, the project components are proposed to be packed in four groups.

Package 1: Civil Construction Works - Major Bridges

Package 2: Civil Construction Works – Permanent Way, Minor Bridges, Culvers, Stations, Residential Buildings, Yards, etc.

Package 3: Signalling Works – Cables & Equipment

Package 4: Telecommunication Works – Cables & Equipment

12.3 SCHEDULE FOR PROCUREMENT

Procurement Plan is prepared keeping in view the construction packages discussed above and the total construction period. The procurement plan is based on the GOB's Public Procurement Rules and the requirements of the donor agency/ country. Immediately after the finalization and approval of Detailed Design for the rail alignment along with the tender document, the procurement process will start.

Procurement for Package 1 and Package 2 will start simultaneously. The procurement

for other two packages – Package 3 and Package 4 – can start after a period of one year, however, the preparation of bid documents and process for these two packages can start along with the other two packages.

12.4 IMPLEMENTATION SCHEDULE

For preparing the project implementation schedule, the following major components of the project are critical and needs to be grouped and scheduled in a manner that facilitates construction, and is in accordance with the procurement plan and schedule.

i. Embankment, culverts, minor bridges, etc.

ii. Major Bridges

iii. Railway Track

iv. Station buildings, approach roads, yards etc.

v. Signaling and telecommunication work

All the major bridges will be constructed over the navigable rivers. The navigational requirements such as height of the bridge, provision for providing adequate navigational span, etc. will be factored in construction planning and implementation schedule of major bridges. In view of the above requirements, it is proposed for the major bridge to have:

i. Superstructure steel through type truss girder for main bridges and composite steel girder for approach bridges

ii. Type of foundation – (a) Piers with RCC wall type having1.2m/ 2.5m diameter, bored-cast-in-situ pile having permanent steel casing part of pile length, (b) Abutment with RCC wall type with 1.2m RC Bored cast-in-situ pile having permanent steel casing part of pile length

iii. Substructure: Piers and abutment RCC wall type.

iv. Bearings: Steel Roller and Rocker Bearings

The construction time schedule is based on the assumption that major components of construction works are to be given critical time requirement so as to make construction cost reasonable. The major works are planned in sequence and proper combination of heavy equipment and materials with an aim to utilize them repeatedly several times.This construction works require fully-equipped construction planning comprising of concrete batching plant, transit mixer, erection cranes, concrete pumping machine and so forth. Construction sites will be planned at suitable locations andaccess by roads and /or waterways shall be provided as appropriate. Separate construction sites will be planned in case there is more than one major bridge to be constructed.

12.5 LAND ACQUISITION AND REHABILITATION &RESETTLEMENT

In addition to the procurement and construction plans, the Land Acquisition works should be substantially completed before the construction work starts. Also substantial Rehabilitation &Resettlement (R&R) of the affected persons (as per the Resettlement Plan) should be over before award of the construction works.

12.6 ENVIRONMENTAL ISSUES

The environmental clearances for the project are to be taken before the start of construction activities. The process for getting environmental clearances will start after the Environmental Report is submitted and approved by BR.

12.7 METHODOLOGY FOR PROJECT BENEFIT MONITORING

Project benefits will accrue after the start of operations. The project construction period is considered for two years - 2014-15 & 2015-16, and the first year of rail operations will be 2016-17. The project benefit monitoring has to be with respect to a bench mark situation and monitored in periods after the start of the project. The benefit monitoring is proposed for the following situations.

- Base Year Situation – Pre Construction Period
- After Construction – Post Construction Situation
- Two Years from the start of the project

The factors to be included in each of the above period are listed below:

- Socio-economic condition of the Project Area
- Traffic Analysis
- Impact on Mongla Port
- Transport cost to the Users
- Benefit to Bangladesh Railways
- Environmental Condition
- Status of Project Affected People

CHAPTER 13 RECOMMENDATIONS AND CONCLUSIONS

13.1 INTRODUCTION

The recommendations are based on the various aspects related to engineering, traffic, social and environment studies that were carried out by the Consultant as a part of the Feasibility Study. These studies were supported by appropriate preliminary surveys and investigations made by the Consultant.

The main focus is to study all the possible alignment options for the proposed rail line (new Broad Gauge) and suggest the most suitable alignment for approval by Bangladesh Railway for further investigations, surveys and detailed engineering design in Phase –II study.

13.2 SELECTED ALIGNMENT

Considering the requirement of the Amendment No. 2 to the Request for Proposal (RFP), dated 30.04.2011, issued by Bangladesh Railways, the Consultant studied four alignment (A,B,C,D) options on the Eastern side (detail is in chapter 5) to avoid Rupsha River. However, during preliminary survey it was observed that while avoiding river Rupsha, all these alignments on East Side will be passing through three major navigable rivers, viz., Bhairab, Atai and Attarobaki (River Bhairab is of the same class as Rupsha River, requiring navigational clearance of 60 feet). For crossing the three consecutive rivers, construction of high embankment for a considerable length of about 26 Km will be required.

Finally combination of C and A option designated as modified option C was found the most suitable option on East Side and termed as Eastern Alignment. This alignment will be passing through three major navigable rivers, viz., Bhairab, Atai and Attarobaki.

The Consultant further considered four more alignment options:

One option on the Western part was taken for study which will be passing through one major navigable river, viz., Rupsha River, requiring navigational clearance of 60 feet and termed as Western Alignment.

Three options F,G and H (detail is in chapter 5) on the Central part of the project area were studied. The alignment F and G will be passing through one major navigable river Rupsha. The option H will cross two navigable rivers,viz., Bhairab and Attarobaki. River Bhairab is of the same class as Rupsha River, requiring navigational clearance of 60 feet. Finally option H was found the most suitable option on Central Part and termed as Central Alignment..

Based on the above preliminary study most suitable one alignment on each side viz East,West and Center, further study and investigations were carried out to finalize the most suitable alignment.

A comparative analysis of the three Preliminary selected alignment one on each side (East,West and Central) is presented in Table 13.1.

Table 13.1: Comparative Analysis of Selected Alignment

Attribute	Eastern Alignment	Western Alignment	Central Alignment
Length (Km)	59.60	60.40	49.2
Embankment Height/ Physical Obstruction	Major Issue	Not a Major Issue	Major Issue
Major Bridges	3 Nos.	1 No.	2 Nos.
Road Over Bridge	1 No.	---	---
Accessibility	Low	High	Moderate
Constructability	Difficult	Easier	Easy
Station Height	1 at Approx. 10 m ht.	All at Grade	All at Grade
Social Impact	Moderate	Low	High
Operating & Maintenance Cost	High	Low	Moderate
Serviceability	Low	High	High
Safety	Lower	High	Low
Land Constraint	Critical from Phultola to BADC Godown	Negligible	Critical (City Area on both side of Rupsha)
Approx. Construction Cost (Crore Taka)	2472.57	1895.51	2035.63
Social Cost including LA	442.76	480.01	512.20
Environmental Cost	2.05	2.06	1.75

13.3 RESULTS OF ECONOMIC ANALYSIS

The results of the economic analysis of the three alignments are set out in Table 13.2.

