FINAL FEASIBILITY REPORT

Consultancy Services for Preparation of Two-stage

Detailed Project Report (DPR) of Cluster 4 of Proposed 53 National Waterways

Budha Balanga (NW 23)

FEEDBACK INFRA (P) LIMITED

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Abbreviations

BM	Bench Mark
CAD	Computer Aided Design
CD	Chart Datum
CH	Chainage
CRZ	Coastal Regulation Zone
CWC	Central Water Commission
DF	Dual Frequency
DGLL	Directorate General of Lighthouses and Lightships
DGPS	Differential Global Positioning System
DPR	Detailed Project Report
DXF	Drawing Interchange Format
GPS	Global Positioning System
HFL	High Flood Level
HTL	High Tension Line
HC	Horizontal Clearance
IWAI	Inland Waterways Authority of India
IWT	Inland Water Transport
km	kilometre
LAT.	Latitude
LONG.	Longitude
m	meter
m/s	meter per second
MSL	Mean Sea level
MTPA	Million Tonnes per Annum
MoEF	Ministry of Environment and Forest
NH	National Highways
NW	National waterways
PWD	Public Works Department
SBES	Single Beam Echo Sounder
SH	State Highways
UTM	Universal Transverse Mercator
VC	Vertical Clearance
WGS	World Geodetic System
PSU	Public Sector Undertaking
USA	United States of America

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CHAPTER 1
EXECUTIVE SUMMARY

1 Executive Summary

A total of 56 km of Budha Balanga river system from Patalipura village to Chandipur fishing harbour was studied. The study mainly consists of carrying out single line bathymetry/topography. The survey was carried out in February 2016. Major inventories like cross structures, dams, barrages and details of these structures in terms of vertical and horizontal clearances were collected. The river was found to have 11bridges and 13 other cross structures. A lot of island formations were observed along the river stretches, mainly of sand, during the survey.

As part of the present study, a preliminary market analysis was also carried out to ascertain the traffic potential along the study stretch. Balasore is the major industrial cluster along the study stretch that can generate the traffic. Aluminium and ferro alloys are the main industries. The total traffic potential estimated is 0.28MTPA in 2015. Chandipur fishing port is located in this stretch. Waterfalls at Joranda and Duduma and wildlife sanctuary at Similipal are potential tourist attractions.The summary of the study along with the major findings are as mentioned below:

Salient Features at a Glance – Budha Balanga River

<table>
<tr><th>S.No.</th><th>Particulars</th><th>Details</th></tr>
<tr><td>1.</td><td>Name of the Consultant</td><td>Feedback Infra Pvt. Ltd.</td></tr>
<tr><td>2.</td><td>Cluster number & States</td><td>Cluster 4 : Odisha</td></tr>
<tr><td>3.</td><td>Waterway stretch, NW#

From ….. to ; total length</td><td>National Waterway no. : 23
Stretch : From Patalipura village to Chandipur Fishing harbour

Total Length : 56 km</td></tr>
<tr><td>4.</td><td>Navigability Status</td><td>Presently no navigation exists.</td></tr>
<tr><td>a)</td><td>Tidal and non-tidal portions

(from ----- to ….. length, average tidal variation)</td><td>i) 38 km stretch upstream from Budha Balanga mouth is under the tidal influence
ii) Average Tidal variation: 2.1m</td></tr>
<tr><td>b)</td><td>i) Survey period (---- to -----)

LAD Status (w.r.t.CD)

ii) < 1.0 m (km)
iii) 1.0m to 1.5m (km)
iv) 1.5m to 2.0 m (km)
v) >2.0m (km)</td><td>i) Survey period: February 2016
ii) LAD status
<table>
<tr><th rowspan="2">Depth (m)</th><th colspan="7">Length of river (km)</th></tr>
<tr><th>0 - 10</th><th>Oct-20</th><th>20 - 30</th><th>30 - 40</th><th>40 - 50</th><th>50 - 56</th><th>Total</th></tr>
<tr><td><1.0</td><td>2.08</td><td>5.85</td><td>3.85</td><td>4.06</td><td>3.23</td><td>0.62</td><td>19.69</td></tr>
<tr><td>1.0-1.5</td><td>5.73</td><td>1.48</td><td>1.87</td><td>2.19</td><td>1.35</td><td>0.58</td><td>13.2</td></tr>
<tr><td>1.5-2.0</td><td>0.83</td><td>0.52</td><td>0.84</td><td>0.83</td><td>1.46</td><td>0.42</td><td>4.9</td></tr>
<tr><td>>2.0</td><td>1.36</td><td>2.15</td><td>3.44</td><td>2.92</td><td>3.96</td><td>4.38</td><td>18.21</td></tr>
</table></td></tr>
<tr><td>c)</td><td>Cross Structures
i) Dams, weirs, barrages etc. (total number; with navigational locks or not)
ii) Bridges, power cables etc. (total number ; range of horizontal and vertical clearance w.r.t. H.F.L)</td><td>i. No barrages

ii. Bridges : 11; HT Lines : 13
Range of Horizontal Clearance: 12-35m
Range of Vertical clearance: 3.5-9.5m</td></tr>
</table>

d)	Avg discharge & no. of days	Avg Discharge: 0.54m^3/s to 2886m^3/s <200 - 312days 200-500 – 36days 500-700 – 7days 700-900 – 4days >900 – 7days
e)	Slope (1 in -----)	1 in 6870
5.	Traffic potential	Total Traffic potential from Balasore – 0.28MTPA for the year 2015
a)	Present IWT operations, ferry services, tourism, cargo, if any	No operations.
b)	Important industries within 50km	Balasore Alloys, Birla Tyres, Alom Extrusion Ltd., Emami Paper Mill
c)	Distance of rail and road from Industry	1 - 4km from main line
6.	Consultant's recommendation for going ahead with Stage-II (DPR preparation)	56km of Budha Balanga can be considered for Stage –II (DPR preparation). As the Divertible Traffic is only estimated at 0.28MTPA, the waterway can be developed for passenger movement. This in turn can improve the connectivity for the population along the waterway, thus, helping in social upliftment of the local population.
7.	Any other information/comments	Chandipur fishing port is located in this stretch. Waterfalls at Joranda and Duduma and wildlife sanctuary at Similipal are potential attractions

CHAPTER 2
INTRODUCTION

2 Introduction

2.1 Inland Waterways Authority of India

Inland Waterways Authority of India (IWAI) was set up on 27th October 1986 in order to develop and regulate the inland waterways for shipping and navigation in India. The Authority primarily undertakes projects for development and maintenance of IWT infrastructure on National Waterways (NW).

2.2 Brief introduction to waterways of India

Given India's long coastline and many waterways, coastal shipping and Inland Water Transport (IWT) segments have huge potential. India has about 14,500 km of navigable waterways which comprise rivers, canals, backwaters, creeks, etc. However, its operations are currently restricted to a few stretches in the Ganga-Bhagirathi-Hooghly Rivers, the Brahmaputra, the Barak River, the rivers in Goa, the backwaters in Kerala, inland waters in Mumbai and the delta in regions of the Godavari-Krishna Rivers. There is a need to promote these environment-friendly and cost-effective modes of transport as these remain largely underutilized accounting for less than 0.5% of total traffic within India.

In a bid to boost transportation of goods and passengers through waterways, the government gave its nod for enactment of legislation for covering 106 river stretches across the country as National Waterways.

2.3 Project overview

Inland Waterways Authority of India (IWAI) initiated the project for preparation of detailed project report of 53 inland waterways in India. The project has been divided into eight clusters and FEEDBACK INFRA Pvt. Ltd. has been engaged for the preparation of Detailed Project Report for cluster 4 which includes the following four river stretches of Odisha:

S.No.	River Name	Total Length	Length under project
1	Baitarani River	360 km	49 km
2	Birupa/Badi Genguti/ Brahamani River	799 km	152 km
3	Budha Balanga	198.75 km	56 km
4	Mahanadi	851 km (494 km in Odisha)	425 km

Table 1: List of the river stretches under study

2.4 Objective of the study

Objective of present study is to explore the potential of rivers in cluster four for year round commercial navigation. To achieve this, the consultant needs to conduct a two stage study, Stage-1 consisting of a feasibility study and recommendations thereafter for a possibility of composite and integrated development of proposed waterways to achieve navigation and to develop water transport facilities in the study area. If feasibility study establishes the scope for navigation and potential to develop waterway transport facility, a Detailed Project Report needs to be prepared for identified feasible waterways and that would include detailed hydrographic surveys, investigation, traffic survey, proposed location for terminals and cost assessment etc.

The present Draft Feasibility Report covers the review of data, reconnaissance survey, present state of affairs, traffic analysis, and available navigable stretches for Budha Balanga River.

2.5 Scope

Scope of Work - Stage 1

Stage-I study consists of conducting feasibility study of the waterway for navigation. Broad scopes of Stage-1 activities are as mentioned below,

a) Reconnaissance Survey
b) Collection and review of available data
c) Feasibility Report

Scope of Work - Stage 2

Stage -2 study consists of preparation of detailed project report for feasible stretch of the river. Broad scope of stage-2 activities are mentioned below.

a) Detailed Hydrographic Survey & hydro-morphological survey
b) Traffic Survey & Techno economic feasibility
c) Preparation of Detailed Project Report

The present study is limited to establish the feasibility of waterways for inland navigation i.e. upto Stage -1 only.

CHAPTER 3
APPROACH & METHODOLOGY

3 Approach & Methodology

3.1 Stage - 1

To successfully deliver the project requirements, the Consultant prepared a stepwise delivery model. The approach and methodology used for Stage -1 studies are as mentioned below:

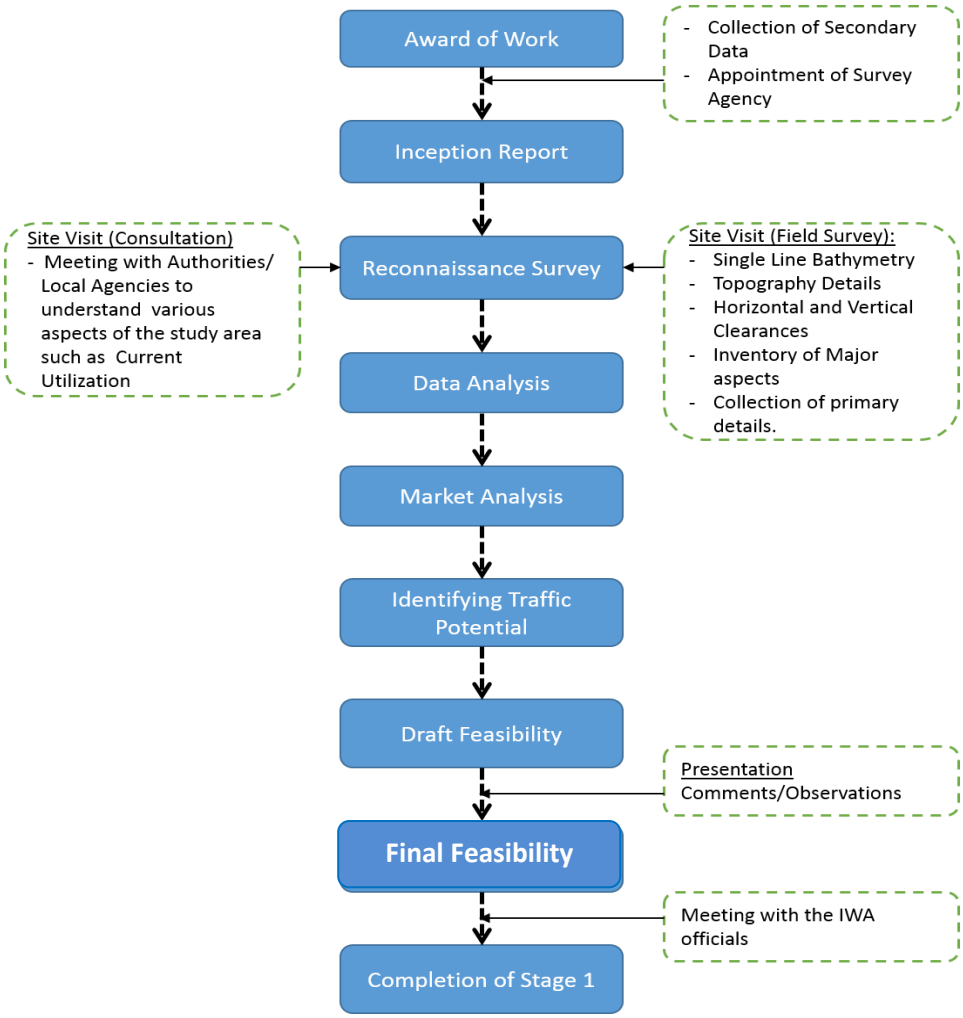


Figure 1: Stage-1 methodology flowchart

Subsequent to award of the assignment, the consultant engaged a survey agency for the collection of the required primary and secondary data. Parallel to the submission of the Inception report, the consultant visited the site for reconnaissance survey, site supervision and stakeholder consultation. Present condition of the rivers was visually assessed. Survey progress was checked and secondary data pertaining to the present river was obtained. The data thus collected was analysed to determine the navigational feasibility of the earmarked river stretches along with the market analysis and the analysis of the traffic potential on the navigable stretches.

CHAPTER 4
STUDY AREA PROFILE

4 Study area profile

Odisha is a state on the eastern seaboard of India, located between 17^0 49' and 22^0 36' North latitudes and between 81^0 36' and $87^0$18' East longitudes. It spreads over an area of 1, 55,707 sq km. It is bounded by West Bengal in north-east, Bihar in the north, Madhya Pradesh in the west, Andhra Pradesh in the south and the Bay of Bengal in the east.

4.1 Physiography

On the basis of homogeneity, continuity and physiographical characteristics, Odisha has been divided into five major morphological regions: the Odisha coastal plain in the east, the middle mountainous and Highlands Region, the Central plateaus, the western rolling uplands and the major flood plains.

The Odisha Coastal Plains are the depositional landforms of recent origin and geologically belong to the post-tertiary period. This region stretches from the West Bengal border.

This region is the combination of several deltas of varied sizes and shapes formed by the major rivers of Odisha, such as the Subarnarekha, the Budhabalanga, the Baitarani, the Brahmani, the Mahanadi, and the Rushikulya. Therefore, the coastal plain of Odisha is called the "Hexadeltaic region".

Middle Mountainous and Highlands Region covers about three-fourth of the entire State. Geologically it is a part of the Indian Peninsula which as a part of the ancient landmass of the Gondwanaland. The major rivers of Odisha with their tributaries have cut deep and narrow valleys. This region mostly comprises the hills and mountains of the eastern ghats which rise abruptly and steeply in the east and slope gently to a dissected plateau in the west running from north-east (Mayurbhanj) to north-west (Malkangirig). This region is well marked by a number of interfluves or watersheds.

The Central plateaus are mostly eroded plateaus forming the western slopes of the Eastern Ghats with elevation varying from 305-610 metres. The Panposh - Keonjhar -Pallahara plateau comprises the Upper Baitarani catchment basin.

The western rolling Uplands are lower in elevation than the plateaus having heights varying from 153 metres to 305 metres.

4.2 Rivers

4.2.1 River System of Odisha

There are four groups of rivers which flow through Odisha into the Bay of Bengal forming the flood plains.

- Rivers with source outside the state (the Subarnarekha, the Brahmani and the Mahanadi)
- Rivers with source inside the state (the Budhabalanga, the Baitarani, the salandi, and the Rusikulya)
- Rivers with source inside the Odisha flow through other states (the Bahudu the Vansadhara, and the Nagavali)

- Rivers with source inside Odisha, but tributary to rivers which flow through other states (the Machkund, the sileru, the Kolab and the Indravati)

The state accommodates the river basins of 12 rivers flowing through the state.

4.2.2 Rivers under Study

The study area includes sections of four main river stretches namely Mahanadi, Baitarani, Budha Balanga, Brahmani, Badi Genguti and Birupa that form part of an elaborate network of rivers flowing through the State of Odisha. Given below is the map of four main stretches earmarked for the study.

Figure 2: Rivers stretches under study

The present Draft Feasibility Report covers the review of data, reconnaissance survey, present state of affairs, traffic analysis, and available navigable stretches for Budha Balanga River.

