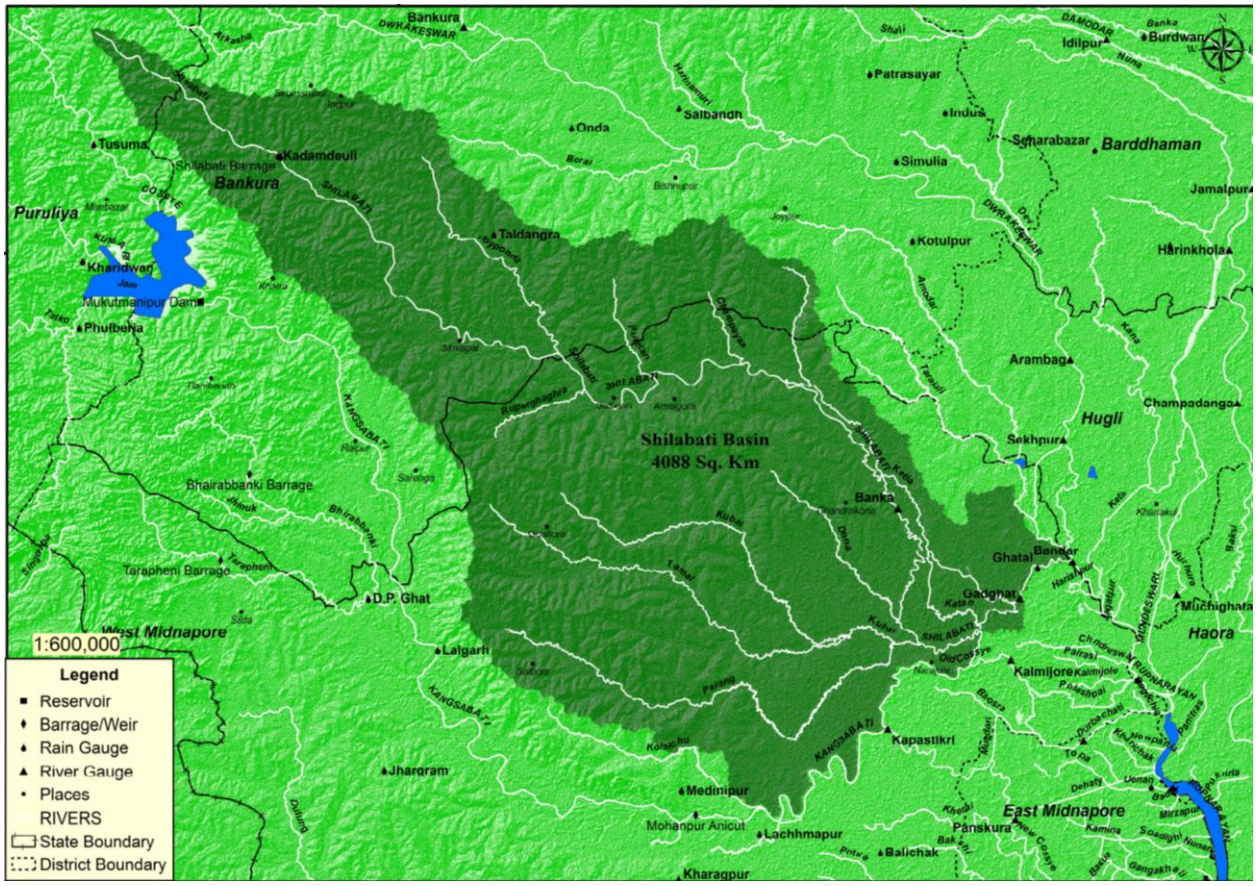
Consultancy Services for preparation of Two Stage Detailed Project Report (DPR) of National Waterway 92, Cluster - I: Silabati River

FINAL FEASIBILTY REPORT



Inland Waterway Authority of India

Cluster – I : Silabati River

Final Feasibility Report

Revision 0

November 2016

Consultancy Services for preparation of Two Stage Detailed Project Report (DPR) of National Waterway 92, Cluster - I: Silabati River

FINAL FEASIBILITY REPORT

Project **IWAI Cluster-I, Silabati River**

Owner **IWAI, Ministry of Shipping**

Consultant **Egis India Consulting Engineers**

<table>
<tr><td colspan="3">Authors

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PT/EIPTIWB003

Report No:
PT/EIPTIWB003/2016/FR/006

Approved by:

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<tr><td>0</td><td>Feasibility Report</td><td>Nov 2016</td><td>DM</td><td>AK</td><td>JKP</td></tr>
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LIST OF ABBREVIATIONS

IWAI	Inland Waterways Authority of India
IWT	Inland Water Transportation
MOS	Ministry of Shipping
NW	National Waterway
DPR	Detailed Project Report
WW	Waterway
AtoN	Aid to Navigation
VC	Vertical Clearance
HC	Horizontal Clearance

ACKNOWLEDGEMENT

*Egis India Consulting Engineers Pvt Ltd (EIPL) express their gratitude to **Shri Amitabh Verma, IAS, Chairman,** for spending their valuable time and guidance for completing this Project of "Feasibility report of two stage detailed project report of National Waterway 92, Cluster – I, Silabati River. EIPL would also like to thanks **Shri Pravir Pandey, Vice Chairman IA&AS**.*

*EIPL wishes to express their gratitude to **Cdr. P.K. Srivastava, Hydrographic Chief, IWAI** for his guidance and inspiration for this project. EIPL would also like to thank **Sh. Rajiv Singhal, A.H.S., IWAI** for their invaluable support and suggestions provided throughout the project duration. EIPL is pleased to place on record their sincere thanks to other staff and officers of IWAI for their excellent support and co-operation throughout the project duration.*

SALIENT FEATURES

<table>
<tr><th>Sl. No.</th><th>Particulars</th><th>Details</th></tr>
<tr><td>1.</td><td>Name of Consultant</td><td>Egis India Consulting Engineers Pvt. Ltd.</td></tr>
<tr><td>2.</td><td>Cluster number</td><td>Cluster I</td></tr>
<tr><td>3.</td><td>Waterway stretch (from. To, total length)</td><td>Silabati River (National Waterway 92)
(From Barrage near Shimulia village at Lat 22°34'53.20"N, Long 87°38'30.54"E to confluence of Dwarakeswar and Silai rivers at Pratappur Lat 22°40'16.94"N, Long 87°46'42.57"E);
Total Length: 26 Km</td></tr>
<tr><td>4.</td><td>Navigability status</td><td></td></tr>
<tr><td>a)</td><td>Tidal & non tidal portions (from ... to, length, average tidal variation)</td><td>Tidal portion: 0 – 15.75 Km
Non-tidal: 15.75 – 26.00 km.
Tidal variation: 0.7 m.</td></tr>
<tr><td>b)</td><td>LAD status
Survey period (.. to ..)
< 1.0 m (km)
1.m to 1.5 m (km)
1.5 m to 2.0 m (km)
> 2.0 m (km)</td><td>
<table>
<tr><th></th><th>0 - 10 km</th><th>10 – 15.70 km</th><th>15.70 - 26 km</th><th>Total Km</th></tr>
<tr><td>Survey Period</td><td colspan="3">8th Jan to 12th Jan 2016</td><td></td></tr>
<tr><td>< 1.0 m</td><td>5.46</td><td>2.13</td><td>10.30</td><td>17.89</td></tr>
<tr><td>1 to 1.5 m (km)</td><td>3.08</td><td>2.80</td><td>0.00</td><td>5.88</td></tr>
<tr><td>1.5 to 2.0 m (km)</td><td>1.08</td><td>0.68</td><td>0.00</td><td>1.75</td></tr>
<tr><td>> 2.0 m (km)</td><td>0.38</td><td>0.10</td><td>0.00</td><td>0.48</td></tr>
</table>
</td></tr>
<tr><td>c)</td><td>Cross structures
i) Dams, wires, barrages etc (number, with navigation locks or not).
ii) Bridges, Power cables etc [number, HC (... to ...). VC (.. to ..)]</td><td>i) Dams, Weirs, Barrages, Locks = Not Available.
ii) Bridges = 1 number, HC (3.0 m), VC (5.0 m).
iii) Power Cable = Not Available.
*Vertical clearance is above MHWS on the basis of visual assessment.</td></tr>
<tr><td>d)</td><td>Avg. discharge & no. of days</td><td>Request for discharge data was made to CWC, however the same is still awaited. Shall be provided in DPR Stage.</td></tr>
</table>

Sl. No.	Particulars	Details
e)	Slope (1 in ..)	Approximate slope of waterway is 1 in 1300.
f)	Consultants inference	➢ The horizontal and vertical clearance of existing cross-structures is 3m and 5m respectively. ➢ Taking in to account the water availability, 0.48 Km stretch of waterway have draft more than 2.0 m, 1.75 Km stretch have draft of 1.50 m to 2.0 m, 5.88 km have draft of 1.0 m to 1.50 m and remaining 17.89 km stretch of waterway have less than 1.0 m draft with respect to chart datum respectively. ➢ Taking advantage of tidal window of 0.7m, the LAD of 1.0 m will have more under keel clearance of minimum 1.2 m. ➢ The connectivity of Silabati waterway with Dwarekeswar and Rupnarayan Waterway and thereby with National Waterway – 1 and Haldia Port provides an added advantage for traffic potential. ➢ The waterway will provide a short, convenient and cheap mode of connectivity, considering the lack of railway network near Silabati waterway. ➢ Not only there is existing traffic but also the development of waterway will trigger new traffic.
5.	**Traffic potential**	
a)	Present IWT operations, ferry services, tourism, cargo, if any	Localised passenger and cargo ferry services were operational.
b)	Important industries within 50 km	Not Available.

Sl. No.	Particulars	Details
6.	Consultant's recommendation for going ahead with Stage-II (DPR preparation)	Silabati waterway is recommended for Stage – II DPR preparation in view of the following potential advantages: a) Connectivity of the waterway with proposed NW – 35 & 86. b) Connectivity with NW-1, Haldia and Kolkata port including their hinterland through NW -86. c) Increasing cargo potential. d) Reduction in existing traffic load on rail and road infrastructure. In view of the above, it is recommended to develop the Silabati waterway for Cargo and Passenger ferry services.

1.0 CONTEXT

IWAI, Ministry of Shipping, Government of India is exploring the potential of additional waterways across the country for year round commercial navigation, for this it is planned to conduct a Feasibility Study and recommending thereafter the possibility of Composite and Integrated development of National waterways to achieve navigation and to develop water transport facilities across India. Upon completion of feasibility study, IWAI will select the stretches having potential for navigation to undertake a Detailed Project Report. The DPR stage would include detailed hydro-graphic surveys and investigation, traffic survey, proposed location for terminals and cost assessment etc.

There are 106 new waterways has been identified and declared as national waterways as per "The National Waterway Act, 2016", No. 17 of 2016, published in the Gazette of India, Part – II- Section 1 no. 18, New Delhi, Saturday, March 26/2016/Chaitra 6, 1938 (Saka), by Ministry of Law and Justice (Legislative Department).

Out of these 106 waterways, IWAI had invited international online bids for preparation of 2 stage Detailed Project Report (DPR) for National waterways, in a set of 8 Clusters from Cluster I to VIII through Tender No. IWAI/PR/40NW/2015/I. Egis Consulting Engineers was awarded the work for Cluster I and Cluster III respectively.

This feasibility report provides the technical viability of throughout the year inland navigation in the waterways, by taking into account the constraints and other functions of the rivers/canals such as water conveyance, tidal effects, floods, draughts, existing structures etc.

As stated above, 7 rivers out of 106 National waterways are clubbed in Cluster – I of two stages DPR studies for inland waterways project. The detail descriptions of these 7 waterways are presented in **Table 1**. The total length of stretches of 7 rivers under Cluster – I is 820 km. Among these 7 waterways, 5 are connected to the National Waterway 1 between Farakka to Haldia.

Table 1: National Waterways of Cluster - 1

S. No	River	National Waterway No.	Length (km)	Description
1.	Ajoy River	National Waterway 7	96	From Bridge on Morgram-Panagarh State Highway No 14 at Illambazar Lat 23°36'56.10"N, Long 87°31'58.07"E to confluence of river Ajay with river Bhagirathi at Katwa Lat 23°39'23.33"N, Long 88° 7'56.72"E
2.	Damodar River	National Waterway 29	135	From Krishak Setu, Bardhman on State Highway No 8 at Lat 23°12'39.83"N, Long 87°50'53.85"E to confluence with Hooghly river near Purbba Basudebpur at Lat 22°21'0.58"N, Long 88° 5'19.31"E
3.	Dwarekeswar River	National Waterway 35	113	From Bridge near Abantika Lat 23° 6'54.76"N, Long 87°18'46.99"E to confluence of Dwarakeswar and Silai rivers at Pratappur Lat 22°40'16.94"N, Long 87°46'42.57"E.
4.	Ichamati River	National Waterway 44	64	From Bridge on Border Main Road at Gobra near Bangladesh Border at Lat 22°53'49.64"N, Long 88°53'48.87"E to near Bangladesh Border at Bansjhari Mallikpur Lat 22°39'6.71"N, Long 88°55'35.35"E.
5.	Rupnarayan River	National Waterway 86	72	From confluence of Dwarakeswar and Silai rivers at Pratappur Lat 22°40'16.94"N, Long 87°46'42.57"E to confluence with Hooghly river at Geonkhali Lat 22°12'41.58"N, Long 88° 3'13.99"E
6.	Silabati River	National Waterway 92	26	From Barrage near Shimulia village at Lat 22°34'53.20"N, Long 87°38'30.54"E to confluence of Dwarakeswar and Silai rivers at Pratappur Lat 22°40'16.94"N, Long 87°46'42.57"E.
7.	Subarnrekha River	National Waterway 96	314	From Chandil Dam at Lat 22°58'29.39"N, Long 86° 1'14.03"E to confluence with Bay of Bengal at Lat 21°33'28.75"N, Long 87°22'58.60"E.