Table 13.2: Results of Economic Analysis of Selected Alignments

S. No.	Alignment	NPV (@15%) (Lac Taka)	EIRR (%)	B/C Ratio
1	Eastern Alignment (modified Alignment C)	1,547	15.10%	1.01
2	Western Alignment (Alignment E)	39,326	17.84%	1.26
3	Central Alignment (Alignment H)	28,387	16.94%	1.18

The minimum discount rate suggested in the RFP is 15%. The above alignment options

have EIRR of more than 15% and the NPV of these alignments is positive at 15% social discount rate, indicating that the investments on the alignment options will be desirable from the point of view of the economy of the country. However , the priority for investment should be for the alignment option with the highest EIRR and NPV.

13.4 RECOMMENDED ALIGNMENT OPTION

Based on the results of the above two tables it is inferred that:

a) Western Alignment is most economic viable (EIRR 17.84%) with least social & environmental issues is the preferred alignment that would impart maximum benefit to the economy, both in percentage as well in quantity terms.

b) Though the economic returns of the Central Alignment (EIRR 16.94%) is marginally higher than Eastern Alignment (EIRR 15.10%), but from the social impact perspective the Central Alignment will be difficult to implement.

c) Eastern Alignment is economically viable (EIRR 15.10%) with moderate social impact issues can be implemented by meticulously addressing the issues relating to high embankment and accessibility to the site during construction.

Following the conditions specified in Terms of Reference (TOR), the Eastern Alignment (Modified Alignment C) is recommended.

Based on higher economic return and other project related issues, the Western Alignment (AlignmentE) is recommended.

The above recommendations are placed to Bangladesh Railway for taking decision on approval of the alignment through the Draft Final Report of Feasibility Study Volume I (Main Report) on May 2013.

13.5 APPROVAL OF ALIGNMENT

Bangladesh Railway communicated to the Consultant the approval of alignment vide letter no. ENC/P/AGT/K-M/01 dated 03.06.2013, attached at Appendix 13.1. Among the various alternative options proposed by the Consultant, the Western Alignment has been approved. Consultant will carry out the detail engineering design & bidding services (Phase II) for this approved Western Alignment.

RECORD OF BORING AND TESTING

PROJECT : Khulna–Mongla Port Railway Line. | Client : Bangladesh Railway.

Borehole No : EBH-1
Method of Boring : WASH
Boring Dia : 10.16 cm
Depth of Boring : 21.20 m

Existing Ground Level (EGL): 3.425 m PWD
Ground Water Level (GWL) : 0.80 m below EGL
Date Starting : 08.03.13 Time : 01:30 P.M.
Date Completion : 09.03.13 Time : 01:30 P.M.

Soil strata legend : Sand, Peat/organic, Silt, Mica, Clay, Sampling spoon sample (D), Grit/pea–gravel, Undisturbed sample (U)

Location of boring : E–756382.00, N–2536304.00, Shiromoni.

Sample No.	Type of Sample	Depth below E.G.L.(m)	Thickness (m)	DESCRIPTION OF SOIL STRATA	Soil strata legend	SPT Intervals (meter)	BLOWS ON SPOON PER 15cm PENETRATION 15 cm	15 cm	15 cm	N - Value
D1		1	5.60	Light brown/grey very soft/soft CLAY, trace fine sand, medium plastic (CL)		1.5	1	1	1	2
D2		3				3	1	1	1	2
D3		4				4.5	1	1	2	3
D4		6	1.30	Grey/Dark grey medium stiff CLAY, with decomposed wood, high plastic (CH)		6	2	2	3	5
D5		7	3.10	Grey medium stiff CLAY, trace fine sand, medium plastic (CL)		7.5	2	3	3	6
D6		9				9	3	2	3	5
D7		10	2.80	Dark grey medium stiff CLAY with decomposed wood, high plastic (CH)		10.5	2	2	3	5
D8		12				12	2	3	4	7
D9		13	8.40	Grey medium stiff CLAY, trace fine sand, medium plastic (CL)		13.5	2	3	3	6
D10		15				15	2	3	3	6
D11		16				16.5	2	2	3	5
D12		18				18	2	2	3	5
D13		19				19.5	2	2	3	5
D14		21				21	2	2	3	5
D15		22				22.5				
D16		24				24				
D17		25				25.5				
D18		27				27				
D19		28				28.5				
D20		30				30				

GRAPHICAL REPRESENTATION OF N – VALUES
00 10 20 30 40 50

Geotechnical and Material Laboratory, DDC Ltd.
63/1, New Eskaton Road

Fig: Borehole Log

RECORD OF BORING AND TESTING

PROJECT : Khulna–Mongla Port Railway Line.		Client : Bangladesh Railway.
Borehole No : EBH-2 Method of Boring : WASH Boring Dia : 10.16 cm Depth of Boring : 21.20 m	Existing Ground Level (EGL): 1.875 m PWD Ground Water Level (GWL) : 1.40 m below EGL Date Starting : 09.03.13 Time : 04:00 P.M. Date Completion : 10.03.13 Time : 12:00 P.M.	Soil strata legend : Sand, Peat/organic, Silt, Mica, Clay, Sampling spoon sample (D), Grit/pea-gravel, Undisturbed sample (U)

Location of boring : Ch. 10+000 km, E–761885.00, N–2534046.00, Panigati Uttor Para.

Sample No.	Type of Sample	Depth below E.G.L.(m)	Thickness (m)	DESCRIPTION OF SOIL STRATA	Soil strata legend	SPT Intervals (meter)	BLOWS ON SPOON PER 15cm PENETRATION 15 cm	15 cm	15 cm	N - Value
U1		1	7.00	Brownish grey very soft to soft CLAY, trace fine sand, high pastic (CH)						
D1		2				–1.5	1	1	1	2
D2		3				–3	1	1	2	3
D3		4				–4.5	1	1	1	2
D4		5				–6	1	1	1	2
D5		6	14.20	Grey soft to medium stiff SILT, trace fine sand, low/medium plastic (ML)		–7.5	1	2	2	4
D6		7				–9	1	2	3	5
D7		8				–10.5	1	2	2	4
D8		9				–12	1	2	3	5
D9		10				–13.5	2	2	3	5
D10		11				–15	1	2	3	5
D11		12				–16.5	2	2	3	5
D12		13				–18	2	2	4	6
D13		14				–19.5	2	2	4	6
D14		15				–21	2	2	4	6
D15		16				–22.5				
D16		17				–24				
D17		18				–25.5				
D18		19				–27				
D19		20				–28.5				
D20		21				–30				

GRAPHICAL REPRESENTATION OF N – VALUES: 00 10 20 30 40 50

Geotechnical and Material Laboratory, DDC Ltd.
63/1, New Eskaton Road

Fig: Borehole Log

Note: Description of soil strata based on visual classification tests. It may be changed after laboratory classification tests.

