TRACTEBEL

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CONSULTANCY SERVICES FOR PREPARATION OF TWO STAGE DPR OF CLUSTER VII OF PROPOSED 53 NATIONAL WATERWAYS

FEASIBILITY REPORT-SAL RIVER (14KM) - (NW-88)
Project No. P.009051
Document No. P.009051-W-10204-D03
Final Report

Goa and Maharashtra | INDIA

Inland Waterways Authority of India (IWAI) - Government of India Ministry of Shipping - Head Office

23 September 2016

Report

Rev.03

RESTRICTED

CATEGORY-II WATERWAYS: STAGE-I REPORTS
SALIENT FEATURES AT A GLANCE

<table>
<tr><th>Sl. No.</th><th>Particulars</th><th>Details</th></tr>
<tr><td>1.</td><td>Name of Consultant</td><td>Tractebel Engineering Pvt. Ltd.</td></tr>
<tr><td>2.</td><td>Cluster Number & State(s)</td><td>Cluster-VII & Goa</td></tr>
<tr><td>3.</td><td>Waterway stretch, NW#</td><td>Sal River (14 km), NW-88</td></tr>
<tr><td>4.</td><td><u>Navigability status</u></td><td></td></tr>
<tr><td>a)</td><td>Tidal & non tidal portions (from…….to, length, average tidal variation)</td><td>Fully Tidal (Chainage 0.0 km to Chainage 14.26 km, average tidal variation of 1.15 m)
Tidal Variation 0.00m/2.30m</td></tr>
<tr><td>b)</td><td>LAD status (w.r.t.CD)
i) Survey period (01/03/2016)
ii) < 1.0 m (km)
iii) 1.0 m to 1.5 m (km)
iv) 1.5 m to 2.0 (km)
v) >2.0 m (km)</td><td>
<table>
<tr><th>0 - 3</th><th>3 - 7</th><th>7 - 10</th><th>10 – 14.26</th><th>Total</th></tr>
<tr><td>0.37</td><td>1.03</td><td>1.04</td><td>1.96</td><td>4.40</td></tr>
<tr><td>0.68</td><td>1.03</td><td>0.23</td><td>1.27</td><td>3.21</td></tr>
<tr><td>0.97</td><td>0.82</td><td>0.92</td><td>0.69</td><td>3.40</td></tr>
<tr><td>0.97</td><td>1.12</td><td>0.81</td><td>0.35</td><td>3.25</td></tr>
</table>
</td></tr>
<tr><td>c)</td><td>Cross Structures
i) Dams, weirs, barrage etc. (total number; with navigation locks or not)
ii) Bridges, Power cables etc. (total number; range of horizontal and vertical clearances)</td><td>Cross Structures
i) Nil
ii) 1 no. of Bridge, HC: 42 m , VC: 8.5 m
1 no. HT line, VC : 10.0 m
2 no. Electric line, VC: 6.5 m – 8.5 m
(VC are above MHWS/HFL)</td></tr>
<tr><td>d)</td><td>Avg. discharge & no. of days</td><td>Since the entire stretch is tidal, discharge of the river is not relevant for navigability.</td></tr>
<tr><td>e)</td><td>Slope (1 in……)</td><td>1 in 7000</td></tr>
<tr><td>5.</td><td><u>Traffic Potential</u></td><td></td></tr>
<tr><td>a)</td><td>Present IWT operations, ferry services, tourism, cargo, if any</td><td>Ferry services are under operation at Cavelossim and Aslona.</td></tr>
<tr><td>b)</td><td>Important industries within 50 km</td><td>Cuncolim Industrial Estate (Approx 8km from nearest River Front) & Margao Industrial Estate (Approx 8km from nearest River Front) (For details Refer Annexure 4.1)</td></tr>
<tr><td>c)</td><td>Distance of Rail & Road from Industry</td><td>--</td></tr>
<tr><td>6.</td><td>Consultant’s recommendation for going ahead with Stage-II (DPR preparation)</td><td>Recommended for development as Class-III waterway for Ch 0.00 km to 14.26km.</td></tr>
<tr><td>7.</td><td>Any other information/comment</td><td>MHWS –2.37m, HTL—2.37m, LTL—0.00m, Average Tidal Variation—1.15m, Port Name: Marmagao Port.</td></tr>
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Date: 23-09-2016

Consultant signature

CONSULTANCY SERVICES FOR PREPARATION OF TWO STAGE DETAILED PROJECT REPORT OF PROPOSED 53 NATIONAL WATERWAYS

SAL RIVER

(NW-88)

CLUSTER - VII

GOA AND MAHARASHTRA, INDIA

					
03	23.09.2016	For Acceptance	N Bawa	Pradyumna Machhkhand	B. C. Jha
Rev.	Date	Description	Prepared By	Checked By	Approved By

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LIST OF ABBREVIATIONS

Abbreviations	Acronyms
BFL	Bombay Floating Light
CD	Chart Datum
Ch	Chainage
CRZ	Coastal Regulation Zone
CWC	Central Water Commission
DGPS	Differential Global Positioning System
DFPCL	Deepak Fertilizers & Petrochemical Corporation
DMIC	Delhi Mumbai Industrial Corridor
DPR	Detailed Project Report
FSL	Full Supply Level
GAIL	Gas Authority of India Ltd.
HC	Horizontal Clearance
IO	Iron Ores
IOCL	Indian Oil Corporation Ltd.
IWAI	Inland Waterways Authority of India
IWT	Inland Water Transportation
KP	Km Points
LAD	Least Available Depth
LNG	Liquefied Natural Gas
MHWS	Mean High Water Spring
MIDC	Maharashtra State Industrial Development Corporation
MMB	Maharashtra Maritime Board
MMTPA	Million Metric Tonne Per Annum
MnT	Million Tonnes
MOEFCC	Ministry of Environment, Forest & Climate Change
MOS	Ministry of Shipping
MSEB	Maharashtra State Electricity Board
MSME	Micro, Small & Medium Enterprises
MSPGC	Maharashtra State Power Generation company
MTPA	Metric Tonne Per Annum
NH	National Highway
NTPC	National Thermal Power Corporation
NTPC 1980	National Transport Policy Committee, 1980
NW	National Waterway
PGCIL	Power Grid Corporation of India Limited
PWD	Public Works Department
RGPPL	Ratnagiri Gas and Power Private Limited
SEB	State Electricity Board
SH	State Highway

Abbreviations	Acronyms
UP	Uttar Pradesh
VC	Vertical Clearance
WRD	Water Resources Department
WRIS	Water Resources Information System of India

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Annexure 3.4	Photos Captured by Survey Team during Reconnaissance Survey
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EXECUTIVE SUMMARY

A. Introduction

The available water resource in the globe can be used and utilized in various ways whereas Inland Water Transport (IWT) is one among them. The water bodies can be utilized for IWT also. India has been bestowed with vast water bodies consisting of rivers, canals, backwaters, creeks and lakes and having the potential for development of efficient waterways transport network. However, when compared to the development of IWT in certain countries, the same is to be geared up in our country. IWT mode remains underdeveloped and its share in overall internal cargo transport remains abysmally low. IWT sector presently has a meager modal share of 0.1% in India compared to 42% in European Union, 8.7% in China and over 8% in USA. This is a great economic opportunity loss to the country.

Based on various earlier studies on IWT, subsequent to the recommendations of National Transportation Policy Committee (NTPC 1980) and in order to give more thrust to the Inland Water Transport mode, duly keeping in view the major benefits of this mode viz., Cheaper operational cost on comparison / Higher fuel efficiency / Eco friendly nature of the mode, the IWT development system is under consideration in our country. The potential through IWT mode can be used as an alternate and supplementary mode of transportation in certain favorable conditions.

India has about 14,500 km of navigable waterways which comprise Rivers, Canals, Backwaters, Creeks, etc., out of which about 5200 km of the river and 4000 km of canals can be used by mechanized crafts. About 55 million tonnes of cargo is being moved annually by Inland Water Transport (IWT). Its operations are currently restricted to a few stretches in the Ganga-Bhagirathi-Hooghly Rivers, the River Brahmaputra, the River Barak, the Rivers in Goa, the Backwaters in Kerala, Inland Waters in Mumbai area and the Deltaic regions of the Godavari - Krishna Rivers.

Inland Waterways Authorities of India (IWAI), a statutory body under the Ministry of Shipping, Government of India, intends to explore the navigational potential of newly declared national waterways across the country for year round commercial navigation.

National Waterways Act, 2016 has come into force to make provisions for existing national waterways and to provide for the declaration of certain inland waterways to be national waterways and also to provide for the regulation and development of the said waterways for the purposes of shipping and navigation and for matters connected therewith or incidental thereto. There are now a total of one hundred and eleven national waterways altogether across the country which include five existing national waterway besides 106 newly declared waterways as national waterways through National Waterways Act, 2016. The objective is to

promote integrated development of waterways throughout the country so as to have a considerable and maximum mode shift to IWT, which can reduce the density in rail/road apart from the environmental benefits of IWT mode.

It has been planned to study in two stages comprising feasibility study in stage-I followed by preparation of DPR in stage-II and recommending thereafter the possibility of composite and integrated development of proposed newly declared national waterways to achieve navigation and to develop water transport facilities.

This report presents study detail of stage-I of national waterway of Sal River in the State of Goa. Sal River has been designated as national waterway-88 with its description in the gazette notification as, Sal River from Arabian Sea at Mobor Lat 15° 8'31.93"N, Long 73°56'59.89"E to Orlim Deusa Bridge at Lat 15°13'11.41"N, Long 73°57'29.77"E.

Sl No.	Introductory Consideration	Description of the River
1	Name of the river / canal	Sal River (NW-88)
2	State/ District through which river passes	The Sal River passes through the South Goa district of Goa State.
3	Length of the river / canal	Out of the total 35km length, 14km length of the Sal River starts from Arabian Sea at Mobor Lat 15° 8'31.93"N, Long 73°56'59.89"E to Orlim Deusa Bridge at Lat 15°13'11.41"N, Long 73°57'29.77"E has been declared as new national waterway.
4	Catchment Area	The total catchment area of Sal River is 301 sq. km.

B. Methodology Adopted

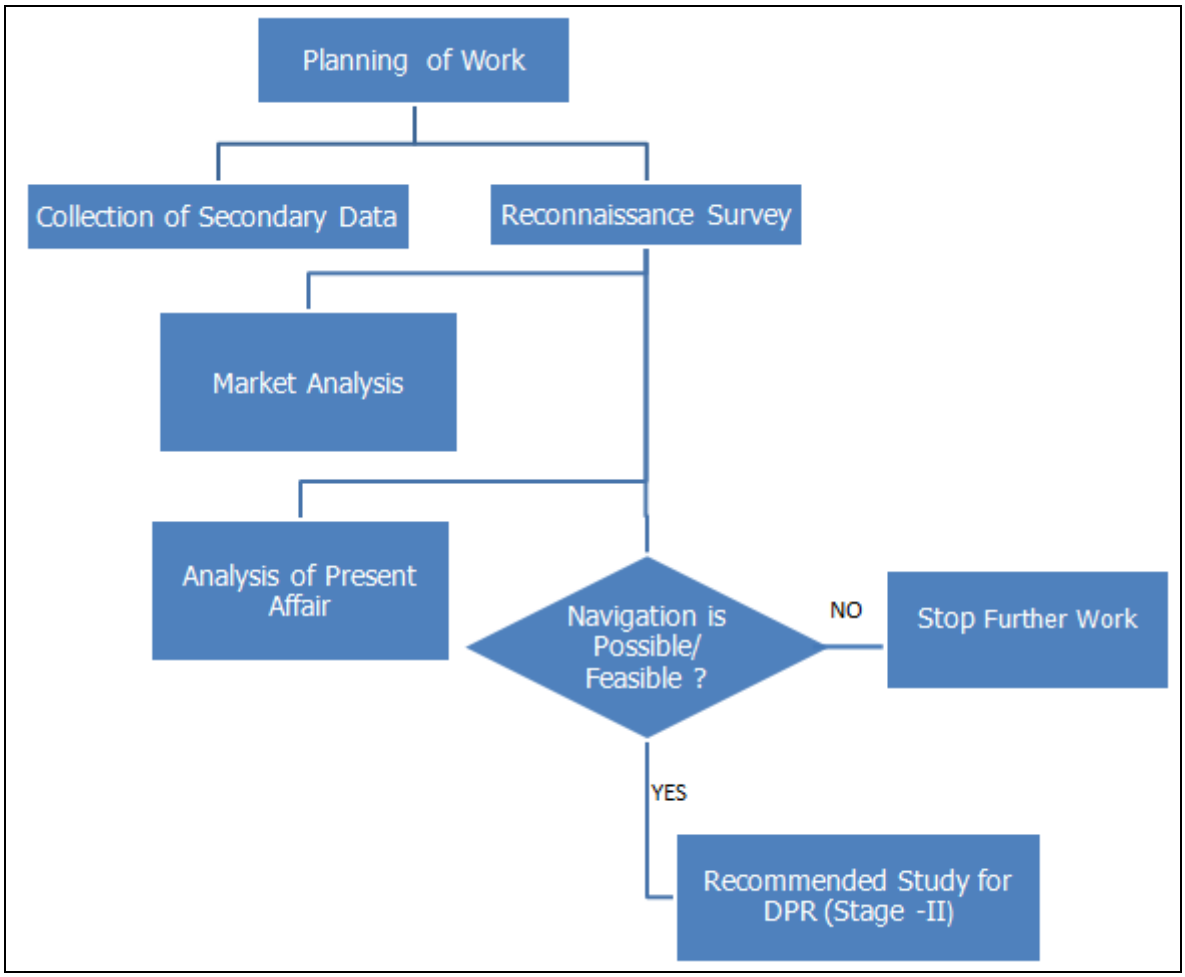
The feasibility of the navigation in the considered waterway has been examined from the following three perspectives:

a) The Physical System: - It includes the study of hydrographic characteristics of the channel/stability of channel/water depth/width of river/ LAD/ terminal/ infrastructure/ cross over structure/ sediment analysis/ physical constraints/ hindrances etc.

b) The Current Functions: - It covers the current utilization of the river – existing navigation/ ferry services/ jetties/ cross over structures/ irrigation facilities/ dam/ barrage/ canals/ fishery/mining etc.

c) The Market Potential: - This aspect covers ferry services, existing cargo movement, existing rail & road network, population served, local produces, industrial establishment, future potential, transfer of cargo movement to inland waterways transport system etc.

Work Execution for stage-I study has been depicted through following diagram.



Execution Diagram of Stage I

C. Collection of Data and Analysis

Reconnaissance survey has been conducted through an expert agency for collection of primary data and various secondary data have also been collected from different sources e.g. benchmark, G & D data & chart datum from IWAI, Govt. of India / Mormugoa Port Trust, Goa / District Industries Authorities, Goa / Fisheries Department, Government of Goa, Goa / Goa Tourism, Goa / Directorate of Mines & Geology, Government of Goa, Goa / Captain of Ports, Govt. of Goa / WRD, Govt. of Goa / respective district authorities of State Govt. of Goa and information available in the public domain through web.

A review of the existing data available with the State Agencies and Central Water Commission for the proposed Inland Waterways has been done for determining the nature, extent, adequacy, validity of the available data and identifying the data gaps.

D. Observations and Inferences

Following conclusions have been derived for establishing the navigability of the proposed waterway;

1. The river length as given by IWAI is 14km, whereas the total surveyed length along the river to capture the thalweg is 14.26km. The deepest channel route has been reckoned as 14.26km. All inferences derived for identifying the navigable length have been derived with reference to the deepest channel length (14.26km).
2. The full study stretch of river is under tidal effect. The relevant chart datum has been used. However, only 23% of the surveyed length has water depth more than 2.0 m, which is also not continuous. The average tidal variation is 1.15m with maximum high tide of 2.3m and low tide of 0.0m as per the records available for this region. The average tide height of 1.15m would be an added advantage for the safe navigation.
3. As per the observation, the feasibility study suggests that the river is navigable without any significant obstructions up to the end of the stretch i.e., up to the Orlim Deusa Bridge (at the end of the stretch). Smoothening of the bends is required at the critical bends and modifications in the clearances under H. T. Line and Electric Lines are to be carried out. By considering the above, the entire stretch can be considered under Class III Waterway.
4. The lengths of the waterway, with a depth more than 2.0m, 1.5m and 1.0m with reference to the Chart datum have been compiled in the main report. This is given in Table 3.7 of the report and is being reproduced below:

Maximum – Minimum Depth in Sal River from Ch 0.00km to Ch 14.26km

Chainage (Km)	Draft Available		Length of River (Km)			
	Max. (m)	Min. (m)	>2m	1.5-2.0m	1-1.5m	<1m
0-3	6.66	0.75	0.97	0.97	0.68	0.37
3-7	3.68	0.09	1.12	0.82	1.03	1.03
7-10	4.37	0.02	0.81	0.92	0.23	1.04
10-14.26	2.65	0.12	0.35	0.69	1.27	1.96
Total			**3.25**	**3.40**	**3.21**	**4.40**

5. Two Electric Lines and one H. T. Line are crossing the study stretch with the vertical clearance ranging from 2.2m to 10.00m above MHWS. The minimum vertical clearance required shall be 20.1m corresponding to 220kVA transmission line.

The description & classification of the waterway has been presented schematically based on the survey observation and duly keeping in view the river classification criteria in Table 3.16 as reproduced below.

Criteria	Classification																			
Length of waterway from start (km)	1	1	2	3	4	4	5	6	6	7	8	9	9	10	11	11	12	13	14	14
Chainage length in %	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Depth availble	C-III																			
Raod Bridge Vert. Clearance	C-III																			
Raod Bridge Hor. Clearance	C-III																			
HT Line Vert. Clearance	Needs Raising of HT Base																			
Bend Radius	C-III																			
Index	All Class		Class-V		Class-IV		Class-III		Class-II		Class-I									

E. Cargo Feasibility

The present Cargo mobility in the Sal River area is comparatively minimal. However, the Fishing activity in the study stretch is in a buzz.

Subsequent to the preliminary market survey and its analysis, there is a possible growth of Fishing and Tourism in the study stretch. Further, the possible Cargo mobility linking two Industrial Estates in the hinterland is to be examined. Possibility of IWT mobility of Laterite from mining area is also to be examined and analyzed.

In order to expand the Fishing and Tourism activities and establish the possible IWT mobility of Laterite, the waterway development is felt essential. Accordingly, the waterway is to be developed to Class III to meet the above activities.

F. SWOT Analysis

SWOT analysis has been carried out for deriving meaningful information specifying the objectives of the study for development of the waterway for year round commercial navigation and identifying the internal & external factors that are favorable and unfavorable in the development of the waterway.

Strength

1. 23% of the surveyed length has water depth more than 2 m and is safe for navigation.
2. The above depth availability is for the initial 2kms to 3 kms. Certain patches may be required to be attended with a considerable conservancy activity involving dredging in the study stretch.
3. The maximum water level (tidal) fluctuation of 2.3m has been observed and this will strengthen the safe mobility of vessels in the waterway.
4. The study stretch of Sal River is flowing through Salcete Taluka of South Goa District. Approximately 2.94 lacs of population is residing in the Salcete Taluka, in the vicinity of Sal River, which will have direct or indirect benefits from the IWT and related projects coming up in the area.
5. Fishing activity is flourishing in the Sal River area with Betul and Virca ports as hub.
6. Numbers of Hotels are observed on the banks of Sal River, which may be strength for Tourism activity in the River. The Betul Beach is also observed in the vicinity.

7. Two industrial estates viz., Margao Industrial Estate (12kms from the nearest river front) and Cuncolim Industrial Estate (8kms from the nearest river front) are in the catchment of Sal River.
8. Laterite Mining is in the catchment of Sal River.
9. The above Industrial Estates and the Mining zone are well connected with Road and also with Mormugoa Port.

Weakness

1. Presently, there is no IWT movement.
2. Connectivity of Industrial Estates / Mining Zone with Road may be a weakness, if not used advantageously for IWT.

Opportunity

1. 23 % of the existing waterway is having a depth more than 2m, which can be used advantageously for the mobility of hinterland cargo.
2. The existing fishing activity (through the river and Betul fishing Port & Verca fishing Port) will get encouragement with the development of Sal River.
3. Since many Hotels are on the banks of Sal River and with the presence of Betul Beach in the proximity, Tourism may flourish, if the Sal River is developed.
4. The existence of two industrial estates viz., Margao Industrial Estate and Cuncolim Industrial Estate in the catchment of Sal River is an opportunity, if used by IWT.
5. Possibilities of Laterite mobility from the Mines in the hinterland through IWT can be explored.
6. The present Rail and Road connectivity though may be competing with IWT may also be an opportunity for creating an efficient intermodal hub for IWT.
7. Policies are to be firmed up for development of IWT in this stretch.

Threat

1. The Mumbai-Goa Highway in the study area may create competing mode of transport.
2. The Sal River banks covered by marginal mangrove trees in certain places may involve some socio-environmental issues and may require statutory approvals and clearances to construct the jetties/ terminal/ ports/ intermodal connectivity.

G. Development Cost (Tentative)

The reconnaissance survey data with regard to physical constraints may have cost implications for making the river stretch navigable to the required standards of Waterway. Henceforth, the development of the proposed national waterway involves physical interference in the form of dredging, construction of terminals at the identified locations, modification of HT Lines at crossing locations to provide a minimum vertical clearance of 20.1m (with respect to 220 kVA) or the case may be combined with some unforeseen expenses. Moderate dredging effort has been envisaged with an average dredging of 1.0m required in 11.0km of the length of proposed waterway reckoned with reference to ascertained data. The cost of dredging has been considered

@ INR 230 per cum. The cost of terminal has been estimated @ INR 20.0 crore each for one terminal. HT line / Electric Lines crossing shall need modification which shall require two towers at the bank of requisite height and the stringing over pair of poles crossing the Sal River. The cost of transmission tower has been estimated to be INR 20.00 lacs each and the stringing cost across the towers shall be INR 4.0 lacs per pair of towers. The total estimated cost for modification to the three HT / Electric Lines shall be INR 3 x 44.0 lacs = INR 132.0 lacs. No modification is required for bridge structures. The cost of navigational aids for day/night navigation has been considered as INR 263 lacs. 10% of the amount for dredging, terminal construction, tower / bridge modification and night navigational aids has been envisaged as unforeseen. The tentative total cost of development to make the river navigable round the year to achieve safe navigation for the required classification of vessel mobility has been estimated to INR 37.50 crore. (Reproduced below is Table 5.1).

Sl No.	Name of Waterway	Length of Waterway	Dredging Required (wrt. 2 m draft & 40.0m width)	Dredging Cost @ INR 230/ cum	Terminal Proposed	Terminal Cost @ INR 20 Cr each	Cost of Modification of Transmission line	Night Navigation	Total cost incld. 10% unforeseen
		(km)	(km)	(INR in Cr.)	(Nos.)	(INR in Cr.)	(INR in Cr.)	(INR in Cr.)	(INR in Cr.)
1	Sal River	14.26	11.0	10.12	1	20.00	1.32	2.63	37.50

H. Classification of Waterway

The Ministry of Shipping, Road Transport and Highways (Inland Waterways Authority of India) has classified the Inland waterways into seven categories for rivers and canals for safe plying of self propelled vessels up to 2000 DWT and tug-barge formation in push tug + four barge units of carrying capacity up to 8000 DWT (Ref: IWAI, Gazette Notification dated 26th January 2007).

As per the above Classification of Inland Waterways, the entire waterway of Sal River (NW 88) of 14.26km length has been classified based on available minimum water depth, bottom width, minimum vertical and horizontal clearances of cross over structures and bend radius in the river. The classification of Sal River is described below. (Reproduced below is Table 5.2).

Chainage (km)	Minimum Depth (m)	Bottom Width (m)	Minimum Vertical Clearance (m)	Minimum Horizontal Clearance (m)	Bend Radius (m)	Classification of Waterway (Proposed)
0.0 – 14.26	0.02	120.0	6.5 (Bridge & H. T. Line)	25 (Bridge)	165	**Class – III**

The study stretch of the waterway is amenable for development as Class III waterway as explained above. However, considerable Dredging may be required.

In order to consider the full stretch as **Class III**, smoothening of bends is essential.

The above stretch of the waterway, hence, can be considered under Class III which is navigable without any hindrance and shall be used for plying self-propelled vessel of carrying capacity upto 500 DWT (approximate size 58m overall length, 9m moulded breadth and 1.5m loaded draft) or one tug and twor barges combination of 1000 DWT (approximate size 141m overall length, 9m breadth and 1.5m loaded draft).

I. Recommendation

The national waterway-88 of Sal River has been identified having potential for development as waterway of Class III for a distance of 14.26km as described above. This stretch of the river is, therefore, recommended for stage-II study for preparation of Detailed Project Report (DPR) to establish the viability for implementation as a project.

Accordingly, the national waterway NW-88 of Sal River is proposed for development as **Class III** waterway in the stretch of the waterway as depicted below:

River Stretch	0.00km 14.26km
Classification	
	Class III
Horizontal clearance (m)	50
Vertical clearnce (m)	7
Minimum Depth(m)	1.7
Bottom Width (m)	50
Self Propelled Vessel	
Dead Weight Tonnage	500
Vessel size (m)	(58 x 9 x 1.5)
Tug + Barge	
Dead Weight Tonnage	1000
Vessel size (m)	(141 x 9 x 1.5)

Note:

1. All vertical clearances of cross over structures have been reckoned with MHWS of 2.30m above MSL and details are described in Para 3.3.5.
2. The depths have been reckoned in the tidal stretch with reference to the chart datum of 1.30m (below mean sea level)
3. MHWS –2.37m, HTL—2.37m, LTL—0.00m, Average Tidal Variation—1.15m, Port Name: Marmagao Port

CHAPTER 1: INTRODUCTION

1.1 Introduction to Inland Waterways

The Inland Waterways Authority of India (IWAI) came into existence on 27th October 1986 for development and regulation of inland waterways for shipping and navigation. Inland Waterways Authority of India (IWAI) is the statutory authority in charge of the waterways in India. The Authority primarily undertakes projects for development and maintenance of IWT infrastructure on national waterways through grant received from the Ministry of Shipping, Government of India. The head office of the Authority is at Noida, UP. It does the function of building the necessary infrastructure in these waterways, surveying the economic feasibility of new projects and also administration. The Authority also has its regional offices at Patna, Kolkata, Guwahati and Kochi and sub-offices at Allahabad, Varanasi, Bhagalpur, Farakka, Swaroopganj, Hemnagar, Dibrugarh (Assam), Dhubri, Kollam, Vijayawada (Andhra Pradesh) and Bhubaneshwar (Odisha).

India has about 14,500 km of navigable waterways which comprise Rivers, Canals, Backwaters, Creeks, etc., out of which about 5200km of the river and 4000km of canals can be used by mechanized crafts. About 55 million tonnes of cargo is being moved annually by Inland Water Transport (IWT), a fuel - efficient and environment - friendly mode. Freight transportation by waterways is highly underutilized in India compared to other large countries and geographic areas like the United States, China and the European Union. Its operations are currently restricted to a few stretches in the Ganga-Bhagirathi-Hooghly Rivers, the River Brahmaputra, the River Barak, the Rivers in Goa, and the Backwaters in Kerala, Inland Waters in Mumbai area and the Deltaic regions of the Godavari - Krishna Rivers.

Besides these organized operations by mechanized vessels, country boats of various capacities also operate in various rivers and canals and substantial quantum of cargo and passengers are transported in this unorganized sector as well. The total cargo moved (in tonne kilometres) by the inland waterway was just 0.1% of the total inland traffic in India. There are now one hundred and eleven national waterways across the country which include five existing national waterways besides 106 waterways which have been declared recently as national waterways through a central legislation.