The detailed layout plan of the above waterways is shown in Drawing No. PT/EIPTIWB003/2016/FR/0001 submitted with Volume – III (Drawings) and provided in **Figure 1**.

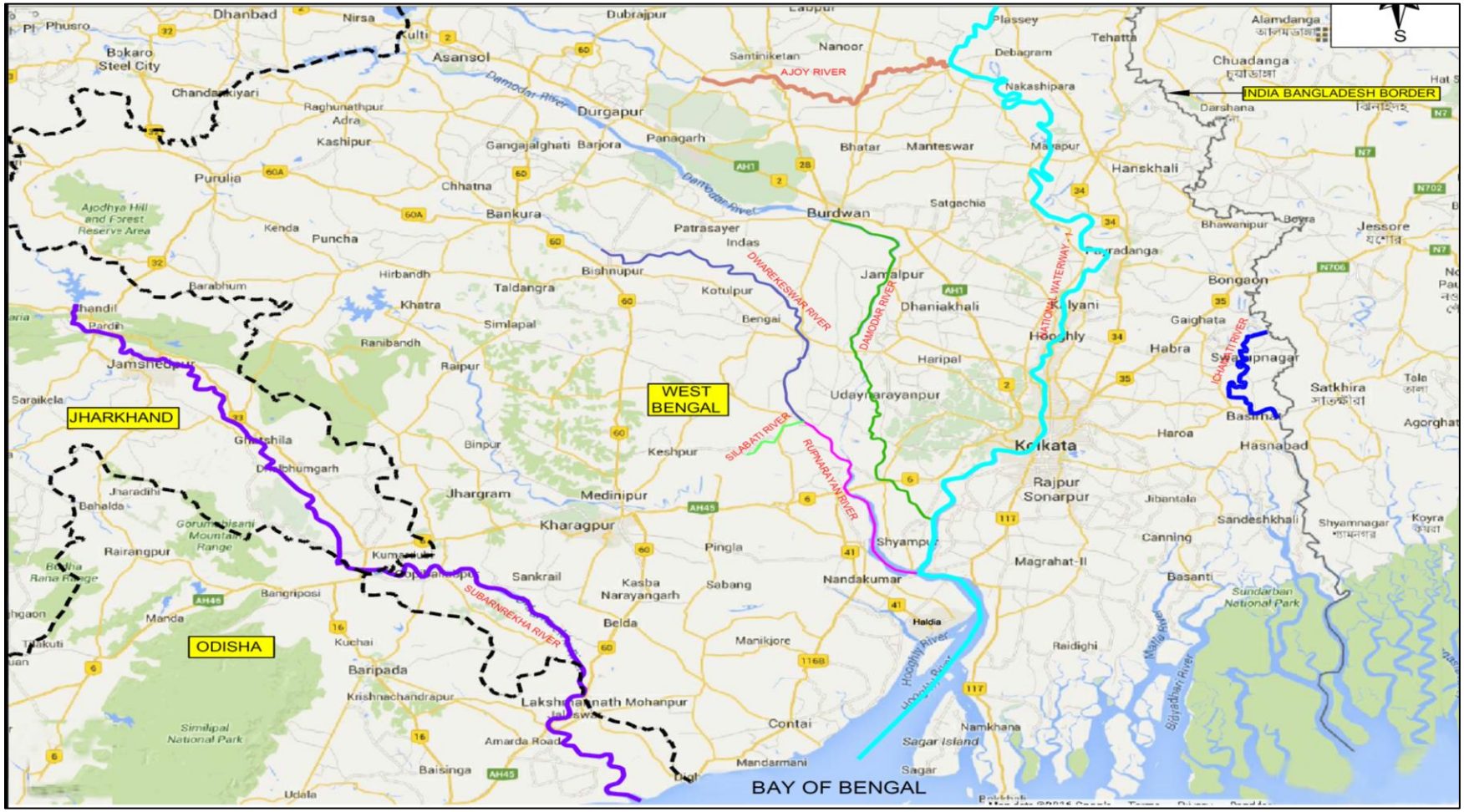

Figure 1: Layout Map of Cluster 1 National Waterways

2.0 OBJECTIVE

Government of India intends to explore the potential of additional waterways across the country for year round commercial navigation, for this it is planned to conduct a Feasibility Study and recommending thereafter the possibility of Composite and Integrated development of National waterways to achieve navigation and to develop water transport facilities across India. The whole of study comprises of two stages, feasibility and DPR as Stage-I and Stage-II as presented below.

Stage-1

1A. Reconnaissance Survey

1B. Collection and review of available data

1C. Feasibility Report

Stage-2

2A. Hydrographic Survey & hydro-morphological survey

2B. Traffic Survey & Techno economic feasibility

2C. Preparation of Detailed Project Report

The current scope for stage-I is executed as per following framework as per **Figure 2** .

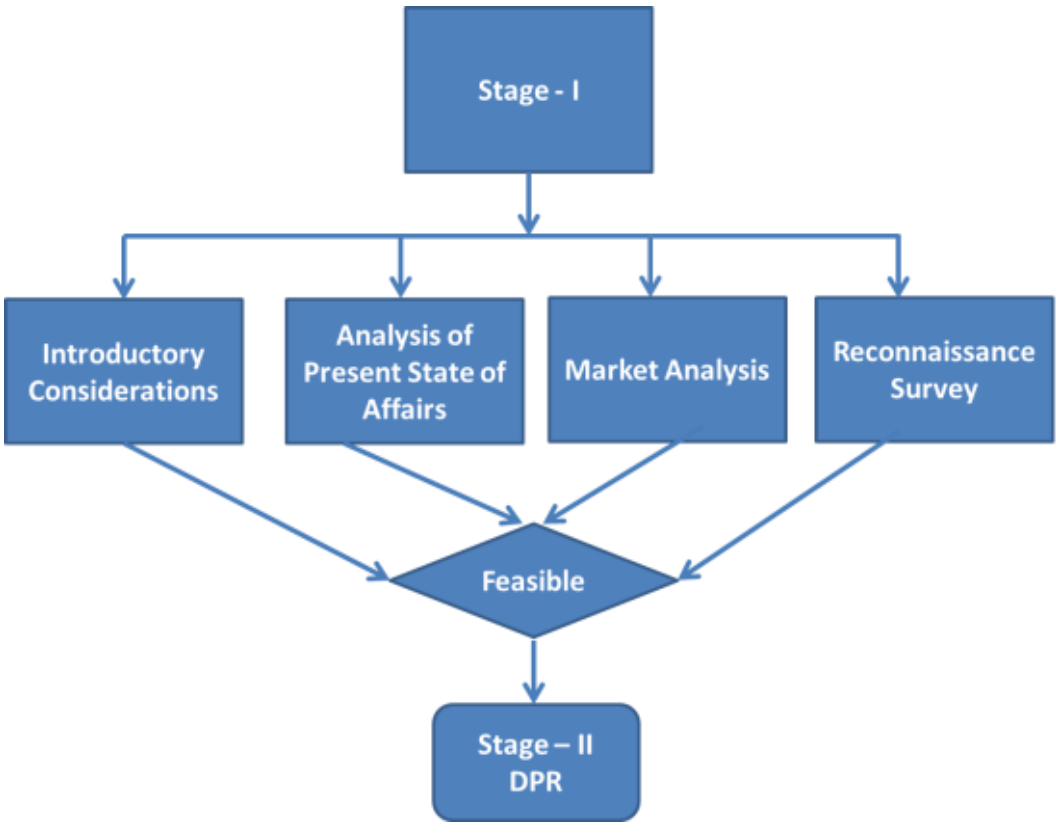

Figure 2: Framework of Studies

3.0 REPORT STRUCTURE

This report comprises of Feasibility Study for Silabati River waterway (length = 26 Km). The report is arranged in following main chapters,

I. **Introductory Consideration**: This section comprises of,

1) Name of the river/canal;
2) Length of the river/canal;
3) State/ District through which river passes;
4) Map;
5) Characteristics of River;
   a. River Course: Background/Historical information, Origin, End
   b. Tributaries/ Network of Rivers/ Basin
6) Methodology Adopted to undertake the Study;
   a. Primary Data
   b. Secondary Data

II. **Analysis of Present State of Affairs**: This section comprises of,

1) Existing Dams, Barrages and Locks;
2) Existing Bridges and Crossings over River;
3) Other Cross structures, High Tension Lines, pipe-lines, cables;
4) Hindrances/ Encroachment to the Waterway;
5) Details of Protected Area- Wildlife, Defence;
6) NH/SH/MDR along and/or in vicinity;
7) Railway Line and Stations in the vicinity.

III. **Reconnaissance Survey**: This section provides the,

1) Methodology adopted including resources and equipment;
2) Description of Bench marks, reference levels, chart and sounding datum;
3) Details of collected water levels, discharge data, HFL and FSL;
4) Details and description of bathymetric and topographic survey including observations;
5) Detail about Soil, Water and Bank characteristics.

IV. **Market Analysis**: This section comprises of,

1) Land use pattern along Waterway;
2) Crop/Agriculture in the region;

3) Availability of Bulk/Construction Material;
4) Existing industries along waterway;
5) Details of existing Jetties and Terminals;
6) Preliminary traffic identified;
7) Existing cargo movement;
8) Prominent City/ Town/ Places of worship/ Historical places for tourism;
9) Availability of passenger ferry services;
10) Available and probable water sport/recreational facilities.

V. **Observation and Inferences**: This section comprises of,
1) Observation on Waterway, Length, LAD, Cross-Structures;
2) Water availability for different periods and depths;
3) Cargo/Passenger/Tourism/RO-RO facility;
4) Suitability of waterway for navigation;
5) Proposed alternative methods for making waterway feasible;
6) SWOT analysis;
7) Way forward for Stage – 2 DPR studies.

In addition to the above, following digital data and charts shall also be submitted along with this report:

I. **Bathymetric Survey**: Hypack software output files with RAW, EDIT, SORT, TIDE extensions;
II. **Topographic Survey**: csv and xyz extension files;
III. **Survey Charts**: Geo-coded dxf and dwg files in scale as per width in AutoCAD formats;

4.0 INTRODUCTORY CONSIDERATIONS

The consultant discussed here, the introductory considerations for feasibility and the scope of the assignment in subsequent phase of DPR for feasible stretches.

The present feasibility report provides the technical feasibility of the 26 km stretch of Silabati River, declared as National Waterway 92, clubbed under Cluster – I, as stated in earlier sections. The detail description of national waterway analysed in this feasibility report are described in subsequent paragraphs.

4.1 DETAILS OF NATIONAL WATERWAY 92 (SILABATI RIVER)

Details of the waterways are as follows:

Table 2: Description of Rivers/ Canals

Sl. No	Name of the River/Canal	Local Name	Length of waterway (km)	State/District through which river passes
1.	Silabati River	Silai River Shilabati River	26	**State: West Bengal** *Purulia District* *Bankura District* *Paschim (West) Medinipur District*

4.2 CHARACTERISTICS OF SILABATI RIVER

Characteristics of Silabati River considered for waterway is described in subsequent paragraph.

River Course: Silabati River originates in the terrain of Chhota Nagpur Plateau in the Purulia district of the state of West Bengal in eastern India. It flows in an almost south-easterly direction through the districts of Bankura and West Medinipur. Silabati joins the Dwarakeswar River near Ghatal and afterwards is known as Rupnarayan River. Rupnarayan River finally joins the Hooghly River, which empties into the Bay of Bengal. Almost every year the Silabati causes flooding, particularly in Banka, Khirpai and Ghatal area. There is a small reservoir on the Silabati near Khatra known as Kadam Deuli Dam where a canal from Mukutmanipur Kangsabati dam meets.

Catchment Area: The total catchments area of the Silabati river system is 4088 sq. Km.

Tributaries: Joyponda, Ketia, Donai, Kubai, Champayan are the major tributaries of Silabati river system.

The section of the Silabati River under feasibility study for inland waterway is presented in Drawing No. PT/EIPTIWB003/2016/FR/0007A and is also presented as **Figure 3**. The detail layout maps of the waterway are shown in Drawing No. PT/EIPTIWB003/2016/FR/0007.