RECORD OF BORING AND TESTING

PROJECT : Khulna–Mongla Port Railway Line.	Client : Bangladesh Railway.

Borehole No : EBH-3
Method of Boring : WASH
Boring Dia : 10.16 cm
Depth of Boring : 21.20 m

Existing Ground Level (EGL): 0.150 m PWD
Ground Water Level (GWL) : 0.70 m below EGL
Date Starting : 10.03.13 Time : 04:00 P.M.
Date Completion : 11.03.13 Time : 10:00 A.M.

Soil strata legend : Sand, Silt, Clay, Grit/pea–gravel, Peat/organic, Mica, Sampling spoon sample (D), Undisturbed sample (U)

Location of boring : Ch. 13+800 km, E–763750.00, N–2532620.00, Laskarpur.

Sample No.	Type of Sample	Depth below E.G.L.(m)	Thickness (m)	DESCRIPTION OF SOIL STRATA	Soil strata legend	SPT Intervals (meter)	BLOWS ON SPOON PER 15cm PENETRATION 15 cm	15 cm	15 cm	N - Value
D1		1	1.80	Light brown soft CLAY, trace fine sand, medium plastic (CL)		1.5	1	2	2	4
D2		3				3	1	2	2	4
D3		4	5.20	Blackish grey organic clayey soil, trace fine sand, high plastic (OH)		4.5	1	2	2	4
D4		6				6	1	2	3	5
D5		7				7.5	2	2	3	5
D6		9				9	2	2	3	5
D7		10				10.5	2	2	3	5
D8		12				12	1	2	2	4
D9		13	14.20	Grey soft/medium stiff/stiff CLAY, trace fine sand, medium plastic (CL)		13.5	2	2	4	6
D10		15				15	2	3	7	10
D11		16				16.5	2	2	3	5
D12		18				18	1	2	2	4
D13		19				19.5	2	2	4	6
D14		21				21	3	3	4	7
D15		22				22.5				
D16		24				24				
D17		25				25.5				
D18		27				27				
D19		28				28.5				
D20		30				30				

GRAPHICAL REPRESENTATION OF N – VALUES
00 10 20 30 40 50

Geotechnical and Material Laboratory, DDC Ltd.
63/1, New Eskaton Road

Fig : Borehole Log

Note: Description of soil strata based on visual classification tests. It may be changed after laboratory classification tests.

RECORD OF BORING AND TESTING

PROJECT : Khulna–Mongla Port Railway Line.		Client : Bangladesh Railway.
Borehole No : EBH-4 Method of Boring : WASH Boring Dia : 10.16 cm Depth of Boring : 12.20 m	Existing Ground Level (EGL): 0.33 m PWD Ground Water Level (GWL) : Date Starting : 11.03.13 Time : 12:00 P.M. Date Completion : 11.03.13 Time : 05:00 P.M.	Soil strata legend : Sand, Peat/organic, Silt, Mica, Clay, Sampling spoon sample (D), Grit/pea-gravel, Undisturbed sample (U)

Location of boring : Ch. 23+400 km, E–769976.00, N–2523820.00, Alaipur.

Sample No.	Type of Sample	STRATIFICATION: Depth below E.G.L.(m)	Thickness (m)	DESCRIPTION OF SOIL STRATA	Soil strata legend	SPT Intervals (meter)	STANDARD PENETRATION TEST (SPT): BLOWS ON SPOON PER 15cm PENETRATION 15 cm	15 cm	15 cm	N - Value
D1		1	7.00	Grey very soft/soft SILT, trace fine sand, low to medium plastic (ML)		1.5	1	1	1	2
D2		3				3	1	1	1	2
D3		4				4.5	1	1	2	3
D4		6				6	1	2	2	4
D5		7	2.80	Grey loose to medium dense SILT, little fine sand, non plastic (ML)		7.5	3	4	5	9
D6		9				9	3	5	6	11
D7		10	2.20	Grey medium dense Fine SAND, trace silt, non plastic (SM)		10.5	10	15	20	35
D8		12				12	14	26	27	53
D9		13				13.5				
D10		15				15				
D11		16				16.5				
D12		18				18				
D13		19				19.5				
D14		21				21				
D15		22				22.5				
D16		24				24				
D17		25				25.5				
D18		27				27				
D19		28				28.5				
D20		30				30				

GRAPHICAL REPRESENTATION OF N – VALUES: 00 10 20 30 40 50

Geotechnical and Material Laboratory, DDC Ltd.
63/1, New Eskaton Road

Fig : Borehole Log

Note: Description of soil strata based on visual classification tests. It may be changed after laboratory classification tests.

RECORD OF BORING AND TESTING

PROJECT : Khulna–Mongla Port Railway Line.		Client : Bangladesh Railway.
Borehole No : EBH-5 Method of Boring : WASH Boring Dia : 10.16 cm Depth of Boring : 15.20 m	Existing Ground Level (EGL): 0.41 m PWD Ground Water Level (GWL) : 1.20 m below EGL Date Starting : 12.03.13 Time : 12:00 A.M. Date Completion : 12.03.13 Time : 05:00 P.M.	Soil strata legend : Sand, Peat/organic, Silt, Mica, Clay, Sampling spoon sample (D), Grit/pea-gravel, Undisturbed sample (U)

Location of boring : Ch. 24+300 km, E–769725.00, N–2523309.00, Shamontosena

Sample No.	Type of Sample	Depth below E.G.L.(m)	Thickness (m)	DESCRIPTION OF SOIL STRATA	Soil strata legend	SPT Intervals (meter)	BLOWS ON SPOON PER 15cm PENETRATION 15 cm	15 cm	15 cm	N - Value
D1		1–2	2.20	Brown very soft CLAY, trace fine sand, medium plastic (CL)		1.5	1	1	1	2
D2		3	4.60	Grey soft CLAY, trace fine sand, low to medium plastic (CL)		3	1	1	2	3
D3		4–5				4.5	1	2	2	4
D4		6				6	2	2	2	4
D5		7–8	8.40	Grey medium dense Fine SAND, trace silt, trace mica, non plastic (SM)		7.5	3	5	6	11
D6		9				9	5	8	8	16
D7		10–11				10.5	5	6	7	13
D8		12				12	5	6	8	14
D9		13–14				13.5	6	7	8	15
D10		15				15	6	8	9	17
D11		16–17				16.5				
D12		18				18				
D13		19–20				19.5				
D14		21				21				
D15		22–23				22.5				
D16		24				24				
D17		25–26				25.5				
D18		27				27				
D19		28–29				28.5				
D20		30				30				