1) National Waterway 1

The Ganga - Bhagirathi - Hooghly river system between Haldia (Sagar) & Allahabad.

Declared	= October 1986.
Length	= 1620 km
Fixed terminals	= G R Jetty 2, Kolkatta, Pakur, Farakka, Gaighat (Patna) & Allahabad.
Floating terminals	= Kolkatta, Diamond Harbour, Katwa, Bahrampur, Jangipur, Bhagalpur, Semaria, Doriganj, Ballia, Ghazipur, Varanasi, Chunar, Allahabad.
Cargo Movement	= 3 million tonnes Approx.

2) National Waterway 2

Sadiya — Dhubri stretch of Brahmaputra river.

Estd = September 1988.

Length = 891 km

Fixed terminals = Pandu

Floating terminals = Dhubri, Jogighopa, Tezpur, Silghat, Jamgurhi, Bogibil, Dibrugarh, Saikhowa and Sadiya

Cargo Movement = 2.0 million tonnes Approx.

3) National Waterway 3

Kottapuram-Kollam stretch of the West Coast Canal, Champakara Canal and Udyogmandal Canal.

Estd = February 1993

Length = 205 km

Fixed terminals = Kottapuram, Aluva, Bolgatty, Willingdon Island, Maradu (Kochi), Cherthala (Vaikom), Thannermukkom, Alappuzha, Thrikkunnapuzha, Kayamkulam (Ayiramthengu), Chavara and Kollam.

Cargo Movement = 1.0 million tonnes Approx.

4) National Waterway 4

Kakinada–Pondicherry stretch of canals and the Kaluvelly Tank, Bhadrachalam – Rajahmundry stretch of River Godavari and Wazirabad – Vijayawada stretch of River Krishna.

Estd = November 2008

Length = 1095 km

Tentative Cargo Potential = 2.0 million tonnes Approx which can go up to 4.0 million tonnes in next 15 Years or so.

5) National Waterway 5

Talcher–Dhamra stretch of the Brahmani River, the Geonkhali - Charbatia stretch of the East Coast Canal, the Charbatia–Dhamra stretch of Matai river and the Mangalgadi - Paradip stretch of the Mahanadi River Delta.

Established = November 2008

Length = 623 km

Tentative Cargo Potential = Coal from Talcher to Dhamra and Paradip ports is the most important potential cargo for this waterway. Immediately after the development of the waterway, it is estimated in the DPR that about 11.0 million tonnes of cargo can be transported per year which can go up to 23.0 million tonnes in next 15 years or so.

6) 106 Newly Declared National Waterways

For newly declared national waterways, IWAI is carrying out feasibility studies /DPR preparation through a number of consultants.

1.2 Project Background of the Present Study

IWAI, Ministry of Shipping, 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 study in two stages comprising feasibility study followed by preparation of DPR and recommending thereafter the possibility of composite and integrated development of proposed waterways to achieve navigation and to develop water transport facilities across India.

106 more waterways across the country have been declared as new national waterways through a bill passed in the Parliament in March 2016 with contention that the measure is aimed at providing a cheaper mode of transport and reducing traffic burden on the roads. These 106 new national waterways will be in addition to the five existing national waterways. The proposed legislation is aimed at integrated development of inland waterways throughout the country since the water transport is "lagging behind" road and rail sectors. Promotion of waterways is a priority as it is a cheaper mode of transportation, being economical compared to roads and railways, and at the same time it is environment friendly too.

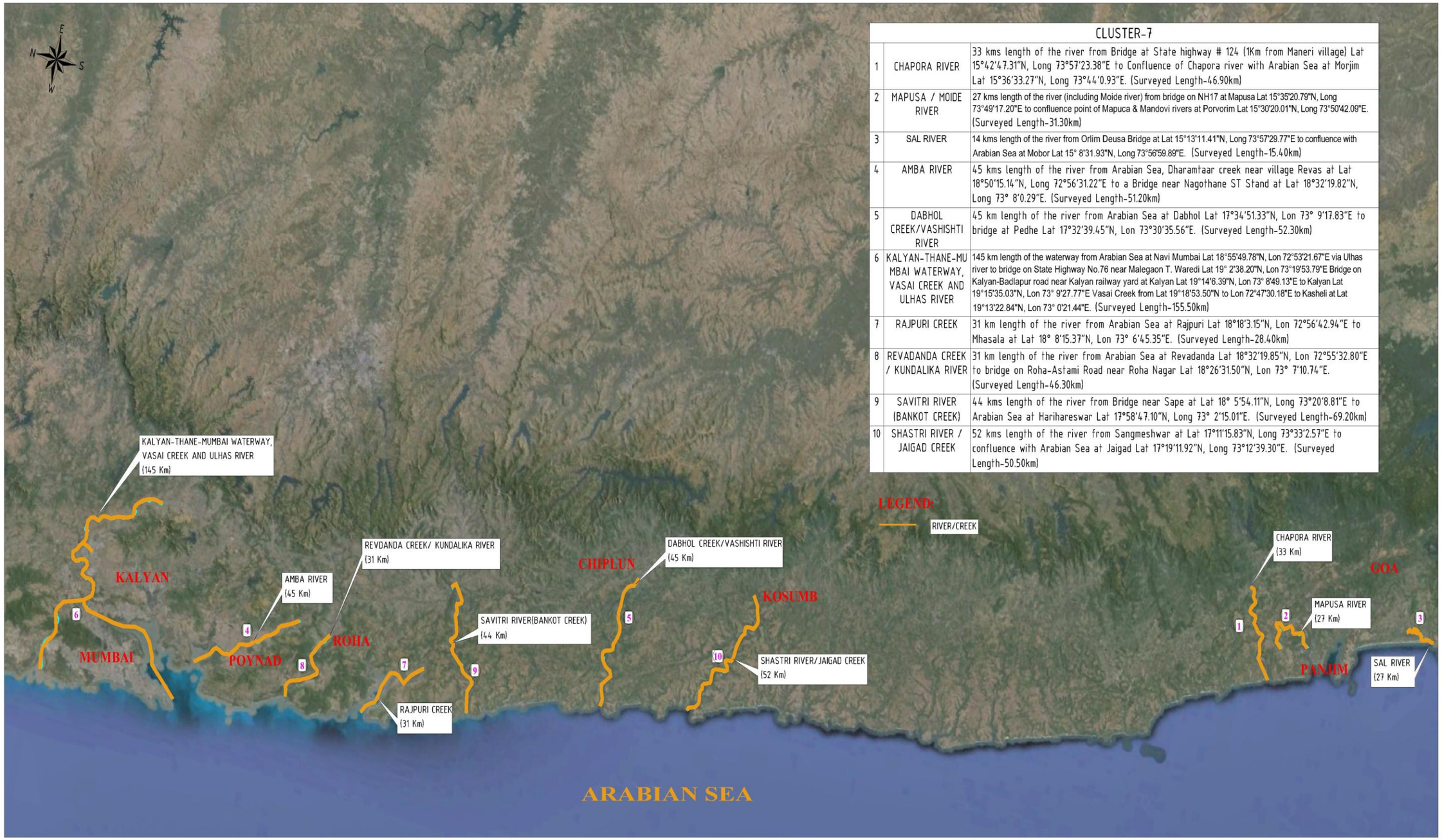
Feasibility study shall examine the viability of navigational routes and therefore potential to develop waterway transport facility is to be established. This shall be followed by preparation of Detailed Project Report (DPR) for those feasible waterways, which would include detailed hydrographic surveys and investigation, traffic survey, proposed location for terminals and cost assessment etc. Tractebel Engineering had been awarded two of the clusters i.e. Cluster-VI & Cluster-VII consisting of the rivers/canals/creeks for two stage studies, screen the rivers with respect to navigational feasibility and subsequently prepare a Detailed Project Report for the development of Inland Waterways. This report deals with the study of Sal River which is one of the waterways of Cluster-VII which consists of rivers/creeks of Maharashtra and Goa (length-467km) and described in **Table 1.1** as shown below:-

Table 1.1: List of Rivers/Creeks of Maharashtra and Goa under Cluster-VII (length-467.0 km)

Sl No.	Name of Rivers/ Creeks	National Water Way (NW)	Length (km)	State
1.	Chapora River	NW-25	33	Goa
2.	Mapusa / Moide River	NW-71	27	Goa
3.	**Sal River**	**NW-88**	**14**	**Goa**
4.	Amba River	NW-10	45	Maharashtra
5.	Dabhol Creek/ Vashishti River	NW-28	45	Maharashtra

Sl No.	Name of Rivers/ Creeks	National Water Way (NW)	Length (km)	State
6.	Kalyan-Thane-Mumbai Waterway, Vasai Creek and Ulhas River	NW-53	145	Maharashtra
7.	Rajpuri Creek	NW-83	31	Maharashtra
8.	Revadanda Creek / Kundalika River	NW-85	31	Maharashtra
9.	Savitri River (Bankot Creek)	NW-89	44	Maharashtra
10.	Shastri River/ Jaigad creek	NW-91	52	Maharashtra
	Total		**467**	

The layout plan of all the ten rivers/creeks covered in Cluster-VII, showing the location and Index Map of Sal River are shown in **Figure 1.1** and **Figure 1.2** respectively.



CLUSTER-7		
1	CHAPORA RIVER	33 kms length of the river from Bridge at State highway # 124 (1Km from Maneri village) Lat 15°42'47.31"N, Long 73°57'23.38"E to Confluence of Chapora river with Arabian Sea at Morjim Lat 15°36'33.27"N, Long 73°44'0.93"E. (Surveyed Length-46.90km)
2	MAPUSA / MOIDE RIVER	27 kms length of the river (including Moide river) from bridge on NH17 at Mapusa Lat 15°35'20.79"N, Long 73°49'17.20"E to confluence point of Mapuca & Mandovi rivers at Porvorim Lat 15°30'20.01"N, Long 73°50'42.09"E. (Surveyed Length-31.30km)
3	SAL RIVER	14 kms length of the river from Orlim Deusa Bridge at Lat 15°13'11.41"N, Long 73°57'29.77"E to confluence with Arabian Sea at Mobor Lat 15° 8'31.93"N, Long 73°56'59.89"E. (Surveyed Length-15.40km)
4	AMBA RIVER	45 kms length of the river from Arabian Sea, Dharamtaar creek near village Revas at Lat 18°50'15.14"N, Long 72°56'31.22"E to a Bridge near Nagothane ST Stand at Lat 18°32'19.82"N, Long 73° 8'0.29"E. (Surveyed Length-51.20km)
5	DABHOL CREEK/VASHISHTI RIVER	45 km length of the river from Arabian Sea at Dabhol Lat 17°34'51.33"N, Lon 73° 9'17.83"E to bridge at Pedhe Lat 17°32'39.45"N, Lon 73°30'35.56"E. (Surveyed Length-52.30km)
6	KALYAN-THANE-MUMBAI WATERWAY, VASAI CREEK AND ULHAS RIVER	145 km length of the waterway from Arabian Sea at Navi Mumbai Lat 18°55'49.78"N, Lon 72°53'21.67"E via Ulhas river to bridge on State Highway No.76 near Malegaon T. Waredi Lat 19° 2'38.20"N, Lon 73°19'53.79"E Bridge on Kalyan-Badlapur road near Kalyan railway yard at Kalyan Lat 19°14'6.39"N, Lon 73° 8'49.13"E to Kalyan Lat 19°15'35.03"N, Lon 73° 9'27.77"E Vasai Creek from Lat 19°18'53.50"N to Lon 72°47'30.18"E to Kasheli at Lat 19°13'22.84"N, Lon 73° 0'21.44"E. (Surveyed Length-155.50km)
7	RAJPURI CREEK	31 km length of the river from Arabian Sea at Rajpuri Lat 18°18'3.15"N, Lon 72°56'42.94"E to Mhasala at Lat 18° 8'15.37"N, Lon 73° 6'45.35"E. (Surveyed Length-28.40km)
8	REVADANDA CREEK / KUNDALIKA RIVER	31 km length of the river from Arabian Sea at Revadanda Lat 18°32'19.85"N, Lon 72°55'32.80"E to bridge on Roha-Astami Road near Roha Nagar Lat 18°26'31.50"N, Lon 73° 7'10.74"E. (Surveyed Length-46.30km)
9	SAVITRI RIVER (BANKOT CREEK)	44 kms length of the river from Bridge near Sape at Lat 18° 5'54.11"N, Long 73°20'8.81"E to Arabian Sea at Harihareswar Lat 17°58'47.10"N, Long 73° 2'15.01"E. (Surveyed Length-69.20km)
10	SHASTRI RIVER / JAIGAD CREEK	52 kms length of the river from Sangmeshwar at Lat 17°11'15.83"N, Long 73°33'2.57"E to confluence with Arabian Sea at Jaigad Lat 17°19'11.92"N, Long 73°12'39.30"E. (Surveyed Length-50.50km)

Figure 1.1: Location Map of the Proposed Waterway of Cluster-VII in Goa and Maharashtra

Figure 1.2: Index Map of Sal River

1.3 Objectives of the Study

IWAI, Ministry of Shipping, Government of India intends to explore the potential of additional waterways across the country for commercial navigation.

The objectives of the study shall necessarily include:

1. To Explore the Potential of Year Round Commercial Navigation on the Proposed National Waterways by conducting Feasibility Studies.
2. Recommending thereafter the possibility of Composite and Integrated development of proposed waterways under cluster – VII consisting of Creeks/ Rivers to achieve navigation and to develop water transport facilities on these waterways.

After carrying out the feasibility study, if there is scope for navigation and potential to develop waterway transport facility, a Detailed Project Report needs to be prepared for those waterways which would include detailed hydrographic surveys and investigation, traffic survey, proposed location for terminals and cost assessment, viability etc.

1.4 Scope of the Assignment

The complete scope of the assignment shall include the study in 2 stages:

1. **Stage-I** is only for feasibility of the waterway for navigation, which may have the potential for year round navigation or at least for a few months in a year.
2. **Stage-II** would consist of the detailed hydrographic survey, topographic survey, detailed traffic survey including the divertible traffic, selection of terminal locations and preparation of detailed project report including the returns /viability analysis for implementation as a project.

This report covers the activities of Stage-I only for feasibility of the **Sal River** for navigation, which may have the potential for year round navigation or at least for a few months in a year.

Stage-I consists of the following activities:

A. Reconnaissance Survey

B. Collection and review of available data

C. Feasibility Report

1.5 Methodology Adopted

The Stage I Feasibility Study of the Inland Waterway stretches is based on three approaches:

1. The Physical System
2. The Current Functions and
3. The Market Potential

1.5.1 Physical System

The potential for inland navigation strongly depends on the physical environment. Success of navigation will depend on:

- The stability of the channel: frequent variations of channel positions requires river conservancy measures;
- The regime: in most cases good navigation conditions are required most of the time for fluvial navigation to develop as a competitive transport mode, if such conditions are not met, other - more reliable - modes of transportation will be used, making it difficult to get a return on the investments required for navigation (ships, maintenance, port infrastructure):
    - The regime which defines the variability of water depth, draught and water level (position of port infrastructure, vertical clearance at bridges).
    - Sediment supply: certain stretches are characterized by high sediment supply; developing such sections would require high maintenance efforts to keep the channels at depth; it must be economically and technically feasible to maintain a balance between dredging and sediment supply; therefore, the decision to construct barrages to increase the water depth, must be taken with care, as these may act as sediment traps.
- Hydrographic characteristics of the channel: depth and width of the channel. The fairway design shall conform to channel geometry. The discharge should guarantee sufficient water depth alternatively, weirs, canals could be constructed to allow required water depth for safe navigation.

From a quick scan of satellite images it becomes clear that the morphological and hydrological conditions of the different rivers vary strongly, even within the same river. Satellite images provide a complete, accessible and qualitative data source for a first appraisal of potential.

Morphological features can be easily derived from satellite images. The morphological analysis of satellite images, therefore, has been used as a basis for a first, but reliable appraisal of the physical potential of the river (for navigation). Such analysis is, therefore, proposed as one of the methods in stage I.

It should be pointed out, however, that the period in which the satellite images have been taken may strongly affect the appearance: otherwise dry sections may well be flooded in monsoon season. A careful evaluation shall be contemplated. Also, information obtained from water managers such as CWC, and local authorities will be useful complement to evaluate navigability.

1.5.2 Current Functions

Current functions of the river have also been taken into consideration:

- Navigation, present in certain areas – it's relevant to know why, how it's organized:
    - Transportation of people (including the tourism potential) and goods
- Structures aligned to rivers

- Crossing infrastructure
  - Bridges: vertical clearance, may even be absent for navigation.
  - Weirs, barrages: water supply, regulation, hydropower.
  - Ferry terminals: variations in water levels and terminal infrastructure.
- Fishery
- Mining, occurring along certain rivers, and depending on (the often) shallow channels for processing
- Irrigation/ water supply, the available water may be shared between different functions, barrages exist to tap water for supply – as Indian agriculture is important for the GDP and the employment of most of the population, an equilibrium must be found between available water resources and additional uses such as use for navigation.

1.5.3 Market Potential

Historically, economic demand is a driving force behind waterway development. In several cases waterways were constructed and developed for specific industries. Also navigation was developed using existing irrigation or water supply canals. Further, the accessibility also was another driving force, when alternative mode development was difficult/ uneconomical.

In an emerging economy, such as India, the presence of waterways probably will also stimulate further economic development. While rail and road networks connect cities and industrial areas independently of the hydrographic network, now it must be analyzed where the hydrographic network can establish alternative and new links between cities. In navigable portions such links would be logical.

Environmental concerns viz. the emissions, consequences on air pollution and climate change, and social and economic pressure of congestion, led to a boost of inland navigation projects in all around the world. Such development can also be expected in India, as the development of waterways may be economically and socially more beneficial than the construction of the road and rail networks, not necessarily as a substitute, but to be developed in parallel, in a multi-modal transportation system.

The current scope for Stage I is executed as per following framework shown in **Figure 1.4**.

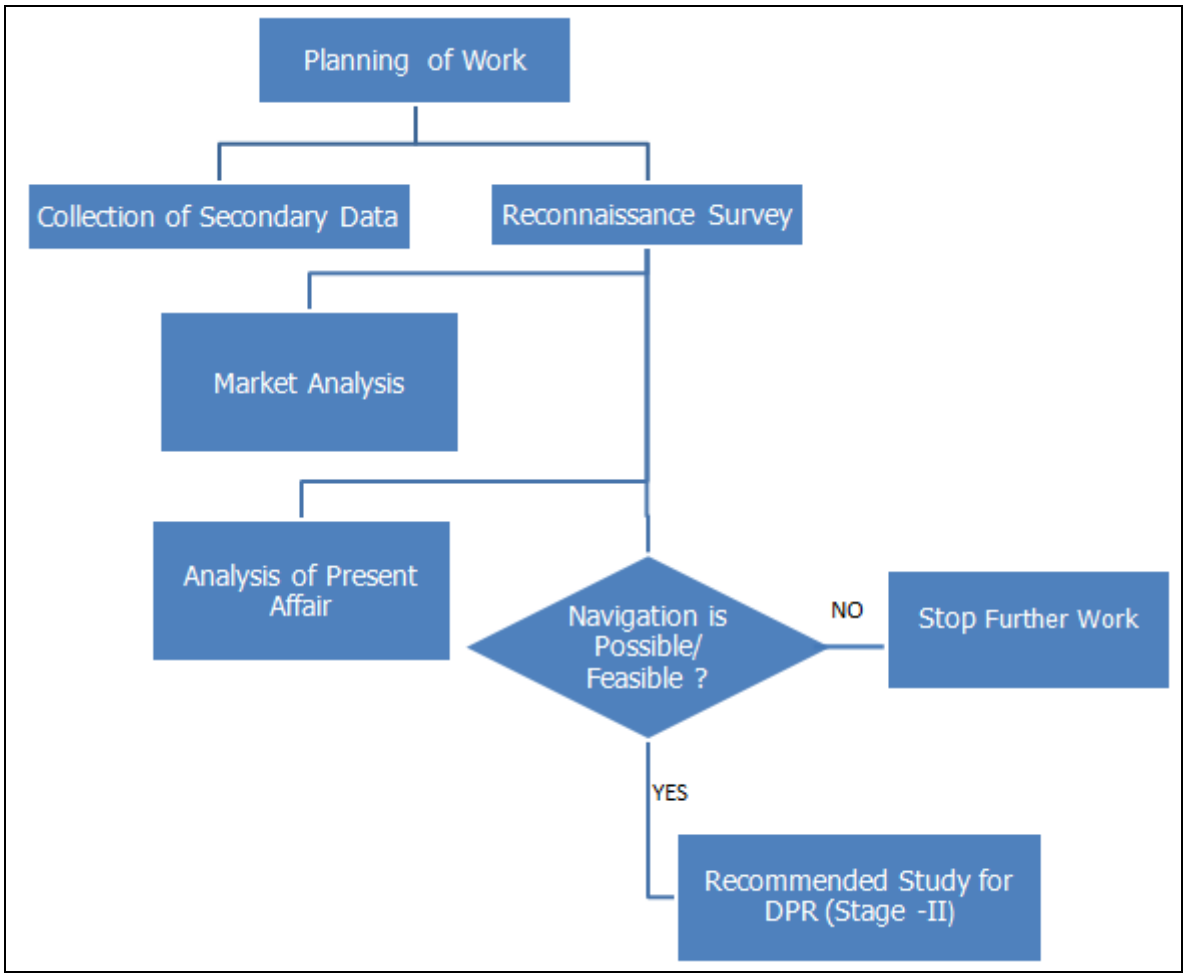


Figure 1.4: Execution Framework for Stage I

1.6 Collection of Data

For evaluating the feasibility of the waterway in Sal River for year round navigation, the reconnaissance survey for collecting the Primary data has been taken up. Secondary data have also been collected from various sources. IWAI issued a letter in the name of M/s Tractebel, to all the concerned stakeholders for data collection from State/ Central Government.

(A) **Primary Data:** M/s Tractebel Engineering Pvt. Ltd. has appointed a separate survey agency M/s Fugro Survey (India) Pvt. Ltd. (FSINPVT) for carrying out the reconnaissance survey for collection of following primary data:

(i) Single line longitudinal survey (Bathymetric survey or Topographic survey);

(ii) Details (horizontal and vertical clearances above High Flood Level of bridges, aqueducts, electric lines, telephone lines, pipe lines, cables en-route etc;)

(iii) Details of locations of permanent structures viz. Bridges, Barrages, Dams, Locks, Jetties, Ports etc;

(iv) Photographs of important structures along the route;

(v) Topographical features of the proposed Inland Waterways;

(vi) Typical physical features along the alignment i.e. land use pattern;

(vii) Preliminary identification of stretches having year round flow;

(viii) Critical depth for navigational purpose;

(ix) Preliminary traffic identification on the proposed Inland Waterways;

(x) Inland Waterway width, Terrain, Bridges and structures across the proposed Inland Waterways;

(xi) Urban areas (location & extent);

(xii) Geologically sensitive areas and environmental features;

(xiii) Critical areas requiring detailed investigations;

(xiv) Soil (textural classifications) (only visual inspection at every 10km);

(xv) Drainage conditions;

(xvi) Existing utility services along the alignment;

(xvii) Present Status of navigation on different sub stretches of the waterway;

All the data derived from the above reconnaissance surveys shall be utilized for planning and programming the detailed surveys and investigations. All reconnaissance field studies including the traffic surveys have been taken up and the classification of proposed waterway has been carried out as per IWAI guidelines on this matter. The list of data collected and sources of data are being enclosed as **Annexure 1.1**.

(B) **Secondary Data:** The following secondary data has been collected from the concerned authorities as well as from sources available in public domain.

(i) Benchmark Data from IWAI, Noida;

(ii) Chart Datum data and other related data from Captain of Ports, Goa;

(iii) Mormugao Port Trust, Goa;

(iv) District Industries Authorities, Goa;

(v) Fisheries Department, Government of Goa, Goa;

(vi) Goa Tourism, Goa;

(vii) Directorate of Mines & Geology, Government of Goa, Goa;

(viii) WRD, Govt. of Goa

All the data derived from the above reconnaissance surveys details shall be utilized for determining the navigability of the proposed national waterway. A review of the existing data available with the State Agencies and Central Water Commission for the proposed Inland Waterways has been done for determining the nature, extent, adequacy, validity of the available data and identifying the data gaps. Feasibility Report is to be prepared for the proposed national waterway based on the available data, reconnaissance survey and the market analysis. The structure of the report has been elaborated in succeeding section 1.9 of this chapter.

1.7 Expected Outcome of the Assignment

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 with regard to physical constraints may have cost implications for making the river stretch navigable. The potential of possible navigation in the stretches of proposed inland waterways has been determined using raw water depths reduced to the chart datum in the area of tide affected rivers. To define the navigability of river/creeks, several gradations can be distinguished:

- No or limited effort: navigable (for a specific draught) without measures;
- Limited to moderate effort: e.g. occasional dredging works at a limited number of location;
- Moderate to high: frequent dredging over a considerable length or large number of locations;
- High to very high: the construction of one or more weirs and or locks, or the construction of a canal;

In accordance with the above criteria, the stretch of the proposed waterway of Sal River under Cluster VII has been defined in the context of availability of navigable depth (more than 2m). Taking into account for further development in the stretches of less than 2m depth, the solutions for the navigation have been proposed.

Combining economic potential and physical characteristics allows categorizing the river or specific stretches for navigation potential on the basis of following criteria:

(i) Water Availability
(ii) Flow Depth
(iii) Vertical & Horizontal Clearance
(iv) Nautical Continuity
(v) Cargo Availability
(vi) Economic & Social Parameters

The analyses of physical and economic parameters have been the basis of a suggestion for classification of Inland Waterways for further study. The waterways shall be classified into categories of Class-I to Class VII as per description derived from the compilation of Inland Waterways Authority of India (Classification of Inland Waterways in India) Regulations, 2006. Referring the data derived from the reconnaissance single beam bathymetry survey, cargo traffic details, market potential, vertical and horizontal clearances with respect to existing cross over structures, the proposed waterway has been classified in to seven categories on the basis of IWAI guidelines for safe plying of self-propelled vessels up to 2000 Dead Weight Tonnage (DWT) and tug-barge formation in push-tow units of carrying capacity up to 8000 DWT. A recommendation of a selection of proposed inland waterway stretch has been done (based on IWAI classification) for further analysis and preparation of DPR in Stage II.

1.8 Description of Sal River (NW-88)

The Sal River originates from Verna hills near Mahalsa temple and flows parallel to the west coast in South Goa district of Goa State. It is one of the nine main rivers of Goa and add to the economy of Goa due to their impact on fishing and trade. The detailed description of the river has been compiled in **Table 1.2**.

Table 1.2: Description of Sal River (NW-88)

Sl. No.	Introductory Consideration	Description of the River
1	Name of the river / canal	Sal River (NW-88)
2	State/ District through which river passes	The Sal River passes through the South Goa district of Goa State.
3	Length of the river / canal	Out of the total 35km length, 14km length of the Sal River starts from Arabian Sea at Mobor Lat 15° 8'31.93"N, Long 73°56'59.89"E to Orlim Deusa Bridge at Lat 15°13'11.41"N, Long 73°57'29.77"E has been declared as new national waterway.
4	Map	The index map of Sal River showing proposed waterway stretch, topographic features and road networks is shown in **Figure 1.2**. The section of the Sal River under feasibility study for inland waterway showing reconnaissance survey routes is presented in **Drawing No. P. 009051-W-20201-A03.**
Characteristic of River		
5	River Course	The Sal River originates from Verna hills near Mahalsa temple and flows parallel to the west coast in South Goa district of Goa State. It is the only river in Goa which flows in north-south direction. The River passes through Margao, Dramapur, Chinchinim, Navelim and Assolna and eventually meets Arabian Sea at Betul in Southern Goa. The Sal River flows on a flat plain and its morphology makes the river basin extremely vulnerable to the impact of rising sea levels. Sal River opens in Cavelossim, which is a town in Southern Goa and is home to one of the best known beaches in Goa.
6	Tributaries / Network of Rivers / Basin	The tributaries of Sal River are small feeder streams and canals which join into the River at various locations.
7	Catchment Area	The total catchment area of Sal River is 301 sq. km.