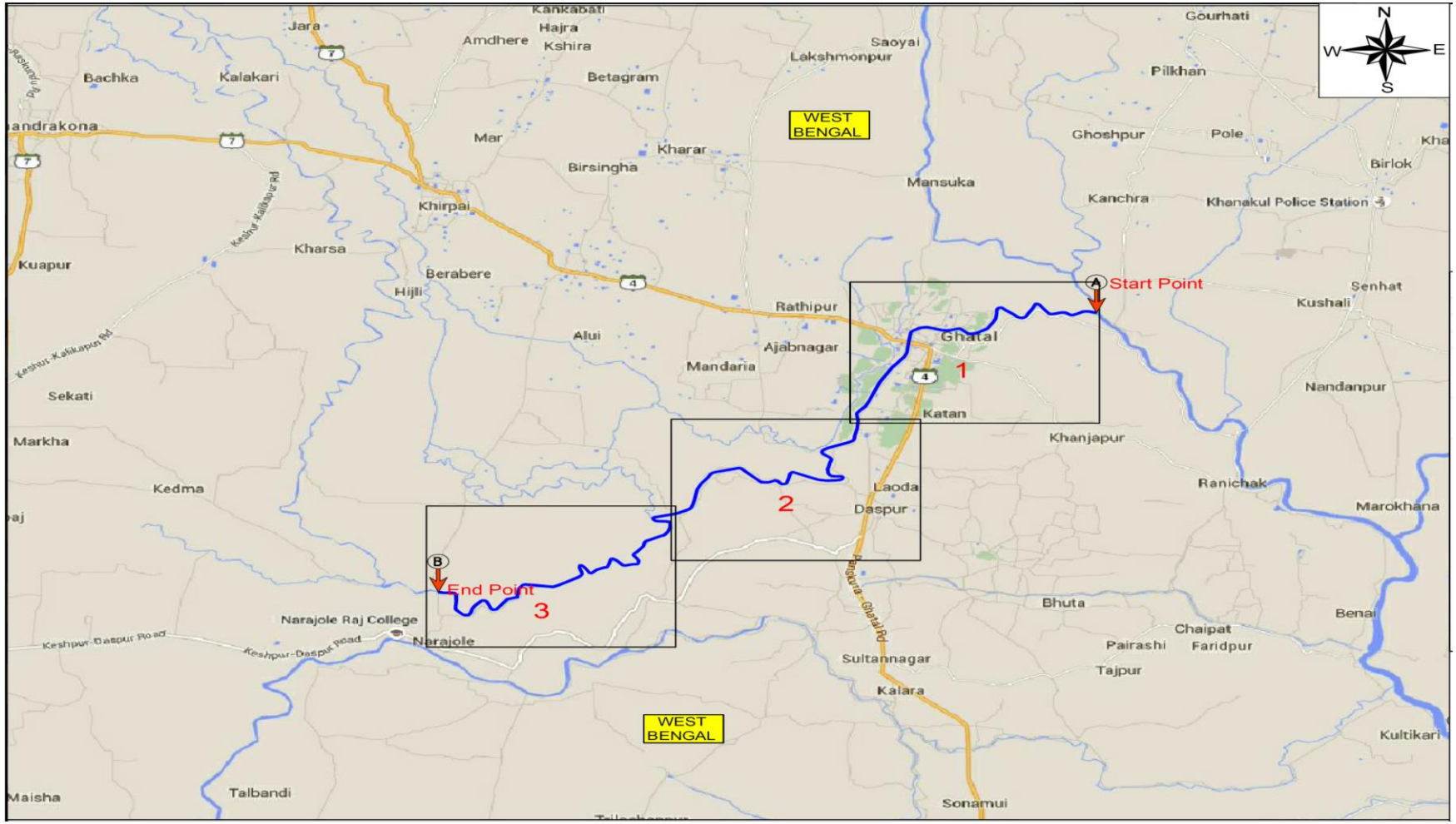

Figure 3: Layout Map of Silabati River Waterway

4.3 METHODOLOGY ADOPTED FOR FEASIBILITY STUDIES AND CRITERIA FOR DPR STUDY

A detail description on Feasibility & DPR methodology and the expected outcome in fulfilling the assignment is presented.

The feasibility study shall be carried out in accordance with TOR in the following steps:

1. Conducting Reconnaissance survey as detailed in Chapter 5.
2. Collection and review of available primary and secondary data as detailed in Chapter 6 and 7.

On the basis of detailed analysis of collected primary and secondary data, throughout the year navigability potential of the waterway is assessed and submitted in the feasibility report.

4.3.1 Classification of Waterways

The classification of waterways by Inland Waterway Authority of India is discussed below and shall be adopted in the study.

1. The waterways shall be classified in the following categories for safe plying of self-propelled vessels up to 2000 tonne Dead Weight Tonnage (DWT) and tug-barge formation in push-tow units of carrying capacity up to 8000 tonne, namely:

   a. **Class I** - Waterways with the following configuration of navigable channel:-
   - i. Rivers: Minimum of 1.2 meter depth, 30 meter bottom width, 300 meter bend radius, 4 meter vertical clearance and 30 meter horizontal clearance between piers, and
   - ii. Canals: Minimum of 1.5 meter depth, 20 meter bottom width, 300 meter bends radius, 4 meter vertical clearance and 20 meter horizontal clearance between piers.

   b. **Class II -** Waterways with the following configuration of navigable channel:-
   - i. Rivers: Minimum of 1.4 meter depth, 40 meter bottom width, 500 meter bend radius, 5 meter vertical clearance and 40 meter horizontal clearance between piers, and
   - ii. Canals: Minimum of 1.8 meter depth, 30 meter bottom width, 500 meter bend radius, 5 meter vertical clearance and 30 meter horizontal clearance between piers.

c. **Class III -** Waterways with the following configuration of navigable channel:-

i. Rivers: Minimum of 1.7 meter depth, 50 meter bottom width, 700 meter bend radius, 7 meter vertical clearance and 50 meter horizontal clearance between piers, and

ii. Canals: Minimum of 2.2 meter depth, 40 meter bottom width, 700 meter bend radius, 7 meter vertical clearance and 40 meter horizontal clearance between piers.

d. **Class IV -** Waterways with the following configuration of navigable channel:-

i. Rivers: Minimum of 2.0 meter depth, 50 meter bottom width, 800 meter bend radius, 10 meter vertical clearance and 50 meter horizontal clearance between piers, and

ii. Canals: Minimum of 2.5 meter depth, 50 meter bottom width, 800 meter bend radius, 10 meter vertical clearance and 50 meter horizontal clearance between piers.

e. **Class V** - Waterways with the following configuration of navigable channel:-

i. Rivers: Minimum of 2.0 meter depth, 80 meter bottom width, 800 meter bend radius, 10 meter vertical clearance and 80 meter horizontal clearance between piers.

f. **Class VI** - Waterways with the following configuration of navigable channel:-

i. Rivers: Minimum of 2.75 meter depth, 80 meter bottom width, 900 meter bend radius, 10 meter vertical clearance and 80 meter horizontal clearance between piers, and

ii. Canals: Minimum of 3.5 meter depth, 60 meter bottom width, 900 meter bend radius, 10 meter vertical clearance and 60 meter horizontal clearance between piers.

g. **Class VII** - Waterways with the following configuration of navigable channel:-

i. Rivers: Minimum of 2.75 meter and above depth, 100 meter and above bottom width, 900 meter bends radius, 10 meter vertical clearance and 80 meter horizontal clearance between piers.

2. Vertical clearance for power cables or telephone lines or cables for any transmission purpose for all the classes of waterways mentioned above shall be as follows:

a. Low voltage transmission lines including telephone lines - 16.5 meters

b. High voltage transmission lines, not exceeding 110 kilo volt - 19.0 meters

c. High voltage transmission line, exceeding 110 kilo volt - 19.0 meters

+1 cm extra for each additional kilovolt

3. In case of underwater pipelines, power cables and other cables, norms to be followed shall be decided as per the site conditions and navigational requirement.

Provided that this classification shall be effective for:

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.

Reference level for vertical clearance in different types of channel shall be:

a. For rivers, over Navigational High Flood Level (NHFL), this is the highest flood level at a frequency of 5% in any year over a period of last twenty years.
b. For tidal canals, over the highest high water level.
c. For other canals, over designed full supply level.

4.3.2 Measures to Improve the Depth

The basic parameters considered for the fairway design are:

- Depth
- Width
- Side slopes
- Bends

As explained above, as the classification of waterways in India is based on the experience gained in various waterways, the characteristic features of the design waterways based on studies carried out by IWAI are furnished below and the same shall be followed.

Fairway Design

The fairway depth should be good enough to ensure steerability of the vessel and to prevent bottom feel. To meet this requirement, the minimum depth that is needed in a channel would commonly be the sum of the draught (draft) of the vessel and other tolerance factors. The tolerance factors to be considered are listed as:

- Factor of keel clearance to avoid touching of the vessel to the ground and minimum free water below the keel for maintaining control on manoeuvring,
- Wave tolerance for the heaving and pitching of the vessel due to wave motion,
- Squat, increase of draft due to ship motion,
- Tolerance for siltation and dredging,
- Increase of draught due to trim and heaving due to unequal loading and steering manoeuvre respectively, and
- Tolerance for the change of draught during the transition from salt water to fresh water.

The keel clearance factor is the prime concern of the all tolerance factors considered. As per the standards laid down by German Code of practice (EAU 80), a 0.3 m layer of water column below the keel of the loaded ship is sufficient for free manoeuvrability of the vessel.

IWAI's experience in inland waterways in India and sub-continent (Bangladesh and Myanmar) shows that the under keel clearance for free manoeuvrability of the vessel varies between 0.2 and 0.5 m depending upon the soil characteristics of the channel bed and other parameters.

Width of a Channel

The total width of a navigation waterway (W) in general is expressed in terms of a beam of a vessel (B). The design width for the proposed two-way navigation can be obtained as:

W = BM + BM1 + C + 2C1

Where: W = Navigation channel width for two-way navigation.

BM = Maneuvering zone for the design vessel which takes into account the directional stability of vessel.

BM1 = Maneuvering zone for the upcoming vessel which takes into account the directional stability of vessel.

C = Width of separating zone.

C1 = Width of the security area, between the maneuvering zone and the channel side which is accounted for environmental and human factors including bank suction.

Values recommended by various authorities for the above equation vary within wide limits. Some of the recommended values are presented here:

BM = 1.3 B to 3.0 B

BM = BM1

C = 0.5 B to 1.0 B

C1 = 0.3 B to 1.5 B

Where, B = Beam of a design vessel.

Based on the experience and recommendations of experts on Inland Waterways, the factors considered for the present design are:

BM = 1.8 B

BM = BM1

C = 0.5 B

C1 = 0.5 B

The designed channel width = 1.8B+1.8B+0.5B+2x0.5B for two way navigation at draft level = 5.1B. The bottom width of the channel for two-way navigation for the design vessel can generally be considered as 5 x B.

Slopes

The selection of slope is in accordance with the soil characteristics of the bed and banks, width of the waterway etc. The adopted channel slope shall be 1:5

Width Allowance at Bends

In bends, the width of the fairway should be more than the width of the canal that is designed for a straight reach to allow for a drift of the vessel in a curved portion of the waterway. It means that the vessel occupies a greater width in bends than in a straight stretch of the waterway. The drift of the vessel depends on the radius of the bend, the speed of the vessel, wind forces, the flow pattern and the loading of the vessel. The drift angle is larger for vessels travelling in the downstream than the upstream direction. The drift angle is inversely proportional to the bend radius 'R', that is, the larger the radius the smaller the value of drift angle. Unloaded ships normally subjected to more drift and consequently take up a greater width in bends than loaded ships and therefore the proposed allowance at the keel level of the unloaded ships is larger than the loaded ships.

Dredging of Navigational Channel

The dredging quantities for the above design channel shall be worked out based on the bathymetric surveys carried out. The system and different type of navigation marks shall be proposed in the DPR are given as follows:

- Lateral marks, to mark the left and right sides of the navigation route to be followed by navigator;
- Bifurcation marks, to mark the middle ground between the navigation channel, bifurcated channel and isolated dangers in the middle of the navigational channel;
- Shore marks;
- Bank wise marks, to indicate the channel at point where it approaches a bank;
- Crossing marks, to indicated crossing and alignment of the channel from one bank to another;
- Marks of prohibited areas, to indicate no permission of entry;
- Sound signal marks, to indicate use of horning or other sound signals;
- Marks for traffic control, to control up bound or down bound vessel in one way or sequence passage or to prohibit navigation;
- Marks on bridges, to indicate the passage through bridges;
- Depth indicator marks, to indicate shallow areas ahead in the navigation channel;
- Width indicator marks, to indicate the narrow stretches ahead in the navigational channel;
- River training marks, to indicate the ongoing river training works in the river to the navigators.

4.3.3 IWT Terminal Planning

The terminal planning and design includes selection of suitable sites in the vicinity of cargo potential considering all the relevant technical variables such as choosing the type of berthing facility and providing of covered/open storage facility, cargo handling systems and other ancillary facilities required for efficient terminal operation. Based on the projected traffic, the selection of various facilities shall be planned. The cost estimate including capital and operating costs shall be estimated for each of the proposed system considering the design. These above aspects are briefly explained in the following subsequent sections.

Planning Considerations

The terminal facilities proposed for this project shall include the following:

i) Berthing Facilities for vessels;
ii) Cargo Storage Facilities;
iii) Cargo Handling Facilities;
iv) Other ancillary Facilities.

Terminal Facilities

The type of cargo handling system required at the terminal is generally dependent on the type of cargo, the annual volume required to be handled and the size of the vessels.

The various type of cargo foreseen to be handled at the proposed IWT Terminals are primarily grouped into:

i) Incoming Cargo, and
ii) Outgoing Cargo.

These above two groups are further subdivided into bulk, bagged and other miscellaneous general cargo for the purpose of planning the cargo handling equipment. The quantum and other cargo compositions shall be based on the traffic study. The same may be classified as below:

- Bulk Cargo - Construction materials such as Sand, stone, bricks, Marble, Iron steel, Machinery – Light, Heavy and ODC, Mineral Ore such as coal, lime stone, iron, fly ash, copper ore etc., bamboo, etc.
- Bagged Cargo - Cement, Fertilizer, wine and beverages, acids, cereals, cash crops, wheat, rice, Bajra, gram, pulses, cotton, etc.
- Misc. General Cargo – Consumer goods, animals, oil cake, edible oil, refined oil, paper products, jute products, etc
- Ferry – Passenger vessels for Tourists

4.3.4 Identification of IWT Terminals

Site selection is the most important as it decides the investment for establishing the terminal facilities. Hence, proper consideration has to be given to select the most optimum location which will minimise the capital investment and other recurring cost during operation. The selection of suitable site shall be carried out with the view of following considerations:

- Water availability near the terminal land throughout the year especially during lean season;
- Stable river channel with sufficient depth;
- Favourable hydraulic conditions for berthing and cargo handling;
- Availability of terminal land for infrastructure, cargo storage and handling;
- Traffic potential and cargo characteristics; and
- Navigational safety.

The proposed IWT Terminals shall be planned with the following infrastructure facilities for operation:

i) Steel Gangway resting on a floating pontoon. The detailed engineering & design of gangway arrangement shall be carried out during the construction stage. The preliminary layout drawing shall be proposed in the DPR;
ii) Administration Building and Bank protection arrangement;
iii) Covered Storage Shed/Transit Shed;
iv) Open storage area;
v) Security Shed;
vi) Forklift Trucks, Pay loaders & Dumper tracks; and
vii) Weigh Bridge, Watch and ward, Compound wall, Firefighting arrangement, Electrical & PH Facilities including DG.