GRAPHICAL REPRESENTATION OF N – VALUES

00 10 20 30 40 50

Geotechnical and Material Laboratory, DDC Ltd.
63/1, New Eskaton Road

Fig : Borehole Log

Note: Description of soil strata based on visual classification tests. It may be changed after laboratory classification tests

RECORD OF BORING AND TESTING

PROJECT : Khulna–Mongla Port Railway Line.		Client : Bangladesh Railway.
Borehole No : EBH-6 Method of Boring : WASH Boring Dia : 10.16 cm Depth of Boring : 09.20 m	Existing Ground Level (EGL): Ground Water Level (GWL) : 2.40 m below EGL Date Starting : 11.03.13 Time : 12:30 P.M. Date Completion : 11.03.13 Time : 05:00 P.M.	Soil strata legend : Sand, Peat/organic, Silt, Mica, Clay, Sampling spoon sample (D), Grit/pea-gravel, Undisturbed sample (U)

Location of boring : Ch. 35+000 km, E–772440.00, N–2513118.00, Chulkati.

Sample No.	Type of Sample	Depth below E.G.L.(m)	Thickness (m)	DESCRIPTION OF SOIL STRATA	Soil strata legend	SPT Intervals (meter)	BLOWS ON SPOON PER 15cm PENETRATION 15 cm	15 cm	15 cm	N - Value
D1		1–3	5.20	Light brown loose/medium dense Fine SAND, trace silt, trace mica, non plastic (SM)		1.5	3	4	5	9
D2		3–5				3	5	6	10	16
D3		4–5				4.5	6	8	12	20
D4		6–7	4.00	Grey medium dense Fine SAND, trace silt, trace mica, non plastic (SM)		6	6	8	13	21
D5		7–8				7.5	6	7	11	18
D6		9				9	4	6	7	13
D7		10–11				10.5				
D8		12				12				
D9		13–14				13.5				
D10		15–16				15				
D11		16–17				16.5				
D12		18–19				18				
D13		19–20				19.5				
D14		21–22				21				
D15		22–23				22.5				
D16		24–25				24				
D17		25–26				25.5				
D18		27–28				27				
D19		28–29				28.5				
D20		30				30				

GRAPHICAL REPRESENTATION OF N – VALUES

00 10 20 30 40 50

Geotechnical and Material Laboratory, DDC Ltd.
63/1, New Eskaton Road

Fig : Borehole Log

Note: Description of soil strata based on visual classification tests. It may be changed after laboratory classification tests

RECORD OF BORING AND TESTING

PROJECT : Khulna–Mongla Port Railway Line.		Client : Bangladesh Railway.
Borehole No : EBH-7 Method of Boring : WASH Boring Dia : 10.16 cm Depth of Boring : 18.20 m	Existing Ground Level (EGL): Ground Water Level (GWL) : 0.45 m below EGL Date Starting : 10.03.13 Time : 08:00 A.M. Date Completion : 10.03.13 Time : 01:30 P.M.	Soil strata legend : Sand, Peat/organic, Silt, Mica, Clay, Sampling spoon sample (D), Grit/pea-gravel, Undisturbed sample (U)

Location of boring : Ch. 55+100 km, E–766433.00, N–2495472.00, Digraj Apabari.

Sample No.	Type of Sample	Depth below E.G.L.(m)	Thickness (m)	DESCRIPTION OF SOIL STRATA	Soil strata legend	SPT Intervals (meter)	BLOWS ON SPOON PER 15cm PENETRATION 15 cm	15 cm	15 cm	N - Value
D1		1–2	5.60	Grey very soft CLAY, trace fine sand, medium plastic (CL)		1.5	1	1	1	2
D2		3				3	1	1	1	2
D3		4–5				4.5	1	1	1	2
D4		6	2.80	Grey stiff SILT, trace fine sand, slight plastic (ML)		6	2	5	6	11
D5		7–8				7.5	4	5	7	12
D6		9	9.40	Grey medium dense Fine SAND, little silt, trace mica, non plastic (SM)		9	5	6	9	15
D7		10–11				10.5	5	7	8	15
D8		12				12	4	7	12	19
D9		13–14				13.5	4	8	13	21
D10		15				15	5	8	11	19
D11		16–17				16.5	5	7	10	17
D12		18	0.2	Grey stiff SILT, trace fine sand, low plastic (ML)		18	2	4	5	9
D13		19–20				19.5				
D14		21				21				
D15		22–23				22.5				
D16		24				24				
D17		25–26				25.5				
D18		27				27				
D19		28–29				28.5				
D20		30				30				

GRAPHICAL REPRESENTATION OF N – VALUES

00 10 20 30 40 50

Geotechnical and Material Laboratory, DDC Ltd.
63/1, New Eskaton Road

Fig : Borehole Log

Note: Description of soil strata based on visual classification tests. It may be changed after laboratory classification tests.

RECORD OF BORING AND TESTING

PROJECT : Khulna–Mongla Port Railway Line.		Client : Bangladesh Railway.
Borehole No : WBH-1 Method of Boring : WASH Boring Dia : 10.16 cm Depth of Boring : 21.20 m	Existing Ground Level (EGL): 0.83 m PWD Ground Water Level (GWL) : 0.40 m below EGL Date Starting : 13.03.13 Time : 11:30 A.M. Date Completion : 13.03.13 Time : 04:40 P.M.	Soil strata legend : Sand, Peat/organic, Silt, Mica, Clay, Sampling spoon sample (D), Grit/pea-gravel, Undisturbed sample (U)

Location of boring : Ch. 09+125 km, E–755275.00, N–2531383.00, Arongghata.

Sample No.	Type of Sample	STRATIFICATION: Depth below E.G.L.(m)	Thickness (m)	DESCRIPTION OF SOIL STRATA	Soil strata legend	STANDARD PENETRATION TEST (SPT): SPT Intervals (meter)	BLOWS ON SPOON PER 15cm PENETRATION: 15 cm	15 cm	15 cm	N - Value
D1		1	6.80	Grey very loose Fine SAND, little silt, trace mica, non plastic (SM)		1.5	1	1	2	3
D2		3				3	1	1	2	3
D3		4				4.5	3	3	5	8
D4		6				6	3	4	6	10
D5		7	10.40	Grey very loose/loose/medium dense SILT, trace fine sand, trace mica, non plastic (ML)		7.5	1	1	2	3
D6		9				9	1	1	2	3
D7		10				10.5	2	2	4	6
D8		12				12	2	3	4	7
D9		13				13.5	2	3	3	6
D10		15				15	3	4	7	11
D11		16				16.5	2	3	5	8
D12		18	4.00	Grey stiff CLAY, trace fine sand, low to medium plastic (CL)		18	2	3	5	8
D13		19				19.5	2	3	6	9
D14		21				21	3	3	4	7
D15		22				22.5				
D16		24				24				
D17		25				25.5				
D18		27				27				
D19		28				28.5				
D20		30				30				

GRAPHICAL REPRESENTATION OF N – VALUES: 00 10 20 30 40 50

Geotechnical and Material Laboratory, DDC Ltd.
63/1, New Eskaton Road

Fig : Borehole Log

Note: Description of soil strata based on visual classification tests. It may be changed after laboratory classification tests.

