Preface

India is the largest peninsula in the world with a coastline of about 7517 km with 12 major ports and 185 non-major / intermediate ports with a very impressive water network consisting of rivers, lakes, creeks and canals.

An efficient transport sector is vital for development of the economy to stimulate optimum competitive business environment. Indian transport system comprises various modes, viz. Railways, Roadways, Inland Waterways, Coastal Shipping and Airways. Integrated development of waterways can generate waterway grid that may in future help shift cargo traffic from road transport to the cheaper and eco-friendly inland waterways.

The first national waterways were established in India in mid 1980s & 1993 with a combined length of 2,716 km:

NW 1 (1620 km): Ganga - Bhagirathi- Hooghly river system between Haldia & Allahabad declared as National waterway in 1986

NW 2 (891 Km): Brahmaputra River between Bangladesh Border and Sadiya declared as National waterway in 1988

NW 3 (205 km): West coast canal (168 km) - Udyog mandal canal (23 km) - Champakara canal (14 km) declared as National waterway in 1993

The government also declared the following two inland waterways as national waterways during 2008:

NW 4 (1078 km): Kakinada-Pondicherry canal - Godavari and Krishna rivers

NW 5 (588 km): East Coast Canal - Brahmani River and Mahanadi delta

Given the untapped potential of India's inland waterways, the Govt. of India desires to explore the commercial navigation potential on year round basis. Ministry of Shipping (MoS), Govt. of India has directed Inland Waterways Authority of India (IWAI) to identify the viable waterways in India for their phased development.

Accordingly, 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, National Waterway Act, 2016 has received the assent of the President on the 25th March, 2016 declaring a total of 111 National Waterways.

IWAI, a statutory body under MoS, Govt. of India, has entrusted WAPCOS with the responsibility for preparation of two stages DPR of proposed six waterways in Tamil Nadu and Andhra Pradesh: **National waterway No's 55 (Kaveri Kollidam), 75 (Palar), 77 (Pazhyar), 79 (Pennar), 80 (Ponniyar) and 99 (Tamaraparani)** for a total length of 763 km.

This Final Feasibility report (Stage-I) covers the review of data, reconnaissance survey, preliminary traffic and market analysis and navigation development feasibility for Tamaraparani river. The consultant team has physically visited the 64 km river stretch and gathered all requisite information.

Acknowledgement

This Final Feasibility report (Stage 1) is the outcome of review of existing infrastructure along the Tamaraparani River, present state of affairs and the probability of development as Inland waterway. This vision is shared jointly by IWAI and WAPCOS Limited.

This report gives the present status of water ways assets, topographic features, climatic variability, land use / land cover pattern, details of all cross structures, socio-economic information of the waterways and the feasibility of its development as national waterway as per classification by Govt. of India (Gazette Notification).

We, WAPCOS project team acknowledge Cdr. P. K. Srivastava, Hydrographic Chief, Inland Waterways Authority of India; Sh Rajiv Singhal, AHS for constant encouragement and guidance, technical discussions and for evincing keen interest in the project and this report.

WAPCOS Team

Sector -18, Gurgaon
Haryana- 122015

List of Abbreviations

ATT	Admiralty Tide Table
BM	Bench Mark / Local Reference Level
CH	Chainage
CM	Central Meridian
CRZ	Coastal Regulation Zone
CWC	Central Water Commission
CVT	Calibration, Verification & Test
DF	Dual Frequency
DGPS	Differential Global Positioning System
DPR	Daily Progress Report
GPS	Global Positioning System
HFL	High Flood Level
HC	Horizontal Clearance
HSE	Health, Safety and Environment
KHz	kilohertz
km	kilometer
m	meter
MHWS	Mean High Water Spring
mmtpa	million metric tons per annum
MN	million
m/s	meter per second
ms	milliseconds
MSL	Mean Sea Level
PWD	Public Works Department
QA/QC	Quality Assurance / Quality Control
QMS	Quality Management System
Rev	Revision
Rep.	Representative
SBES	Single Beam Echo sounder
SD	Standard Deviation
Sr	Senior
UTM	Universal Transverse Mercator
VC	Vertical Clearance
WGS	World Geodetic System

Table of Contents

List of Tables

List of Figures

List of Annexure

SUMMARY: SALIENT FEATURES AT A GLANCE

<table>
<tr><th>Sr. No.</th><th>Particulars</th><th>Details</th></tr>
<tr><td>1.</td><td>Name of Consultant</td><td>WAPCOS Limited</td></tr>
<tr><td>2.</td><td>Cluster number and State(s)</td><td>Cluster-5, Tamil Nadu & Andhra Pradesh</td></tr>
<tr><td>3.</td><td>Waterway stretch, NW</td><td>64 km length from Sulochana Mudalir bridge, Tirunelveli to confluence with Bay of Bengal near Punnaikayal,
(National Waterways 99)</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>During the reconnaissance survey carried out in the river, tidal influence was observed upto 9.23 kms.
The Nearest Port is Tuticorin (about 15 km away). As per tide data from Tuticorin Port the tidal variation is about 0.74 m. (refer Para 4.3)
(Source : Admiralty tide table ATT Volume 3)</td></tr>
<tr><td>b)</td><td>LAD status (w.r.t. CD)
i) Survey period (April to May)</td><td>
<table>
<tr><th>LAD (m)</th><th>0-9.3</th><th>9.3-20</th><th>20-30</th><th>30-40</th><th>40-50</th><th>50-64</th><th>Total</th></tr>
<tr><td>< 1.0</td><td>5.18</td><td>5.22</td><td>5.94</td><td>7.91</td><td>8.48</td><td>9.78</td><td>42.51</td></tr>
<tr><td>1.0 -1.2</td><td>0.19</td><td>1.22</td><td>1.01</td><td>0.32</td><td>0.60</td><td>1.09</td><td>4.43</td></tr>
<tr><td>1.2 - 1.4</td><td>1.03</td><td>0.47</td><td>0.84</td><td>0.67</td><td>0.56</td><td>0.70</td><td>4.26</td></tr>
<tr><td>1.4 - 1.7</td><td>1.13</td><td>2.34</td><td>0.63</td><td>0.80</td><td>0.25</td><td>0.38</td><td>5.52</td></tr>
<tr><td>1.7 - 2.0</td><td>1.1</td><td>1.28</td><td>0.48</td><td>0.29</td><td>0.17</td><td>0.27</td><td>3.59</td></tr>
<tr><td>> 2.0</td><td>0.6</td><td>0.08</td><td>1.07</td><td>0.00</td><td>0.00</td><td>0.03</td><td>1.79</td></tr>
</table>
</td></tr>
<tr><td>c)</td><td>Cross structures
i) Dams, weirs, barrages etc. (total number; with navigation locks or not)
ii) Bridges, Power Cables etc. (total number; range of horizontal and vertical clearances)</td><td>There are six check dams dams namely, Latchumipuram Check Dam, Kurangini Check Dam, Srivaiguntam Check Dam, Pakkappati Dam, Kaliyuvar Dam and one Check Dam in the present study stretch. The present study stretch starts from D/S of Latchumipuram Check Dam. Navigational lock is not provided in any of the dams/weir/Anicuts/Barrages in the present study stretch.

Twelve existing road bridges and one under construction bridge, and three pipeline bridge crosses Tamaraparani river in this stretch.
VC from H.F.L. for bridges varies from 2m to 7.75 m.
HC for bridges varies from 5.25m to 19m.

5 HT lines, 4 HC lines and 8 electric lines cross Tamaraparani River in this stretch.
VC from H.F.L. for Power Cables varies from 6m to 18m.
HC for Power Cables varies from 200m to 350m.</td></tr>
</table>

<table>
<tr><td>d)</td><td>Avg discharge & no. of days</td><td>No of Gauge Stations: One at Murappanadu, Tuticorin dist, Tamil Nadu at Chainage 40.55 km
Murappanadu
June to September 7 to 9 m^3/s
October 9 to 20 m^3/s
November - December 40 to 50 m^3/s
January –February 10 to 20 m^3/s
February –June 7 to 8 m^3/s

Murappanadu Gauge-discharge data analysis
The depths are estimated at gauging station at Murappanadu as per CWC data. Even for the lower discharges, the depths of the order of 1 m or more are possible because of river cross-sections at weir at downstream.</td></tr>
<tr><td>e)</td><td>Slope (1 in ….)</td><td>Average slope of river : 1/2940
<table>
<tr><th rowspan="2">River</th><th colspan="2">Reach</th><th rowspan="2">River Bed Lvl change</th><th rowspan="2">Distance</th><th rowspan="2">Slope</th></tr>
<tr><th>From</th><th>To</th></tr>
<tr><td>Tamaraparani</td><td>Murappandu RBL 14.215 m</td><td>Mouth RBL 0.0 m</td><td>14.215 m</td><td>40.55 km</td><td>1/2940</td></tr>
</table></td></tr>
<tr><td>f)</td><td>Consultant’s inference</td><td>0-9.3 km (river mouth to Latchipuram check dam)
This is Tidal reach where bathymetry survey is carried out. This reach has the potential to be developed as class I waterway with little dredging for 365 days in a year.
9.3 - 25.7 km (Latchipuram to Srivaiguntam weir)
Latchipuram check dam exist at downstream end and srivaiguntam weir forms the upstream end of this stretch. Controlled flow at upstream and check dam at downstream ensure availability of water for about 1-2.5 m depth (raw depth) all round the year (365 days).
25.7 – 45.94 km (Srivaiguntam Weir – Kaliyavur weir)
srivaiguntam weir exist at downstream end and Kaliyavur weir forms the upstream end of this stretch. Pakapatti weir also exist at chainage of about 40.60 km. Controlled flow at both the ends ensure availability of water for about 1 -2.5 m depth (raw depth) all round the year (365 days).
45.94 – 64 km (Kaliyavur weir- Sulochana Mudliar Bridge)
Navigation is feasible for about 245 days (8 months) in year with little capital dredging at some shallow reaches as about 1 m depth is available without dredging at Murappanadu gauge station. Actual availability of depth of water</td></tr>
</table>

		all along the river stretch will only be commented after having cross-section data of the river in Stage II.
5.	Traffic Potential	
a)	Present IWT operations, ferry services, tourism, cargo, if any	**Cargo** The potential exists for minerals and general cargo. Mouth of the river is close to the port and River has substantial share of minerals products that are mostly exported to Maldives using small vessels. Potential exists for minerals & boulders which are minor & fragmented segment. A large volume of stones, boulders, etc. could be transported using River Sea Class ships in the Tamaraparani River to VOC Port. Presently, about 1 mn Tonnes of these commodities are transported to VOC port using road route to Zone B of port. The Zone B of VOC Port is an old port located closer to city. About 1 mn Tonnes of cargo is available annually. Limestone, Rough stone, garnet and granite may be transported from trivenveli district using inland waterway. **Ferry services** There are no passenger ferry services available on the proposed stretch of Tamaraparani River but they can be developed near river mouth. **Tourism** As there are a number of towns around the river for which passenger, Tourism and Ro-Ro facilities can be developed can be developed. The Significant places are Tuticorin City, Tiruchendur temple, hare Island, Roche Park, Church of Lady of Snow, Kulasekarapattinam Mutharamman Temple, Kanthimathi-Nellaiappar Temple located very near to Tamarapani river for which waterway can be developed for tourism and local ferry services.
b)	Important Industries within 50 km	There are three industrial areas each in Tuticorin and Tiruneveli, which are in 50 km range from river. SIDCO Pettai Industrial area is the largest one with an aggregate of 51 acres. There are 71 units operating in the industrial estate. The industrial area is located at a distance of 6 km from Tamaraparani River.
c)	Distance of Rail & Road from industry	Tuticorin & Tirunelveli are the two districts near Tamaraparani River. While trade is happening, it is all being conducted via road and rail and not via waterways. All the industrial areas are well connected by Road. Nearest Railway station is Trivenveli, Thathankulam and srivaikundam (less than 2 km from River).

6.	Consultant's recommendation for going ahead with Stage-II (DPR preparation)	As traffic potential for Granite, Rough stone and Garnet exist and Tuticorin port exists very near to river mouth. As depths of about 1 m are available without dredging for 6-7 months, **we recommend Stage II studies (Detailed studies and investigations) to examine the possibility of various alternative methods (Like raising the height of existing weirs, construction of locks, etc.) to make the waterway feasible all-round the year for class I and Class II navigation for Tourism, ferry and cargo development.**
7.	Any other information/ comment	-----

1. About the Studies

M/s Inland Waterways Authority of India (IWAI), a statutory body under ministry of shipping, Govt. of India, has entrusted WAPCOS with the responsibility for preparation of two stages DPR for 6 inland waterways of rivers Pennar, Kaveri/Kollidam, Palar, Pazhyar, Ponniyar, Tamaraparani in Tamil Nadu and Andhra Pradesh. The approximate length and approx. average width of all six rivers are given in the table below:

Sl. No.	Name of the River / Canal	Description of Inland Waterway	From:	Up to:
1.	Pennar River, Andhra Pradesh	29 km length of the river from Penna Barrage, Pothireddypalem to confluence with Bay of Bengal near Kudithipalem (NATIONAL WATERWAY 79)	14°28'8.38"N, 79°59'9.31"E	14°35'36.75"N, 80°11'30.61"E
2.	Palar River, Tamilnadu	141 km length of the river from rail bridge at Virudampattu, Vellore to confluence with Bay of Bengal at Sadurangapattinam (NATIONAL WATERWAY 75)	12°56'14.07"N 79° 7'29.70"E	12°27'52.16"N, 80° 9'13.47"E
3.	Ponniyar River, Tamilnadu	125 km length of the river from Sathanur DamtoCuddalore at confluence of Bay of Bengal (NATIONAL WATERWAY 80)	12°11'0.06"N, 78°51'1.25"E	11°46'21.76"N, 79°47'41.70"E
4.	Kaveri Kollidam, Tamilnadu	364 km length of the river from Uratchikottai Barrageto confluence with Bay of Bengal at Pazhaiyar (NATIONAL WATERWAY 55)	11°29'3.09"N7 7°42'13.68"E	11°21'37.97"N7 9°49'53.23"E
5.	**Tamaraparani River, Tamilnadu**	**64 km length of the river from Sulochana Mudalir bridge, Tirunelveli to confluence with Bay of Bengal near Punnaikayal (NATIONAL WATERWAY 99)**	**8°43'43.17"N, 77°42'53.94"E**	**8°38'24.90"N, 78° 7'37.85"E**
6.	Pazhyar River, Tamil Nadu	20 km length of the river from Bridge near Veeranarayana Mangalam village to confluence with Arabian Sea at Manakudi (NATIONAL WATERWAY 77)	8°13'48.97"N7 7°26'27.34"E	8°5'15.01"N77° 29'7.61"E

Table 1: National Waterways in Tamilnadu and Andhra Pradesh

The Google Map showing all river stretches is enclosed as **Figure 1**.

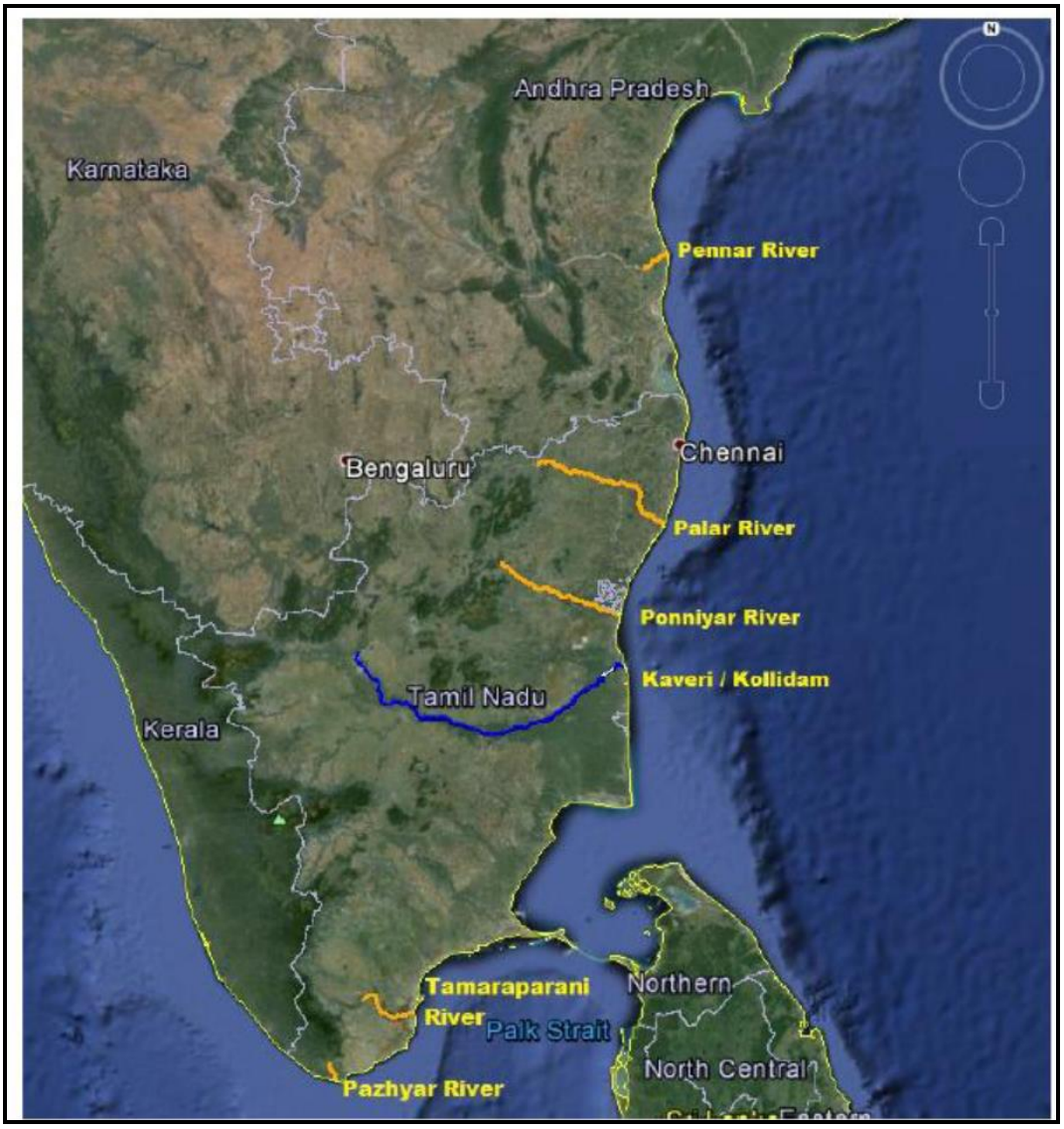


Figure 1: Google Map showing six rivers in Andhra Pradesh & Tamilnadu

Accordingly, WAPCOS Ltd. has undertaken the studies for 6 national waterways (Pennar, Kaveri/Kollidam, Palar, Pazhyar, Ponniyar and Tamaraparani) in Tamil Nadu and Andhra Pradesh. The brief scope of work is depicted as under:

Stage-1

A. Reconnaissance Survey

B. Collection and Review of available data

C. Feasibility Report

Stage-2

A. Hydrographic Survey &Hydro-morphological survey

B. Traffic Survey & Techno economic feasibility

C. Preparation of Detailed Project Report

The present studies are limited to establish the feasibility of national waterways for Inland navigation i.e. up to Stage 1 only**.**

The present **Final Feasibility Report** covers the review of data, reconnaissance survey, present state of affairs, traffic analysis, possible navigable stretches for Tamaraparani River as detailed below:

- ✓ **Introductory Considerations**
- ✓ **Classification of waterways**
- ✓ **Details of existing structures**
- ✓ **Reconnaissance survey & site visit**
- ✓ **Single Line Longitudinal Survey**
- ✓ **Bed Profile**
- ✓ **Soil Texture**
- ✓ **Hydrological Data collection and analysis**
- ✓ **Preliminary Traffic studies and Market analysis**
- ✓ **Results and feasibility of waterways**

2. Introductory Considerations

As discussed in previous chapter, Cluster 5 consists of six rivers in the states of Tamil Nadu and Andhra Pradesh. This chapter covers the introductory considerations, origin, hydrological parameters like altitude, length, catchment area, Annual rainfall, major dams, and barrages along the river, tributaries, and major cities along river bank, historical and religious places for Tamaraparani River.

2.1 Name of River: Tamaraparani

2.2 Length of River

Tamaraparani River is declared as National Waterway 99 as per the Gazette Notification published on 26 March 2016. The total length of the river from origin to its outfall in the Bay of Bengal is 125 km. The length under consideration for present studies is detailed below:

64 km length from Sulochana Mudalir bridge, Tirunelveli to confluence with Bay of Bengal near Punnaikayal	**From: 8°43'43.17"N, 77°42'53.94"E**	**Upto: 8°38'24.90"N, 78° 7'37.85"E**

Table 2: Location detail of river stretch

2.3 State, District through which river passes

The Tamaraparani River moves through Tirunelveli and Palayamkottai towns of Tirunelveli district and Srivaikundam and Tiruchendur towns of Thoothukkudi district before it joins the Gulf of Mannar at Punnaikayal in Tiruchendur town of Thoothukkudi district.

2.4 Maps

A Map showing Tamaraparani basin (Source: CWC) and Present study stretch is attached as **Figure 2** and **Figure 3** respectively.

2.5 River Characteristics

2.5.1 River Course

Tamaraparani River originates from the Agastyarkoodam peak in the hills of the Western Ghats above Papanasam in the Ambasamudram taluk and flows through Tirunelveli and Tuticorin districts of the Tamil Nadu and outfalls near Punnaikayal village.

2.5.2 River Basin (Catchment Area)

The river with its tributaries covers an area of about 4,400 square kilometer. Most of its catchment lies in the Western Ghats; the river gets water from both the monsoons, which make the river perennial.

2.5.3 Tributaries

There are a number of tributaries joining the river – Peyar, Ullar, Karaiyar, Servallar, Pampar, Manimuthar, Varahanathi, Ramanathi, Jambunathi, Gadananathi, Kallar, Karunaiyar, Pachaiyar, Chittar, Gundar, Aintharuviar, Hanumanathi, Karuppanathi and Aluthakanniar.

2.5.4 Topography

The river originates at an altitude of 1725 m above sea level near Peria Pothigai hills. The total length of the river is 125 km up to Gulf of Mannar. It moves through Tirunelveli and Palayamkottaitalukas of Tirunelveli district and Srivaikundam and Tiruchendurtalukas of Thoothukkudi district before it joins the Gulf of Mannar at Punnaikayal in Tiruchendurtaluk of Thoothukkudi district.

2.5.5 Climate, Temperature & Humidity

Four distinct seasons occur in the area, winter, summer, South-East monsoon and North-East monsoon. The basin is subject to a tropical climate.

2.5.6 Rainfall

The basin receives most of its rains from north-east monsoon which accounts for 65% of the total precipitation. It receives 11% of the total precipitation from south-west monsoon.

2.5.7 Demography

The main districts are Thoothukkudi (population 17.50 Lakhs), Tuticorin (population 30.78 Lakhs) and Tirunelveli.

2.5.8 Dams, Barrages/ Weirs/ Anicuts in River Basin

Kodaimelaalaga in anicut, Nathiyunni anicut, Kannadian anicut, Ariyanayagipuram anicut, Palavur anicut, Suthamalli anicut, Maruthur anicut are main dams and anicut on the river. Ramanadhi Reservoir, Karuppanadi irrigation project are the main irrigation projects.

2.5.9 Tourism

Agasthiyar Falls is the main tourist spot.

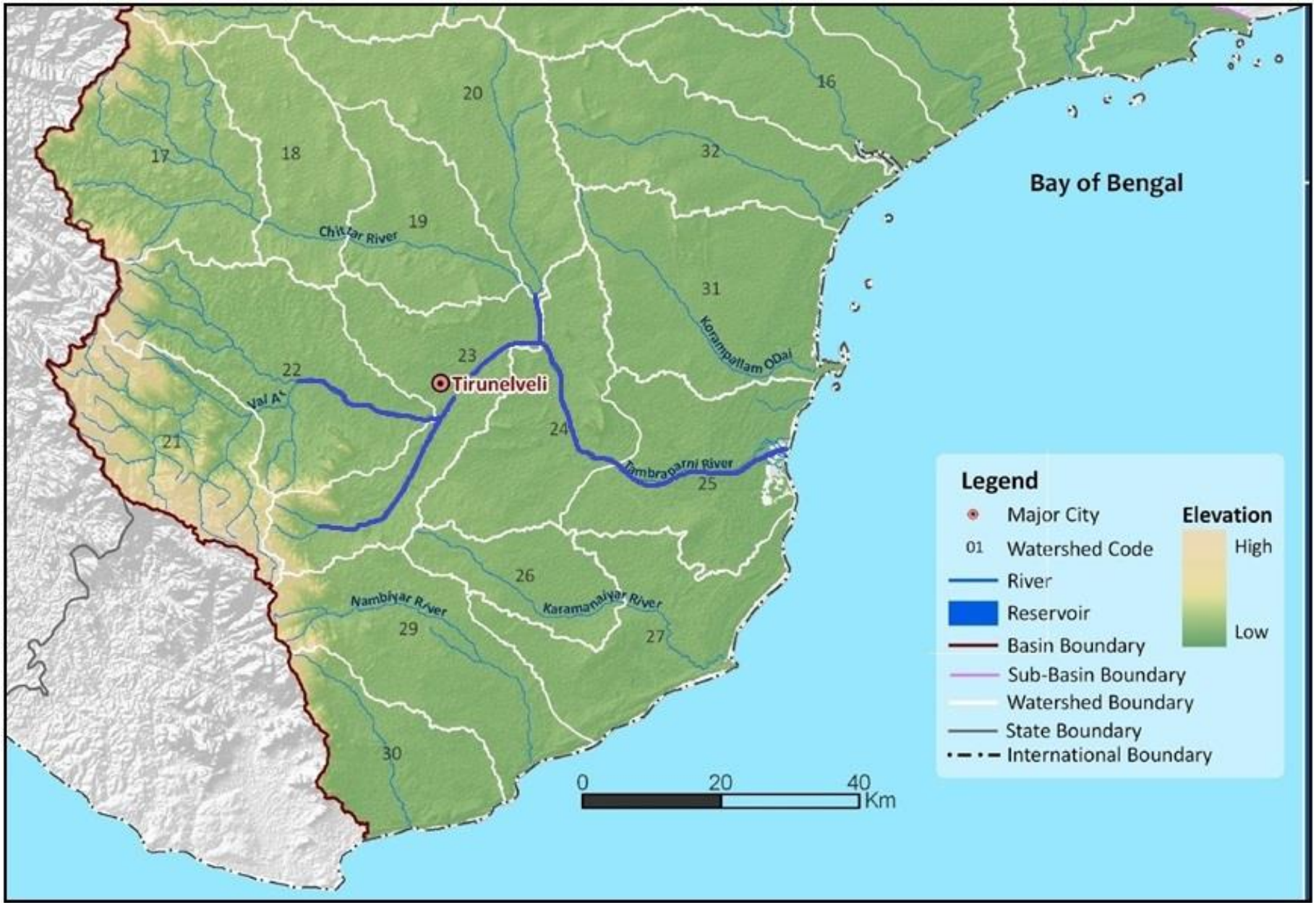


Figure 2: Tamaraparani River catchment (Source: CWC)

Figure 3: Google image showing Tamaraparani River stretch under present studies

2.6 Methodology and Data collection

2.6.1 Importance of Hydrological and Topographical data

Navigability of a natural river channel or tidal creek primarily depends upon hydraulic parameters like water discharge, flow depth, velocity, sediment load and width of river channel. These parameters are function of topography/bathymetry of river bed and discharge in river during different seasons. Apart from these important parameters, there are other natural factors such as tidal range and length of tidal reach type/nature of river bed (rocky, sandy, silty, clayey), bends in river course and stability of alignment of deep channel of river over long period. Apart from above natural factors, information on other factors such as various structures across (Dams/weirs/barrages/bridges) and along the river bank (river training and bank protection works).

2.6.2 Data Requirement

The following data was required for Stage-1 feasibility report:

1. Type of crops (in different seasons) and industries along the waterway
2. Availability of passenger ferry services. Prominent towns / City along the waterway.
3. Historical and tourist places.
4. Existing water sport and recreational activities and future probability.
5. Details of cross-structures (bridges, aqueducts, electric lines, telephone lines, pipe lines, cables) and their clearances. Salient features of Dams / Barrages / Weirs.
6. Availability of water in different seasons. Also to correlate this with CWC / Irrigation datum's.
7. Ponding level and limit of Dams / Barrages / Weirs.
8. Encroachment in the waterway, width of the waterway, sharp bends.
9. Environmental impacts. CRZ or wildlife clearances.
10. Local/pronounced name of the rivers in different stretches.
11. Any Border issue with other country.
12. Incorporation of topographical features (outside survey limits) from Google Earth imageries.
13. Obstructions to the navigation and un-approachable areas.
14. Photographs of all cross-structures, gauges, obstructions - annotated with location & chainage. In report with lat/long, easting/northing, chainage details
15. Permanent structures located within this corridor.
16. All prominent shore features (locks, bridges, aqueducts, survey pillars if available etc.) and other conspicuous objects shall be fixed and indicated on the chart and included in the report.
17. Details of water intake/ structures shall be collected and shown on the charts and include in the report.
18. Availability of berthing place, existing jetty, ferry ghats, approach roads etc. in the area shall be indicated on the charts and include in the report.
19. During the survey, condition of the banks shall also be collected, whether that banks are pitched (protected) or not protected. The length of bank protection, where banks erosion is taking place shall also be estimated.
20. Positions and levels of corners of permanent structures within the corridor shall be physically surveyed and marked on survey charts.

2.6.3 Primary Data- Sources

A. Survey of India (SOI) Dehradun, during February & March 2016

Toposheets and satellite imageries are useful to obtain information such as extent of tidal reach, HTL & LTL, width of river and deep channel, important places, nature of river bed and bank along reach, channel bends, slope of river channel, and locations of various structures across and along river course and tendency of shifting of deep channel (general morphology of the deep channel of the river course).

As the coastal zone falls under restricted category, the restricted and non-restricted Toposheets of Survey of India / hydrographic charts and satellite imageries has been collected after taking approval from **Ministry of Water Resources, Govt. of India**. A total of 43 toposheets were procured from Survey of India (SOI) (39 no.'s toposheets of 1: 50000 scale and 04 No's toposheets of 1:25000 scale) and analysed to study various aspects mentioned above. The satellite imageries of different years from Google are also analysed. The details of toposheets for Tamaraparani River as collected from SOI are given as under:

Tamaraparani River	**58 H/10, 58 H/13, 58 H/14, 58 L/2, 58 L**

Table 3: SOI Toposheets

B. Data from Site Visit and Reconnaissance survey during March & April 2016

The site visit and reconnaissance survey was carried out in March and April 2016.

The details of existing cross-structures, Weirs, Barrages, Anicut, Dams, HT/ LT line, Type of Crops, Soils, shore protection along the waterway, Historical and tourist places, existing ferry services were collected. The collected data and photographs have been detailed in Chapter 3.

The details of existing industries, major commodities, production were also collected from various industries located around main industrial clusters, important towns in the vicinity of waterways and important ports near river mouth. These details have been presented in Chapter 5.

2.6.4 Secondary Data- Sources

A. Central Water Commission (CWC), Govt of India and Water Resource Division (WRD), Chennai during February, March and April 2016

These data give most vital information on water availability in river reach and sediment concentration in river water.

Gauge- discharge, sediment and river cross section data (at gauging site) was collected from CWC for one gauging station on Tamaraparani River. Following Table gives details of gauging stations and data collected.