The terminal shall be proposed with suitable mooring facilities, firefighting water line, water supply pipeline, power line for shore connection to barges, fenders etc. Preliminary planning and master plan shall be prepared in the DPR stage as per the relevant IS codes. It is envisaged and proposed that to the extent possible, all shore/river bank based buildings / godown are prefabricated, pre-engineered type conforming to the best standards in vogue in logistic / supply chain industry.

Other Alternatives to Improve for Navigation

Based on our earlier study for Ganga River between the reach from Allahabad to Ghazipur, there are many methods available to improve river navigation. Bandalling work – it has to follow closely falling stage of river, closing minor channels and diverting river flow in single channel to increase depth in the navigable channel in mainly due done by bandalling. In some reaches this method becomes successful but some river stretches remain shallow and need other training measures including dredging. Channelization of river and Construction of barrages at suitable locations, creating ponding conditions with required depth and navigational locks for ships and vessel movement shall be studied. The examination of various options/measures to improve the water depth shall be studied. The most suitable method for development shall be identified with consideration on the likely morphological, sediment transport, and dredging aspects of different options. This task is expected to be fed back into from the financial and economic analysis providing refinement to the proposed development until a recommended solution is reached. The most appropriate type of river development including drudging option along the river shall be identified and likely impacts of these developments on river flow depths as well as sedimentation and morphology shall be investigated. This analysis will constitute an iterative process in which problems relating to LAD will be addressed to find more successful solutions where necessary. This will however, not be an open-ended process as the assessment of techno-economic feasibility updation only requires an indication of the likely costs of building and maintaining the structures which are shown to support achievement of LAD as intended.

4.3.5 Rapid EIA

Suitable Rapid Environmental Impact Assessment shall be performed and report shall be included in final DPR. The Rapid EIA Studies can be broadly divided in to three phases.

- The first phase involves identification of significant environmental components in the area where the project is located and assessing their baseline (pre-project or existing) status within the study zone. In case of existing projects, environmental performance of existing manufacturing / pollution control plants is also required to be covered.
- The second phase involves prediction of impacts on various identified significant environmental parameters due to proposed project.
- The third phase includes the evaluation of final impacts and delineation of an Environmental Management Plan to mitigate adverse impacts on the quality of surrounding environment.

4.3.6 Concept Design and Cost Estimates

Preliminary Design shall be performed for all the structures /developmental works proposed as per the above analysis and mathematical model studies carried out conforming to relevant IS Codes. Design drawings shall be prepared and submitted based on the preliminary design. Bill of quantities and cost estimates shall be prepared for all the proposed structures / developmental works. Based on the cargo potential and other considerations necessary for locating an IWT terminal, extent of land required for setting up of IWT terminals and other suitable locations shall be identified. Preliminary topographic survey shall be carried out and layout plan for all suggested locations shall be prepared clearly indicating all facilities e.g. jetty, approach to jetty, bank protection, covered and open storage, roads, office, sentry hut, boundary wall, bank protection, bunkering facility, water facility, turning circle for IWT vessels location of depth contours of 2m and 2.5m in the river near the terminal sites. Preliminary engineering design and drawings for setting up of terminals with related facilities including mechanical loading/ unloading at the proposed sites shall be prepared. Also inter modal cargo transfer facilities required at these terminals shall be indicated.

4.3.7 Financial and Economic Analysis

Financial and economic analysis through FIRR and EIRR of the project including SWOT analysis shall be carried out for the project. For the Financial Internal Rate of Return shall be computed as follows:

- Costs shall be calculated as total capital investment for the Project components, net rate of interest charges during construction and operations & maintenance costs for the Project;

- Income flows shall be calculated based on gross revenues of projected goods to be transported through private operators with permissible assumptions such as project life etc.;
- Economic Internal Rate of Return shall be computed taking into account the following factors;
- The assumed life of the project as per norms;
- Costs shall be calculated as Government contribution and other sources. A standard conversion factor shall be used to reduce financial costs to economic costs;
- Benefits shall be estimated as Government revenues, calculated as net profit share, royalties and tax;
- Social Benefits like fuel saving, reduction in environment pollution and carbon emission, accident reduction, decongestion of rail and roads, etc.

The financial viability and sustainability of this project depend upon the adaptation to the prevailing context in which they operate. In working out the Financial Viability and sustainability, the following factors shall be considered.

- budgeting and cost accounting systems,
- resource mobilization for capital investments,
- cost recovery and operational financing,
- cost reduction and control.

The Profitability projections and financial analysis for each of the project components shall be worked out in detail and presented in the report. The financial statements shall be prepared on the basis of the suitable assumptions. The cost benefit analysis for the proposed project shall be calculated. The Net Present Value (NPV) with interest and depreciation, IRR and preliminary expenses shall be suitably considered and estimated. Break-even analysis shall be performed and presented in the report.

4.3.8 Implementation & Monitoring Mechanism

Project financial structuring shall be worked out in detail which will examine the sources and composition of funding for the project. The Project financial structuring can involve a combination of equity, grant, debt and finance from private participation (and in some cases, contribution from user communities). The scope and options for possible debt and private sector financing shall be reviewed elaborately and presented in the report. The suitable monitoring mechanism shall be evolved.

5.0 COLLECTION AND REVIEW OF DATA

5.1 PRIMARY DATA

In order to collect primary data and to access the latest hydro-morphological condition of the waterways reconnaissance survey was done. Following aspects had been covered in the reconnaissance survey as per TOR:

a) Single line longitudinal survey (Bathymetric survey or Topographic survey) in the deepest depths or lowest height lands, with the help of DGPS using Automatic Hydrographic Survey System. Bathymetric surveys in the national waterways are to be carried out in the deepest route. Deepest route can be accessed by taking two or three longitudinal line soundings at equal interval. Topographic survey, if required, is to be taken up at lowest ground levels, which can be decided on visual assessment.

b) Details (horizontal and vertical clearances above High Flood Level of bridges, aqueducts, electric lines, telephone lines, pipe lines, cables en-route are to be collected and indicated on the chart and also included in the report along with their co-ordinates and location. Details about Barrages, Dams, Locks en-route are also to be collected horizontal and vertical clearance is to be given as approximate on visual assessment.

c) Photographs are required to be submitted in the report.

d) Topographical features of the Inland Waterways.

e) Typical physical features along the alignment i.e. land use pattern:

f) Preliminary identification of stretches having year round flow and critical depth for navigational purpose.

g) Inventory of major aspects including Inland Waterway width, Terrain, Bridges and structures across the Inland Waterways (Type, size and location), urban areas (location extent). Geologically sensitive areas environmental features. Hydrological features

h) Critical areas requiring detailed investigations and

i) Requirements for carrying out supplementary investigations

j) Soil (textural classifications) (only visual inspection at every 10km) and drainage conditions.

k) Type and extent of existing utility services along the alignment.

All the above details are collected during field survey as well as by interaction with the concerned authorities from 8th January 2016 to 12th January February 2016 by the Consultant.

5.2 REVIEW OF SECONDARY DATA

Location and its Catchment: River Shilabati (also known as Shilai), another major river in the western part of West Bengal, originates in the terrain of the Chhota Nagpur Plateau in the Purulia district. After traversing through the districts of Bankura and Paschim Medinipur it meets with Dwarakeswar to form Rupnarayan. River Joyponda, Ketia, Donai, Kubai are major tributaries of Shilabati. There is a small barrage constructed across the river near Khatra as a part of 'Kangsabati Reservoir Project' which is popularly known as Kadam Deuli barrage.

The detail of its catchment is follows:

Name of River	Catchment Area (Sq. Km)	
	Total	West Bengal
Silabati	4088	4088

Source: Annual Flood Report 2014

Status of river gauges installed in Silabati Sub basins are given below:

Name of River	Name of Gauge Station	Name of District	Danger Level (DL) (m amsl)	Extreme Danger Level (EDL) (m amsl)
Silabati	Gadighat	Paschim Medinipur	8.99	9.60

Source: Annual Flood Report 2014
DL is considered as HFL for assessing the Minimum Vertical Clearance

Habitats along Silabati mostly belong to farmers and they depend on Silabati for irrigation. A large number of fishermen also earn their livelihood from this river. Silabati is also used as waterways for transporting goods and passengers on boats. Almost every year Silabati causes floods particularly in Banka, Khirpai and Ghatal area. There is a small reservoir on Silabati near Khatra known as Kadam Deuli Dam where a canal from Mukutmanipur Kangsabati dam meets. You will get a picturesque view of this beautiful river near Garbeta while traveling by train in Kharagpur-Adra section of South Eastern Railway.

Meteorological Conditions: The climate of the area is characterised by moderate winters and hot & humid summers. Like the rest of India, the region experiences two principal rainy seasons. In the winters from December to March there is little rain. In the summer months, June to September, the flow of air is from sea to land and the season is characterised by high humidity, clouds and rain. The

direction of winds being south-westerly, the season is named South-West Monsoon which is the main season producing rains. Between these two principal seasons are the transition seasons of the hot weather months of April & May and the retreating monsoon months of October & November.

Industrial and Agricultural Status: The villages and small towns in the bank of Silabati produces crops, like Paddy, Potato, Wheat, Jute and vegetables of different kinds. Other small scale activities are fishing, weaving, and manufacture of bell metal articles.

6.0 ANALYSIS OF PRESENT STATE OF AFFAIRS

6.1 EXISTING DAMS, BARRAGE & LOCKS

Silabati waterway starts from the downstream of a Barrage near Shimulia village. However, no dams, barrage and locks exist along the waterway stretch of Silabati River.

6.2 EXISTING BRIDGES ALONG THE WATERWAY

The existing bridges and crossings encountered during survey are listed in **Table 3.**

Table 3: Details of existing Major Road and Rail Bridges over Silabati River

Sl. No	Location	Chainage (km)	Easting	Northing	Vertical Clearance w.r.t MHWS (m)	Horizontal Clearance b/w piers (m)
Major Road Bridges						
1	Ghatal	6.62	575165.50	2506268.00	5.00 m	3.00 m

Vertical Clearances are on the basis of visual assessment s per Ref No. 2, page 2 of 27, replies to Pre-bid queries raised by Prospective bidders in Pre-bid meeting held on 23.04.2015, wherein it was clarified by IWAI that, "In Stage –I, horizontal and vertical clearance is to be given as approximate on visual assessment."

6.3 EXISTING HIGH TENSION LINES AND OTHER CROSS STRUCTURES

No High tension lines are located along the waterway during reconnaissance survey.

6.4 HINDRANCES/ ENCROACHMENT ALONG THE WATERWAY

Hindrances/encroachments for waterway are defined as any natural or manmade structure, which can cause obstruction or danger to navigation. In order to start navigation in the waterway, these structures are either to be removed or taken care adequately. These hindrances/encroachments are may be rock outcrop from the river bed, wooden or sand bridges, etc. Major hindrances/encroachments identified en-route the Silabati waterway are wooden and bamboo bridges, which are to be dismantled or re-located as per the navigational requirements. The list of these hindrances is provided in **Table 4**. Photographs of the hindrances are provided in **Annexure 4** .

Table 4: Details of Wooden and Bamboo bridges located along the Waterway

Sr. No.	Location	Chainage (Km)	Easting	Northing
1.	Ghatal	6.5	575213.80	2506582.00
2.	Haridaspur	10.0	573858.10	2503619.00
3.	Gadighat	11.0	573784.40	2502923.00
4.	Gopalnagar	12.0	573094.30	2502132.00
5.	Gopalnagar	14.0	572791.50	2501276.00
6.	Bhangadaha	15.5	571931.60	2501091.00

6.5 FOREST AREA / PROTECTED AREA / DEFENCE AREA

No forest, protected and defence areas exist along the Waterway stretch of Silabati River.

6.6 ROAD AND RAIL INFRASTRUCTURE

No railway station or railway line is available within 5.0 km radius of Silabati waterway. The nearest railway station available is Godghat Railway station, which 30 km from the waterway.

Detail of major roads connecting to the Silabati waterway is provided in **Table 5**.

Table 5: Details of Major Road connected to Silabati

National/State Highway	Other Major Roads
a) State Highway 4	Panskura Ghatal Road

7.0 RECONNAISSANCE SURVEY

Egis, India carried out the reconnaissance survey as required for the feasibility studies and detailed as per TOR as below:

- Single line longitudinal survey (Bathymetric survey or Topographic survey) in the deepest depths or lowest height lands, with the help of DGPS using Automatic Hydrographic Survey System.
- Horizontal and vertical clearances above High Flood Level of bridges, aqueducts, electric lines, telephone lines, pipe lines, cables en-route are to be charted.
- Details about Barrages and Dams en-route are also to be reported.
- Topographical features of the Inland Waterways are to be reported.
- Typical physical features along the alignment i.e. land use pattern are to be reported
- Stretches having year round flow and critical depth for navigational purpose are to be reported.
- Preliminary Traffic on the Inland Waterways is to be identified.
- Inventory of major aspects including Inland Waterway width, Terrain, Bridges and structures across the Inland Waterways (Type, size and location) will be reported.
- Urban areas (location extent) are to be reported.
- Geologically sensitive areas environmental features are to be reported
- Hydrological features are to be reported.
- Critical areas requiring detailed investigations are to be reported.
- Requirements for carrying out supplementary investigations are to be reported.
- Visual inspection of Soil (textural classifications) are to be reported
- Major Drainage conditions are to be reported.
- Type and extent of existing utility services along the alignment are to be identified.
- Identification of various agencies of the govt. from whom the concerned project clearances for implementation are to be sought.

7.1 DETAIL METHODOLOGY FOR SURVEY

The surveyor deployed a team of personnel to carry out the reconnaissance survey; the detailed methodology is described in following sub sections.

7.1.1 Resource for Survey Work

Off shore Key Personal:

- Project in-charge: 1 no.
- Senior Surveyor: 4 nos.
- Survey Engineer: 3 nos.

On shore Key Personal:

- Project manager: 1 no.
- Survey manager: 2 nos.
- Reports Coordinator: 1 no.