I. Budha Balanga

The BudhaBalanga originates from the Similipal range of hills in Mayurbhanj district and travels a total length of 198.75 km. before it finally meets Bay of Bengal. Prominent tributaries of the Budhabalanga are Palapala, Sunei, Kalo, Sanjo, Deo, Gangahari and Katra.

56 kms length of the river from Barrage (approx 300m from Patalipura village) at Lat 21°38'12.96"N, Long 86°50'53.17"E to confluence of Budha Balanga river with Bay of Bengal at Chandipur Fishing Port Lat 21°28'12.14"N, Long 87° 4'11.60"E has been earmarked for the present study. The study stretch is as shown in Figure 3-2.

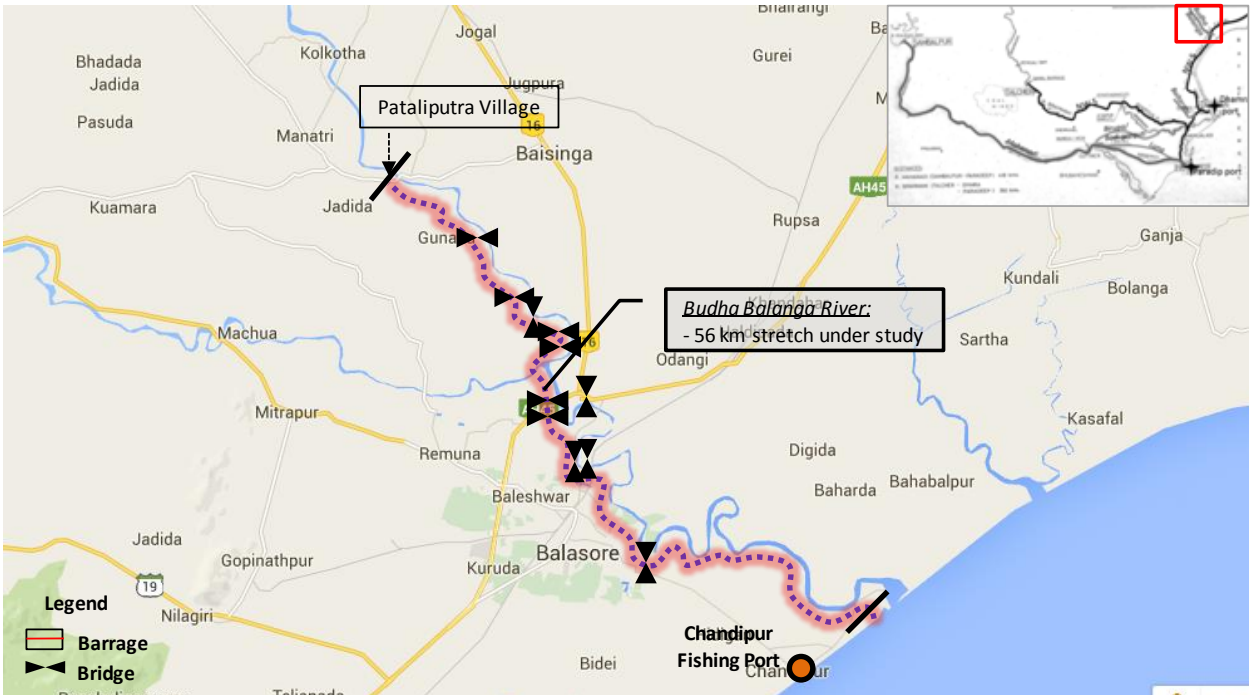


Figure 3: Budha Balanga river stretch under study

4.3 Climate

The state has tropical climate, characterized by high temperature, high humidity, medium to high rainfall and short and mild winters. The south-west monsoon normally sets in the first week of June in the coastal plain, and by first week of July, the whole of the state is under the full sway of the south-west monsoons. By mid-October, the south-west monsoon withdraws completely from Orissa.

4.3.1 Rainfall

The normal rainfall of the state is 1451.2 mm. About 75% to 80% of rainfall is received from June to September. Floods, droughts and cyclones occur almost every year varying intensity. The graph below shows the rainfall trend from 1961 to 2013.

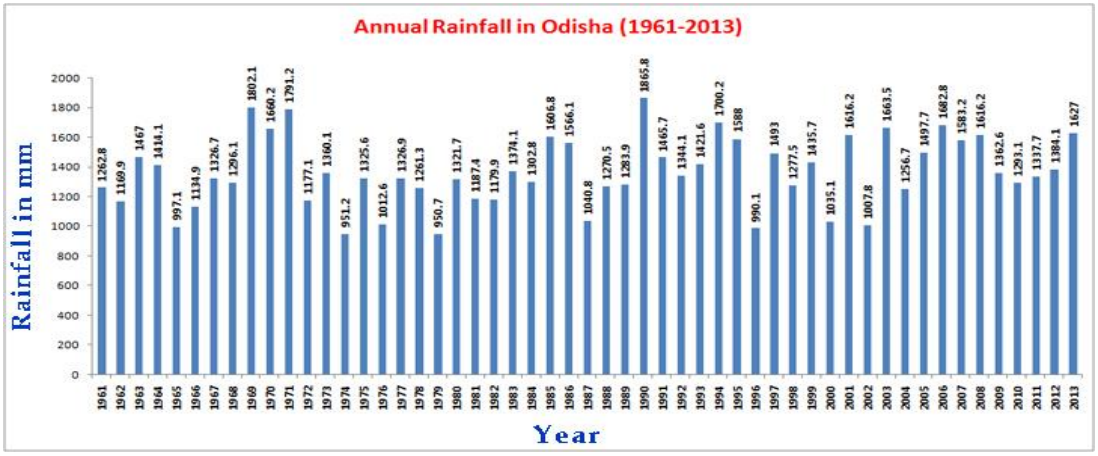


Figure 4: Rainfall trend from 1961-2013

CHAPTER 5
DATA COLLECTION AND SURVEY METHODOLOGY

5 Data Collection and Survey Methodology

5.1 Details of primary and secondary surveys for stage 1

In addition to the methodology flowchart presented, a detailed descriptive methodology of surveys and analysis for stage-1 has also been prepared which further details out the aspects which shall be covered and sample templates of the analysis which shall be carried out.

5.2 Secondary data collection

Consultant carried out secondary data collection from various stakeholders related to the waterway which included various Govt. agencies, PSUs, Central Water Commission etc. Detailed list of stakeholders consulted are as mentioned in Table 2 below:

Central Water Commission	Pollution Control Boards
River Boards	Committees
Survey of India	Census of India
Industry Boards	Statistical Department
MoEF	MoS/ IWAI

Table 2: List of Stakeholders consulted

5.3 Primary data collection (Reconnaissance survey)

As a part of the reconnaissance survey, the Consultant carried out the field surveys covering the inventory of major aspects including terrain, cross structures, land use, existing facilities etc. across the proposed Inland Waterways. The detailed flowchart of the reconnaissance survey is shown in Figure mentioned below.

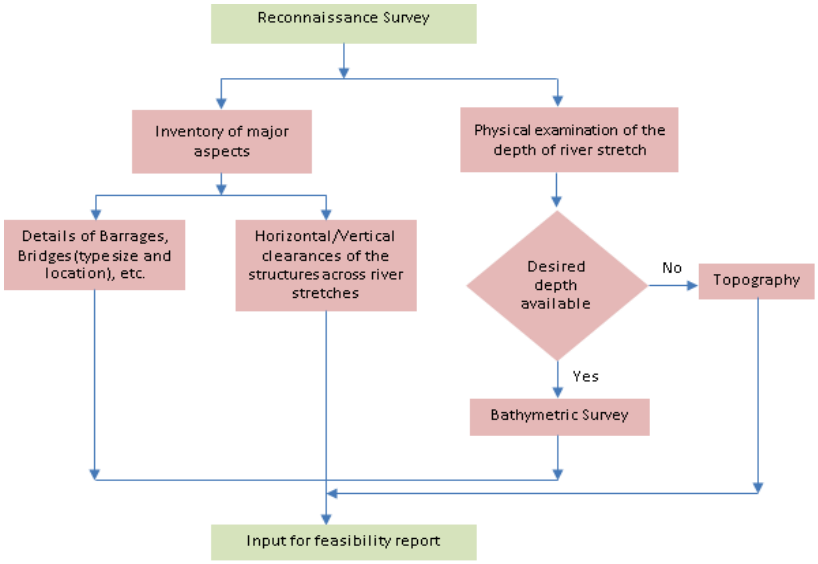


Figure 5: Flowchart showing Reconnaissance survey methodology

As a part of the reconnaissance survey, the Consultant carried out single line bathymetric/ topographic survey. In addition to the single line bathymetry/topographic survey, details of bridges,

cross structures such as barrages, weirs, terrain details, vertical and horizontal clearance etc. were collected during this reconnaissance survey.

Survey agency was appointed to carry out the above mentioned reconnaissance task. Given below are the details of the agency:

S.No.	Survey Agency	River	Total length
1	GMI	Budha Balanga River	56 km

Table 3: Survey agency appointed for Survey

The data received from the reconnaissance survey was analysed to identify the relevant river stretches for navigational potential and commercial viability.

5.4 Survey equipment details for reconnaissance survey

5.4.1.1 Bathymetric survey

The bathymetry survey will be carried out using Bathy 500 portable shallow water Echo sounder supported by DGPS Beacon Receiver and HYPACK data collection and processing software. The survey will be carried out using a fiber boat with safety equipment. The Bathy- 500MF echo sounder is an electronic hydro-graphic survey instrument used for measuring depths with precision chart recordings and digital data output. The Bathy-500 echo sounding systems are based on the principle that when a sound signal is sent into the water it will be reflected back when it strikes an object. HYPACK survey software is used for bathymetry data collection and processing. The Echo sounder and DGPS receiver were interfaced through HYPACK software with onboard PC. The position and depth will be recorded along the pre-planned transect at determined interval continuously.

Survey vessel

Locally hired survey vessel will be used for carrying out the survey. A small inflatable boat with draught of 0.2 metres is used for collecting bathymetry data.

Figure 6: Survey vessel

Position fixing

The position fixing was done by using differential global positioning system not less than 12 Channel receivers for sub-metre accuracy. Differential Global Positioning System (DGPS) is an enhancement to Global Positioning System that provides improved location accuracy.

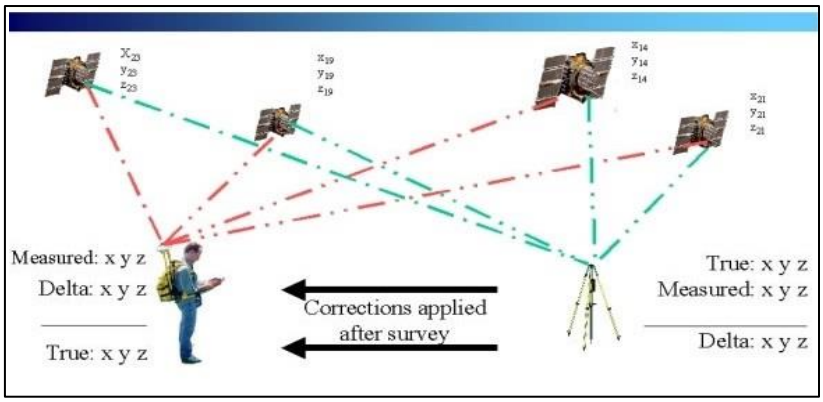


Figure 7: Position fixing using differential GPS

Other instruments

Hemisphere R110 DGPS system

For present study one Hemisphere R110 DGPS system (Receiver) will be used.

Navigation & data logging system

- To provide on-line route guidance, log navigation data, provide QC of navigation data, etc. The system comprises of the following equipment:
- One HP Laptop
- One HYPACK Version 2012 Navigation & Data Logging Software
- One Positioning & sensor interfaces
- Sufficient Paper Rolls

The survey was conducted in WGS-84 spheroid with no datum transformation.

Local Datum Geodetic Parameters	
Spheroid	WGS-84
Datum Transformation	None
Semi-major axis (a)	6378137.0000 m
Semi-minor axis (b)	6356752.3142 m
Eccentricity	0.0818 191909 28906
Inverse flattening (1/f)	298.257223563
Projection Parameters	
Grid Projection	Universal Transverse Mercator
Central Meridian (CM)	87 o East (Zone 45)
Origin Latitude (False Lat)	0.0o
Hemisphere	North
False Easting (FE)	500000.0 m
False Northing (FN)	0.0 m
Scale Factor on CM	0.999600
Units	International Meters

Table 4: Local Datum Geodetic Parameters

Single Beam Echo Sounder System

Single beam echo sounders are by far the most numerous sonar systems in use today. They are used on a wide range of vehicles from small pleasure boats, to huge cruise ships and tankers. They span a wide range of applications including:

- Water depth indicators, both for bottom avoidance and for navigation
- Fish finding, both sport and commercial
- Bottom classification, (rock, silt, eelgrass, etc.)
- Military, target localization
- Upward looking, for submarine ice avoidance
- Surveying, both for navigational charts and for resources exploration

Single beam sonars measure the time it takes for an acoustic pulse to travel from the sonar transducer to the bottom and back up to the sonar transducer.

The depth is given by the following equation.
Z=t*c/2

Where Z is the depth, t is the time, c is the average sound speed and the division by two accounts for the pulse having to travel the distance in both directions. Following are some of the instruments used for present study.

Bathy 500 dual frequency Echo Sounder

One Dual frequency transducer 33kHz & 200 kHz + mounting bracket & base plate

Survey software (HYPACK)

Survey software was used for data collection and processing. It is integrated, first generation hydro graphic survey software developed by Coastal Oceanographical INC., USA. It works in MS Windows operating environment. The HYPACK's design program allows importing background map in CAD's DFX or Microsoft's DGN format. It enables to quickly create planned survey lines, plotting sheets and bottom coverage grids in a graphical environment. The survey tracks were planned using this software for accurate manoeuvring of the vessel and to keep the accuracy of the track. The post processing of the survey data and preparation of map were carried out using this software.

II. Topographic survey

Following are the instruments used for topographical survey

- Two Trimble SPS 855 RTK System with one Base and two Rover
- One Nikon Auto level with levelling staff
- Three Auto Level with levelling staves and tripod
-

Figure 8: Topographic Survey Instrument (Two Trimble SPS 855 RTK System)

CHAPTER 6
TECHNICAL ANALYSIS

6 Technical Analysis

In this section, various parameters like analysis of present state of affairs, details of single line bathymetry/topography survey, water depth details, details of bridges/cross structures and other salient features along the river, river bed profile, available navigable stretch, classification of waterways etc. are covered.

6.1 Analysis of present state of affairs

The survey area originates from 300 metre approximately from Pataliputra village and ends at the confluence of Budha Balanga River with Bay of Bengal at Chandipur Fishing Port which is 56 kms. This river is found to be tidal influenced from the river mouth to Gambharia village, the total tidal influence zone is about 38km. The H.F.L at Govindpur gauge station i.e. 9.5m above M.S.L has been adopted for this river. There are no major industries lies in the stretch. Main crops grown are paddy. Budha Balanga river study stretch is as shown in Figure mentioned below.