River	Gauging station	Data type	From	To	Frequency
Tamaraparani	Murappanadu, Tuticorin dist, TN 08^0 42′ 52" N 77^0 50′ 06" E (CH-40.0)	Gauge- discharge	1977	2012	daily
		Sediment	1979	2012	daily
		Cross-section	1999	2012	2 days/year

Table 4: Gauge Discharge Sediment data collected from CWC

2.6.5 Methodology

The studies are being carried out as detailed below:

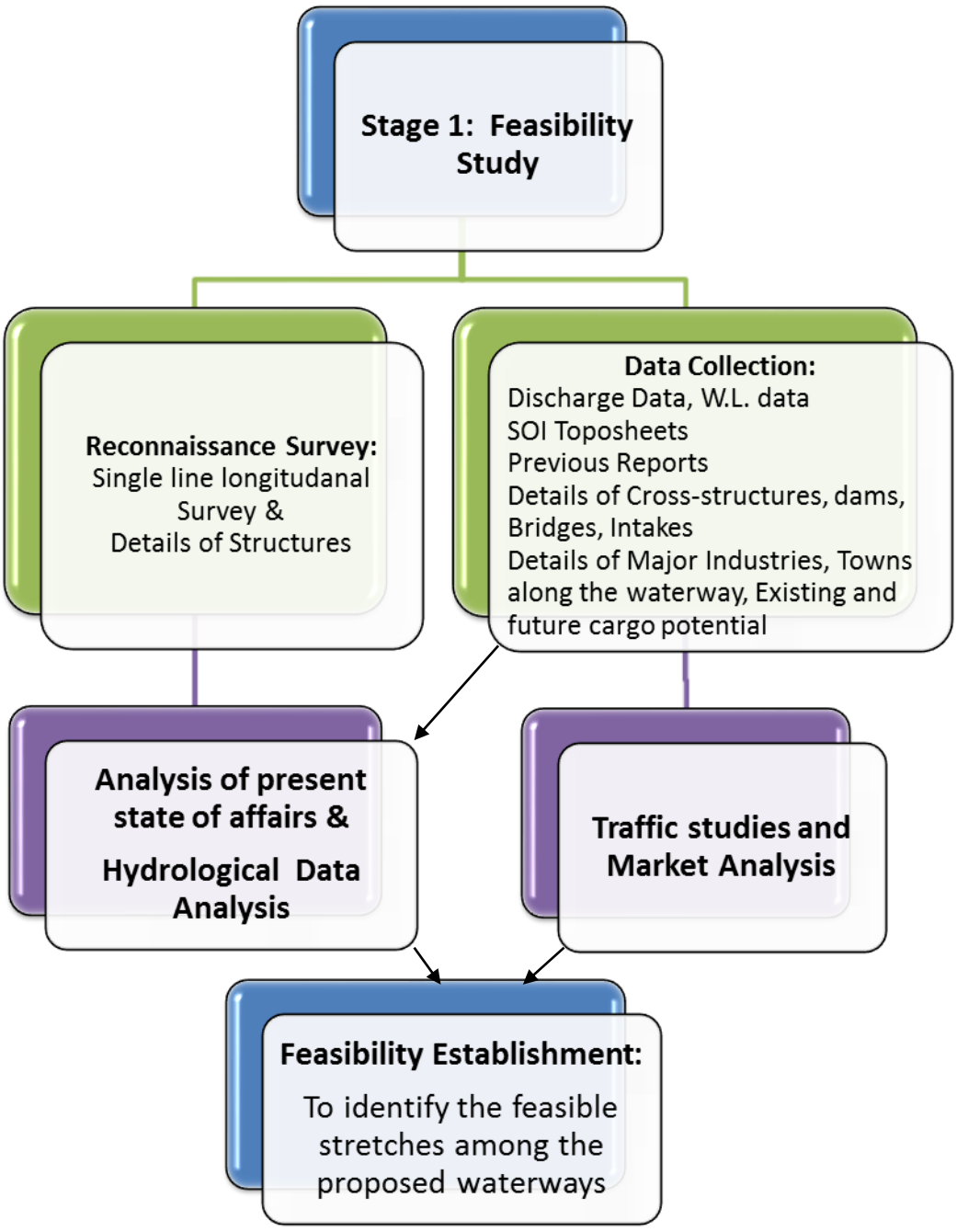


Figure 4: Feasibility Studies (Stage 1)

The detail methodology for reconnaissance survey, Hydrological data analysis and Traffic studies is given in their respective chapters. The feasibility of waterways is established after hydrological and traffic studies and analysis. Based on hydraulic conditions (depth, width, curvatures etc.) of the navigation channel, the class of the waterway is established in accordance with the classification notified by the Inland Waterways Authority of India (IWAI) vide Gazette Notification dated 26 January 2007. The same has been detailed below:

2.6.6 Classification of Waterways

In India, the inland waterways are classified into seven categories for rivers as well as canals by the Inland Waterways Authority of India (IWAI) vide Gazette Notification dated 26 January 2007 for safe passage 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 tonnes.

The classification of waterways is discussed below.

A. Classification of Inland waterways for Rivers

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

Table 5: Inland Waterway classification for Rivers

B. Classification of Inland waterways for Canals

Class of Waterway	Canals				
	Minimum Depth	Bottom Width	Bend Radius	Vertical Clearance	Horizontal Clearance
I.	1.5 m	20 m	300 m	4 m	20 m
II.	1.8 m	30 m	500 m	5 m	30 m
III.	2.2 m	40 m	700 m	7 m	40 m
IV.	2.5 m	50 m	800 m	10 m	50 m
V.	-	-	-	-	-
VI.	3.50 m	60 m	900 m	10 m	60 m
VII.	-	-	-	-	-

Table 6: Inland Waterway classification for Canals

The above classification for Rivers and Canals shall be effective if:

- Minimum depth of channel should be available for about 330 days in a year (about 90% days in a year).
- Vertical clearance at cross structures over the waterway should be available at least in central 75% portion of each of the spans in entire width of the waterway.

C. *Vertical Clearance for Power Cables / Telephone Lines for all Classes*

- Telephone lines and Low Voltage lines 16.5 m
- High Voltage Transmission lines not exceeding 110 KV – 19 m
- High Voltage Transmission lines exceeding 110 KV – 19 m + 1 cm per each KV

In case of underground pipe / power lines and other cables norms to be decided as per conditions and navigational requirement

D. *Reference level for vertical clearance for different types of channels*

- For rivers – over navigational HFL which is highest flood level at frequency of 5% in any year over a period of last 20 years
- HTL for tidal channels
- For channels design FSL

E. *Type of vessels to be used in different class waterways*

Class	Self-propelled vessel	Tug with barges
I.	Self-propelled, carrying capacity 100 DWT, Size (32m X 5m), Loaded draft 1m	1 Tug + 2 barges – 200 DWT, length 80m X breadth 5m , loaded draft 1m
II.	Self-propelled, carrying capacity 300 DWT, Size (45m X 8m), Loaded draft 1.2m	1 Tug + 2 barges – 600 DWT, length 110m X breadth 8m , loaded draft 1.2m
III.	Self-propelled, carrying capacity 500 DWT, Size (58m X 9m), Loaded draft 1.5m	1 Tug + 2 barges – 1000 DWT, length 141m X breadth 9m , loaded draft 1.5m
IV.	Self-propelled, carrying capacity 1000 DWT, Size (70m X 12m), Loaded draft 1.8m	1 Tug + 2 barges – 2000 DWT, length 170m X breadth 12m , loaded draft 1.8m
V.	Self-propelled, carrying capacity 1000 DWT, Size (70m X 12m), Loaded draft 1.8m	1 Tug + 2 barges – 2000 DWT, length 170m X breadth 24m , loaded draft 1.8m (moulded with 24 m)
VI.	Self-propelled, carrying capacity 2000 DWT, Size (86m X 14m), Loaded draft 2.5m	1 Tug + 2 barges – 4000 DWT, length 210m X breadth 14m , loaded draft 2.5m
VII.	Self-propelled, carrying capacity 4000 DWT, Size (86m X 14m), Loaded draft 2.9m	1 Tug + 4 barges – 8000 DWT, length 210m X breadth 28m , loaded draft 2.5m

Table 7: Type of vessels to be used in different class of waterways

All structures to be constructed across waterway classified should conform to respective requirement of vertical clearance and horizontal clearance before construction of any structure across the national waterway.

WAPCOS has carried out hydrological studies to establish the feasibility of development of national waterway 99 for Inland Navigation. In cases where minimum depth (of 1.2m as per Govt. of India notification) is not available round the year, the no. of days of availability and available depth is calculated and presented in chapter 4. The project authorities may review the waterway classification for navigation. The feasibility of these stretches may be established for some part of the year after detailed studies in stage 2 after the approval. Measures to improve the depth are also stressed upon.

3. Analysis of present state of affairs

This chapter identifies the existing cross-structures viz. Dams, Weirs, Barrages, Locks, Bridges, Crossings, pipelines, cables, HT/LT line, National and State highways including railway lines in the river stretch collected during the site visit and reconnaissance survey. The details of all structures across the river are tabulated in **Annexure 2.**

3.1 Existing Dams, Weir, Barrage, Anicut and Locks

It may be noted that none of these dams have navigational lock due to which through navigation in the river is not possible without constructing new locks.

Sl No	Structure Name	CH (km)	Location	Position (Above survey track)			
				WGS84 Datum; UTM Projection: CM 075°E , Zone 43N			
				Latitude [N]	Longitude [E}	Easting [m}	Northing [m}
1	Latchumipuram Check Dam	9.4	Latchumipuram	08°37'23.94"	78°02'53.57"	835532.950	954546.740
2	Kurangini Check Dam	16.0	Kurangani	08°37'09.75"	77°59'49.51"	829903.489	954065.797
3	Srivaiguntam Dam	25.7	Pudhukudi Melur	08°37'28.41"	77°54'33.28"	820221.852	954564.730
4	Pakkappati Dam	40.6	Pakkapatti	08°42'31.90"	77°50'19.79"	812395.461	963837.453
5	DAM-KALIYUVAR	48.3	Maruthur	8°45' 46.26"	77° 49'19.49"	810506.051	969799.379
6	Check Dam	50.3	Kansapuram	8°46' 44.93"	77°48'40.53"	809300.884	971594.284

Table 8: Details of existing Dams, Weir, Anicut and Barrages

3.2 Existing Bridges and Crossing Over River

Sl No	Structure Name	CH (km)	Location	Position (Above survey track) WGS84 Datum; UTM Projection: CM 075°E , Zone 43N				Vertical clearance above H.F.L. (m)	Horizontal clearance (m)
				Latitude [N]	Longitude [E]	Easting [m]	Northing [m]		
1	Authoor New Road Bridge (SH-176)	6.7	Serndamangalam	8°37’37.67”	78°04’09.27”	837846.316	954987.529	6	10
2	Authoor Old Road Bridge (SH-176)	7.0	Authoor	08°37'37.51”	78°04’10.58”	837886.448	954982.931	2.5	3
3	Eral Bridge (MDR-1047)	13.0	Thiruvaluthi Nadar Vilai	08°37'04.11"	78°01'11.00"	832398.736	953912.006	2.25	15
4	Temporary Bridge made of Bricks and sand	17.7	Kurangani	08°36'35.10"	77°59'08.01"	828641.789	952990.368	-	
5	Alwarthopu Bridge (Near SH-40)	21.4	Alagiamanavalapuram	08°36'25.78"	77°56'38.19"	824059.043	952668.241	2.5	10
6	Srivaiguntam New Road Bridge (MDR-435)	25.6	Pudhukudi Melur	08°37'21.63"	77°54'36.38"	820318.302	954356.983	6.0	20
7	Srivaiguntam Old Road Bridge (SH-40)	25.7	Pudhukudi Melur	08°37'28.41"	77°54'33.28"	820221.852	954564.730	2.0	11.5
8	Kongaraya Kurichi Bridge Under construction	33.2	Arampanni	08°39'06.18"	77°51'30.57"	814608.427	957528.582	-	-
9	Murappanadu Old Road Bridge,	41.1	Samathanapuram	08°42'46.55"	77°50'20.41"	812411.045	964288.026	4.0	11
10	Murappanadu New Road Bridge (NH-138)	41.3	Samathanapuram	08°42'45.84"	77°50'12.32"	812163.724	964264.337	7.75	25
11	Water pipeline bridge	42.4	Samathanapuram	08°43'04.12"	77°49'58.41"	811733.984	964823.182	4.0	10
12	Sivalaperi Road Bridge	50.5	Kansapuram	08°46'51.05"	77°48'35.52"	809146.242	971781.298	4.5	10

Sl No	Structure Name	CH (km)	Location	Position (Above survey track)				Vertical clearance above H.F.L. (m)	Horizontal clearance (m)
				WGS84 Datum; UTM Projection: CM 075°E , Zone 43N					
				Latitude [N]	Longitude [E]	Easting [m]	Northing [m]		
	(SH-45)								
13	Water pipeline bridge	50.8	Kansapuram	08°46'50.38"	77°48'33.72"	809091.343	971760.287	4.75	9
14	**NH-7** High Way Bridge	59.7	Senthimangalam	08°45'21.36"	77°44'19.45"	801334.648	968965.964	6.5	19
15	Water pipeline bridge / Vanarpettai Bridge	62.7	N Bypass	08°44'20.72"	77°43'09.29"	799202.260	967086.128	3.25	15
16	Kokarkullam Bridge	64.0	Kailash Nagar	08°43'42.05"	77°42'54.84"	798768.849	965894.107	6.0	18

Table 9: Details of existing Bridges and Crossings

Note: All bridges are to be considered as road bridges unless specified.

Note: Vertical clearance is measured above H.F.L. The HFL for tidal reach is MHWS (ATT- Vol 3) and HFL at gauge site is calculated as maximum water level in last twenty years Gauge Discharge Data as collected from CWC.

3.3 Pipelines and cables

Sl No.	Chainage (Km)	Utility/Pipelines		Vertical clearance above H.F.L. (m)	Horizontal Clearance (m)
		Name	Position		
1	42.4	Water pipeline bridge.	08°43'04.12"N, 77°49'58.41"E	4.0	10.0
2	50.8	Water pipeline bridge.	08°46'50.38"N, 77°48'33.72"E	4.75	9.0
3	62.7	Water pipeline bridge	08°44'20.72"N, 77°43'09.29"E	3.25	15.0

Table 10: Details of Pipelines and cables across river

Note: All bridges are to be considered as road bridges unless specified.

Note: Vertical clearance is measured above H.F.L. The HFL for tidal reach is MHWS (ATT- Vol 3) and HFL at gauge site is calculated as maximum water level in last twenty years Gauge Discharge Data as collected from CWC.

3.4 Details of High Tension and Electric Lines across River

Sl No	Structure Name	CH (km)	Location	Position (Above survey track)				Vertical clearance above H.F.L. (m)	Horizontal Clearance (m)
				WGS84 Datum; UTM Projection: CM 075°E , Zone 43N					
				Latitude [N]	Longitude (E)	Easting [m]	Northing [m]		
1	Electric Lines	5.2	Serndamangalam	8°38’09.70”	78°05’00.75”	839413.882	955985.235	6.0	250
2	HT Line	8.1	Authoor	08°37'18.65"	78°03'35.52”	836818.108	954394.333	10.0	350
3	Electric Lines	9.6	Latchumipuram	08°37'24.05"	78°02'49.09"	835395.816	954549.028	5.25	200
4	Electric Lines	10.0	Latchumipuram	08°37'22.72"	78°02'33.72"	834925.757	954504.377	6.0	200
5	Electric line	16.0	Kurangani	08°37'11.50"	77°59'54.14"	830044.76	954120.722	7.25	200
6	HT Line	16.6	Kurangani	08°37'02.67"	77°59'28.47"	829261.305	953843.039	8.75	350
7	HT Line	27.0	Srivaikuntam	08°38'06.01"	77°54'19.49"	819791.069	955717.631	6.0	300

Sl No	Structure Name	CH (km)	Location	Position (Above survey track)				Vertical clearance above H.F.L. (m)	Horizontal Clearance (m)
				WGS84 Datum; UTM Projection: CM 075°E , Zone 43N					
				Latitude [N]	Longitude (E)	Easting [m]	Northing [m]		
8	Electric line	34.0	Arampanni	08°39'15.44"	77°51'15.08"	814132.347	957809.737	10.5	250
9	HC Line	42.1	Samathanapuram	08°42'48.56"	77°50'10.13"	812096.101	964347.464	18.0	350
10	HC Line	43.0	Agaram	08°43'16.02"	77°49'56.89"	811684.742	965188.710	13.0	300
11	HT Line	48.3	Maruthur	8° 45' 54.51"	77°49' 09.23"	810190.327	970050.676	8.0	300
12	HT Line	48.5	Maruthur	8°46' 01.50"	77°49'09.83"	810207.066	970265.726	7.0	300
13	ET line	49.5	Keezhathonithurai	8°46'24.45"	77°48'57.93"	809837.795	970968.607	6.5	200
14	HC Line	50.9	Kansapuram	08°46'52.16"	77°48'31.06"	809009.577	971814.404	19.0	350
15	Electric line	55.9	Palamadai	08°46'36.58"	77°45'52.18"	804153.841	971299.300	8.5	200
16	HC Line	60.2	Senthimangalam	08°45'14.02"	77°43'59.05"	800712.347	968735.767	17.25	350
17	Electric line	62.6	N Bypass	08°44'22.20”	77°43'10.09"	799226.400	967131.804	9.0	250

Table 11: Details of High Tension and Electric Lines

Note: Vertical clearance is measured above H.F.L. The HFL for tidal reach is MHWS (ATT- Vol 3) and HFL at gauge site is calculated as maximum water level in last twenty years Gauge Discharge Data as collected from CWC.

3.5 Horizontal and Vertical Clearances

Sl No	Structure Name	CH (km)	Location	Vertical clearance above H.F.L. (m)	Horizontal clearance (m)
1	Electric Lines	5.2	Serndamangalam	6.0	250
2	Authoor New Road Bridge	6.7	Serndamangalam	6.0	10
3	Authoor Old Road Bridge	7.0	Authoor	2.5	3
4	HT Line	8.1	Authoor	10.0	350
5	Electric Lines	9.6	Latchumipuram	5.25	200
6	Electric Lines	10.0	Latchumipuram	6.0	200
7	Eral Bridge	13.0	Thiruvaluthi Nadar Vilai	2.25	15
8	Electric line	16.0	Kurangani	7.25	200
9	HT Line	16.6	Kurangani	8.75	350
10	Temporary Bridge made of Bricks and sand	17.7	Kurangani	-	
11	Alwarthopu Bridge	21.4	Alagiamanavalapuram	2.5	10
12	Srivaiguntam New Road Bridge	25.6	Pudhukudi Melur	6.0	20
13	Srivaiguntam Old Road Bridge	25.7	Pudhukudi Melur	2.0	11.5
14	HT Line	27.0	Srivaikuntam	6.0	300
15	Kongaraya Kurichi Bridge Under construction	33.2	Arampanni	-	-
16	Electric line	34.0	Arampanni	10.5	250
17	Murappanadu Old Road Bridge,	41.1	Samathanapuram	4.0	11
18	Murappanadu New Road Bridge	41.3	Samathanapuram	7.75	25
19	HC Line	42.1	Samathanapuram	18.0	350
20	Water pipeline bridge	42.4	Samathanapuram	4.0	10
21	HC Line	43.0	Agaram	13.0	300
22	HT Line	48.3	Maruthur	8.0	300
23	HT Line	48.5	Maruthur	7.0	300
24	ET line	49.5	Keezhathonithurai	6.5	200
25	Sivalaperi Road Bridge	50.5	Kansapuram	4.5	10
26	Water pipeline bridge	50.8	Kansapuram	4.75	9
27	HC Line	50.9	Kansapuram	19.0	350
28	Electric line	55.9	Palamadai	8.5	200
29	NH-7 HIgh Way Bridge	59.7	Senthimangalam	6.5	19

Sl	Structure Name	CH	Location	Vertical	Horizontal
30	HC Line	60.2	Senthimangalam	17.25	350
31	Electric line	62.6	N Bypass	9.0	250
32	Water pipeline bridge /Vanarpettai Bridge	62.7	N Bypass	3.25	15
33	Kokarkullam Bridge	64.0	Kailash Nagar	6.0	18

Table 12: Details of Horizontal and Vertical clearance

Note: Vertical clearance is measured above H.F.L. The HFL for tidal reach is MHWS (ATT- Vol 3) and HFL at gauge site is calculated as maximum water level in last twenty years Gauge Discharge Data as collected from CWC.

Note: All bridges are to be considered as road bridges unless specified.

3.6 Hindrances in conducting the reconnaissance survey

No hindrance was encountered in the river stretch while carrying out the reconnaissance survey. However, Rocky strata have been observed near chainage 60-64 km.

3.7 Encroachment to the waterway

There is no encroachment in the waterway in the reach under consideration in this study.

3.8 Details of Protected Area, Wildlife, Defence

There are no such areas present in the vicinity of river.

3.9 NH/SH/MDR along and/or in Vicinity

SH 93, SH 40, SH 176 are the state highways near the river stretch. NH 7A also crosses Tamaraparani River.

Main roads in the vicinity of river are Pudukudi – Keelur road, Srivaikundam-Eral road, Punnikayal road, Kovipatti- Ottapidaram- pudukudi- Eral- Mukkani road.

3.10 Railway Line and stations in the vicinity

Srivaikundam, Thathankulam, Alwar Tirumagri and Kurumbur Railway stations are located in the vicinity of Tamaraparani River.

4. Reconnaissance Survey

This chapter gives the stretch wise description (20-30 km stretch) of entire river stretches and presents the observed water level during survey. This chapter also covers the Hydrological analysis of the collected data viz. Minimum and maximum water levels, discharges, average 10 daily discharges, change in cross-section over the years and establishment of sounding datum in river. The route map of Tamaraparani River is given below:

Figure 5: Route map of Tamaraparani River

4.1 Resources, Equipment used and Methodology adopted

4.1.1 Resources & Equipment used

Personnel Name	Function
Deepak Jana	Surveyor , Fugro Limited
Arun Balaji	Engineer, Fugro Limited

Table 13: Survey Personnel

Following equipment and systems were mobilised for the data acquisition.

Equipment / System	Description / Make / Model/Resolution /Accuracy
Software / Navigation	Starfix.Seis V. 10.1 PC based data acquisition and survey vessel navigation package and accessories
Positioning	12 Channel Single frequency (L1 & L2) DGPS System and accessories
Echo Sounder	ODOM Hydrotrac single Frequency Echo sounder, 210KHz Transducer and accessories
Soil sample	Grab Sampler with accessories

collection	
Trimble Total station with accessories & Laser Distometer	

Table 14: Equipment for data acquisition

Survey Vessel

Locally Hired boat 'Micheal' was used for carrying out the bathymetry survey.

4.1.2 Detailed methodology adopted for survey

a) Specifications for survey: Survey Geodesy

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

Global Positioning System Geodetic Parameters	
Datum:	World Geodetic System 1984
Spheroid:	World Geodetic System 1984
Semi major axis:	a = 6 378 137.000 m
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:	500 000 m
False Northing:	0 m
Scale factor on Central Meridian:	0.9996
Units:	Meter

Table 15: Global Positioning System Geodetic Parameters

b) Field Calibrations & Verifications

All survey equipments used for the survey were calibrated and bench tested prior to their mobilisation for this task. After installation on the survey vessel, field verification and tests were carried out as per standard survey methods. On completion of successful Mobilization, Calibration, Verification and Testing of all equipment as per the relevant work practices, the survey task was commenced.

c) DGPS Calibrations

In order to ensure the integrity of the horizontal control of survey the DGPS system was bench checked against a known point, prior to mobilisation to site, at workshop and found to be satisfactory.

d) Single Beam Echo Sounder (SBES)

Odom Hydrotrac single frequency (210 kHz) echo sounder was used for measuring water depths. The echo sounder system was bench calibrated at FSINPVT workshop prior to mobilization for the survey. The echo sounder transducer was side mounted on the survey vessel and its draft below the water-line was measured and recorded. Thereafter, the echo-sounder was calibrated by the standard bar-check method at site, prior to deployment on the survey job. The echo sounder system was interfaced with the Starfix.Seis navigation and survey system for navigation and data logging.

e) Data Acquisition & Survey Run-Line Logs

The Navigation and depth data from the Starfix.HP DGPS was logged continuously and monitored using the Starfix.Seis navigation suite. A survey run-line log book was

maintained where the quality of data was noted. Details such as horizontal and vertical clearances above high flood level of bridges, aqueducts, electric lines, telephone lines, pipe lines, cables enroute were assessed on the spot and recorded, and their coordinates and location were plotted on the chart and included in the report. Photographs of important structures along the route are included as part of this report.

f) Soil Sampling and Visual Analysis

Soil samples were collected from the river bed along the surveyed route at about 10 km intervals, and the nature and texture of the samples collected were visually analysed and reported.

g) On-line QC of Data Logged

Real Time Graphs and QC Plots as provided by the Starfix survey software suite were used by experienced surveyors to monitor and control the quality of sensor data on-line, before they are logged. Time stamping on all the data was done by means of Starfix Timing Module through Navigation network synchronized with the GPS (high precision) 1PPS time signal. The data / record obtained from each survey sensor such as Navigation, Heading, SBES and Motion Sensor etc. were quality checked and an extract of the same were made available for verification and confirmation to proceed further.

h) Survey of Data Processing and interpretation methods

The survey data was logged in Binary Format (BF), and processed using the Starfix.Proc software. Heading, motion and position data were processed and checked to ensure good data quality.

The measured offsets for all survey sensors was entered into the navigation system and processed using Starfix.Proc to enable track charts was plotted and 'corrected' navigation files was integrated with other sensor data at a later stage. These included:

- GPS position absolute of the primary & secondary positioning systems.
- Common Reference Point.
- Single beam echo sounder.

i) Bathymetry Data Analysis and Presentation

Starfix.Proc and Starfix.Workbench was used to import and process the navigation, bathymetry, tides and sound velocity data. The data was filtered, cleaned, and combined to create geographically positioned bathymetric data set that has been corrected for tides and sound speed.

j) Equipment Layout Diagram

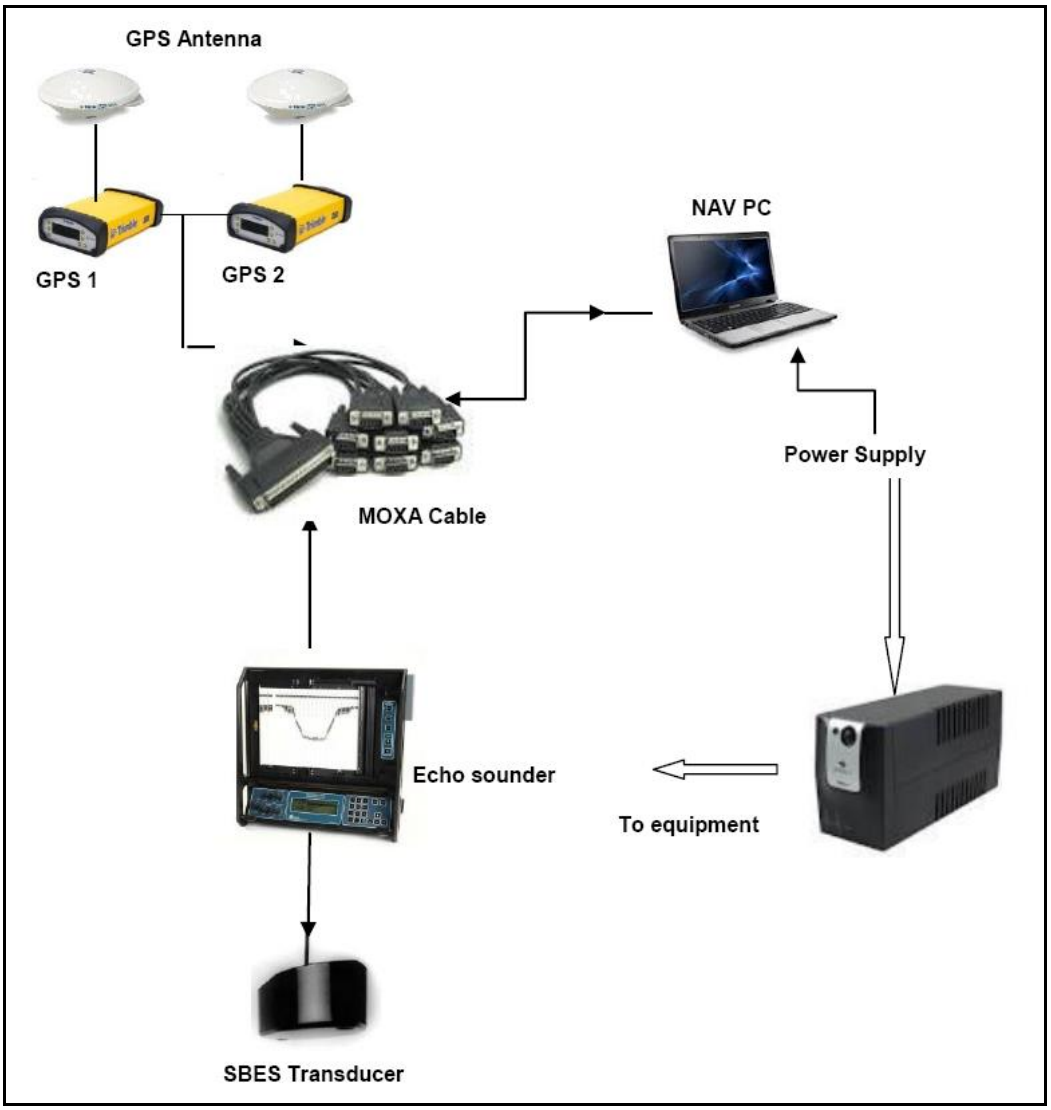


Figure 6: Equipment layout diagram

4.2 Description of bench marks (B.M.)/ authentic reference level used

A CWC Musto Type bench mark was successfully recovered on the river stretch at Murappanadu Township, which was 21.57 m above the BM as per the Client supplied information. All the heights of the riverbed in this report are referenced to this BM for obtaining their height above the MSL.