Survey Equipment and Software:

Table 6: List of Equipment Mobilised for Survey

Sl. No.	Survey Equipment/Systems Used for the Data Acquisition	
	Equipment/System	Description/Make/Model
1.	Software / Navigation	HYPACK 2015 computer acquisition and data logging Software
2.	Positioning System	Trimble SPS 351(DGPS) & 855 RTK DGPS (One Base & Two Rover)
3.	Single beam Echo Sounder	Sonar Mite
4.	Tidal Observation	Valeport Automatic Tide Gauge/ Manual Tide Gauge
5.	Levelling	Sokkia B40 Auto Level
6.	Total Station	Trimble TS 635
7.	Data Acquisition System	Dell laptop/ HP laptop

Survey Vessel

Considering the geographical and topographical feature, length of river, shallow and dry patch, inaccessibility to survey area, due to insufficient water for regular boat, inflatable Zodiac Boat "Aqua Marina-1", "Aqua Marina 2" were used to carry out bathymetric survey. The names and specifications of the survey boats are provided in **Table 7**.

Table 7: Details of Survey Boats Used

Name of the Boat	Length (m)	Width (m)	Draft (m)
Aqua Marina - 1	3.0	1.5	0.020
Aqua Marina – 2	2.5	1.29	0.020

7.1.2 Geodetic Parameters

The geodetic parameters used for survey were as follows:-

Global Positioning System Geodetic Parameters							
Datum:	World Geodetic System 1984 (WGS84)						
Spheroid:	World Geodetic System 1984						
Semi major axis:	a = 6 378 137.000 m						
Inverse Flattening:	$^1/_f$ = 298.257 223 563						
Local Datum Geodetic Parameters							
Datum:	World Geodetic System 1984 (WGS84)						
Spheroid:	World Geodetic System 1984						
Semi major axis:	a = 6 378 137.000 m						
Inverse Flattening:	$^1/_f$ = 298.257 223 563						
Datum Transformation Parameters from WGS84 to WGS84							
Shift dX:	0.0 m	Rotation rX:	0.000	arcsec	Delta Scale :	0.0000	ppm
Shift dY:	0.0 m	Rotation rY:	0.000	arcsec			
Shift dZ:	0.0 m	Rotation rZ:	0.000	arcsec			
Local Projection and Grid Parameters [2)]							
Map Projection:	Universal Transverse Mercator						
Grid System:	UTM Zone 45 N						
Central Meridian:	087° 00’ 00” West						
Latitude of Origin:	0° 00’ 00” North						
False Easting:	500 000 m						
False Northing:	0.0000						
Scale factor on Central Meridian:	0.9996						
Units:	metres						

Notes:

1) Hypack navigation software always uses WGS84 geodetic parameters as a primary datum for any geodetic calculations.
2) This is the right-handed coordinate frame rotation convention used by the Hypack navigation software.

7.1.3 Survey Data Processing

General

The survey data was logged in HYPACK On-line Survey Software, and was processed using the HYPACK Processing, AUTOCAD and Spectra Precision Survey Office. The data was processed, checked and verified to ensure good quality data. Single Beam (SB) Editor was used for the automated and manual processing of logged data sets.

Navigation and Positioning

The DGPS Receiver Antenna was mounted exactly above the echo sounder transducer. The echo sounder transducer was mounted on the side of the boat, without any offset to ensure accuracy in the position of soundings. The bar-checks were carried out before/after each sounding session. Transducer draft was measured and recorded, and the same was used while processing. On all such occasions the error observed was zero or near zero. Therefore, no corrections were necessary.

Bathymetry

HYPACK Processing suite was used to import quality check and process the navigation, bathymetry and tidal data. The data was filtered, cleaned, and combined to create geographically positioned bathymetric data set.

7.2 DESCRIPTION OF BENCH MARKS/ REFERENCE LEVELS

Due to non-availability of any permanent BM near the project area during reconnaissance survey, benchmarks was established by DGPS observation for 12 hours using Trimble SPS 855 positioning system and post processing through AUSPOS and Spectra Precision Survey Office to get the value of the TBMs with respect to MSL. The final co-ordinates of the BM and height above MSL and other details are provided in **Table 8** as below

Table 8 : Temporary Benchmark established along Silabati Waterway

Sl. No.	TBM	Easting	Northing	Chainage (m)	CD wrt MSL (m)	Ht (m) above MSL
1.	Bondar	580048.36	2507307.57	-0.077	1.000	1.860
2.	Ghadighat	573825.90	2502913.46	10.482	6.495	9.875

7.3 LEVELLING OF TEMPORARY TIDE POLES

Two temporary bench marks were established in between the course of survey at different places by using Trimble RTK SPS 855. Auto level SOKIA B-30 was used to establish the zero of the tide gauge with reference the TBMs. The observed readings in Auto Level are provided in **Annexure 1**. The water levels observed on the tide poles during reconnaissance survey are provided in **Annexure 2**. The CD/SD adopted for obtaining reduced depth along the waterway is given in **Figure 4**.

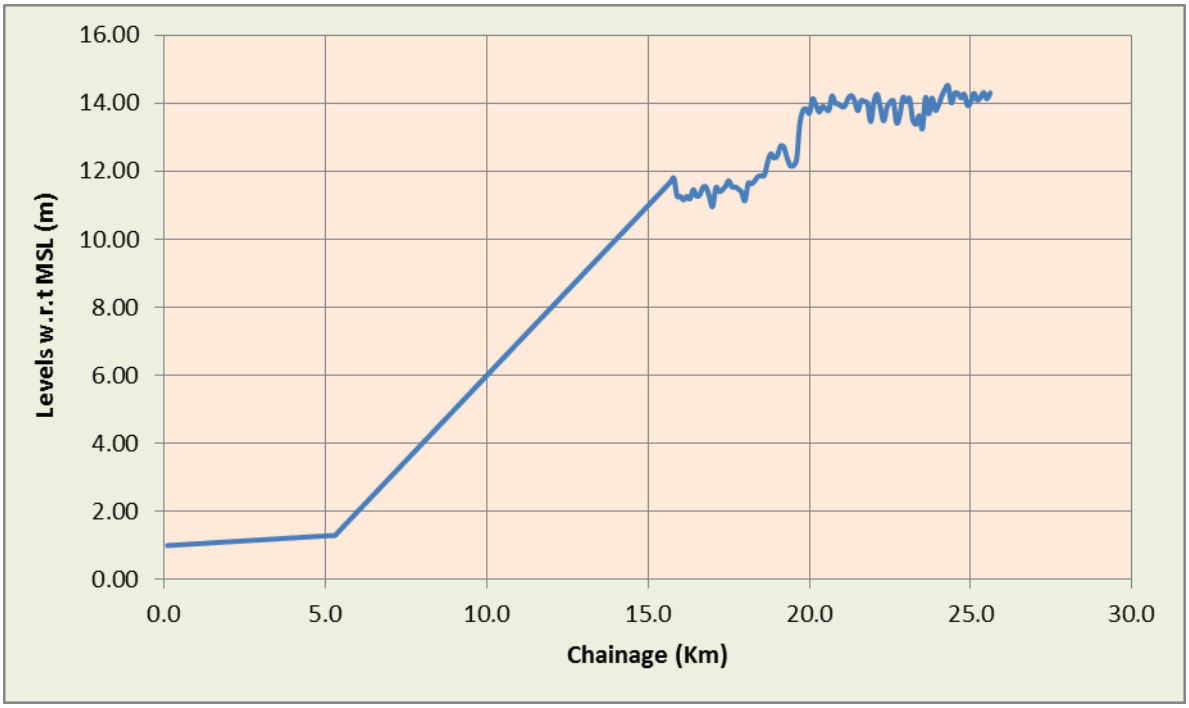

Figure 4: Graph showing Chart Datum/Sounding Datum w.r.t. MSL

7.4 HYDROGRAPIC SURVEY

Single line longitudinal survey (Bathymetric survey or Topographic survey) in the deepest depths or lowest height lands, with the help of DGPS using Automatic Hydrographic Survey System has been carried out for the length as shown in **Table 9**.

Table 9: Survey Length of Waterway

Total Length of Waterway as per TOR	Length of Bathymetric Survey	Length of Topographic Survey
26 Km	15.70 Km	10.30 Km

7.5 WATER DEPTH

Water depths along the waterway have been observed during Reconnaissance survey as per the scope of works and requirement for feasibility studies. Single line longitudinal bathymetric/topographic survey has been carried out for obtaining the water depth along the deepest route or lowest height lands of waterway. The observed depth are then corrected by applying a reduction factor as provided above for different stretches to calculate the reduced water depths available for navigation. The reduced water depths at every 10 km interval are presented in **Table 10**. Detailed water depths along the Silabati waterway is also provided in **Annexure 3**.

Table 10: Reduced water depth along the Waterway

Chainage (Km)	Draft Variation		Length of River (Km) with following draft			
	Max. Available (m)	Min. Available (m)	<1m	1.0 -1.5m	1.5 -2.0 m	>2.0m
0 – 10	3.15	-1.09	7.04	1.73	0.62	0.62
10 – 20	1.37	-0.41	9.30	0.70	0.00	0.00
20 – 26	Topographic Survey done		6.00	0.00	0.00	0.00
Total			**22.34**	**2.43**	**0.62**	**0.62**

It can be inferred from the above table that **0.62 Km stretch of waterway have draft more than 2.0 m, 0.62 Km stretch have draft of 1.50 m to 2.0 m, 2.43 km have draft of 1.0 m to 1.50 m and remaining 22.34 km stretch of waterway have less than 1.0 m draft with respect to chart datum** respectively.

7.6 SOIL CHARACTERISTICS

On the basis of visual assessment done during longitudinal survey, the characteristics of soil of the waterway are provided in **Table 11**.

Table 11: Soil Characteristics along Silabati River

S. No.	Chainage (Km)	Latitude	Longitude	Easting (m)	Northing (m)	Soil Type
1.	0.0	$22^0$40'17.25"N	$87^0$46'41.33"E	579939.14	2507360.32	Muddy sand
2.	10.0	$22^0$38'06.64"N	$87^0$43'08.37"E	573881.15	2503313.36	Muddy sand

S. No.	Chainage (Km)	Latitude	Longitude	Easting (m)	Northing (m)	Soil Type
3.	20.0	$22^0$35'44.88"N	$87^0$39'58.66"E	568485.70	2498929.20	Sand
4.	26.0	$22^0$34'46.36"N	$87^0$37'01.71"E	563440.77	2497107.74	Sand

7.7 TIDAL WATERWAY SECTION

It is seen from the data collected during Reconnaissance survey that out of 26 Km of the Silabati Waterway, about 15 Km is having Tidal influence. The tide location starts at Bondor and ends at Gadighat. Tidal variation of 0.7 m is observed along the waterway.

8.0 MARKET ANALYSIS

Preliminary market analysis has been done on the basis of reconnaissance survey, Consultants site visit, available secondary information and published literature at the feasibility stage of the project.

8.1 LAND USE PATTERN

Land use pattern along the Silabati River can be characterized as Agricultural and Residential as presented in **Table 12**.

Table 12: Land Use Pattern along Waterway

Length (km)	Agricultural		Residential	
	Length (km)	%	Length (km)	%
26	22.88	88%	3.12	12%

8.2 CROPS /AGRICULTURE PRODUCTS

The waterway stretch passes through the two major district, namely Bankura and Pachim (West) Medinipur of West Bengal. The details about the crops/agriculture pattern along the waterway in these districts are as follows:

Bankura: Rice is the main crop of this district. Though the district is prone to drought, it can raise surplus food production in years of good rainfall. Besides rice, the major crops are Potato, wheat, Vegetables, Mustard, Summer Til etc. Like rice, the district is also surplus in Potato & Vegetable production. The district is lagging behind in the production of Pulses & Oilseeds. However, special emphasis is started giving in production of Oilseeds & Pulses by introducing new varieties of Pulse Crops like Arhar, Lentil, Gram, Khesari, Kalai, Moong etc. Ground Nut and Sunflower have also been introduced in Rabi season to meet up the gap between demand and production of Oilseed crops. Broccoli and Capsicum are also cultivated by farmers of this district to meet up the demand of the local people.

Table 13: Average Production and Productivity of major crops in Bankura district (2004-09)

Name of Crop	Kharif		Rabi		Summer		Total	
	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)
Major Field Crops								
Rice	49.17	2602	906.33	2770	152.83	2636	1108.33	2744
Wheat	-	-	11.03	2073	-	-	11.03	2073
Pulses	-	-	0.32	671	-	-	0.32	671
Oilseeds	-	-	25.35	705	-	-	25.35	705
Potato	-	-	682.78	19489	-	-	682.78	19489
Maize	1.44	2352	-	-	-	-	1.44	2352
Major Horticultural Crops								
Cucurbits	-	-	-	-	-	-	161.43	13703
Brinjal	-	-	-	-	-	-	194.85	19504
Okra	-	-	-	-	-	-	64.29	11180
Cauliflower	-	-	-	-	-	-	145.65	27429
Cabbage	-	-	-	-	-	-	155.33	32495

Source: Agriculture Contingency Plan

Paschim Medinipur: The district is primarily agricultural in nature, with cultivation being the chief livelihood of a majority of the people. Paddy occupies the first place in production. The district has a suitable agro-climatic condition for cultivation of mulberry and horticulture crops such as mango, banana, guava, lemon, mousambi, papaya, cashew and jackfruit. The district is well known for the production of mulberry and tussar silks, and Silk saris from Medinipur are much in demand.

Table 14: Average Production and Productivity of major crops in Paschim Medinipur district (2004-08)

Name of Crop	Kharif		Rabi		Summer		Total	
	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)
Major Field Crops								
Rice	84.33	2063	1205.30	2505	452.29	3156	1742.42	7724
Wheat	-	-	17.68	2141	-	-	17.68	2141
Jute	66.29	2845	-	-	-	-	66.29	2845
Pulses	-	-	4.33	659	-	-	4.33	659
Oilseeds	-	-	102.47	1055	-	-	102.47	1055
Potato	-	-	1412.56	19484	-	-	1412.56	19484

Source: Agriculture Contingency Plan

8.3 AVAILABILITY OF PASSENGER FERRY SERVICES

Locally organised passenger and light goods ferry services are located along the waterway. Location of these ferry services along the Silabati waterway are given in **Table 15**.