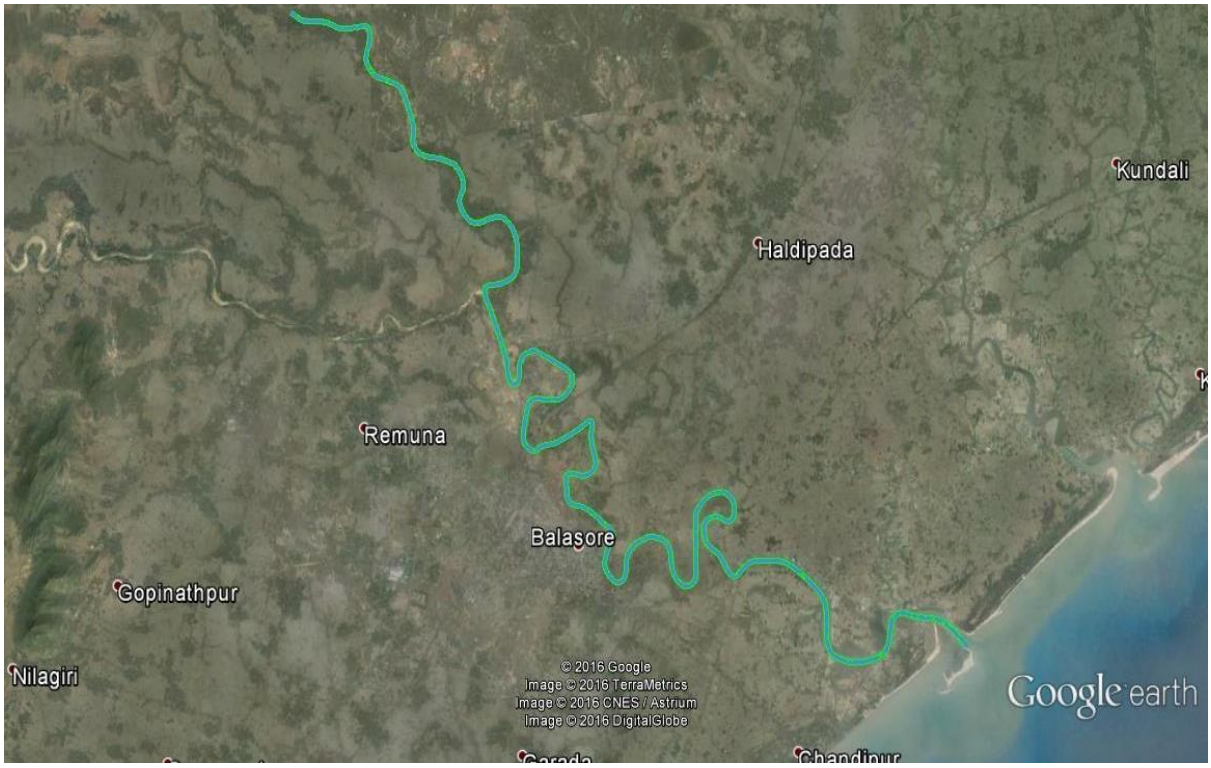


Figure 9: Budha Balanga river stretch under study

I. Water Depth Details

Out of total study stretch of 56km, 18.0 km is found to have water depth of greater than 2m(when adjusted to chart datum). Around 20.0 km i.e. 35 percent of the study stretch has less than 1.0 m of water depth available.

Chainage (km)	Draft Variation		Length of River (km)			
	Max. Available w.r.t. CD (m)	Min. Available w.r.t. CD (m)	<1m	1-1.5m	1.5-2.0m	>2.0m
0-10	7.6	0.7	2.08	5.73	0.83	1.36
10-20	8.4	0.4	5.85	1.48	0.52	2.15
20-30	9.4	0.3	3.85	1.87	0.84	3.44
30-40	15.1	-0.5	4.06	2.19	0.83	2.92
40-50	6.7	-0.4	3.23	1.35	1.46	3.96
50-56	14.7	0.5	0.62	0.58	0.42	4.38
	Total		**19.69**	**13.2**	**4.9**	**18.21**

Table 5: Water depth details

II. Bridge Details

Given below are the details of bridges along the study stretch of Budha Balanga River.

S.No.	Name	Chainage (km)	Easting	Northing	Horizontal Clearance (m)	Vertical Clearance w.r.t. HFL (m)	Location
1	Balighat bridge	32.3	495083.86	2376763.10	30.0	6.5	Near Oupada village
2	Railway bridge	24.8	492884.07	2379908.56	30.0	8.0	Near Kasamila
3	Railway bridge	24.7	492843.05	2379902.13	30.0	7.0	Near Kasamila
4	Under construction bridge	7.1	488439.79	2388702.21	Under construction		Gandarda Palasia
5	Wooden bridge	9.7	489989.42	2387069.93	Temporary bridge		Mukundapur
6	Wooden bridge	10.9	490769.46	2386433.07			Haldia
7	Under construction bridge	12.6	491915.94	2385758.82	Under construction		Dumuda
8	Wooden bridge	12.7	491989.29	2385737.40	Temporary bridge		Dumuda
9	NH 5 bridge	16.5	491465.90	2382857.38	35.5	12.0	Balasore
10	NH 5 bridge	16.6	491469.67	2382839.46	35.0	11.0	Balasore
11	Iron bridge	19.9	493174.15	2382409.27	12.5	12.5	Fuludi

Table 6: Bridges across Budha Balanga river

III. Other Cross Structures

Given below are details of High tension lines/cable/electric lines along the study stretch of Budha Balanga River.

S.No.	Name	Easting	Northing	Vertical Clearance w.r.t. HFL(m)
1	HTL	413541.27	2261787.05	15
2	HTL	425732.82	2263573.55	6
3	HTL	425746.51	2263586.69	5
4	HTL	428923.73	2262474.35	4

S.No.	Name	Easting	Northing	Vertical Clearance w.r.t. HFL(m)
5	Electric line	430340.91	2261812.87	5
6	HTL	431264.46	2262506.51	4
7	HTL	432657.45	2262204.92	4
8	HTL	438346.24	2261227.29	5.5
9	HTL	439014.71	2261384.86	5
10	HTL	447161.33	2256798.63	15
11	HTL	447234.36	2256746.87	15
12	HTL	450859.10	2257373.95	5
13	Cable Line	451117.09	2257369.92	3

Table 7: HTL/Cable lines across Budha Balanga River

IV. Images of Structures across Budha Balanga River

Given below are the images of structures across Budha Balanga River:

Figure 10: Balighat Bridge(Ch: 32.3km)

Figure 11: Balaramgadi Fishing Harbour (CH:54.3km)

Figure 12: Under construction Dhumuda Bridge(CH:12.6km)

Figure 13: Fuludi Bridge (CH:19.9km)

Figure 14: Under construction Palasia Bridge (CH:7.1km)

Figure 15: NH5 Bridge (CH:16.5km)

Figure 16: Railway Bridge(CH:24.7km)

6.2 Reconnaissance Survey

The survey was carried out from 13th Feb, 2016 to 15th Feb, 2016. The survey area originates from 300 metre approximately from Pataliputra village and ends at the confluence of Budha Balanga river with Bay of Bengal at Chandipur Fishing Port which is 56 kms.

Tidal Influence zone and Tidal Range:

It was observed that 38km from the Budha Balanga mouth is tidal effected. The tidal range in Odisha coast varies from 2.8 m during springs to 0.7 m during neaps.

6.2.1 Description of the Benchmarks

I. Horizontal Control

The survey boat used for the survey operations throughout the project was positioned by the Differential Global Positioning System (DGPS). Differential corrections were received continuously from the nearest existing DGLL beacons at Paradip which are capable of transmitting corrections up to range of 250 kilometres. The Hemisphere DGPS Receiver was used for positioning of the depths. The position correction details were received from the nearest DGLL Beacon at Paradip Port and position data were found to be in differential mode, and in order.

For topographic survey, horizontal control was carried out from IWAI Bench mark BM1 in NW-5 for Budha Balanga River.

II. Vertical Control

Chart Datum(CD) :

For establishment of CD in tidal portion, transfer of sounding datum was carried out from Dhamra fishing harbour (already established benchmark BM1 of NW5) to Budha Balanga mouth. The tidal effect is up to 38kms i.e, till bench mark BU4. The CD value of tidal stretch is derived by interpolation technique. As there was non-availability of any CWC gauge or any reference gauge in this stretch, the CD value of non tidal area was derived by considering the MSL value of bench marks and Zero of established gauge during survey.

The maps below show the location of benchmarks.

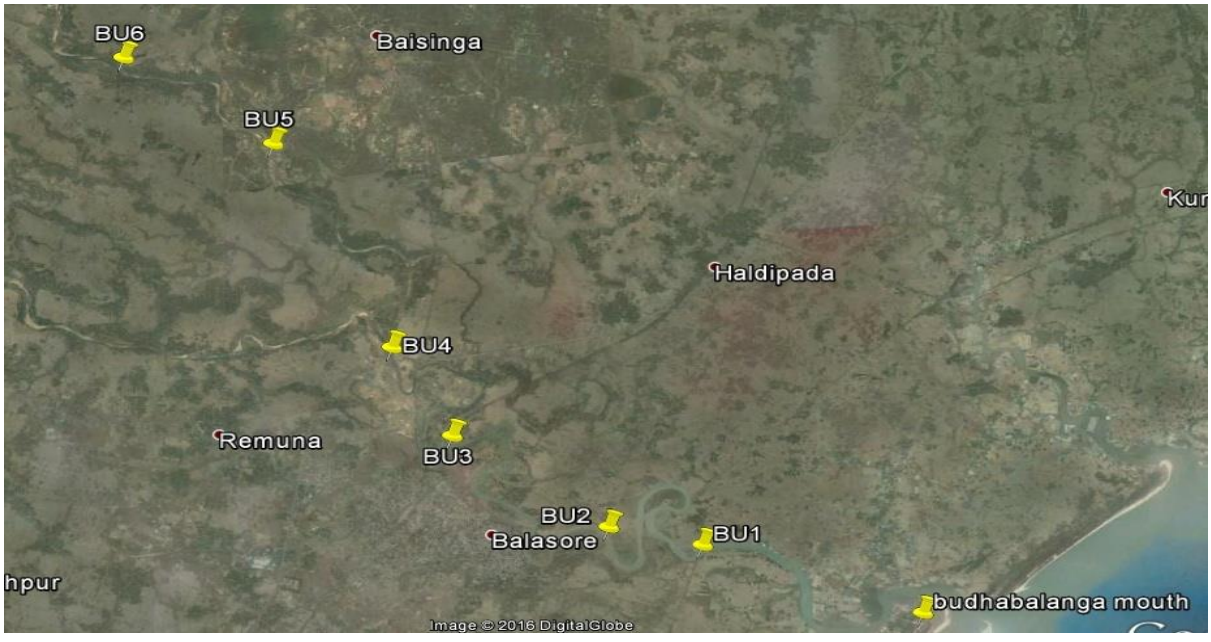


Figure 17: Bench Mark details

6.2.2 Hydrographic Surveys

I. Bathymetric Survey

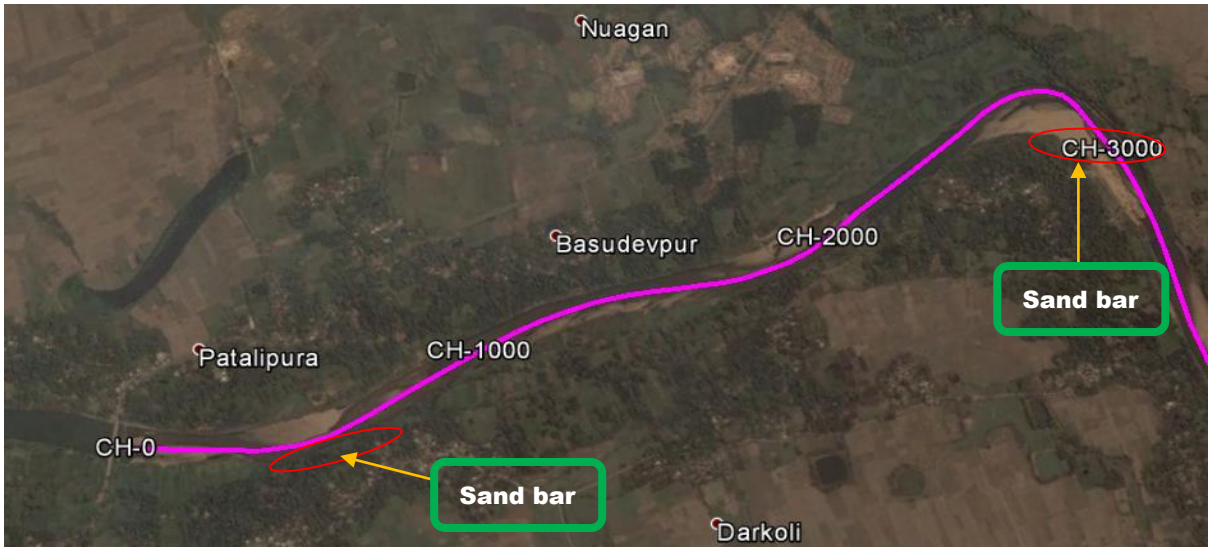
On conduct of Bathymetric survey from Budha Balanga mouth, it was found that the tidal area is up to 38km. Hence the Bathymetric Survey could be conducted in the water bound areas from Chainage 0km to Chainage 56km. The minimum depth of the river was observed at 0.7 m and minimum width observed was 40 m.

6.3 River details

6.3.1 Bathymetry Data Collected - Budhabalanga River:

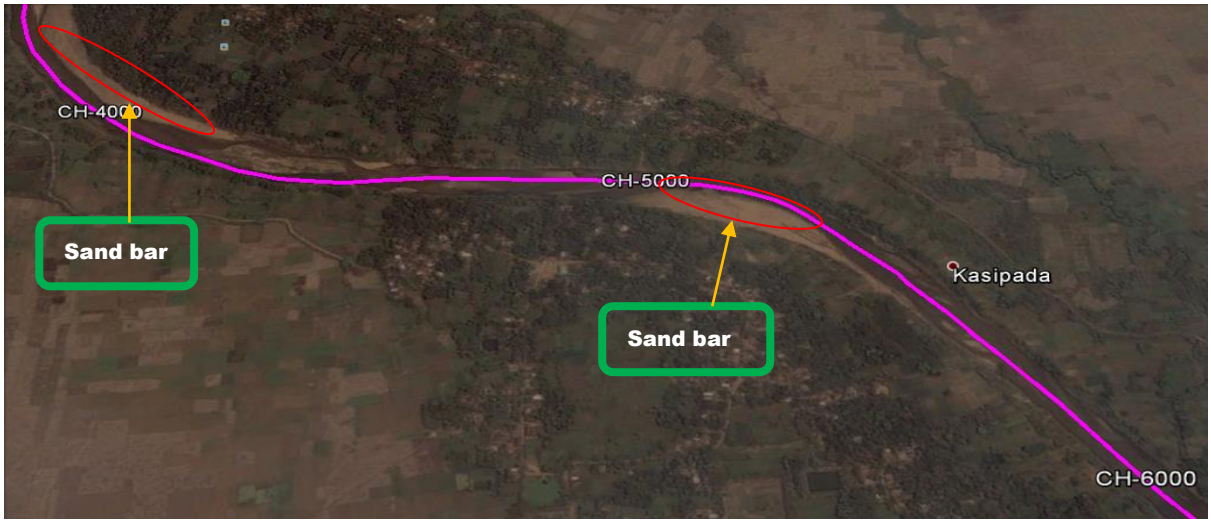
Budha Balanga River from (CH: 0km - 3.5km)

This section extends from Patalipura/Nakhara to Sankarpur. The minimum depth recorded in this section is o.7m and the maximum depth recorded is 1.5m. The width of the river varies from 10m to 40m in this section. Sand depositions were observed in this section.