1.9 Structure of the Feasibility Study Report (FSR)

The Feasibility Study Report for proposed Inland Waterways of **Sal River** has been prepared and emphasized with stretches of proposed inland waterways having the potential for navigation. Stage-II study for preparation of DPR shall be carried out only for those stretches of proposed inland waterways, which have the potential for navigation.

The Feasibility Study Report starts with a comprehensive report in the form of executive summary giving description of the methods used for the data collection, overview of the collected data followed by a description of the Present State of Affairs, Reconnaissance Survey, findings of Market Potential and observations & inferences thereof.

The executive summary concludes with Waterway Navigation Potential of the proposed waterway on **Sal River** followed with recommendations for going ahead with classification of river. The structure of FSR is as below;

I. **Executive Summary:** Executive summary describes the suitability of the proposed waterway in terms of its navigability and market potential. It contains a brief statement of the characteristics of the river, present use of the river, data captured in the reconnaissance survey, hindrances, acceptability of the waterway, enhanced connectivity to the region, capability to decongest the existing mode of transport, important aspects for techno commercial viability etc. The background information, concise analysis and main conclusions form part of the document. It helps to understand the overall scenario and decide the suitability of development of a specific waterway.

II. **Introduction:** This chapter describes the Project background of the present study, objective of the assignment, scope of the assignment, methodology adopted, outcome of the assignment, river characteristics including the structure of the feasibility study report.

III. **Analysis of Present State of Affairs**: It provides the details about the existing town/ city/ taluka/ historical & tourist places, current utilization of proposed waterway, status of goods transport, road and rail transport as well as existing river facilities. The quantitative and qualitative description of the current utilization of proposed inland waterways are provided in the report. In addition, the descriptions about the status of goods transport, including utilization of road and transport services as well as river facilities have been covered.

IV. **Reconnaissance Survey:** The analysis of the data collected in the reconnaissance survey has been carried out to reflect the possibility of year round flow in the proposed Inland Waterways to achieve the commercial navigation. Bathymetry survey details, observed bed profiles and soil texture classification @ 10 km are compiled in this section. Observed waterway bed profile has been plotted with respect to existing Chart Datum in case of tidal affected rivers else the bed profile relates to CWC/ Irrigation water level data or FSL in case of canal. Maps of proposed Inland Waterways have been generated and referred with at the relevant locations indicating existing cross structures viz. bridges, jetties, established chart datum locations, dams, barrages, HT line, LT line, water pipe line, cables etc.

V. **Market Analysis:** The analysis of the market and potential usage of proposed Inland Waterways have been carried out. In the analysis, both the existing market and the potential future market have been examined. The details of available existing industries along the waterway, type of production in

these industries, ferry services, cargo movement, type of crop along the waterway, previous history of movement of cargo in the waterway etc. have been collected and included in the report. All the data have been collected after discussion with local people while conducting reconnaissance survey etc. and also after interaction with State Govt. Officials, Irrigation / Water Resources Departments and other stakeholders. The possible divertible cargo to IWT has been assessed.

VI. **Observations and Inferences**: The observations and Inferences of the feasibility study are presented in context of stretches of proposed inland waterways, which have potential for navigation and for which Stage-II studies may be conducted. Technical Feasibility has been discussed which shall establish the navigability and potential usage of proposed Inland Waterway. The stretches of proposed inland waterways which have potential for navigation have been categorized into Class-I to Class VII as per description derived from classification of rivers/canals by Inland Waterways Authority of India Regulations, 2006. SWOT Analysis of Proposed Waterway has also been described covering the overall aspect of the proposed waterway in terms of its Strength, Weakness, Opportunity and Threat to decide the suitability and the ranking of the waterway.

CHAPTER 2 ANALYSIS OF PRESENT STATE OF AFFAIRS

In order to establish the feasibility of waterways the present state of affairs as existing today along proposed inland waterway on Sal River (NW-88) is studied. Out of total 35 km length of the river, 14 km has been proposed by IWAI for feasibility study. This chapter provides details about the current affairs, status of goods transport including utilization of road and rail transport along or near by the waterway.

2.1 Current Utilization

The River Sal originates from Verna hills near Mahalsa temple and flows parallel to the west coast. It is third largest river in the state of Goa, India. It passes through Margao, Dramapur, Chinchinim, Navelim, Assolna, before leading into the Arabian Sea at Betul in Goa. The total length of the river is about 35 km before joining the sea. The river is under tidal effect of the Arabian Sea (backwater effect) upto Deusua about 14 km from sea. Currently there is no cargo movement in the river; however a ferry service between Cavelossim & Asolna is functional across Sal.

2.2 Existing Waterway Structures

There are five jetties existing in this waterway. Table 2.1 below provides the details of existing facilities along Sal River waterway with current utilization status. Further two Fish Landing Jetties also are existing in the Sal River at Betul (Medium) and Verca (Minor).

Table 2.1: Existing Facilities on Sal River (NW 88)

Sl. No.	Existing Facility	Coordinates DD MM SS	Chainage	Current Utilization
1.	Cutbona Fishing Jetty	15 09 06.9 N 73 57 07.9 E	1.22 km	Fishing jetty
2.	Boat Repairing Jetty	15 10 07.8 N 73 56 42.8 E	3.41 km	Local boat repairing jetty
3.	Ferry Jetty	15 10 48.21 N 73 57 40.73 E	6.28 km	Ferry Jetty connecting Cavelossim & Asolna is functional across Sal.
4.	Asolna Ferry Jetty	15 10 47.05 N 73 57 46.05 E	6.28 km	
5.	Ferry Jetty	15 12 07.27 N 73 58 19.85 E	9.84 km	

Figures 2.1 to 2.5 show some of facilities along Sal River.

Figure 2.1: Cutbona Fishing jetty at Chainage 12.00 km (15˚09'06.9"N, 73˚57'07.9"E)

Figure 2.2: Hotel on the Sal River bank at Chainage 10.70 km (15˚10'19.0"N, 73˚56'46.1"E)

Figure 2.3: Boat Repairing Yard at Chainage 11.00 km (15˚10'07.8"N, 73˚56'42.8"E)

Figure 2.4: Asolna Ferry Jetty at Chainage 7.90 km (15˚10'47.0485"N, 73˚57'46.0493"E)

Figure 2.5: Ferry Jetty of Cavelossim village at Chainge 8.00 km (15˚10'48.2124"N, 73˚57'40.7286"E)

2.3 Crossing Over Sal River Water Way

Apart from existing waterway facilities on banks of the river as described in 2.1.1, one road bridge is existing in the study stretch of the river. **Table 2.2** shows the inventory of existing structure on Sal River waterway.

Table 2.2: Details of Rail and Road Bridges across Sal River

Sl. No.	Name of Structure	Chainage from confluence with sea (km)	Horizontal Clearance (m)	Vertical Clearance Above MHWS (m)	Position	
1.	Asolna Bridge	06	42	8.5	15°10'41.95"N	73°57'38.74"E
2.	Orlim Deusua Bridge	14	25	6.5	15°13'11.41"N	73°57'29.06"E

2.4 Connectivity of Waterway

Proposed stretch of Sal River waterway lies in the coastal area of Goa which is well connected with the tehsils and villages through road and rail. Figure 2.6 shows road and rail connectivity of the area adjacent of Sal River in the study stretch.

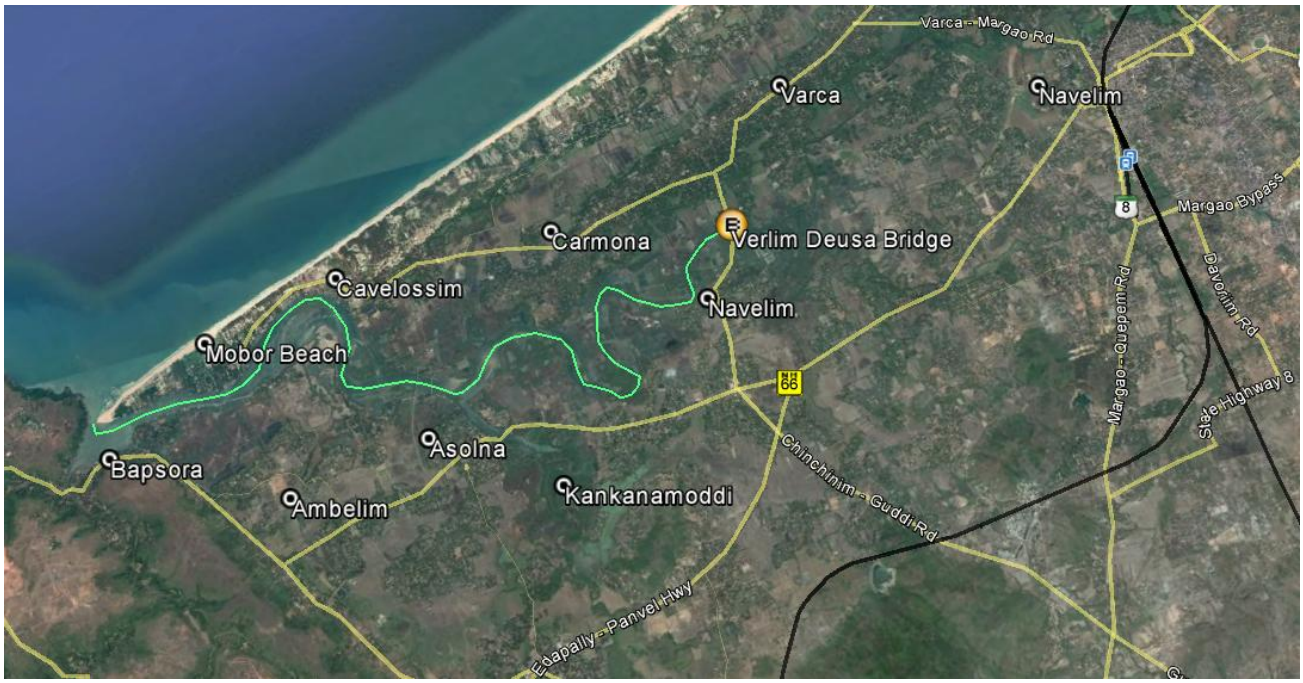


Figure 2.6: View of Rail and Road Network around Sal River

In **Figure 2.6**, Sal River is shown in green colour whereas yellow and black colors represent the road and rail network respectively around the Sal River.

2.5 Important Places

Sal River is in the vicinity of various important places of South Goa. **Table 2.3** shows the distance of Sal River from nearby important places.

Table 2.3: List of District/Town/Taluka in vicinity of Sal River Waterway

Sl No.	Important Places	Category	Distance from Creek/River (km)	Bank
1.	Salcette	Taluka	4.0	Right
2.	Quepem (Taluka)	Taluka , Town with Municipal Council	12.0	Right
3.	Sanguem (Taluka)	Taluka, Municipal Council	18.0	Right
4.	Margao	City	7.5	Right
5.	Dramapur	Village	4.0	Right
6.	Chinchinim	Village	1.5	Right
7.	Navelim	Village	0.2	Right
8.	Paroda	Village	7.0	Right
9.	Asolna	Village	0.8	Right
10.	Carmona	Village	1.4	Left
11.	Cavelossim	Village	0.2	Left
12.	Varca	Town	2.0	Left
13.	Fatrade	Village	2.3	Left
14.	Kankanamoddi	Village	1.9	Right
15.	Cuncolim	City and Municipal Council	2.5	Right
16.	Ambelim	Village	1.7	Right
17.	Fatorpa	Village	4.5	Right
18.	Quitol	Village	1.5	Right
19.	Morpirla	Village	6.0	Right

2.6 Road Connectivity

Sal River in the study stretch is well connected with Mumbai Goa National Highway and is surrounded by roads on left and right bank. The roads surrounding Sal River connects to Mumbai Goa National Highway at end of study stretch by Verlim Deusa Bridge.

2.7 Rail Connectivity

Railway transport in Sal River catchment is developed under the Konkan Railway Project. The main trunk route of the railway is aligned almost parallel to the coast line. The end point of study stretch of the river is at Dasgaon and nearest railway station is 9.5 km from end point i.e. at Madgaon.

Madgaon railway station is on the Konkan Railway and is the busiest railway station in the state of Goa and has direct rail connection with several major cities in India and is connected with Mumbai Goa National Highway 66.

2.8 Status of Goods Transport

Status of goods transport through River waterway is detailed in **Chapter 4 on Market Analysis of this report**.

2.9 Conclusion

a) The River Sal is third largest river in the state of Goa, India. The Sal River flows typically runs parallel to the west coast.

b) Total length of Sal River is 35 km before joining the sea. The river is under tidal influence of Arabian Sea (backwater effect) upto Deusua (about 14 km), thus total study stretch of National Waterway (NW-88) is under tidal effect

c) There are five (05) jetties in the study stretch of the river.

d) Sal River in the study stretch is well connected with Mumbai Goa National Highway and is surrounded by roads on both banks.

e) Railway transport in Sal river catchment is developed under the Konkan Railway Project. The end point of study stretch of the river is 9.5 km from Madgaon railway station. Railway station is connected to NH-66 (Mumbai – Goa).

f) Two road bridges exist in the study stretch of which one is at the end of the stretch.

CHAPTER 3 RECONNAISSANCE SURVEY

3.1 River Profile

The Sal River originated as a small stream from Verna hills near Mahalsa temple and flows parallel to the west coast. It is the only river which flows in north-south direction prior to its flowing into the Arabian Sea at Betul in Southern Goa. The total catchment area of Sal River basin is about 301 sqkm. The total length of the river from its origin to outfall in the Arabian Sea is about 35 km. The catchment receives an average annual rainfall of about 2800mm. A map showing Sal catchment basin is shown in **Figure 3.1**. Sal River has a relatively small catchment area and its tributaries are small feeder streams and canals. It passes through Margao, Dramapur, Chinchinim, Navelim and Assolna before draining into the Arabian Sea. The Sal River is the life line to the Salcete taluka. The Sal River flows on a flat plain and its morphology makes the river basin extremely vulnerable to the impact of rising sea levels.

Figure 3.1 indicates that most part of the river flows close to the coastal region; thus the lower stretch of river is expected to be tidal affected zone. Given the size of the river, lower reaches may have navigation potential. IWAI expects the lower 14.00km, shown in green colour in Figure 3.1, to have potential for navigation and thus, the subject of study under this assignment.

Figure 3.1: Catchment Area of Sal River

The stretch of the Sal River considered for assessment of navigation potential is defined as below:

14 km length of the river from Arabian Sea at Mobor to Orlim Deusa Bridge	From: 15°8'31.93" N, 73° 56'59.89" E	Up to: 15°13'11.41" N, 73°57'29.77" E	National Waterway: 88

3.2 Reconnaissance Survey

This section presents a stretch-wise description of Sal River. It also covers the Hydrological analysis of collected data viz maximum and minimum water depths. The route map of Sal River is shown in **Figure 3.2** below.

Figure 3.2: Route Map of Sal River

3.2.1 Methodology of Survey

Single beam bathymetry survey was carried out to determine river profile along its deepest route (single line survey) through the proposed waterway by deploying DGPS positioning system and single beam echo sounder. Wherever bathymetry survey was not feasible due to shallow water depths, survey was continued using topography survey method.

Along with the river bathymetry, other relevant data/information like horizontal and vertical clearances above high flood level of bridges, aqueducts, electric lines, telephone lines, pipe lines, cables en-route were collected along with their coordinates and locations. Soil samples were also collected along the survey area at about 10.0km interval. Texture of the collected soil samples was analyzed visually.

The survey was conducted in WGS84 datum; UTM Projection (Zone 43 N, CM 075° E). The geodetic parameters used during the survey are mentioned in **Table 3.1**:

Table 3.1: Geodetic Datum and Projection Parameters

Global Positioning System Geodetic Parameters	
Datum:	World Geodetic System 1984
Spheroid:	World Geodetic System 1984
Semi Major Axis:	a = 6 378 137.000m
Inverse Flattening:	1/f = 298.257 223 563
Map Projection:	Universal Transverse Mercator
Grid System:	UTM Zone 43 N;
Central Meridian:	075° 00′ 00″ East
Latitude of Origin:	0° 00′ 00″ North
False Easting:	500 000m
False Northing:	0m
Scale Factor on Central Meridian:	0.9996
Units:	Metre

The layout diagram of the equipment used for bathymetric survey has been shown in **Figure 3.3** below:

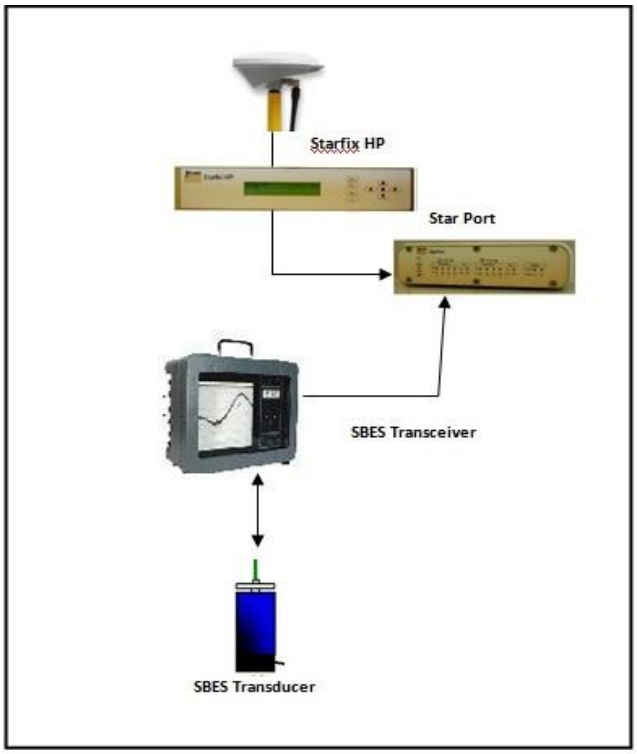


Figure 3.3: Equipment Diagram

Team surveying at site with equipment mounted on the boat is depicted in **Figure 3.4** as shown below:

Figure 3.4: Team Surveying at Site with Equipment Mounted on the Boat

An overview chart for Sal River bathymetry is enclosed as **Annexure 3.1.**

3.2.2 Chart Datum of the Proposed Waterway

The water depths have been determined as a result of all soundings reduced to Chart Datum (the lowest tide level observed for a considerable period at specific location) in the area. Tidal heights predicted using Mormugao Port data were used to reduce the raw water depths to Chart Datum. The locations with coordinates of Chart Datum obtained from Mormugao Port have been used to reduce the soundings along the surveyed stretch as compiled in **Table 3.2**. Also, daily data of heights of high and low waters at Marmagao for the year 2015, obtained from Captain of Ports Department, Panaji, Goa has been given in **Annexure 3.2**.

Table 3.2: Details of Chart Datum Used for Data Reduction

Sl. No.	Location	Latitude	Longitude	Z_0 *(m)
1	Mormugao	15° 25' 00"	73° 48' 00"	1.30

**- Below Mean Sea Level*

3.2.3 Bathymetry and Site Data Collected

A. Sal River (Ch 0.00km to Ch 3.00km)

Mobor beach is seen along the west bank of the river from Ch 0.10km onwards. A shallow patch is observed in between Ch 0.20km to Ch 0.60km. High Tension lines were observed crossing the river near the Ch 2.20km.

Cutbona Jetty may also be seen at Ch 2.20km. Along the East bank, numbers of wharves are present in the stretches. Again, shallow patch was seen at the centre of the river from Ch 2.20km to Ch 3.00km. Fishing stakes may be seen at Ch 2.20km. The minimum depth recorded in this section is 0.8m at Ch 2.69km and the maximum depth is 6.7m at Ch 0.00km as given below in **Table 3.3.** The stretch is shown in **Figure 3.5**.

Table 3.3: Maximum – Minimum Depth in Sal River from Ch 0.00km – Ch 3.00km

Maximum –Minimum Depth			
Chainage (km)		Reduced Water Depth (m) w. r. t. Chart Datum	
From	To	Max	Min
0.0	**3.0**	6.7	0.8

Figure 3.5: Route Chart of the Survey from Ch 0.00km to Ch 3.00km

B. Sal River (Ch 3.00km to Ch 7.00km)

A boat yard is seen at the west side of the river at Ch 3.59km. Cavelossim town is located along the West bank from Ch 3.60km to Ch 3.90km. An electric wire crosses the river at Ch 4.21km. An island has been observed in the river portion between Ch3.0km and Ch 4.0km. Also there is another island observed between Ch5.0km and 6.0km. These islands typically describe the river meandering phenomenon. Green pastures and vegetations have also been observed in these islands. A series of shallow patches along the East bank were recorded between Ch 5.30km to Ch 6.30km. Cavelossim on the West bank and Asolna on the East bank are

connected by Asolna Bridge at Ch 6.20km. Vegetations are observed along both the banks of the river. Ferry jetties are present at Ch 6.40km. A small tributary joins the Sal River near Ch 6.80km from the left (East). The minimum depth recorded in this section is 0.1m at Ch 6.76km and the maximum depth is 3.7m at Ch 4.99km as given below in **Table 3.4.** The stretch is shown in **Figure 3.6**.

Table 3.4: Maximum – Minimum Depth in Sal River from Ch 3.00km to Ch 7.00km

Maximum –Minimum Depth			
Chainage (km)		Reduced Water Depth (m) w. r. t. Chart Datum	
From	To	Max	Min
3.0	**7.0**	3.7	0.1

Figure 3.6: Route Chart of the Survey from Ch 3.00km to Ch 7.00km

C. Sal River (Ch 7.00km to Ch 10.00km)

A shallow patch with some vegetation is observed in between Ch 8.90km to Ch 9.30km. An electric line crosses the river at approx. Ch 9.55km. Vegetation and Agricultural Fields are observed along the Sal river along both the west and east banks. The minimum depth recorded in this section is 0.00m at Ch 9.01km and the maximum depth is 4.4m at Ch 9.80km as given below in **Table 3.5.** The stretch is shown in **Figure 3.7**

Table 3.5: Maximum – Minimum Depth in Sal River from Ch 7.00km to Ch 10.00km

Maximum –Minimum Depth			
Chainage (km)		Reduced Water Depth (m) w.r.t. Chart Datum	
From	To	Max	Min
7.0	10.0	4.4	0.00

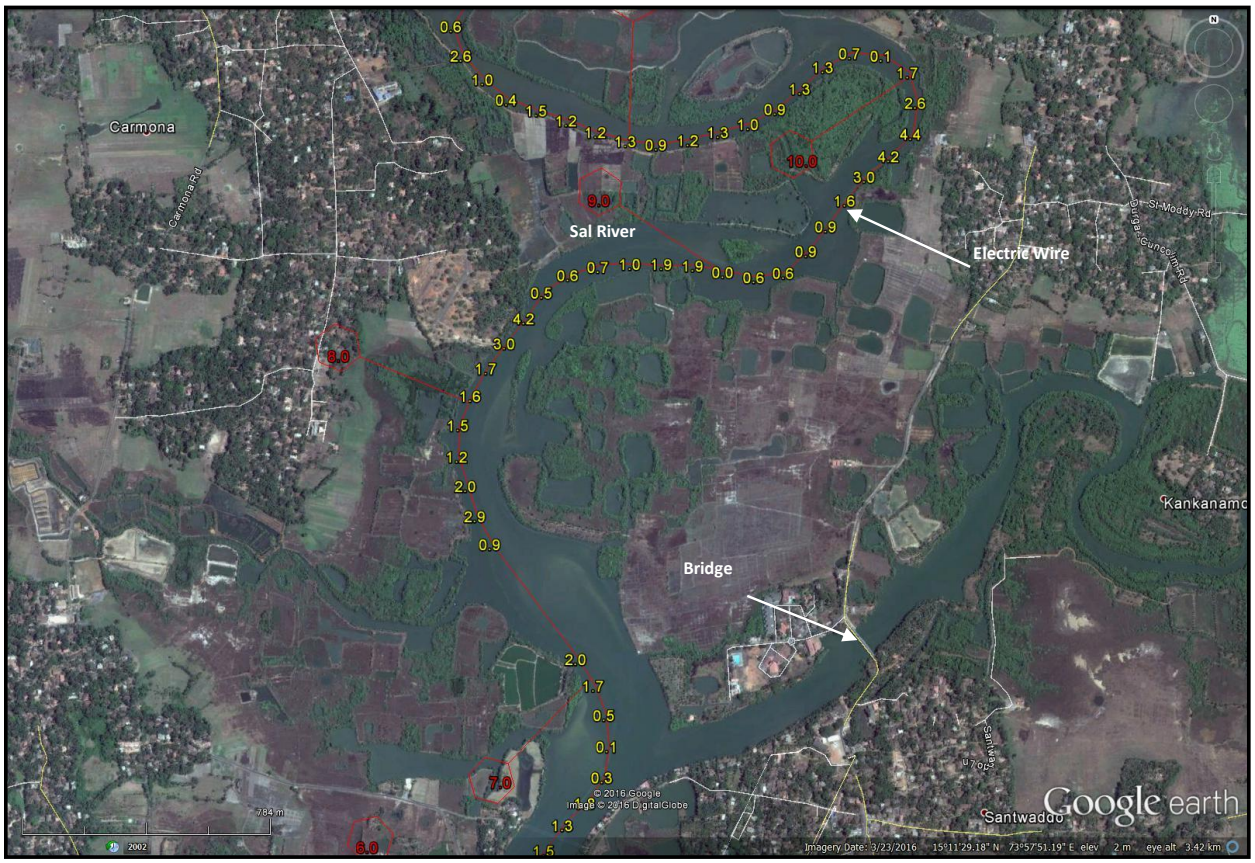


Figure 3.7: Route Chart of the Survey from Ch 7.00km to Ch 10.00km

D. Sal River (Ch 10.00km to Ch 14.26km)

The waterways stretch for the Sal River ends at the Orlim Deusa Bridge (Ch 14.26km, 15°13'11.41"N, 73°57'29.77"E) having vertical clearance of 4.5m and horizontal clearance of 25m. A jetty is located at Ch 10.20km on the left bank. Agricultural Fields and Vegetation are seen on either sides of the river. Shallow patch is observed in between Ch 12.20km to Ch 12.80km. Orlim village is located at the West bank at Ch 14.10km. Thereafter, no settlements were observed on the either sides of the river. The minimum depth recorded in this section is 0.10m at Ch 10.10km and the maximum depth is 2.6m at Ch 11.59km as given below in **Table 3.6.** The stretch is shown in **Figure 3.8**

Table 3.6: Maximum – Minimum Depth in Sal River from Ch 10.00km to Ch 14.26km

Maximum –Minimum Depth			
Chainage (km)		Reduced Water Depth (m) w. r. t. Chart Datum	
From	To	Max	Min
10.0	14.26	2.6	0.10

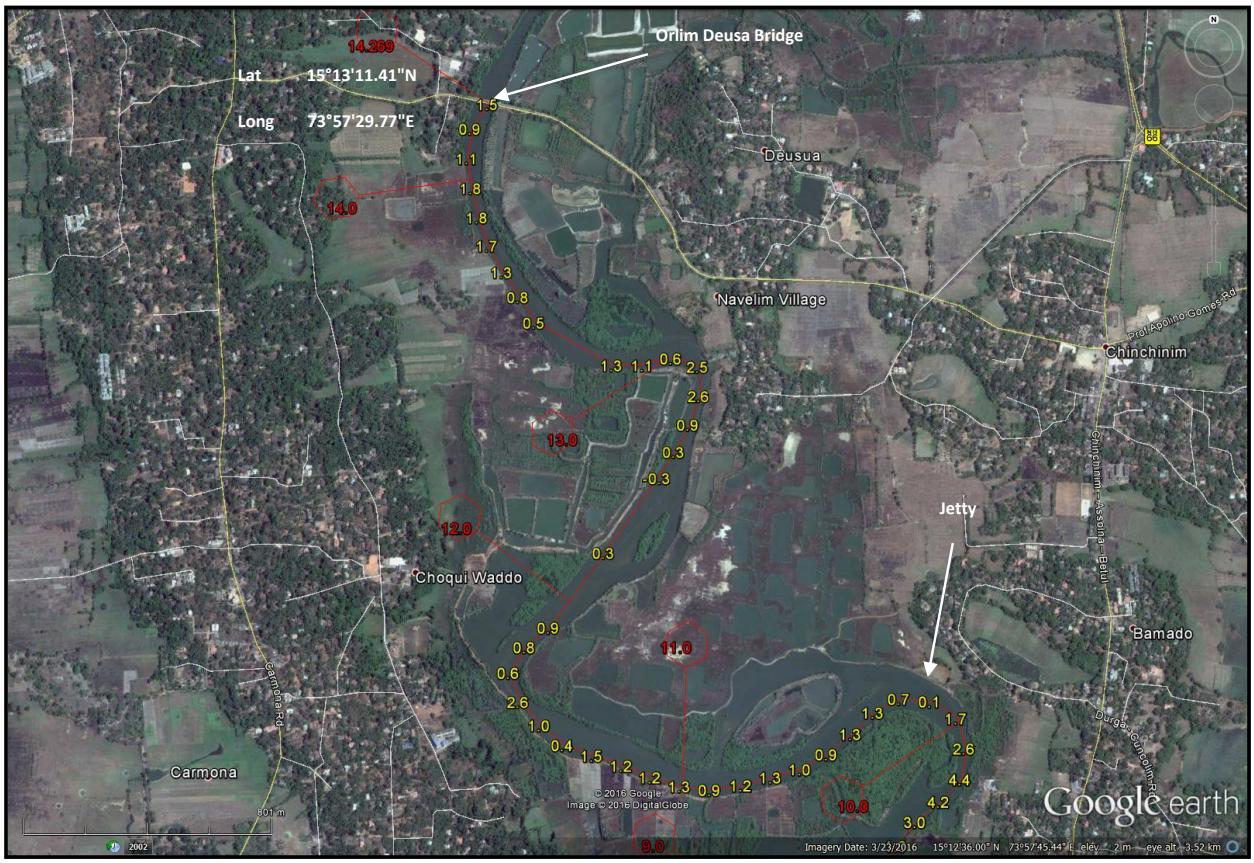


Figure 3.8: Route Chart of the Survey from Ch 10.00km to Ch 14.26km

The maximum and minimum depth with reference to the Chart Datum (CD) in the small intervals have been summarized in **Table 3.7,** which describes the length of stretch showing various ranges of water depth available.