Table 15: Existing Ferry locations along Silabati River

S. No	Location	Chainage (Km)	Easting	Northing
1.	Batapur	2.50	578265.40	2507407.00
2.	Nischindpur	5.50	576170.60	2506653.00
3.	Ghatal	6.50	575458.60	2506760.00
4.	Shilarajnagar	9.50	574077.50	2503883.00

8.4 EXISTING JETTIES AND TERMINALS

The ferry services operational along Silabati waterway is locally operated and used for passenger and small cargo transports like fish, vegetables, agricultural goods, bricks and locally made tiles only.

As observed during the survey, temporary structures made of wooden planks, stones are used for embarking/disembarking purposes. And no permanent structural RCC jetty is located along the waterway.

8.5 PROMINENT PLACES ALONG THE SILABATI RIVER

The Silabati River (also known as Silai) originates in the terrain of the Chhota Nagpur Plateau in the Purulia district of the state of West Bengal in eastern India. It flows in an almost south-easterly direction through the districts of Bankura and West Medinipur. The Silabati joins the Dwarakeswar near Ghatal and afterwards is known as Rupnarayan. It finally joins the Hooghly River, which empties into the Bay of Bengal.

Almost every year the Silabati causes flooding, particularly in Banka, Khirpai and Ghatal area. There is a small reservoir on the Silabati near Khatra known as Kadam Deuli Dam where a canal from Mukutmanipur Kangsabati dam meets. The following prominent City /Town falls along the Silabati River:

Ghatal: Ghatal is headquarters of Ghatal subdivision in Paschim Medinipur district, West Bengal, India. It also has a community development block. Ghatal is flood-prone area and in many years is flooded by the Rupnarayan River. This town is old one. The river Shilabati divided the town into two parts. There is one peculiar floating bridge on the river made of by joining some boats tied with rope from the both sides in the banks, called "Bhasa Pool" (Floating bridge). Also one cement bridge is constructed on the main pitch road passing through Chandrakona Town, Ghatal, Daspur and Mechhogram.

8.6 HISTORICAL AND TOURIST PLACE ALONG THE WATERWAYS

Ghatal Sub-Division and the town Ghatal have their old history of civilization, business, struggle for freedom of India, Many Patriots, Social reformers, freedom fighters were the sons of this PS area. The river Dwarakeswar and Silabati meet with rivers Jhumi and Damodar at a place named as Bandar (Port) 3 km (2 mi) East from Ghatal PS. This is the Subdivision of Pandit Ishwar Chandra Vidyasagar, Patriot Pradyot Bhattacharya, Patriot Pravangsu Paul, Patriot Mohini Mondal, Raja Narendralal Khan, Patriot Manabendranath Roy and so many ever-memorable persons.

In ancient time when Tamralipta was important port for shipping for export and imoprt between Bengal and other countries including Sri Lanka, this Bandar of Ghatal was also used as port for anchoring boats and ships with goods. Ghatal had once become famous for manufacture of cotton, tusser silk, bell-metal utensils, earthen ware etc. and was so important that Dutch had a factory in the

headquarters town, which is still used as a sub divisional courts and in the early days of British occupation three Commercial Residents were located in the locality to supervise local trade. The old industries like cultivation and weaving of silk and cotton for which Ghatal and his nearest areas were famous from ancient times were systematically wiped away by the policy of the East India Company's administration. Withdrawal of Company's investments, shrinkage in the marketability of textile goods at home and abroad and heavy competition of the foreign goods were responsible for the decline of textile industries in Ghatal and his nearest areas like Radhanagar, Khirpai, Chandrokona, Khrar. This area was also famous for sugar industry (mainly in Radhanagar areas) in ancient times.

8.7 AVAILABILITY OF CONSTRUCTION MATERIAL

Major construction materials available along the waterway are Sand, Bricks and tiles.

8.8 INDUSTRIES ALONG THE WATERWAY

The confluence point of Dwarekeswar and Silabati River known as Ghatal, is famous for textile, paper, tin and bronze industries. Most of the people living along the banks of waterway depend upon agriculture. Kharif and Rabi, both types of crops are cultivated here along with Bittle tree cultivation.

The likely exportable items are follows:

1) Tobacco Products,
2) Construction material like bricks and sand.
3) Fresh water Fish and poultry,
4) Agriculture products including Bittle,
5) Tin and Bronze products,
6) Textile,
7) Paper,

8.9 EXISTING WATER SPORT AND RECREATIONAL ACTIVITIES AND FUTURE PROBABILITY

Water recreational activities are currently not available along the waterway. However, the waterway has huge potential to be developed for water sports and recreational activities especially in the tidal stretch.

8.10 ESTIMATED CARGO MOVEMENT

Existing passengers and cargo movements are available along Silabati River. Inland waterways mode of transport has immense potential for domestic cargo transportation as well as for cruise, tourism

and passenger traffic in Silabati waterway. The connectivity of Silabati Waterway with Dwarekeswar Waterway, Rupnarayan Waterway and thereby with National Waterway – 1 and Haldia Port gives an added advantage for Cargo movement through water transport mode in Silabati Waterway

Forecasted cargo potential has been estimated on the basis of last 13 year growth pattern of Cargo movement from 2002-2003 to 2014 – 2015 for National waterway-1, as provided in the IWAI Annual reports (Refer **Table 16**) . Linear correlation between existing and declared National Waterways has been done, to estimate the forecasted cargo potential. In Stage-I of the study a base figure of 0.0 tonnes cargo movement is assumed for estimating the forecasted figures as shown in **Figure 5**.

Table 16: Cargo Movement in National Waterway – 1 from 2002 – 2015

Sl. No.	Year	Cargo Movement for NW-1 (tonnes)
1.	2002-03	632,037
2.	2003-04	786,159
3.	2004-05	887,328
4.	2005-06	1,001,450
5.	2006-07	1,317,387
6.	2007-08	1,497,964
7.	2008-09	1,348,385
8.	2009-10	1,811,070
9.	2010-11	1,871,178
10.	2011-12	3,309,839
11.	2012-13	2,716,437
12.	2013-14	3,349,138
13.	2014-15	5,050,209

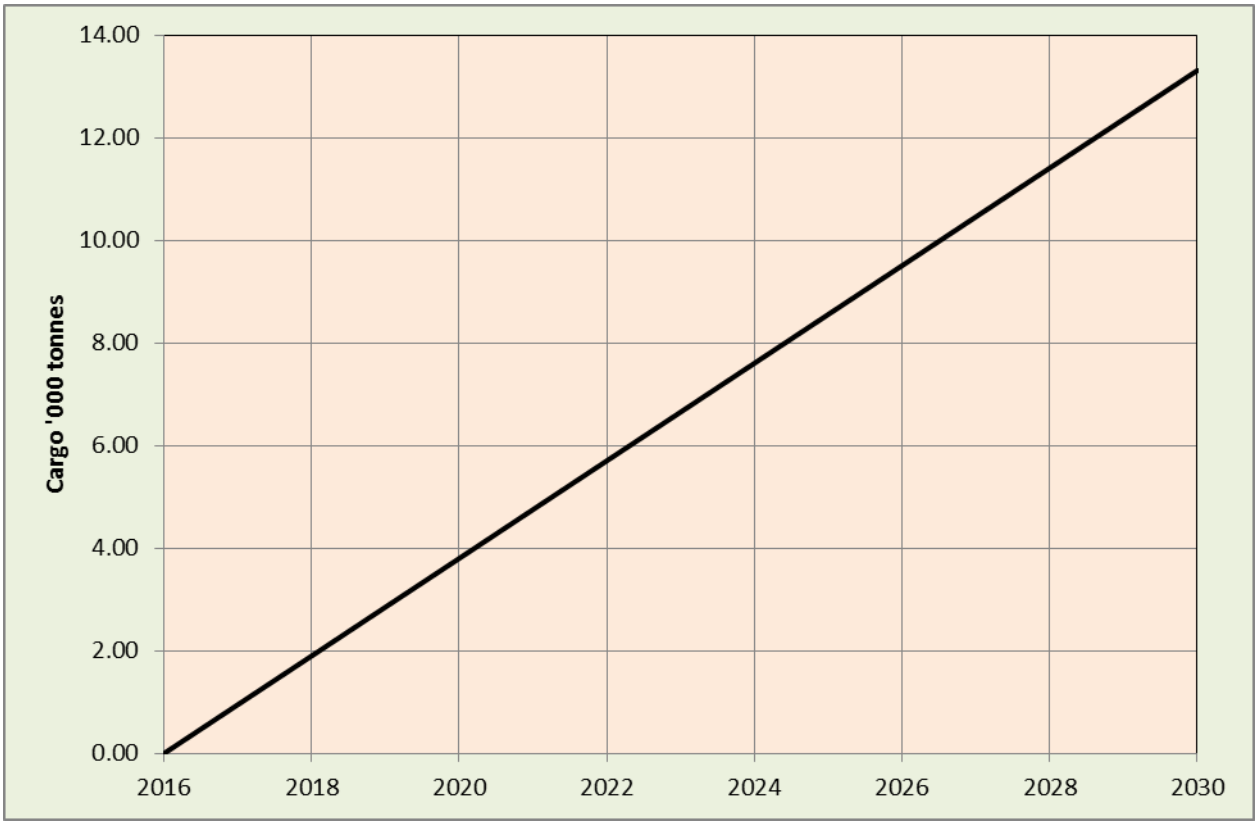

Figure 5: Forecasted Cargo Potential

Prima facie Silabati waterway has huge economical potential for development of Inland waterway. Not only there is existing traffic but also the development of waterway will trigger new traffic. Extent of development and prioritisation of inland waterways will be prepared in subsequent phase of the DPR study.

9.0 OBSERVATION AND INFERENCE

On the basis of reconnaissance survey as well as primary and secondary data collected from IWAI, central and state government departments and other stakeholders, following observations and inferences are made on the Silabati River (National Waterway 92).

9.1 WATERWAY

The Silabati River (also known as Silai) originates in the terrain of the Chhota Nagpur Plateau in the Purulia district of the state of West Bengal in eastern India. It flows in an almost southeasterly direction through the districts of Bankura and West Midnapore. The Silabati joins the Dwarakeswar near Ghatal and afterwards is known as Rupnarayan. It finally joins the Hooghly River, which empties into the Bay of Bengal.

9.2 LEAST AVAILABLE DEPTH (LAD)

LAD of the Silabati waterway is estimated on the basis of applying exceedance probability approach on the reduced water depth. Reduced water depth is calculated after applying corrections on the water depths observed during single line hydrographic survey with reference to Chart/Sounding datums. Navigable stretch available for least available depth (LAD) of <1.0 m, 1.0 m to 1.5 m, 1.5 m to 2.0 m and >2.0 m for the waterway is presented in **Table 17**.

Table 17: Waterway length with varying LAD

Sl. No.	Features	Results
1.	Waterway Length	26.0 Km
2.	Length with Topographic Survey	10.30 Km
3.	Length with Bathymetric Survey	15.70 Km
4.	Maximum available draft	2.99 m
5.	Minimum available draft	0.00 m
6.	Waterway length with <1.0 m draft	17.89 Km
7.	Waterway length with 1.0 – 1.5 m draft	5.88 Km
8.	Waterway length with 1.5 – 2.0 m draft	1.75 Km
9.	Waterway length with >2.0 m draft	0.48 Km

By taking into account the tidal advantage of 0.7 m in the tidal stretch of waterway. The available draft in this stretch can be conveniently raised above 1.2 m from 1.0 m.

9.3 CROSS - STRUCTURES

During reconnaissance survey, details of cross-structures have been collected and their minimum horizontal and vertical clearance has been evaluated on the basis of visual assessment as shown in **Table 18** below. The detailed list of cross-structures is provided in **Table 3**.

Table 18: Minimum Horizontal and Vertical Clearance along Waterways

Waterway Length (km)	Dams/ Barrages/Locks	Bridges/ Crossing	Min Ver. /Hor. Clearance (m)	High-Tension Lines	Min Ver. Clearance (m)
26	0	1	5.0/3.0	0	-

Vertical clearance is with reference to the MHWS.
Horizontal Clearance is the minimum distance between the bridge piers.

9.4 SWOT ANALYSIS

SWOT analysis is a technique commonly used to assist in identifying strategic direction for an organization or practice. It helps to make an assessment of internal environment and scrutiny of external environment, with an objective to take maximum benefits by having an appropriate proposition. It is preferred for the present work as it yields useful information about the future viability of the considered inland waterway system. The predictive capabilities in the technique come about from the consideration of system's strengths and weaknesses in the context of the development of Inland Waterway System, which may present opportunities and threats.

The strengths and weaknesses of a system are determined by the internal elements, whereas external forces dictate opportunities and threats. Strengths can be defined as any available resource that can be used to improve its performance. Weaknesses are flaws/shortcomings of any system that may cause to lose a competitive advantage, efficiency or resources. Sometimes it is recommended to identify opportunities and threats first in order to more quickly ring to light the system's strengths and weaknesses. Many of the threats are based on weaknesses. Further, SWOT analysis helps in categorizing the key internal and external factors that are important to achieving the objective. With regards to assessing the feasibility of proposed waterway for navigation, this exercise will help us identify the important factors to be considered while designing the future action for DPR study in Stage 2 and strategic plan for its development.