Brief Narrative on the Recovery of the Station									
a) What is the Source of Station Description Data;	CWC site office, Murappanadu								
b) Was the station recovered successfully?	Yes								
c) What were the differences in Coordinates after verification using Starfix.HP?	No earlier coordinates available								
d) Give Link to Starfix Mean Posn/Final Fix Report.	Mean Position Report_MTBM_MURUPANAADU.pdf								
Final Coordinates in WGS84 Datum after verification using Starfix.HP									
GEOGRAPHICAL COORDINATES:			UTM COORDINATES:	Zone No:	43	CM:	075	°E	
LATITUDE :	8°42'56.0043"	N	EASTING:	811 781.736	m	(+/-0.10 m)			
LONGITUDE :	77°49'59.9098"	E	NORTHING:	964 573.988	m	(+/- 0.09 m)			
ELLIPSOIDAL HEIGHT :	-74.81	m	Ht above MSL/~~GD~~	21.57	M				
Describe the General Location & Access to the Station :	The station is situated on a stone inside a concrete well (1.3m x 1.3m x 0.45m). The well is also filled with sand. The well is situated inside the campus of CWC site office, Murappanadu. The station is 1.8 mtrs East of the wall of CWC site office building. The CWC site office is in the village of Murappanadu, 30 Kms from the Tirunelveli.								
Describe how the Stn is marked on the Ground	The station is marked by a stone on ground.								
Expected durability of the Station (in Years) :									10

DETAILED DIAGRAM :

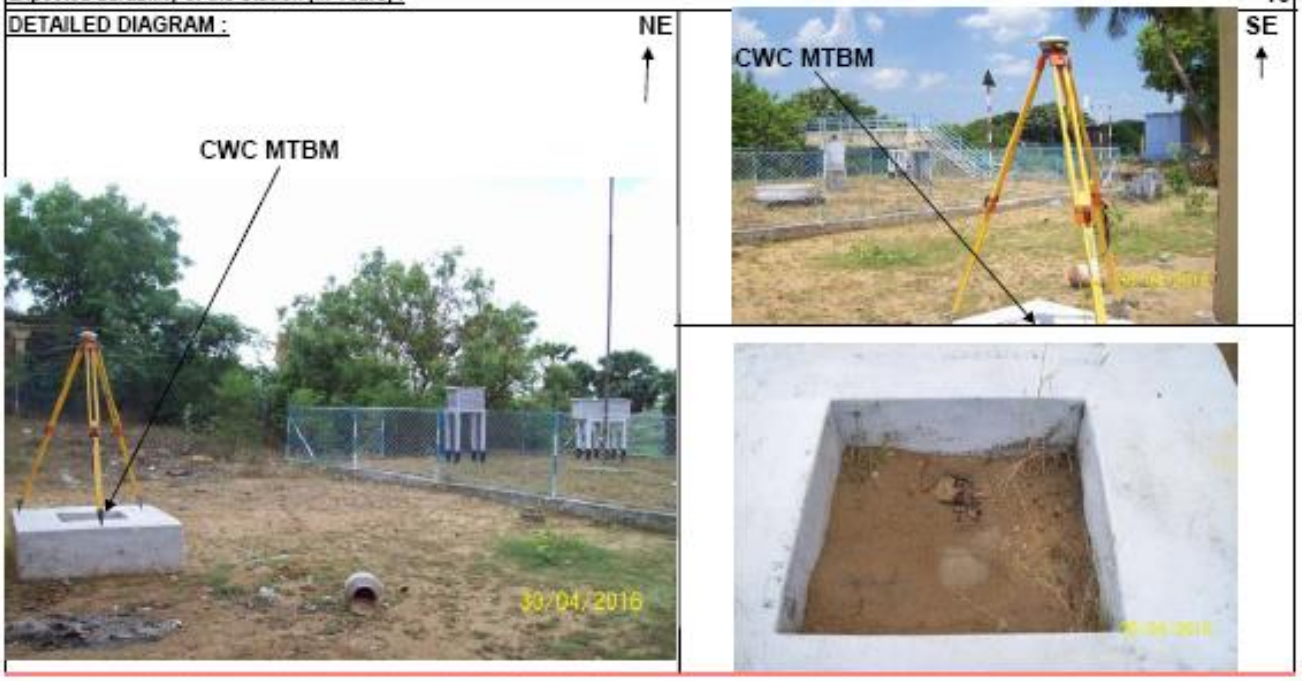


Figure 7: Details of Benchmark at Murappanadu

SL	RIVER	POINT	DESCRIPTION	WGS 84 COORDINATES			LOCAL COORDINATES (UTM ZONE 43)		OTHER INFORMATION	REMARKS
				LATITUDE (N)	LONGITUDE (E)	ELLIPSOIDAL HEIGHT (M)	EASTING (M)	NORTHING (M)		
1	TAMARAPARANI	CWC MTBM, MURAPPANADU	MTBM IS ESTABLISHED BY CWC AND SITUATED INSIDE THE CWC SITE OFFICE, MURAPPANADU.	8°42'56.0043"	77°49'59.9098"	-74.81	811 781.736	964 573.988	VALUE OF MTBM IS 21.570 MTRS ABOVE MSL (WRITTEN BY THE SIDE OF MTBM BY THE CWC SITE OFFICE, MURAPPANADU)	DERIVED BY STARFIX MEAN POSITION. ANTENNA HEIGHT (2.00 M) IS REDUCED TO THE OBSERVED ELLIPSOIDAL HEIGHT.

Figure 8: Murappanadu benchmark - CWC value

Starfix Mean Position Report v5.02.24

Vessel

Vessel Name	
Project Name	RIVER RECCEE SURVEY
Project Number	J_MAR_16_020
Offset Name	MainVessel_CRP
Sampling Started	30-Apr-2016 13:26:58 (UTC+05:30)
Sampling Ended	30-Apr-2016 13:37:01 (UTC+05:30)
Comment	MTBM IS SITUATED INSIDE THE PREMISES OF CWC SITE OFFICE MURUPPANADU

Results

	Mean	Standard Deviation
Local Latitude	8°42'56.0043"N	
Local Longitude	77°49'59.9098"E	
Ellipsoidal Height	-72.81 m	
Local Easting	151498.20 m	0.10 m
Local Northing	964865.61 m	0.09 m
Orthometric Height	-72.81 m	0.10 m
WGS84 Latitude	8°42'56.0043"N	
WGS84 Longitude	77°49'59.9098"E	
Ellipsoidal Height	-72.81 m	
Quality	1.10	0.00 m
Depth	0.00 m	0.00 m
Heading	0.48°G	0.00°

Line Navigation Data		**Point Navigation Data**	
Line Name	**N/A**	Point Name	**N/A**
Chainage	N/A	Easting	N/A
Cross Track	N/A	Northing	N/A
		Range	N/A
		Bearing TO	N/A
Observations		FROM	N/A
Used 167 out of 167			

Geodetic Parameters

Geodetic Datum	**WGS84**		
Ellipsoid	**WGS84**		
Semi-Major Axis	6378137.000		
Inverse Flattening	298.2572235630		
Eccentricity^2	0.006694379990141		
DX	0.0000m	RX	0.0000 arc seconds
DY	0.0000m	RY	0.0000 arc seconds
DZ	0.0000m	RZ	0.0000 arc seconds
D Scale	0.0000ppm		
Rotation Convention	+RZ=-RLongitude		
Projection	**Transverse Mercator (UTM) Zone: 44**		
Latitude of Origin	0°00'00.0000"N		
Longitude of Origin	81°00'00.0000"E		
False Easting	500000.000m		
False Northing	0.000m		
Convergence	- 0°28'49.2014"		
Calculation Mode	Grid		

Mean Position Report_MTBM_MURUPANAADU 121 13 37 05.pdf 13:37 April 30, 2016

Figure 9: Murappanadu Benchmark - Fugro

4.3 Tidal Influence Zone and Tidal Variation in different stretches

During the reconnaissance survey carried out in the river, tidal influence was observed upto 9.23 kms.

The Nearest Port is VOC port (Tuticorin Port) about 15 km away. As per tide data from Tuticorin Port the tidal variation is about 0.74 m.

4.4 Chart datum / Sounding datum and reduction details

4.4.1 Horizontal control

Worldwide Starfix.HP DGPS was used for positioning the survey vessel during this survey. The accuracy of the x, y, and z position data obtained from the Starfix.HP DGPS system is +/- 10 cm at 95% assurance levels. Starfix software suite was used for navigation, data logging, and online quality control of the survey data logged.

4.4.2 Vertical control

a) Chart Datum at the River Estuary

From Kp 0.0 to Kp 9.23 which have tidal influence, the soundings were reduced to Chart Datum using real time tidal observations and applying MSL-CD value of 0.567 m for the nearest port Tuticorin, obtained from ATT Vol-3. The coordinates of Chart Datum (CD) used is given below:

Sr. No.	Location	Latitude	Longitude	Z0 (m)
1	Tuticorin	8° 48' 00'' N	78° 9' 00'' E	0.567

Table 16: Details of Chart Datum Used for Reduction of Soundings

Z0 is below M.S.L

b) Chart Datum for the upstream part of the River

The CD value at the two gauge stations on this Tamaraparani River are tabulated below. No other gauge station data for this river was available. As directed by the IWAI, the average height of last six years Minimum Water Levels at this gauge station was to be taken as the Chart Datum for the survey of the entire stretch of the River, from the estuary till the last Kp upstream. This is detailed in Para 4.18.

Gauging station	Latitude	Longitude	Elevation of CD from MSL
Murappanadu CH 40.55 Km	08^0 42’ 52” N	77^0 50’ 06” E	14.42 m

Table 17: Chart Datum Details for the Gauge Station

4.5 Hydrographic Survey

4.5.1 Hydrographic Survey

a) Length of stretch for which bathymetry survey has been carried out

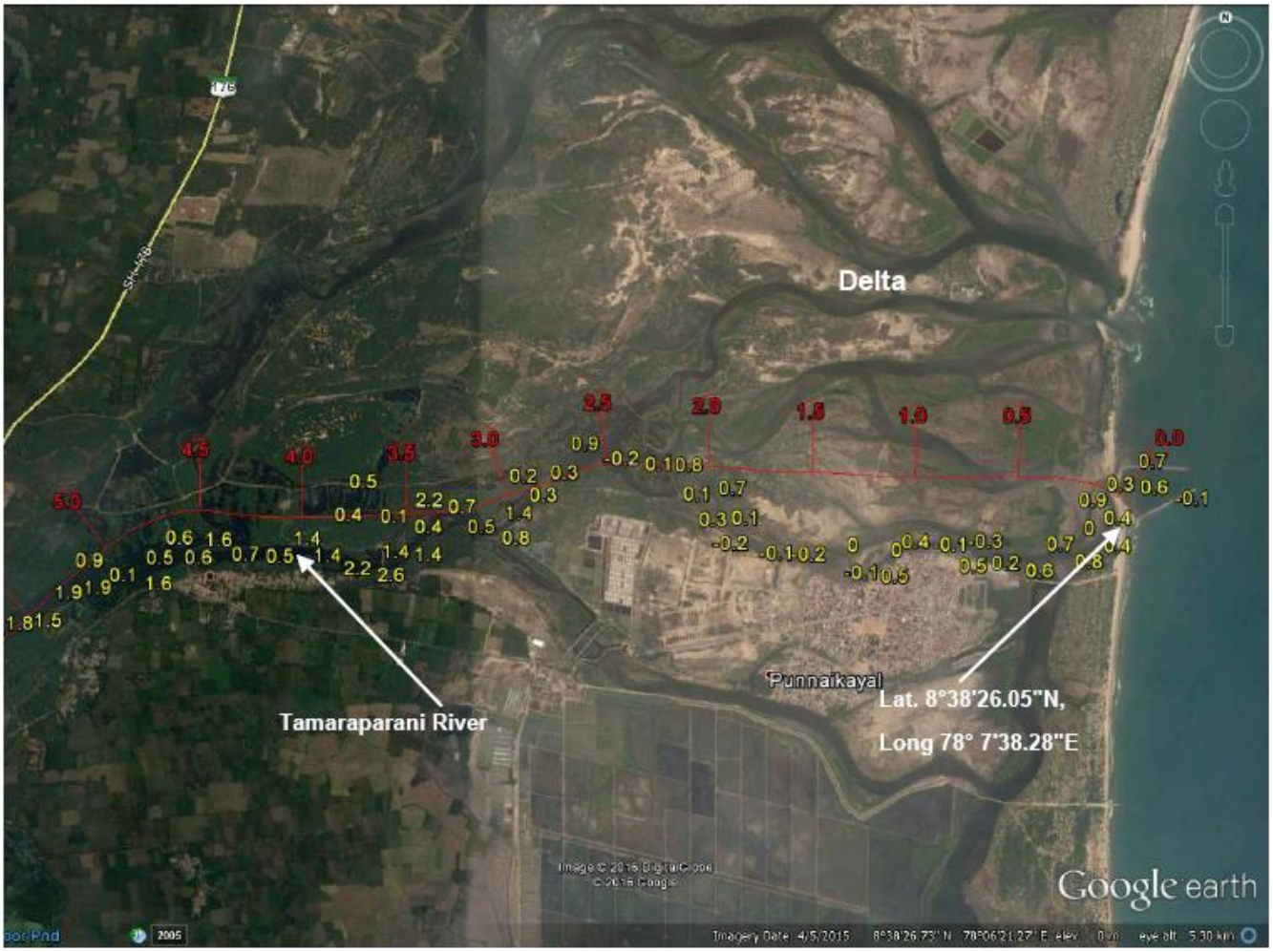
The bathymetry survey has been carried out in the stretch of 9.3 km from river mouth.

b) Minimum and Maximum Depths

River Stretch (From CH 0.0 to CH 5.5)

This is the Estuary portion of the river where it meets the Bay of Bengal, and hence influenced by the tidal variations. Depths shown in the diagram up to CH 9.23 are

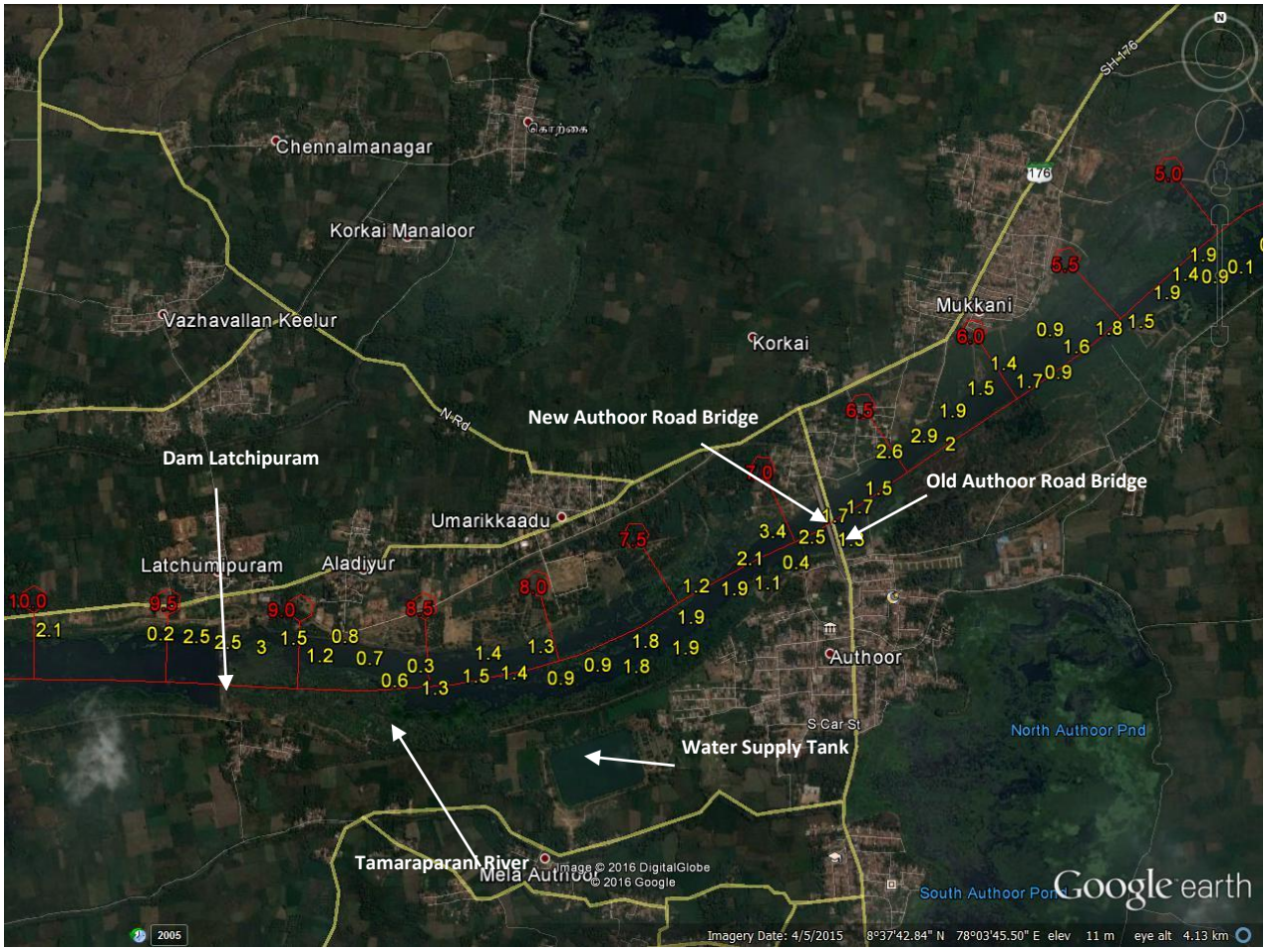
reduced to Chart Datum which is 0.567m below the MSL. In general, agricultural land use was seen on either side of the river bank. In the upstream areas, the heights of the river bed with reference to the interpreted Chart Datum levels are shown (+ve heights are below CD). In this portion, the minimum water depth is -0.3 m (CH 0.5) and the maximum is 2.6 m (CH 3.6) below the CD.



Chainage (km)		Water Depths below Chart Datum	
From	To	Minimum	Maximum
0.0	5.0	-0.3	2.6

River Stretch from CH 5.0 to CH 10.0

In this section, the banks of the river are mostly covered with vegetation and agricultural fields. The Authoor Road Bridge (old and new) crosses the river at CH 6.8 & CH 6.85 with a vertical clearance of 2.5 m & 7.0 m and distance of 3 m &10 m between columns.



Chainage (km)		Water Depths below Chart Datum	
From	To	Minimum	Maximum
5.0	10.0	0.1	3.4

c) Water levels during reconnaissance survey

Chainage (Km) A	Easting (m) B	Northing (m) C	Raw Depth w.r.t River Bed level(m) D	Tide(m) E	Reduced Depth w.r.t. CD (m) F = D-E
-0.16	844481.77	956545.76	0.37	0.51	-0.1
-0.10	844382.75	956536.38	1.07	0.51	0.6
-0.06	844143.73	956307.86	0.89	0.52	0.4
-0.06	844209.06	956383.61	0.97	0.54	0.4
-0.02	844047.97	956269.75	0.56	0.56	0.0
-0.01	844005.96	956228.70	1.34	0.58	0.8
0.00	844304.20	956598.28	1.29	0.61	0.7
0.03	844155.81	956468.32	1.54	0.63	0.9
0.03	844218.87	956546.06	0.98	0.63	0.3
0.37	843869.08	956188.56	1.37	0.64	0.7
0.47	843769.55	956178.32	1.22	0.65	0.6
0.57	843672.84	956152.67	0.89	0.66	0.2

Chainage (Km) A	Easting (m) B	Northing (m) C	Raw Depth w.r.t River Bed level(m) D	Tide(m) E	Reduced Depth w.r.t. CD (m) F = D-E
0.58	843659.43	956196.83	0.37	0.67	-0.3
0.68	843582.82	956196.39	1.18	0.68	0.5
0.77	843490.98	956237.35	0.62	0.69	-0.1
0.85	843391.80	956244.49	0.78	0.52	0.3
1.01	843235.16	956243.50	0.88	0.52	0.4
1.10	843144.41	956201.38	0.52	0.52	0.0
1.17	843069.53	956135.11	1.02	0.52	0.5
1.24	842979.73	956089.74	0.45	0.52	-0.1
1.31	842907.87	956159.41	0.49	0.52	0.0
1.41	842815.70	956196.79	0.63	0.52	0.1
1.52	842718.53	956170.44	0.34	0.53	-0.2
1.67	842565.95	956172.53	0.39	0.53	-0.1
1.71	842520.72	956188.64	0.75	0.53	0.2
1.79	842423.70	956215.43	0.35	0.53	-0.2
1.88	842344.50	956275.79	0.62	0.54	0.1
1.90	842322.40	956327.20	0.81	0.54	0.3
1.96	842278.35	956417.03	1.26	0.54	0.7
2.00	842243.97	956448.32	0.63	0.54	0.1
2.09	842145.26	956464.37	0.73	0.54	0.2
2.17	842064.14	956523.02	1.32	0.55	0.8
2.25	841986.59	956586.31	0.68	0.55	0.1
2.35	841887.94	956610.06	0.33	0.55	-0.2
2.45	841790.23	956631.45	0.34	0.55	-0.2
2.54	841690.79	956633.07	1.53	0.55	1.0
2.67	841558.84	956612.33	1.44	0.55	0.9
2.76	841461.03	956591.30	0.85	0.56	0.3
2.85	841397.85	956513.68	0.75	0.56	0.2
2.92	841363.18	956419.76	0.86	0.56	0.3
2.99	841312.07	956333.80	1.95	0.56	1.4
3.09	841234.26	956270.80	1.31	0.56	0.8
3.19	841134.68	956260.86	1.05	0.56	0.5
3.25	841041.18	956296.34	1.23	0.56	0.7
3.34	840945.57	956325.83	2.79	0.56	2.2
3.41	840878.31	956254.04	0.99	0.56	0.4
3.48	840810.46	956180.43	1.99	0.56	1.4
3.50	840782.29	956302.71	0.64	0.57	0.1
3.57	840722.78	956132.22	1.94	0.57	1.4
3.60	840683.27	956317.16	0.76	0.57	0.2
3.67	840636.62	956076.37	3.17	0.57	2.6
3.70	840583.24	956318.44	2.12	0.57	1.5
3.76	840541.20	956046.36	2.81	0.57	2.2
3.79	840492.00	956402.87	1.04	0.57	0.5

Chainage (Km) A	Easting (m) B	Northing (m) C	Raw Depth w.r.t River Bed level(m) D	Tide(m) E	Reduced Depth w.r.t. CD (m) F = D-E
3.80	840489.68	956302.81	1.01	0.57	0.4
3.84	840461.30	956106.49	1.99	0.57	1.4
3.93	840363.17	956125.82	1.97	0.57	1.4
4.03	840264.42	956110.06	1.15	0.57	0.6
4.12	840165.44	956095.52	1.11	0.57	0.5
4.22	840065.64	956102.17	1.33	0.58	0.7
4.30	839965.64	956100.08	1.61	0.58	1.0
4.40	839865.87	956107.17	2.16	0.58	1.6
4.53	839769.98	956078.76	1.21	0.58	0.6
4.67	839675.59	956111.95	1.21	0.58	0.6
4.80	839583.56	956072.80	1.10	0.58	0.5
4.94	839508.48	956006.66	2.16	0.58	1.6
5.03	839410.93	955984.60	0.69	0.58	0.1
5.11	839311.21	955992.41	1.51	0.58	0.9
5.19	839212.07	955979.01	2.53	0.58	1.9
5.29	839146.05	955903.87	1.97	0.58	1.4
5.39	839076.18	955832.28	2.45	0.59	1.9
5.47	838977.66	955814.97	2.06	0.59	1.5
5.57	838910.74	955740.62	2.35	0.59	1.8
5.67	838840.39	955669.52	2.22	0.59	1.6
5.74	838741.39	955683.97	1.50	0.59	0.9
5.84	838668.99	955614.96	1.53	0.59	0.9
5.94	838612.09	955532.69	2.28	0.59	1.7
6.01	838513.76	955550.91	1.98	0.59	1.4
6.11	838426.80	955501.52	2.11	0.59	1.5
6.20	838376.10	955415.26	2.53	0.59	1.9
6.30	838315.81	955335.42	2.55	0.59	2.0
6.39	838217.51	955316.89	3.51	0.59	2.9
6.49	838138.00	955256.23	3.16	0.59	2.6
6.57	838100.95	955163.33	2.10	0.60	1.5
6.67	838030.65	955092.18	2.25	0.60	1.7
6.77	837937.40	955056.04	2.32	0.60	1.7
6.85	837893.40	954966.18	1.93	0.60	1.3
6.95	837801.58	954926.51	3.10	0.60	2.5
7.03	837703.37	954945.43	3.97	0.60	3.4
7.07	837689.18	954874.91	0.96	0.60	0.4
7.13	837621.54	954887.94	2.69	0.60	2.1
7.21	837581.91	954796.11	1.68	0.60	1.1
7.30	837510.54	954726.06	2.47	0.60	1.9
7.40	837418.45	954687.08	1.83	0.60	1.2
7.50	837348.80	954615.32	2.52	0.60	1.9
7.60	837276.66	954546.04	2.54	0.61	1.9

Chainage (Km) A	Easting (m) B	Northing (m) C	Raw Depth w.r.t River Bed level(m) D	Tide(m) E	Reduced Depth w.r.t. CD (m) F = D-E
7.69	837179.80	954521.18	2.39	0.61	1.8
7.79	837092.60	954472.02	2.38	0.61	1.8
7.89	837002.79	954427.96	1.49	0.61	0.9
7.98	836916.98	954376.54	1.49	0.61	0.9
8.07	836818.23	954392.55	2.48	0.61	1.9
8.13	836732.03	954443.33	1.93	0.61	1.3
8.14	836736.07	954402.52	1.92	0.61	1.3
8.24	836632.30	954435.19	2.00	0.61	1.4
8.34	836534.58	954413.94	2.00	0.62	1.4
8.34	836542.40	954374.90	2.12	0.62	1.5
8.44	836442.27	954374.11	1.93	0.62	1.3
8.54	836334.73	954407.64	0.89	0.62	0.3
8.64	836235.27	954397.01	1.27	0.62	0.6
8.73	836141.22	954431.04	1.33	0.62	0.7
8.84	836046.67	954463.69	1.46	0.63	0.8
8.94	835948.38	954482.49	1.84	0.63	1.2
9.03	835849.68	954498.88	2.18	0.63	1.5
9.14	835750.08	954508.16	3.67	0.63	3.0
9.23	835654.89	954477.46	3.13	0.63	2.5

Table 18: Bathymetry survey levels

4.5.2 Topographic Survey

A. Length of stretch for which topography survey has been carried out

As the river depths are shallow and Bathymetry Survey was not possible, the topography survey has been carried out from chainage 9.4 km to 29.0 km from Tamaraparani river mouth.

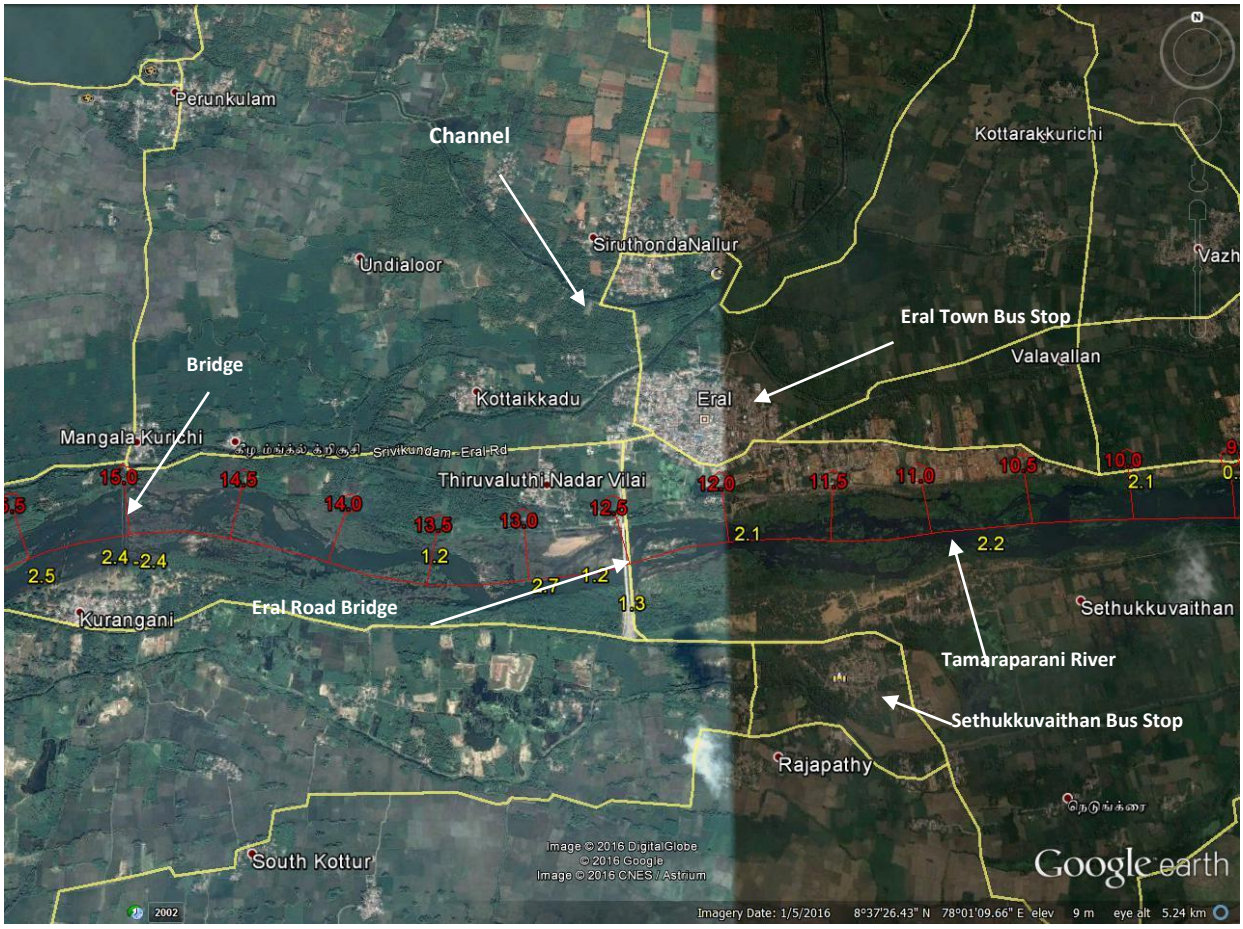
B. Minimum and Maximum Depths

As per IWAI suggestion, following sign convention is adopted

(+) : Riverbed below CD
(-) : Riverbed above CD
(+) : Water Depth below CD
(-) : Water Depth above CD

River Stretch from CH 10.0 to CH 15.0

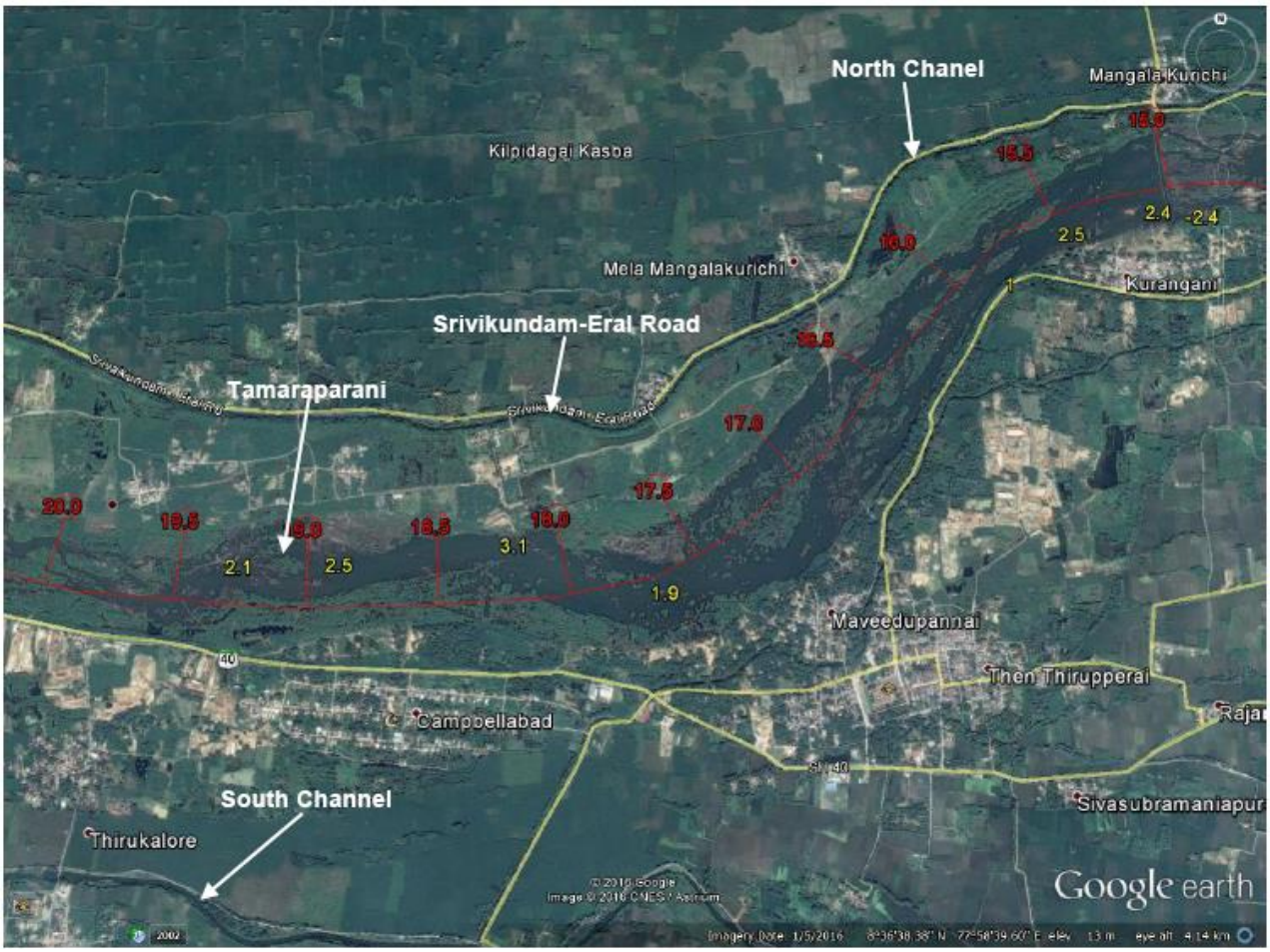
Both banks of the river are covered with marshy land and one channel parallel to the river at the northern side. The river banks are covered with vegetation and open fields. The Eral Road Bridge crosses the river at CH 12.5 with a vertical clearance of 5 m and distance of 15 m between columns. The river banks are covered with vegetation and open fields.