Table 3.7: Maximum – Minimum Depth in Sal River from Ch 0.00km to Ch 14.26km

Chainage (Km)	Draft Available		Length of River (Km)			
	Max. (m)	Min. (m)	>2m	1.5-2.0m	1-1.5m	<1m
0-3	6.66	0.75	0.97	0.98	0.68	0.37
3-7	3.68	0.09	1.12	0.82	1.03	1.03
7-10	4.37	0.02	0.81	0.92	0.23	1.04
10-14.26	2.65	0.12	0.35	0.68	1.27	1.96
Total			**3.25**	**3.40**	**3.21**	**4.40**

The above data indicates that the availability of water depth of 2.0m and above is not found in continuous stretch. However, 23% of stretches have more than 2.0 water depth available. About 70% of the stretches

have water depth of 1.0m and above. It may be noted that the above depths have been reckoned with CD. Since the entire study stretch of Sal River is under tidal influence and hence the available effective depths would be more than 1.15m (average tide height) which will be advantageous for safe navigation. The detailed hydrographic survey information indicating location, observed water depth (at each point of data reading) has been given in **Annexure 3.3**.

3.2.4 Soil Texture Classification

The soil texture has been observed during the reconnaissance survey. The observed soil texture at 10km interval has been given in **Table 3.8**.

Table 3.8: Soil Texture in Sal River at 10.0km Interval

Chainage (Km)	Latitude	Longitude	Depth (m)	Soil Texture
0.01	15°08'31.126"	73°57'00.571"	6.7	Sand
10.00	15°12'06.147"	73°58'21.190"	1.7	Sand
14.26	15°13'11.316"	73°57'29.944"	1.5	Sand

From the above table, it is observed that Sandy soil is present in most part of the river under study stretch.

3.3 Classification of Waterways

The Ministry of Shipping, Road Transport and Highways (Inland Waterways Authority of India) has classified the Inland waterways into seven categories for rivers and canals for safe plying of self propelled vessels up to 2000 Dead Weight Tonnage (DWT) and tug-barge formation in push-two units of carrying capacity up to 8000 DWT (Ref: IWAI, Gazette Notification 2006). The classification criteria of waterways are mentioned in **Table 3.9** for Rivers and in **Table 3.10** for canals.

Table 3.9: Classification of Inland Waterways for Rivers

Class of Waterways	Rivers				
	Minimum Depth (m)	Bottom Width (m)	Bend Radius (m)	Vertical Clearance (m)	Horizontal Clearance (m)
I	1.2	30	300	4	30
II	1.4	40	500	5	40
III	1.7	50	700	7	50
IV	2.0	50	800	10	50
V	2.0	80	800	10	80
VI	2.75	80	900	10	80
VII	2.75	100	900	10	100

Table 3.10: Classification of Inland Waterways for Canals

Class of Waterways	Rivers				
	Minimum Depth (m)	Bottom Width (m)	Bend Radius (m)	Vertical Clearance (m)	Horizontal Clearance (m)
I	1.5	20	300	4	20
II	1.8	30	500	5	30
III	2.2	40	700	7	40

IV	2.5	50	800	10	50
V	-	-	-	-	-
VI	3.5	60	900	10	60
VII	-	-	-	-	-

The vessel sizes for self propelled or tug and barge combinations for different classes of waterways are described in **Table 3.11**.

Table 3.11: Classification of Vessel Size

Class of Waterways	Self Propelled Vessel Tonnage (Size, L x B x Draft in m)	Tug and Barges Combination Tonnage (Size, L x B x Draft in m)
I	100 (32 x 5 x 1)	200 (80 x 5 x 10)
II	300 (45 x 8 x 1.2)	600 (110 x 8 x 1.2)
III	500 (58 x 9 x 1.5)	1000 (141 x 9 x 1.5)
IV	1000 (70 x 12 x 1.8)	2000 (170 x 12 x 1.8)
V	1000 (70 x 12 x 1.8)	4000 (170 x 24 x 1.8)
VI	2000 (86 x 14 x 2.5)	4000 (210 x 14 x 2.5)
VII	2000 (86 x 14 x 2.5)	8000 (210 x 28 x 2.5)

Vertical Clearance for power cables or telephone lines or cables for any transmission purpose for all classes

- Low Voltage Transmission lines and Telephone line 16.5m
- High Voltage Transmission line not exceeding 110 kV 19.0m
- High Voltage Transmission line exceeding 110 kv 19.0m +1 cm per each additional kv

In case of underwater pipelines, power cables and other cables, norms are to be decided as per site condition and navigational requirement.

Reference level for vertical clearance for different types of channels

- For Rivers:- Over the Navigational High Flood Level (NHFL), which is the highest flood level at frequency of 5 % in any year over a period of last twenty years;
- For Tidal Canals:- Over the highest high water level;
- For Other Canal:- Over designed full supply level (FSL);

The above classification for rivers and channels shall be effective if:

- Minimum depth of channel is available for about 330 days in a year (about 90% days in a year)

- Vertical clearance at cross structure over the waterways is available at least in central 75% portion of each of the spans in the entire width of the waterways.

The data gathered through the reconnaissance study has been analyzed from the parameters mentioned hereinabove and conclusions have been made with regard to the class of navigation channel that the relevant stretch of Sal River falls into. Furthermore, it is to be determined whether the entire 14.0km stretch can be classified under one class of channel or there is a possibility and advantage of developing sub-reaches under different classes of navigation channel.

3.3.1 Cross Over Structures

The details of High Tension lines and Bridges crossing the Sal River are given below in **Table 3.12**, and **Table 3.13**.

Table 3.12: Details of High Tension and Electric Lines across Sal River

Sl. No.	Cross-Structure Name	Chainage (km)	Position (Above vessel track)		Vertical Clearance above MHWS (m)
			Latitude	Longitude	
1.	HT Line	2.20	15°09'33.31" N	73°57'12.13" E	10.00
2 .	Electric Line	4.21	15°10'14.26 N	73°56'56.79" E	8.50
3 .	Electric Line	9.55	15°11'53.95 N	73°58'15.20" E	6.50

Table 3.13: Details of Bridges across Sal River

Sl. No.	Name of Structure	Chainage (km)	Vertical Clearance above MHWS (m)	Horizontal Clearance (m)	Center Position	
					Latitude	Longitude
1.	Asolna Bridge	6.20	8.50	42.00	15°10'41.95"N	73°57'38.74"E
2.	Orlim Deusa Bridge	14.26	6.50	25.00	15°13'11.41"N	73°57'29.06"E

From the above information, it may be inferred that the support base of HT line and electric lines will have to be raised to about 9.0m to 10.0m to get the required clearance.

The horizontal and vertical clearances at Asolna Bridge at Ch 6.20km are sufficient for **Class III**. Orlim Deusa Bridge at Ch 14.26km is located at the upstream end of the proposed waterway and hence its vertical clearance as well as horizontal clearance has not been considered for analysis. Hence, the entire stretch is suitable for class II.

Photos of important structures such as port, bridges, jetties, transmission lines and plants as taken during site visit are shown in **Annexure 3.4**.

3.3.2 Dams, Barrages and Reservoirs

No dams, barrages or reservoirs exist there along the surveyed route.

3.3.3 Bends along the Route

On the proposed waterway route, there are many bends in Sal River, which are given below in **Table 3.14.**

Table 3.14: River Bend Radius in Sal River

Sl. No.	Chainage (Km)	Radius (m)
1	3.66	450
2	4.95	300
3	6.95	350
4	7.95	500
5	8.80	500
6	10.00	165
7	11.75	175
8	12.90	100

In the study stretch, based on the river radius criteria, it may be fit only for Class I Vessels up to Ch 10.0km. Keeping in view the maximum utility of this stretch for various activities including Fishing and Tourism, the study stretch of Sal river can be developed for **Class III**, however by smoothening the bends.

The pictorial detailed information showing the proposed waterway indicating various cross-structures (i.e. bridges, transmission lines etc.), major industrial locations and important places along the waterway have been shown in **Drawing No P009051-W-20201-A03**. Drawing also depicts various information such as Jetties, Rail and Road location along the waterway.

3.3.4 Gauge & Discharge data

In the Sal River catchment, no gauge and discharge site as established by Central Water Commission was observed. For the Stage II study, the gauge data will be analyzed if the same is available within a reasonable reach and if found relevant.

3.3.5 Bed Profile of Waterway

All soundings were reduced to Chart Datum in the area. Tidal heights are predicted using Marmagao data to reduce the raw water depths to Chart Datum. The observed bed profile of Sal River waterway is shown below in **Figure 3.9** and presented in **Annexure 3.5**.

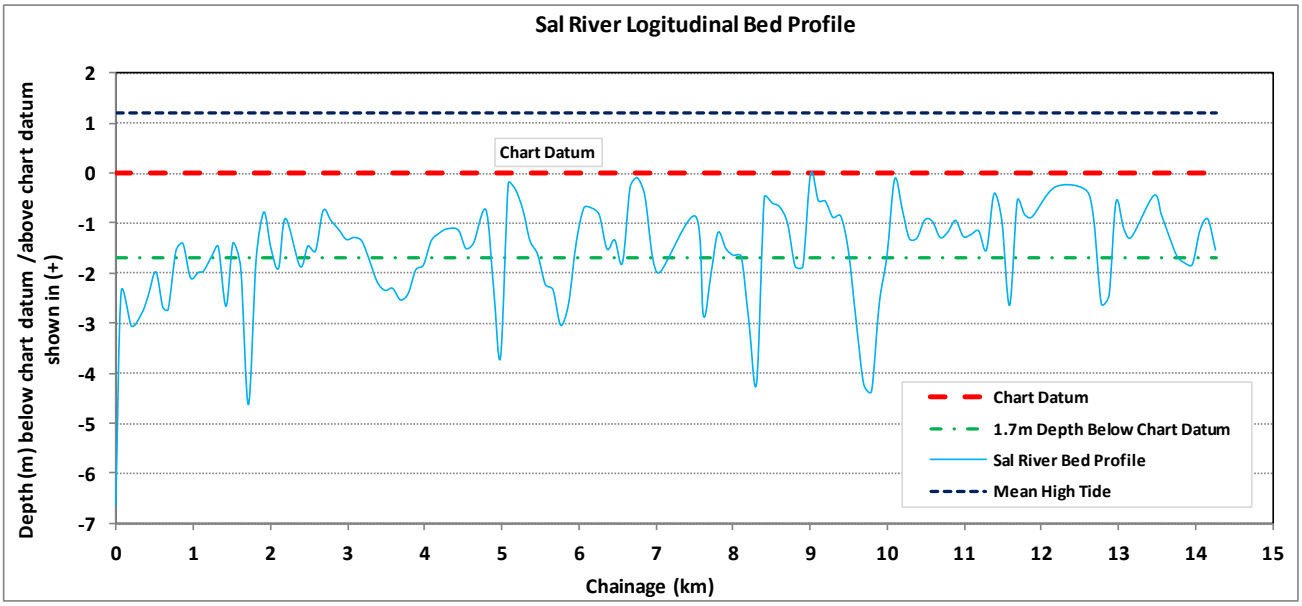


Figure 3.9: Longitudinal River Bed Depth Profile of Sal River from Ch 0.00km to Ch 14.26km

Figures 3.9 also shows the Chart Datum line, 1.7m below the Chart Datum line and mean tide variation 1.15m above Chart Datum. However, high tides in this region were observed in the range of about 0.00m to 2.30m (MHWS) *(Ref: Indian Tide Tables, 2016, Survey of India)*. The following key observations are made from Figure 3.9:

(i) The tidal effect of the Arabian Sea in the Sal River is affected up to the Khareband Bridge at about 22.0 km from the sea (*Ref: Information as gathered from the office of Captain of Ports Department, Goa*). The study stretch ends upto Orlim Deusa Bridge at about 14.0 km from the sea. It has been observed that the study stretch is under tidal affect. The tide in the region is Semi-Diurnal characteristics.

(ii) As observed from the site, the study stretch has the soil texture as sandy.

(iii) The initial half of the river stretch from the mouth is flatter which gradually becomes steeper having an overall average slope of 1 in 7000 in 14km of the river stretch under study.

(iv) An average 1.7m depth is available in the initial 4kms stretch of the waterway which suggests only minimum dredging requirement.

(v) With minimum to moderate dredging in the entire stretch, a minimum depth of 1.7m for **Class III** may be achieved.

3.4 Agencies to be approached for Clearances, if any

Based on reconnaissance survey, interaction with local people and consultation with government officials, the information regarding clearances and approvals required from the concerned authorities for operation of National Waterway NW-88 (Sal River) has been given in **Table 3.15**.

Table 3.15: List of Clearances and Approvals Required

Environment Clearance	Forest Clearance	Wildlife Clearance	Coastal Regulation Zone (CRZ) Clearance	Consent to Establish/ Operate	No Objection Certificate from Directorate of Fisheries	NOC from WRD/PWD/ Railways
√	To be ascertained at DPR Stage-II	To be ascertained at DPR Stage-II	√	√	√	√

3.4.1 Compilation of Data in Feasibility Format

The field information gathered through single line bathymetry survey, data collection from IWAI, data collection from various agencies, site visit and information derived from web has been compiled in the format as provided by IWAI for the Sal River. The consolidated data shall be useful in deriving basic information about each of the waterway in IWAI format as enclosed in **Annexure 3.6**.

3.5 Conclusion

Based on the survey observation, the classification of proposed waterways based on various criteria has been summarized in below **Table 3.16**.

Table 3.16: Classification of Proposed Waterway

Criteria	Classification																			
Length of waterway from start (km)	1	1	2	3	4	4	5	6	6	7	8	9	9	10	11	11	12	13	14	14
Chainage length in %	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Depth availble	C-III																			
Raod Bridge Vert. Clearance	C-III																			
Raod Bridge Hor. Clearance	C-III																			
HT Line Vert. Clearance	Needs Raising of HT Base																			
Bend Radius	C-III																			
Index	All Class		Class-V		Class-IV		Class-III		Class-II		Class-I									

Finally, with due consideration of all aspects, the classification of the proposed Sal Waterway in light of technical navigability may be adopted as shown in **Table 3.17** below:

Table 3.17: Final Conclusion for Possible Navigation

River Stretch	0.00km 14.26km
Classification	
	Class III
Horizontal clearance (m)	50
Vertical clearnce (m)	7
Minimum Depth(m)	1.7
Bottom Width (m)	50
Self Propelled Vessel	
Dead Weight Tonnage	500
Vessel size (m)	(58 x 9 x 1.5)
Tug + Barge	
Dead Weight Tonnage	1000
Vessel size (m)	(141 x 9 x 1.5)

The conclusion has been drawn keeping in view the present river condition and linking the same with various characteristics of classification viz., available draft; vertical clearance under Road Bridge/ HT Line and Bend Radius etc.

In order to consider the full stretch as **Class III**, smoothening of bends along with moderate dredging is essential.

CHAPTER 4 MARKET ANALYSIS

4.1 Introduction

Market analysis of Sal river catchment area comprises of existing waterway traffic (cargo and passenger traffic), its trends and feasibility of diversion from existing modes of transportation to waterways.

The methodology that has been adopted for examining the market potential is as shown in **Figure 4.1** below:

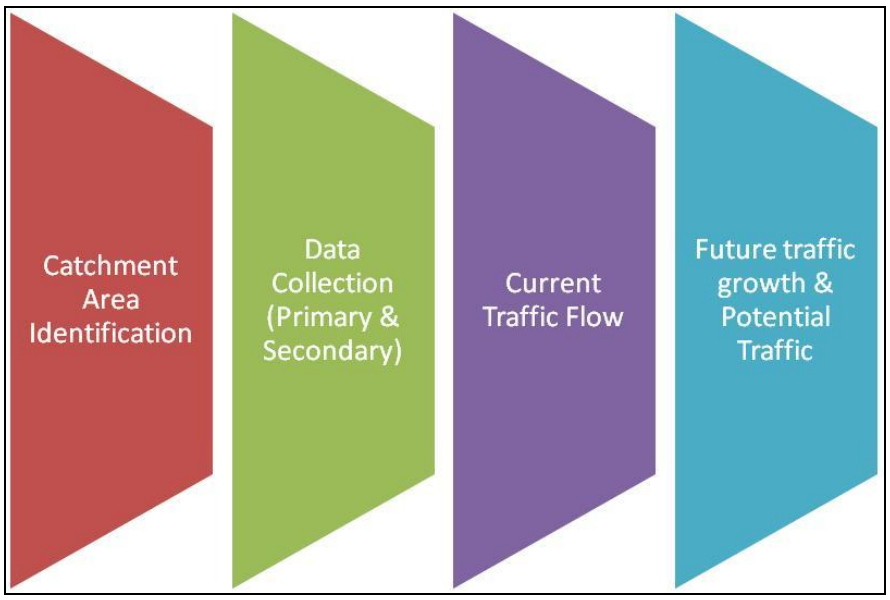


Figure 4.1: Methodology for Market Potential Analysis

4.2 Existing Profile

Sal river waterway falls under South Goa district of the State and the district headquarters of South Goa district is at Margao. Margao is one of the major commercial areas in Goa. The district is further divided into six (6) talukas namely Salcete, Quepem, Canacona, Sanguem, Darbandora and Mormugao. The catchment area of Sal River has been observed to be within Salcete Taluka. The area includes the laterite mine in Deusua, industrial clusters in Margao, Cuncolim and industries as well as fishing centers along the waterway.

River Sal falls under Salcete taluka which has a total population 294,464 (Census 2011). The proposed waterway stretch has a total length of 14 km.

Industrial Profile

South Goa district has seen a continuous increase in the industrial investments over the past years. The details of total no. of units registered and related information is given in **Table 4.1**.

Table 4.1: Industrial Units in South Goa

Sl. No.	Profile of Industries	Quantity (No.)
1.	Registered Industrial Units	2,940
2.	Total Industrial Units (Goa)	51,492
3.	Registered Medium & Large Units	75
4.	No. of Industrial Areas	6

Source: Industrial Profile of South Goa District, MSME, Govt. of India

These registered units include various types of industries and the details of the same are given in **Table 4.2**.

Table 4.2: Industrial Profile of South Goa District

Sl. No.	Type of Industry
1.	Food Products
2.	Beverages & Tobacco products
3.	Jute, hemp & Mesta Textile
4.	Textile Products & Garments
5.	Wood Products & Wooden Furniture, Fixture
6.	Paper Products including Printing/publishing
7.	Leather & Leather Products
8.	Rubber, Plastic, Petroleum and coal products
9.	Chemical Products (except Petroleum and coal products)
10.	Non Metallic Minerals
11.	Basic Metal & Alloys
12.	Metal Products & parts (except M/c. & transport eqpt.)
13.	Machinery, Tools & Parts (except & electrical m/c.)
14.	Electrical Machinery & Apparatus & Supplier Parts
15.	Transport Equipment & Parts
16.	Other Mfg. Industries
17.	Repair/Services

Source: Industrial Profile of South Goa District, MSME, Govt. of India

These industries are located in various industrial clusters; the location of the same is shown in **Figure 4.2**. Out of all the clusters, two (2) clusters fall in the vicinity of the Sal River, namely Margao Industrial Estate & Cuncolim Industrial Estate.

Refer **Annexure 4.1** & **Map 4.1** for location of major industries along the waterway & in its vicinity.

Source: GDITC, Govt. of Goa

Figure 4.2: Industrial Estates of Goa

Connectivity

The industrial clusters & tourism areas in the catchment of Sal River are well connected with other parts of Goa as well as other regional centers by an efficient road & rail network. **Figure 4.3** shows Road & Rail connectivity of major industrial clusters it the catchment of Sal River.

Road Connectivity

Industrial Clusters of both Margao & Cuncolim are well connected by the road network of National Highway, State Highway and other roads. The Cuncolim Cluster is directly accessible from National Highway 66. The Cluster at Margao is also served by State Highways which connects it to National Highway No. 66 for regional connectivity. The existing road network also ensures good connectivity of these industrial clusters with the Mormugao Port Trust.

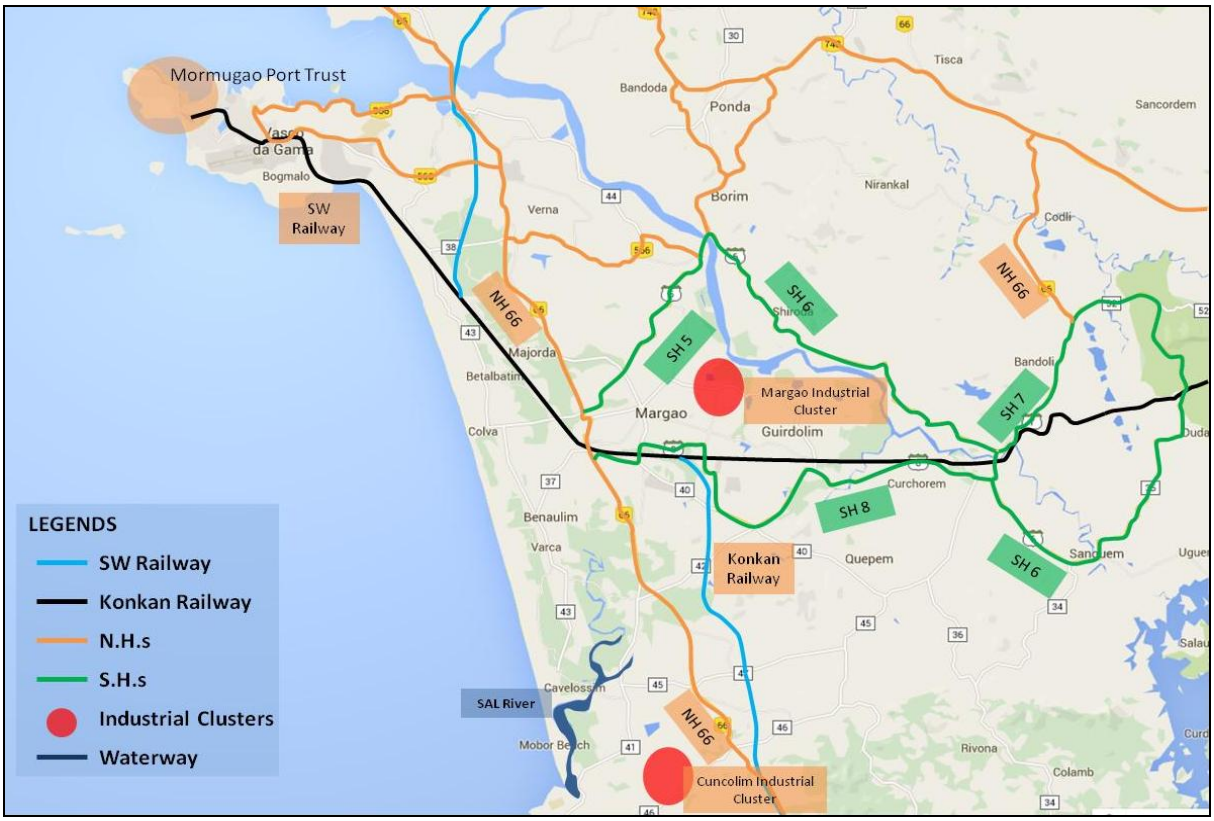


Figure 4.3: Road/Rail Connectivity of Sal River Catchment Area

Rail Connectivity

Sal river basin & the industries in its vicinity are well served by South Western & Konkan Railway. Both the railway sections are Single line sections with Diesel traction of locomotives. Both the industrial clusters of Cuncolim & Margao are also located in close vicinity of the same. Railway connectivity to Mormugao port Trust is also available.

4.3 Existing Cargo Traffic

In the current scenario, it has been observed that the waterway currently is not being used for any cargo operations. The major business that the study stretch is being used is for fish production.

4.4 Future Cargo Potential

A limited potential of future cargo exists to be transported in Sal River, which is described as below:

Fisheries

Major business at Sal river waterway is fish production. There has been a steady growth in fish production in Goa at a CAGR of 3.15% (2001-2015), which includes both Inland & Marine Fish production. **Figure 4.4** & **Table 4.3** show the growth in annual fish production from 2001 to 2015.