RECORD OF BORING AND TESTING

PROJECT : Khulna–Mongla Port Railway Line.		Client : Bangladesh Railway.
Borehole No : WBH-2 Method of Boring : WASH Boring Dia : 10.16 cm Depth of Boring : 21.20 m	Existing Ground Level (EGL): 0.96 m PWD Ground Water Level (GWL) : 1.20 m below EGL Date Starting : 08.03.13 Time : 03:00 P.M. Date Completion : 09.03.13 Time : 01:30 P.M.	Soil strata legend : Sand, Peat/organic, Silt, Mica, Clay, Sampling spoon sample (D), Grit/pea–gravel, Undisturbed sample (U)
Location of boring : Chainage 22+575, E–762730.00, N–2520831.00, Putimari.		

Sample No.	Type of Sample	Depth below E.G.L.(m)	Thickness (m)	DESCRIPTION OF SOIL STRATA	Soil strata legend	SPT Intervals (meter)	BLOWS ON SPOON PER 15cm PENETRATION 15 cm	15 cm	15 cm	N - Value
D1		1	1.80	Grey very soft SILT, trace fine sand, low plastic (ML)		–1.5	1	1	1	2
D2		3	1.80	Blackish organic clayey soil, high plastic (OH)		–3	1	1	2	3
D3		4	4.40	Grey very soft/soft CLAY, trace fine sand, medium plastic (CL)		–4.5	1	1	2	3
D4		6				–6	1	1	1	2
D5		7				–7.5	1	1	1	2
D6		9	5.80	Grey loose SILT, trace fine sand, trace mica, non plastic (ML)		–9	2	4	5	9
D7		10				–10.5	2	3	5	8
D8		12				–12	2	3	4	7
D9		13				–13.5	3	3	3	6
D10		15	7.40	Grey medium dense Fine SAND, some silt, trace mica, non plastic (SM)		–15	5	5	9	14
D11		16				–16.5	5	6	10	16
D12		18				–18	6	8	12	20
D13		19				–19.5	5	6	9	15
D14		21				–21	5	6	10	16
D15		22				–22.5				
D16		24				–24				
D17		25				–25.5				
D18		27				–27				
D19		28				–28.5				
D20		30				–30				

GRAPHICAL REPRESENTATION OF N – VALUES

00 10 20 30 40 50

Geotechnical and Material Laboratory, DDC Ltd.
63/1, New Eskaton Road

Fig : Borehole Log

RECORD OF BORING AND TESTING

PROJECT : Khulna–Mongla Port Railway Line. | Client : Bangladesh Railway.

Borehole No : WBH-3
Method of Boring : WASH
Boring Dia : 10.16 cm
Depth of Boring : 18.20 m

Existing Ground Level (EGL): 0.85 m PWD
Ground Water Level (GWL) : Same as EGL
Date Starting : 12.03.13 Time : 11:00 A.M.
Date Completion : 12.03.13 Time : 04:00 P.M.

Soil strata legend : Sand, Silt, Clay, Grit/pea-gravel, Peat/organic, Mica, Sampling spoon sample (D), Undisturbed sample (U)

Location of boring : Ch. 27+400 km, E–766744.00, N–2518483.00, Narankhali.

Sample No.	Type of Sample	Depth below E.G.L.(m)	Thickness (m)	DESCRIPTION OF SOIL STRATA	Soil strata legend	SPT Intervals (meter)	BLOWS ON SPOON PER 15cm PENETRATION 15 cm	15 cm	15 cm	N - Value
U1		1	3.80	Grey very soft CLAY, trace fine sand, medium plastic (CL)		1.5	1	1	1	2
D1		2								
U2		3				3	1	1	1	2
D2										
D3		4	1.40	Blackish soft organic clayey soil, high plastic (OH)		4.5	1	1	2	3
		5								
D4		6	1.80	Grey medium stiff SILT, trace fine sand, low plastic (ML)		6	2	3	4	7
		7								
D5		8	7.80	Grey medium dense Fine SAND, little silt, trace mica, non plastic (SM)		7.5	4	5	6	11
D6		9				9	4	6	7	13
D7		10				10.5	3	5	6	11
		11								
D8		12				12	3	5	7	12
		13								
D9		14	5.20	Grey medium stiff CLAY, trace fine sand, medium plastic (CL)		13.5	2	3	3	6
D10		15				15	2	2	3	5
		16								
D11		17				16.5	2	3	3	6
D12		18				18	3	3	4	7
D13		19				19.5				
		20								
D14		21				21				
D15		22				22.5				
		23								
D16		24				24				
D17		25				25.5				
		26								
D18		27				27				
		28								
D19		29				28.5				
D20		30				30				

GRAPHICAL REPRESENTATION OF N – VALUES
00 10 20 30 40 50

Geotechnical and Material Laboratory, DDC Ltd.
63/1, New Eskaton Road

Fig : Borehole Log

Note: Description of soil strata based on visual classification tests. It may be changed after laboratory classification tests

RECORD OF BORING AND TESTING

PROJECT : Khulna–Mongla Port Railway Line.		Client : Bangladesh Railway.
Borehole No : WBH-4 Method of Boring : WASH Boring Dia : 10.16 cm Depth of Boring : 15.20 m	Existing Ground Level (EGL): Ground Water Level (GWL) : 0.18 m below EGL Date Starting : 10.03.13 Time : 03:00 P.M. Date Completion : 11.03.13 Time : 10:00 A.M.	Soil strata legend : Sand, Peat/organic, Silt, Mica, Clay, Sampling spoon sample (D), Grit/pea-gravel, Undisturbed sample (U)

Location of boring : Ch. 45+500 km, E–771429.00, N–2503525.00, Bhaga.