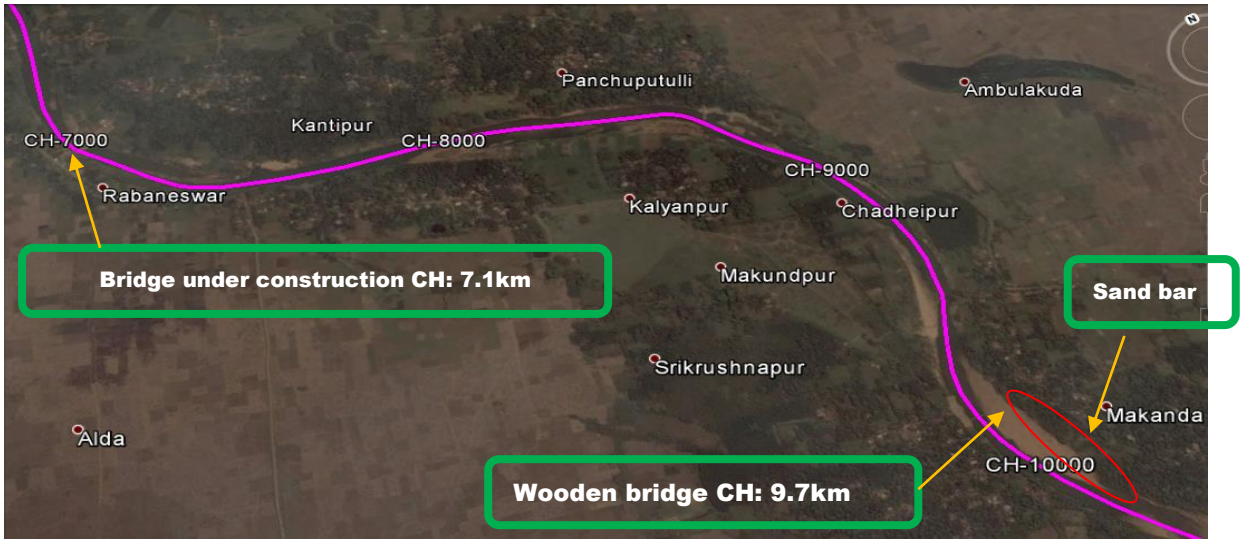
Budha Balanga River from (CH: 3.6km - 6.3km)

This section from CH:3.6km to 6.3km at Sankarpur is seen to be a dry area. Sand depositions were seen at this section



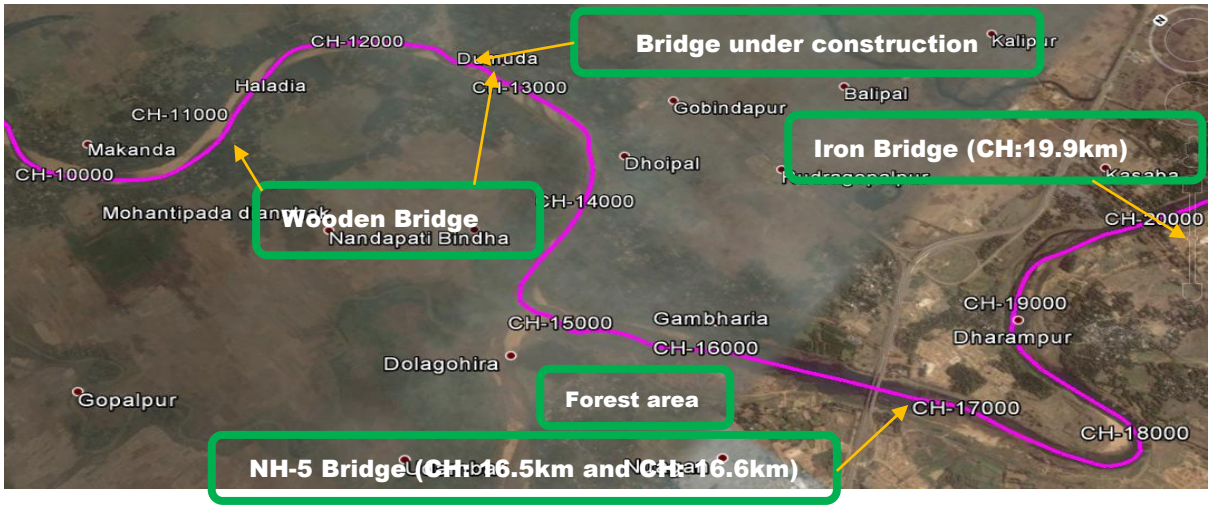
Budha Balanga River from (CH: 6.3km - 10km)

This section extends from Sankarpur to Makanda. The minimum depth recorded in this section is 0.7m and the maximum depth recorded is 7.6m. The width of the river varies from 10m to 50m in this section. At CH: 7.1km, a bridge is under construction and at CH: 9.7, a wooden bridge is present. One number of High tension line and 2 nos. of cable line passes across the river at this section. Sand depositions were observed in this section.



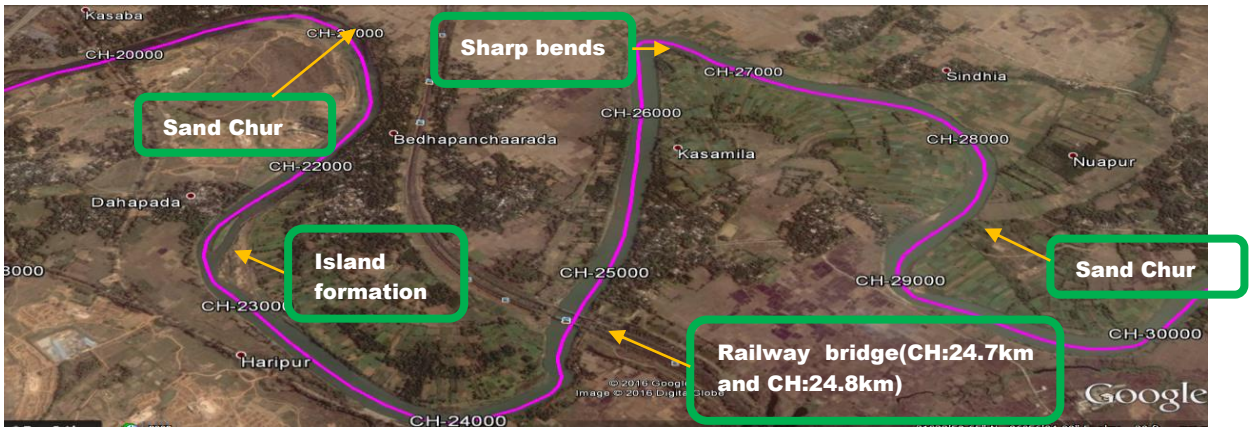
Budha Balanga River from (CH: 10km - 20km) – Tidal zone

This section extends from Makanda to Kasaba. The minimum depth recorded in this section is 0.4m and the maximum depth recorded is 8.4m. The width of the river varies from 20m to 174m in this section. The tidal effect ends at this section at CH:18km. Two number of NH-5 bridges(CH: 16.5km and 16.6km), one iron bridge(CH: 19.9km) and two Wooden bridges(CH: 10.9km and 12.7km) are present in this section. One bridge at CH:12.6km is under construction. Seven nos. of High tension line and two nos. of cable line passes across the river at this section. Sharp bends can be observed in this section.



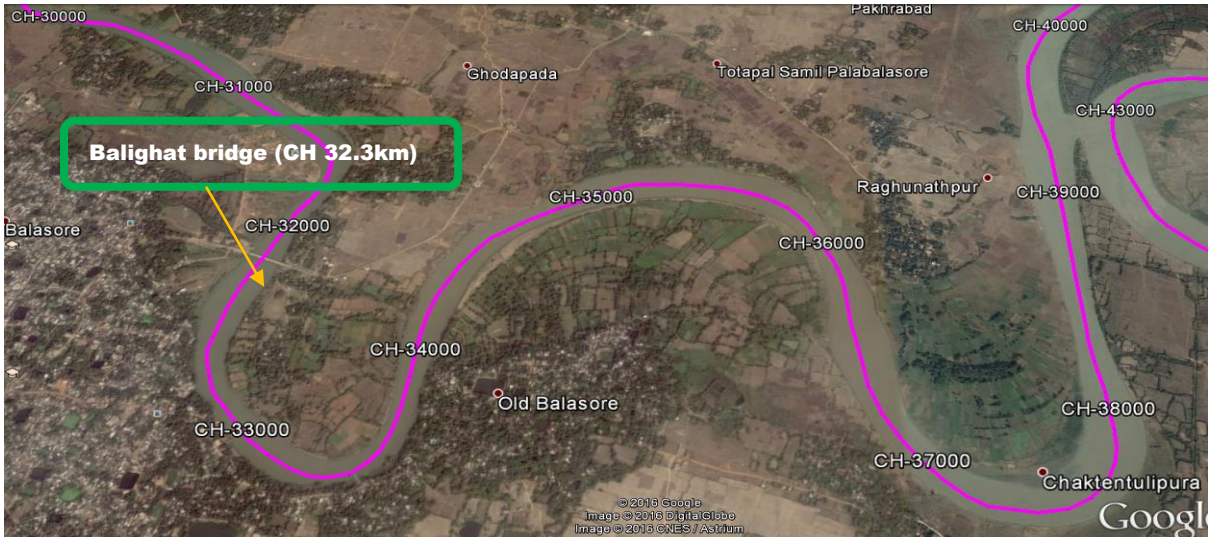
Budha Balanga River from (CH: 20km - 30km) – Tidal Zone

This section extends from Kasaba to Nuapur. The minimum depth recorded in this section is 0.3m and the maximum depth recorded is 9.4m. The width of the river varies from 20m to 110m in this section. Two number of railway bridges(CH:24.7km and CH:24.8km), one no. of high tension line and 1 no. of electric line passes across the river at this section. Sand deposition and island formations are seen at various places in this section. Sharp bends can be observed in this section.



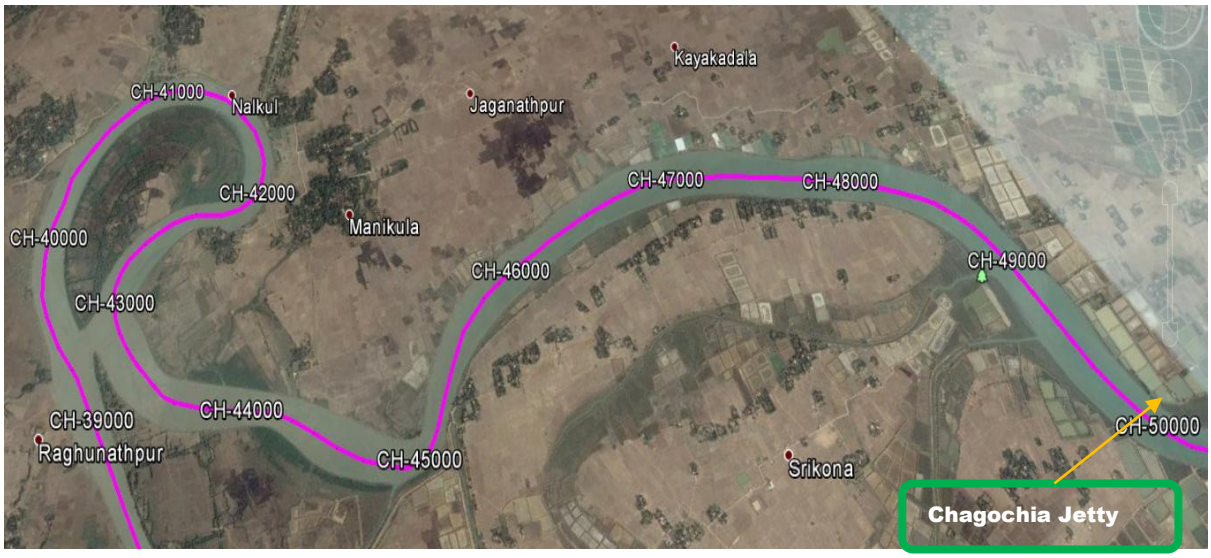
Budha Balanga River from (CH: 30km - 40km) – Tidal zone

This section extends from Nuapur to Pakhrabad. The minimum depth recorded in this section is -0.5m and the maximum depth recorded is 15.1m. The width of the river varies from 20m to 200m in this section. 1 Bridge(Balighat bridge CH:32.3km), 1 no. of High tension line and 1 no. of cable line passes across the river at this section.



Budha Balanga River from (CH: 40km - 50km) – Tidal zone

This section extends from Pakhrabad to Chagochia. The minimum depth recorded in this section is -0.4m and the maximum depth recorded is 6.7m. The width of the river varies from 30m to 300m in this section. Chagochia jetty is present at this section. Sharp bends can be observed in this section.



Budha Balanga River from (CH: 50km - 56km) – Tidal zone

This section extends from Chagochia to Dighapur where it meets Bay of Bengal. The tidal zone starts at this section and extends for about 38km(i.e.CH:18km). The minimum depth recorded in this section is 0.5m and the maximum depth recorded is 14.7m. The width of the river varies from 30m to 300m in this section. Balaramgadi fishing harbour(CH:54.3km) is present in this section.

6.4 Bed Profile of Proposed Waterway

All soundings were reduced to chart datum in the area. Chainage Vs water depth and soil texture @100m interval is shown in Annexure-I. The observed bed profile of Budha Balanga river waterways are presented below in Figures mentioned below.

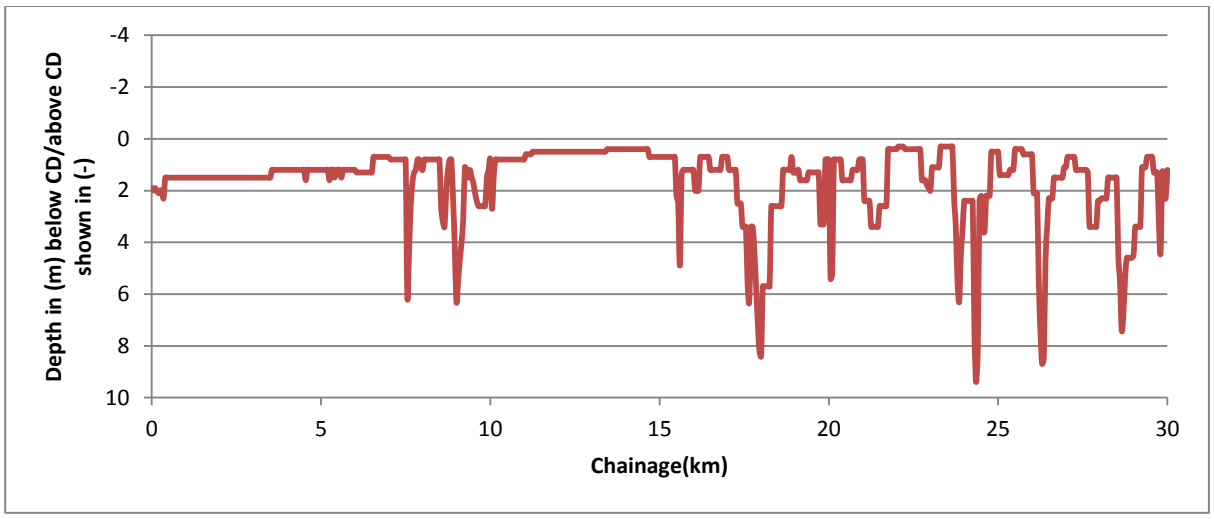


Figure 18: Longitudinal River bed profile of Budha Balanga River (w.r.t. CD) from CH: 0.00km to 30.00km

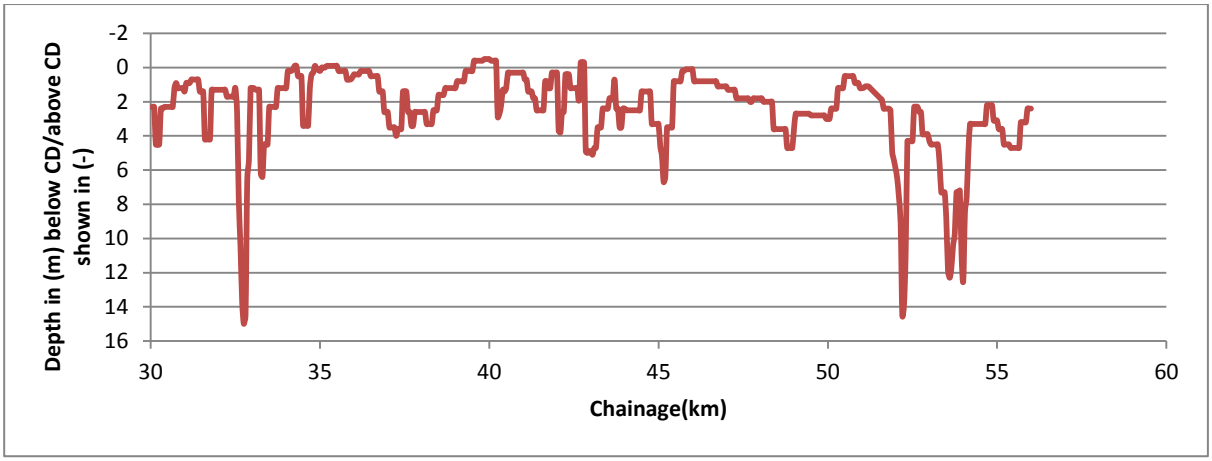


Figure 19: Longitudinal River bed profile of Budha Balanga River (w.r.t. CD) from CH: 30.00km to 56.00km

6.5 Available Navigable Stretch

The table below shows the representation of available navigable stretch for – 1.0m, 1.5m & 2.0m LAD @ chainage of 10 km along with draft variation for Budha Balanga river under cluster IV

S.No.	Chainage (km)	Draft Variation		Length of River (km)			
		Max. Available w.r.t. CD (m)	Min. Available w.r.t. CD (m)	<1m	1-1.5m	1.5-2.0m	>2.0m
1	0-10	7.6	0.7	2.08	5.73	0.83	1.36
2	10-20	8.4	0.4	5.85	1.48	0.52	2.15
3	20-30	9.4	0.3	3.85	1.87	0.84	3.44
4	30-40	15.1	-0.5	4.06	2.19	0.83	2.92
5	40-50	6.7	-0.4	3.23	1.35	1.46	3.96
6	50-56	14.7	0.5	0.62	0.58	0.42	4.38
		TOTAL		**19.69**	**13.2**	**4.9**	**18.21**

Table 8: Available navigable stretch @ chainage of 10km along with draft variation

6.6 Gauge Discharge Analysis

An average gauge discharge for 13 years (2000-2013) at Govindpur gauge station has been analysed and following are the observations:

S.No.	Discharge(m^3/s)	Availability period in No. of days per year	% days in year
1	<200	312	85.4%
2	200-500	36	10.0%
3	500-700	7	1.8%
4	700-900	4	1.0%
5	>900	7	1.8%

Table 9: Water Availability in Budha Balanga River

The average discharge in the river varies from 0.54m^3/s to 2886m^3/s.