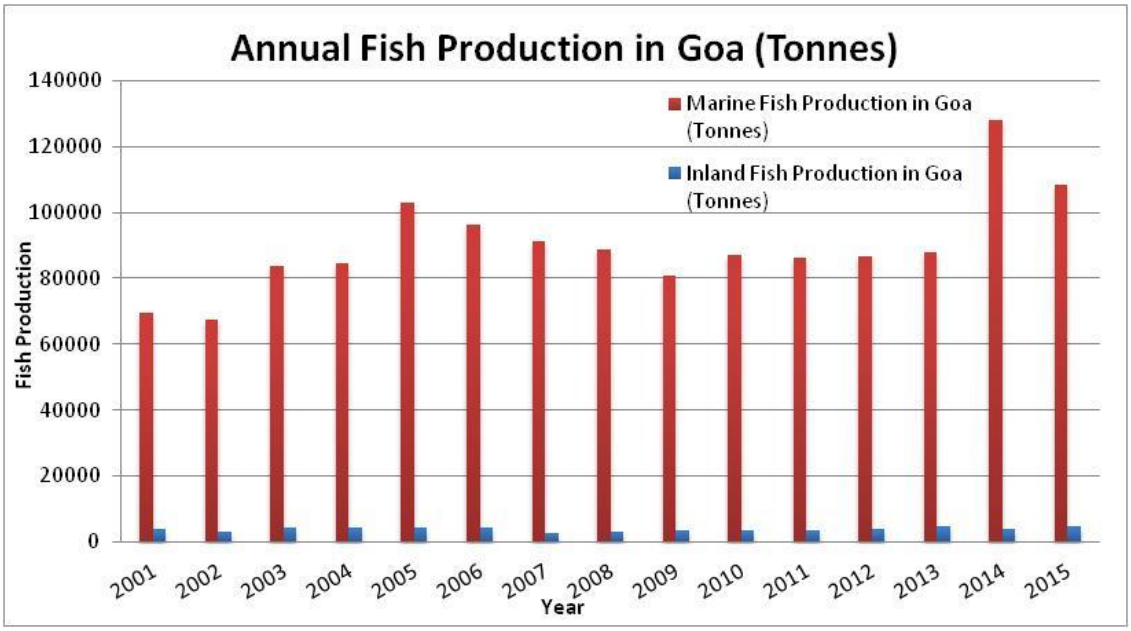


Figure 4.4: Annual Fish Production in Goa

Table 4.3: Fish Production in Goa

Year	Marine Fish Production in Goa (Tonnes)	Inland Fish Production in Goa (Tonnes)
2001	69,386	3,713
2002	67,563	3,148
2003	83,756	4,285
2004	84,394	4,397
2005	1,03,087	4,194
2006	96,326	4,131
2007	91,185	2,447
2008	88,771	3,077
2009	80,687	3,283
2010	87,062	3,311
2011	86,185	3,538
2012	86,628	3,887
2013	87,984	4,678
2014	1,28,107	3,718
2015	1,08,240	4,648
CAGR	**3.23%**	**1.62%**

Inland fish production is also done along the inland portion of Sal river basin. Two Inland fish landing centres are located along the river:

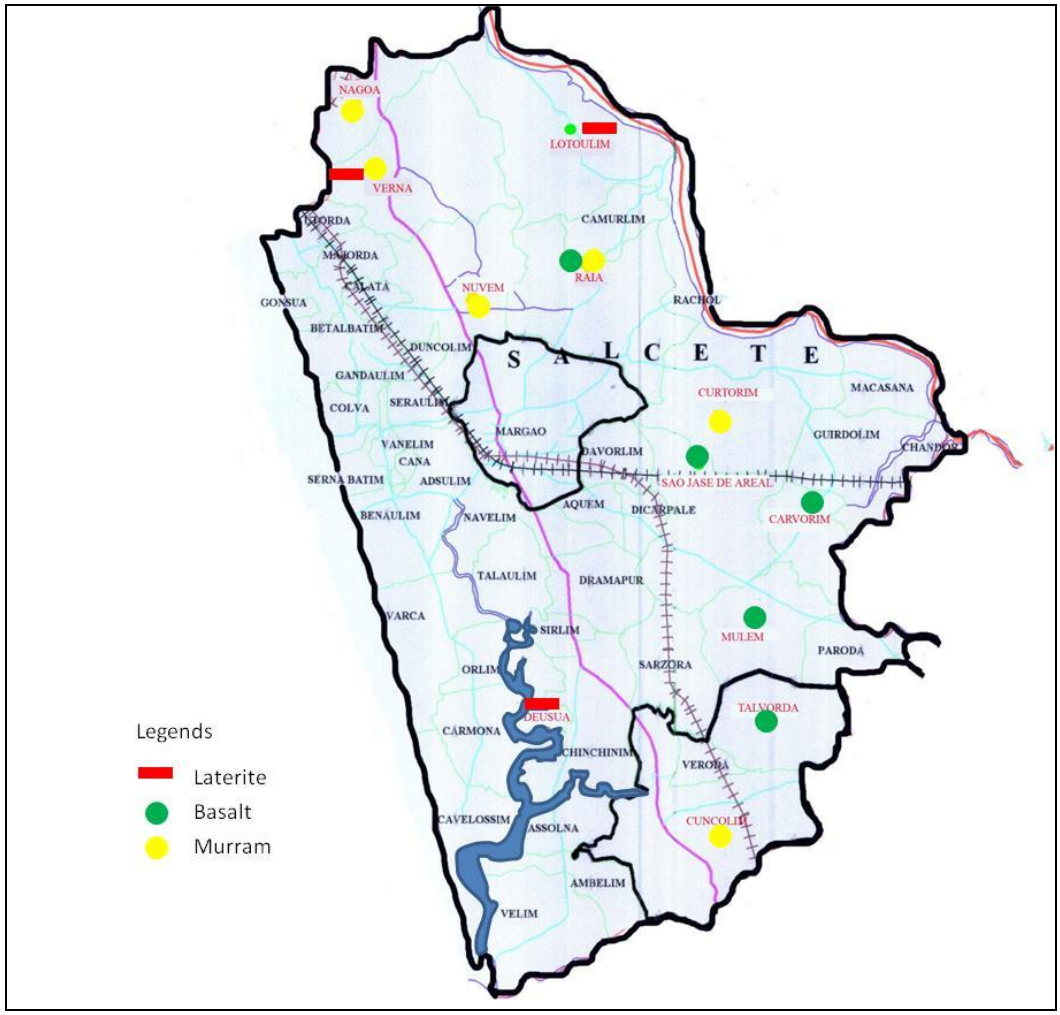
a. Betul (Medium) &

b. Varca (Minor).

There is a possibility to transport fish through inland water and coastal shipping from Sal river basin to Mormugao Port and other coastal destinations. The feasibility of the same will be studied in a detailed manner at the DPR stage.

Mining traffic

Very limited number of mineral mining sites is located in Salcete, location of the same is shown in **Figure 4.5**. It has been observed that one Laterite mining site is located along the waterway at Deusua and few other mines of Laterite, Murram & Basalt mines are located in the hinterland.



Source: Directorate of Mines & Geology, Govt. of Goa

Figure 4.5: Mining Areas in Salcete

The probability of moving the minerals from hinterland through waterway transportation is limited, because of good road connectivity. However, if a small amount can be transported through waterway from Deusua mine, it will be examined in detail at DPR stage.

Industrial Clusters

Two Industrial estates viz. Cuncolim & Margao Industrial estates are located in close vicinity of the waterway corridor. A small amount of cargo may be diverted from Margao Industrial Area through Sal river. However, this will be studied in detail at DPR stage.

Diversion from Mormugao Port Traffic

Mormugao Port is one of the major ports of India located on the North of Sal River and is handling about 15-18 MMTPA of traffic. Figure 4.6 shows the growth in traffic at Mormugao Port.

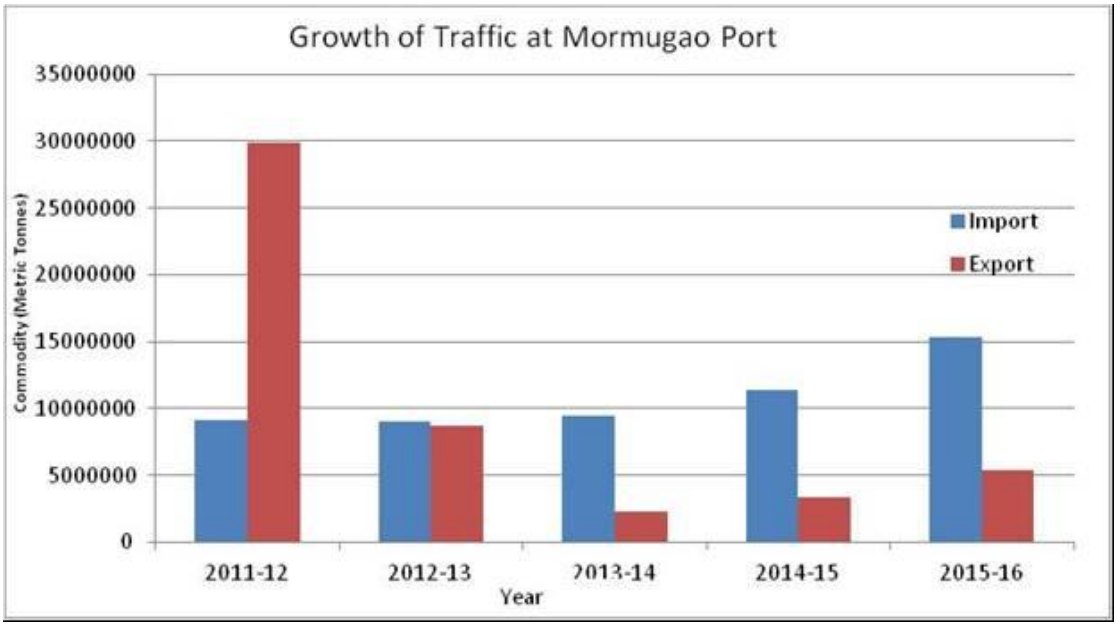


Figure 4.6: Traffic Growth at Mormugao Port

Right now there is no cargo movement between Sal waterway and Mormugao Port. As the Port is at a distance (45 km) from the Sal river. The possibility of carrying port cargo through Sal river is negligible.

Tourist Traffic

Sal river basin & coastal area is popular for its beaches & scenic beauty. Betul beach is considered to be one of the most popular tourist beaches in Goa. The region currently has a number of tourist resorts along the coastline and along the study stretch. Table 4.4 shows the growth in tourists from 2001 to 2015. It has been observed that the overall growth in tourist traffic has been at a CAGR of 10.08% from 2001 to 2015.

Table 4.4: Tourist Growth in Goa

Year	Domestic	Foreign	Total
2001	11,20,242	2,60,071	13,80,313
2002	13,25,296	2,71,645	15,96,941
2003	17,25,140	3,14,357	20,39,497
2004	20,85,729	3,63,230	24,48,959
2005	19,65,343	3,36,803	23,02,146

Year	Domestic	Foreign	Total
2006	20,98,654	3,80,414	24,79,068
2007	22,08,986	3,88,457	25,97,443
2008	20,20,416	3,51,123	23,71,539
2009	21,27,063	3,76,640	25,03,703
2010	22,01,752	4,41,053	26,44,805
2011	22,25,002	4,45,935	26,70,937
2012	23,37,499	4,50,530	27,88,029
2013	26,29,151	4,92,322	31,21,473
2014	35,44,634	5,13,592	40,58,226
2015	47,56,422	5,41,480	52,97,902
CAGR	**10.88%**	**5.38%**	**10.08%**

Source: Department of Tourism, Govt. of Goa

The total number of tourists in Sal river catchment was 9,70,633 during 2013-14. The growth in foreign tourist traffic has been comparatively higher as compared to domestic tourists. **Table 4.5** & **Figure 4.7** shows the growth in International & Domestic tourists in Salcete taluka.

Table 4.5: Tourist Growth in Salcete

Year	Domestic	Foreign	Total
2008-09	490563	101973	592536
2009-10	549938	105194	655132
2010-11	577264	123352	700616
2011-12	769904	166022	935926
2012-13	773950	168514	942464
2013-14	790791	179842	970633
CAGR	**10.02%**	**12.02%**	**10.37%**

Source: Statistical Handbook of Goa, Govt. of Goa

A CAGR of 10.02% has been observed in growth of domestic tourists and 12.02% for the case of international tourists for the period of 2008 to 2013. The overall growth rate for the same period is 10.37%.

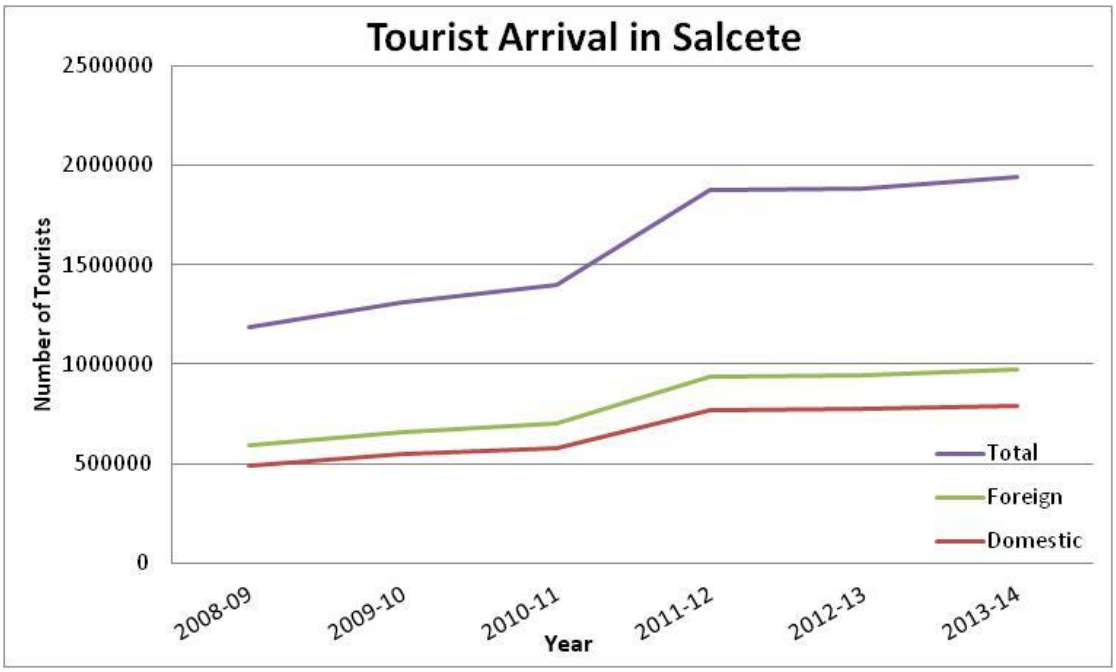


Figure 4.7: Tourist Growth in Salcete

Since, the region is already popular among tourists, there is a possibility for development of the Sal river region & coastline as a water sports area.

4.5 Conclusions

The availability of inland & coastal fish production and landing centers along the river may come up as an opportunity for development of the waterway for fish production & shipping. The feasibility of the same will be studied at DPR stage.

Keeping in view the laterite mine zone in the vicinity, the economies of moving the same through inland water ways will be examined at DPR stage.

Further, Feasibility of tourism as one of the potential areas for development of the study stretch will be analysed in detail at DPR stage.

CHAPTER 5 OBSERVATIONS AND INFERENCES

5.1 Waterway Feasibility

Based on the details presented in the Chapter-3, following conclusions have been derived for establishing the navigability of the proposed waterway;

1. The river length as given by IWAI is 14km, whereas the total surveyed length along the river to capture the thalweg is 14.26km. The deepest channel route has been reckoned as 14.26km. All inferences derived for identifying the navigable length have been derived with reference to the deepest channel length (14.26km).
2. The full study stretch of river is under tidal effect. The relevant chart datum has been used. However, only 23% of the surveyed length has water depth more than 2.0m, however not continuous. The average tidal variation is 1.15m with maximum high tide of 2.3m and low tide of 0.0m as per the records available for this region. The average tide height of 1.2m would be an added advantage for the safe navigation.
3. As per the observation, the feasibility study suggests that the river is navigable without any significant obstructions up to the end of the stretch i.e., up to the Orlim Deusa Bridge (at the end of the stretch). Smoothening of the bends is required at the critical bends and modifications in the clearances under H. T. Line and Electric Lines are to be carried out. By considering the above, the entire stretch can be considered under Class III Waterway.
4. The lengths of the waterway, with a depth more than 2.0m, 1.5m and 1.0m with reference to the Chart Datum have been compiled in the main report. This is given in Table 3.7 of the report and is being reproduced below:

Maximum – Minimum Depth in Sal River from Ch 0.00km to Ch 14.26km

Chainage (Km)	Draft Available		Length of River (Km)			
	Max. (m)	Min. (m)	>2m	1.5-2.0m	1-1.5m	<1m
0-3	6.66	0.75	0.97	0.97	0.68	0.37
3-7	3.68	0.09	1.12	0.82	1.03	1.03
7-10	4.37	0.02	0.81	0.92	0.23	1.04
10-14.26	2.65	0.12	0.35	0.69	1.27	1.96
Total			**3.25**	**3.40**	**3.21**	**4.40**

5. Two Electric Lines and one H. T. Line are crossing the study stretch with the vertical clearance ranging from 2.2m to 10.00m above MHWS. The minimum vertical clearance required shall be 20.1m corresponding to 220kVA transmission line.

The description & classification of the waterway has been presented schematically based on the survey observation and duly keeping in view the river classification criteria in Table 3.16 as reproduced below.

Criteria	Classification																			
Length of waterway from start (km)	1	1	2	3	4	4	5	6	6	7	8	9	9	10	11	11	12	13	14	14
Chainage length in %	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Depth availble	C-III																			
Raod Bridge Vert. Clearance	C-III																			
Raod Bridge Hor. Clearance	C-III																			
HT Line Vert. Clearance	Needs Raising of HT Base																			
Bend Radius	C-III																			
Index	All Class		Class-V		Class-IV		Class-III		Class-II		Class-I									

5.2 Cargo Feasibility

The present Cargo mobility in the Sal River area is comparatively minimal. However, the Fishing activity in the study stretches is in a buzz.

Subsequent to the preliminary market survey and its analysis, there is a possible growth of Fishing and Tourism in the study stretch. Further, the possible Cargo mobility linking two Industrial Estates in the hinterland is to be examined. Possibility of IWT mobility of Laterite from mining area is also to be examined and analyzed.

In order to expand the Fishing and Tourism activities and establish the possible IWT mobility of Laterite, the waterway development is felt essential. Accordingly, the waterway is to be developed to Class III to meet the above activities.

5.3 SWOT Analysis

SWOT analysis has been carried out for deriving meaningful information specifying the objectives of the study for development of the waterway for year round commercial navigation and identifying the internal & external factors that are favorable and unfavorable in the development of the waterway.

Strength

1. 23% of the surveyed length has water depth more than 2 m and is safe for navigation.
2. The above depth availability is for the initial 2kms to 3 kms. Certain patches may be required to be attended with a considerable conservancy activity involving dredging in the study stretch.
3. The maximum water level (tidal) fluctuation of 2.3m has been observed and this will strengthen the safe mobility of vessels in the waterway.
4. The study stretch of Sal River is flowing through Salcete Taluka of South Goa District. Approximately 2.94 lacs of population is residing in the Salcete Taluka, in the vicinity of Sal River, which will have direct or indirect benefits from the IWT and related projects coming up in the area.
5. Fishing activity is flourishing in the Sal River area with Betul and Virca ports as hub.

6. Numbers of Hotels are observed on the banks of Sal River, which may be a strength for Tourism activity in the River. The Betul Beach is also observed in the vicinity.
7. Two industrial estates viz., viz., Margao Industrial Estate (12kms from the nearest river front) and Cuncolim Industrial Estate (8kms from the nearest river front) are in the catchment of Sal River.
8. Laterite Mining is in the catchment of Sal River.
9. The above Industrial Estates and the Mining zone are well connected with Road and also with Mormugoa Port.

Weakness

1. Presently, there is no IWT movement.
2. Connectivity of Industrial Estates / Mining Zone with Road may be a weakness, if not used advantageously for IWT.

Opportunity

1. 23 % of the existing waterway is having a depth more than 2m, which can be used advantageously for the mobility of hinterland cargo.
2. The existing fishing activity (through the river and two ports) will get encouragement with the development of Sal River.
3. Since many Hotels are on the banks of Sal River and with the presence of Betul Beach in the proximity, Tourism may flourish, if the Sal River is developed.
4. The existence of two industrial estates viz., Margao Industrial Estate and Cuncolim Industrial Estate in the catchment of Sal River is an opportunity, if used by IWT.
5. Possibilities of Laterite mobility from the Mines in the hinterland through IWT can be explored.
6. The present Rail and Road connectivity though may be competing with IWT may also be an opportunity for creating an efficient intermodal hub for IWT.
7. Policies are to be firmed up for development of IWT in this stretch.

Threat

1. The Mumbai-Goa Highway in the study area may create competing mode of transport.
2. The Sal River banks covered by marginal mangrove trees in certain places may involve some socio-environmental issues and may require statutory approvals and clearances to construct the jetties/ terminal/ ports/ intermodal connectivity.

5.4 Development Cost (Tentative)

The reconnaissance survey data with regard to physical constraints may have cost implications for making the river stretch navigable to the required standards of Waterway. Henceforth, the development of the proposed national waterway involves physical interference in the form of dredging, construction of terminals at the identified locations, modification of HT Lines at crossing locations to provide a minimum vertical clearance of 20.1m (with respect to 220 kVA) or the case may be combined with some unforeseen expenses. Moderate

dredging effort has been envisaged with an average dredging of 1.0m required in 11.0km of the length of proposed waterway reckoned with reference to ascertained data. The cost of dredging has been considered @ INR 230 per cum. The cost of terminal has been estimated @ INR 20.0 crore each for one terminal. HT line / Electric Lines crossing shall need modification which shall require two towers at the bank of requisite height and the stringing over pair of poles crossing the Sal River. The cost of transmission tower has been estimated to be INR 20.00 lacs each and the stringing cost across the towers shall be INR 4.0 lacs per pair of towers. The total estimated cost for modification to the three HT / Electric Lines shall be INR 3 x 44.0 lacs = INR 132.0 lacs. No modification is required for bridge structures. The cost of navigational aids for day/night navigation has been considered as INR 263 lacs. 10% of the amount for dredging, terminal construction, tower / bridge modification and night navigational aids has been envisaged as unforeseen. The tentative total cost of development to make the river navigable round the year to achieve safe navigation for the required classification of vessel mobility has been estimated to INR 37.50 crore.

Table 5.1: Tentative Development Cost of Sal River Waterway (NW 88)

Sl No.	Name of Waterway	Length of Water way	Dredging Required (wrt. 2 m draft & 40.0m width)	Dredging Cost @ INR 230/ cum	Terminal Proposed	Terminal Cost @ INR 20 Cr each	Cost of Modification of Transmission line	Night Navigation	Total cost incld. 10% unforeseen
		(km)	(km)	INR in Cr.)	(Nos)	(INR in Cr.)	(INR in Cr.)	(INR in Cr.)	(INR in Cr.)
1	Sal River	14.26	11.0	10.12	1	20.00	1.32	2.63	37.50

5.5 Classification of Waterway

The Ministry of Shipping, Road Transport and Highways (Inland Waterways Authority of India) has classified the Inland waterways into seven categories for rivers and canals for safe plying of self propelled vessels up to 2000 DWT and tug-barge formation in push tug + four barge units of carrying capacity up to 8000 DWT (Ref: IWAI, Gazette Notification dated 26th January 2007).

As per the above Classification of Inland Waterways, the entire waterway of Sal River (NW 88) of 14.26km length has been classified based on available minimum water depth, bottom width, minimum vertical and horizontal clearances of cross over structures and bend radius in the river. The classification of Sal River is described below.

Table 5.2: Classification of Sal River (NW 88)

Chainage (km)	Minimum Depth (m)	Bottom Width (m)	Minimum Vertical Clearance (m)	Minimum Horizontal Clearance (m)	Bend Radius (m)	Classification of Waterway (Proposed)
0.0 – 14.26	0.02	120.0	6.5 (Bridge & H. T. Line)	25 (Bridge)	165	**Class – III**

The study stretch of the waterway is amenable for development as Class III waterway as explained above. However, considerable Dredging may be required.

In order to consider the full stretch as **Class III**, smoothening of bends is essential.

The above stretch of the waterway, hence, can be considered under Class III which is navigable without any hindrance and shall be used for plying self-propelled vessel of carrying capacity upto 500 DWT (approximate size 58m overall length, 9m moulded breadth and 1.5m loaded draft) or one tug and two barges combination of 1000 DWT (approximate size 141m overall length, 9m breadth and 1.5m loaded draft).

5.6 Recommendation

The national waterway-88 of Sal River has been identified having potential for development as waterway of Class III for a distance of 14.26km as described above. This stretch of the river is, therefore, recommended for stage-II study for preparation of Detailed Project Report (DPR) to establish the viability for implementation as a project.