Sample No.	Type of Sample	Depth below E.G.L.(m)	Thickness (m)	DESCRIPTION OF SOIL STRATA	Soil strata legend	SPT Intervals (meter)	BLOWS ON SPOON PER 15cm PENETRATION 15 cm	15 cm	15 cm	N - Value
D1		1	13.00	Grey very soft CLAY, trace fine sand, medium plastic (CL)		1.5	1	1	1	2
D2		3				3	1	1	1	2
D3		4				4.5	1	0	1	1
D4		6				6	1	0	1	1
D5		7				7.5	1	1	1	2
D6		9				9	1	1	1	2
D7		10				10.5	1	1	1	2
D8		12				12	1	0	1	1
D9		13	2.20	Grey medium dense Fine SAND, trace silt, trace mica, non plastic (SM)		13.5	6	6	7	13
D10		15				15	7	7	8	15
D11		16				16.5				
D12		18				18				
D13		19				19.5				
D14		21				21				
D15		22				22.5				
D16		24				24				
D17		25				25.5				
D18		27				27				
D19		28				28.5				
D20		30				30				

GRAPHICAL REPRESENTATION OF N – VALUES

00 10 20 30 40 50

Geotechnical and Material Laboratory, DDC Ltd.
63/1, New Eskaton Road

Fig : Borehole Log

Note: Description of soil strata based on visual classification tests. It may be changed after laboratory classification tests.

Economic Analysis - Modified Alignment 'C' (Eastern Alignment)

(in Lac Taka)

Year	Project Cost					Project Benefit						Net Benefit
	Const. Cost	R & M*	Social	Env.	Total Cost	Savg. in Opt. Cost	Savg. in Time	Net Income**	Coal Traffic	Induced Traffic	Total Benefit	
2014-15	69232	0	12397	57	81686	0	0	0	0	0	0	-81686
2015-16	128574	0	23023	106	151703	0	0	0	0	0	0	-151703
2016-17		0.0004			0.0004	16148	537	2237	2692	834	22448	22448
2017-18		0.0004			0.0004	17162	572	2371	2692	887	23685	23685
2018-19		0.0004			0.0004	18057	610	2514	4285	933	26398	26398
2019-20		0.0004			0.0004	18998	649	2664	4285	982	27579	27579
2020-21		0.0004			0.0004	22043	698	2824	7581	1137	34282	34282
2021-22		0.0004			0.0004	23115	732	2994	7581	1192	35614	35614
2022-23		0.0004			0.0004	24242	768	3173	9174	1251	38608	38608
2023-24		0.0004			0.0004	25425	807	3364	9174	1312	40081	40081
2024-25		0.0004			0.0004	26668	847	3566	9174	1376	41630	41630
2025-26		0.0004			0.0004	27969	884	3780	12964	1443	47040	47040
2026-27		0.0004			0.0004	29336	924	4006	12964	1513	48743	48743
2027-28		0.0004			0.0004	30772	965	4247	12964	1587	50535	50535
2028-29		0.0004			0.0004	32280	1008	4502	12964	1664	52418	52418
2029-30		0.0004			0.0004	33864	1054	4772	12964	1746	54400	54400
2030-31		0.0004			0.0004	35541	1095	5058	12964	1832	56490	56490
2031-32		0.0004			0.0004	37302	1139	5361	12964	1922	58688	58688
2032-33		0.0004			0.0004	39154	1184	5683	12964	2017	61002	61002
2033-34		0.0004			0.0004	41100	1230	6024	12964	2117	63435	63435
2034-35		0.0004			0.0004	43146	1279	6386	12964	2221	65996	65996
2035-36		0.0004			0.0004	45297	1330	6769	12964	2331	68691	68691
2036-37		0.0004			0.0004	47555	1382	7175	12964	2447	71524	71524
2037-38		0.0004			0.0004	49926	1437	7605	12964	2568	74501	74501
2038-39		0.0004			0.0004	52415	1494	8062	12964	2695	77630	77630
2039-40		0.0004			0.0004	55028	1553	8545	12964	2829	80920	80920
2040-41		0.0004			0.0004	57772	1614	9058	12964	2969	84377	84377
2041-42		0.0004			0.0004	57772	1614	9058	12964	2969	84377	84377
2042-43		0.0004			0.0004	57772	1614	9058	12964	2969	84377	84377
2043-44		0.0004			0.0004	57772	1614	9058	12964	2969	84377	84377
2044-45		0.0004			0.0004	57772	1614	9058	12964	2969	84377	84377
2045-46	-19781	0.0004			-19781	57772	1614	9058	12964	2969	84377	104158

*** Repairs & Maintenance** **** Net Income from Nepal & Bhutan Traffic**

EIRR	**15.10%**
NPV(@15%)	**1,547**
B/C Ratio	**1.01**

Appendix 10.2

Economic Analysis - Alignment 'E' (Western Alignment)

(in Lac Taka)

Year	Project Cost					Project Benefit						Net Benefit
	Const. Cost	R & M*	Social	Env.	Total Cost	Savg. in Opt. Cost	Savg. in Time	Net Income**	Coal Traffic	Induced Traffic	Total Benefit	
2014-15	53074	0	13440	57	66572	0	0	0	0	0	0	-66572
2015-16	98567	0	24961	107	123634	0	0	0	0	0	0	-123634
2016-16		0.0004			0.0004	16502	615	2237	2692	856	22901	22901
2017-18		0.0004			0.0004	17544	657	2371	2692	910	24174	24174
2018-19		0.0004			0.0004	18469	701	2514	4285	958	26927	26927
2019-20		0.0004			0.0004	19444	748	2664	4285	1010	28150	28150
2020-21		0.0004			0.0004	22515	802	2824	7581	1166	34887	34887
2021-22		0.0004			0.0004	23616	842	2994	7581	1223	36256	36256
2022-23		0.0004			0.0004	24772	885	3173	9174	1283	39288	39288
2023-24		0.0004			0.0004	25987	930	3364	9174	1346	40801	40801
2024-25		0.0004			0.0004	27264	978	3566	9174	1412	42394	42394
2025-26		0.0004			0.0004	28595	1022	3780	12964	1481	47842	47842
2026-27		0.0004			0.0004	29993	1069	4006	12964	1553	49585	49585
2027-28		0.0004			0.0004	31462	1117	4247	12964	1629	51419	51419
2028-29		0.0004			0.0004	33004	1168	4502	12964	1709	53347	53347
2029-30		0.0004			0.0004	34625	1221	4772	12964	1792	55375	55375
2030-31		0.0004			0.0004	36332	1270	5058	12964	1880	57504	57504
2031-32		0.0004			0.0004	38125	1320	5361	12964	1972	59743	59743
2032-33		0.0004			0.0004	40010	1372	5683	12964	2069	62098	62098
2033-34		0.0004			0.0004	41990	1426	6024	12964	2171	64576	64576
2034-35		0.0004			0.0004	44072	1483	6386	12964	2278	67182	67182
2035-36		0.0004			0.0004	46260	1542	6769	12964	2390	69925	69925
2036-37		0.0004			0.0004	48557	1603	7175	12964	2508	72806	72806
2037-38		0.0004			0.0004	50967	1666	7605	12964	2632	75835	75835
2038-39		0.0004			0.0004	53498	1732	8062	12964	2761	79017	79017
2039-40		0.0004			0.0004	56154	1801	8545	12964	2898	82362	82362
2040-41		0.0004			0.0004	58942	1872	9058	12964	3041	85876	85876
2041-42		0.0004			0.0004	58942	1872	9058	12964	3041	85876	85876
2042-43		0.0004			0.0004	58942	1872	9058	12964	3041	85876	85876
2043-44		0.0004			0.0004	58942	1872	9058	12964	3041	85876	85876
2044-45		0.0004			0.0004	58942	1872	9058	12964	3041	85876	85876
2045-46	-15164	0.0004			-15164	58942	1872	9058	12964	3041	85876	101041