Chainage (km)		Reduced Water Depth w.r.t. Chart Datum	
From	To	Minimum	Maximum
10.0	15.0	-0.11	1.856

River Stretch from CH 15.0 to CH 20.0:-

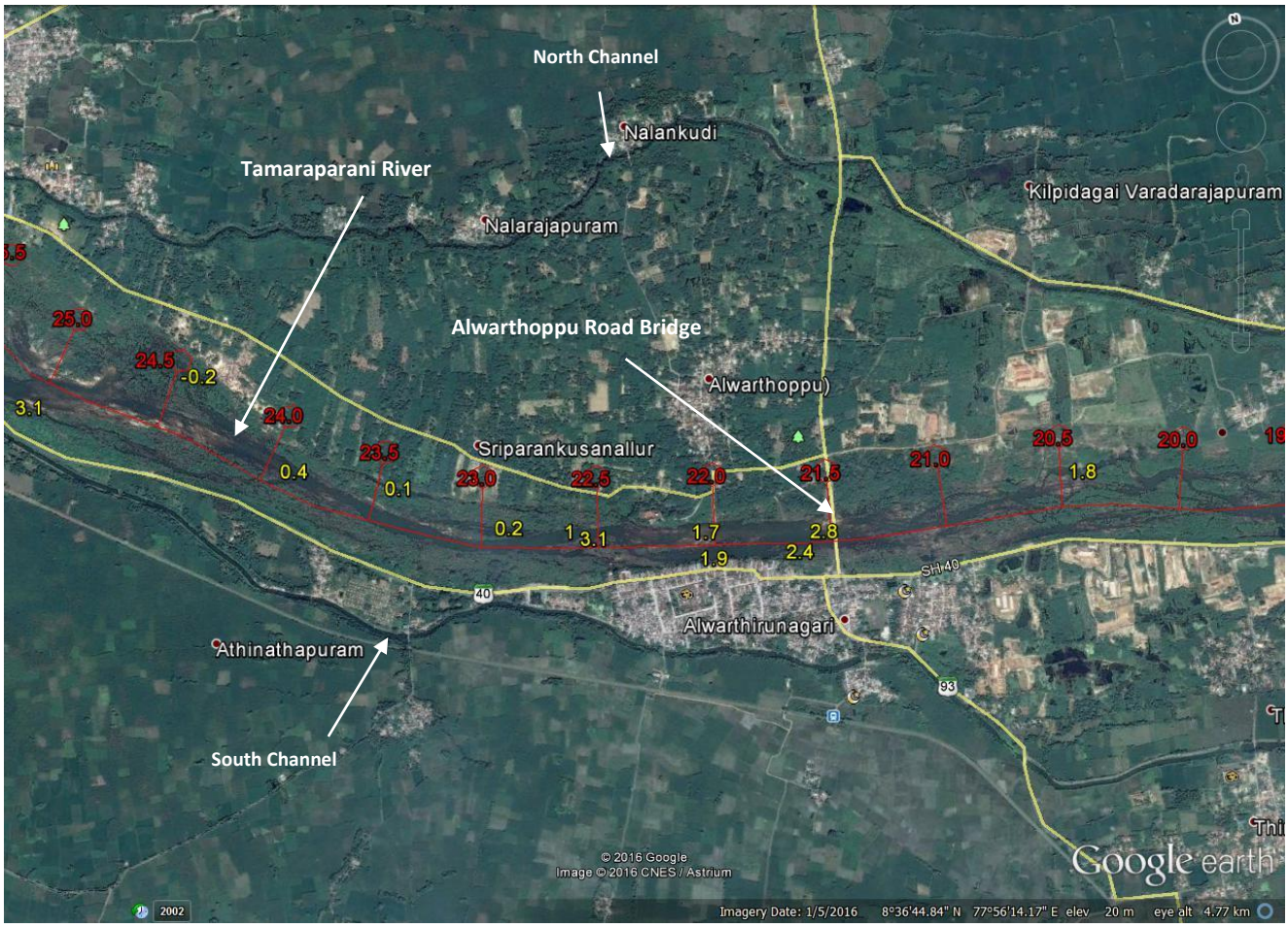
Both banks of the river are covered with marshy land. North and South channel parallel along the river. The river banks are covered with vegetation and open fields.



Chainage (km)		Reduced Water Depth w.r.t. Chart Datum	
From	To	Minimum	Maximum
15.0	20.0	-1.06	2.016

River Stretch from CH 20.0 to CH 25.0:-

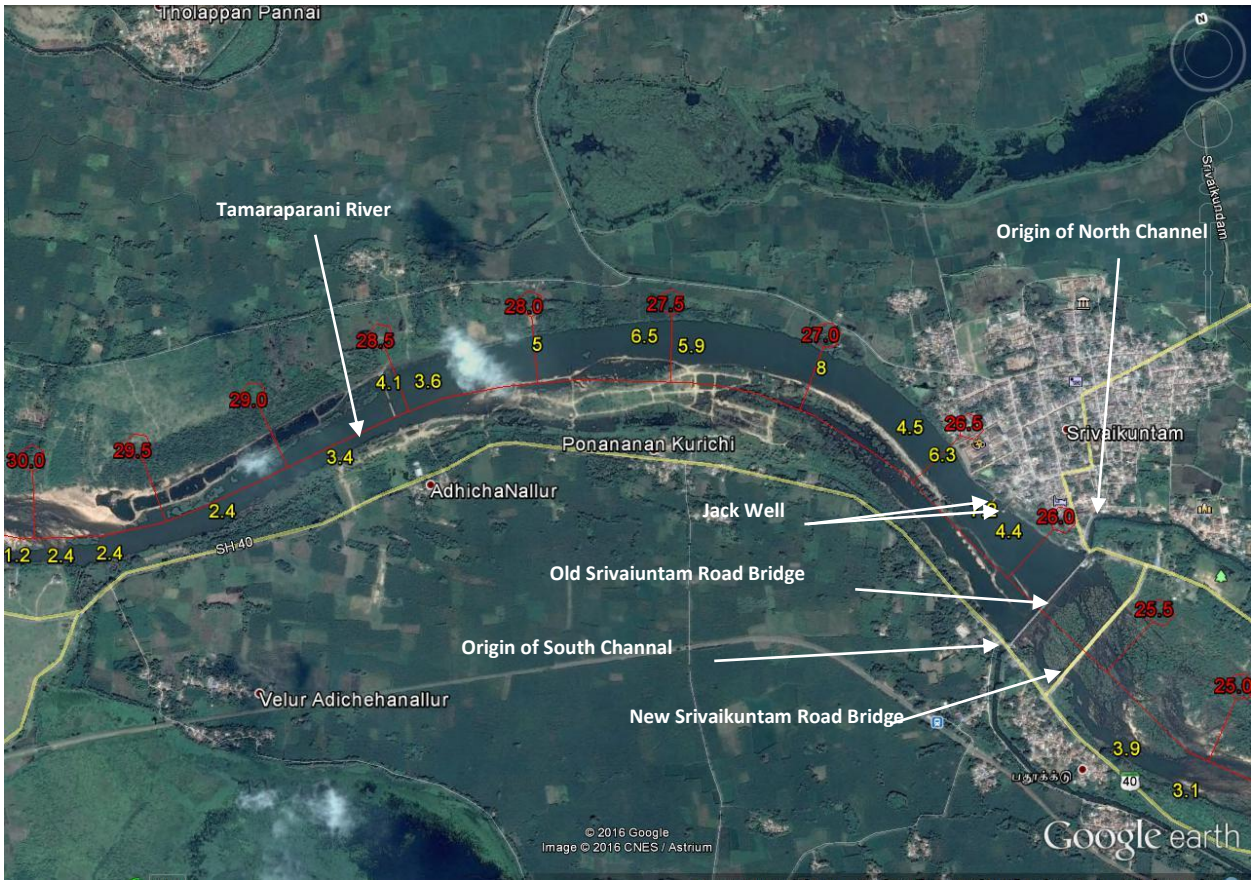
In this section, the banks of the river are mostly covered with vegetation and open fields. The Alwarthoppu Road Bridge crosses the river at CH 21.5 with a vertical clearance of 5m and distance of 10 m between columns.



Chainage (km)		Reduced Water Depth w.r.t. Chart Datum	
From	To	Minimum	Maximum
20.0	25.0	-1.398	1.321

River Stretch From CH 25.0 to CH 30.0:-

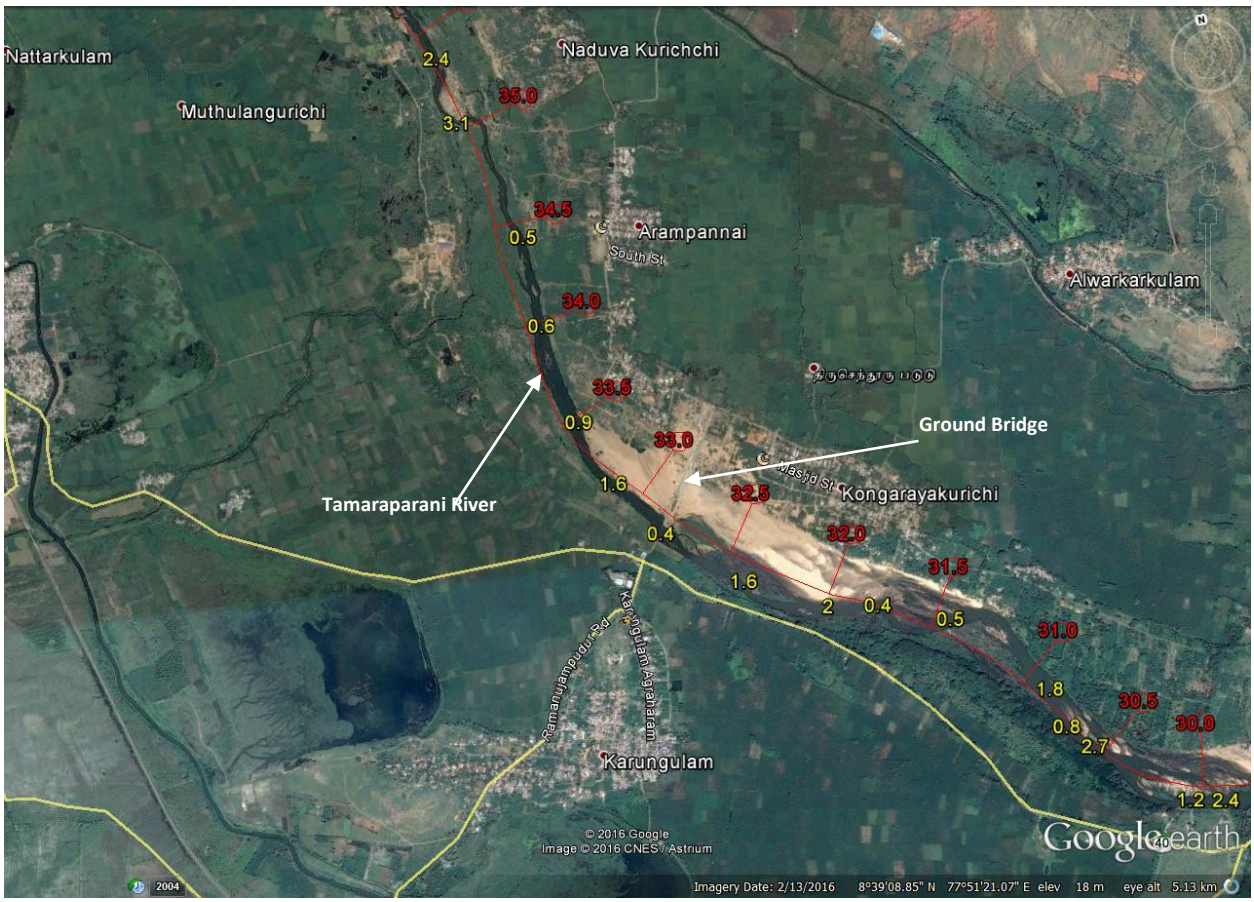
In this section, the banks of the river are mostly covered with vegetation and agricultural fields. The Srivaikuntam Road Bridge (old and new) crosses the river at CH 25.8 & CH 25.6 with a vertical clearance of 4.2 m & 8.0 m and distance of 11.5 & 20 m between columns. The origin of North and South channels are at approx. CH 25.9 and 25.8. Two jack wells are observed at CH 26.5.



Chainage (km)		Reduced Water Depth w.r.t. Chart Datum	
From	To	Minimum	Maximum
25.0	30.0	0.05	3.297

River Stretch from CH 30.0 to CH 35.0:-

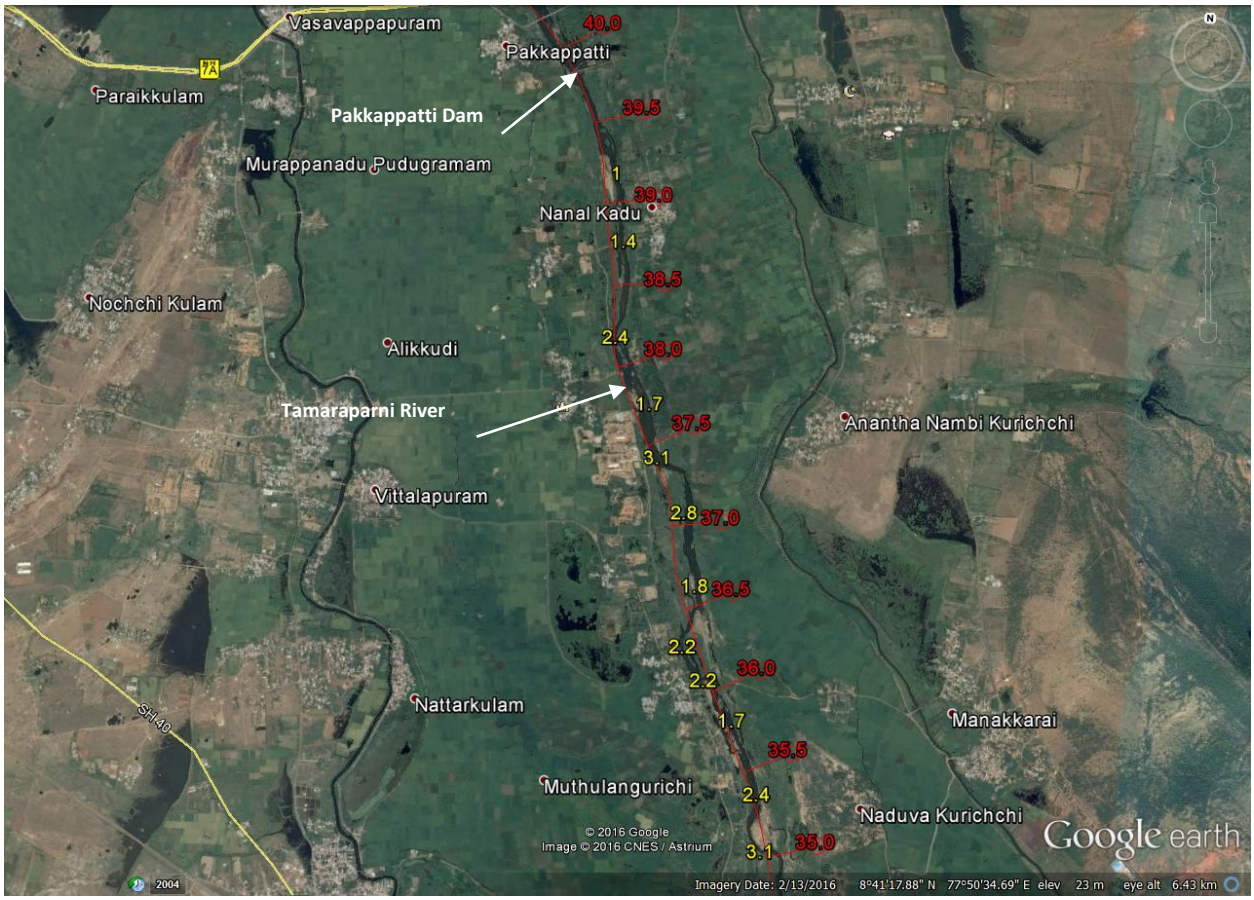
Dense mangrove vegetation is seen on both banks for this entire stretch. One village of Kongaraya kurichi is present on the North bank. A ground bride is crossing the river at CH.32.8.



Chainage (km)		Reduced Water Depth w.r.t. Chart Datum	
From	To	Minimum	Maximum
30.0	35.0	-0.909	1.513

River Stretch from CH 35.0 to CH 40.0:-

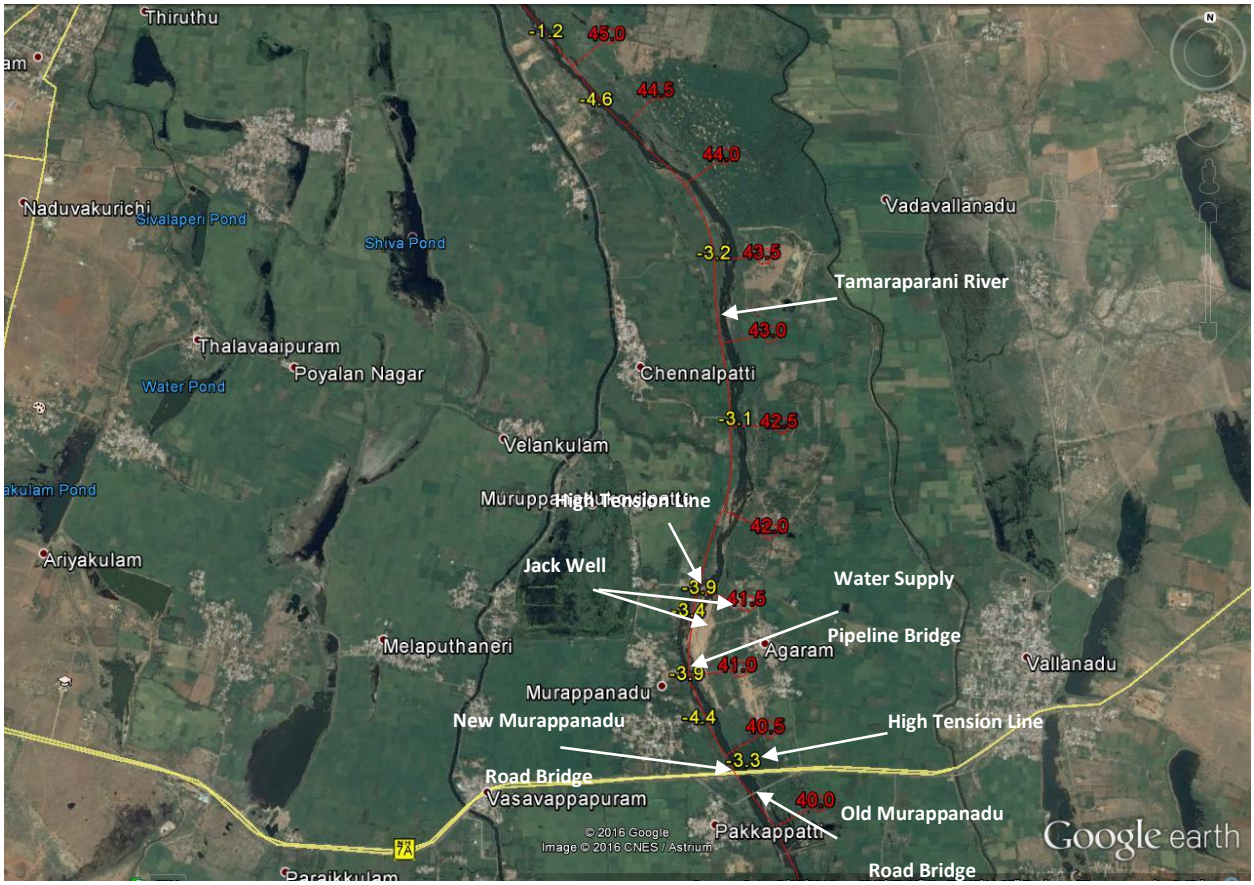
In this section, the banks of the river are mostly covered with vegetation and agricultural fields. The Pakkappatti dam is on the river at CH 39.8.



Chainage (km)		Reduced Water Depth w.r.t. Chart Datum	
From	To	Minimum	Maximum
35.0	40.0	-2.113	1.861

River Stretch from CH 40.0 to CH 45.0:-

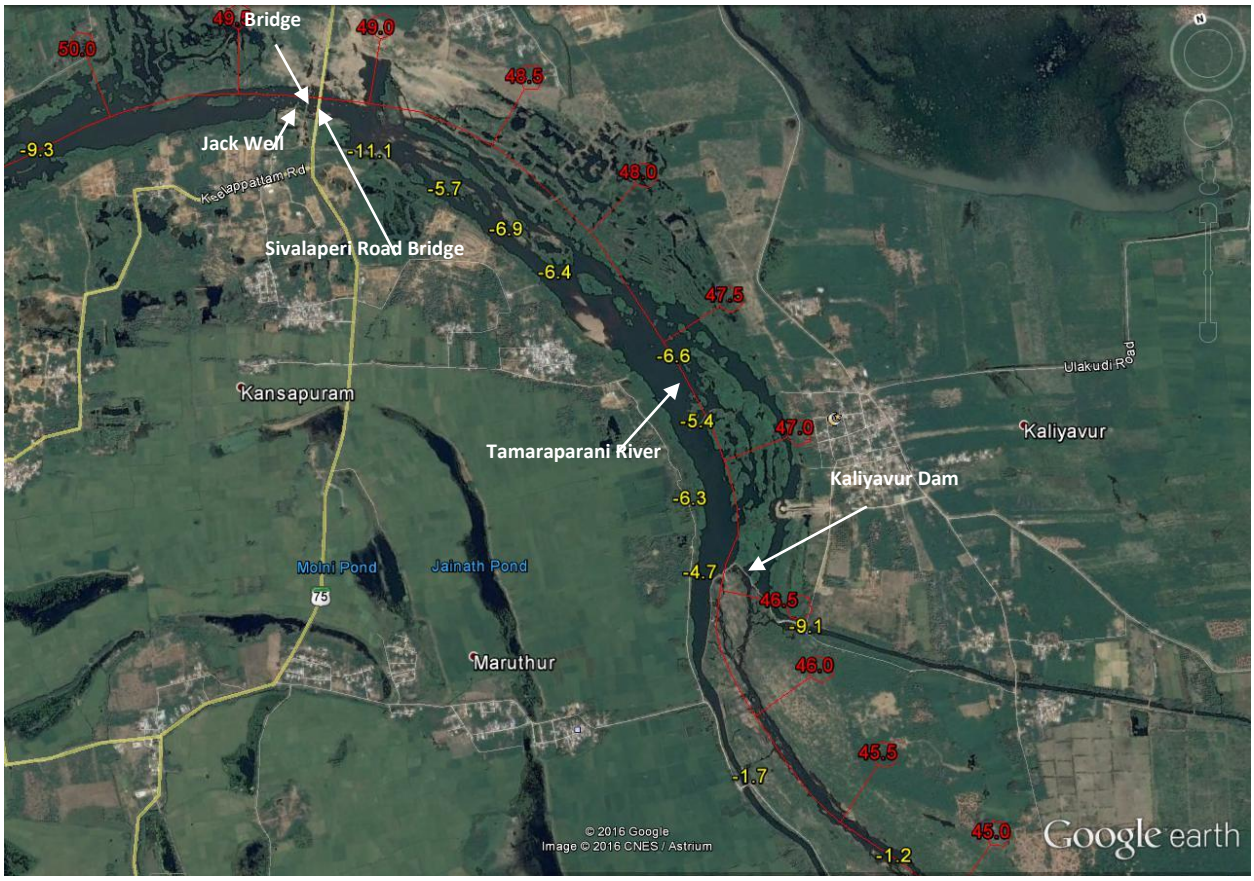
In this section, the banks of the river are mostly covered with vegetation and agricultural fields. The Muraooanadu Road Bridge (old and new) crosses the river at CH 40.2 & CH 40.3 with a vertical clearance of 5.5 m & 9.0 m and distance of 11 m & 25 m between columns. The Water supply pipeline bridge crosses the river at CH 41.0 with a vertical clearance 6m and distance of 10m between columns. Two high tension lines and two jack wells are also in this section.



Chainage (km)		Reduced Water Depth w.r.t. Chart Datum	
From	To	Minimum	Maximum
40.0	45.0	-3.582	1.973

River Stretch from CH 45.0 to CH 50.0:-

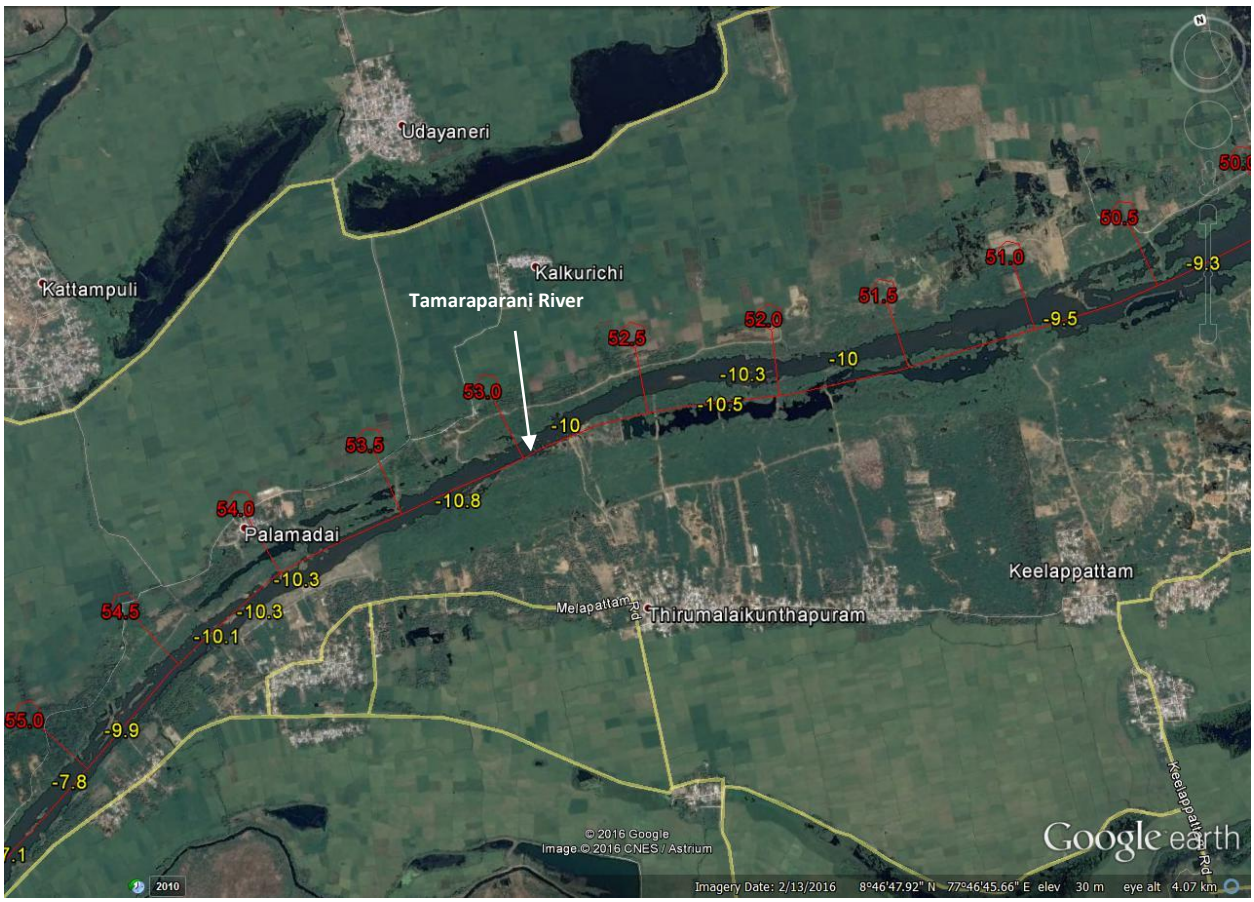
In this section, the banks of the river are mostly covered with vegetation and agricultural fields and small ponds on both side of the river. The Chittar River joins Tamaraparani at Sivalaperi. The Sivalaperi Bridge (old and new) crosses the river at CH 49.2 & CH 49.25, a jack well was also observed near the old bridge. South channel originates near the Kaliyavur dam.



Chainage (km)		Reduced Water Depth w.r.t. Chart Datum	
From	To	Minimum	Maximum
45.0	50.0	-4.552	1.798

River Stretch from CH 50.0 to CH 55.0

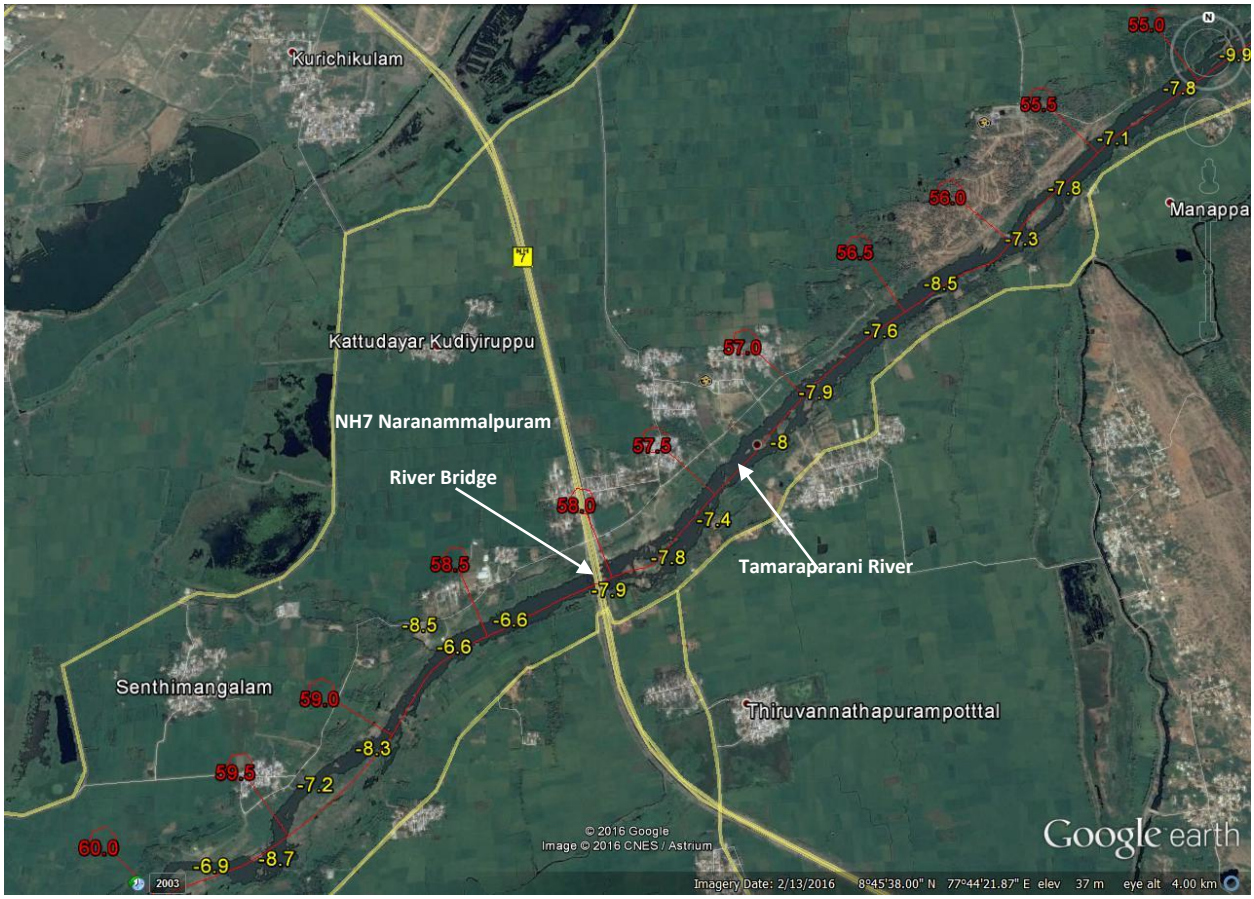
In this section, the banks of the river are mostly covered with vegetation and agricultural fields and small ponds on both side of the river.