Accordingly, the national waterway NW-88 of Sal River is proposed for development as **Class III** waterway in the stretch of the waterway as depicted below:

River Stretch	0.00km 14.26km
Classification	
	Class III
Horizontal clearance (m)	50
Vertical clearnce (m)	7
Minimum Depth(m)	1.7
Bottom Width (m)	50
Self Propelled Vessel	
Dead Weight Tonnage	500
Vessel size (m)	(58 x 9 x 1.5)
Tug + Barge	
Dead Weight Tonnage	1000
Vessel size (m)	(141 x 9 x 1.5)

ANNEXURE 1.1

DATA COLLECTION & SOURCE OF DATA

Annexure 1.1: Data Collection Source of Data

(Cluster-7)

Sl. no	Name of Authority, place	Contacted Person	Designation	Required Data	Collected Data	Date of Receiving Data	Remarks
MAHARASHTRA							
1	Office of Hydrographer, Maharashtra Maritime Board, Khar (West), Mumbai	Mr. Sandip Dhuraji	Hydrographer	Chart Datum & Structure Detail in Water Way	Yes	3/4/2016	Official Letter Submitted to the Department. Data Received
2	Office of Hydrographer, Maharashtra Maritime Board, Khar (West), Mumbai	Mr. Anil Kadam	Assistant Hydrographer	River Gauge & Discharge Data/ Structure Detail	Yes	3/4/2016	Official Letter Submitted to the Department. Data Received
3	Kolkewadi Dam Maintainance Division, Alore, WRD, Maharashtra	Mr.K M Mane	Sectional Engineer (Admin)	River Gauge & Discharge Data/ Structure Detail/ Chart Datum	---	---	Official Letter Submitted to the Department. Data is Awaited
4	Indian Oil Corporation Ltd. (IOCL), Indian Oil Bhawan, G-9, Ali Yavar Jung Marg, Bandra (East), Mumbai	Mr. R. D. Kherdekar	GM (Consumer)	POL Data	Yes	7/6/2016	Discussion
5	Maharashtra Maritime Board, Main Office, Ramji Bhai Kamani Marg Ballard Estate, Mumbai	Mr. Atul Patane	Chief Executive Officer	existing traffic data on Cluster-7 Inland waterways and associated ports in Maharashtra	Yes	8/6/2016	Official Letter Submitted to the Department. Data Received
6	Maharashtra Industrial Development Corporation, Udyog Sarathi, Andheri (E), Mumbai	Mr. Yuvraj Poman	OSD (Markering)	Industries along the Cluster-7 Inland waterways in Maharashtra	Yes	8/6/2016	Official Letter Submitted to the Department. Maharashtra MIDC Industrial Area Map Received
7	Maharashtra Tourism Development Corporation Ltd. Opp. LIC (Yogakshema) Building, Madame Cama Road, Mumbai	Mr. Satish Soni	Director of Tourism & Jt. MD	Existing Tourism Development and Future Plan on Cluster-7 Inland waterways in Maharashtra	Yes	8/6/2016	Discussion
8	Direcorate of Industries, Government of Maharashtra	Mr. S. B. Patil	Jt. Director	Industries along the Cluster-7 Inland waterways in Maharashtra	To be Provided	---	Data is Awaited
9	Collectorate & DM Office, Raigarh, Maharashtra	Mr. Sagar Pathak	District Disaster Management Officer	Population data along the Cluster-7 Inland waterways in Ragarh district	Yes	9/6/2016	Population Data Received

Annexure 1.1: Data Collection Source of Data

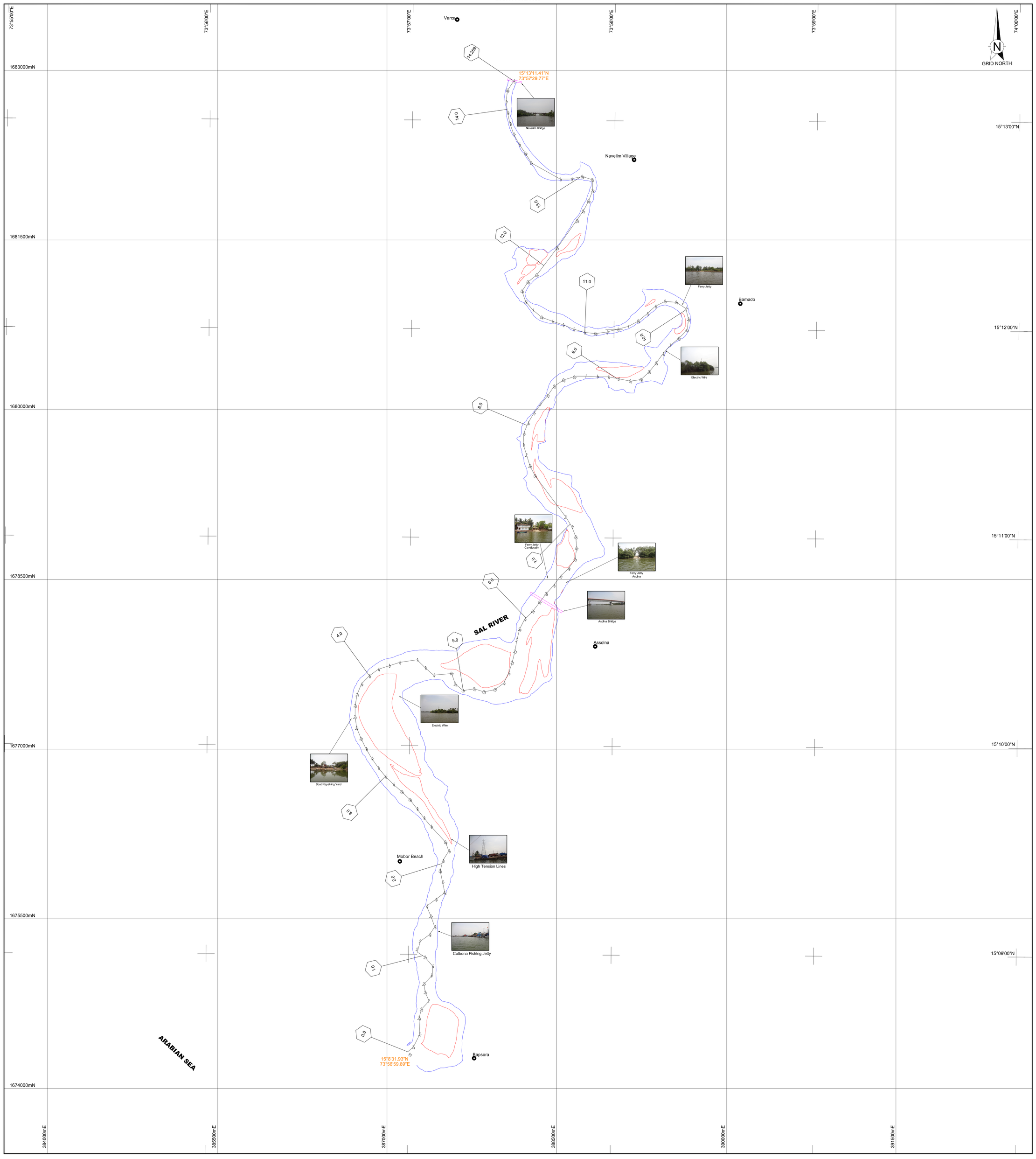
(Cluster-7)

Sl. no	Name of Authority, place	Contacted Person	Designation	Required Data	Collected Data	Date of Receiving Data	Remarks
10	District Industrial Centre, Raigarh, Maharashtra	Mr. Lohnde	GM	Industries along the Cluster-7 Inland waterways in Raigarh district	Yes	9/6/2016	Industrial Data Received
11	Collectorate & DM Office, Raigarh, Maharashtra	Mr. K. Shinde	Superintendent of Agriculture	Crops/Fruits along the Cluster-7 Inland waterways in Raigarh district	Yes	9/6/2016	Agriculture/Horticulture Data Received
12	Collectorate & DM Office, Ratnagiri, Maharashtra	Mr. Suryavanshi	District Disaster Management Officer	Population data along the Cluster-7 Inland waterways in Ratnagiri district	To be Provided	10/6/2016	Data is Awaited
13	Collectorate & DM Office, Ratnagiri, Maharashtra	Mr. Vidyadhar Vaidya	Superintendent of Agriculture	Crops/Fruits along the Cluster-7 Inland waterways in Ratnagiri district	Yes	10/6/2016	Agriculture/Horticulture Data Received
14	District Industrial Centre, Ratnagiri, Maharashtra	Mrs. Ranjana Basantrao Pol	Manager	Industries along the Cluster-7 Inland waterways in Ratnagiri district	Yes	10/6/2016	Industrial Data Received
GOA							
1	Works Division - III, Water Resource Department, Goa	Mr. R. B. Ghanti,	Executive Engineer	River Gauge & Discharge Data/ Structure Detail	---	---	Official Letter Submitted to the Department. Data is Awaited
2	Water Resource Department, Goa	Mr. S T Nandkarni	Chief Engineer	River Gauge & Discharge Data/ Structure Detail	---	---	Official Letter Submitted to the Department. Data is Awaited
3	Water Resource Department, Works Division-III, Goa	Mr. P. B. Badami	Executive Engineer	River Gauge & Discharge Data/ Structure Detail	---	---	Official Letter Submitted to the Department. Data is Awaited
4	Water Resource Department, Works Division-III, Goa	Mr. Rajan	Section Engineer, WRD. Goa	River Gauge & Discharge Data/ Structure Detail	---	---	Official Letter Submitted to the Department. Data is Awaited
5	Captain of Ports Department, Govt. of Goa.	Mr. Sagar Chandra Rai	Captain	River Gauge & Discharge Data/ Structure Detail	---	---	Official Letter Submitted to the Department. Data is Awaited

ANNEXURE 3.1

OVERVIEW CHART FOR SAL RIVER BATHYMETRY

BATHYMETRY



LEGEND:

FEATURES IDENTIFIED FROM CURRENT SURVEY	FEATURES OBTAINED FROM OTHER SOURCES (AS INDICATED)
GENERAL	
GEOGRAPHICAL GRATICULE INTERSECTION	RIVER BOUNDARY (DRAWN FROM GOOGLE)
	CLIENT PROVIED CENTERLINE (WITH CHAINAGE)
BATHYMETRY	
4_7 DEPTHS IN METRES BELOW CHART DATUM	SHALLOW PATCHES
$\underline{1}_7$ HEIGHTS IN METRES ABOVE CHART DATUM	BRIDGE

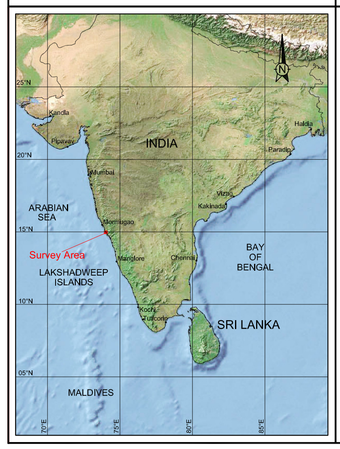
NOTES:

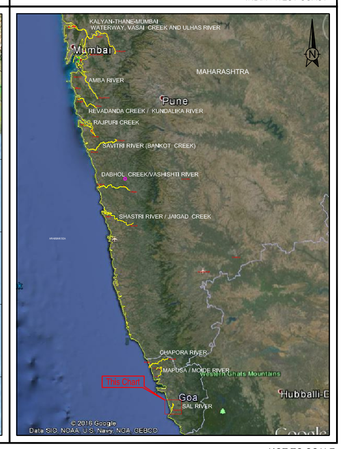
1) SURVEY VESSEL GIRESWAR WAS DEPLOYED FOR THIS SURVEY IN FEBRUARY 2016.
2) THE COORDINATES OF THE SURVEY CORRIDOR WERE PROVIDED BY THE CLIENT.
3) FUGRO'S STARFIX SYSTEM WAS USED FOR POSITIONING AND CONTROL OF SURVEY.
4) REFER TO FSINPVT SURVEY REPORT NO. J-MAR-16-012 FOR DETAILS ON THE RESOURCES MOBILISED AND METHODOLOGY ADOPTED FOR THIS SURVEY.
5) SOUNDINGS WERE REDUCED TO CHART DATUM USING REAL TIME TIDAL HEIGHTS OBSERVED IN THE SURVEY AREA APPLYING MSL-CD RELATIONSHIP OF 1.30 m.
6) THE RESULTS OF SURVEY ARE PLOTTED IN WGS84 DATUM, UTM PROJECTION, ZONE 43N; CENTRAL MERIDIAN 075° E.

REFERENCE DRAWINGS

Rev. No:	Date:	Drawing No.	Source	Description:
-	-	-	-	-

OVERVIEW PLAN | LAYOUT PLAN — INDIA - WEST COAST





NOT TO SCALE

CLIENT

TRACTEBEL ENGINEERING PVT. LTD.
2nd FLOOR, BUILDING NO-10C,
DLF CYBER CITY,
GURGAON - 122002
HARYANA (INDIA)

SURVEY CONTRACTOR

FUGRO SURVEY (INDIA) PVT. LTD.
FUGRO HOUSE
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MUMBAI - 400 706, INDIA
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(AN ISO 9001:2008 COMPANY)

PROJECT TITLE

RECONNAISSANCE SURVEY AND FEASIBILITY REPORT FOR STAGE-1 IN MAHARASHTRA AND GOA WEST COAST OF INDIA

FEBRUARY 2016

CHART SHOWING

OVERVIEW CHART FOR SAL RIVER

BATHYMETRY

SHEET 01 OF 01

HORIZONTAL SCALE 1 : 15,000

300m 0m 300m 600m 900m 1200m 1500m

Vessel:- GIRESWAR | Project Ref: J-MAR-16-012

Rev. No:	Date:	Description:	Surveyed :	Interpr:	Drawn:	Chkd:	Appr:
0	13/06/2016	ISSUE FOR APPROVAL	SD	–	RP	KS/PM	MI

Drawing File No: 7444-01R0

Drawing No: J-MAR-16-012/TRACTEBELENGINEERING/GOA/B/B/01/7444

Encl: 01 OF 01

ANNEXURE 3.2

DAILY HEIGHTS OF HIGH AND LOW WATERS AT MORMUGAO OBTAINED FROM CAPTAIN OF PORTS, PANAJI, GOA

MARMAGAO – INDIA, WEST COAST

LAT. 15° 25′ N. LONG. 73° 48′ E.

TIME ZONE -0530 — TIMES AND HEIGHTS OF HIGH AND LOW WATERS — YEAR 2015

JANUARY

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 F	0307	2.14	16 SA	0256	2.33
	0959	0.98		0945	0.71
	1531	1.58		1542	1.81
	2051	1.07		2122	1.01
2 SA	0342	2.06	17 SU	0336	2.23
	1048	0.96		1044	0.66
	1645	1.53		1732	1.78
	2142	1.23		2233	1.21
3 SU	0420	1.98	18 M	0426	2.12
	1140	0.91		1144	0.59
	1829	1.58		1857	1.86
	2308	1.36		2351	1.35
4 M	0506	1.92	19 TU	0526	2.02
	1234	0.83		1250	0.51
	1945	1.69		2012	1.99
5 TU	0028	1.43	20 W	0114	1.39
	0601	1.88		0655	1.96
	1328	0.72		1354	0.41
	2057	1.84		2118	2.12
6 W	0152	1.44	21 TH	0233	1.34
	0706	1.87		0759	1.96
	1418	0.59		1450	0.32
	2145	1.99		2210	2.23
7 TH	0300	1.39	22 F	0332	1.25
	0802	1.89		0853	1.97
	1501	0.47		1538	0.27
	2224	2.12		2252	2.31
8 F	0350	1.32	23 SA	0423	1.14
	0851	1.92		0943	1.99
	1542	0.37		1623	0.25
	2302	2.23		2329	2.35
9 SA	0433	1.25	24 SU	0509	1.05
	0935	1.96		1033	2.00
	1620	0.29		1702	0.28
	2339	2.32			
10 SU	0512	1.18	25 M	0001	2.36
	1019	2.00		0553	0.97
	1657	0.25		1119	1.99
				1739	0.36
11 M	0012	2.38	26 TU	0031	2.36
	0549	1.10		0632	0.92
	1102	2.03		1203	1.96
	1733	0.25		1808	0.46
12 TU	0042	2.42	27 W	0100	2.33
	0628	1.00		0709	0.88
	1147	2.05		1245	1.90
	1811	0.30		1838	0.59
13 W	0110	2.45	28 TH	0128	2.29
	0710	0.91		0742	0.86
	1238	2.02		1326	1.83
	1853	0.41		1906	0.73
14 TH	0141	2.45	29 F	0157	2.23
	0758	0.84		0819	0.86
	1334	1.97		1409	1.75
	1940	0.58		1937	0.89
15 F	0216	2.41	30 SA	0222	2.15
	0850	0.77		0858	0.85
	1434	1.89		1457	1.68
	2027	0.79		2011	1.04
			31 SU	0247	2.07
				0943	0.85
				1553	1.62
				2051	1.20

FEBRUARY

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 M	0321	1.99	16 TU	0357	2.02
	1034	0.84		1118	0.54
	1712	1.59		1838	1.87
	2143	1.34		2340	1.35
2 TU	0409	1.90	17 W	0502	1.88
	1132	0.81		1225	0.55
	1849	1.65		1958	1.95
	2318	1.45			
3 W	0505	1.83	18 TH	0107	1.36
	1231	0.75		0648	1.81
	2005	1.78		1335	0.52
				2105	2.05
4 TH	0100	1.48	19 F	0227	1.28
	0610	1.79		0758	1.82
	1333	0.65		1436	0.47
	2111	1.92		2156	2.13
5 F	0234	1.42	20 SA	0327	1.15
	0727	1.81		0854	1.86
	1429	0.53		1527	0.44
	2156	2.07		2235	2.19
6 SA	0329	1.31	21 SU	0414	1.03
	0829	1.87		0945	1.90
	1517	0.41		1612	0.43
	2235	2.20		2308	2.22
7 SU	0413	1.19	22 M	0455	0.92
	0921	1.95		1031	1.94
	1559	0.32		1649	0.46
	2311	2.31		2334	2.23
8 M	0451	1.06	23 TU	0532	0.83
	1007	2.02		1115	1.96
	1640	0.27		1722	0.51
	2342	2.39			
9 TU	0529	0.91	24 W	0000	2.24
	1055	2.09		0603	0.76
	1719	0.27		1156	1.96
				1749	0.59
10 W	0010	2.45	25 TH	0027	2.23
	0607	0.76		0631	0.71
	1144	2.14		1234	1.94
	1800	0.33		1817	0.69
11 TH	0038	2.48	26 F	0052	2.20
	0649	0.63		0700	0.68
	1236	2.14		1312	1.90
	1843	0.45		1843	0.80
12 F	0110	2.48	27 SA	0112	2.15
	0734	0.54		0730	0.67
	1333	2.10		1349	1.85
	1928	0.63		1913	0.91
13 SA	0147	2.42	28 SU	0130	2.09
	0823	0.50		0804	0.68
	1429	2.02		1430	1.79
	2018	0.84		1945	1.04
14 SU	0225	2.31	29 M	0154	2.02
	0917	0.49		0842	0.70
	1532	1.92		1518	1.73
	2112	1.06		2026	1.16
15 M	0308	2.17			
	1014	0.52			
	1708	1.85			
	2223	1.24			

MARCH

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 TU	0226	1.93	16 W	0339	1.85
	0927	0.73		1049	0.55
	1614	1.68		1812	1.89
	2119	1.29		2332	1.26
2 W	0310	1.83	17 TH	0451	1.71
	1023	0.75		1158	0.64
	1742	1.68		1928	1.92
	2233	1.39			
3 TH	0419	1.74	18 F	0100	1.23
	1133	0.75		0652	1.66
	1907	1.76		1313	0.67
				2037	1.97
4 F	0019	1.41	19 SA	0218	1.11
	0532	1.70		0805	1.71
	1242	0.70		1418	0.66
	2009	1.88		2127	2.02
5 SA	0202	1.34	20 SU	0312	0.98
	0704	1.72		0907	1.77
	1348	0.61		1510	0.65
	2103	2.02		2203	2.05
6 SU	0303	1.20	21 M	0356	0.86
	0815	1.81		0955	1.83
	1446	0.51		1553	0.65
	2148	2.14		2230	2.07
7 M	0346	1.02	22 TU	0431	0.76
	0910	1.94		1034	1.89
	1535	0.43		1630	0.67
	2224	2.25		2254	2.08
8 TU	0424	0.82	23 W	0501	0.67
	1000	2.06		1112	1.94
	1619	0.39		1701	0.70
	2255	2.34		2319	2.09
9 W	0502	0.62	24 TH	0527	0.59
	1051	2.16		1149	1.98
	1702	0.40		1730	0.75
	2326	2.41		2343	2.08
10 TH	0542	0.44	25 F	0554	0.53
	1143	2.23		1225	1.99
	1746	0.46		1800	0.82
11 F	0000	2.43	26 SA	0003	2.06
	0624	0.31		0621	0.50
	1236	2.25		1300	1.98
	1832	0.58		1829	0.89
12 SA	0036	2.41	27 SU	0024	2.02
	0709	0.24		0650	0.49
	1328	2.22		1335	1.95
	1920	0.73		1900	0.98
13 SU	0117	2.33	28 M	0046	1.97
	0757	0.25		0721	0.51
	1422	2.14		1411	1.91
	2011	0.91		1935	1.06
14 M	0159	2.20	29 TU	0116	1.91
	0849	0.32		0757	0.55
	1519	2.02		1453	1.86
	2110	1.08		2019	1.15
15 TU	0246	2.03	30 W	0149	1.83
	0946	0.44		0842	0.61
	1640	1.92		1542	1.81
	2219	1.21		2114	1.24
			31 TH	0230	1.73
				0935	0.67
				1644	1.79
				2228	1.30

APRIL

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 F	0346	1.64	16 SA	0042	1.06
	1041	0.73		0650	1.56
	1812	1.81		1238	0.83
	2354	1.28		1941	1.91
2 SA	0509	1.60	17 SU	0155	0.95
	1157	0.74		0808	1.62
	1917	1.90		1347	0.86
				2027	1.92
3 SU	0120	1.18	18 M	0246	0.84
	0655	1.65		0908	1.70
	1306	0.71		1442	0.87
	2008	2.01		2101	1.93
4 M	0227	0.99	19 TU	0325	0.73
	0806	1.78		0950	1.79
	1411	0.66		1527	0.87
	2051	2.11		2129	1.94
5 TU	0312	0.78	20 W	0357	0.63
	0901	1.94		1027	1.87
	1507	0.61		1603	0.87
	2129	2.20		2157	1.95
6 W	0353	0.54	21 TH	0424	0.53
	0955	2.09		1102	1.95
	1557	0.59		1637	0.89
	2206	2.28		2224	1.95
7 TH	0434	0.33	22 F	0451	0.45
	1047	2.22		1139	2.01
	1645	0.60		1711	0.91
	2244	2.32		2251	1.94
8 F	0515	0.14	23 SA	0519	0.39
	1142	2.30		1215	2.04
	1732	0.65		1746	0.95
	2323	2.33		2318	1.92
9 SA	0558	0.04	24 SU	0549	0.36
	1234	2.34		1250	2.05
	1821	0.73		1819	0.99
				2344	1.90
10 SU	0005	2.29	25 M	0618	0.35
	0643	0.03		1323	2.03
	1323	2.31		1853	1.04
	1910	0.84			
11 M	0050	2.19	26 TU	0014	1.86
	0730	0.11		0648	0.38
	1412	2.23		1357	2.01
	2005	0.95		1931	1.09
12 TU	0137	2.04	27 W	0048	1.82
	0822	0.25		0726	0.43
	1503	2.11		1434	1.97
	2105	1.05		2016	1.14
13 W	0229	1.87	28 TH	0126	1.74
	0918	0.43		0812	0.51
	1604	1.99		1519	1.94
	2212	1.11		2112	1.17
14 TH	0328	1.70	29 F	0215	1.66
	1021	0.61		0904	0.61
	1733	1.92		1612	1.91
	2320	1.12		2220	1.18
15 F	0444	1.57	30 SA	0334	1.58
	1127	0.74		1007	0.71
	1842	1.90		1716	1.90
				2332	1.11

MARMAGAO – INDIA, WEST COAST

LAT. 15° 25′ N. LONG. 73° 48′ E.

TIME ZONE -0530 — TIMES AND HEIGHTS OF HIGH AND LOW WATERS — YEAR 2015

MAY

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 SU	0458	1.55	16 M	0116	0.85
	1120	0.78		0740	1.54
	1826	1.94		1255	1.01
				1919	1.85
2 M	0041	0.98	17 TU	0206	0.75
	0649	1.63		0843	1.64
	1229	0.82		1358	1.04
	1921	2.01		1957	1.84
3 TU	0145	0.78	18 W	0244	0.65
	0757	1.76		0928	1.74
	1335	0.83		1450	1.04
	2005	2.08		2032	1.84
4 W	0237	0.54	19 TH	0317	0.55
	0853	1.95		1009	1.85
	1439	0.83		1534	1.04
	2046	2.14		2104	1.84
5 TH	0322	0.31	20 F	0346	0.44
	0949	2.11		1047	1.95
	1536	0.82		1613	1.03
	2127	2.19		2138	1.84
6 F	0406	0.11	21 SA	0417	0.35
	1045	2.25		1125	2.02
	1628	0.82		1652	1.03
	2209	2.21		2210	1.84
7 SA	0449	-0.04	22 SU	0451	0.29
	1137	2.33		1203	2.07
	1718	0.83		1730	1.04
	2252	2.20		2242	1.83
8 SU	0533	-0.09	23 M	0523	0.26
	1225	2.37		1238	2.08
	1808	0.85		1807	1.06
	2340	2.14		2316	1.82
9 M	0619	-0.05	24 TU	0554	0.26
	1312	2.34		1312	2.08
	1900	0.89		1843	1.07
				2350	1.81
10 TU	0029	2.04	25 W	0627	0.29
	0706	0.07		1344	2.07
	1357	2.27		1921	1.08
	1957	0.94			
11 W	0120	1.91	26 TH	0029	1.78
	0755	0.26		0706	0.35
	1442	2.16		1418	2.05
	2056	0.97		2008	1.08
12 TH	0215	1.75	27 F	0116	1.72
	0849	0.46		0752	0.45
	1531	2.05		1457	2.03
	2157	0.99		2103	1.06
13 F	0312	1.60	28 SA	0213	1.64
	0948	0.66		0843	0.57
	1630	1.96		1542	2.01
	2259	0.98		2203	1.01
14 SA	0424	1.49	29 SU	0329	1.58
	1049	0.82		0942	0.71
	1740	1.90		1630	1.99
				2305	0.92
15 SU	0008	0.93	30 M	0451	1.56
	0625	1.48		1048	0.83
	1151	0.94		1725	1.98
	1835	1.87			
			31 TU	0007	0.77
				0639	1.64
				1157	0.93
				1825	2.00

JUNE

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 W	0107	0.58	16 TH	0157	0.62
	0745	1.79		0857	1.68
	1304	0.99		1408	1.16
	1920	2.03		1942	1.75
2 TH	0204	0.36	17 F	0234	0.51
	0846	1.95		0945	1.80
	1415	1.01		1503	1.14
	2008	2.06		2022	1.76
3 F	0254	0.16	18 SA	0312	0.39
	0945	2.09		1027	1.91
	1518	0.99		1550	1.12
	2054	2.09		2101	1.77
4 SA	0342	0.01	19 SU	0350	0.30
	1041	2.21		1108	2.00
	1613	0.96		1633	1.09
	2142	2.10		2141	1.79
5 SU	0428	-0.08	20 M	0427	0.23
	1129	2.29		1146	2.05
	1704	0.93		1713	1.07
	2230	2.08		2217	1.80
6 M	0513	-0.10	21 TU	0502	0.20
	1214	2.32		1222	2.08
	1754	0.90		1750	1.05
	2320	2.03		2255	1.81
7 TU	0558	-0.03	22 W	0536	0.20
	1256	2.30		1255	2.10
	1846	0.88		1827	1.03
				2336	1.82
8 W	0012	1.94	23 TH	0611	0.23
	0643	0.11		1326	2.11
	1337	2.25		1906	0.98
	1941	0.88			
9 TH	0106	1.83	24 F	0021	1.80
	0728	0.29		0650	0.29
	1416	2.17		1357	2.11
	2037	0.88		1952	0.93
10 F	0158	1.70	25 SA	0112	1.75
	0815	0.48		0735	0.41
	1457	2.08		1430	2.10
	2132	0.88		2044	0.87
11 SA	0253	1.58	26 SU	0213	1.68
	0905	0.68		0825	0.55
	1541	1.99		1508	2.08
	2227	0.87		2139	0.80
12 SU	0353	1.47	27 M	0321	1.62
	1002	0.85		0918	0.72
	1627	1.91		1550	2.04
	2322	0.84		2238	0.70
13 M	0532	1.43	28 TU	0441	1.59
	1101	0.98		1020	0.89
	1722	1.84		1635	2.00
				2336	0.58
14 TU	0019	0.80	29 W	0627	1.65
	0650	1.48		1129	1.02
	1158	1.09		1727	1.96
	1815	1.79			
15 W	0113	0.72	30 TH	0036	0.43
	0755	1.57		0735	1.77
	1302	1.14		1242	1.10
	1900	1.76		1835	1.95

JULY

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 F	0138	0.28	16 SA	0157	0.51
	0839	1.91		0919	1.74
	1358	1.11		1434	1.20
	1941	1.95		1944	1.69
2 SA	0234	0.13	17 SU	0243	0.39
	0941	2.04		1006	1.85
	1504	1.07		1528	1.15
	2034	1.96		2033	1.72
3 SU	0325	0.03	18 M	0327	0.29
	1033	2.14		1045	1.95
	1600	1.00		1613	1.09
	2127	1.97		2118	1.77
4 M	0413	-0.03	19 TU	0407	0.21
	1118	2.20		1123	2.02
	1651	0.92		1652	1.02
	2217	1.97		2200	1.81
5 TU	0458	-0.02	20 W	0444	0.17
	1158	2.23		1158	2.08
	1742	0.85		1730	0.95
	2308	1.94		2244	1.85
6 W	0542	0.05	21 TH	0519	0.16
	1236	2.23		1228	2.12
	1831	0.80		1807	0.87
	2358	1.88		2329	1.87
7 TH	0622	0.17	22 F	0556	0.20
	1312	2.20		1256	2.15
	1920	0.78		1846	0.78
8 F	0049	1.80	23 SA	0017	1.87
	0702	0.33		0636	0.27
	1348	2.15		1324	2.17
	2009	0.77		1930	0.70
9 SA	0138	1.69	24 SU	0110	1.83
	0737	0.50		0720	0.40
	1423	2.08		1358	2.16
	2057	0.78		2019	0.63
10 SU	0227	1.59	25 M	0209	1.77
	0815	0.68		0806	0.57
	1500	1.99		1434	2.12
	2145	0.78		2112	0.57
11 M	0321	1.49	26 TU	0311	1.70
	0900	0.85		0858	0.76
	1536	1.90		1514	2.05
	2233	0.77		2209	0.51
12 TU	0426	1.43	27 W	0427	1.64
	0956	1.00		1000	0.94
	1616	1.81		1559	1.96
	2322	0.75		2309	0.45
13 W	0558	1.44	28 TH	0612	1.67
	1104	1.12		1113	1.08
	1658	1.73		1654	1.87
14 TH	0012	0.69	29 F	0012	0.38
	0709	1.51		0724	1.76
	1211	1.19		1231	1.15
	1749	1.68		1811	1.81
15 F	0104	0.61	30 SA	0117	0.29
	0818	1.62		0833	1.88
	1324	1.22		1351	1.13
	1849	1.66		1931	1.81
			31 SU	0219	0.20
				0934	1.99
				1457	1.04
				2029	1.84

AUGUST

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 M	0312	0.13	16 TU	0301	0.34
	1023	2.07		1013	1.93
	1552	0.94		1552	1.01
	2121	1.86		2104	1.77
2 TU	0400	0.10	17 W	0343	0.26
	1104	2.12		1049	2.02
	1641	0.84		1630	0.89
	2210	1.88		2150	1.85
3 W	0444	0.12	18 TH	0423	0.22
	1139	2.15		1120	2.10
	1726	0.75		1706	0.76
	2259	1.88		2235	1.92
4 TH	0525	0.18	19 F	0501	0.21
	1211	2.16		1147	2.16
	1810	0.69		1743	0.63
	2347	1.85		2323	1.97
5 F	0601	0.28	20 SA	0539	0.24
	1242	2.14		1215	2.20
	1850	0.66		1821	0.51
6 SA	0032	1.80	21 SU	0012	1.98
	0632	0.40		0619	0.33
	1314	2.10		1246	2.22
	1928	0.65		1904	0.42
7 SU	0117	1.73	22 M	0106	1.96
	0703	0.55		0704	0.47
	1345	2.03		1321	2.19
	2006	0.66		1952	0.36
8 M	0202	1.65	23 TU	0202	1.90
	0735	0.70		0752	0.65
	1416	1.94		1359	2.11
	2046	0.68		2043	0.36
9 TU	0249	1.57	24 W	0301	1.82
	0813	0.86		0847	0.84
	1444	1.85		1443	2.00
	2129	0.69		2141	0.38
10 W	0341	1.50	25 TH	0413	1.74
	0857	1.00		0952	1.01
	1517	1.75		1532	1.87
	2219	0.70		2242	0.41
11 TH	0449	1.47	26 F	0556	1.73
	0955	1.13		1108	1.12
	1600	1.67		1634	1.74
	2313	0.68		2350	0.42
12 F	0624	1.50	27 SA	0712	1.79
	1123	1.22		1227	1.15
	1654	1.60		1814	1.67
13 SA	0012	0.63	28 SU	0100	0.40
	0735	1.59		0822	1.88
	1245	1.25		1351	1.08
	1757	1.58		1935	1.69
14 SU	0113	0.55	29 M	0206	0.36
	0843	1.70		0919	1.97
	1412	1.20		1454	0.95
	1913	1.61		2033	1.75
15 M	0211	0.45	30 TU	0301	0.31
	0934	1.82		1004	2.03
	1508	1.12		1545	0.83
	2013	1.68		2125	1.81
			31 W	0349	0.29
				1041	2.06
				1628	0.72
				2212	1.85

MARMAGAO – INDIA, WEST COAST

LAT. 15° 25′ N. LONG. 73° 48′ E.