POSITIVE	INTERNAL		NEGATIVE
	STRENGTH	**WEAKNESS**	
	➢ Commitment of Govt. of India for Developing Inland Waterways Sector. ➢ Environmental friendly mode of Transport ➢ Increase in Infrastructure Facilities as alternative mode of transport. ➢ Comparatively high level of transport safety. ➢ Reliable services under predictable weather conditions. ➢ Low transport costs (per km) for bulk shipments. ➢ Long term effective cost control measures (O&M). ➢ Capable of bringing down decongestion from the Road Transport. ➢ Availability of tidal window, which provides additional draft for navigation.	➢ Huge Initial Investment ➢ High Maintenance Cost ➢ High tariff structure for Inland Transport. ➢ Limited knowledge of IWT among shippers. ➢ Dependence on inter-modality for door-to door services. ➢ Substantial cost differentials w.r.t other transports. ➢ Water level fluctuations having impacts on Ships Ballast /Loading conditions. ➢ Dredging capability of GoI is 16% of National requirement. ➢ Non availability of major industries along the waterway.	
	OPPORTUNITY	**THREAT**	
	➢ Trigger new traffic in the hinterland ➢ Boost International and National trade of commodities. ➢ Improvement of the capacity/quality of the Infrastructure. ➢ Integration of Ports with Roads & Railways. ➢ Enhance inter-modality. ➢ Implementation of infrastructure links. ➢ Improved Supply-Demand logistic chains ➢ Creation of reliable employment for the people. ➢ Connectivity with Dwarekeswar, Rupnarayan and National waterway – 1, including Haldia port, will trigger more traffic. ➢ Non availability of Railway network nearby waterway.	➢ Lack of Skilled Man-power. ➢ Environmental policy restrictions on transport infrastructure policies. ➢ Limited financial means. ➢ Fast growing economic sectors often road oriented: low IWT affinity. ➢ Priority of investments in road/ rail infrastructure as per the present scenario. ➢ Land Acquisition	
	EXTERNAL		

Figure 6: SWOT Analysis

9.5 SUMMARY

The salient features of the feasibility study for 26 km stretch of Silabati waterway are,

- The horizontal and vertical clearance of existing cross-structures is 3m and 5m respectively.
- Taking in to account the water availability, 0.48 Km stretch of waterway have draft more than 2.0 m, 1.75 Km stretch have draft of 1.50 m to 2.0 m, 5.88 km have draft of 1.0 m to 1.50 m and remaining 17.89 km stretch of waterway have less than 1.0 m draft with respect to chart datum respectively.
- Taking advantage of tidal window of 0.7m, the LAD of 1.0 m will have more under keel clearance of minimum 1.2 m.
- The connectivity of Silabati waterway with Dwarekeswar and Rupnarayan Waterway and thereby with National Waterway – 1 and Haldia Port provides an added advantage for traffic potential.
- The waterway will provide a short, convenient and cheap mode of connectivity, considering the lack of railway network near Silabati waterway.
- Not only there is existing traffic but also the development of waterway will trigger new traffic.

9.6 CRITICAL AREAS REQUIRING DETAILED INVESTIGATIONS

Critical areas along the waterways, requiring detailed investigations during Stage – II, are identified on the basis of draft availability, location of hindrances, areas requiring clearances etc. On the basis of above, following locations require detailed investigations during stage –II of the study:

Table 19: Locations along the waterway requiring detail investigation in Stage-II

Sr. No.	Location	Chainage (Km)	Easting	Northing
1.	Ghatal	6.5	575213.80	2506582.00
2.	Haridaspur	10.0	573858.10	2503619.00
3.	Gadighat	11.0	573784.40	2502923.00
4.	Gopalnagar	12.0	573094.30	2502132.00
5.	Gopalnagar	14.0	572791.50	2501276.00
6.	Bhangadaha	15.5	571931.60	2501091.00

In addition to the above, the length of the waterway having flow depth of less than 1 m w.r.t Chart Datum also requires detail investigation during DPR stage studies.

9.7 SURVEY AND INVESTIGATIONS REQUIRED FOR STAGE – II STUDIES

Following survey and investigations are required to be done during Stage – II studies:

i) Hydrographic and Hydro morphological Survey, as per TOR, comprising of:

   a) Erection of bench mark pillars and water level gauges and observing reading.
   b) Detailed bathymetric and topographic survey.
   c) Current velocity and discharge measurement.
   d) Collection of water and bottom samples and testing.
   e) Collection of topographical features.

ii) Traffic Survey.

iii) Geo-tech investigation on proposed locations for Jetties and Terminal structures.

iv) Environmental impact assessment (EIA).

9.8 WAY FORWARD: WATERWAY DEVELOPMENT

The Combining knowledge on the physical constraints, actual and future uses of the river and the valley, economic potential and needs, or absence thereof, allows the characterization of the river for development as a waterway. The reconnaissance survey data collected with regard to physical constraints can be turned into cost to make a river navigable. Although several challenges do exist to make Silabati River as a National waterway, but with respect to long-term economic interest of the nation the financial investment is advisable.

Economic Interest / **Financial Investment**	Local	Regional	National	International
Low			Silabati Waterway	
Moderate				
High				
Very High				

Silabati waterway is recommended for Stage – II DPR preparation in view of the following potential advantages:

a) Connectivity of the waterway with proposed NW – 35 & 86.
b) Connectivity with NW-1, Haldia and Kolkata port including their hinterland through NW -86.
c) Increasing cargo potential.
d) Reduction in existing traffic load on rail and road infrastructure.

In view of the above, it is recommended to develop the Silabati waterway for Cargo and Passenger ferry services.

Annexure 1: Levelling Results

LEVELLING BETWEEN TEMPORARY BENCH MARK 1 & TIDE POLE

BS	FS	HI	RL	REMARK
1.002		2.862	1.86	TBM1
	2.191		0.671	TIDE POLE

BS	FS	HI	RL	REMARK
2.669		3.34	0.671	TBM1
	1.48		1.86	TIDE POLE

LEVELLING BETWEEN TEMPORARY BENCH MARK 2 & TIDE POLE

BS	FS	HI	RL	REMARK
0.418		10.293	9.875	TBM 2
0.704	3.606	7.391	6.687	CP 1
0.771	2.596	5.566	4.795	CP 2
1.123	3.16	3.529	2.406	CP 3
	3.724	-0.195	-0.195	TIDE POLE

BS	FS	HI	RL	REMARK
3.955		3.76	-0.195	TIDE POLE
2.672	0.405	6.027	3.355	CP 4
2.49	0.374	8.143	5.653	CP 5
3.067	0.424	10.786	7.719	CP 6
	0.91	9.876	9.876	TBM 2

Annexure 2: Observed water levels on Tide Poles

Bondar TBM - 1 Time (IST) in hh:mm & Hts are in Mtrs. Water Level are with respect to MSL.		
TIME	DATE	WATER LEVEL
11:30	08-Jan-16	3.328
11:45	08-Jan-16	3.318
12:00	08-Jan-16	3.294
12:15	08-Jan-16	3.27
12:30	08-Jan-16	3.245
12:45	08-Jan-16	3.231
13:00	08-Jan-16	3.356
13:15	08-Jan-16	3.428
13:30	08-Jan-16	3.491
13:45	08-Jan-16	3.568
14:00	08-Jan-16	3.62
14:15	08-Jan-16	3.681
14:30	08-Jan-16	3.75
14:45	08-Jan-16	3.831
15:00	08-Jan-16	3.957

Ghadighat TBM - 2 Time (IST) in hh:mm & Hts are in Mtrs. Water Level are with respect to MSL.		
TIME	DATE	WATER LEVEL
9:30	11-Jan-16	4
9:45	11-Jan-16	3.977
10:00	11-Jan-16	3.893
10:15	11-Jan-16	3.87
10:30	11-Jan-16	3.81
10:45	11-Jan-16	3.78
11:00	11-Jan-16	3.73
11:15	11-Jan-16	3.71
11:30	11-Jan-16	3.68
11:45	11-Jan-16	3.64
12:00	11-Jan-16	3.62
12:15	11-Jan-16	3.57
12:30	11-Jan-16	3.55
12:45	11-Jan-16	3.51
13:00	11-Jan-16	3.48
13:15	11-Jan-16	3.45
13:30	11-Jan-16	3.42
13:45	11-Jan-16	3.38

Annexure 3: Water Depth along Silabati Waterway

(Start Chainage - 0.0 Km is at confluence of Silabati River with Rupnarayn River)

(End Chainage – 26.0 Km is at Barrage near Shimulia village)

White Cell shows	Stretch with Bathymetric Survey, showing depth (m)
Highlighted Cell shows	Stretch with Topographic Survey, showing elevation (m amsl)

Chainage (Km)	Raw Depth (m)	CD/SD w.r.t MSL (m)	Observed W.L. w.r.t MSL (m)	Reduction in soundings (m)	Reduced Depth (m)
	A	B	C	D = C - B	E = A-D
0.1	1.74	1.000	1.440	0.44	1.30
0.2	1.47	1.006	1.445	0.44	1.03
0.3	2.40	1.012	1.450	0.44	1.96
0.4	1.38	1.017	1.455	0.44	0.94
0.5	1.78	1.023	1.460	0.44	1.34
0.6	2.11	1.029	1.465	0.44	1.67
0.7	2.24	1.035	1.470	0.44	1.80
0.8	2.18	1.040	1.475	0.43	1.75
0.9	1.55	1.046	1.480	0.43	1.12
1.0	1.46	1.052	1.495	0.44	1.02
1.1	1.19	1.058	1.550	0.49	0.70
1.2	1.63	1.063	1.615	0.55	1.08
1.3	2.52	1.069	1.650	0.58	1.94
1.4	1.70	1.075	1.695	0.62	1.08
1.5	1.64	1.081	1.730	0.65	0.99
1.6	1.32	1.087	1.755	0.67	0.65
1.7	0.92	1.092	1.780	0.69	0.23
1.8	3.70	1.098	1.805	0.71	2.99
1.9	2.92	1.104	1.830	0.73	2.19
2.0	2.30	1.110	1.855	0.75	1.55
2.1	1.56	1.115	1.880	0.76	0.80
2.2	1.35	1.121	1.895	0.77	0.58
2.3	1.89	1.127	1.930	0.80	1.09
2.4	3.39	1.133	1.945	0.81	2.58
2.5	3.72	1.138	1.970	0.83	2.89
2.6	2.43	1.144	2.005	0.86	1.57

White Cell shows	Stretch with Bathymetric Survey, showing depth (m)
Highlighted Cell shows	Stretch with Topographic Survey, showing elevation (m amsl)

Chainage (Km)	Raw Depth (m)	CD/SD w.r.t MSL (m)	Observed W.L. w.r.t MSL (m)	Reduction in soundings (m)	Reduced Depth (m)
	A	B	C	D = C - B	E = A-D
2.7	1.80	1.150	2.030	0.88	0.92
2.8	1.67	1.156	2.055	0.90	0.77
2.9	1.63	1.162	2.080	0.92	0.71
3.0	1.35	1.167	2.095	0.93	0.42
3.1	1.31	1.173	2.120	0.95	0.36
3.2	1.10	1.179	2.145	0.97	0.13
3.3	1.54	1.185	2.170	0.99	0.55
3.4	0.96	1.190	2.195	1.00	0.00
3.5	1.42	1.196	2.230	1.03	0.39
3.6	1.72	1.202	2.255	1.05	0.67
3.7	1.44	1.208	2.290	1.08	0.36
3.8	1.31	1.213	2.325	1.11	0.20
3.9	1.34	1.219	2.350	1.13	0.21
4.0	1.51	1.225	2.375	1.15	0.36
4.1	1.48	1.231	2.400	1.17	0.31
4.2	2.08	1.237	2.435	1.20	0.88
4.3	1.71	1.242	2.450	1.21	0.50
4.4	1.22	1.248	2.485	1.24	0.00
4.5	2.18	1.254	2.500	1.25	0.93
4.6	2.17	1.260	2.525	1.27	0.90
4.7	2.29	1.265	2.560	1.29	1.00
4.8	1.03	1.271	2.585	1.31	0.00
4.9	1.66	1.277	2.610	1.33	0.33
5.0	1.41	1.283	2.625	1.34	0.07
5.1	1.24	1.288	2.650	1.36	0.00
5.2	1.43	1.294	2.675	1.38	0.05

White Cell shows	Stretch with Bathymetric Survey, showing depth (m)
Highlighted Cell shows	Stretch with Topographic Survey, showing elevation (m amsl)

Chainage (Km)	Raw Depth (m)	CD/SD w.r.t MSL (m)	Observed W.L. w.r.t MSL (m)	Reduction in soundings (m)	Reduced Depth (m)
	A	B	C	D = C - B	E = A-D
5.3	1.33	1.300	2.220	0.92	0.41
5.4	1.66	1.400	2.331	0.93	0.73
5.5	1.15	1.500	2.432	0.93	0.22
5.6	1.12	1.600	2.543	0.94	0.18
5.7	1.35	1.700	2.655	0.95	0.40
5.8	1.09	1.800	2.766	0.97	0.12
5.9	1.33	1.899	2.877	0.98	0.35
6.0	0.48	1.999	2.988	0.99	0.00
6.1	1.14	2.099	3.089	0.99	0.15
6.2	1.19	2.199	3.200	1.00	0.19
6.3	0.94	2.299	3.301	1.00	0.00
6.4	0.61	2.399	3.393	0.99	0.00
6.5	0.98	2.499	3.484	0.98	0.00
6.6	0.97	2.599	3.575	0.98	0.00
6.7	0.88	2.699	3.666	0.97	0.00
6.8	0.60	2.799	3.757	0.96	0.00
6.9	0.90	2.898	3.848	0.95	0.00
7.0	0.88	2.998	3.939	0.94	0.00
7.1	0.83	3.098	4.031	0.93	0.00
7.2	0.79	3.198	4.122	0.92	0.00
7.3	0.70	3.298	4.213	0.91	0.00
7.4	0.70	3.398	4.304	0.91	0.00
7.5	0.70	3.498	4.395	0.90	0.00
7.6	1.04	3.598	4.486	0.89	0.15
7.7	0.00	3.698	4.577	0.88	0.00
7.8	1.51	3.798	4.669	0.87	0.64