Chainage (km)		Reduced Water Depth w.r.t. Chart Datum	
From	To	Minimum	Maximum
50.0	55.0	-1.187	1.097

River Stretch from CH 55.0 to CH 60.0

In this section, the banks of the river are mostly covered with vegetation and agricultural fields and small ponds on both side of the river. The NH7 Road Bridge cross the river at CH 58.0.



Chainage (km)		Reduced Water Depth w.r.t. Chart Datum	
From	To	Minimum	Maximum
55.0	60.0	-0.456	1.547

C. Water levels during reconnaissance survey

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
9.35	835536	954496.019	0.24	2.5	2	1.76
9.44	835442	954531.432	0.28	2.6	2	1.72
9.54	835346	954544.27	0.301	2.3	2.01	1.71
9.64	835246	954534.814	0.286	2.5	2.01	1.72
9.73	835147	954525.357	0.27	2.1	2.02	1.75
9.83	835047	954515.901	0.5	2.3	2.02	1.52
9.93	834948	954506.444	0.45	2.2	2.03	1.58
9.95	834926	954504.377	0.6	2	2.03	1.43
10.03	834853	954475.469	0.75	2.1	2.03	1.28
10.12	834760	954438.473	0.65	2.15	2.04	1.39
10.21	834667	954401.477	0.55	2.3	2.04	1.49
10.31	834574	954364.481	0.3	2.2	2.05	1.75
10.4	834482	954327.485	0.4	2.15	2.05	1.65
10.5	834389	954290.489	0.35	2.05	2.06	1.71
10.59	834296	954253.493	0.45	2.1	2.06	1.61
10.69	834203	954216.497	0.5	2.05	2.07	1.57
10.73	834161	954199.673	0.51	2	2.07	1.56
10.79	834106	954201.936	0.55	2.05	2.07	1.52
10.88	834006	954206.086	0.6	2.01	2.08	1.48
10.99	833906	954210.236	0.45	2.1	2.08	1.63
11.09	833806	954214.386	0.35	2.05	2.09	1.74
11.18	833706	954218.536	0.5	1.95	2.09	1.59
11.28	833607	954222.686	0.6	2	2.1	1.50
11.38	833507	954226.836	0.35	2.05	2.1	1.75
11.48	833407	954230.986	0.25	2.1	2.11	1.86
11.58	833307	954235.137	0.5	2	2.11	1.61
11.68	833207	954239.287	0.6	2.05	2.12	1.52
11.78	833107	954243.437	0.55	2.3	2.12	1.57
11.88	833006	954233.029	0.6	2.05	2.13	1.53
11.92	832972	954226.387	0.63	2.1	2.13	1.50
11.97	832916	954215.491	0.7	1.9	2.13	1.43
12.07	832820	954185.171	0.8	2.05	2.14	1.34
12.15	832741	954159.158	0.85	2.1	2.14	1.29
12.25	832658	954138.925	0.7	1.95	2.14	1.44
12.32	832589	954129.29	0.9	1.75	2.15	1.25
12.41	832502	954110.984	1.2	1.7	2.15	0.95
12.47	832439	954098.899	1.1	1.5	2.16	1.06

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
12.59	832329	954059.921	1.3	1.55	2.16	0.86
12.67	832239	954032.651	1.38	1.35	2.17	0.79
12.77	832146	954034.096	1.4	1.35	2.17	0.77
12.86	832048	954013.158	1.45	1.32	2.18	0.73
12.96	831951	954006.149	1.35	1.42	2.18	0.83
13.06	831854	954031.687	1.22	1.35	2.19	0.97
13.15	831758	954057.226	1.3	1.45	2.24	0.94
13.25	831661	954082.764	1.35	1.35	2.3	0.95
13.35	831564	954108.303	1.45	1.32	2.36	0.91
13.44	831468	954133.842	1.5	1.54	2.42	0.92
13.48	831433	954143.02	1.51	1.5	2.44	0.93
13.56	831369	954141.991	1.45	1.4	2.49	1.04
13.66	831269	954140.386	1.4	1.35	2.55	1.15
13.76	831169	954138.78	1.6	1.32	2.61	1.01
13.87	831069	954137.175	1.65	1.4	2.67	1.02
13.96	830969	954135.569	2.5	1.45	2.73	0.23
14.06	830869	954133.963	2.35	1.42	2.78	0.43
14.15	830769	954132.358	2.65	1.25	2.84	0.19
14.25	830669	954130.752	2.55	1.35	2.9	0.35
14.35	830569	954129.146	2.75	1.43	2.96	0.21
14.45	830469	954127.541	2.92	1.45	3.02	0.10
14.55	830369	954125.935	3.115	1.51	3.08	0.00
14.65	830269	954124.329	3.25	1.55	3.14	0.00
14.78	830169	954122.724	3.3	1.45	3.22	0.00
14.88	830069	954121.118	3.35	1.48	3.28	0.00
15	829969	954129.091	3.4	1.45	3.35	0.00
15.09	829870	954140.263	3.51	1.5	3.41	0.00
15.09	829870	954140.236	3.6	1.55	3.41	0.00
15.19	829773	954115.173	3.45	1.47	3.47	0.02
15.3	829676	954090.11	3.4	1.4	3.53	0.13
15.42	829580	954065.047	3.35	1.48	3.6	0.25
15.48	829519	954049.248	3.46	1.5	3.64	0.18
15.52	829490	954026.131	3.6	1.45	3.66	0.06
15.61	829412	953963.594	3.565	1.51	3.72	0.16
15.78	829334	953901.056	4.25	1.35	3.82	0.00
15.87	829261	953843.039	4.94	1.5	3.87	0.00
15.88	829256	953838.274	4.85	1.45	3.88	0.00
15.98	829181	953772.338	4.7	1.35	3.94	0.00

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
16.08	829106	953706.403	4.7	1.35	4	0.00
16.08	829086	953675.403	4.75	1.25	4.85	0.10
16.18	829030	953640.467	4.65	1.36	4.85	0.20
16.28	828955	953574.532	4.62	1.56	4.86	0.24
16.39	828880	953508.596	4.45	1.45	4.86	0.41
16.49	828805	953442.661	4.35	1.35	4.86	0.51
16.58	828730	953376.725	4.62	1.2	4.87	0.25
16.68	828654	953310.79	4.55	1.25	4.87	0.32
16.78	828579	953244.854	4.25	1.32	4.87	0.62
16.88	828504	953178.919	4.35	1.45	4.87	0.52
16.98	828429	953112.983	4.25	1.35	4.88	0.63
17.08	828354	953047.048	4.32	1.25	4.88	0.56
17.18	828278	952981.113	4.23	1.2	4.88	0.65
17.28	828203	952915.177	4.15	1.115	4.89	0.74
17.38	828128	952849.242	4.25	1.2	4.89	0.64
17.48	828053	952783.306	4.18	1.1	4.89	0.71
17.58	827978	952717.371	4.05	0.95	4.9	0.85
17.66	827903	952651.435	4.1	1.1	4.9	0.80
17.67	827889	952639.155	4.02	1	4.9	0.88
17.74	827811	952663.451	4.05	1.05	4.9	0.85
17.83	827715	952693.307	4.15	1.2	4.9	0.75
17.92	827620	952723.164	3.5	1.35	4.91	1.41
18	827525	952753.02	3.35	1.22	4.91	1.56
18.11	827429	952782.877	3	1.4	4.91	1.91
18.21	827334	952812.733	3.15	1.75	4.92	1.77
18.22	827319	952817.385	2.9	2	4.92	2.02
18.3	827235	952808.332	3.12	1.95	4.92	1.80
18.4	827135	952797.607	3	1.8	4.92	1.92
18.5	827036	952786.883	3.35	1.75	4.92	1.57
18.6	826937	952776.159	3.25	1.65	4.93	1.68
18.71	826837	952765.434	3.4	1.62	4.93	1.53
18.81	826738	952754.71	3.42	1.55	4.93	1.51
18.89	826655	952745.808	3.48	1.5	4.94	1.46
18.91	826638	952745.496	3.5	1.52	4.94	1.44
19.01	826538	952743.663	3.65	1.45	4.94	1.29
19.12	826438	952741.829	3.75	1.35	4.94	1.19
19.22	826338	952739.995	3.81	1.22	4.95	1.14
19.28	826278	952738.882	3.89	1	4.95	1.06

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
19.32	826239	952744.76	3.75	1.08	4.95	1.20
19.42	826140	952759.712	3.62	1.11	4.95	1.33
19.52	826041	952774.663	3.85	0.95	4.96	1.11
19.62	825942	952789.615	3.77	0.9	4.96	1.19
19.72	825843	952804.566	3.95	0.85	4.96	1.01
19.82	825744	952819.517	4.12	0.75	4.97	0.85
19.95	825646	952834.469	4.25	0.5	4.97	0.72
20.05	825547	952849.42	4.15	0.35	4.97	0.82
20.15	825448	952864.372	4.35	0.45	4.98	0.63
20.25	825349	952879.323	4.5	0.36	4.98	0.48
20.33	825250	952894.275	4.55	0.25	4.98	0.43
20.43	825151	952909.226	4.63	0.35	4.98	0.35
20.43	825150	952909.434	4.75	0.3	4.98	0.23
20.51	825052	952900.301	4.61	0.26	4.99	0.38
20.61	824952	952891.039	4.5	0.45	4.99	0.49
20.71	824852	952881.778	4.25	0.62	4.99	0.74
20.81	824753	952872.516	4.35	0.46	5	0.65
20.91	824653	952863.254	4.2	0.55	5	0.80
21.01	824554	952853.993	4.15	0.58	5	0.85
21.11	824454	952844.731	4.05	0.62	5.01	0.96
21.21	824355	952835.469	3.95	0.75	5.01	1.06
21.31	824255	952826.208	3.98	0.95	5.01	1.03
21.41	824155	952816.946	3.75	0.84	5.01	1.26
21.51	824056	952807.684	3.86	0.98	5.02	1.16
21.61	823956	952798.423	3.7	0.92	5.02	1.32
21.62	823949	952797.78	3.76	1	5.02	1.26
21.7	823866	952788.001	3.86	1.05	5.02	1.16
21.79	823774	952827.433	3.965	0.95	5.03	1.07
21.89	823682	952866.865	4.25	0.55	5.03	0.78
21.99	823590	952906.297	4.56	0.35	5.03	0.47
22.03	823531	952805.63	4.73	0.2	5.03	0.30
22.1	823465	952827.896	4.62	0.35	5.04	0.42
22.2	823370	952859.922	4.4	0.4	5.04	0.64
22.3	823275	952891.948	4.75	0.52	5.04	0.29
22.39	823181	952923.974	4.93	0.65	5.05	0.12
22.49	823086	952956	5.1	0.85	5.05	-0.05
22.59	822995	952996.954	5.3	1.1	5.05	-0.25
22.62	822965	953014.078	5.59	1.2	5.05	-0.54

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
22.69	822901	953028.246	5.3	1.05	5.05	0.00
22.79	822804	953049.922	5.75	0.45	5.06	0.00
22.89	822706	953071.598	6.1	0.36	5.06	0.00
22.91	822684	953076.498	6.44	0.2	5.06	0.00
22.99	822608	953097.728	6.35	0.25	5.06	0.00
23.11	822512	953134.835	6.25	0.34	5.07	0.00
23.22	822412	953177.097	6.4	0.4	5.07	0.00
23.33	822308	953210.081	6.25	0.36	5.07	0.00
23.42	822231	953251.311	6.34	0.34	5.08	0.00
23.51	822145	953295.634	6.25	0.5	5.08	0.00
23.61	822054	953345.139	6.34	0.45	5.08	0.00
23.71	821975	953390.492	6.2	0.41	5.09	0.00
23.82	821890	953441.298	6.15	0.45	5.09	0.00
23.9	821814	953466.818	6.16	0.4	5.09	0.00
23.92	821802	953482.683	6.2	0.35	5.09	0.00
24.02	821744	953563.663	6.25	0.26	5.1	0.00
24.13	821658	953634.894	6.36	0.36	5.1	0.00
24.23	821582	953699.207	6.5	0.3	5.1	0.00
24.33	821514	953765.168	6.45	0.32	5.11	0.00
24.38	821458	953822.885	6.32	0.4	5.11	0.00
24.47	821369	953847.621	6.35	0.35	5.11	0.00
24.55	821298	953874.005	6.42	0.38	5.11	0.00
24.64	821211	953906.986	6.5	0.4	5.11	0.00
24.72	821133	953929.817	6.45	0.43	5.12	0.00
24.81	821033	953928.389	6.35	0.4	5.12	0.00
24.89	820933	953926.961	6.4	0.35	5.12	0.00
24.97	820833	953925.532	6.43	0.41	5.13	0.00
25.05	820735	953924.13	6.51	0.4	5.13	0.00
25.05	820734	953925.433	6.25	0.42	6.3	0.05
25.1	820663	953996.176	6.1	0.75	6.3	0.20
25.2	820592	954066.919	5.95	0.9	6.31	0.36
25.26	820546	954113.031	5.72	1	6.32	0.60
25.3	820535	954145.959	5.7	1.05	6.32	0.62
25.39	820503	954240.533	5.5	0.95	6.33	0.83
25.49	820470	954335.107	5.352	1.12	6.34	0.99
25.59	820438	954429.681	5.204	1.25	6.34	1.14
25.68	820405	954524.255	5.056	1.4	6.35	1.29
25.78	820373	954618.829	5.056	1.4	6.36	1.30

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
25.87	820340	954713.403	4.76	1.63	6.37	1.61
25.97	820308	954807.977	4.612	1.85	6.37	1.76
26.06	820275	954902.551	4.464	1.8	6.38	1.92
26.16	820243	954997.125	4.316	1.88	6.39	2.07
26.19	820231	955029.43	5.26	2	6.39	1.13
26.26	820189	955079.178	5.15	2.05	6.4	1.25
26.36	820146	955169.274	5.2	2.155	6.4	1.20
26.46	820102	955259.369	5.35	2.25	6.41	1.06
26.53	820047	955342.184	5.25	2.05	6.42	1.17
26.63	819984	955419.463	5.15	2.12	6.43	1.28
26.64	819983	955420.516	5.14	2.1	6.43	1.29
26.73	819912	955489.401	4.95	2.05	6.43	1.48
26.83	819841	955559.237	4.75	2.25	6.44	1.69
26.93	819769	955629.073	4.82	2.35	6.45	1.63
27	819698	955698.686	4.45	2.42	6.46	2.01
27.1	819604	955732.709	4.2	2.35	6.46	2.26
27.18	819510	955766.732	4.05	2.22	6.47	2.42
27.28	819415	955800.756	3.95	2.36	6.48	2.53
27.36	819321	955834.779	3.86	2.4	6.48	2.62
27.45	819227	955868.981	3.5	2.35	6.49	2.99
27.55	819135	955906.63	3.35	2.5	6.5	3.15
27.65	819040	955937.386	3.25	2.45	6.55	3.30
27.75	818941	955947.843	3.35	2.41	6.59	3.24
27.84	818842	955958.3	3.4	2.36	6.64	3.24
27.93	818742	955968.757	3.55	2.45	6.68	3.13
28.01	818662	955977.176	4.63	2.5	6.72	2.09
28.03	818643	955976.876	4.75	2.29	6.73	1.98
28.13	818543	955975.337	4.88	2.35	6.77	1.89
28.22	818443	955973.799	5	2.1	6.82	1.82
28.32	818343	955972.26	5.25	1.85	6.86	1.61
28.4	818243	955970.721	5.35	1.55	6.9	1.55
28.5	818145	955955.107	5.5	1.25	6.95	1.45
28.55	818088	955935.921	5.54	1	6.97	1.43
28.58	818060	955907.17	5.65	0.95	6.99	1.34
28.67	817991	955834.944	5.78	0.65	7.03	1.25
28.75	817922	955762.718	6	0.62	7.07	1.07
28.83	817857	955694.325	6.19	0.5	7.11	0.92
28.84	817852	955693.017	6.1	0.42	7.11	1.01

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
28.94	817755	955668.366	6.35	0.35	7.16	0.81
29.04	817658	955643.716	6.5	0.46	7.2	0.70
29.14	817561	955619.066	6.68	0.35	7.25	0.57
29.24	817464	955594.415	6.95	0.48	7.3	0.35
29.32	817387	955574.847	7.22	0.5	7.33	0.11
29.34	817367	955571.256	7.15	0.65	7.34	0.19
29.44	817268	955553.839	7.05	0.8	7.39	0.34
29.53	817170	955536.422	7.15	0.74	7.43	0.28
29.63	817071	955519.005	7.22	0.81	7.48	0.26
29.73	816973	955501.588	7.15	0.95	7.53	0.38
29.75	816944	955496.471	7.25	1	7.54	0.29
29.81	816874	955505.413	7.15	0.91	7.57	0.42
29.91	816775	955518.076	7	1	7.62	0.62
29.93	816762	955519.697	7.26	0.8	7.62	0.36
30.01	816676	955536.232	7.1	0.75	7.66	0.56
30.1	816582	955564.217	7.15	0.8	7.7	0.55
30.21	816472	955594.036	7	0.85	7.76	0.76
30.29	816400	955662.099	7.105	0.91	7.79	0.69
30.38	816351	955754.972	6.95	0.95	7.84	0.89
30.48	816274	955818.557	6.9	0.89	7.88	0.98
30.56	816208	955872.513	6.95	1	7.92	0.97
30.58	816197	955883.24	7.2	0.95	7.93	0.73
30.67	816127	955954.07	7.45	0.88	7.98	0.53
30.77	816083	956039.684	7.65	0.81	8.02	0.37
30.86	816060	956137.048	7.7	0.7	8.06	0.36
30.89	816053	956168.988	7.86	0.6	8.08	0.22
30.96	816005	956216.771	7.95	0.65	8.11	0.16
31.07	815974	956340.387	8.1	0.55	8.16	0.06
31.17	815917	956429.641	8.45	0.41	8.21	0.00
31.26	815856	956511.755	8.65	0.35	8.25	0.00
31.36	815751	956547.457	8.8	0.42	8.3	0.00
31.44	815656	956569.732	9.12	0.4	8.34	0.00
31.45	815653	956571.034	9.25	0.41	8.34	0.00
31.54	815560	956606.768	9.15	0.38	8.39	0.00
31.64	815466	956642.503	9.05	0.35	8.43	0.00
31.74	815373	956678.237	9.15	0.45	8.48	0.00
31.78	815333	956693.369	9.21	0.4	8.5	0.00
31.84	815276	956702.416	9.1	0.35	8.53	0.00

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
31.94	815177	956718.107	9.05	0.42	8.57	0.00
32.02	815081	956740.198	8.75	0.3	8.61	0.00
32.12	814981	956752.941	8.65	0.35	8.66	0.01
32.23	814883	956814.994	8.45	0.31	8.71	0.26
32.34	814786	956861.033	8.25	0.38	8.76	0.51
32.41	814731	956915.77	8.01	0.4	8.8	0.79
32.42	814725	956921.593	8.25	0.35	8.8	0.55
32.52	814648	956986.018	8.46	0.3	8.85	0.39
32.6	814572	957050.443	8.62	0.31	8.89	0.27
32.71	814495	957114.868	8.8	0.4	8.94	0.14
32.8	814419	957179.294	8.9	0.32	8.98	0.08
32.83	814388	957204.994	9.2	0.3	8.99	0.00
32.89	814355	957255.067	9.05	0.25	9.02	0.00
32.99	814300	957338.372	8.75	0.45	9.07	0.32
33.09	814244	957421.677	8.15	0.76	9.12	0.97
33.15	814208	957475.766	7.99	1	9.15	1.16
33.18	814197	957508.913	7.65	1.25	9.16	1.51
33.28	814164	957603.428	7.97	1.35	9.21	1.24
33.37	814132	957697.942	8.35	1.22	9.25	0.90
33.47	814100	957788.893	8.73	1.2	9.3	0.57
33.48	814099	957792.596	8.85	1.1	9.3	0.45
33.58	814080	957890.799	8.88	1.05	9.35	0.47
33.69	814062	957989.002	8.7	1.2	9.4	0.70
33.79	814043	958087.205	8.83	1.15	9.45	0.62
33.89	814024	958185.409	8.95	1.02	9.5	0.55
33.97	814008	958269.409	9.06	1	9.54	0.48
33.99	814007	958283.867	9.1	1.05	9.54	0.44
34.09	814005	958383.833	9.15	1.1	9.59	0.44
34.18	814002	958483.8	9.12	1.25	9.63	0.51
34.28	814000	958583.766	9.05	1.15	9.68	0.63
34.4	813997	958683.733	9.11	1	9.74	0.63
34.41	813997	958701.336	9.1	0.8	9.74	0.64
34.49	813969	958778.884	9.05	0.85	9.78	0.73
34.59	813935	958873.006	9.15	0.9	9.83	0.68
34.69	813934	958975.784	9.12	0.8	9.87	0.75
34.79	813917	959075.605	9.05	0.85	9.92	0.87
34.88	813905	959163.268	9.35	0.65	9.96	0.61
34.98	813881	959266.58	9.56	0.7	10.01	0.45

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
35.08	813762	959341.575	9.85	0.75	10.06	0.21
35.19	813734	959443.61	9.95	0.6	10.11	0.16
35.28	813749	959544.204	10.1	0.65	10.16	0.06
35.36	813739	959620.922	10.23	0.5	10.19	0.00
35.38	813730	959641.77	10.1	0.45	10.2	0.10
35.48	813692	959734.066	10.25	0.55	10.25	0.00
35.58	813653	959826.361	10.35	0.6	10.3	0.00
35.68	813615	959918.657	10.5	0.4	10.34	0.00
35.78	813576	960010.952	10.7	0.45	10.39	0.00
35.81	813567	960032.58	10.91	0.5	10.4	0.00
35.88	813519	960092.084	10.95	0.52	10.44	0.00
35.98	813456	960169.798	10.55	0.45	10.48	0.00
36.08	813393	960247.513	10.4	0.4	10.53	0.13
36.08	813388	960254.157	10.46	0.5	10.53	0.07
36.17	813334	960328.34	10.5	0.4	10.57	0.07
36.26	813276	960409.457	10.35	0.45	10.62	0.27
36.3	813253	960440.711	10.44	0.3	10.64	0.20
36.36	813262	960501.609	10.4	0.38	10.66	0.26
36.43	813295	960591.585	10.5	0.41	10.7	0.20
36.51	813320	960686.088	10.55	0.35	10.73	0.18
36.61	813325	960796.874	10.25	0.38	10.78	0.53
36.73	813300	960897.031	10.05	0.45	10.84	0.79
36.83	813261	960994.657	9.85	0.56	10.89	1.04
36.93	813241	961092.59	9.6	0.75	10.93	1.33
37.02	813249	961186.383	9.55	0.98	10.98	1.43
37.13	813228	961290.995	9.6	1.1	11.03	1.43
37.24	813173	961405.763	9.43	1	11.08	1.65
37.32	813106	961468.733	9.4	1.15	11.12	1.72
37.42	813035	961536.779	9.54	1.2	11.16	1.62
37.42	813034	961542.372	9.45	1.15	11.17	1.72
37.52	813012	961639.991	9.35	1.2	11.21	1.86
37.62	812991	961737.61	9.56	1.12	11.26	1.70
37.71	812969	961835.23	9.75	1.11	11.3	1.55
37.81	812923	961923.189	9.88	1	11.35	1.47
37.91	812872	962009.184	10.1	1.1	11.4	1.30
38.02	812821	962095.179	10.05	0.95	11.45	1.40
38.12	812770	962181.173	10.15	0.85	11.49	1.34
38.18	812737	962236.515	10.26	0.8	11.52	1.26

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
38.21	812737	962272.158	10.11	0.82	11.54	1.43
38.32	812779	962382.307	10.35	0.75	11.59	1.24
38.41	812790	962475.193	10.42	0.7	11.63	1.21
38.5	812788	962570.099	10.55	0.65	11.68	1.13
38.6	812779	962671.063	10.65	0.75	11.72	1.07
38.69	812758	962763.941	10.85	0.7	11.77	0.92
38.75	812744	962817.705	11.22	0.8	11.79	0.57
38.8	812736	962871.417	11.15	0.6	11.82	0.67
38.91	812720	962970.134	11.2	0.75	11.87	0.67
39.01	812704	963068.851	11.45	0.55	11.91	0.46
39.11	812688	963167.568	11.5	0.4	11.96	0.46
39.17	812678	963228.305	11.63	0.3	11.99	0.36
39.21	812660	963262.439	11.65	0.35	12.01	0.36
39.3	812614	963351.158	11.55	0.4	12.05	0.50
39.4	812576	963449.983	11.85	0.55	12.1	0.25
39.5	812543	963544.58	12	0.45	12.15	0.15
39.61	812499	963639.177	12.65	0.5	12.2	0.00
39.73	812438	963736.762	12.95	0.65	12.25	0.00
39.82	812396	963821.027	13.2	0.6	12.3	0.00
39.91	812347	963896.617	13.85	0.4	12.34	0.00
40.01	812291	963972.194	14.5	0.55	12.39	0.00
40.11	812245	964060.914	14.95	0.6	12.44	0.00
40.21	812199	964149.633	15.2	0.65	12.48	0.00
40.3	812153	964238.352	15.55	0.7	12.53	0.00
40.41	812106	964327.072	15.65	0.72	12.58	0.00
40.43	812096	964347.462	15.96	0.8	12.59	0.00
40.5	812037	964396.984	16.05	0.75	12.62	0.00
40.6	811960	964461.283	16.25	0.6	12.67	0.00
40.6	811940	964506.283	16.25	0.6	16.5	0.25
40.7	811914	964544.245	16.3	0.55	16.52	0.22
40.78	811880	964615.848	16.25	0.65	16.53	0.28
40.88	811819	964702.265	16.35	0.75	16.55	0.20
41	811759	964812.638	16.4	0.83	16.58	0.18
41.02	811734	964823.179	16.49	0.8	16.58	0.09
41.07	811732	964881.447	16.5	0.65	16.59	0.09
41.16	811712	964978.308	16.65	0.7	16.61	0.00
41.27	811710	965084.478	16.35	0.63	16.63	0.28
41.37	811721	965181.244	16.25	0.52	16.65	0.40

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
41.37	811720	965188.976	16	0.5	16.65	0.65
41.46	811755	965274.374	16.15	0.45	16.67	0.52
41.55	811804	965360.253	16.25	0.42	16.69	0.44
41.64	811842	965444.201	16.35	0.35	16.7	0.35
41.73	811872	965528.149	16	0.55	16.72	0.72
41.86	811917	965647.899	16.25	0.45	16.75	0.50
41.96	811936	965745.426	16.3	0.65	16.77	0.47
42.07	811973	965852.088	16.25	0.6	16.79	0.54
42.18	811987	965968.134	16.11	0.63	16.81	0.70
42.26	811995	966053.836	16.05	0.68	16.82	0.77
42.36	811989	966152.079	15.95	0.7	16.84	0.89
42.47	811976	966260.779	16	0.71	16.87	0.87
42.57	811950	966357.935	16.05	0.76	16.89	0.84
42.67	811920	966457.731	16.1	0.65	16.91	0.81
42.77	811910	966557.288	15.95	0.68	16.92	0.97
42.87	811901	966656.845	15.85	0.72	16.94	1.09
42.96	811891	966756.402	15.9	0.75	16.96	1.06
43.07	811856	966850.049	15.95	0.9	16.98	1.03
43.17	811842	966951.636	16.1	0.96	17	0.90
43.27	811838	967051.849	15.05	0.86	17.02	1.97
43.37	811823	967150.69	15.75	0.92	17.04	1.29
43.48	811830	967256.395	15.7	0.96	17.06	1.36
43.53	811838	967319.757	15.84	1	17.07	1.23
43.56	811814	967344.051	15.9	0.94	17.08	1.18
43.63	811784	967420.151	15.8	0.86	17.09	1.29
43.72	811740	967500.164	15.85	0.8	17.11	1.26
43.82	811688	967588.664	15.95	0.75	17.13	1.18
43.95	811613	967702.622	16.2	0.76	17.16	0.96
44.03	811548	967757.176	16.45	0.82	17.17	0.72
44.12	811476	967813.264	16.65	0.68	17.19	0.54
44.24	811383	967888.634	16.8	0.64	17.21	0.41
44.35	811298	967946.015	16.85	0.63	17.23	0.38
44.46	811204	968004.994	16.93	0.55	17.26	0.33
44.57	811119	968082.509	17.05	0.52	17.28	0.23
44.66	811050	968139.803	17.2	0.58	17.3	0.10
44.75	810971	968198.001	17.15	0.48	17.31	0.16
44.76	810966	968202.736	17.2	0.5	17.32	0.12
44.85	810907	968274.487	17.15	0.43	17.33	0.18

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
44.95	810843	968351.352	17.05	0.5	17.35	0.30
45.05	810779	968428.217	17.2	0.45	17.37	0.17
45.15	810715	968505.082	17.25	0.42	17.39	0.14
45.25	810651	968581.948	16.98	0.48	17.41	0.43
45.28	810633	968603.334	16.82	0.5	17.42	0.60
45.35	810579	968650.913	16.9	0.42	17.43	0.53
45.45	810504	968716.834	16.92	0.45	17.45	0.53
45.55	810428	968782.755	16.98	0.55	17.47	0.49
45.64	810353	968848.675	17	0.62	17.49	0.49
45.72	810278	968914.596	17.22	0.63	17.5	0.28
45.8	810203	968980.516	17.35	0.68	17.52	0.17
45.83	810179	969001.489	17.3	0.74	17.53	0.23
45.9	810162	969063.706	17.32	0.88	17.54	0.22
45.98	810140	969141.356	17.45	0.94	17.55	0.10
46.03	810127	969208.221	17.52	1.2	17.56	0.04
46.12	810125	969296.656	17.9	1.12	17.58	0.00
46.17	810127	969361.364	18.22	1.25	17.59	0.00
46.23	810127	969423.916	18.35	1.35	17.6	0.00
46.31	810123	969516.664	18.94	1.28	17.62	0.00
46.35	810131	969572.745	19.5	1.35	17.63	0.00
46.41	810134	969648.238	19.82	1.42	17.64	0.00
46.49	810157	969730.202	20.05	1.42	17.65	0.00
46.53	810167	969774.694	20.36	1.5	17.66	0.00
46.57	810203	969805.695	20.21	1.46	17.67	0.00
46.63	810238	969869.515	20.15	1.42	17.68	0.00
46.77	810273	969961.859	20.45	1.3	17.71	0.00
46.93	810276	970100.374	20.82	1.32	17.74	0.00
47.04	810292	970195.434	20.96	1.52	17.76	0.00
47.15	810271	970293.19	21	1.35	17.78	0.00
47.18	810282	970325.632	21.04	1.2	17.79	0.00
47.24	810274	970390.947	21.45	1.1	17.8	0.00
47.34	810262	970490.174	21.56	1.23	17.82	0.00
47.44	810246	970587.883	21.62	1.28	17.84	0.00
47.54	810179	970662.153	21.75	1.18	17.86	0.00
47.63	810112	970736.423	21.92	1.22	17.88	0.00
47.72	810045	970810.693	21.86	1.29	17.9	0.00
47.82	809978	970884.963	21.74	1.25	17.91	0.00
47.91	809911	970959.233	21.96	1.21	17.93	0.00