TIME ZONE -0530 — TIMES AND HEIGHTS OF HIGH AND LOW WATERS — YEAR 2015

SEPTEMBER

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 TH	0431	0.31	16 F	0400	0.37
	1111	2.08		1027	2.14
	1708	0.63		1638	0.53
	2255	1.88		2230	2.04
2 F	0508	0.36	17 SA	0440	0.37
	1137	2.08		1059	2.21
	1742	0.57		1715	0.36
	2337	1.88		2319	2.11
3 SA	0539	0.45	18 SU	0522	0.41
	1207	2.06		1132	2.25
	1812	0.53		1756	0.23
4 SU	0019	1.87	19 M	0008	2.15
	0607	0.55		0605	0.50
	1235	2.02		1208	2.25
	1841	0.51		1838	0.15
5 M	0059	1.83	20 TU	0102	2.14
	0636	0.67		0653	0.62
	1259	1.96		1248	2.19
	1910	0.52		1924	0.15
6 TU	0140	1.77	21 W	0154	2.09
	0707	0.79		0744	0.78
	1319	1.88		1330	2.08
	1944	0.54		2013	0.22
7 W	0219	1.70	22 TH	0249	1.99
	0741	0.92		0842	0.93
	1338	1.81		1416	1.92
	2020	0.58		2111	0.33
8 TH	0304	1.64	23 F	0355	1.89
	0823	1.04		0950	1.06
	1408	1.72		1512	1.76
	2105	0.63		2217	0.45
9 F	0359	1.58	24 SA	0534	1.83
	0915	1.15		1104	1.12
	1454	1.63		1621	1.62
	2203	0.67		2326	0.55
10 SA	0515	1.56	25 SU	0650	1.85
	1037	1.24		1224	1.10
	1607	1.55		1829	1.58
	2315	0.68			
11 SU	0646	1.61	26 M	0039	0.59
	1210	1.25		0759	1.91
	1722	1.52		1347	0.99
				1947	1.65
12 M	0025	0.65	27 TU	0149	0.58
	0748	1.71		0854	1.96
	1344	1.18		1444	0.85
	1852	1.57		2049	1.73
13 TU	0131	0.58	28 W	0247	0.57
	0837	1.83		0935	1.99
	1443	1.05		1529	0.73
	2001	1.68		2136	1.82
14 W	0229	0.49	29 TH	0334	0.56
	0919	1.95		1004	2.00
	1525	0.89		1607	0.62
	2053	1.80		2217	1.88
15 TH	0318	0.41	30 F	0414	0.58
	0955	2.05		1030	2.01
	1603	0.71		1641	0.53
	2142	1.93		2254	1.94

OCTOBER

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 SA	0448	0.63	16 SU	0421	0.63
	1055	2.00		1017	2.25
	1708	0.46		1648	0.14
	2332	1.97		2315	2.28
2 SU	0519	0.69	17 M	0506	0.65
	1122	1.99		1057	2.27
	1734	0.42		1729	0.02
3 M	0010	1.98	18 TU	0005	2.33
	0547	0.76		0554	0.71
	1144	1.95		1137	2.25
	1801	0.39		1812	-0.01
4 TU	0046	1.96	19 W	0055	2.33
	0618	0.85		0643	0.80
	1205	1.91		1221	2.17
	1829	0.40		1857	0.05
5 W	0121	1.93	20 TH	0144	2.27
	0649	0.93		0735	0.90
	1227	1.86		1307	2.04
	1859	0.44		1948	0.19
6 TH	0157	1.87	21 F	0233	2.17
	0723	1.02		0836	0.99
	1255	1.80		1359	1.88
	1933	0.50		2043	0.37
7 F	0234	1.81	22 SA	0329	2.05
	0805	1.10		0942	1.06
	1327	1.73		1500	1.71
	2016	0.58		2149	0.56
8 SA	0322	1.76	23 SU	0455	1.96
	0858	1.18		1052	1.09
	1409	1.63		1612	1.57
	2110	0.67		2258	0.71
9 SU	0420	1.72	24 M	0615	1.93
	1012	1.24		1210	1.04
	1527	1.54		1832	1.56
	2216	0.75			
10 M	0542	1.73	25 TU	0010	0.82
	1139	1.22		0716	1.94
	1657	1.50		1328	0.92
	2336	0.78		1952	1.65
11 TU	0655	1.80	26 W	0124	0.86
	1303	1.12		0806	1.95
	1841	1.56		1423	0.79
				2054	1.76
12 W	0046	0.76	27 TH	0225	0.88
	0745	1.90		0842	1.95
	1409	0.95		1505	0.67
	1951	1.70		2139	1.86
13 TH	0149	0.71	28 F	0312	0.88
	0827	2.01		0910	1.95
	1453	0.75		1539	0.57
	2044	1.87		2216	1.95
14 F	0247	0.66	29 SA	0353	0.90
	0905	2.11		0938	1.95
	1532	0.53		1609	0.48
	2135	2.03		2249	2.02
15 SA	0335	0.63	30 SU	0428	0.92
	0942	2.19		1007	1.95
	1610	0.32		1634	0.41
	2224	2.17		2325	2.08
			31 M	0501	0.94
				1034	1.94
				1702	0.35

NOVEMBER

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 TU	0000	2.11	16 W	0000	2.47
	0533	0.98		0543	0.91
	1101	1.92		1112	2.22
	1730	0.33		1750	-0.05
2 W	0035	2.11	17 TH	0045	2.48
	0605	1.02		0634	0.93
	1126	1.90		1200	2.14
	1758	0.35		1836	0.05
3 TH	0107	2.08	18 F	0130	2.43
	0639	1.07		0727	0.97
	1154	1.87		1250	2.02
	1828	0.39		1924	0.22
4 F	0138	2.05	19 SA	0215	2.34
	0713	1.11		0826	1.01
	1227	1.82		1345	1.87
	1900	0.47		2015	0.44
5 SA	0212	2.01	20 SU	0303	2.22
	0755	1.16		0929	1.03
	1303	1.76		1444	1.72
	1941	0.56		2117	0.67
6 SU	0253	1.97	21 M	0356	2.11
	0847	1.20		1033	1.02
	1348	1.67		1553	1.59
	2032	0.68		2223	0.87
7 M	0342	1.93	22 TU	0509	2.02
	0955	1.21		1139	0.98
	1501	1.57		1810	1.56
	2132	0.80		2327	1.02
8 TU	0440	1.92	23 W	0614	1.97
	1109	1.16		1250	0.90
	1635	1.53		1933	1.64
	2245	0.90			
9 W	0551	1.94	24 TH	0036	1.12
	1218	1.04		0702	1.94
	1827	1.59		1348	0.80
				2042	1.76
10 TH	0001	0.96	25 F	0147	1.17
	0655	2.00		0741	1.93
	1324	0.86		1432	0.68
	1938	1.76		2128	1.87
11 F	0109	0.97	26 SA	0243	1.18
	0741	2.08		0818	1.92
	1416	0.64		1505	0.58
	2034	1.95		2204	1.98
12 SA	0213	0.96	27 SU	0328	1.17
	0823	2.15		0853	1.92
	1500	0.40		1535	0.49
	2129	2.13		2238	2.07
13 SU	0312	0.93	28 M	0407	1.16
	0903	2.20		0925	1.92
	1542	0.19		1604	0.40
	2223	2.29		2313	2.15
14 M	0404	0.91	29 TU	0444	1.15
	0943	2.24		0957	1.92
	1624	0.03		1637	0.35
	2312	2.41		2349	2.20
15 TU	0454	0.90	30 W	0519	1.14
	1027	2.25		1030	1.91
	1706	-0.06		1708	0.33

DECEMBER

	TIME	Ht.		TIME	Ht.
	h m	m		h m	m
1 TH	0024	2.22	16 W	0034	2.64
	0554	1.15		0622	0.98
	1101	1.91		1146	2.12
	1737	0.34		1818	0.10
2 F	0055	2.21	17 TH	0114	2.60
	0629	1.16		0716	0.96
	1133	1.89		1236	2.03
	1807	0.38		1903	0.28
3 SA	0124	2.20	18 F	0154	2.43
	0704	1.16		0811	0.95
	1208	1.87		1333	1.90
	1839	0.45		1948	0.50
4 SU	0155	2.18	19 SA	0233	2.34
	0745	1.16		0907	0.96
	1250	1.81		1427	1.77
	1919	0.54		2036	0.73
5 M	0230	2.16	20 SU	0314	2.23
	0834	1.16		1002	0.95
	1340	1.73		1528	1.64
	2005	0.68		2132	0.96
6 TU	0311	2.14	21 M	0359	2.11
	0934	1.13		1058	0.93
	1450	1.65		1709	1.57
	2058	0.83		2234	1.15
7 W	0356	2.11	22 TU	0448	2.01
	1037	1.06		1157	0.89
	1614	1.60		1845	1.61
	2200	0.98		2339	1.29
8 TH	0445	2.09	23 W	0546	1.93
	1139	0.93		1257	0.82
	1805	1.65		2011	1.71
	2315	1.11			
9 F	0542	2.08	24 TH	0048	1.37
	1239	0.76		0642	1.88
	1924	1.81		1347	0.73
				2107	1.83
10 SA	0029	1.19	25 F	0205	1.39
	0645	2.10		0728	1.86
	1337	0.55		1427	0.63
	2026	2.00		2148	1.96
11 SU	0144	1.21	26 SA	0301	1.36
	0740	2.13		0809	1.86
	1430	0.34		1504	0.53
	2125	2.18		2224	2.07
12 M	0254	1.19	27 TU	0348	1.32
	0829	2.16		0850	1.87
	1518	0.15		1541	0.44
	2220	2.34		2301	2.17
13 TU	0350	1.14	28 W	0427	1.26
	0917	2.19		0929	1.89
	1603	0.02		1616	0.37
	2309	2.46		2336	2.23
14 W	0442	1.08	29 TH	0506	1.22
	1006	2.20		1006	1.91
	1648	-0.04		1651	0.34
	2353	2.52			
15 TH	0532	1.02	30 F	0010	2.28
	1055	2.18		0543	1.19
	1733	-0.01		1042	1.93
				1722	0.33
			31 SA	0041	2.30
				0617	1.16
				1120	1.93
				1753	0.36

ANNEXURE 3.3

BATHYMETRIC SURVEY AS RECEIVED FROM HYDROGRAPHIC SURVEYOR

Annexure 3.3: Bathymetric Survey as Received from Hydrographic Surveyor

Chainage (km)	Easting(m)	Northing(m)	Raw Depth(m)	Reduced Depth w.r.t CD (m)
0.00	15° 08' 30.96245"	73° 57' 00.28704"	7.26	6.66
0.07	15° 08' 33.18133"	73° 57' 01.28422"	3.00	2.39
0.20	15° 08' 36.81169"	73° 57' 03.20921"	3.73	3.06
0.34	15° 08' 41.45687"	73° 57' 02.91964"	3.49	2.80
0.42	15° 08' 44.01879"	73° 57' 03.57475"	3.17	2.46
0.52	15° 08' 46.37158"	73° 57' 05.86757"	2.70	1.98
0.61	15° 08' 48.86496"	73° 57' 04.72755"	3.42	2.69
0.68	15° 08' 51.29749"	73° 57' 04.28973"	3.46	2.73
0.78	15° 08' 53.86684"	73° 57' 06.40494"	2.30	1.56
0.87	15° 08' 56.50274"	73° 57' 06.87309"	2.15	1.41
0.97	15° 08' 58.97146"	73° 57' 04.69754"	2.85	2.10
1.07	15° 09' 01.26491"	73° 57' 02.27625"	2.75	1.99
1.14	15° 09' 03.60060"	73° 57' 03.19919"	2.73	1.96
1.25	15° 09' 05.51330"	73° 57' 05.95894"	2.42	1.65
1.33	15° 09' 07.75057"	73° 57' 07.48179"	2.27	1.48
1.43	15° 09' 10.80182"	73° 57' 06.28940"	3.47	2.67
1.52	15° 09' 13.69557"	73° 57' 05.03009"	2.21	1.40
1.62	15° 09' 15.63727"	73° 57' 07.72910"	2.72	1.90
1.72	15° 09' 17.58411"	73° 57' 10.34466"	5.47	4.64
1.82	15° 09' 20.65330"	73° 57' 09.72244"	2.57	1.73
1.92	15° 09' 23.83418"	73° 57' 08.97335"	1.63	0.78
2.01	15° 09' 26.82412"	73° 57' 09.78556"	2.35	1.49
2.11	15° 09' 29.58745"	73° 57' 11.55514"	2.78	1.91
2.20	15° 09' 32.12451"	73° 57' 10.50230"	2.09	0.91
2.39	15° 09' 36.66003"	73° 57' 06.22033"	3.05	1.87
2.49	15° 09' 39.14898"	73° 57' 04.06064"	2.65	1.46
2.59	15° 09' 41.72278"	73° 57' 02.02182"	2.75	1.56
2.69	15° 09' 44.30411"	73° 56' 59.92464"	1.95	0.75
2.79	15° 09' 46.55790"	73° 56' 57.51712"	2.15	0.95
2.89	15° 09' 48.68010"	73° 56' 55.08544"	2.34	1.13
2.99	15° 09' 50.97477"	73° 56' 52.65357"	2.54	1.33
3.09	15° 09' 53.47847"	73° 56' 50.52589"	2.51	1.29
3.19	15° 09' 56.11931"	73° 56' 48.56673"	2.59	1.36
3.29	15° 09' 58.91296"	73° 56' 46.85542"	2.98	1.75
3.39	15° 10' 01.83831"	73° 56' 45.33243"	3.42	2.18
3.49	15° 10' 04.83230"	73° 56' 44.01650"	3.60	2.35
3.59	15° 10' 08.02872"	73° 56' 43.46586"	3.57	2.31
3.69	15° 10' 11.27943"	73° 56' 43.53050"	3.80	2.54
3.79	15° 10' 14.46875"	73° 56' 44.10609"	3.69	2.42
3.89	15° 10' 17.47896"	73° 56' 45.42042"	3.22	1.94
3.99	15° 10' 19.83766"	73° 56' 47.71274"	3.12	1.84
4.09	15° 10' 21.76439"	73° 56' 50.39625"	2.64	1.36
4.19	15° 10' 22.89237"	73° 56' 53.54077"	2.50	1.21
4.29	15° 10' 23.75534"	73° 56' 56.73420"	2.41	1.12

Chainage (km)	Easting(m)	Northing(m)	Raw Depth(m)	Reduced Depth w.r.t CD (m)
4.44	15° 10' 24.55633"	73° 57' 01.92403"	2.44	1.14
4.54	15° 10' 22.27646"	73° 57' 04.25406"	2.81	1.51
4.64	15° 10' 20.16189"	73° 57' 06.78966"	2.71	1.40
4.80	15° 10' 20.63941"	73° 57' 12.06652"	2.06	0.74
4.90	15° 10' 17.59043"	73° 57' 13.18696"	3.64	2.32
4.99	15° 10' 15.75799"	73° 57' 15.51641"	5.00	3.68
5.09	15° 10' 16.28492"	73° 57' 18.82542"	1.53	0.20
5.18	15° 10' 15.39762"	73° 57' 21.66757"	1.67	0.32
5.28	15° 10' 16.06364"	73° 57' 24.94138"	2.09	0.74
5.37	15° 10' 17.93985"	73° 57' 27.56524"	2.70	1.35
5.47	15° 10' 20.86512"	73° 57' 29.03431"	2.98	1.63
5.57	15° 10' 23.95573"	73° 57' 30.01335"	3.58	2.23
5.67	15° 10' 27.12057"	73° 57' 30.79133"	3.69	2.34
5.77	15° 10' 30.32099"	73° 57' 31.37847"	4.40	3.05
5.87	15° 10' 33.47828"	73° 57' 32.14208"	3.98	2.63
5.97	15° 10' 36.37881"	73° 57' 33.68168"	2.75	1.40
6.07	15° 10' 38.62798"	73° 57' 36.02970"	2.05	0.70
6.17	15° 10' 41.19406"	73° 57' 38.01395"	2.05	0.70
6.27	15° 10' 43.73134"	73° 57' 39.96485"	2.19	0.84
6.37	15° 10' 46.14911"	73° 57' 42.25244"	2.87	1.52
6.47	15° 10' 48.76204"	73° 57' 44.23483"	2.69	1.34
6.57	15° 10' 51.03644"	73° 57' 46.62804"	3.15	1.80
6.67	15° 10' 53.67411"	73° 57' 48.47428"	1.63	0.28
6.76	15° 10' 56.84533"	73° 57' 49.01340"	1.43	0.09
6.86	15° 11' 00.06982"	73° 57' 48.68200"	1.79	0.45
6.96	15° 11' 03.07960"	73° 57' 47.51960"	3.02	1.68
7.06	15° 11' 05.81391"	73° 57' 45.68765"	3.32	1.98
7.52	15° 11' 17.60217"	73° 57' 36.54061"	2.21	0.87
7.62	15° 11' 20.48124"	73° 57' 34.98367"	4.20	2.86
7.72	15° 11' 23.58356"	73° 57' 33.99163"	3.34	2.00
7.81	15° 11' 26.59134"	73° 57' 33.03657"	2.52	1.19
7.91	15° 11' 29.82277"	73° 57' 33.15410"	2.84	1.51
8.01	15° 11' 32.82106"	73° 57' 34.43964"	2.98	1.65
8.11	15° 11' 35.63821"	73° 57' 36.10376"	3.00	1.67
8.21	15° 11' 38.19266"	73° 57' 38.10529"	4.31	2.98
8.31	15° 11' 40.75581"	73° 57' 40.16075"	5.53	4.20
8.41	15° 11' 43.40352"	73° 57' 42.06166"	1.81	0.48
8.51	15° 11' 45.21101"	73° 57' 44.82359"	1.93	0.60
8.61	15° 11' 46.05797"	73° 57' 48.04129"	2.01	0.68
8.71	15° 11' 46.37362"	73° 57' 51.43016"	2.32	1.00
8.81	15° 11' 46.36007"	73° 57' 54.78177"	3.19	1.87
8.91	15° 11' 46.19742"	73° 57' 58.12439"	3.19	1.87
9.01	15° 11' 45.54177"	73° 58' 01.33368"	1.34	0.02
9.11	15° 11' 45.00330"	73° 58' 04.62383"	1.87	0.55
9.20	15° 11' 45.44955"	73° 58' 07.76475"	1.88	0.56

Chainage (km)	Easting(m)	Northing(m)	Raw Depth(m)	Reduced Depth w.r.t CD (m)
9.30	15° 11' 47.68210"	73° 58' 10.19895"	2.21	0.89
9.40	15° 11' 50.21410"	73° 58' 12.28888"	2.18	0.86
9.50	15° 11' 52.87024"	73° 58' 14.27132"	2.88	1.56
9.60	15° 11' 55.31616"	73° 58' 16.39889"	4.28	2.96
9.70	15° 11' 57.40477"	73° 58' 18.95751"	5.56	4.24
9.80	15° 11' 59.69157"	73° 58' 21.30606"	5.69	4.37
9.90	15° 12' 02.87622"	73° 58' 21.79701"	3.94	2.62
10.00	15° 12' 05.98418"	73° 58' 20.95788"	2.99	1.66
10.10	15° 12' 07.72072"	73° 58' 18.18598"	1.45	0.12
10.20	15° 12' 07.98689"	73° 58' 14.83272"	2.07	0.74
10.29	15° 12' 06.56332"	73° 58' 11.96119"	2.64	1.31
10.39	15° 12' 04.34890"	73° 58' 09.50674"	2.63	1.30
10.49	15° 12' 02.26134"	73° 58' 06.89919"	2.27	0.94
10.59	15° 12' 00.72209"	73° 58' 03.99945"	2.30	0.97
10.69	15° 11' 59.89059"	73° 58' 00.80370"	2.62	1.29
10.79	15° 11' 59.07032"	73° 57' 57.57641"	2.51	1.18
10.89	15° 11' 58.61137"	73° 57' 54.23040"	2.28	0.95
10.99	15° 11' 58.96894"	73° 57' 50.95984"	2.61	1.27
11.09	15° 11' 59.89400"	73° 57' 47.74850"	2.57	1.23
11.19	15° 12' 01.08734"	73° 57' 44.63839"	2.50	1.16
11.29	15° 12' 02.11570"	73° 57' 41.46239"	2.88	1.54
11.39	15° 12' 03.21496"	73° 57' 38.28033"	1.75	0.41
11.49	15° 12' 05.27305"	73° 57' 35.75813"	2.30	0.96
11.59	15° 12' 07.69609"	73° 57' 33.47776"	4.00	2.65
11.69	15° 12' 10.71181"	73° 57' 32.41065"	1.90	0.55
11.78	15° 12' 13.36165"	73° 57' 34.13631"	2.17	0.82
11.88	15° 12' 15.39365"	73° 57' 36.74139"	2.23	0.88
12.18	15° 12' 23.19302"	73° 57' 42.74566"	1.64	0.28
12.58	15° 12' 33.82776"	73° 57' 50.42732"	1.71	0.34
12.68	15° 12' 36.70142"	73° 57' 52.00319"	2.29	0.92
12.78	15° 12' 39.74346"	73° 57' 53.18212"	3.99	2.62
12.88	15° 12' 42.86585"	73° 57' 53.08443"	3.83	2.45
12.97	15° 12' 43.75661"	73° 57' 50.12845"	1.96	0.58
13.07	15° 12' 43.02812"	73° 57' 46.98366"	2.49	1.11
13.17	15° 12' 43.02479"	73° 57' 43.58094"	2.66	1.28
13.46	15° 12' 47.57776"	73° 57' 35.02916"	1.84	0.45
13.56	15° 12' 50.32587"	73° 57' 33.23771"	2.23	0.84
13.66	15° 12' 53.00280"	73° 57' 31.39600"	2.66	1.27
13.76	15° 12' 55.84079"	73° 57' 29.75791"	3.05	1.66
13.86	15° 12' 58.89625"	73° 57' 28.63120"	3.20	1.80
13.96	15° 13' 02.05838"	73° 57' 27.91082"	3.23	1.83
14.06	15° 13' 05.27623"	73° 57' 27.48745"	2.54	1.14
14.16	15° 13' 08.46115"	73° 57' 27.82303"	2.32	0.92
14.26	15° 13' 11.15310"	73° 57' 29.71314"	2.94	1.54

Note: Reduced depth has been reckoned by applying tide variation Min 0.60m & Max 1.40m

ANNEXURE 3.4

PHOTOS CAPTURED BY SURVEY TEAM DURING RECONNAISSANCE SURVEY

Annexure 3.4: PHOTOS CAPTURED BY SURVEY TEAM DURING RECONNAISSANCE SURVEY

Photo 1: Shallow Patch on the River at Ch 0.52km (15˚08'46.7"N, 73˚57'08.1"E)

Photo 2: Cutbona Fishing jetty at Ch 1.31km (15˚09'06.9"N, 73˚57'07.9"E)

Photo 3: Coast along bank of River at Ch 1.95km (15˚09’24.7”N, 73˚57’09.1”E)

Photo 4: High Tension line Crossing Over River at Ch 2.20km (15˚09'33.3089"N, 73˚57'12.1275"E)

Photo 5: Fishing stakes in the middle of the River at Ch 2.32 km (15°09'35.1275"N, 73°57'07.8832"E)

Photo 6: Cutbona fishing jetty at Ch 2.34km (15°09'39.4690"N, 73°57'11.8464"E)

Photo 7: Boat Repairing Yard at Ch 3.58km (15˚10'07.8"N, 73˚56'42.8"E)

Photo 8: Hotel on the River bank at Ch 3.94km (15˚10'19.0"N, 73˚56'46.1"E)

Photo 9: Electric Wire crossing River at Ch 4.21km
(15°10'14.2572"N, 73°56'56.7898"E)

Photo 10: Asolna Bridge at Ch 6.20km
(15°10'41.9539"N, 73°57'38.7456"E)

Photo 11: Ferry Jetty of Cavelossim village at Ch 6.39km (15°10'48.2124"N, 73°57'40.7286"E)