6.7 Classification of Waterways

The Inland waterways in India are classified into seven categories for rivers as well as canals as per the 'The Inland Waterways Authority of India Act, 1985' for safe plying of self-propelled vessels upto 2000 dead weight tonnage(DWT) and tug-barge formation in push-tow units of carrying capacity upto 8000tonnes.

The classification of waterways is discussed below:

For Rivers:

S.No.	Class of Waterways	Minimum Depth (m)	Bottom Width (m)	Bend Radius (m)	Vertical Clearance (m)	Horizontal Clearance (m)
1	Class I	1.2	30	300	4	30
2	Class II	1.4	40	500	5	40
3	Class III	1.7	50	700	7	50
4	Class IV	2.0	50	800	10	50
5	Class V	2.0	80	800	10	80
6	Class VI	2.75	80	900	10	80
7	Class VII	2.75	100	900	10	100

Table 10: Classification of Inland Waterways for Rivers

For Canals

S.No.	Class of Waterways	Minimum Depth (m)	Bottom Width (m)	Bend Radius (m)	Vertical Clearance (m)	Horizontal Clearance (m)
1	Class I	1.5	20	300	4	20
2	Class II	1.8	30	500	5	30
3	Class III	2.2	40	700	7	40
4	Class IV	2.5	50	800	10	50
5	Class VI	3.50	60	900	10	60

Table 11: Classification of Inland Waterways for Canals

Provided that this classification shall be effective only if:

a) Minimum depth of channel should normally be available for about 330 days of the year.
b) Vertical clearance at cross structure over the waterway should be available at least in central 75% portion of each of the spans in entire width of the waterway.
c) Refererence level for vertical clearance in different types of channel shall be :
    i. For rivers, over Navigational High Flood Level (NHFL), which is the highest flood level at a frequency of 5% in any year over a period of last twenty years.
    ii. For tidal canals, over the highest high water level.
    iii. For other canals, over designed full supply level.

The details of different types of vessels that can be used for different class of waterways as per 'Inland Waterways Authority of India Act 1985' are given in table below:

Class of Waterways	Self-propelled Vessel	Tug with barges
Class I	Carrying capacity -100DWT (Size - 32m LOA, 5m moulded breadth and 1m loaded draft)	1 Tug + 2 barges – 200DWT (Size – 80m LOA, 5m moulded breadth and 1m loaded draft)
Class II	Carrying capacity -300DWT (Size - 45m LOA, 8m moulded breadth and 1.2m loaded draft)	1 Tug + 2 barges – 600DWT (Size – 110m LOA, 8m moulded breadth and 1.2m loaded draft)
Class III	Carrying capacity -500DWT (Size - 58m LOA, 9m moulded breadth and 1.5m loaded draft)	1 Tug + 2 barges – 1000DWT (Size – 141m LOA, 9m moulded breadth and 1.5m loaded draft)
Class IV	Carrying capacity -1000DWT (Size - 70m LOA, 12m moulded breadth and 1.8m loaded draft)	1 Tug + 2 barges – 2000DWT (Size – 170m LOA, 12m moulded breadth and 1.8m loaded draft)
Class V	Carrying capacity -1000DWT (Size - 70m LOA, 12m moulded breadth and 1.8m loaded draft)	1 Tug + 4 barges – 4000DWT (Size – 170m LOA, 24m moulded breadth and 1.8m loaded draft)
Class VI	Carrying capacity -2000DWT (Size - 86m LOA, 14m moulded breadth and 2.5m loaded draft)	1 Tug + 2 barges – 4000DWT (Size – 210m LOA, 14m moulded breadth and 2.5m loaded draft)
Class VII	Carrying capacity -2000DWT (Size - 86m LOA, 14m moulded breadth and 2.5m loaded draft)	1 Tug + 4 barges – 8000DWT and above (Size – 210m LOA, 28m moulded breadth and 2.5m loaded draft or with higher dimensions)

Table 12: Types of vessels to be used in different Class waterways

All new structures to be constructed across the national waterways classified under these regulations shall conform to the respective criteria of horizontal and vertical clearances of the appropriate class of waterway as provided.

6.8 Dredging

Generally dredging works in river areas are carried out to create depth in case of new developments and to maintain the dredged depths in the already existing developments for the safe movement of barges / vessels.

Dredging quantity has been worked out for a channel width of 50m and a depth of 1.7m with a side slope of 1:5 and the preliminary dredging quantity is found to be around 2.5million cubic meter. Detailed dredging quantity can be calculated only after detailed bathymetric survey.

CHAPTER 7
MARKET ANALYSIS & TRAFFIC POTENTIAL

7 Market Analysis and Traffic Potential

7.1 Market Overview

Odisha has an agriculture-based economy which is in transition towards an industry and service-based economy. According to the 2011 Census of India, 61.8% of the working is engaged in agricultural activities. However, the agricultural contribution to the GSDP was 16.3% in the fiscal year 2013-14 and it was estimated to be 15.4% in 2014-15. The area under cultivation was 5,691 hectare in 2005-06 and it dropped to 5,424 hectare in 2013-14. Rice is the dominant crop in Odisha.

During 2013-14, the state exported 4.13 lakh tonnes and 1,800 crore worth of seafood. In 2014-15, the value of exports rose by 26% to 2,300 crore with 4.67 lakh tonnes being exported. Odisha is the fourth largest shrimp producing state in India.

Since the state is rich in mineral resources like bauxite, iron ore, lime stone, dolomite, chromite etc., more of mineral based industries came up. Orissa being a rich repository of major minerals like Coal, iron ore, Chromite ore, Manganese ore, Bauxite, Dolomite and lime stone etc., has become a prime destination for primary metallurgical industries.

Odisha has oldest coal mines at Talcher and Ib valley and after nationalization of coal in 1975 and the national policy on energy sector, many power plants have come up in Odisha.

Major industries in Odisha are concentrated in clusters of Rourkela, Kalinganagar, Jharsuguda, Angul, Dhenkanal, Cuttack, Sundargarh, Kendujhar, Khorda, Paradip and Koraput.

S.No.	Region	Type of Industries
1	Rourkela- Rajganpur	Iron & Steel, Sponge Iron, Cement, Secondary Steel melting and rooling Mill, Refractories, Chemicals and Engineering
2	Ib valley & Jharsuguda area	Thermal Power, Sponge Iron, Refractories and Coal Mines (Aluminium, Coal Washeries)
3	Hirakud	Aluminium, Rolling Mill
4	Talchar - Angul	Thermal Power, Aluminium, Coal Washeries, Ferro Alloys, Coal Mines
5	Choudwar	Ferro Alloys, Thermal power, Pulp and Paper, Coke Oven
6	Balasore	Pulp and Paper, Ferro Alloys, Rubber Industries
7	Chandikol	Stone crusher, Coke oven
8	Duburi	Integrated Steel, Ferro Alloys, Mineral Processing
9	Paradeep	Fertilizer, Sea Food Processing, Petroleum Coke
10	Khurda- Tapang	Stone Crusher
11	Joda - Barbil	Pig Iron, Sponge Iron, Ferro Alloys, Iron Ore Crusher, Mineral Processing
12	Rayagada	Pulp and Paper, Ferro Alloys

Table 13: Region wise major industrial clusters

Location and size of these clusters depending upon the number of large and medium scale units and PSUs is presented in the figure below:

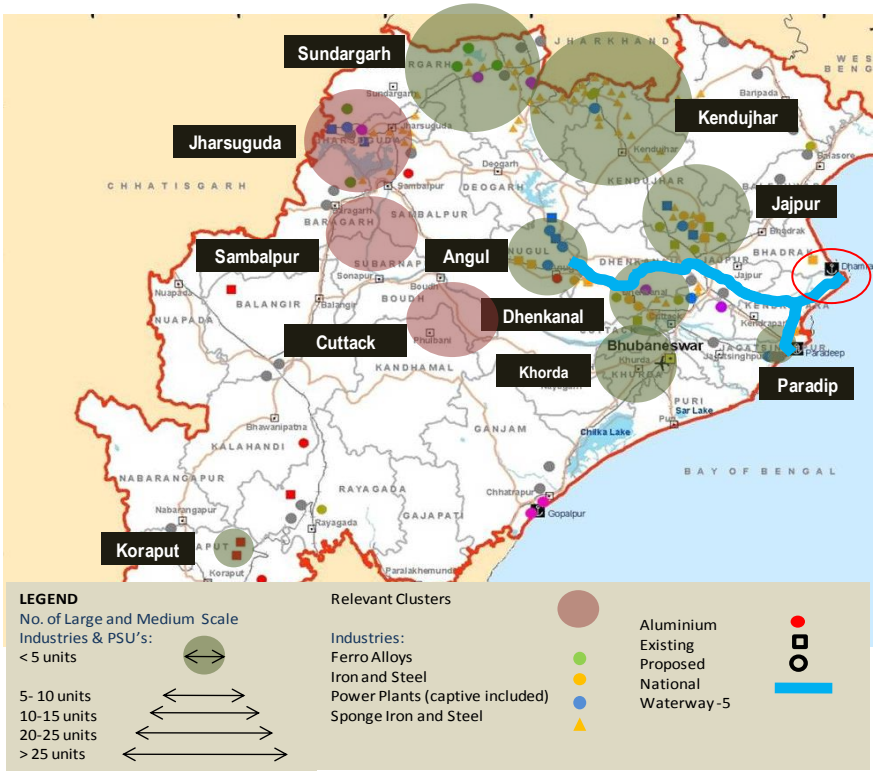


Figure 20: Industrial Clusters in Odisha

Tourism

Odisha is enriched with enormous potentialities of tourism like: eco-tourism, rural tourism and agri-tourism. Day by day more and more tourists are attracted to come Odisha to witness and inculcate especially tribal culture, car festivals/ratha yatra, Konark sculpture, historical importance of Dhauli, Odishi dance, Chilika and other local festivals that strengthen the state economy as well as national economy by inflow of foreign currency.

The table below shows the trend of tourist influx in Odisha from 2002-03 to 2011-12.

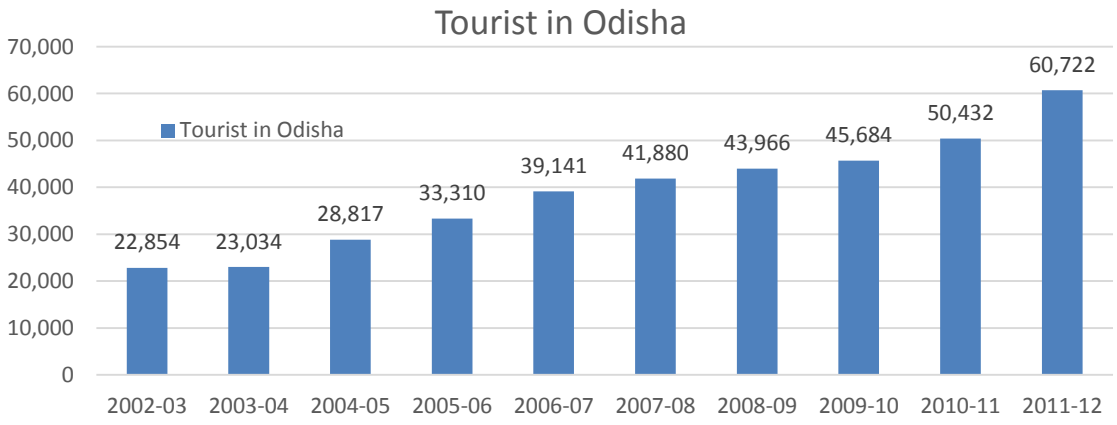


Figure 21: Trend of tourist influx in Odisha from 2002-03 to 2011-12

7.2 Market setup along Budha Balanga River

The river passes through Balasore and Mayurbanj districts of Odisha. 33 percent of the total basin area comes under forest with approx. 45 percent under cultivation.

Balasore district has the industrial cluster with Pulp and Paper, Ferro Alloy and Rubber industries.

7.2.1 Industries along the study stretch

Major industries along Budha balanga are in Balasore District. A total of 2306 industrial units have been registered of which 9 are medium and large units.

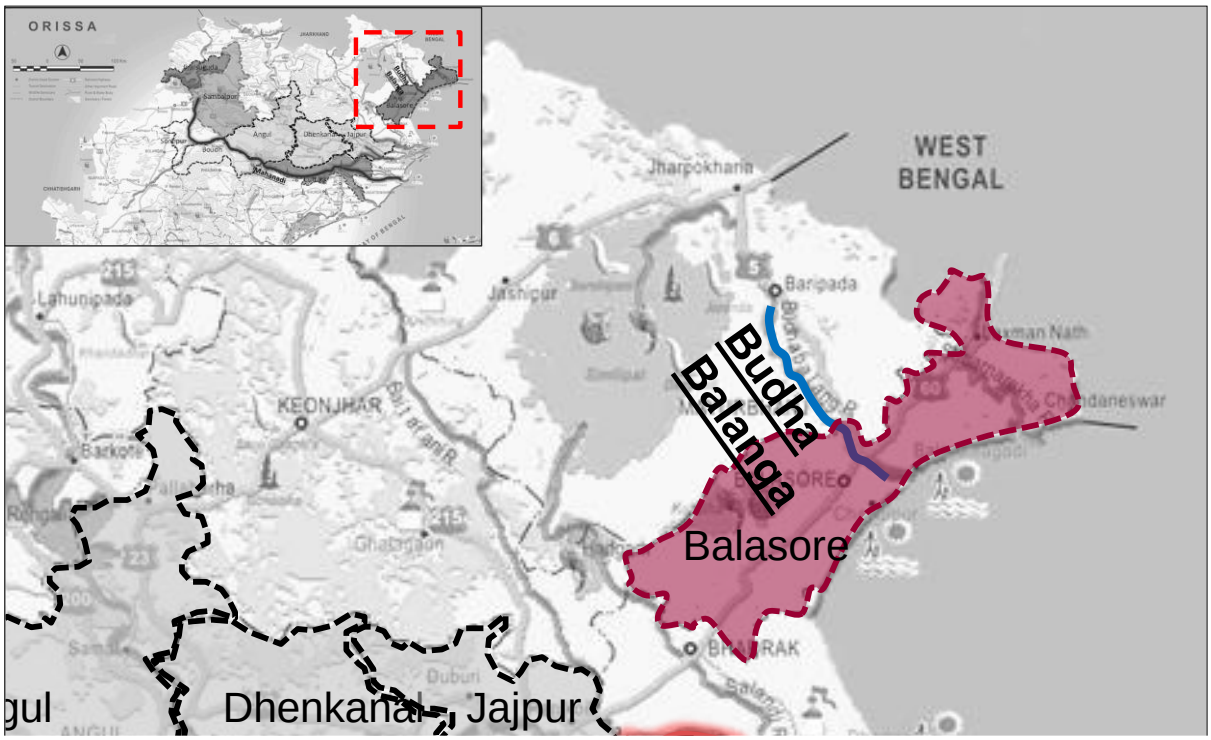


Figure 22: Industrial clusters for Budha Balanga

Given below is the table showing industries at a glance.