White Cell shows	Stretch with Bathymetric Survey, showing depth (m)
Highlighted Cell shows	Stretch with Topographic Survey, showing elevation (m amsl)

Chainage (Km)	Raw Depth (m)	CD/SD w.r.t MSL (m)	Observed W.L. w.r.t MSL (m)	Reduction in soundings (m)	Reduced Depth (m)
	A	B	C	D = C - B	E = A-D
7.9	1.03	3.898	4.760	0.86	0.17
8.0	0.70	3.997	4.851	0.85	0.00
8.1	0.75	4.097	4.942	0.84	0.00
8.2	1.00	4.197	5.033	0.84	0.16
8.3	1.05	4.297	5.124	0.83	0.22
8.4	0.73	4.397	5.215	0.82	0.00
8.5	1.20	4.497	5.307	0.81	0.39
8.6	0.73	4.597	5.398	0.80	0.00
8.7	0.77	4.697	5.489	0.79	0.00
8.8	0.63	4.797	5.580	0.78	0.00
8.9	0.74	4.897	5.671	0.77	0.00
9.0	0.59	4.996	5.762	0.77	0.00
9.1	0.64	5.096	5.853	0.76	0.00
9.2	0.64	5.196	5.945	0.75	0.00
9.3	0.96	5.296	6.036	0.74	0.22
9.4	0.76	5.396	6.127	0.73	0.03
9.5	1.48	5.496	5.818	0.32	1.16
9.6	1.35	5.596	5.899	0.30	1.05
9.7	1.12	5.696	5.990	0.29	0.83
9.8	1.15	5.796	6.081	0.29	0.86
9.9	1.09	5.896	6.163	0.27	0.82
10.0	1.20	5.996	6.254	0.26	0.94
10.1	1.33	6.095	6.345	0.25	1.08
10.2	1.45	6.195	6.426	0.23	1.22
10.3	1.44	6.295	6.517	0.22	1.22
10.4	1.51	6.395	6.598	0.20	1.31

White Cell shows	Stretch with Bathymetric Survey, showing depth (m)
Highlighted Cell shows	Stretch with Topographic Survey, showing elevation (m amsl)

Chainage (Km)	Raw Depth (m)	CD/SD w.r.t MSL (m)	Observed W.L. w.r.t MSL (m)	Reduction in soundings (m)	Reduced Depth (m)
	A	B	C	D = C - B	E = A-D
10.5	1.51	6.495	6.689	0.19	1.32
10.6	1.78	6.595	6.781	0.19	1.59
10.7	1.18	6.695	6.862	0.17	1.01
10.8	1.41	6.795	6.953	0.16	1.25
10.9	1.72	6.895	7.044	0.15	1.57
11.0	1.78	6.995	7.135	0.14	1.64
11.1	1.17	7.094	7.226	0.13	1.04
11.2	1.29	7.194	7.307	0.11	1.18
11.3	1.26	7.294	7.399	0.10	1.16
11.4	1.24	7.394	7.490	0.10	1.14
11.5	0.72	7.494	7.561	0.07	0.65
11.6	1.51	7.594	7.652	0.06	1.45
11.7	1.98	7.694	7.743	0.05	1.93
11.8	0.66	7.794	7.824	0.03	0.63
11.9	0.96	7.894	7.915	0.02	0.94
12.0	1.53	7.994	8.007	0.01	1.52
12.1	0.90	8.094	8.088	-0.01	0.91
12.2	0.58	8.193	8.169	-0.02	0.60
12.3	0.55	8.293	8.240	-0.05	0.60
12.4	0.99	8.393	8.331	-0.06	1.05
12.5	0.96	8.493	8.412	-0.08	1.04
12.6	0.40	8.593	8.503	-0.09	0.49
12.7	1.12	8.693	8.595	-0.10	1.22
12.8	1.15	8.793	8.686	-0.11	1.26
12.9	0.90	8.893	8.777	-0.12	1.02
13.0	0.72	8.993	8.868	-0.12	0.84

White Cell shows	Stretch with Bathymetric Survey, showing depth (m)
Highlighted Cell shows	Stretch with Topographic Survey, showing elevation (m amsl)

Chainage (Km)	Raw Depth (m)	CD/SD w.r.t MSL (m)	Observed W.L. w.r.t MSL (m)	Reduction in soundings (m)	Reduced Depth (m)
	A	B	C	D = C - B	E = A-D
13.1	0.96	9.093	8.959	-0.13	1.09
13.2	1.56	9.192	9.050	-0.14	1.70
13.3	0.63	9.292	9.131	-0.16	0.79
13.4	1.06	9.392	9.223	-0.17	1.23
13.5	0.61	9.492	9.314	-0.18	0.79
13.6	1.18	9.592	9.405	-0.19	1.37
13.7	0.84	9.692	9.496	-0.20	1.04
13.8	0.94	9.792	9.577	-0.21	1.15
13.9	0.37	9.892	9.668	-0.22	0.59
14.0	0.40	9.992	9.759	-0.23	0.63
14.1	0.97	10.092	9.841	-0.25	1.22
14.2	0.58	10.192	9.932	-0.26	0.84
14.3	0.39	10.291	10.023	-0.27	0.66
14.4	0.75	10.391	10.104	-0.29	1.04
14.5	1.32	10.491	10.195	-0.30	1.62
14.6	1.14	10.591	10.286	-0.30	1.44
14.7	0.76	10.691	10.367	-0.32	1.08
14.8	0.96	10.791	10.459	-0.33	1.29
14.9	1.81	10.891	10.540	-0.35	2.16
15.0	0.37	10.991	10.631	-0.36	0.73
15.1	0.96	11.091	10.712	-0.38	1.34
15.2	0.75	11.191	10.753	-0.44	1.19
15.3	0.00	11.290	10.824	-0.47	0.47
15.4	0.40	11.390	10.915	-0.47	0.87
15.5	0.48	11.490	10.987	-0.50	0.98
15.6	0.75	11.590	11.068	-0.52	1.27

White Cell shows	Stretch with Bathymetric Survey, showing depth (m)
Highlighted Cell shows	Stretch with Topographic Survey, showing elevation (m amsl)

Chainage (Km)	Raw Depth (m)	CD/SD w.r.t MSL (m)	Observed W.L. w.r.t MSL (m)	Reduction in soundings (m)	Reduced Depth (m)
	A	B	C	D = C - B	E = A-D
15.7	1.18	11.690	11.109	-0.58	1.76
15.8	0.00	11.790	0.000	Not Applicable	
15.9	0.00	11.260	0.000	Not Applicable	
16.0	0.00	11.260	0.000	Not Applicable	
16.1	0.00	11.160	0.000	Not Applicable	
16.2	0.00	11.260	0.000	Not Applicable	
16.3	0.00	11.190	0.000	Not Applicable	
16.4	0.00	11.460	0.000	Not Applicable	
16.5	0.00	11.270	0.000	Not Applicable	
16.6	0.00	11.300	0.000	Not Applicable	
16.7	0.00	11.530	0.000	Not Applicable	
16.8	0.00	11.530	0.000	Not Applicable	
16.9	0.00	11.250	0.000	Not Applicable	
17.0	0.00	10.960	0.000	Not Applicable	
17.1	0.00	11.520	0.000	Not Applicable	
17.2	0.00	11.400	0.000	Not Applicable	
17.3	0.00	11.450	0.000	Not Applicable	
17.4	0.00	11.560	0.000	Not Applicable	
17.5	0.00	11.720	0.000	Not Applicable	
17.6	0.00	11.540	0.000	Not Applicable	
17.7	0.00	11.540	0.000	Not Applicable	
17.8	0.00	11.470	0.000	Not Applicable	
17.9	0.00	11.380	0.000	Not Applicable	
18.0	0.00	11.130	0.000	Not Applicable	
18.1	0.00	11.650	0.000	Not Applicable	
18.2	0.00	11.630	0.000	Not Applicable	

White Cell shows	Stretch with Bathymetric Survey, showing depth (m)
Highlighted Cell shows	Stretch with Topographic Survey, showing elevation (m amsl)

Chainage (Km)	Raw Depth (m)	CD/SD w.r.t MSL (m)	Observed W.L. w.r.t MSL (m)	Reduction in soundings (m)	Reduced Depth (m)
	A	B	C	D = C - B	E = A-D
18.3	0.00	11.710	0.000	Not Applicable	
18.4	0.00	11.840	0.000	Not Applicable	
18.5	0.00	11.870	0.000	Not Applicable	
18.6	0.00	11.870	0.000	Not Applicable	
18.7	0.00	12.250	0.000	Not Applicable	
18.8	0.00	12.510	0.000	Not Applicable	
18.9	0.00	12.390	0.000	Not Applicable	
19.0	0.00	12.440	0.000	Not Applicable	
19.1	0.00	12.730	0.000	Not Applicable	
19.2	0.00	12.720	0.000	Not Applicable	
19.3	0.00	12.420	0.000	Not Applicable	
19.4	0.00	12.170	0.000	Not Applicable	
19.5	0.00	12.160	0.000	Not Applicable	
19.6	0.00	12.330	0.000	Not Applicable	
19.7	0.00	13.380	0.000	Not Applicable	
19.8	0.00	13.790	0.000	Not Applicable	
19.9	0.00	13.830	0.000	Not Applicable	
20.0	0.00	13.710	0.000	Not Applicable	
20.1	0.00	14.130	0.000	Not Applicable	
20.2	0.00	13.940	0.000	Not Applicable	
20.3	0.00	13.740	0.000	Not Applicable	
20.4	0.00	13.900	0.000	Not Applicable	
20.5	0.00	13.850	0.000	Not Applicable	
20.6	0.00	13.790	0.000	Not Applicable	
20.7	0.00	14.210	0.000	Not Applicable	
20.8	0.00	14.000	0.000	Not Applicable	

White Cell shows	Stretch with Bathymetric Survey, showing depth (m)
Highlighted Cell shows	Stretch with Topographic Survey, showing elevation (m amsl)

Chainage (Km)	Raw Depth (m)	CD/SD w.r.t MSL (m)	Observed W.L. w.r.t MSL (m)	Reduction in soundings (m)	Reduced Depth (m)
	A	B	C	D = C - B	E = A-D
20.9	0.00	13.980	0.000	Not Applicable	
21.0	0.00	13.900	0.000	Not Applicable	
21.1	0.00	13.920	0.000	Not Applicable	
21.2	0.00	14.140	0.000	Not Applicable	
21.3	0.00	14.220	0.000	Not Applicable	
21.4	0.00	14.070	0.000	Not Applicable	
21.5	0.00	13.780	0.000	Not Applicable	
21.6	0.00	14.070	0.000	Not Applicable	
21.7	0.00	14.050	0.000	Not Applicable	
21.8	0.00	14.000	0.000	Not Applicable	
21.9	0.00	13.460	0.000	Not Applicable	
22.0	0.00	14.050	0.000	Not Applicable	
22.1	0.00	14.260	0.000	Not Applicable	
22.2	0.00	13.870	0.000	Not Applicable	
22.3	0.00	13.480	0.000	Not Applicable	
22.4	0.00	13.870	0.000	Not Applicable	
22.5	0.00	14.030	0.000	Not Applicable	
22.6	0.00	14.070	0.000	Not Applicable	
22.7	0.00	13.420	0.000	Not Applicable	
22.8	0.00	13.640	0.000	Not Applicable	
22.9	0.00	14.170	0.000	Not Applicable	
23.0	0.00	14.040	0.000	Not Applicable	
23.1	0.00	14.140	0.000	Not Applicable	
23.2	0.00	13.520	0.000	Not Applicable	
23.3	0.00	13.380	0.000	Not Applicable	
23.4	0.00	13.630	0.000	Not Applicable	

White Cell shows	Stretch with Bathymetric Survey, showing depth (m)
Highlighted Cell shows	Stretch with Topographic Survey, showing elevation (m amsl)

Chainage (Km)	Raw Depth (m)	CD/SD w.r.t MSL (m)	Observed W.L. w.r.t MSL (m)	Reduction in soundings (m)	Reduced Depth (m)
	A	B	C	D = C - B	E = A-D
23.5	0.00	13.250	0.000	Not Applicable	
23.6	0.00	14.170	0.000	Not Applicable	
23.7	0.00	13.690	0.000	Not Applicable	
23.8	0.00	14.150	0.000	Not Applicable	
23.9	0.00	13.790	0.000	Not Applicable	
24.0	0.00	13.940	0.000	Not Applicable	
24.1	0.00	14.210	0.000	Not Applicable	
24.2	0.00	14.410	0.000	Not Applicable	
24.3	0.00	14.510	0.000	Not Applicable	
24.4	0.00	14.010	0.000	Not Applicable	
24.5	0.00	14.290	0.000	Not Applicable	
24.6	0.00	14.290	0.000	Not Applicable	
24.7	0.00	14.160	0.000	Not Applicable	
24.8	0.00	14.260	0.000	Not Applicable	
24.9	0.00	13.930	0.000	Not Applicable	
25.0	0.00	14.040	0.000	Not Applicable	
25.1	0.00	14.290	0.000	Not Applicable	
25.2	0.00	14.090	0.000	Not Applicable	
25.3	0.00	14.170	0.000	Not Applicable	
25.4	0.00	14.310	0.000	Not Applicable	
25.5	0.00	14.130	0.000	Not Applicable	
25.6	0.00	14.300	0.000	Not Applicable	

Annexure 4: Photographs along Silabati Waterway

BATTAPUR FERRY POINT CHAINAGE 2.5 KM

BINDA SAGAR SCHOOL CHAINAGE 6.5 KM

FISHING STAKES CHAINAGE 10 KM

FISHING STAKES CHAINAGE 1.5 KM

GATTAL FERRY CHAINAGE-7.0 KM

GHATAL BRIDGE CHAINAGE-6.2 KM

MOBILE TOWER CHAINAGE 6.0 KM

SHALLOW PATCH CHAINAGE-14.0 KM

WODDEN BRIDGE GHATAL CHAINAGE-6.50 KM