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
48	809883	970990.468	22.03	1.2	17.95	0.00
48.06	809849	971037.478	22.32	1.05	17.96	0.00
48.15	809791	971118.608	22.41	0.88	17.98	0.00
48.24	809739	971190.78	22.55	0.6	18	0.00
48.25	809731	971198.712	22.5	0.95	18	0.00
48.25	809693	971208.312	22.5	0.95	23	0.50
48.37	809661	971270.556	22.12	0.85	23.05	0.93
48.52	809592	971342.399	21.75	0.82	23.1	1.35
48.59	809545	971390.723	21.33	0.8	23.13	1.80
48.65	809520	971411.69	21.54	0.86	23.15	1.61
48.75	809443	971475.738	21.75	0.82	23.19	1.44
48.9	809366	971539.786	21.96	0.91	23.25	1.29
49.02	809287	971620.874	22.21	0.95	23.29	1.08
49.11	809221	971721.02	22.45	1.1	23.33	0.88
49.23	809108	971768.512	22.76	1.15	23.38	0.62
49.39	808965	971791.971	23.1	1.13	23.44	0.34
49.5	808862	971810.472	23.65	1.32	23.48	0.00
49.56	808801	971823.687	23.87	1.46	23.5	0.00
49.63	808732	971834.26	23.96	1.52	23.53	0.00
49.76	808629	971858.047	24.01	1.55	23.58	0.00
49.86	808526	971884.477	24.09	1.51	23.62	0.00
49.96	808431	971905.621	25.01	1.62	23.66	0.00
50.06	808328	971918.836	24.86	1.66	23.7	0.00
50.16	808236	971902.978	24.92	1.86	23.73	0.00
50.28	808115	971890.264	24.88	1.92	23.78	0.00
50.33	808061	971879.26	24.97	2	23.8	0.00
50.33	808041	971875.61	24.97	2	26	1.03
50.38	808019	971872.977	24.95	2.05	26	1.05
50.48	807920	971858.332	24.91	2.12	26.01	1.10
50.58	807821	971843.687	25.1	2.23	26.01	0.91
50.68	807722	971829.043	25.16	2.16	26.02	0.86
50.78	807623	971814.398	25.18	2.09	26.02	0.84
50.88	807524	971799.753	25.21	2.1	26.03	0.82
50.92	807482	971793.457	25.13	2	26.03	0.90
50.98	807425	971795.634	25.2	1.96	26.03	0.83
51.08	807325	971799.453	25.25	2.01	26.04	0.79
51.18	807225	971803.273	25.36	1.98	26.04	0.68
51.27	807125	971807.092	25.46	1.88	26.05	0.59

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
51.37	807025	971810.911	25.59	1.76	26.05	0.46
51.47	806925	971814.731	25.78	1.61	26.06	0.28
51.58	806825	971818.55	25.49	1.43	26.06	0.57
51.68	806725	971822.369	25.68	1.21	26.07	0.39
51.76	806647	971825.369	25.61	1	26.07	0.46
51.78	806625	971826.822	25.615	0.98	26.07	0.46
51.88	806526	971833.596	25.68	1.05	26.08	0.40
51.99	806426	971840.369	25.78	0.94	26.08	0.30
52.09	806326	971847.142	25.88	0.71	26.09	0.21
52.15	806263	971851.421	25.96	0.3	26.09	0.13
52.19	806224	971851.31	25.91	0.26	26.09	0.18
52.28	806138	971865.726	25.88	0.21	26.1	0.22
52.37	806041	971871.493	25.61	0.29	26.1	0.49
52.44	805965	971864.285	25.59	0.38	26.11	0.52
52.53	805871	971861.401	25.68	0.36	26.11	0.43
52.63	805773	971854.193	25.77	0.44	26.11	0.34
52.74	805663	971833.002	25.61	0.48	26.12	0.51
52.83	805569	971810.609	25.65	0.5	26.12	0.47
52.84	805562	971807.903	25.61	0.59	26.13	0.52
52.94	805470	971769.964	25.88	0.48	26.13	0.25
53.03	805377	971732.026	26.05	0.46	26.14	0.09
53.13	805285	971694.087	26.12	0.51	26.14	0.02
53.23	805192	971656.148	26.26	0.62	26.14	0.00
53.31	805115	971624.306	26.43	0.6	26.15	0.00
53.33	805099	971620.611	26.25	0.65	26.15	0.00
53.43	805002	971597.618	26.91	0.69	26.15	0.00
53.53	804904	971574.624	26.8	0.71	26.16	0.00
53.63	804807	971551.63	26.78	0.86	26.16	0.00
53.73	804710	971528.636	26.31	0.94	26.17	0.00
53.83	804612	971505.643	26.08	0.84	26.17	0.09
53.94	804515	971482.649	26.05	0.96	26.18	0.13
53.99	804466	971471.011	25.96	1	26.18	0.22
54.05	804421	971451.011	25.91	1.05	26.19	0.28
54.15	804329	971410.513	25.88	0.85	26.19	0.31
54.25	804238	971370.015	25.86	0.74	26.2	0.34
54.27	804215	971360.015	25.99	0.6	26.2	0.21
54.34	804144	971334.169	25.84	0.56	26.2	0.36
54.35	804136	971331.146	25.77	0.5	26.2	0.43

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
54.45	804059	971282.675	25.98	0.54	26.21	0.23
54.55	803974	971229.524	25.83	0.63	26.21	0.38
54.65	803890	971176.372	25.81	0.72	26.22	0.41
54.75	803805	971123.22	25.74	0.84	26.22	0.48
54.84	803725	971073.237	25.59	0.8	26.23	0.64
54.85	803720	971070.066	25.69	0.84	26.23	0.54
54.95	803635	971016.893	25.73	0.83	26.23	0.50
55.05	803551	970963.719	25.98	0.95	26.24	0.26
55.1	803502	970932.93	26.45	1	26.24	0.00
55.15	803469	970906.708	26.32	1.05	26.24	0.00
55.25	803391	970844.417	26.05	0.98	26.25	0.20
55.35	803312	970782.127	25.88	0.91	26.25	0.37
55.44	803240	970724.704	25.8	0.8	26.26	0.46
55.44	803235	970719.079	25.86	0.83	26.26	0.40
55.54	803165	970647.08	25.73	0.96	26.26	0.53
55.64	803096	970575.081	25.63	1.05	26.27	0.64
55.72	803044	970521.576	25.56	1.2	26.27	0.71
55.72	803044	970521.576	26.5	1	26.27	-0.23
55.74	803028	970501.826	26.21	0.98	26.27	0.06
55.84	802964	970424.938	26.18	0.91	26.28	0.10
55.95	802900	970348.051	26.09	0.82	26.28	0.19
55.99	802875	970317.409	25.92	0.6	26.28	0.36
56.04	802823	970287.202	25.83	0.65	26.29	0.46
56.15	802736	970236.98	25.74	0.62	26.29	0.55
56.25	802650	970186.757	25.86	0.69	26.3	0.44
56.35	802563	970136.463	25.91	0.59	26.3	0.39
56.45	802486	970072.989	26.05	0.55	26.31	0.26
56.55	802409	970009.514	26.13	0.52	26.31	0.18
56.64	802336	969949.745	26.22	0.5	26.32	0.10
56.65	802332	969945.676	26.29	0.51	26.32	0.03
56.75	802260	969875.978	26.35	0.56	26.32	0.00
56.85	802188	969806.279	26.42	0.42	26.33	0.00
56.95	802117	969736.58	26.51	0.46	26.33	0.00
56.98	802091	969711.52	26.57	0.4	26.33	0.00
57.05	802054	969659.409	26.61	0.42	26.34	0.00
57.14	801991	969586.534	26.68	0.49	26.34	0.00
57.22	801955	969520.826	26.64	0.4	26.34	0.00
57.25	801926	969508.746	26.61	0.42	26.35	0.00

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
57.34	801865	969436.032	26.52	0.45	26.35	0.00
57.43	801800	969367.544	26.59	0.46	26.36	0.00
57.53	801733	969298.721	26.68	0.48	26.36	0.00
57.62	801671	969233.615	26.82	0.51	26.36	0.00
57.74	801596	969145.38	26.74	0.56	26.37	0.00
57.83	801518	969092.845	26.79	0.49	26.37	0.00
57.94	801432	969021.438	26.68	0.46	26.38	0.00
58.04	801345	968972.12	26.61	0.42	26.39	0.00
58.06	801335	968966.273	26.56	0.4	26.39	0.00
58.14	801251	968939.119	26.26	0.68	26.39	0.13
58.24	801156	968908.313	26.05	0.84	26.4	0.35
58.34	801061	968877.507	25.74	0.93	26.4	0.66
58.43	800979	968851.159	25.25	1	26.4	1.15
58.44	800967	968844.702	25.18	1.05	26.41	1.23
58.54	800877	968800.076	25.21	1.26	26.41	1.20
58.64	800788	968755.449	25.26	1.43	26.42	1.16
58.65	800779	968751.006	25.23	1.5	26.42	1.19
58.69	800740	968729.119	25.28	1.61	26.42	1.14
58.73	800708	968709.562	25.32	1.53	26.42	1.10
58.78	800674	968656.911	25.45	1.41	26.42	0.97
58.87	800626	968572.667	25.56	1.36	26.43	0.87
58.99	800573	968471.877	25.78	1.28	26.43	0.65
59.08	800511	968406.786	25.88	1.11	26.44	0.56
59.18	800437	968344.669	26	1.03	26.44	0.44
59.28	800353	968290.597	25.88	0.95	26.45	0.57
59.35	800303	968258.708	25.82	0.8	26.45	0.63
59.38	800286	968221.629	25.62	0.82	26.45	0.83
59.48	800243	968131.25	25.73	0.78	26.46	0.73
59.56	800200	968040.87	25.66	0.62	26.46	0.80
59.65	800124	967995.671	25.57	0.72	26.47	0.90
59.75	800025	967983.124	25.51	0.78	26.47	0.96
59.82	799953	967973.929	25.59	0.8	26.47	0.88
59.85	799919	967971.112	25.45	0.72	26.48	1.03
59.93	799844	967948.694	25.39	0.83	26.48	1.09
60.04	799764	967840.754	25.31	0.85	26.49	1.18
60.14	799717	967747.228	25.23	0.83	26.49	1.26
60.15	799710	967740.358	25.14	0.8	26.49	1.35
60.24	799646	967676.785	25.22	0.89	26.5	1.28

Chainage (km) A	Easting (m) B	Northing (m) C	River Bed Level w.r.t MSL (m) D	Measured Water Depths (m) E	Adopted C.D. w.r.t. MSL (m) F	Reduced Depth w.r.t. C.D. (m) G=F-D
60.34	799575	967606.226	25.48	0.83	26.5	1.02
60.44	799505	967535.668	25.69	0.96	26.51	0.82
60.44	799504	967535.338	25.83	1	26.51	0.68
60.55	799431	967468.42	25.68	1.05	26.51	0.83
60.65	799357	967401.189	25.26	1.1	26.52	1.26
60.67	799340	967386.58	24.97	1	26.52	1.55
60.75	799309	967314.972	25.36	1.08	26.52	1.16
60.88	799242	967201.063	25.56	1.06	26.53	0.97
60.93	799209	967157.718	25.88	1	26.53	0.65
61.05	799147	967054.75	26.05	0.94	26.54	0.49
61.16	799113	966962.672	25.75	0.84	26.54	0.79
61.25	799085	966868.27	25.36	0.86	26.55	1.19
61.36	799045	966777.775	25.06	0.75	26.55	1.49
61.46	799025	966679.72	24.85	0.71	26.56	1.71
61.57	799006	966581.664	24.68	0.68	26.56	1.88
61.64	798993	966518.3	24.54	0.6	26.57	2.03
61.67	798986	966483.54	24.65	0.63	26.57	1.92
61.77	798968	966385.291	24.88	0.66	26.57	1.69
61.86	798950	966289.862	24.98	0.7	26.58	1.60
61.86	798948	966287.352	25.03	0.73	26.58	1.55
61.96	798916	966186.747	25.23	0.78	26.58	1.35
62.07	798862	966094.837	25.36	0.68	26.59	1.23
62.18	798810	966008.672	25.48	0.65	26.59	1.11
62.25	798763	965949.266	25.34	0.56	26.6	1.26
62.3	798736	965904.937	25.23	0.5	26.6	1.37
62.31	798732	965898.275	25.3	0.48	26.6	1.30

Table 19: Topographic Survey data

Note: Negative (-) ive depths are reduced to zero as per discussions with IWAI officials.

4.6 Observed and reduced bed profile along the river

4.6.1 Observed & reduced bed profile along the river

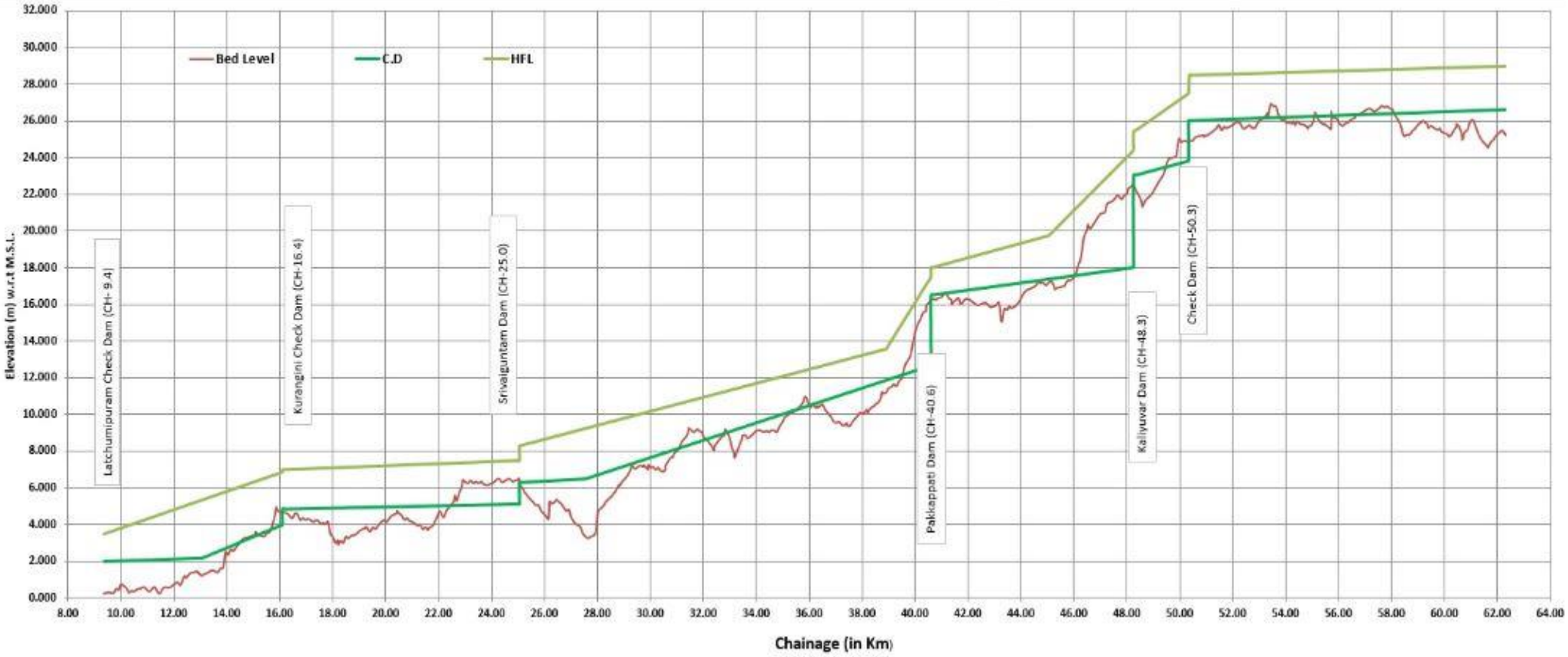


Figure 10: Riverbed profile from the Estuary (CH-9.4) up to (CH-64)

Source: Deepest level single line longitudinal survey carried out at site in March-April 2016 and Gauge –Discharge data collected from CWC.

Source data table is attached as Annexure 4.

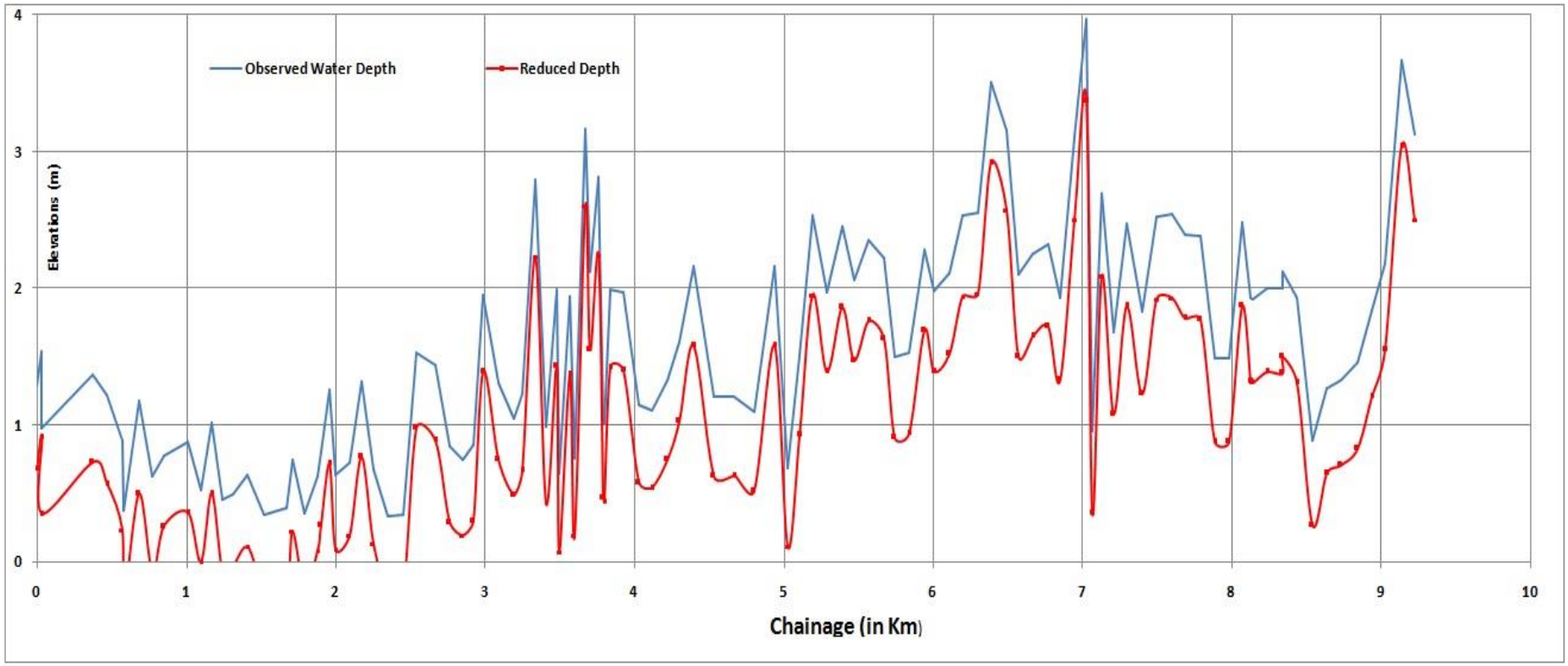


Figure 11: Depth Profile at the Estuary (CH 0 to CH 9.23), up to tidal influence.

4.7 Results from Hydrographic/Topographic Survey

- The Tamaraparani River was generally observed having water even upstream of the estuary.
- Bathymetry survey was carried out from river mouth to chainage 9.23 km.
- For CH 9.5 to CH 64, water depths are measured manually since the depths are shallow and it was not possible to carry out bathymetry survey.

4.8 Soil characteristics

Soil samples were collected from the river bed along the surveyed route at about 10 km intervals (7 samples were collected), and the nature and texture of the samples collected were visually analysed and the details of CH vs depth & soil textures are tabulated in **Annexure 1.**

In general the river bed material is mostly medium and coarse sand with some silt and clay. In upper reaches the river bed comprises of coarse sand.

Rocky River bed is observed from 60-64 km. However wild life sanctuaries, ecological parks has not been found in the stretch under present studies.

Critical areas requiring Detailed Investigations.

Detailed investigations shall be required at proposed ferry locations nearby temples, Existing boating points and ghats.

4.9 Water characteristics

From visual observation, clear water was found from chainage 0 to 9 km and after 9 km, Muddy water with sand was observed up to 13 km.

4.10 Condition of banks

Condition of banks was depicted in inventory of structures in **Annexure 2.**

At some chainages, rocky banks were observed with some grass.

The photographs showing condition of banks along the riverbanks during the Stage-1 survey are also attached at the end.

4.11 Details of collected water level and Discharge data

The details of gauging stations and collected data as detailed in chapter 2 (refer 2.6.3 and 2.6.4) is again given below:

Name	**Location**	
	Lat.	Long.
Gauging station Murappanadu, Tuticorin dist, Tamil Nadu (CH-40.0)	08^0 42′ 52” N	77^0 50′ 06” E

Table 20: Location details of gauging station

The details of Gauge station, jurisdiction, establishment and data availability are presented in the tables below:

General Details	
Station Name	Murappanadu

Station Code	CT000H9
Operational Status	Existing
Activity	HO
Station Type (Current)	GDSQ
Tehsil/Taluk	Srivaikundam
District	Tuticorin
State	Tamil Nadu
Latitude (DMS)	08°43'02"N
Longitude (DMS)	77°49'59"E
Altitude (m)	25.00
Distance to Outlet (km)	-
Toposheet No.	58H14
Catchment Area (sq. km)	4380.00

Table 21: Murappanadu GD site- General details

Jurisdiction Details	
Owner Agency	CWC
State/Regional Office	C&S RO, Coimbatore
Circle Office	S.E.(C&SR), Bangalore
Divisional Office	SR Division, Coimbatore
Sub Divisional Office	Vaigal SD, Madurai
Section Office	Murappanadu
Nearest Airport	Tutukudi (Vakaikulam)
Town	Tirunelveli
Railway Station	Tirunelveli
Bus Stand	Murappanadu
Station Bank	Right
Zero of Gauge (m)	14.00

Table 22: Murappanadu GD site- Jurisdiction details

Establishment Details	
Date of establishment	29/8/1977
Date of closure	-
Parameters	**Start Date**
Gauge	29/8/1977
Discharge	23/11/1977
Sediment	15/02/1979
Water Quality	15/02/1978
Rainfall(ORG)	25/10/1985
Rainfall(SRG)	1/6/1999
Temperature	1/10/1978
Wind Velocity	17/09/1978
Evaporation	4/8/1989
Humidity	5/11/1989

Sunshine	3/7/2000

Table 23: Murappanadu GD site- Establishment details

Parameters	Start Date	End Date
Water Level	29/8/1977	30/5/2012
Discharge	23/11/1977	30/5/2012
Sediment	15/02/1979	30/5/2012
Water Quality	15/08/1978	1/5/2012
Rainfall	25/10/1985	31/5/2008
Temperature	1/1/1978	31/5/2009
Climatic	1/6/1999	31/5/2008

Table 24: Murappanadu GD site - Data availability

4.12 Methodology for analysis of Gauge- Discharge Data

The gauge-discharge data available for number of years for all gauging stations were analysed in different ways as given below:

10 Daily average discharges

The ten daily average discharges in each month for each year were worked out and then the average of average 10 daily discharges over the entire period of data were worked out to get idea about availability of 10 daily average discharge during different months of the year. Based on these average 10 daily discharges it will be possible to work out available depth of flow for natural or design cross section of river. These data analysis will be helpful for navigation feasibility in given stretch of river. The outcome from this analysis will also be useful for mathematical model studies(to be carried out in stage II) to predict longitudinal water surface profiles for different discharges along given reach of river and also to design section of navigation channel on river bed.

Maximum minimum discharges and water levels

The yearly maximum discharge and water level for the entire period of data were extracted and then these data were statistically analysed using Gumbel extreme value distribution to estimate flood discharges for different return periods such as 2,5, 10, 25 ,50 and 100 years. Similarly high flood levels were analysed. The minimum flow and minimum water level data was also analysed. The estimated HFLs and Minimum water levels will be useful for planning navigation as well as for design of terminals for cargo and passenger traffic.

Gauge discharge curves

Using available gauge discharge data G-Q curves were developed for each gauge station. These will be helpful to compute water level for any discharge. Also for calibration and validation of mathematical model (studies required in stage II) this data will be very useful.

Comparison of River Cross Section Data:

The river cross sections at gauging stations on different station were available for different years. For a given gauging station the cross sections for different years

including the latest cross section were superimposed to study changes in river bed levels and shifting of the deep channel if any over the period of data.

Period of availability for range of discharges

For a navigation channel to be feasible it is necessary that adequate discharge is available to maintain required depth/draft for fairly longer duration during the year. The data for each gauge station was analysed to find out period of availability for the different range of discharges. Based on past 20 to 30 years of data, % of days in a year for availability of different range of discharges were worked out. These data will be very useful to estimate number of days for which minimum discharge required to facilitate navigation will be available in different rivers.

Discharge- sediment flow data

These data was analysed to prepare discharge v/s sediment concentration plot for each gauging station. This analysis will be useful to understand sediment concentration in reach for range of discharges.

4.13 Bed Slope

The average bed slopes for Tamaraparani River for the reach under consideration are given in table below:

River	Reach		River Bed Level Change	Distance	Slope
	From	To			
Tamaraparani	**Murappandu RBL 14.215 m**	**Mouth RBL 0.0 m**	**14.215 m**	**40.55 km**	**1/2940**

Table 25: Bed Slopes of the River

RBL – River Bed Level (These are taken from CWC river cross sections at gauging sites)

4.14 River Cross sections

The CWC data of river cross sections at gauging sites on six rivers in cluster 5 was available for number of years. The river cross sections at a gauging site for different years were compared to understand morphological changes over the longer period. Figure 12shows plot for Tamaraparani river cross section indicating comparison of cross sections in different years. Following table shows abstract of review of these studies.

River & Gauge location	General Description & Bank to Bank width	River bed level in 2012	Bank Levels	Comments/ observations
Tamaraparani at Murappanadu	Wide c/s, width - 600 m, deep channel near left bank (Figure 11)	14.215m	22 to 24 m	Practically no change in river section during 1999 to 2012

Table 26: River cross-sections over different years

4.15 Ten- Daily average Discharges

Analysis of 10 daily average flows (from CWC data) is presented in Table 27. Figure 13shows bar chart indicating variation in 10 daily average flows round the year. The

results of this analysis indicate range of average 10 daily flows in different period of year as follows:

- ➔ June to September 7 to 9 m^3/s
- ➔ October 9 to 20 m^3/s
- ➔ November - December 40 to 50 m^3/s
- ➔ January –February 10 to 20 m^3/s
- ➔ February –June 7 to 8 m^3/s

The gauge- discharge curve derived from the daily flow data during periods of high floods is presented vide figure 14.

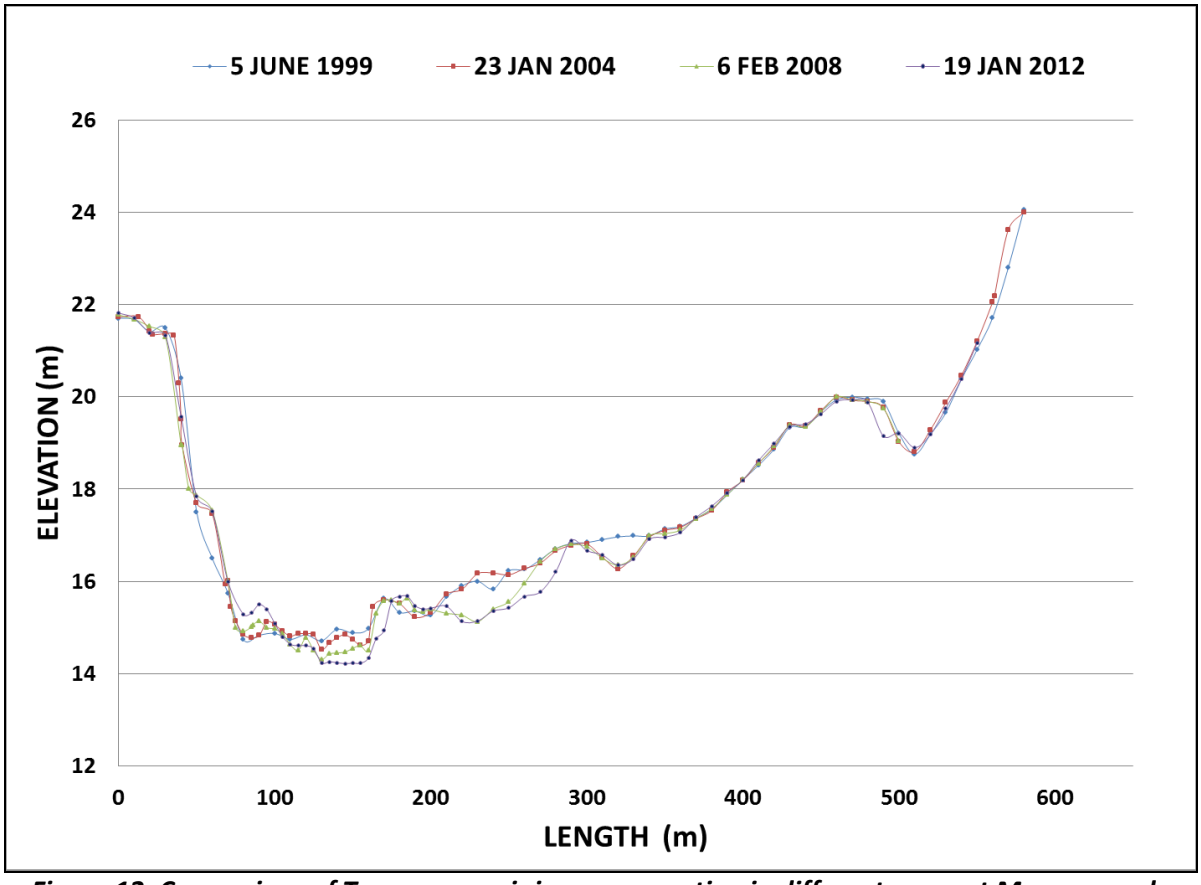


Figure 12: Comparison of Tamaraparani river cross-section in different years at Murappanadu gauging station

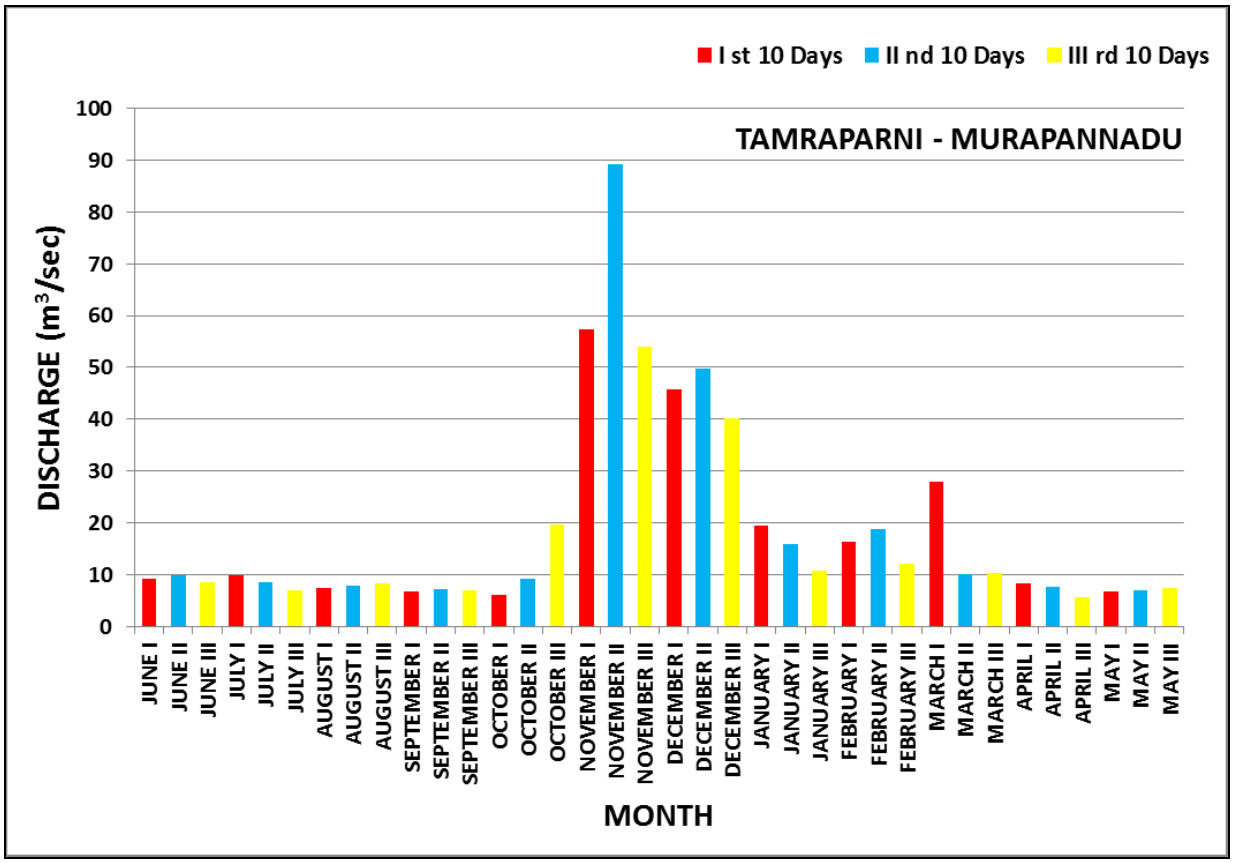


Figure 13: Average 10 daily discharges at Murappanadu gauging site on Tamaraparani River