S.No.	Head	Particulars (Units)
1	Registered Industrial Unit	2306
2	Total industrial unit	8060
3	Registered medium & large units	9
4	Total employment in small scale industries	44999
5	Employment in large & medium industries	5624
6	No. of industrial area	8

Table 14: Industries at a glance

Given below is the list of major industries along the river.

S. No.	Name of Industry	Products	Production Capacity
1	Balasore Alloys	Ferro Manganese, Ferro Silicon, Ferro Chrome and Silico Manganese	0.1 MTPA
2	Birla tyres, Bamapada, Chhanpur	Automobile tyre, tubes and flaps	1.5 Million Nos
3	B & A Multiwal Packaging Limited, Balgopalpur Ind. Area	Multiwal Paper sacks	18 million nos. PA, 2160 TPA lamination film
4	Alom extrusion limited, Ganeswarpur Ind. Area, Balasore	Aluminium extruded sections	15,000 TPA
5	Polar Pharma India Ltd.,Somanathpur Ind. Area	Condoms	750 Million Nos. PA
6	Hyderabad Industries Ltd. , I.A, Somanathapur , Remuna, Balasore	Asbestos	0.25 MTPA
7	Emami Paper Mill, Balasore	Paper	36,500 TPA
8	Facor Group, Bhadrak and Balasore	Ferro chrome	65,000 TPA

Table 15: List of major industries

7.2.2 Agricultural scenario along the study stretch

Kharif is the main cropping season and rice is the principal crop of during kharif season. Cropping during Rabi season is mainly confined to the irrigated areas. Other important crops produced are pulses (Arhar, Mung, Biri, Kulthi), oil seeds (Groundnut, Til, Mustard and Nigar), Fibres (Jute, Mesta, Cotton), Sugarcane, Vegetables and Spices. In 2011-12, rice production in Balasore and Mayurbhanj combined occupied 507000 HA in the Kharif season and 27720 HA in the Rabi season. The table below gives details of the other produces during 2011-12.

S.No.	Name of the district	Rice	Other cereals	Total cereals	Total pulses	Total foodgrains	Total oilseeds	Total vegetables	Total fibres	Total Spices	Total cropped area
1	Balasore	211.82	0.64	212.46	0.04	212.5	0.02	12.67	1.87	2.6	229.66
2	Mayurbhanj	295.17	14.85	310.02	34.62	344.64	8.08	12.83	2.87	1.42	369.84

Table 16: District wise Kharif cropped area (Budha Balanga) in '000 Ha

S. No.	Name of the district	Rice	Other cereals	Total cereals	Total pulses	Total food grains	Total Oilseeds	Total vegetables	Total spices	Sugarcane	Total cropped area
1	Balasore	23.68	1.09	24.77	22.18	46.95	28.76	16.9	4.03	0.35	96.99
2	Mayurbhanj	4.04	2.11	6.15	26.36	32.51	23.47	21.19	2.46	0.03	79.66

Table 17: District wise Rabi cropped area (Budha Balanga) in '000 Ha

7.2.3 Mineral Availability

In Balasore district, minerals like soft stones, limestone, stone chips are available in the district, which are mainly used in industrial units in the district. The huge deposits of granite stones at Nilgiri provides tremendous scope for development of few more industries based on this resources. Except these, no minerals in large quantity which can be explored for commercial purpose found in the district.

Iron-ore (hematite), vanadiferous and titaniferous magnetic, chaina clay, galena (lead ore), Kyanite, asbestos, steatite (soap stone) and quartzite constitute the principal mineral resources of Mayurbhanj district.

7.2.4 Tourism setup

The tourism sector has a potential to generate high employment growth and revenue through a mix of activities of hotels, transport, shopping, food, entertainment and other areas. There are 21 tourist places in Balasore district and 16 in Mayurbanj district with Waterfalls at Joranda and Duduma and wildlife sanctuary at Similipal as major attractions along the river among others. Presently, there is no ferry service along the River.

7.3 Rail/Road Connectivity

Rail Connectivity: Cuttack is part of the East Coast Railway zone and is well connected to various cities of Odisha such as Puri and Bhubaneswar

Paradip Port is connected by a double, electrified line section with Cuttack which connects to the Howrah Chennai Trunk Line. The 155 km Daitari- Banspani rail line is also under construction. The 78 km Haridaspur-Paradip Rail Link to provide a dedicated corridor from the Port to the iron ore mines and steel plants is also under construction.

Dhamra port has acquired a 125 meter wide corridor from Dhamra to Bhadrak which can accommodate two rail tracks and a four lane road along with service lines viz. transmission line and pipe lines. Sambalpur and Jharsuguda clusters have a well-established rail connectivity to Vizag and Gangavaram Port in Tamil Nadu.

Road Connectivity: Paradip port is connected to NH-5 through a 2-lane road up to Chandikol and 4-laning of the road is in process. The two lane SH-12 from Paradip port to Cuttack provides network between the port and the mines. Jharsuguda and Sambalpur clusters connected to Paradip port through NH 200.

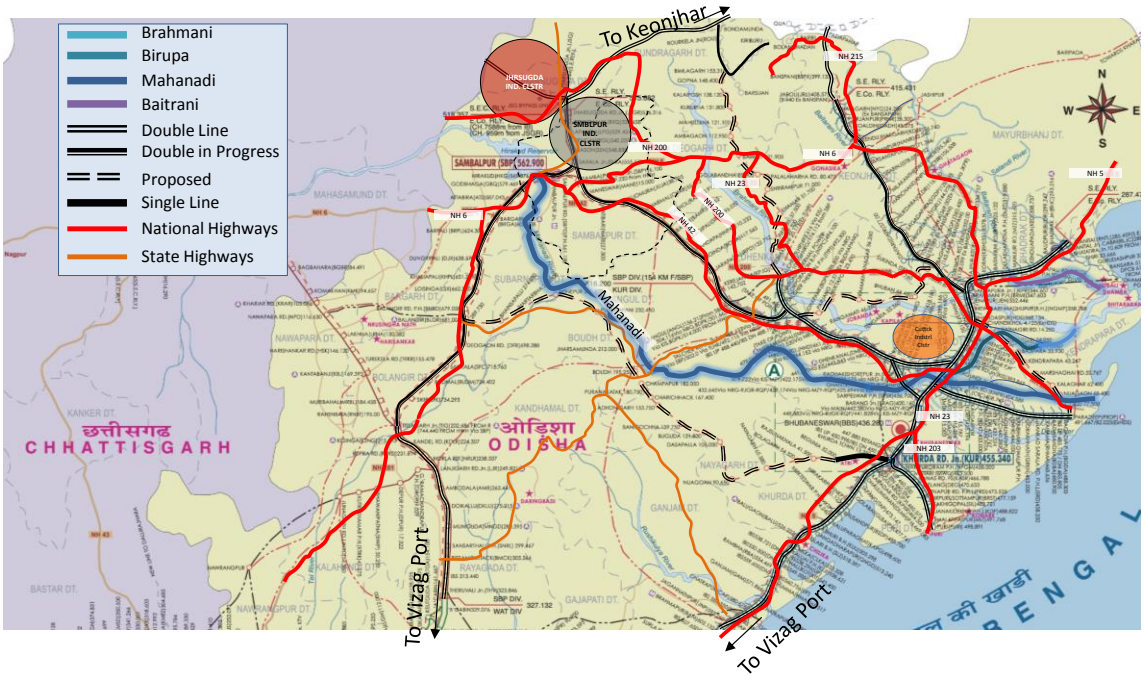


Figure 23: Road/Rail Connectivity

7.4 Traffic Potential

The **total traffic potential** in the hinterland of Budha Balanga River includes the inbound and outbound traffic of all the industries in the Balasore cluster and EXIM traffic at Paradip and Dhamra ports. Of the total traffic in the region, the **relevant traffic potential** for these stretches is considered to be the portion of total traffic whose origin and/or destination points are in the vicinity of the river stretches, and whose direction of movement (or a part thereof) corresponds to the alignment of the waterway.

Approach & Methodology

The Consultants carried out preliminary analysis of the expected traffic for the waterway. The proposed approach and methodology has been depicted in the flowchart given in Figure 6-5.

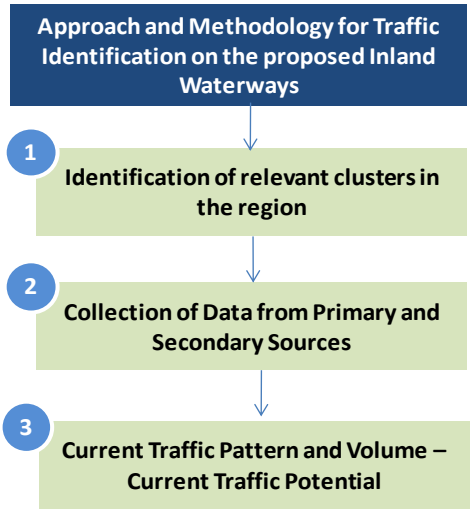


Figure 7-24: Flowchart showing approach and methodology for traffic identification

Each of the steps mentioned in the flowchart above have been described in detail as follows

Step 1: Identification of relevant clusters in the region

The relevant clusters include major industrial clusters and tourism locations such as temples, waterfalls, etc.

Major industries in Odisha are concentrated in the clusters of Rourkela, Jaipur, Jharsuguda, Angul, Dhenkanal, Sundargarh, Sambalpur, Cuttack, Keonjhar, Khorda, Paradip and Koraput. Out of these industrial clusters, traffic study was conducted for the relevant clusters along the waterway i.e. Angul, Dhenkanal, Jaipur, Jharsuguda Sambalpur and Cuttack. It is assumed that traffic from these clusters currently moving along the railway and roadway may shift onto the waterway. The clusters would be delineated according to district boundaries.

Odisha is also enriched with enormous potentialities of tourism like: eco-tourism, rural tourism and agri- tourism. Day by day more and more tourists are attracted to come Odisha to witness and inculcate especially tribal culture. Tourist spots along the waterway can be utilized for water tourism.

Step 2: Collection of data from primary and secondary sources

This step involves carrying out interviews with the industries like steel plants, thermal power plants and related industrial associations to get estimates on quantum of inflow of raw materials and outflow of finished products, proposed expansion plans, probability of shifting cargo from existing modes i.e. rail and road to waterways

This step also includes collection of information about the major tourist spots along the waterway.
Secondary data collection for industries was carried out from related websites and review of reports like

- Brief Industrial Profile of Districts, Ministry of MSME (Ministry of Micro, Small and Medium Enterprises)
- Orissa state Economic Survey Report
- Official websites of relevant districts
- Department of Steel and Mines, Govt. of Odisha
- Orissa Power Generation Company
- National Thermal Power Corporation
- Mahanadi Coal Fields Ltd

For tourism related information, the data was collected from the following sources.

- Orrisa Tourism web portal
- District websites
- Published literature to identify tourist places along the study stretch

Step 3: Study and analysis of the current and future traffic potential

Based on the data collected from primary and secondary sources, a preliminary traffic potential was worked out.

Thermal power plants and Steel plants are likely to be the key traffic generators, considering the first cut profile of existing industrial clusters.

For steel plants, current finished product offtake would be estimated based on the installed capacity of steel plants and their current utilization levels. Assumptions like requirement of raw material per tonne of finished product would be made to estimate the raw material intake.

Similarly, coal requirement for thermal power plants would be estimated based on the installed capacity, current utilization levels and coal required per 1000 megawatt of power generated.

7.4.1 Cargo Potential

Baleswar cluster is predominated by Plastic and allied industries and constitute about 70% of the state's plastic units and by the end of XI Five Year Plan, around 100 more plastic processing industries are expected to be established in and around Balasore. Currently raw material to Balasore Plastic and allied sector is supplied by local suppliers, petroleum industry at Haldia and Paradip and through imports from Paradip and Kolkata port. Plastic Park is also being developed at Paradip which will facilitate the plastic industry in the region by ensuring the raw material availability, ease of exports and other infrastructure support.

Most of the products in Plastic cluster of Balasore are made of thermoplastics – HDPE, LDPE, PP and PVC which is commonly used in pipe fittings, plastic furniture, house wares etc. The major plastic manufacturing units in the region are Ore Plast Ltd., Jaiswal Plastic Tubes Ltd., Hari Ydyog Pvt. Ltd etc. The total plastic production capacity of the Balasore cluster is about 60,000 Tonnes per annum. The major raw material used in the sector includes HDPE/LDPE/PP/PVC Resins. Reliance and Pharma Polymer are the major indigenous suppliers of PVC resins in Balasore. Plants in Balasore have MOU's signed with these suppliers and raw material is locally supplied from their godowns in Balasore and Cuttack. Some amount of raw material is also imported from Kolkata and Paradip port depending upon the prices of imported resins.

Total inbound traffic to Balasore from Plastic & allied and Iron & Steel Industry is presented in the table below.

S.No.	Company	Industry	Product	Production (MTPA)	Raw Material	Raw Material (MTPA)
1	Plastic Industry	Plastic	PVC	0.06	Resins	0.06
2	Balasore Alloys	Iron and Steel	Ferro Alloy	0.05	Coal	0.06
3	Balasore Alloys	Iron and Steel	Ferro Alloy	0.05	Dolomite/Quartzite	0.02
4	Balasore Alloys	Iron and Steel	Ferro Alloy	0.05	Chrome Ore	0.14
5			Total			**0.28 MTPA**

Table 18: Inbound Traffic at Balasore Cluster

Source: Primary and Secondary Research and Feedback's Analysis

The total cargo potential is calculated at 0.28 MTPA along the river.

7.4.2 Tourism Potential

The following water based tourism options have been explored, and suitable ones then narrowed upon, considering the catchment area and current tourist profile

- River Cruise
- Riverfront development
- Riverside Wildlife sanctuaries
- Waterfalls

Waterfalls at Joranda and Duduma and wildlife sanctuary at Similipal are potential attractions that can be reached via Budha Balanga River and thus, can act as potential traffic generators.

CHAPTER 8
SWOT ANALYSIS

8 SWOT Analysis of Proposed Waterway

Swot Analysis (Strength Weaknesses Opportunities Threats) has been carried out and is presented in the Table mentioned below:

	Helpful	**Harmful**
Internal	*STRENGTHS* - Out of 56kms, 38kms are tidal influence zone. Hence less dredging is required when compared to other rivers. - Tourism potential - - Can be connected to East Coast canal.	*WEAKNESSES* - 11 No. Of bridges are crossing this river - Less traffic potential for cargo movement along the stretch - 12 turning radius issues were identified along the river.
External	*OPPORTUNITIES* - Waterfalls at Joranda and Duduma and wildlife sanctuary at Similipal can be developed for tourism.	*THREATS* - Maintenance dredging will be more as river is close to mouth of sea. - Constraints in navigation in terms of size of the barges due to cross structures

Table 19: SWOT Analysis of Budha Balanga River

CHAPTER 9
OBSERVATIONS & SUGGESTIONS

9 Observations and Suggestions

1.1 Observations

River	Waterway	Length	Cross Structures	Cargo/Passenger/ Tourism/RO-RO
Budha Balanga	The waterway is found to be without any show stoppers such as rapids, rocky strata, waterfalls etc. Hence it can be made navigable. The tidal influence zone is found in 38kms from Budha Balanga mouth. From the survey it is found that for about 20km, water depth is <1m; for about 18km, water depth is between 1-2m and water depth is >2m for about 18km. Turning radius issues have been identified.	56 km of the river length has been surveyed	11 Bridges are there across the river stretch under study. 13 other cross structures were observed	The cargo potential for this river is found to be 0.28MTPA. Presently no passenger service was observed along the river stretch

Table 20: Observations

1.2 Suggestions

Following points are suggested for the navigability of the rivers

- The development of Budha Balanga River will help in developing east coast canal and connectivity to NW-5 and Dhamra port can be achieved.
- Waterfalls at Joranda and Duduma and wildlife sanctuary at Similipal are potential attractions that can be reached via Budha Balanga River and thus, can act as potential traffic generators.
- As, the nearest industrial cluster i.e. Balasore has estimated cargo potential of only 0.28MTPA, the potential for the use of waterway for cargo movement may not be feasible. Therefore, development of this river may not be commercially viable. However, the same can be developed as a commuting mode for the population of the region resulting in improved connectivity. This may in turn help in social upliftment of the local population.