Photo 12: Asolna Ferry Jetty at Ch 6.46km (15°10'47.0485"N, 73°57'46.0493"E)

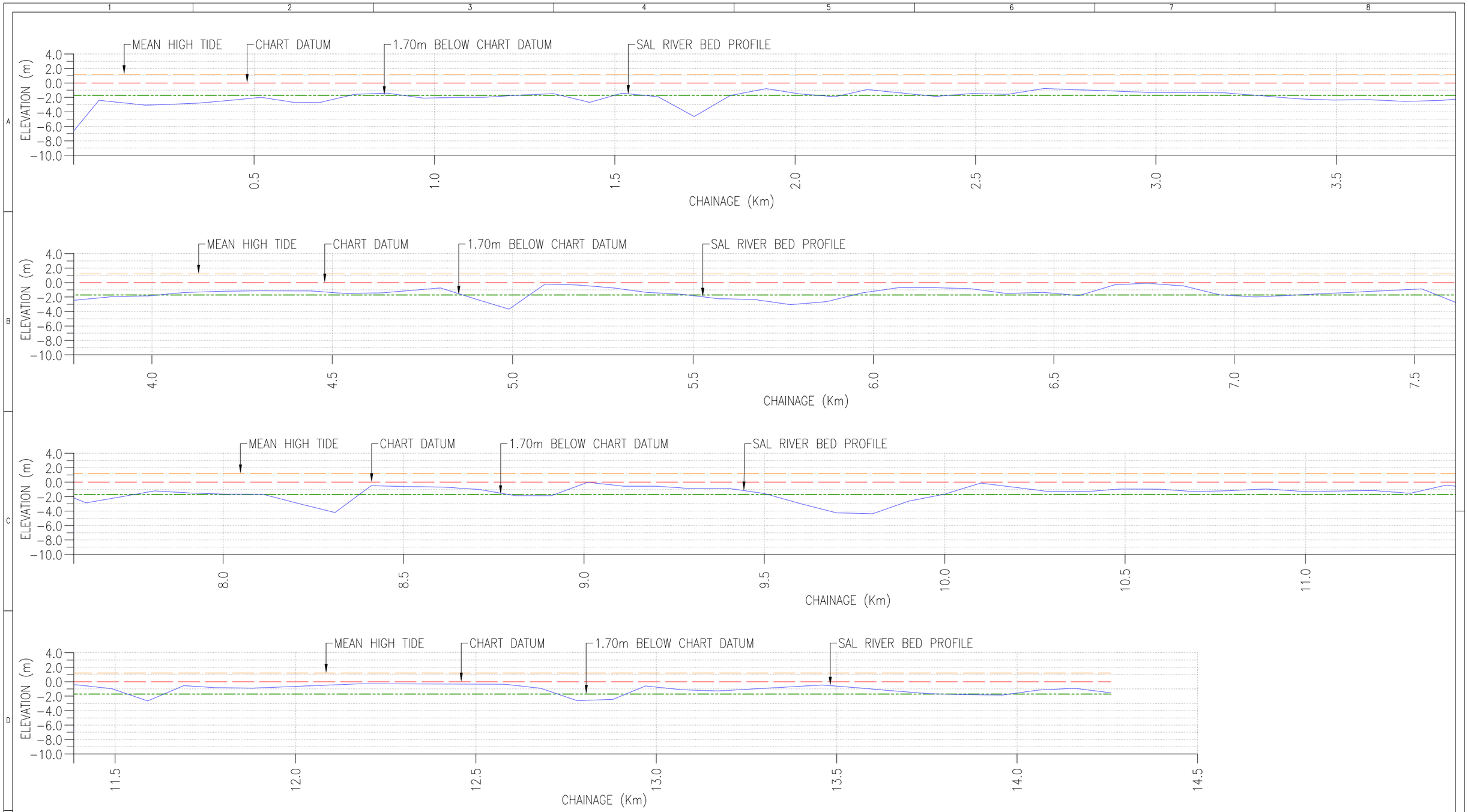
Photo 13: Electric Wire Crossing River at Ch 9.55km
(15°11'53.9536"N, 73°58'15.2019"E)

Photo 14: Ferry Jetty at Ch 10.05km
(15°12'07.2748"N, 73°58'19.8492"E)

Photo 15: Navelim Bridge at Ch 14.26km
(15°13'11.4112"N, 73°57'29.0631"E)

ANNEXURE 3.5

LONGITUDINAL BED PROFILE OF SAL RIVER WATERWAY



LEGENDS

- MEAN HIGH TIDE
- CHART DATUM
- 1.70m DEPTH BELOW CHART DATUM
- SAL RIVER BED PROFILE

ANNEXURE 3.5

SAL RIVER LONGITUDINAL BED PROFILE

ANNEXURE 3.6

COMPILATION OF FIELD INFORMATION OF SAL RIVER IN IWAI FORMAT

Annexure 3.6: Compilation of Field Information of Sal River in IWAI Format

SL#	DESCRIPTION	DETAILS	REMARKS
	NAME OF THE FIRM	**Fugro Survey (India) Pvt Ltd**	
	REGION / CLUSTER NO.	**Cluster-7/ Stage-I/ Goa**	
1	NAME OF THE WATERWAY	Sal River	
2	LENGTH OF THE WATERWAY (km)	14Kms	
3	WATERWAY IN THE STATES OF	Goa	
4	FIELD WORK COMPLETED FOR THE LENGTH OF THE WATERWAY (km)	14 kms (Data acquisition done on 01.03.2016)	
TIDAL WATERWAYS			
5	Length of the waterway having tidal effects (km)	14Kms	
6	Start & end location name having tidal effects	Betul to Khareband Bridge	
7	Tidal variation (m)		For Tide Variation measurement 24 Hrs continuous observation is required at one place which is not in scope in Stage-1.
DEPTH INFORMATION			
8	Length of the waterway, where depths more than 2m is observed	3.25 Km	
9	Length of the waterway, where depths more than 1.5m is observed	6.65 Km	
	Length of the waterway, where depths more than 1.0m is observed	9.86 Km	
10	Existing Water level (m)	0.02m to 6.66 m	
11	Minimum Water Level (m)	0.02	
12	Highest Flood level (m)	-	We have not seen HFL marking in any Bridges
CROSS-STRUCTURE INFORMATION			
13	Existing list of Dam, Barrages, Locks	Nil	
14	Existing Bridges (nos.)	2	
15	Minimum Vertical and Horizontal clearances (m) as per visual estimation	1) Asolna Road Bridge - Ch 6.20 km, VC: 8.5 m, HC: 42 m 1) Orlim-Deusa Road Bridge - Ch 14.26 km, VC: 6.5 m, HC: 25 m	Assolna Bridge is left with old piers erected below the bridge, hence clearance is reduced, can be seen in photos. Vertical clearance above MHWS
16	High Tension lines	1 HT Line (Near Cutbona fishing jetty at Ch 2.2Km),	1 electric wire at Ch 4.2 km and 2nd electric wire at Ch 9.5 km from starting point
NAVIGATIONAL OBSTRUCTION			
17	Rocks	Nil	
18	Steep gradients		Refer the Drawing
ENVIRONMENTAL & OTHER ISSUES			
19	Details of wildlife /forest area	Nil	
20	Protected areas	Nil	
21	Security clearances	Nil	

SL#	DESCRIPTION	DETAILS	REMARKS
CARGO AND OTHER DETAILS			
22	Availability of passenger ferry services along the waterway	1	Ferry Jetty connecting Cavelossim & Asolna is functional
23	Estimated cargo movement through proposed waterway, road and rail	Nil	
24	Type of crops (in different seasons) and industries along the waterway	Nil	
25	Availability of prominent towns / City along the waterway.	Mober, Bapsora, Cavelossim, Carmona, Bamado, salcete, Margao, Asolna	
26	Historical and tourist places along waterway	Nil	
27	Existing water sport and recreational activities and future probability	Nil	
28	Existing Jetties and Terminals	5 Jetties, No Terminal	Some small jetties are associated with villages on the river bank while some jetties stood isolated.

ANNEXURE 4.1

LIST OF INDUSTRIES IN SAL RIVER CATCHMENT REGION

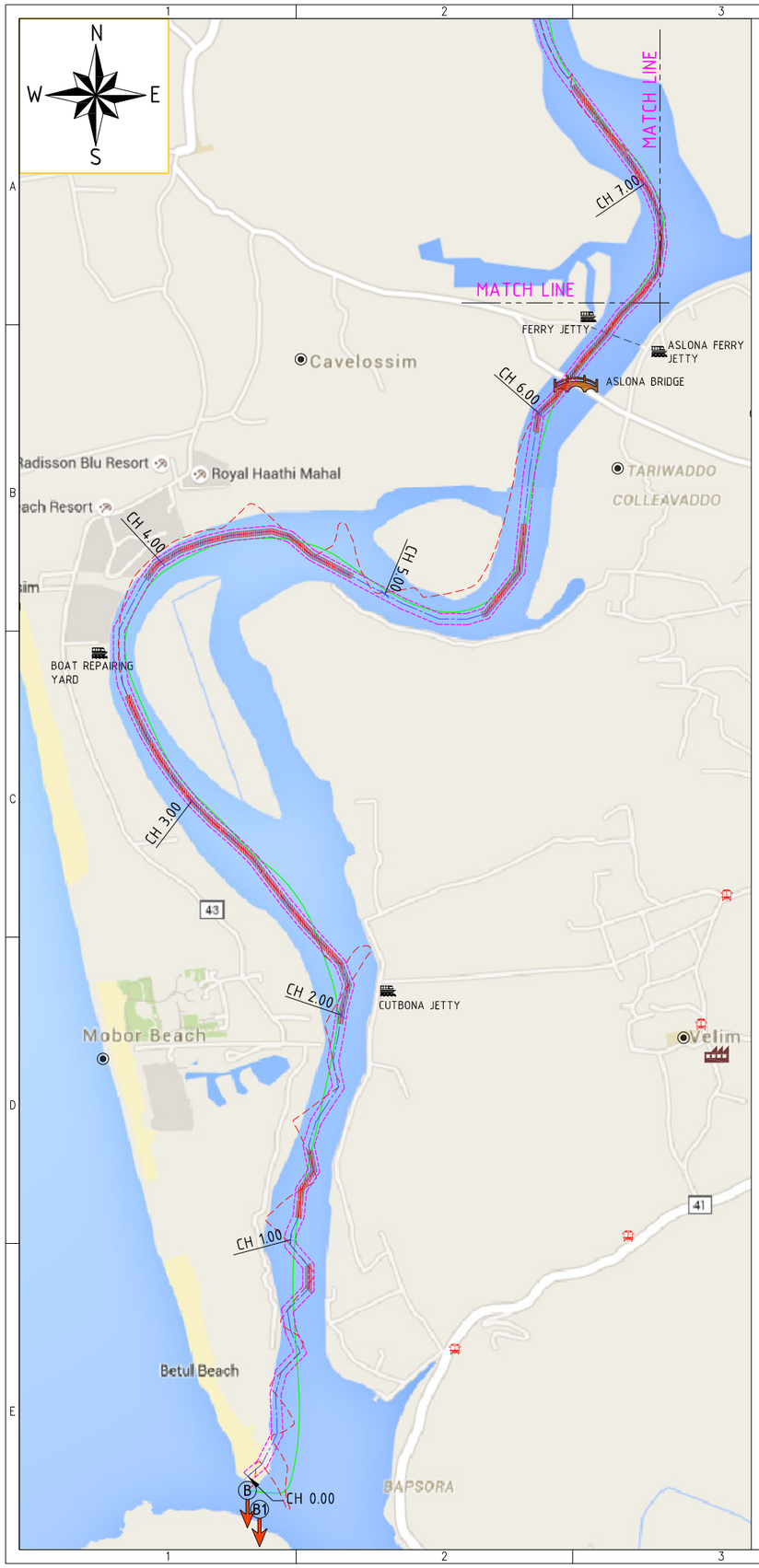
Annexure 4.1: List of Industries in Sal River Catchment Region

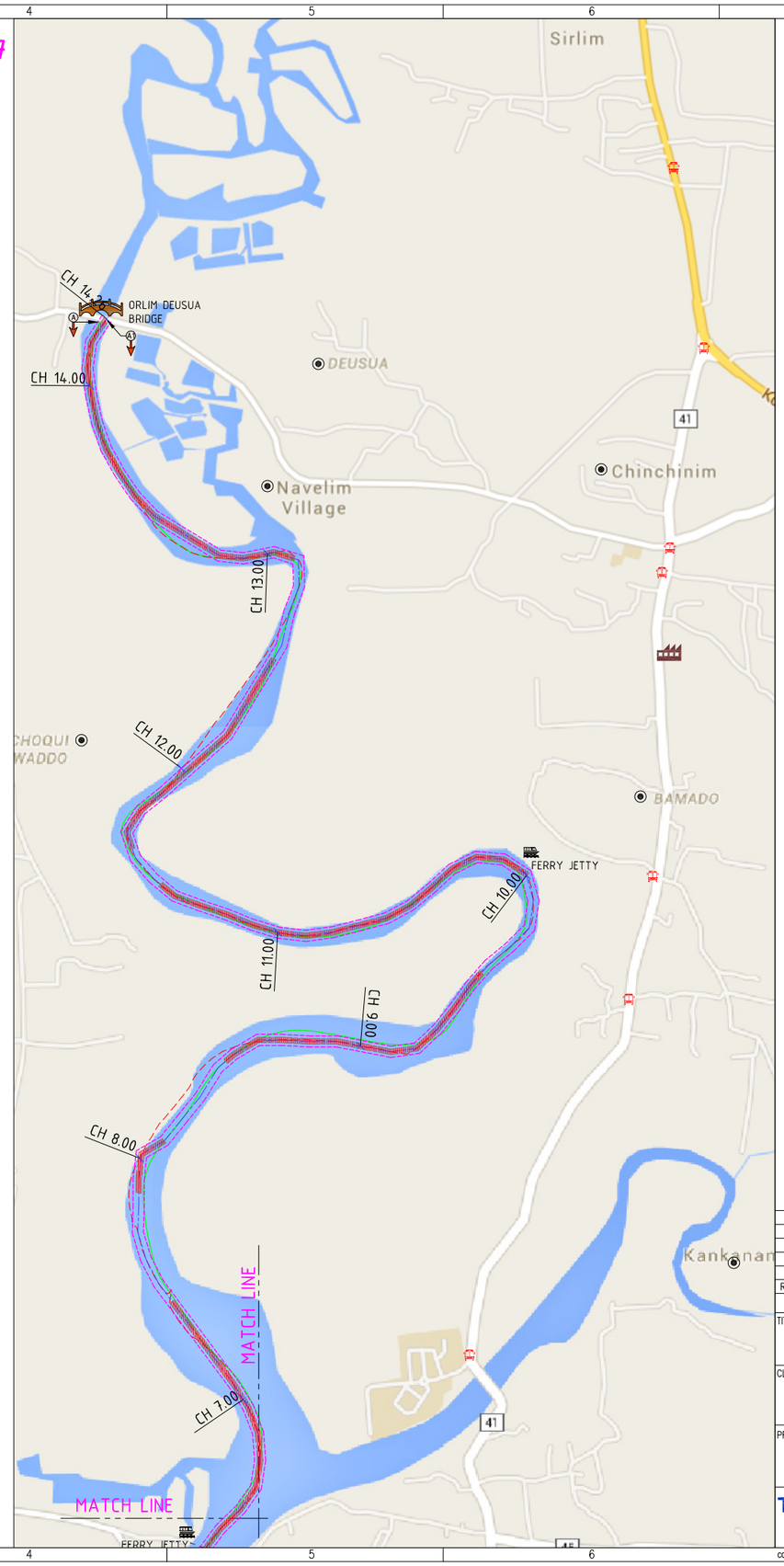
List of Existing Industries, Sal River		
Sl.No.	**Description**	**Symbol**
1	CHOWGULE MARUTI INDUSTRIES LIMITED.	I1
2	VIP INDUSTRIES.	I2
3	EXIDE INDUSTRIES.	I3
4	CAMILSON INDUSTRIES.	I4
5	CHOWGULE INDUSTRIES PVT. LTD.	I5
6	EASYCARE INDUSTRIES.	I6
7	CHEMTECH INDUSTRIES PRIVATE LIMITED.	I7
8	NILMAC PACKAGING INDUSTRIES LIMITED.	I8
9	SIEMENS BUILDINGS TECHNOLOGIES..	I9
10	NICOMAT INDUSTRY LIMITED.	I10
11	NICOMAT INDUSTRIES PRIVATE LIMITED.	I11
12	M/S SHANTADURGA INDUSTRIES -PET BOTTLES.	I12
13	NICOMET INDUSTRIES LIMITED.	I13
14	GLOBAL ISPAT LIMITED.	I14
15	SAGAR FEEDS AND FOOD PROCESSING INDUSTRIES.	I15

DRAWINGS

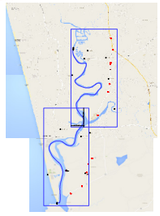
DRAWING NO. P.009051-W-20201-A03 R0 (SHEET-1 TO 1): LAYOUT PLAN – SAL RIVER

53NW CLUSTER-7
STATE OF GOA
SAL RIVER





SHEET INDEX



LEGEND

	BUS STOP
	HISTORICAL PLACE
	PORT
	INDUSTRY
	RAILWAY STATION
	PLACE NAME
	JETTY
	CHART DATUM
	ROAD BRIDGE
	NATIONAL HIGHWAY (Hwy)
	ROAD
	NALA/SUB CREEK/SMALL RIVER
	FERRY LINE
	SURVEY (VESSEL TRACK)
	ROUTE PROVIDED BY IWAI
	DEEPEST SURVEYED WATER DEPTH (THALWEG)
	DREDGED CHANNEL / RIVER LENGTH
	RAILWAY LINE
A	START FROM ORLIM DEUSA BRIDGE AT SAL RIVER AS PROVIDED BY IWAI LAT. 15°13'11.41" LON. 73°57'29.77"
A1	START POINT OF RECONNAISSANCE SURVEY FROM ORLIM DEUSA BRIDGE AT SAL RIVER LAT. 15°13'11.41" LON. 73°57'30"
B	END POINT NEAR ARABIAN SEA AT MOBOR SAL RIVER AS PROVIDED BY IWAI LAT. 15°08'31.93" LON. 73°56'59.89"
B1	END POINT OF RECONNAISSANCE SURVEY MOBOR SAL RIVER LAT. 18°08'31" LON. 73°57'00"

PROPOSED WATERWAY LENGTH 14.0Km

SCALE 0 0.4 1.0KM

BACKGROUND IMAGE REFERENCE FROM "GOOGLE MAP"

REV.	DATE	SIGN	SIGN	SIGN	SIGN	
REVISION		DRAWN	DESIGNED	CHECKED	APPROVED	SUBJECT OF REVISION
–	–	–	–	–	–	–
–	–	–	–	–	–	–
–	–	–	–	–	–	–
–	–	–	–	–	–	–

TITLE: LAYOUT PLAN
SAL RIVER

CLIENT: INLAND WATERWAYS AUTHORITY OF INDIA
MINISTRY OF SHIPPING

PROJECT: CONSULTANCY SERVICE FOR PREPARATION OF TWO STAGE DETAILED PROJECT REPORT (DPR) OF CLUSTER 7 OF PROPOSED 53 NATIONAL WATERWAYS.
STAGE 1 - FEASIBILITY REPORT

PROJECT NO. P.009051

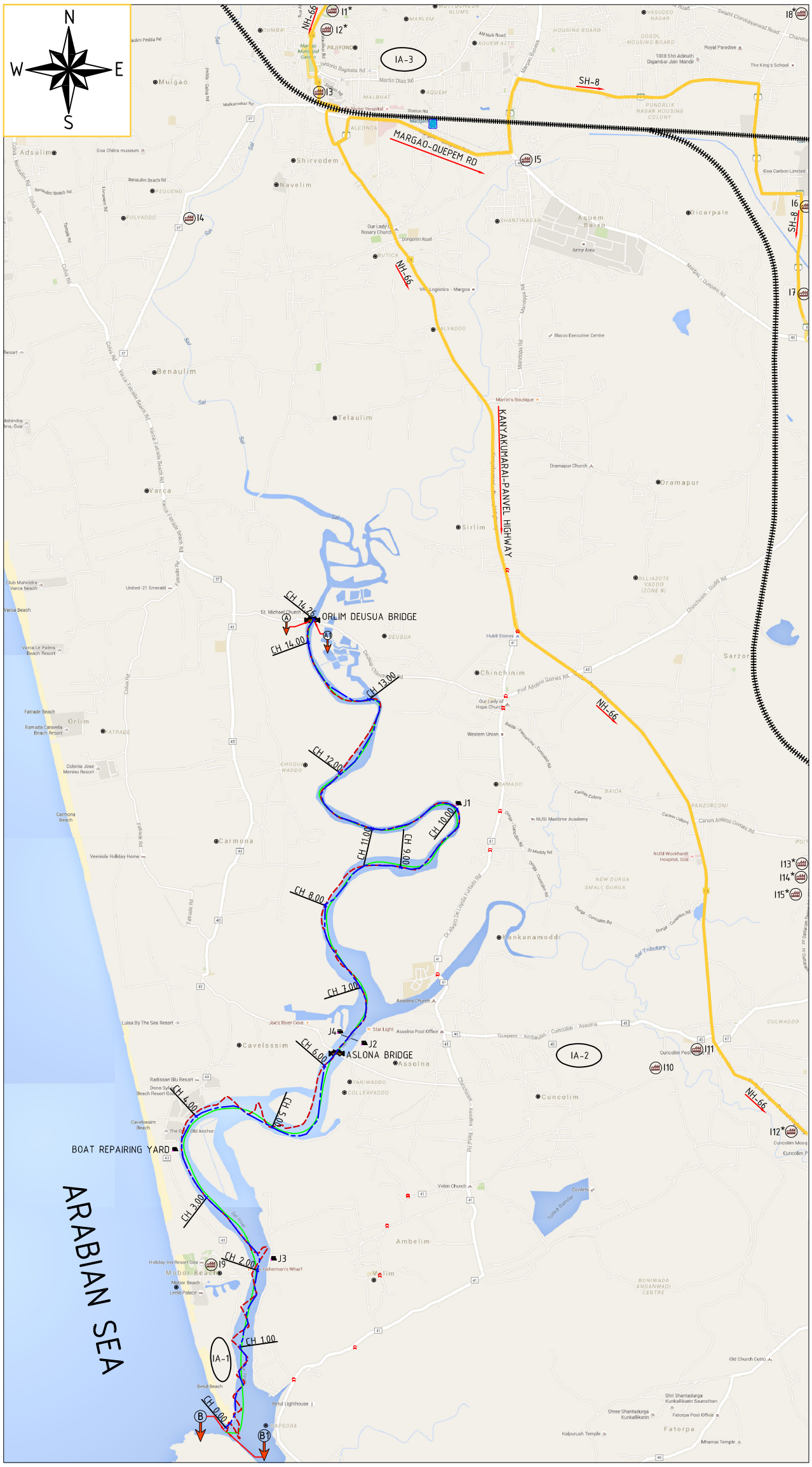
SIZE: A3 | SCALE: 1:20000 | SHEET: 1–1

TRACTEBEL Engineering GDF SUEZ

DRAWING NUMBER: P.009051-W-20201-A03 REV 0

MAPS

MAP 4.1 - LAYOUT MAP SHOWING EXISTING JETTIES AND INDUSTRIES IN VICINITY OF SAL RIVER



LEGEND	MAP 4.1
	BUS STOP
	HISTORICAL PLACE
	PORT
	EXISTING INDUSTRY
	PROPOSED INDUSTRY
	RAILWAY STATION
	PLACE NAME
	JETTY
	CHART DATUM
	ROAD BRIDGE
	NATIONAL HIGHWAY (Hwy)
	ROAD
	NALA/CREEK/SMALL RIVER
	FERRY LINE
	ROUTE PROVIDED BY IWAI
	SURVEY (VESSEL TRACK)
	DEEPEST SURVEYED WATER DEPTH (THALWEG)
	RAILWAY LINE
A	START FROM ORLIM DEUSA BRIDGE AT SAL RIVER AS PROVIDED BY IWAI LAT. 15°13'11.41" LON. 73°57'29.77"
A1	START POINT OF RECONNAISSANCE SURVEY FROM ORLIM DEUSA BRIDGE AT SAL RIVER LAT. 15°13'11.41" LON. 73°57'30"
B	END POINT NEAR ARABIAN SEA AT MOBOR SAL RIVER AS PROVIDED BY IWAI LAT. 15°08'31.93" LON. 73°56'59.89"
B1	END POINT OF RECONNAISSANCE SURVEY MOBOR SAL RIVER LAT. 18°08'31" LON. 73°57'00"

PROPOSED WATERWAY LENGTH 14.0 Km

SCALE 0 2km 5.0KM

BACKGROUND IMAGE REFERENCE FROM "GOOGLE MAP"

LIST OF EXISTING INDUSTRY		
SL.	DESCRIPTION	SYMB.
1	CHOWGULE MARUTI * (TENTATIVE LOCATION)	I1*
2	VIP INDUSTRIES * (TENTATIVE LOCATION)	I2*
3	EXIDE INDUSTRIES	I3
4	CAMILSON INDUSTRIES	I4
5	CHOWGULE INDUSTRIES PVT. LTD.	I5
6	EASYCARE INDUSTRIES	I6
7	CHEMTECH INDUSTRIES PRIVATE LIMITED	I7
8	NILMAC PACKAGING INDUSTRIES LIMITED * (TENTATIVE LOCATION)	I8*
9	SIEMENS BUILDINGS TECHNOLOGIES	I9
10	NICOMAT INDUSTRY LIMITED	I10
11	NICOMAT INDUSTRIES PRIVATE LIMITED	I11
12	M/S SHANTADURGA INDUSTRIES -PET BOTTLES * (TENTATIVE LOCATION)	I12*
13	NICOMET INDUSTRIES LIMITED * (TENTATIVE LOCATION)	I13*
14	GLOBAL ISPAT LIMITED * (TENTATIVE LOCATION)	I14*
15	SAGAR FEEDS AND FOOD PROCESSING INDUSTRIES * (TENTATIVE LOCATION)	I15*

LIST OF JETTIES		
SL.	DESCRIPTION	SYMB.
1	FERRY JETTY	J1
2	ASLONA FERRY JETTY	J2
3	CUTBONA JETTY	J3
4	FERRY JETTY	J4

LIST OF EXISTING INDUSTRIAL AREAS		
SL.	DESCRIPTION	SYMB.
1	BETUL INDUSTRIAL AREA	IA-1
2	CUNCOLIM INDUSTRIAL AREA	IA-2
3	MARGAO INDUSTRIAL AREA	IA-3

TITLE: LAYOUT MAP SHOWING EXISTING JETTIES & INDUSTRIES IN VICINITY OF SAL RIVER (MAP 4.1)

CLIENT: INLAND WATERWAYS AUTHORITY OF INDIA, MINISTRY OF SHIPPING

PROJECT: CONSULTANCY SERVICE FOR PREPARATION OF TWO STAGE DETAILED PROJECT REPORT (DPR) OF CLUSTER 7 OF PROPOSED 53 NATIONAL WATERWAYS. STAGE 1 - FEASIBILITY REPORT

PROJECT NO. P.009051

TRACTEBEL Engineering GDF SUEZ

At the helm of the Energy Transition, Tractebel provides a full range of engineering and consulting services throughout the life cycle of its clients' projects, including design and project management. As one of the world's largest engineering consultancy companies and with more than 150 years of experience, it's our mission to actively shape the world of tomorrow. With about 4,400 experts and offices in 33 countries, we are able to offer our customers multidisciplinary solutions in energy, water and infrastructure.

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