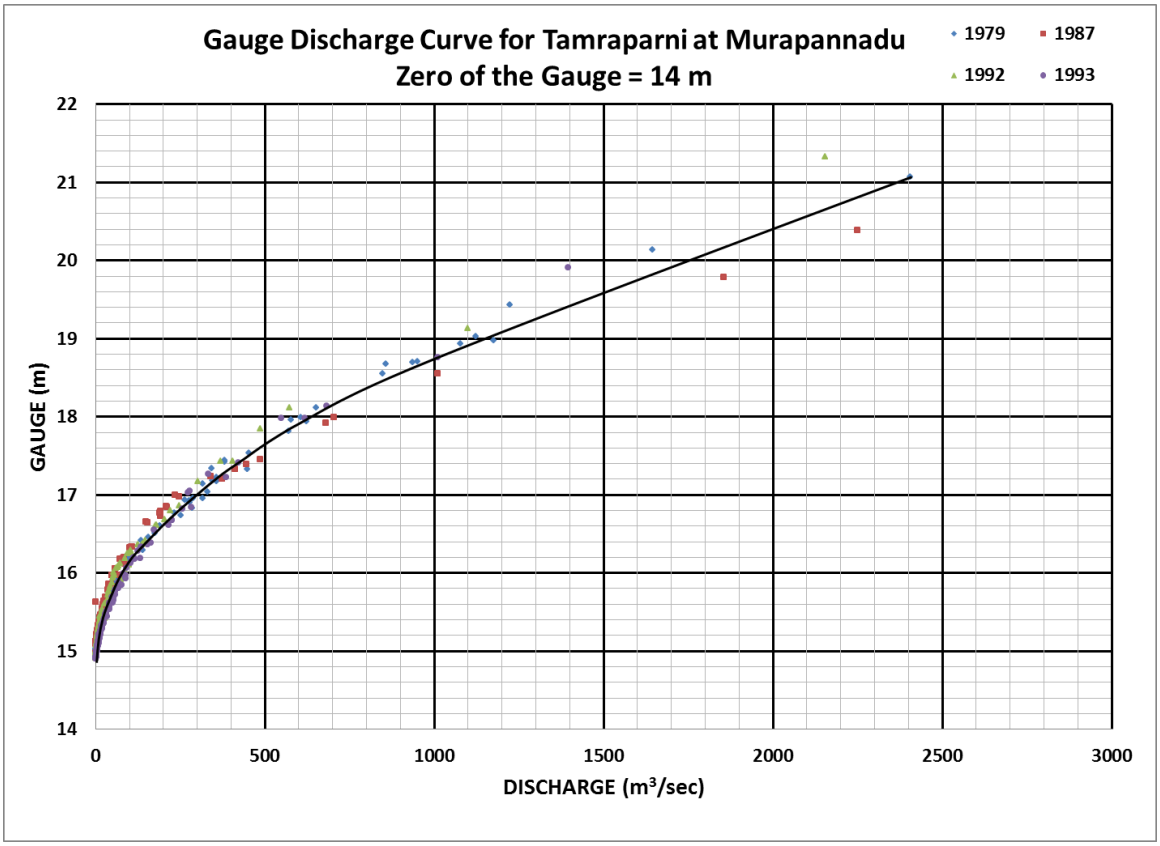


Figure 14: Gauge discharge curve for River Tamaraparani at Murappanadu gauge station

YEAR	JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
1977-1978	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.19	64.96	22.94	10.80	9.81	11.00	7.37	17.88	6.36	20.24	10.70	9.17	3.68	6.67	5.60	7.06	12.68	14.35	9.94
1978-1979	8.15	8.99	14.45	13.57	4.29	7.81	7.61	11.44	6.62	2.55	3.58	1.48	3.44	3.32	2.78	194.30	8.97	10.31	11.27	125.23	164.16	28.45	5.23	14.75	10.66	13.05	7.94	6.61	2.62	1.91	14.37	12.44	12.53	7.21	16.47	15.39
1979-1980	5.42	9.37	13.20	15.28	10.19	2.82	5.01	1.98	4.90	9.36	5.35	1.35	2.44	3.02	74.23	384.56	998.98	404.34	314.57	169.29	72.54	5.98	7.91	10.50	12.08	6.99	12.39	10.20	5.61	3.36	16.04	9.47	12.33	7.04	5.21	7.76
1980-1981	12.28	7.01	6.20	10.48	11.03	6.37	2.97	2.00	4.86	3.96	1.85	3.27	1.74	5.71	3.46	3.08	36.03	4.59	4.65	87.89	17.22	4.09	5.51	4.18	11.18	9.26	7.88	2.76	6.48	6.78	3.37	5.09	4.46	5.44	2.33	5.65
1981-1982	10.99	8.23	6.66	9.52	6.69	5.06	8.46	14.54	10.35	11.10	23.70	18.67	6.18	8.80	38.98	5.43	14.59	2.61	5.56	36.84	36.74	6.27	6.24	6.13	10.46	9.33	5.59	5.10	5.62	4.73	14.48	13.11	2.92	8.63	4.29	10.47
1982-1983	12.52	5.76	9.44	7.38	6.81	4.43	4.74	4.99	5.25	4.42	5.08	0.76	0.20	0.93	2.46	26.80	3.36	45.26	30.47	2.94	2.31	8.04	12.07	16.55	5.35	9.23	14.25	9.90	4.19	2.74	0.36	0.32	1.43	0.72	0.00	0.00
1983-1984	0.10	1.79	1.52	1.14	6.58	2.51	2.79	8.01	5.56	6.87	6.41	3.83	5.72	7.80	6.69	12.07	1.27	4.73	20.41	6.43	23.44	15.21	48.80	8.71	116.08	286.32	41.99	647.47	38.97	4.79	2.74	10.15	6.82	4.39	6.74	12.48
1984-1985	4.41	6.12	13.33	8.81	8.44	18.52	7.80	4.31	4.68	6.30	6.30	4.67	16.50	5.09	6.31	3.83	8.29	5.00	5.09	13.76	8.02	27.87	6.32	4.67	10.49	4.03	9.63	11.57	2.35	6.99	7.14	3.32	2.83	10.75	7.98	7.76
1985-1986	6.64	7.13	11.74	13.68	8.37	7.89	8.51	7.46	4.59	4.00	2.40	7.87	1.56	4.00	13.52	29.08	44.19	4.89	11.80	9.27	5.65	3.46	13.51	10.96	10.15	10.62	5.31	6.57	10.30	3.61	3.85	8.15	6.43	6.44	5.78	11.18
1986-1987	5.21	7.03	9.21	6.47	3.90	6.47	10.97	30.41	9.25	4.78	3.25	3.70	4.42	5.92	15.99	2.80	2.58	2.78	7.49	11.42	9.65	13.40	16.44	8.61	8.15	7.54	12.20	9.43	11.68	3.48	1.10	0.81	2.60	0.86	0.70	1.76
1987-1988	2.70	0.03	4.90	7.97	5.92	0.31	0.92	1.69	6.66	3.46	15.23	9.30	6.51	10.37	47.69	10.52	6.59	10.83	46.12	44.08	16.61	6.70	5.05	5.35	16.49	12.33	17.08	7.43	9.68	3.31	7.11	7.28	2.05	5.02	14.65	13.91
1988-1989	10.62	8.63	11.82	12.96	7.24	3.92	5.16	4.73	10.75	4.36	8.48	3.17	2.97	7.97	5.82	39.24	13.17	5.90	13.92	7.31	6.18	11.29	11.06	8.00	11.58	12.01	4.89	2.84	5.65	1.11	0.31	5.95	1.51	0.07	5.09	1.18
1989-1990	0.47	2.84	3.72	6.51	4.15	19.74	14.39	15.52	10.68	6.36	8.05	13.71	5.43	7.82	12.34	18.23	14.79	4.62	18.20	7.99	10.81	113.49	20.47	10.22	11.67	7.10	11.15	7.14	4.07	6.79	6.96	6.14	3.25	7.02	8.69	5.74
1990-1991	10.98	12.78	13.90	6.84	7.34	6.11	3.77	2.96	3.89	2.92	2.09	3.36	2.20	3.10	39.94	67.70	13.01	44.84	82.08	31.29	16.12	44.18	32.94	14.20	3.88	7.46	13.72	16.01	7.80	5.93	11.15	10.54	11.96	11.61	11.63	12.17
1991-1992	35.07	18.66	8.71	38.69	37.40	5.95	10.50	4.69	2.70	4.02	9.52	6.05	6.52	12.55	37.42	14.47	38.68	21.91	8.14	14.49	8.87	7.90	9.96	11.42	8.97	12.55	15.54	7.17	3.98	4.45	1.64	2.22	2.95	3.75	1.35	3.14
1992-1993	7.41	5.88	7.09	5.43	5.42	6.03	6.85	13.88	10.79	4.31	4.23	12.83	8.02	17.40	12.28	44.56	422.39	110.27	216.95	53.51	26.48	14.95	9.78	15.77	7.75	4.42	14.54	17.16	4.05	2.94	13.83	8.94	8.92	11.48	6.44	4.85
1993-1994	11.23	13.73	11.36	7.78	7.17	7.45	11.89	9.00	4.65	3.43	7.62	2.48	4.63	4.04	3.33	210.56	165.20	72.34	55.20	69.87	384.90	79.94	31.49	13.57	25.81	29.76	12.25	8.34	9.84	11.16	15.73	13.49	7.93	8.75	9.70	18.16
1994-1995	3.84	17.58	9.49	9.61	15.77	8.06	23.19	9.71	12.91	12.60	12.95	24.40	21.57	13.42	14.55	77.79	145.34	31.37	11.68	12.99	18.16	12.10	15.22	11.20	17.22	9.15	5.57	9.74	8.53	5.06	6.66	6.97	6.25	7.68	4.35	9.05
1995-1996	16.31	15.43	10.85	11.47	9.35	6.88	4.19	5.28	9.86	4.67	5.93	5.91	7.37	4.02	13.25	30.03	11.36	21.48	10.75	13.33	9.66	12.05	9.34	3.52	2.02	2.48	1.71	1.64	2.75	3.69	0.22	3.23	1.55	0.26	0.96	2.44
1996-1997	0.35	3.17	5.22	3.11	1.11	5.34	12.11	8.90	11.81	6.46	3.87	2.32	2.48	8.12	10.23	13.61	3.47	5.77	8.93	45.94	6.44	10.76	8.98	7.83	7.15	8.27	7.58	11.70	3.02	4.21	1.46	0.91	0.23	4.77	0.47	0.06
1997-1998	2.32	0.05	1.19	2.07	3.70	3.64	3.17	4.17	5.98	3.86	3.62	9.82	7.38	13.67	15.70	115.98	50.06	76.13	161.96	217.21	155.00	26.72	8.83	6.73	11.99	18.46	10.94	7.84	9.11	5.67	6.77	9.90	10.17	5.27	5.55	2.62
1998-1999	8.05	7.70	9.54	9.96	9.05	8.00	8.71	3.98	5.74	7.54	7.18	7.90	6.51	7.25	16.98	21.36	14.11	12.18	39.93	133.99	12.13	15.04	14.74	7.44	23.85	12.94	20.39	6.34	5.02	4.32	8.00	1.38	1.43	2.10	2.69	1.98
1999-2000	19.02	58.90	11.44	8.46	12.58	5.94	10.60	11.23	6.00	5.37	2.62	3.56	6.42	4.26	6.08	13.31	17.96	37.64	26.30	10.64	15.06	14.82	18.95	8.06	21.15	9.22	9.66	10.83	4.24	2.29	10.99	15.56	8.26	9.37	7.90	3.49
2000-2001	10.19	13.46	8.76	13.23	4.36	4.56	6.41	4.41	40.29	4.35	9.00	18.04	6.21	5.00	4.17	11.70	20.54	58.33	24.58	16.75	50.58	39.25	10.95	16.25	20.54	12.00	12.55	9.65	9.79	14.75	5.77	12.01	3.80	4.29	0.80	1.27
2001-2002	3.59	5.82	6.90	6.19	7.01	5.14	7.06	6.93	3.45	6.07	4.57	4.47	8.16	5.49	6.86	3.78	10.17	14.55	6.67	3.33	39.11	11.01	8.67	8.10	44.92	5.11	12.29	19.99	11.01	7.03	2.74	2.69	3.37	4.68	3.64	3.81
2002-2003	3.23	3.76	7.54	7.70	4.85	5.04	4.03	5.23	7.32	5.46	5.90	4.88	5.97	3.12	3.30	16.01	33.74	31.80	34.46	11.67	13.51	15.85	14.91	12.82	11.67	13.60	6.30	8.24	14.10	4.80	3.23	3.36	3.32	4.29	2.15	3.03
2003-2004	3.93	3.39	2.76	3.81	3.46	2.79	3.47	3.79	5.52	4.91	4.48	2.24	3.38	8.36	7.47	14.05	23.48	32.69	34.58	29.20	17.23	13.32	11.63	18.07	8.67	7.11	19.00	11.94	3.40	1.50	1.57	2.18	1.30	2.88	1.87	3.00
2004-2005	4.17	10.37	8.20	13.23	7.74	4.99	7.13	15.31	9.08	8.67	9.44	11.86	4.72	2.19	33.04	145.92	425.44	64.02	57.61	43.93	8.94	11.63	10.76	13.03	13.73	10.84	8.84	12.37	4.07	1.25	59.05	4.21	5.47	12.71	11.68	11.28
2005-	12.9	10.9	12.3	10.9	13.9	9.50	9.11	11.1	8.95	12.7	11.1	7.33	11.3	6.63	7.07	8.46	29.90	35.90	19.54	252.3	12.61	9.24	78.9	9.93	17.18	12.11	13.2	22.86	14.3	4.65	5.17	11.3	9.86	9.59	11.8	10.0

YEAR	JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
2006	9	2	8	1	7			9		0	5		1							2			4				8		2			4			7	5
2006-2007	18.02	6.87	5.21	9.17	10.87	7.75	6.17	4.49	7.41	15.32	7.60	8.65	7.64	21.92	106.74	261.21	354.69	459.62	62.58	19.48	18.50	15.82	12.10	20.81	8.37	10.39	12.56	9.89	8.56	5.92	11.04	10.78	5.98	6.21	8.16	9.48
2007-2008	10.78	9.98	11.13	11.90	15.32	8.05	5.00	7.69	8.64	10.34	10.98	7.64	4.94	9.87	12.67	37.74	39.44	19.36	13.08	22.11	85.98	19.48	12.27	13.53	18.44	17.65	8.05	9.60	75.23	192.95	22.53	28.93	6.59	12.83	14.30	17.30
2008-2009	18.04	9.63	5.06	7.19	5.24	3.41	6.16	7.61	15.51	8.74	7.83	4.31	6.04	71.49	45.76	9.75	9.32	118.04	48.34	161.87	58.11	11.03	10.49	17.23	11.80	12.65	14.97	10.69	6.95	4.05	8.32	15.80	7.48	9.87	8.74	10.02
2009-2010	7.82	7.90	9.19	8.75	10.70	12.25	8.41	5.91	4.00	7.76	7.14	5.43	4.48	7.80	16.80	68.50	36.60	23.12	28.23	14.19	48.87	12.05	34.43	14.76	11.46	14.29	10.78	10.08	6.29	3.84	5.55	5.63	13.06	16.30	15.46	9.74
2010-2011	9.32	9.23	7.70	14.89	10.45	11.45	7.22	9.22	8.21	8.09	8.91	7.55	3.72	3.83	12.11	13.04	12.57	19.91	60.26	5.44	5.04	9.56	8.95	5.70	15.07	11.72	11.51	5.88	14.71	12.03	2.58	8.22	9.20	10.35	12.03	10.52
2011-2012	12.52	17.48	12.57	8.94	4.53	15.06	3.99	3.96	6.16	11.65	10.43	4.96	5.97	8.95	12.61	21.62	4.23	67.28	34.16	11.50	10.41	16.28	10.27	6.06	8.88	18.06	11.42	12.56	8.28	3.91	3.26	3.16	2.55	1.69	7.26	7.59
MAXIMUM	35.07	58.90	14.45	38.69	37.40	19.74	23.19	30.41	40.29	15.32	23.70	24.40	21.57	71.49	106.74	384.56	998.98	459.62	314.57	252.32	384.90	113.49	78.94	20.81	116.08	286.32	41.99	647.47	75.23	192.95	59.05	28.93	13.06	16.30	16.47	18.16
MINIMUM	0.10	0.03	1.19	1.14	1.11	0.31	0.92	1.69	2.70	2.55	1.85	0.76	0.20	0.93	2.46	2.80	1.27	2.61	4.65	2.94	2.31	3.46	5.05	3.52	2.02	2.48	1.71	1.64	2.35	1.11	0.22	0.32	0.23	0.07	0.00	0.00
AVERAGE	9.08	9.87	8.60	9.80	8.56	7.04	7.31	7.84	8.32	6.67	7.26	6.99	5.96	9.21	19.67	57.39	89.25	54.10	45.73	49.73	40.17	19.34	15.83	10.63	16.36	18.70	12.11	27.95	10.04	10.28	8.34	7.69	5.65	6.77	6.89	7.38

Table 27: Mean 10 daily discharges in cumecs

4.16 Monthly minimum and maximum Water levels

The gauge-discharge data at murappanadu available from 1987-2012 is analysed in different ways. The monthly minimum and maximum water levels for the entire period of data were extracted and are tabulated below.

YEAR	JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		JANUARY		FEBRUARY		MARCH		APRIL		MAY	
	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
1977-1978	-	-	-	-	15.3	15.2	15.8	15.1	17.2	15.6	20.9	15.5	16.4	15.1	15.4	15.1	15.5	15	15.6	15	15.3	15	15.4	15.2
1978-1979	15.5	15.1	15.4	14.9	15.5	15	15.1	14.9	15.2	15	17.4	15	17.5	15	16.2	15	15.5	15	15.4	15	15.5	15	15.7	15.2
1979-1980	15.6	15	15.6	15	15.5	15	15.5	14.9	17.2	14.9	21.1	15.1	17.9	15.3	15.3	15	15.4	14.9	15.3	15	15.9	15.1	15.3	15
1980-1981	15.5	14.9	15.4	15.1	15.2	14.9	15.2	15	15.5	14.9	16.6	15	17.9	15	15.3	15	15.6	14.9	15.4	15	15.3	14.9	15.3	14.9
1981-1982	15.6	15	15.4	15.1	15.7	15.1	16	15.1	16.4	15.1	16.1	15.1	17	15.1	15.3	15	15.4	15.1	15.3	15.1	15.5	15.1	15.5	15
1982-1983	15.6	15.1	15.4	15.1	15.3	15.1	15.4	15	15.2	15	17.1	15.1	16.8	15	15.6	15.1	15.5	15.1	15.4	15	15.2	14.8	15.2	14.9
1983-1984	15.3	14.9	15.5	14.9	15.4	14.9	15.4	15	15.6	15.1	15.7	15	16.4	15.1	16.7	15.1	18.6	15.1	20.4	15	15.6	15	15.4	15
1984-1985	15.5	15.1	15.6	15.2	15.5	15.1	15.4	15.1	15.8	15.1	15.4	15.1	15.5	15.2	16.3	15.1	15.7	15.1	15.5	15	15.4	15	15.4	15.2
1985-1986	15.5	15.1	15.5	15.2	15.5	15.2	15.5	15.1	15.7	15.1	16.8	15.2	15.8	15.2	15.5	15.1	15.6	15.1	15.4	15.1	15.3	15.1	15.5	15.2
1986-1987	15.4	15.1	15.4	15.1	16.1	15.2	15.3	15.1	16.2	15.1	15.2	15.1	15.6	15.2	15.6	15.2	15.4	15.2	15.5	15.1	15.3	15	15.3	14.9
1987-1988	15.4	14.9	15.4	14.9	15.4	14.9	15.5	15.1	16.8	15.1	15.8	15.2	17	15.1	15.3	15.1	15.5	15.3	15.6	15	15.4	15	15.6	15.1
1988-1989	15.5	15.2	15.5	15.1	15.5	15.1	15.4	15.1	15.4	15.1	17	15.1	15.7	15.1	15.6	15.2	15.5	15.1	15.4	14.9	15.3	14.9	15.3	14.9
1989-1990	15.3	14.9	16	15.1	15.5	15.2	15.6	15.1	15.7	15.1	15.9	15.1	16.3	15.2	18.3	15.2	15.4	15.2	15.3	15.1	15.3	15	15.3	15.1
1990-1991	15.5	15.1	15.2	15.1	15.1	15	15.2	15	16.3	14.9	17.1	15.1	16.8	15.1	16.9	15.1	15.5	15	15.4	15	15.4	15.2	15.4	15.2
1991-1992	16.3	15.2	17	15	15.7	15	15.6	15	16.5	15.1	16.3	15.3	15.7	15.2	15.4	15.2	15.5	15.2	15.4	15	15.1	15	15.2	14.9
1992-1993	15.4	15.1	15.4	15	15.5	15.1	15.5	15.1	16.2	15.1	21.3	15.4	18.1	14.9	15.5	14.9	15.4	15	15.5	14.9	15.3	15	15.3	15
1993-1994	15.4	15	15.3	14.9	15.3	14.9	15.2	14.9	15.1	14.9	18.1	15	19.9	15.2	16.9	15.1	16.3	15.1	15.3	15	15.5	15	15.5	15
1994-1995	15.4	14.9	15.5	15	16.1	15.1	15.7	15.2	15.6	15.1	17.8	15.2	15.5	15.1	15.5	15	15.7	15	15.4	15	15.2	15	15.3	14.9
1995-1996	15.4	15.1	15.3	15	15.5	15	15.1	15	15.7	15	16.4	15	15.4	15.1	15.4	15	15.1	14.9	15.1	14.8	15.1	14.7	15.1	14.7
1996-1997	15.2	14.8	15.3	14.9	15.6	15.1	15.2	15	15.6	15	15.5	15	16.5	15	15.3	15	15.3	14.9	15.4	15	15	14.8	15.2	14.7
1997-1998	15.1	14.8	15.2	14.7	15.2	14.9	15.4	14.9	15.8	15	17.1	15.3	18	15.5	16	15	15.5	15	15.2	15	15.3	15	15.2	14.8
1998-1999	15.2	15	15.4	15	15.3	14.9	15.2	15	15.5	15	16	15	17.7	15.1	15.5	15	16	15.1	15.2	14.8	15.2	14.8	14.9	14.8
1999-2000	16.2	14.8	15.4	14.9	15.4	14.9	15.2	14.9	15.2	14.9	16.5	15	16.1	15.1	16.1	15.1	15.8	15.1	15.4	14.8	15.4	14.8	15.3	14.9
2000-2001	15.4	14.9	15.4	14.9	16.9	14.9	15.7	14.9	15.1	14.9	16.7	15	17.3	15.1	17.2	15	16.1	15.1	15.4	15.1	15.4	14.9	15.1	14.8
2001-2002	15.1	14.9	15.5	14.9	15.3	14.9	15.2	14.9	15.3	14.9	16	14.9	17	14.9	15.2	15	17.1	14.9	15.5	15	15	14.8	15.2	14.8
2002-2003	15.2	14.9	15.2	14.9	15.3	14.9	15.3	14.9	15.2	14.8	17	14.9	16.5	15.1	15.3	15.2	15.7	14.9	15.4	14.9	15	14.8	15.1	14.8
2003-2004	14.9	14.7	15	14.8	15	14.7	15	14.7	15.2	14.8	16.5	15	16.5	15.2	15.4	15.1	15.4	14.9	15.2	14.7	14.9	14.6	14.9	14.7
2004-2005	15.2	14.8	15.5	14.8	15.6	14.8	15.5	14.9	16.8	14.7	19.2	14.9	17.1	14.9	15.3	15	15.2	14.9	15.3	14.7	17.6	14.7	15.2	14.9

YEAR	JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		JANUARY		FEBRUARY		MARCH		APRIL		MAY	
	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
2005-2006	15.3	15	15.4	14.9	15.2	14.9	15.3	14.8	15.2	14.8	16.6	14.8	18.9	14.8	17.1	14.8	15.3	14.9	15.6	14.8	15.2	14.7	15.2	14.8
2006-2007	15.3	14.8	15.1	14.8	15.1	14.7	15.4	14.8	16.9	14.7	20.2	16	16.5	14.8	15.8	14.8	15.3	14.7	15	14.7	15.1	14.7	14.9	14.7
2007-2008	15.1	14.8	15.2	14.8	15	14.7	15.2	14.7	15.4	14.7	17.2	14.7	17.9	14.9	15.5	14.9	15.6	14.8	18.5	14.7	15.7	14.6	15.2	14.8
2008-2009	15.1	14.7	14.9	14.6	15.2	14.6	15	14.6	16.9	14.6	17.4	14.7	18.2	14.9	15.2	14.8	15.2	14.9	15	14.6	15.7	14.7	15	14.7
2009-2010	14.9	14.7	15.1	14.7	15	14.5	14.8	14.6	15.1	14.6	18.4	14.7	17.3	14.6	17.3	14.7	15	14.7	14.8	14.5	14.9	14.5	15	14.7
2010-2011	14.8	14.3	15	14.6	14.8	14.6	14.8	14.6	15	14.5	15.5	14.8	17.2	14.5	15	14.5	15.1	14.6	15.1	14.5	14.9	14.4	14.9	14.7
2011-2012	15.3	14.5	15.1	14.5	14.8	14.4	15	14.5	16.4	14.5	18.7	14.5	16.1	14.8	15.5	14.6	15.4	14.7	15.1	14.5	14.6	14.5	15	14.3
MAX.	16.3	15.2	17	15.2	16.9	15.2	16	15.2	17.2	15.6	21.3	16	19.9	15.5	18.3	15.2	18.6	15.3	20.4	15.1	17.6	15.2	15.7	15.2
MIN.	14.8	14.3	14.9	14.5	14.8	14.4	14.8	14.5	15	14.5	15.2	14.5	15.4	14.5	15	14.5	15	14.6	14.8	14.5	14.6	14.4	14.9	14.3

Table 28: Monthly Minimum and Maximum Water levels

4.17 Yearly minimum and maximum Water levels

Below table shows yearly maximum and minimum water levels at Murappanadu gauging site.

YEAR	MAXIMUM WATER LEVEL (m)	MINIMUM WATER LEVEL (m)
1977-1978	16.38	14.95
1978-1979	17.51	14.93
1979-1980	21.075	14.9
1980-1981	17.92	14.86
1981-1982	17.045	15
1982-1983	17.12	14.82
1983-1984	20.39	14.85
1984-1985	16.32	14.98
1985-1986	16.76	15.09
1986-1987	16.183	14.945
1987-1988	17.01	14.92
1988-1989	16.988	14.9
1989-1990	18.135	14.895
1990-1991	17.07	14.925
1991-1992	17.015	14.91
1992-1993	21.325	14.915
1993-1994	19.912	14.898
1994-1995	17.755	14.89
1995-1996	16.383	14.72
1996-1997	16.47	14.745
1997-1998	18.02	14.72
1998-1999	17.735	14.755
1999-2000	16.5	14.76
2000-2001	17.26	14.78
2001-2002	17.105	14.785
2002-2003	16.982	14.795
2003-2004	16.545	14.645
2004-2005	19.24	14.66
2005-2006	18.89	14.7
2006-2007	20.2	14.67
2007-2008	18.505	14.64
2008-2009	18.165	14.56
2009-2010	18.36	14.46
2010-2011	17.2	14.31
2011-2012	18.685	14.345
2012-2013	15.485	14.345
2013-2014	16.585	14.535
MAXIMUM	**21.325**	**15.12**
MINIMUM	**15.485**	**14.33**

Table 29: Yearly minimum and maximum Water Levels

4.18 Chart Datum/ Sounding Datum

As per discussion with IWAI, Chart Datum has been taken as following for different reaches

Tidal Reach:

C.D. is taken as C.D. of nearest port from Admiralty Tide Table (ATT- Volume 3).

Non-Tidal Reach:

As per discussion with IWAI, Sounding datum in rivers is taken as Average of minimum yearly water level for Last six years (2009-2014) at Murappanadu gauging site. The gauge-discharge data of Murappanadu site was collected from CWC. Accordingly, the C.D. at Murappanadu G.D. Site has been arrived as below:

C.D. at Murappanadu G.D. Site = [14.56+14.46+14.31+14.345+14.345+14.535]/6
= **14.42m**

River name	CD Value at the Murappanadu Gauge Station	Gauge Station Position	
		Latitude	Longitude
Tamaraparani	14.4975 meters above MSL at CH 40.55	08^0 42′ 52″ N	77^0 50′ 06″ E

In case of Dams/ Bridges/ Barrages/ Check Dam, the C.D. has been taken as Ponding level or MDDL.

4.19 High Flood Levels

Tidal Reach

In Tidal reach, MHWS at Tuticorin Port as per Admiralty Tide Table (ATT-Vol 3) has been adopted as High Flood Level.

MHWS: 0.99 (w.r.t. C.D.)

MSL : 0.64 (W.r.t. C.D.)

MHWS (w.r.t. M.S.L.) : 0.99 – 0.64 = 0.35 m (w.r.t. M.S.L.)

Non-Tidal Reach

Gauge Sites: High flood levels are computed from last twenty years Gauge discharge data collected from CWC for gauge sites. The maximum water level in last twenty years from the collected data has been adopted as H.F.L.

Murappanadu

HFL at Murappanadu GD site is 20.225 m in Nov. 2006 from last 20 years GD data. Maximum flood discharge & HFL (during period of data) were 2405 m^3/s.

Frequency Analysis of yearly maximum flood data using Gumbel distribution indicate following flood discharges for different return periods..

Return Period in years	2	5	10	20	25	50	75	100	200
Discharge (m^3/s)	252	731.37	1048.76	1353.2	1449.77	1747.27	1920.19	2042.57	2336.79

The 100 year return flood at Murappanadu will be 2042 m^3/s.

4.20 Monthly minimum and maximum Discharges

The monthly minimum and maximum discharges (in cumecs) for the entire period of data were extracted and are tabulated below.