CHAPTER 10
ANNEXURE

10 Annexures

Budha Balanga

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
0	3.3	1.4	1.9	Coarse Sand
0.1	3.3	1.4	1.9	Coarse Sand
0.2	3.5	1.4	2.1	Coarse Sand
0.3	3.4	1.4	2	Coarse Sand
0.4	2.9	1.4	1.5	Coarse Sand
0.5	2.9	1.4	1.5	Coarse Sand
0.6	2.9	1.4	1.5	Coarse Sand
0.7	2.9	1.4	1.5	Coarse Sand
0.8	2.9	1.4	1.5	Coarse Sand
0.9	2.9	1.4	1.5	Coarse Sand
1	2.9	1.4	1.5	Coarse Sand
1.1	2.9	1.4	1.5	Coarse Sand
1.2	2.9	1.4	1.5	Coarse Sand
1.3	2.9	1.4	1.5	Coarse Sand
1.4	2.9	1.4	1.5	Coarse Sand
1.5	2.9	1.4	1.5	Coarse Sand
1.6	2.9	1.4	1.5	Coarse Sand
1.7	2.9	1.4	1.5	Coarse Sand
1.8	2.9	1.4	1.5	Coarse Sand
1.9	2.9	1.4	1.5	Coarse Sand
2	2.9	1.4	1.5	Coarse Sand
2.1	2.9	1.4	1.5	Coarse Sand
2.2	2.9	1.4	1.5	Coarse Sand
2.3	2.9	1.4	1.5	Coarse Sand
2.4	2.9	1.4	1.5	Coarse Sand
2.5	2.9	1.4	1.5	Coarse Sand
2.6	2.9	1.4	1.5	Coarse Sand
2.7	2.9	1.4	1.5	Coarse Sand
2.8	2.9	1.4	1.5	Coarse Sand
2.9	2.9	1.4	1.5	Coarse Sand
3	2.9	1.4	1.5	Coarse Sand
3.1	2.9	1.4	1.5	Coarse Sand
3.2	2.9	1.4	1.5	Coarse Sand
3.3	2.9	1.4	1.5	Coarse Sand
3.4	2.9	1.4	1.5	Coarse Sand
3.5	2.9	1.4	1.5	Coarse Sand
3.6	2.6	1.4	1.2	Coarse Sand
3.7	2.6	1.4	1.2	Coarse Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
3.8	2.6	1.4	1.2	Coarse Sand
3.9	2.6	1.4	1.2	Coarse Sand
4	2.6	1.4	1.2	Coarse Sand
4.1	2.6	1.4	1.2	Coarse Sand
4.2	2.6	1.4	1.2	Coarse Sand
4.3	2.6	1.4	1.2	Coarse Sand
4.4	2.6	1.4	1.2	Coarse Sand
4.5	2.6	1.4	1.2	Coarse Sand
4.6	2.6	1.4	1.2	Coarse Sand
4.7	2.6	1.4	1.2	Coarse Sand
4.8	2.6	1.4	1.2	Coarse Sand
4.9	2.6	1.4	1.2	Coarse Sand
5	2.6	1.4	1.2	Coarse Sand
5.1	2.6	1.4	1.2	Coarse Sand
5.2	2.6	1.4	1.2	Coarse Sand
5.3	2.6	1.4	1.2	Coarse Sand
5.4	2.9	1.4	1.5	Coarse Sand
5.5	2.6	1.4	1.2	Coarse Sand
5.6	2.9	1.4	1.5	Coarse Sand
5.7	2.6	1.4	1.2	Coarse Sand
5.8	2.6	1.4	1.2	Coarse Sand
5.9	2.6	1.4	1.2	Coarse Sand
6	2.0	0.8	1.2	Coarse Sand
6.1	2.1	0.8	1.3	Coarse Sand
6.2	2.1	0.8	1.3	Coarse Sand
6.3	2.1	0.8	1.3	Coarse Sand
6.4	2.1	0.8	1.3	Coarse Sand
6.5	2.1	0.8	1.3	Coarse Sand
6.6	1.5	0.8	0.7	Coarse Sand
6.7	1.5	0.8	0.7	Coarse Sand
6.8	1.5	0.8	0.7	Coarse Sand
6.9	1.5	0.8	0.7	Coarse Sand
7	1.5	0.8	0.7	Coarse Sand
7.1	1.6	0.8	0.8	Coarse Sand
7.2	1.6	0.8	0.8	Coarse Sand
7.3	1.6	0.8	0.8	Coarse Sand
7.4	1.6	0.8	0.8	Coarse Sand
7.5	1.6	0.8	0.8	Coarse Sand
7.6	5.2	0.8	4.4	Coarse Sand
7.7	2.5	0.8	1.7	Coarse Sand
7.8	2.0	0.8	1.2	Coarse Sand
7.9	1.6	0.8	0.8	Coarse Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
8	2.0	0.8	1.2	Coarse Sand
8.1	1.6	0.8	0.8	Coarse Sand
8.2	1.6	0.8	0.8	Coarse Sand
8.3	1.6	0.8	0.8	Coarse Sand
8.4	1.6	0.8	0.8	Coarse Sand
8.5	1.6	0.8	0.8	Coarse Sand
8.6	4.0	0.8	3.2	Coarse Sand
8.7	2.8	0.8	2	Coarse Sand
8.8	1.6	0.8	0.8	Coarse Sand
8.9	3.1	0.8	2.3	Coarse Sand
9	7.1	0.8	6.3	Coarse Sand
9.1	5.5	0.8	4.7	Coarse Sand
9.2	3.9	0.8	3.1	Coarse Sand
9.3	2.0	0.8	1.2	Coarse Sand
9.4	2.0	0.8	1.2	Coarse Sand
9.5	2.5	0.8	1.7	Coarse Sand
9.6	3.2	0.8	2.4	Coarse Sand
9.7	3.4	0.8	2.6	Coarse Sand
9.8	3.4	0.8	2.6	Coarse Sand
9.9	2.3	0.8	1.5	Coarse Sand
10	1.6	0.8	0.8	Coarse Sand
10.1	2.3	0.8	1.5	Coarse Sand
10.2	1.6	0.8	0.8	Coarse Sand
10.3	1.6	0.8	0.8	Coarse Sand
10.4	1.6	0.8	0.8	Coarse Sand
10.5	1.6	0.8	0.8	Coarse Sand
10.6	1.6	0.8	0.8	Coarse Sand
10.7	1.6	0.8	0.8	Coarse Sand
10.8	1.6	0.8	0.8	Coarse Sand
10.9	1.6	0.8	0.8	Coarse Sand
11	1.6	0.8	0.8	Coarse Sand
11.1	1.4	0.8	0.6	Coarse Sand
11.2	1.4	0.8	0.6	Coarse Sand
11.3	1.3	0.8	0.5	Coarse Sand
11.4	1.3	0.8	0.5	Coarse Sand
11.5	1.3	0.8	0.5	Coarse Sand
11.6	1.3	0.8	0.5	Coarse Sand
11.7	1.3	0.8	0.5	Coarse Sand
11.8	1.3	0.8	0.5	Coarse Sand
11.9	1.3	0.8	0.5	Coarse Sand
12	1.3	0.8	0.5	Coarse Sand
12.1	1.3	0.8	0.5	Coarse Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
12.2	1.3	0.8	0.5	Coarse Sand
12.3	1.3	0.8	0.5	Coarse Sand
12.4	1.3	0.8	0.5	Coarse Sand
12.5	1.3	0.8	0.5	Coarse Sand
12.6	1.3	0.8	0.5	Coarse Sand
12.7	1.3	0.8	0.5	Coarse Sand
12.8	1.3	0.8	0.5	Coarse Sand
12.9	1.3	0.8	0.5	Coarse Sand
13	1.3	0.8	0.5	Coarse Sand
13.1	1.3	0.8	0.5	Coarse Sand
13.2	1.3	0.8	0.5	Coarse Sand
13.3	1.3	0.8	0.5	Coarse Sand
13.4	1.3	0.8	0.5	Coarse Sand
13.5	1.2	0.8	0.4	Coarse Sand
13.6	1.2	0.8	0.4	Coarse Sand
13.7	1.2	0.8	0.4	Coarse Sand
13.8	1.2	0.8	0.4	Coarse Sand
13.9	1.2	0.8	0.4	Coarse Sand
14	1.2	0.8	0.4	Coarse Sand
14.1	1.2	0.8	0.4	Coarse Sand
14.2	1.2	0.8	0.4	Coarse Sand
14.3	1.2	0.8	0.4	Coarse Sand
14.4	1.2	0.8	0.4	Coarse Sand
14.5	1.2	0.8	0.4	Coarse Sand
14.6	1.2	0.8	0.4	Coarse Sand
14.7	1.5	0.8	0.7	Coarse Sand
14.8	1.5	0.8	0.7	Coarse Sand
14.9	1.5	0.8	0.7	Coarse Sand
15	1.5	0.8	0.7	Coarse Sand
15.1	1.5	0.8	0.7	Coarse Sand
15.2	1.5	0.8	0.7	Coarse Sand
15.3	1.5	0.8	0.7	Coarse Sand
15.4	1.5	0.8	0.7	Coarse Sand
15.5	3.0	0.8	2.2	Coarse Sand
15.6	5.7	0.8	4.9	Coarse Sand
15.7	2.0	0.8	1.2	Coarse Sand
15.8	2.0	0.8	1.2	Coarse Sand
15.9	2.0	0.8	1.2	Coarse Sand
16	1.4	0.239	1.2	Coarse Sand
16.1	2.2	0.239	2	Coarse Sand
16.2	0.9	0.239	0.7	Coarse Sand
16.3	0.9	0.239	0.7	Coarse Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
16.4	0.9	0.239	0.7	Coarse Sand
16.5	1.4	0.239	1.2	Coarse Sand
16.6	1.4	0.239	1.2	Coarse Sand
16.7	1.4	0.239	1.2	Coarse Sand
16.8	1.4	0.239	1.2	Coarse Sand
16.9	0.9	0.239	0.7	Coarse Sand
17	0.9	0.239	0.7	Coarse Sand
17.1	1.4	0.239	1.2	Coarse Sand
17.2	1.4	0.239	1.2	Coarse Sand
17.3	2.7	0.239	2.5	Coarse Sand
17.4	2.7	0.239	2.5	Coarse Sand
17.5	3.6	0.239	3.4	Coarse Sand
17.6	5.8	0.239	5.6	Coarse Sand
17.7	3.6	0.239	3.4	Coarse Sand
17.8	4.5	0.239	4.3	Coarse Sand
17.9	7.3	0.239	7.1	Coarse Sand
18	8.6	0.239	8.4	Coarse Sand
18.1	5.9	0.239	5.7	Coarse Sand
18.2	5.9	0.239	5.7	Coarse Sand
18.3	2.8	0.239	2.6	Coarse Sand
18.4	2.8	0.239	2.6	Coarse Sand
18.5	2.8	0.239	2.6	Coarse Sand
18.6	2.8	0.239	2.6	Coarse Sand
18.7	1.4	0.239	1.2	Coarse Sand
18.8	1.4	0.239	1.2	Coarse Sand
18.9	0.9	0.239	0.7	Coarse Sand
19	1.5	0.239	1.3	Coarse Sand
19.1	1.4	0.239	1.2	Coarse Sand
19.2	1.8	0.239	1.6	Coarse Sand
19.3	1.8	0.239	1.6	Coarse Sand
19.4	1.5	0.239	1.3	Coarse Sand
19.5	1.5	0.239	1.3	Coarse Sand
19.6	1.5	0.239	1.3	Coarse Sand
19.7	1.5	0.239	1.3	Coarse Sand
19.8	3.5	0.239	3.3	Coarse Sand
19.9	1.0	0.239	0.8	Coarse Sand
20	1.0	0.239	0.8	Coarse Sand
20.1	5.4	0.239	5.2	Coarse Sand
20.2	1.0	0.239	0.8	Coarse Sand
20.3	1.0	0.239	0.8	Coarse Sand
20.4	1.8	0.239	1.6	Coarse Sand
20.5	1.8	0.239	1.6	Coarse Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
20.6	1.8	0.239	1.6	Coarse Sand
20.7	1.4	0.239	1.2	Coarse Sand
20.8	1.4	0.239	1.2	Coarse Sand
20.9	1.0	0.239	0.8	Coarse Sand
21	1.0	0.239	0.8	Coarse Sand
21.1	2.6	0.239	2.4	Coarse Sand
21.2	2.6	0.239	2.4	Coarse Sand
21.3	3.6	0.239	3.4	Coarse Sand
21.4	3.6	0.239	3.4	Coarse Sand
21.5	2.8	0.239	2.6	Coarse Sand
21.6	2.8	0.239	2.6	Coarse Sand
21.7	2.8	0.239	2.6	Coarse Sand
21.8	0.6	0.239	0.4	Coarse Sand
21.9	0.6	0.239	0.4	Coarse Sand
22	0.6	0.239	0.4	Coarse Sand
22.1	0.5	0.239	0.3	Coarse Sand
22.2	0.5	0.239	0.3	Coarse Sand
22.3	0.6	0.239	0.4	Coarse Sand
22.4	0.6	0.239	0.4	Fine Sand
22.5	0.6	0.239	0.4	Fine Sand
22.6	0.6	0.239	0.4	Fine Sand
22.7	0.6	0.239	0.4	Fine Sand
22.8	1.8	0.239	1.6	Fine Sand
22.9	2.0	0.239	1.8	Fine Sand
23	2.2	0.239	2	Fine Sand
23.1	1.3	0.239	1.1	Fine Sand
23.2	1.3	0.239	1.1	Fine Sand
23.3	0.5	0.239	0.3	Fine Sand
23.4	0.5	0.239	0.3	Fine Sand
23.5	0.5	0.239	0.3	Fine Sand
23.6	0.5	0.239	0.3	Fine Sand
23.7	2.5	0.239	2.3	Fine Sand
23.8	5.7	0.239	5.5	Fine Sand
23.9	4.7	0.239	4.5	Fine Sand
24	2.6	0.239	2.4	Fine Sand
24.1	2.6	0.239	2.4	Fine Sand
24.2	2.6	0.239	2.4	Fine Sand
24.3	7.7	0.239	7.5	Fine Sand
24.4	8.4	0.239	8.2	Fine Sand
24.5	2.4	0.239	2.2	Fine Sand
24.6	3.8	0.239	3.6	Fine Sand
24.7	2.4	0.239	2.2	Fine Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
24.8	0.7	0.239	0.5	Fine Sand
24.9	0.7	0.239	0.5	Fine Sand
25	0.8	0.34	0.5	Fine Sand
25.1	1.7	0.34	1.4	Fine Sand
25.2	1.7	0.34	1.4	Fine Sand
25.3	1.7	0.34	1.4	Fine Sand
25.4	1.5	0.34	1.2	Fine Sand
25.5	0.7	0.34	0.4	Fine Sand
25.6	0.7	0.34	0.4	Fine Sand
25.7	0.7	0.34	0.4	Fine Sand
25.8	0.9	0.34	0.6	Fine Sand
25.9	0.9	0.34	0.6	Fine Sand
26	0.9	0.34	0.6	Fine Sand
26.1	2.4	0.34	2.1	Fine Sand
26.2	5.7	0.34	5.4	Fine Sand
26.3	9.0	0.34	8.7	Fine Sand
26.4	5.0	0.34	4.7	Fine Sand
26.5	2.6	0.34	2.3	Fine Sand
26.6	2.6	0.34	2.3	Fine Sand
26.7	1.8	0.34	1.5	Fine Sand
26.8	1.8	0.34	1.5	Fine Sand
26.9	1.8	0.34	1.5	Fine Sand
27	1.4	0.34	1.1	Fine Sand
27.1	1.0	0.34	0.7	Fine Sand
27.2	1.0	0.34	0.7	Fine Sand
27.3	1.5	0.34	1.2	Fine Sand
27.4	1.5	0.34	1.2	Fine Sand
27.5	1.5	0.34	1.2	Fine Sand
27.6	1.5	0.34	1.2	Fine Sand
27.7	3.7	0.34	3.4	Fine Sand
27.8	3.7	0.34	3.4	Fine Sand
27.9	3.7	0.34	3.4	Fine Sand