*** Repairs & Maintenance** **** Net Income from Nepal & Bhutan Traffic**

EIRR	**17.84%**
NPV (@15%)	**39,326**
B/C Ratio	**1.26**

Appendix 10.3

Economic Analysis - Alignment 'H' (Central Alignment)

(in Lac Taka)

Year	Project Cost					Project Benefit						Net Benefit
	Const. Cost	R & M*	Social	Env.	Total Cost	Savg. in Opt. Cost	Savg. in Time	Net Income**	Coal Traffic	Induced Traffic	Total Benefit	
2014-15	56998	0	14342	49	71389	0	0	0	0	0	0	-71389
2015-16	105853	0	26635	91	132579	0	0	0	0	0	0	-132579
2016-16		0.0004			0.0004	16502	615	2237	2692	856	22901	22901
2017-18		0.0004			0.0004	17544	657	2371	2692	910	24174	24174
2018-19		0.0004			0.0004	18469	701	2514	4285	958	26927	26927
2019-20		0.0004			0.0004	19444	748	2664	4285	1010	28150	28150
2020-21		0.0004			0.0004	22515	802	2824	7581	1166	34887	34887
2021-22		0.0004			0.0004	23616	842	2994	7581	1223	36256	36256
2022-23		0.0004			0.0004	24772	885	3173	9174	1283	39288	39288
2023-24		0.0004			0.0004	25987	930	3364	9174	1346	40801	40801
2024-25		0.0004			0.0004	27264	978	3566	9174	1412	42394	42394
2025-26		0.0004			0.0004	28595	1022	3780	12964	1481	47842	47842
2026-27		0.0004			0.0004	29993	1069	4006	12964	1553	49585	49585
2027-28		0.0004			0.0004	31462	1117	4247	12964	1629	51419	51419
2028-29		0.0004			0.0004	33004	1168	4502	12964	1709	53347	53347
2029-30		0.0004			0.0004	34625	1221	4772	12964	1792	55375	55375
2030-31		0.0004			0.0004	36332	1270	5058	12964	1880	57504	57504
2031-32		0.0004			0.0004	38125	1320	5361	12964	1972	59743	59743
2032-33		0.0004			0.0004	40010	1372	5683	12964	2069	62098	62098
2033-34		0.0004			0.0004	41990	1426	6024	12964	2171	64576	64576
2034-35		0.0004			0.0004	44072	1483	6386	12964	2278	67182	67182
2035-36		0.0004			0.0004	46260	1542	6769	12964	2390	69925	69925
2036-37		0.0004			0.0004	48557	1603	7175	12964	2508	72806	72806
2037-38		0.0004			0.0004	50967	1666	7605	12964	2632	75835	75835
2038-39		0.0004			0.0004	53498	1732	8062	12964	2761	79017	79017
2039-40		0.0004			0.0004	56154	1801	8545	12964	2898	82362	82362
2040-41		0.0004			0.0004	58942	1872	9058	12964	3041	85877	85877
2041-42		0.0004			0.0004	58942	1872	9058	12964	3041	85877	85877
2042-43		0.0004			0.0004	58942	1872	9058	12964	3041	85877	85877
2043-44		0.0004			0.0004	58942	1872	9058	12964	3041	85877	85877
2044-45		0.0004			0.0004	58942	1872	9058	12964	3041	85877	85877
2045-46	-16285	0.0004			-16285	58942	1872	9058	12964	3041	85877	102162

*** Repairs & Maintenance** **** Net Income from Nepal & Bhutan Traffic**

EIRR	**16.94%**
NPV (@15%)	**28,387**
B/C Ratio	**1.18**

Financial Analysis - Modified Alignment 'C' (Eastern Alignment)

(in Lac Taka)

Year	Project Cost			Revevue Income				Net Income
	Const. Cost	Operating Cost	Total Cost	Freight	Passenger	Misc. Earnings	Total Imcome	
2014-15	86540	0	86540	0	0	0	0	-86540
2015-16	160717	0	160717	0	0	0	0	-160717
2016-17		24846	24846	42509	778	2164	45451	20605
2017-18		26137	26137	44489	840	2266	47595	21458
2018-19		30535	30535	53272	907	2709	56888	26353
2019-20		31820	31820	55223	980	2810	59013	27193
2020-21		41627	41627	74976	1038	3801	79815	38188
2021-22		43051	43051	77219	1101	3916	82236	39184
2022-23		47740	47740	86523	1167	4384	92074	44334
2023-24		49326	49326	89018	1237	4513	94767	45442
2024-25		50999	50999	91650	1311	4648	97609	46610
2025-26		60295	60295	110916	1377	5615	117908	57613
2026-27		62103	62103	113826	1445	5764	121035	58932
2027-28		64008	64008	116894	1518	5921	124333	60325
2028-29		66015	66015	120131	1594	6086	127810	61795
2029-30		68131	68131	123544	1673	6261	131478	63347
2030-31		70313	70313	127144	1740	6444	135329	65016
2031-32		72611	72611	130942	1810	6638	139389	66779
2032-33		75031	75031	134948	1882	6842	143672	68641
2033-34		77580	77580	139174	1957	7057	148188	70608
2034-35		80265	80265	143633	2036	7283	152952	72687
2035-36		83094	83094	148336	2117	7523	157976	74882
2036-37		86023	86023	153194	2202	7770	163166	77143
2037-38		89054	89054	158211	2290	8025	168526	79472
2038-39		92193	92193	163392	2382	8289	174062	81870
2039-40		95442	95442	168743	2477	8561	179781	84339
2040-41		98806	98806	174269	2576	8842	185687	86881
2041-42		98806	98806	174269	2576	8842	185687	86881
2042-43		98806	98806	174269	2576	8842	185687	86881
2043-44		98806	98806	174269	2576	8842	185687	86881
2044-45		98806	98806	174269	2576	8842	185687	86881
2045-46	-24725.7	98806	74080	174269	2576	8842	185687	111607
							FIRR	**15.32%**
							NPV (@15%)	**5,607**
							B/C Ratio	**1.01**

Appendix 11.2

Financial Analysis - Alignment 'E' (Western Alignment)

(in Lac Taka)