28	2.7	0.34	2.4	Fine Sand
28.1	2.6	0.34	2.3	Fine Sand
28.2	2.6	0.34	2.3	Fine Sand
28.3	1.8	0.34	1.5	Fine Sand
28.4	1.8	0.34	1.5	Fine Sand
28.5	1.8	0.34	1.5	Fine Sand
28.6	5.8	0.34	5.5	Fine Sand
28.7	7.1	0.34	6.8	Fine Sand
28.8	4.9	0.34	4.6	Fine Sand
28.9	4.9	0.34	4.6	Fine Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
29	4.8	0.34	4.5	Fine Sand
29.1	3.7	0.34	3.4	Fine Sand
29.2	3.7	0.34	3.4	Fine Sand
29.3	1.4	0.34	1.1	Fine Sand
29.4	1.0	0.34	0.7	Fine Sand
29.5	1.0	0.34	0.7	Fine Sand
29.6	1.6	0.34	1.3	Fine Sand
29.7	1.6	0.34	1.3	Fine Sand
29.8	4.7	0.34	4.4	Fine Sand
29.9	2.6	0.34	2.3	Fine Sand
30	1.5	0.34	1.2	Fine Sand
30.1	2.6	0.34	2.3	Fine Sand
30.2	4.8	0.34	4.5	Fine Sand
30.3	2.7	0.34	2.4	Fine Sand
30.4	2.6	0.34	2.3	Fine Sand
30.5	2.6	0.34	2.3	Fine Sand
30.6	2.6	0.34	2.3	Fine Sand
30.7	1.5	0.34	1.2	Fine Sand
30.8	1.5	0.34	1.2	Fine Sand
30.9	1.5	0.34	1.2	Fine Sand
31	1.7	0.34	1.4	Fine Sand
31.1	1.2	0.34	0.9	Fine Sand
31.2	1.0	0.34	0.7	Fine Sand
31.3	1.0	0.34	0.7	Fine Sand
31.4	1.0	0.34	0.7	Fine Sand
31.5	1.7	0.34	1.4	Fine Sand
31.6	4.5	0.34	4.2	Fine Sand
31.7	4.5	0.34	4.2	Silt Sand
31.8	1.6	0.34	1.3	Silt Sand
31.9	1.6	0.34	1.3	Silt Sand
32	1.6	0.34	1.3	Silt Sand
32.1	1.6	0.34	1.3	Silt Sand
32.2	1.6	0.34	1.3	Silt Sand
32.3	2.0	0.34	1.7	Silt Sand
32.4	2.0	0.34	1.7	Silt Sand
32.5	1.5	0.34	1.2	Silt Sand
32.6	8.0	0.34	7.7	Silt Sand
32.7	14.0	0.34	13.7	Silt Sand
32.8	14.8	0.34	14.5	Silt Sand
32.9	5.7	0.34	5.4	Silt Sand
33	1.5	0.34	1.2	Silt Sand
33.1	1.6	0.34	1.3	Silt Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
33.2	1.6	0.34	1.3	Silt Sand
33.3	6.7	0.34	6.4	Silt Sand
33.4	4.8	0.34	4.5	Silt Sand
33.5	2.6	0.34	2.3	Silt Sand
33.6	2.6	0.34	2.3	Silt Sand
33.7	2.6	0.34	2.3	Silt Sand
33.8	1.5	0.34	1.2	Silt Sand
33.9	1.5	0.34	1.2	Silt Sand
34	1.5	0.34	1.2	Silt Sand
34.1	0.5	0.34	0.2	Silt Sand
34.2	0.4	0.34	0.1	Silt Sand
34.3	0.2	0.34	0	Silt Sand
34.4	0.8	0.34	0.5	Silt Sand
34.5	3.7	0.34	3.4	Silt Sand
34.6	3.7	0.34	3.4	Silt Sand
34.7	1.5	0.34	1.2	Silt Sand
34.8	0.6	0.34	0.3	Silt Sand
34.9	0.4	0.34	0.1	Silt Sand
35	0.5	0.34	0.2	Silt Sand
35.1	0.3	0.34	0	Silt Sand
35.2	0.2	0.34	0	Silt Sand
35.3	0.2	0.34	0	Silt Sand
35.4	0.2	0.34	0	Silt Sand
35.5	0.2	0.34	0	Silt Sand
35.6	0.5	0.34	0.2	Silt Sand
35.7	0.5	0.34	0.2	Silt Sand
35.8	1.0	0.34	0.7	Silt Sand
35.9	1.0	0.34	0.7	Silt Sand
36	0.6	0.213	0.4	Silt Sand
36.1	0.6	0.213	0.4	Silt Sand
36.2	0.4	0.213	0.2	Silt Sand
36.3	0.4	0.213	0.2	Silt Sand
36.4	0.4	0.213	0.2	Silt Sand
36.5	0.7	0.213	0.5	Silt Sand
36.6	0.7	0.213	0.5	Silt Sand
36.7	0.7	0.213	0.5	Silt Sand
36.8	1.6	0.213	1.4	Silt Sand
36.9	2.8	0.213	2.6	Silt Sand
37	2.8	0.213	2.6	Silt Sand
37.1	3.7	0.213	3.5	Silt Sand
37.2	3.7	0.213	3.5	Silt Sand
37.3	3.8	0.213	3.6	Silt Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
37.4	3.8	0.213	3.6	Silt Sand
37.5	1.6	0.213	1.4	Silt Sand
37.6	2.8	0.213	2.6	Silt Sand
37.7	3.6	0.213	3.4	Silt Sand
37.8	2.8	0.213	2.6	Silt Sand
37.9	2.8	0.213	2.6	Mud Sand
38	2.8	0.213	2.6	Mud Sand
38.1	2.8	0.213	2.6	Mud Sand
38.2	3.5	0.213	3.3	Mud Sand
38.3	3.5	0.213	3.3	Mud Sand
38.4	2.7	0.213	2.5	Mud Sand
38.5	1.8	0.213	1.6	Mud Sand
38.6	1.8	0.213	1.6	Mud Sand
38.7	1.4	0.213	1.2	Mud Sand
38.8	1.4	0.213	1.2	Mud Sand
38.9	1.4	0.213	1.2	Mud Sand
39	1.4	0.213	1.2	Mud Sand
39.1	1.0	0.213	0.8	Mud Sand
39.2	1.0	0.213	0.8	Mud Sand
39.3	0.4	0.213	0.2	Mud Sand
39.4	0.4	0.213	0.2	Mud Sand
39.5	0.4	0.213	0.2	Mud Sand
39.6	0.2	0.213	0	Mud Sand
39.7	0.2	0.213	0	Mud Sand
39.8	0.2	0.213	0	Mud Sand
39.9	0.2	0.213	0	Mud Sand
40	0.2	0.213	0	Mud Sand
40.1	0.2	0.213	0	Mud Sand
40.2	0.2	0.213	0	Mud Sand
40.3	2.9	0.213	2.7	Mud Sand
40.4	1.5	0.213	1.3	Mud Sand
40.5	1.4	0.213	1.2	Mud Sand
40.6	0.5	0.213	0.3	Mud Sand
40.7	0.5	0.213	0.3	Mud Sand
40.8	0.5	0.213	0.3	Mud Sand
40.9	0.5	0.213	0.3	Mud Sand
41	0.5	0.213	0.3	Mud Sand
41.1	0.9	0.213	0.7	Mud Sand
41.2	1.6	0.213	1.4	Mud Sand
41.3	2.0	0.213	1.8	Mud Sand
41.4	2.7	0.213	2.5	Mud Sand
41.5	2.7	0.213	2.5	Mud Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
41.6	2.7	0.213	2.5	Mud Sand
41.7	1.0	0.213	0.8	Mud Sand
41.8	1.4	0.213	1.2	Mud Sand
41.9	0.5	0.213	0.3	Mud Sand
42	0.5	0.213	0.3	Mud Sand
42.1	4.0	0.213	3.8	Mud Sand
42.2	2.8	0.213	2.6	Mud Sand
42.3	0.6	0.213	0.4	Mud Sand
42.4	1.4	0.213	1.2	Mud Sand
42.5	1.4	0.213	1.2	Mud Sand
42.6	1.4	0.213	1.2	Mud Sand
42.7	0.2	0.213	0	Mud Sand
42.8	0.2	0.213	0	Mud Sand
42.9	5.2	0.213	5	Mud Sand
43	5.1	0.213	4.9	Mud Sand
43.1	4.9	0.213	4.7	Mud Sand
43.2	3.7	0.213	3.5	Mud Sand
43.3	3.7	0.213	3.5	Mud Sand
43.4	2.6	0.213	2.4	Mud Sand
43.5	2.6	0.213	2.4	Mud Sand
43.6	2.0	0.213	1.8	Mud Sand
43.7	0.9	0.213	0.7	Mud Sand
43.8	2.6	0.213	2.4	Mud Sand
43.9	3.7	0.213	3.5	Mud Sand
44	2.6	0.213	2.4	Mud Sand
44.1	2.7	0.213	2.5	Mud Sand
44.2	2.7	0.213	2.5	Mud Sand
44.3	2.7	0.213	2.5	Mud Sand
44.4	2.7	0.213	2.5	Mud Sand
44.5	1.6	0.213	1.4	Mud Sand
44.6	1.6	0.213	1.4	Mud Sand
44.7	1.6	0.213	1.4	Mud Sand
44.8	3.5	0.213	3.3	Mud Sand
44.9	3.5	0.213	3.3	Mud Sand
45	3.7	0.362	3.3	Mud Sand
45.1	5.6	0.362	5.2	Mud Sand
45.2	6.8	0.362	6.4	Mud Sand
45.3	3.9	0.362	3.5	Mud Sand
45.4	3.9	0.362	3.5	Mud Sand
45.5	1.2	0.362	0.8	Mud Sand
45.6	1.2	0.362	0.8	Mud Sand
45.7	0.6	0.362	0.2	Mud Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
45.8	0.5	0.362	0.1	Mud Sand
45.9	0.5	0.362	0.1	Mud Sand
46	0.5	0.362	0.1	Mud Sand
46.1	1.2	0.362	0.8	Mud Sand
46.2	1.2	0.362	0.8	Mud Sand
46.3	1.2	0.362	0.8	Mud Sand
46.4	1.2	0.362	0.8	Mud Sand
46.5	1.2	0.362	0.8	Mud Sand
46.6	1.2	0.362	0.8	Mud Sand
46.7	1.2	0.362	0.8	Mud Sand
46.8	1.5	0.362	1.1	Mud Sand
46.9	1.5	0.362	1.1	Mud Sand
47	1.5	0.362	1.1	Mud Sand
47.1	1.7	0.362	1.3	Mud Sand
47.2	1.7	0.362	1.3	Mud Sand
47.3	2.2	0.362	1.8	Mud Sand
47.4	2.2	0.362	1.8	Mud Sand
47.5	2.2	0.362	1.8	Mud Sand
47.6	2.2	0.362	1.8	Mud Sand
47.7	2.4	0.362	2	Mud Sand
47.8	2.2	0.362	1.8	Mud Sand
47.9	2.2	0.362	1.8	Mud Sand
48	2.2	0.362	1.8	Mud Sand
48.1	2.4	0.362	2	Mud Sand
48.2	2.4	0.362	2	Mud Sand
48.3	2.4	0.362	2	Mud Sand
48.4	4.0	0.362	3.6	Mud Sand
48.5	4.0	0.362	3.6	Mud Sand
48.6	4.0	0.362	3.6	Mud Sand
48.7	4.0	0.362	3.6	Mud Sand
48.8	5.1	0.362	4.7	Mud Sand
48.9	5.1	0.362	4.7	Mud Sand
49	4.0	0.362	3.6	Coarse Sand
49.1	3.1	0.362	2.7	Coarse Sand
49.2	3.1	0.362	2.7	Coarse Sand
49.3	3.1	0.362	2.7	Coarse Sand
49.4	3.1	0.362	2.7	Coarse Sand
49.5	3.2	0.362	2.8	Coarse Sand
49.6	3.2	0.362	2.8	Coarse Sand
49.7	3.2	0.362	2.8	Coarse Sand
49.8	3.2	0.362	2.8	Coarse Sand
49.9	3.2	0.362	2.8	Coarse Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
50	3.4	0.362	3	Coarse Sand
50.1	2.8	0.362	2.4	Coarse Sand
50.2	2.8	0.362	2.4	Coarse Sand
50.3	1.6	0.362	1.2	Coarse Sand
50.4	1.6	0.362	1.2	Coarse Sand
50.5	0.9	0.362	0.5	Coarse Sand
50.6	0.9	0.362	0.5	Coarse Sand
50.7	0.9	0.362	0.5	Coarse Sand
50.8	1.3	0.362	0.9	Coarse Sand
50.9	1.3	0.362	0.9	Coarse Sand
51	1.6	0.362	1.2	Coarse Sand
51.1	1.5	0.362	1.1	Coarse Sand
51.2	1.5	0.362	1.1	Coarse Sand
51.3	1.7	0.362	1.3	Coarse Sand
51.4	1.9	0.362	1.5	Coarse Sand
51.5	2.1	0.362	1.7	Coarse Sand
51.6	2.3	0.362	1.9	Coarse Sand
51.7	2.8	0.362	2.4	Coarse Sand
51.8	2.8	0.362	2.4	Coarse Sand
51.9	5.3	0.362	4.9	Coarse Sand
52	6.3	0.362	5.9	Coarse Sand
52.1	8.0	0.362	7.6	Coarse Sand
52.2	14.9	0.362	14.5	Coarse Sand
52.3	11.2	0.362	10.8	Coarse Sand
52.4	4.7	0.362	4.3	Coarse Sand
52.5	4.7	0.362	4.3	Coarse Sand
52.6	2.7	0.362	2.3	Coarse Sand
52.7	3.0	0.362	2.6	Coarse Sand
52.8	4.3	0.362	3.9	Coarse Sand
52.9	4.3	0.362	3.9	Coarse Sand
53	4.7	0.362	4.3	Coarse Sand
53.1	4.9	0.362	4.5	Coarse Sand
53.2	4.9	0.362	4.5	Coarse Sand
53.3	6.0	0.362	5.6	Coarse Sand
53.4	7.7	0.362	7.3	Coarse Sand
53.5	9.3	0.362	8.9	Coarse Sand
53.6	12.7	0.362	12.3	Coarse Sand
53.7	10.8	0.362	10.4	Coarse Sand
53.8	7.7	0.362	7.3	Coarse Sand
53.9	7.6	0.362	7.2	Coarse Sand
54	12.9	0.362	12.5	Coarse Sand
54.1	8.0	0.362	7.6	Coarse Sand

Chainage (km)	Observed water depth(m)	Reduction factor	Water Depth w.r.t. CD (m)	Soil Texture
54.2	3.7	0.362	3.3	Coarse Sand
54.3	3.7	0.362	3.3	Coarse Sand
54.4	3.7	0.362	3.3	Coarse Sand
54.5	3.7	0.362	3.3	Coarse Sand
54.6	3.7	0.362	3.3	Coarse Sand
54.7	2.6	0.362	2.2	Coarse Sand
54.8	2.6	0.362	2.2	Coarse Sand
54.9	3.5	0.362	3.1	Coarse Sand
55	3.5	0.362	3.1	Coarse Sand
55.1	4.0	0.362	3.6	Coarse Sand
55.2	4.9	0.362	4.5	Coarse Sand
55.3	4.9	0.362	4.5	Coarse Sand
55.4	5.1	0.362	4.7	Coarse Sand
55.5	5.1	0.362	4.7	Coarse Sand
55.6	5.1	0.362	4.7	Coarse Sand
55.7	3.6	0.362	3.2	Coarse Sand
55.8	3.6	0.362	3.2	Coarse Sand
55.9	2.8	0.362	2.4	Coarse Sand
56	2.8	0.362	2.4	Coarse Sand

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