Year	Project Cost			Revenue Income				Net Income
	Const. Cost	Operating Cost	Total Cost	Freight	Passenger	Misc. Earnings	Total Income	
2014-15	66343		66343	0	0	0	0	-66343
2015-16	123208		123208	0	0	0	0	-123208
2016-16		24846	24846	42509	803	2166	45478	20631
2017-18		26137	26137	44489	1014	2275	47777	21640
2018-19		30535	30535	53272	1095	2718	57085	26550
2019-20		31820	31820	55223	1182	2820	59226	27405
2020-21		41627	41627	74976	1277	3813	80065	38438
2021-22		43051	43051	77219	1353	3929	82501	39449
2022-23		47740	47740	86523	1435	4398	92355	44615
2023-24		49326	49326	89018	1521	4527	95065	45740
2024-25		50999	50999	91650	1612	4663	97925	46926
2025-26		60295	60295	110916	1709	5631	118256	57961
2026-27		62103	62103	113826	1794	5781	121401	59298
2027-28		64008	64008	116894	1884	5939	124717	60709
2028-29		66015	66015	120131	1978	6105	128214	62199
2029-30		68131	68131	123544	2077	6281	131902	63771
2030-31		70313	70313	127144	2181	6466	135791	65478
2031-32		72611	72611	130942	2268	6660	139870	67260
2032-33		75031	75031	134948	2359	6865	144172	69141
2033-34		77580	77580	139174	2453	7081	148708	71129
2034-35		80265	80265	143633	2551	7309	153493	73228
2035-36		83094	83094	148336	2653	7549	158539	75445
2036-37		86023	86023	153194	2759	7798	163751	77729
2037-38		89054	89054	158211	2870	8054	169135	80080
2038-39		92193	92193	163392	2984	8319	174696	82503
2039-40		95442	95442	168743	3104	8592	180439	84997
2040-41		98806	98806	174269	3228	8875	186372	87566
2041-42		98806	98806	174269	3228	8875	186372	87566
2042-43		98806	98806	174269	3228	8875	186372	87566
2043-44		98806	98806	174269	3228	8875	186372	87566
2044-45		98806	98806	174269	3228	8875	186372	87566
2045-46	-18955.1	98806	79851	174269	3228	8875	186372	106521
							FIRR	**18.65%**
							NPV (@15%)	**52,807**
							B/C Ratio	**1.14**

Financial Analysis - Alignment 'H' (Central Alignment) Annex. 11.3

(in Lac Taka)

Year	Project Cost			Revevue Income				Net Income
	Const. Cost	Operating Cost	Total Cost	Freight	Passenger	Misc. Earnings	Total Imcome	
2014-15	71247	0	71247	0	0	0	0	-71247
2015-16	132316	0	132316	0	0	0	0	-132316
2016-17		24846	24846	42509	803	2166	45478	20631
2017-18		26137	26137	44489	1014	2275	47777	21640
2018-19		30535	30535	53272	1095	2718	57085	26550
2019-20		31820	31820	55223	1182	2820	59226	27405
2020-21		41627	41627	74976	1277	3813	80065	38438
2021-22		43051	43051	77219	1353	3929	82501	39449
2022-23		47740	47740	86523	1435	4398	92355	44615
2023-24		49326	49326	89018	1521	4527	95065	45740
2024-25		50999	50999	91650	1612	4663	97925	46926
2025-26		60295	60295	110916	1709	5631	118256	57961
2026-27		62103	62103	113826	1794	5781	121401	59298
2027-28		64008	64008	116894	1884	5939	124717	60709
2028-29		66015	66015	120131	1978	6105	128214	62199
2029-30		68131	68131	123544	2077	6281	131902	63771
2030-31		70313	70313	127144	2181	6466	135791	65478
2031-32		72611	72611	130942	2268	6660	139870	67260
2032-33		75031	75031	134948	2359	6865	144172	69141
2033-34		77580	77580	139174	2453	7081	148708	71129
2034-35		80265	80265	143633	2551	7309	153493	73228
2035-36		83094	83094	148336	2653	7549	158539	75445
2036-37		86023	86023	153194	2759	7798	163751	77729
2037-38		89054	89054	158211	2870	8054	169135	80080
2038-39		92193	92193	163392	2984	8319	174696	82503
2039-40		95442	95442	168743	3104	8592	180439	84997
2040-41		98806	98806	174269	3228	8875	186372	87566
2041-42		98806	98806	174269	3228	8875	186372	87566
2042-43		98806	98806	174269	3228	8875	186372	87566
2043-44		98806	98806	174269	3228	8875	186372	87566
2044-45		98806	98806	174269	3228	8875	186372	87566
2045-46	-203563	98806	-104757	174269	3228	8875	186372	291129
							FIRR	**17.80%**
							NPV(@15%)	**43,764**
							B/C Ratio	**1.11**

Government of People's Republic of Bangladesh
Office of the Engineer-in-Chief/Project
Bangladesh Railway, CRB, Chittagong

N0: ENC/P/AGT/K-M/01 DATED: 03.06.2013

TO
Mr. R.K. Khanka
Team Leader
Consulting Engineers Group Ltd.
in association with Nippon Koei India Pvt. Ltd,
E-12, Moji Colony, Malviya Nagar,
Jaipur-302017, Rajasthan,
India.
Email; ceg@cegindia.com

Sub : SD1:Consultancy services for the purpose of Construction of Khulna – Mongla Sea Port under Phase-I: Detailed Feasibility Study & Safeguard Policy Study, Phase-II Detailed Engineering Design & bidding Services, Phase-III: Construction Supervision Services" as per TOR. Under Indian Dollar Credit Line Agreement.

Ref :
1. Letter of Acceptance 54.01.0000.006.014.20.2011-307 Dated:-03-06-2012
2. EXIM BANK OF INDIA's Contract Approval No GOILOC-134 [7] vide letter no GOILOC-134/12/1413 Dated 01/10/2012.
3. Ministry of Railways (DEV.-1)'s Letter No 54.00.0000.013.014.34.2013-457 Dated 02.06.2013.

Dear sir,

This is to inform you that **Western Alignment** approved by the Ministry of Railways and confirmed through letter under reference 3.

Now you are hereby requested to complete the balance work as per TOR accordingly.

Thanking You
3.6.13
Md. Khairul Alam
Engineer-in-Chief/Project
& Project Director
Bangladesh Railway, CRB
Chittagong.
Email.encp@railway.gov.bd

Copy is forwarded for information please to;
1. PS to DG, Bangladesh Railway, Railbhaban, Dhaka.
2. General Manager/Project, Bangladesh Railway, Railbhaban, Dhaka.
3. Mr. Bishwas Jain, Managing Director, CEG-NKI JV.
4. Mr. Nurul Amin, Deputy Team Leader CEG-NKI JV.