YEAR	JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		JANUARY		FEBRUARY		MARCH		APRIL		MAY	
	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
1977-1978	-	-	-	-	-	-	-	-	-	-	46.8	0	138	5.11	17.9	4.61	29.5	2.78	29.7	1.78	11.3	1.87	17.7	8.63
1978-1979	27.2	5.48	19.8	0.84	23.2	1.99	6.75	0.58	9.84	1.54	423	1.99	425	2.68	99.8	2.33	26.4	2.67	15.2	1	22.3	2	32.2	4.91
1979-1980	27.5	0.91	25	2	16.4	1	20	0.7	355	0.5	2405	4.2	622	17.4	16.5	3.2	20	2.8	17	2.6	62	5	16.8	2.2
1980-1981	23.6	0.3	17.9	4.1	11.4	0.6	6.9	1.2	25.1	0.6	145	1.4	566	1.5	10.3	1.7	28.3	1.5	13.6	1.7	9.9	0.6	9.5	0.5
1981-1982	26	1.2	12.7	3.1	31.6	3	61.7	1.7	105	2	67.4	1.8	274	1.9	11	2.3	14.5	2.9	9.4	2	20.8	1.6	16.5	0.8
1982-1983	21.5	0.8	13.1	1.9	7.4	2.2	13.1	0.2	4.8	0.1	265	1.8	179	1.6	27.4	2.9	17.9	3.5	16.1	0.5	5.2	0	4.3	0
1983-1984	7.9	0	20.5	0	14	0.2	14.3	0.8	23.3	1.4	27.7	1	114	1.7	192	2.4	1010	2	2249	2.7	20	1.7	17.6	1.6
1984-1985	20.6	1.2	29.1	4.6	18.8	1.4	11.6	2	36.4	2.2	15.1	1.4	21.5	3	103	1.5	31.6	2.1	18.3	1.2	15.9	0.2	15	4.8
1985-1986	18.1	2	21.8	5.1	15.5	3	18.4	1.4	30.6	1.2	182	3.4	37.3	3.4	18.1	2.2	22.4	2.4	15.2	1.7	11	1.1	17.5	3.8
1986-1987	12	2.2	12.3	2.2	76.5	4.7	7.9	2.3	81.1	2.3	5	1.5	21.7	2.9	25.8	3	14.4	5.1	16.9	0.5	7.2	0	7	0
1987-1988	13.8	0	14.5	0	13.9	0	19.5	1.69	146	1.59	36.2	3.28	221	2.62	11.2	3.8	24.5	10.5	27	1.65	13.9	1.26	25.1	2.1
1988-1989	21.7	4.01	19.1	2	22.4	2.75	15.1	0.89	17.1	1.75	151	2.51	32.7	1.74	23.1	3.98	16.5	2.05	12.7	0.1	10.7	0.05	8.75	0
1989-1990	9.27	0.01	60.9	1.59	19.7	5.2	27.6	3.95	32.2	2.21	52.4	3.86	61.9	3.64	494	4.7	16.5	5.9	9.42	2.5	11	0.81	10	5
1990-1991	19.7	5.47	10.1	3.37	6	1.61	7.18	0.75	101	0.53	218	4.24	158	5	201	4.24	19	2.5	19.9	2	16	6.35	16.7	5.5
1991-1992	86.8	5.7	179	2.19	33.7	2.11	24	2.19	107	3.11	81.3	9.1	30.3	5.83	15.6	6.75	20.7	6.29	16.2	2.22	5.04	0.91	5.58	0.48
1992-1993	11.6	4.3	12.5	3.12	19.2	3.87	19.1	3.07	94.2	3.26	2154	17.1	572	1.56	32.3	1.56	25.9	3.66	32.2	1.81	20.7	2.47	15.1	4.15
1993-1994	26.8	3.76	16.9	2.21	22.9	2.4	13	0.99	9.64	1.5	682	5.63	1396	14.8	253	9.43	131	8.47	16.2	5.64	32.7	6.28	28.3	5.88
1994-1995	24.1	0.85	27.2	3.34	85.2	5.16	45.6	7.41	37.9	6.72	483	7.64	33.2	6.35	33.8	4.2	47.8	4.23	18.6	4.25	10.1	4.14	16.9	2.32
1995-1996	21	4.96	13.5	3	30.5	2	7.87	3.51	42.5	2.98	135	4.87	24.4	5.3	26.5	2.57	6.4	0.77	5.75	0.4	5.72	0	7.7	0
1996-1997	8.53	0	12.4	0.54	29.8	3.89	8.49	1.5	28.8	1.52	22.1	2.32	145	2.74	18.1	4.28	14.3	1.6	18.5	2	2.69	0.03	8.35	0.04
1997-1998	6.93	0	6.98	0	9.38	1.31	17.1	1.77	42.6	2.7	242	11.9	510	23.9	65	5.37	22.8	6	11	4.91	14.5	4.52	10.9	1.71
1998-1999	13.2	2.24	17.6	4.79	13.7	2.07	11.7	3.4	23.3	5	58.6	5.08	436	6.12	24	6.42	67.4	7.46	12	1	12.4	0.6	4.04	0.58
1999-2000	89	1.02	19.6	2.08	18.9	1.85	11	2.21	14	3.43	122	3.54	80.2	4.78	83.1	5.26	45.5	6.44	18.6	1.18	17.8	2.5	13.2	1.64
2000-2001	19.8	3.09	20.8	3.1	197	1.83	39.6	2.24	8.79	2.56	187	5.55	246	7.24	224	6.65	68.4	7.43	20.1	5.39	19	2.45	6.78	0.02
2001-2002	8.88	1.9	26.8	1.35	11.3	1.98	10.7	1.8	16.4	2.64	65.5	1.75	220	2.89	15.8	3.29	226	2.62	26.8	5.36	5.4	1.29	9.37	0.99
2002-2003	9.32	1.6	9.99	2.71	15.6	1.9	15.2	2.5	10.6	1.57	228	3.43	144	8.96	18.6	10.3	39	3.49	21.8	2.99	4.74	2.19	8.3	1.77
2003-2004	5	1.34	4.92	1.77	6.38	1.8	7.05	1.11	12.5	2.55	145	5.92	135	13.5	24.5	9.65	24.7	3.8	15.6	0.87	4.1	0.64	6.51	1.4
2004-2005	14.2	2.45	24.3	2.15	30.1	3.11	26	4.31	207	1.66	1153	4.73	251	3.71	22.3	7.14	18.4	4.98	18	0.91	356	1.22	15.4	6.34

YEAR	JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		JANUARY		FEBRUARY		MARCH		APRIL		MAY	
	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
2005-2006	18.4	9.55	20.8	5.86	16	5.22	18.6	4.87	15.7	3.48	147	3.49	916	3.65	255	3.94	23.6	6.93	39.7	3.44	16.8	3.38	18.8	5.04
2006-2007	21.6	4.71	13.1	3.46	12.4	2.43	26	4.71	206	2.96	1321	70.9	144	5.92	76.2	6.32	27.4	3.92	13.6	4.12	19.3	3.92	11	4.54
2007-2008	15.3	7.73	19.4	5.6	14	4.03	23.2	4.66	31.5	3.68	226	4.66	457	7.52	35.8	10.2	40.9	7.48	632	4.98	54.2	3.13	22.6	7.48
2008-2009	20.1	3.34	12	1.82	22.8	4.13	16.3	2.47	189	3.68	274	5.38	487	12	21.2	8.66	21.8	10.3	14.9	2.8	52.8	5.11	13.8	5.68
2009-2010	12.5	5.71	17.5	6.55	15.5	2.08	9.8	3.35	19.5	3.35	271	6.47	117	4.31	116	6.57	18.9	9.26	12.4	2.21	15.3	3.2	19.1	7.43
2010-2011	12.4	0.14	19.7	4.15	13.2	4.67	11.1	4.12	19.5	1.99	36.1	9.04	148	3.2	19.1	2.89	21.9	6.07	22.8	2.77	12.7	1.47	14	7.67
2011-2012	26.3	3.02	18.2	1.99	10.2	1.09	14.9	2.75	84.9	3.06	380	2.57	64.5	8.24	37.1	5.15	25.8	6.22	17.5	2.5	4.59	2.14	14.5	0.76
MAXIMUM	89	9.55	179	6.55	197	5.22	61.7	7.41	355	6.72	2405	70.9	1396	23.9	494	10.3	1010	10.5	2249	5.64	356	6.35	32.2	8.63
MINIMUM	5	0	4.92	0	6	0	6.75	0.2	4.8	0.1	5	0	21.5	1.5	10.3	1.5	6.4	0.77	5.75	0.1	2.69	0	4.04	0

Table 30: Monthly minimum and maximum Discharges in Cumecs

"-"means no data available and "0" means no discharge.

4.21 Yearly minimum and maximum Discharges

Below table shows yearly maximum and minimum discharges at Murappanadu gauging site.

YEAR	MAXIMUM	MINIMUM
	DISCHARGE (m^3/sec)	DISCHARGE (m^3/sec)
1977-1978	138	0
1978-1979	425	0.58
1979-1980	2405.1	0.5
1980-1981	565.7	0.3
1981-1982	273.7	0.8
1982-1983	264.6	0
1983-1984	2248.7	0
1984-1985	102.8	0.2
1985-1986	182.4	1.1
1986-1987	81.1	0
1987-1988	221	0
1988-1989	151	0
1989-1990	493.8	0.011
1990-1991	217.9	0.526
1991-1992	179.3	0.482
1992-1993	2154	1.562
1993-1994	1396	0.99
1994-1995	483.4	0.851
1995-1996	135.3	0
1996-1997	144.7	0
1997-1998	509.5	0
1998-1999	436	0.581
1999-2000	121.8	1.019
2000-2001	245.85	0.024
2001-2002	226	0.988
2002-2003	228.1	1.571
2003-2004	145.1	0.642
2004-2005	1153	0.913
2005-2006	915.7	3.382
2006-2007	1321	2.428
2007-2008	631.84	3.132
2008-2009	486.799	1.816
2009-2010	271.299	2.084
2010-2011	147.842	0.14
2011-2012	380.241	0.758
MAXIMUM	**2405.1**	**3.382**
MINIMUM	**81.1**	**0**

Table 31: Yearly minimum and maximum Discharges

"-"means no data available and "0" means no discharge.

5 Preliminary Traffic studies and Market Analysis

This chapter deals with the status of land use pattern, crops, agriculture existing industries, cargo, jetties and terminals, passenger ferry services along the river route.

5.4 Land use Pattern along waterway

Tamaraparani River moves through Tirunelveli and Palayamkottai talukas of Tirunelveli district and Srivaikundam and Tiruchendur talukas of Thoothukkudi district before it joins the Gulf of Mannar at Punnaikayal in Tiruchendur taluk of Thoothukkudi district. A map showing main talukas is presented below:

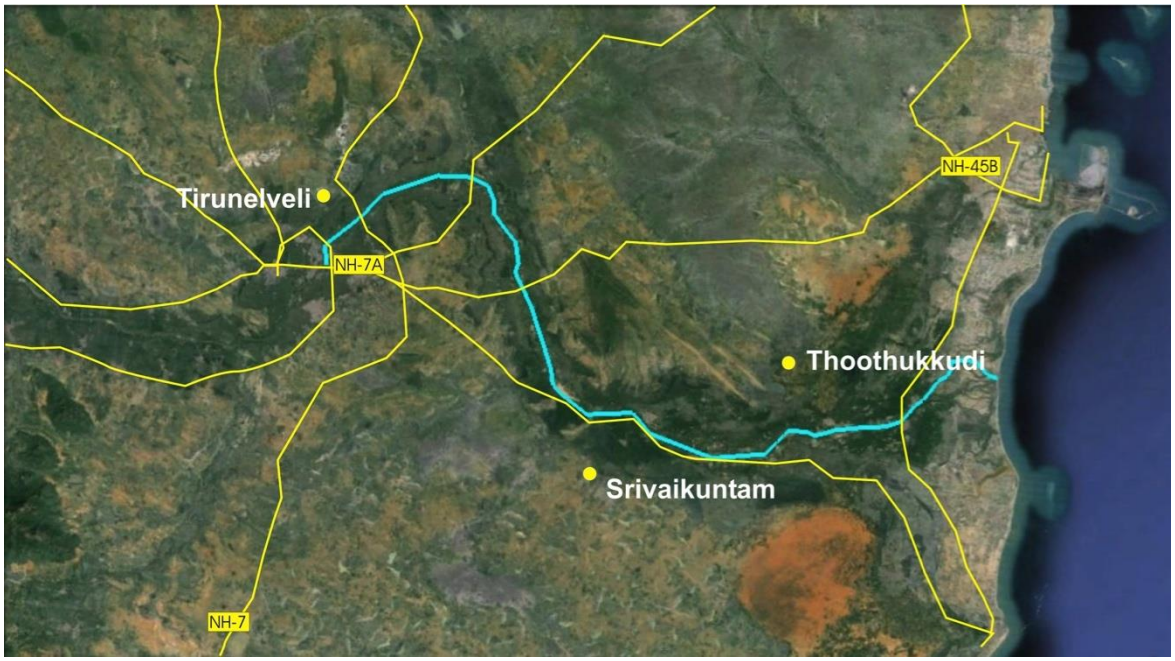


Figure 15: Tamaraparani River and its nearby Talukas

District	Taluka	Population
Tuticorin	Tuticorin	240,498
	Srivaikuntam	15,847
Tirunelveli	Tirnelveli	643,341

Table 32: Population of nearby Talukas as per Census 2011

Tuticorin has seen significant expansion and activities like urban sprawl development and conversion of land into settlement, industrial areas, and saltpan. Mostly, waste land has been used for this development. There are nearly 150,000 farmers in Tuticorin. Of these, more than 50% (88,000) have less than 1 hectare of land each. Together they hold only 22% of the total land. Among the other farmers, nearly 29,000 farmers have land of 2 hectares and above; these farmers have over 55% of the land in the district.

		(Areas in Ha.)
District	**Tuticorin**	**Thiruneveli**
Forest	11,012	120,801
Non Agriculture	74,489	103,669
Net Sown Area	171,815	166,621
Uncultivable Barren Land	19,762	30,961
Fallow lands (current & other)	79,449	197,534
Cultivable waste	58,139	47,442
Permanent and grazing land	5,132	5,271
Land under misc., tree crops and	39,256	10,009
Total Area	459,054	682,308

Table 33: Land use Pattern of Districts along the Tamaraparani River

Out of the total land in Tuticorin district, nearly 38% is net sown area. The next significant land use category is fallow lands (17%), followed by land used for non-agricultural purposes (around 16%). Nearly 13% of the land in the district is cultivable waste land. The land under the miscellaneous, tree crops, etc. takes up nearly 9% of the total land in the Tuticorin district. Uncultivable barren land is around 4%. The district has less forest area of nearly 2.5% of total land.

In Thiruneveli district, the majority of land (29%) is fallow lands. Net sown area is around 25% of the total land. These two categories are followed by forests (around 18%) and land for non-agricultural uses (15%). The district has different types of forests like tropical wet evergreen forests and southern thorn scrub. Cultivable waste takes up 7% and uncultivable barren land is 4.5% of the total land in the district. The average size of holdings in the district is 0.81 hectares.

5.1.1 Tuticorin

Tuticorin is located in the south-eastern corner of the state. It is bounded by Ramanathpuram in north-east, Virudhunagar in the north and Tirunelveli in the west. In the east of the district, flows the Gulf of Mannar. The total geographical area of the district is 4,621 sq. km, which constitutes to 3.5% of the total geographical area of the state. It has a total coastal line of 163 km. stretching from Vembar to Periathalai. The district is home to one of the 12 major ports of the country – VOC Chidambarnar Port also known as Tuticorin Port or Thoothukkudi Port.

5.1.2 Tirunelveli

The district is located in the southern part of Tamil Nadu. It is surrounded by Virudhinagar district in the north, Thoothukkudi district in the east, Kanyakumari district in the south and Western Ghats in the east. It encloses a total geographical area of 6,823 sq. km. It has a coastal length of 50 km in the Gulf of Mannar.

The district is blessed with Western Ghats, which are the origin of most of the perennial rivers flowing in the district. Thamiraparani, Vaippar, Nambiar and Hanumanathi are the major river basins of the district.

5.2 Crops/Agriculture in the region

5.2.1 Tuticorin

Paddy and cotton is majorly grown in the district. Paddy is produced in an area of 11,730 hectares. Fy14 claimed an annual production of 48 mntonnes. Other major food crops produced in the area are pulses, millets and other cereals. Major commercial crops grown in the district are cotton, sugarcane, groundnut and gingelly. Cotton is the largest cash crop cultivated in the district. It had an annual production of more than 2 mntonnes in Fy14. Groundnut is produced in 517 hectares of land. It marked an annual production of 1,400 tonnes in Fy14 throughout the district.

Crops	Area	Production (mn T.)
Paddy	11,730	48
Millets & Other Cereals	79,778	308
Pulses	56,338	42
Sugarcane	204	0
Groundnut	517	1
Gingelly	819	0
Cotton	4,526	2

Table 34: Production of crops

Source: Department of Economics and Statistics, Chennai.

Tuticorin district receives an annual rainfall of 790 mm. It receives most of its rains from northeast monsoons, which accounts for 65% of the total precipitation. From south-west monsoons, it receives 11% of the total precipitation. During summer period, it receives 17% and during winters, it receives 7% of the total precipitation. However, at times there is deviation in the number.

5.2.2 Tirunelveli

Tirunelveli receives abundant rainfall in all the seasons. The annual rainfall in the district is 1,035 mm. It is mostly fed by northeast monsoons, which contribute to 40% of the total precipitation. Summer rainfall with 30% of precipitation, southwest monsoons with 23% and winter rainfall with remaining 7% of the total precipitation follow it.

The total cropped area of the district is 162,144 hectares which accounts for 24% of the total geographical area of the district. Major food crops cultivated in the district are Paddy, Cholam, Ragi, Cumbu Maize and other minor millets. Prominent cash crops grown in the district are Cotton, Chillies, Sugarcane and Groundnut.

5.3 Availability of Bulk / Construction Material

River transportation would be viable for movement of bulk commodities like coal and minerals. Coal is a major import commodity from Tamil Nadu Ports. VOC Port acts as gateway for import of indigenous and foreign coal to the state. Major share of the coal is consumed in the power plants located in the state. Tamil Nadu is a mineral rich state. There is abundant reserve of limestone, rough stone, silica and

granite in the state. There is huge volume of export of minerals from VOC Port. The minerals are mostly sourced from the southern part of the state. They are exported to Maldives, Sri Lanka and other South East Asian countries.

Districts	Commodities Exported	Nearby Ports
Tiruvelveli	Coir products, Gherkins, Cashew, RMG, Herbal Products	VOC
Tuticorin	Coco Pith, Herbals, Garnet, Frozen food, Salt, Illuminate sand, Safety Matches, Copper, Chemicals, Cement, Granite stone	

Table 35: Commodities exported

5.3.1 Minerals

A. Tuticorin

Limestone is majorly produced in the district. In Fy15, it generated aggregate revenue of Rs 47.8 million for the district. There was a minimal production of quartz from the district. It contributed to a production of 50 tonnes. In minor category, rough stone leads the bench with aggregate revenue of about Rs 47 million with an aggregate production of more than 1 million tonnes in Fy 15.

Mineral Catergory	Mineral	Production ('000 tonnes)	Value (in Rs lakhs)
Major Minerals	Limestone	584	478
Minor Minerals	Rough Stone	1,025	469
	Earth/Gravel	173	47
	Quartzite	4	8
	Multi coloured Granite	1	41

Table 36: Total Production of minerals in FY'15

Source: A.D. Mines, Collectorate, Tuticorin

B. Tirunelveli

In the major mineral category, the district is rich in Limestone and Garnet. It accounted an annual production of 1.13 million tonnes of limestone and 1.09 million tonnes of garnet in Fy14. Rough stone, gravel, granite and kankar are the other minor minerals produced in profuse.

Mineral Category	Name of Mineral	Production (in '000 tonnes)
Major Minerals	Limestone	1,134
	Garnet	1,088
Minor Minerals	Rough stone	1,803
	Gravel/Earth	679
	Granite	31
	Kankar	0

Table 37: Production of minerals in FY'14

Source: Assistant Director of Mines, Tirunelveli

Tirunelveli, Palayamkottai, Sankarankoil, Sankarankoil, Ambasamudram, Radhapuram, Alangulam are the major destinations for quarrying and mining

activities. Limestone is majorly extracted from Tirunelveli and Sankarankoil. Radhapuram is the main source for garnet in the district. There were 53 quarrying operations in the taluka for garnet.

Name of Taluka	Major Minerals		Minor Minerals			
	Lime Stone	Garnet	Rough Stone	Earth	Granite	Kankar
Tirunelveli	32	-	49	-	2	-
Palayamkottai	3	-	21	-	2	-
Sankarankoil	13	-	20	-	3	2
Ambasamudram	10	-	22	-	15	-
Nanguneri	3	-	2	-	2	-
Radhapuram	4	53	29	2	3	-
Tenkasi	-	-	11	-	1	-
Sengottai	-	-	8	-	-	-
Sivagiri	6	-	1	-	-	-
Veerakeralampudur	-	-	13	-	0	2
Alangulam	2	-	14	-	1	-
Total	73	53	190	2	29	4

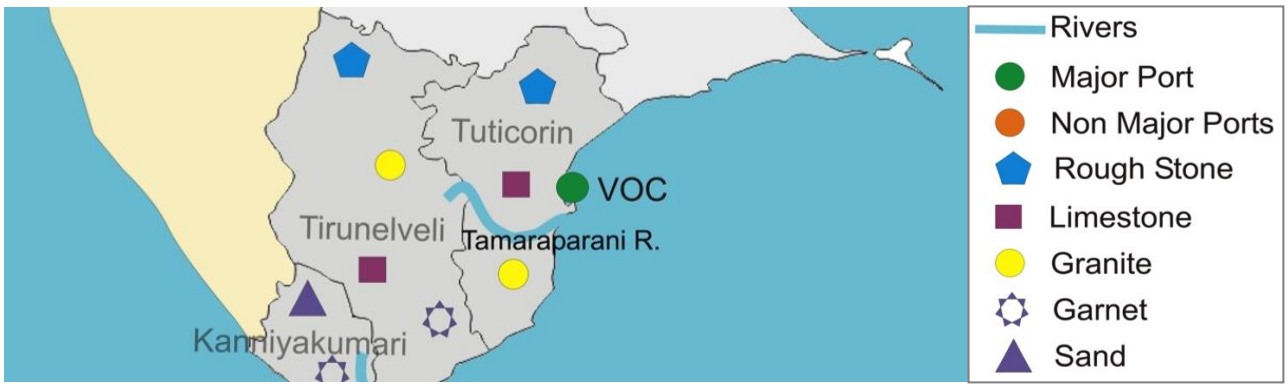
Table 38: Number of mining and quarrying units in the districts

Source: Assistant Director of Mines, Tirunelveli

In minor mineral segment, there are 190 quarrying being done throughout the district for rough stone. Tirunelveli, Palayamkotti, Radhapuram are the major centers for rough stone quarrying. There are 2 quarrying operations for earth, 29 for granite and 4 for kankar all over the district.

C. *Commodities Opportunity*

Following map shows location of mineral of Tamil Nadu with respect to Tamaraparani River as well as the VOC port infrastructure. Mines located closer to rivers would have potential for shift of minerals to river route from existing road route.



The table given below describes location of mines with respect to the VOC port exporting it and the river flowing closer to it.

District	Minerals	Production ('000 T)	Distance from Industrial Area (Km)			Opportunity	Reasoning
			To River	River-Port	Direct to Port		
Tirunelveli	Limestone	1,134	8	80	66	May be	High Volume, Difference bet roadways and waterways is less
	Garnet	1,088					
	Rough Stone	1,803					
	Granite	31					
Tuticorin	Limestone	584	NA	NA	8	No	Minerals mines are located adjacent to port. Hence, it is commercially not viable to use waterways along with multimodal transportation
	Rough Stone	1,025					
	Granite	1					

Table 39: Location of mines with respect to the VOC port

D. Limestone

Limestone is one of the major commodities exported from VOC port. Tamil Nadu produces close to 2.7 million tonnes of limestone every year. Main reserves of the mineral are concentrated in Tiruchirapalli, Tuticorin and Tirunelveli. Tiruchirapalli is 282km from VOC Port by road. While, Karaikal Port is at a distance of about 156 km from Tiruchirapally by roadways. By waterways, the district is at a distance of 220 km to Karaikal Port. Limestone for export can be transported via Kaveri river to the port.

Tuticorin and Tirunelveli collectively have a share of 1.7 million tonnes every year. However these locations are closer to port via roadways. Karur, Namakkal and Cuddalore are the other districts with limestone reserves. However, these have significantly low volume, hence cannot be considered for movement via river.

E. Rough Stone

Rough stone is the other major mineral exported from VOC Port. This is majorly concentrated in Kanyakumari, Tuticorin and Tirunelveli districts. These are located close to VOC Ports. Tuticorin minerals cannot be transported by river as the mineral deposits are located close to the port. Some mineral sites of Tirunelveli located very close to Tamaraparani can be considered for movement via roadways. The rest can be transported directly to the port via roadways. Kanyakumari has huge reserves of rough stone. Coastal movement of these can be considered, as the difference between roadways and waterways is quite less.

Other places, which have deposits of rough-stone, are Namakkal, Erode, Karur, Tiruvannammalai and Tiruchirapalli. However, the volume of production from these places is quite low which does not make it feasible to be transported to the ports via waterways.

F. Granite

Granite is produced in numerous districts in Tamil Nadu. Tirunelveli is the leading producer of granite with an annual production of 31,000 tonnes. Tamaraparani River can be used for transportation of granite from the district to VOC Port. Other major districts into production of granite are Tiruvannamalai, Tiruchirappalli, Erode, Kancheepuram and Tuticorin. However the volume is not enough so that rivers to nearby ports can transport it.

G. Garnet

Radhapuramtaluka is Tirunelveli district is famous for its garnet production. There are 53 mining sites located in the taluka, which produce close to 1.1 million tonnes of the mineral every year. However, it is located far from the river and hence river transportation cannot be utilised for movement of the mineral. Kanyakumari also produces substantial volume of minerals. These can be transported via Pazhyar river to VOC Port through coastal waterways.

5.3.2 Coal

Coal is one of the prime commodities imported in the state. There are 6 coal based thermal power plants in Tamil Nadu. 5 of them are located close to the ports. Indigenous coal is transported from states like Orissa, Jharkhand and West Bengal by sea to Ennore Port and VOC Port.

There are two coal-based power plants located close to VOC Port. These have an installed capacity of 2,050 MW. They consume an annual volume of almost 11 million tonnes of coal. Railways transport coal for Tuticorin (JV) TPP while the other plant transports its coal to VOC Port by sea. Tuticorin TPP consumes major part of the coal imported through the port.

Sr. No	TPS	Capacity (MW)	Requirement ('000 T)	Nearby Port	Distance from Industrial Area (km)			Opportunity
					To River	River-Port	Direct to Port	
1	NLC Tuticorin	1000	5,840	VOC	NA	NA	4	No
2	Tuticorin	1050	5,110	VOC	NA	NA	4	No

Table 40: Coal requirement in Thermal Power Plants of Tamil Nadu

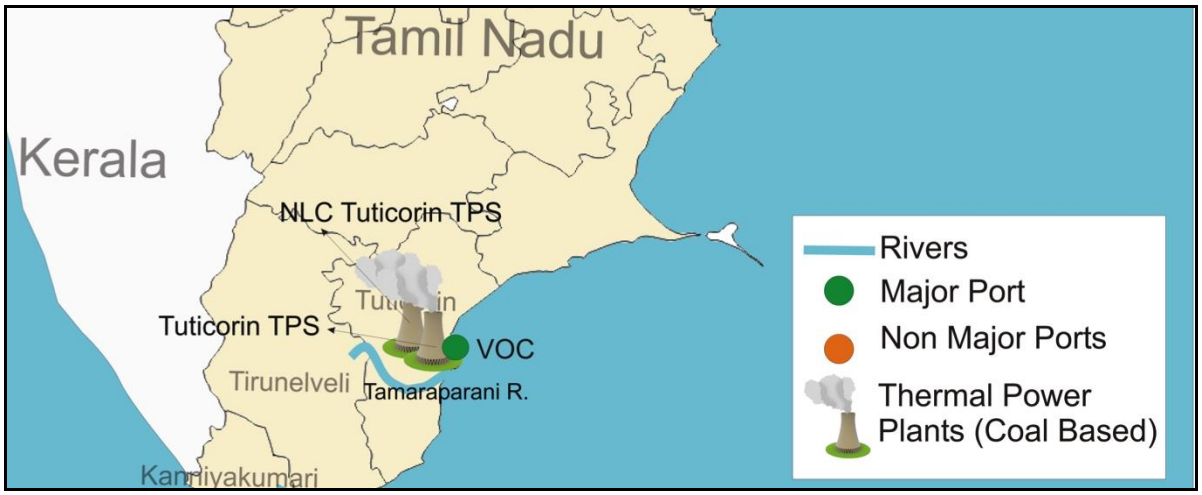


Figure 16: Coal based Thermal Power Plants in Tamil Nadu

H. Tuticorin (JV) TPP

Neyveli has set up a power plant with TANGEDCO near VOC Port. A volume of 3 MTPA Coal is sourced from Mahanadi Coal Fields Ltd. In order to overcome the shortfall in requirement, it has signed a contract with M/s MSTC for supply of imported coal. The power plant is located close to port. This does not provide any opportunity for the river as major supply of coal is from central and eastern parts of the country by Railways. It can either move its coal through ports in West Bengal, Orissa and Andhra Pradesh to Tuticorin Port. The power plant is located close to Tuticorin Port. It coal can be transported to the power plant through conveyor belts.

I. Tuticorin TPS

Tuticorin Thermal Power Station is located close to VOC Port. It consumes close to 5.1 million tonnes of coal every year. Out of this, close to 80% of coal is transported by sea from Haldia, Paradip and Vizag ports. Rest of the coal is imported from Indonesia, Australia etc. to Tuticorin Port. The coal is further carried to the power plant through conveyor belts. Rivers do find significance in the transportation mechanism as the existing infrastructure is already accomplished.

5.3.3 Conclusion

Following table describes potential for cargo movement in the Tamaraparani river of Tamil Nadu.

River	Commodity	Port	Production ('000 tonnes)	Volume ('000 Tonnes)	Reasoning
Tamaraparani	Garnet	VOC	1,088	25	Several commodities of break-bulk item create economy of scale for river transportation. All items go to Maldives using VOC port
	Rough Stone	VOC	2,828	500	
	Granite	VOC	32	84	

Table 41: Potential Opportunity for Tamaraparani River of Tamil Nadu

There is huge reserve of minerals in Tirunelveli and Tuticorin district. Major part of minerals especially limestone and rough stone exported from VOC port are sourced from Tirunelveli and Tuticorin districts. Limestone, garnet and rough stone is majorly found in Tirunelveli district. In Fy14, the district produced more than 1 mn each of limestone and garnet. Rough stone contributed close to 2 mn of production in the district. Garnet is mainly produced in Radhapuram district, which is quite far from the river. These are directly transported to the port via roadways. However, limestone and rough stone is majorly produced in Tirunelveli, Palayamkottai, Sankarankoil, Ambasamudram and Radhapuramtalukas. Out of these, mines located in Tirunelveli, Palayamkottai and Ambasamudramtalukas are within 10 km from the river. This provides a good opportunity for the mines to transport their commodities via river. Alangulam and Veerakeralampudur are located 30 km away from the river. However, these locations are within a distance of about 100 km from VOC Port. Hence mines from these locations may find impracticable to transport via rivers to the port. All other mines are located far off from the rivers.

Tuticorin produces close to 0.6 mntonnes of limestone and 1 mntonnes of rough stone. These are transported via roadways to the port. These mines are located within a radius of 50 km from the port. The river mouth is more than 20 km from the port. Hence river transportation of minerals is impracticable from Tuticorin district to the port

Commodity	Volume (mn T)	Attractive	Reasoning
Pol & Other Products	0.6	No	Most of the consumption centres are located in surrounding areas. Liquid commodities evacuated from port using pipeline cannot be shifted
Edible Oil	0.3	No	Movement of liquid cargo is not possible, 100% goes by road
Fertiliser& FRM	1.5	No	
Coal	8.6	No	Thermal power plants are located adjacent to port. Evacuations of coal to these power plants are undertaken using Conveyors. A large volume of coal, about 3 mntonnes is evacuated to industries using railways. These industries are located away from Tamaraparani River. Hence, it is not possible to transport coal using river.
Containers	11	No	Containers movement on river is not viable.
Others	10.4	Yes	Potential exists for minerals & boulders which are minor & fragmented segment. A large volume of stones, boulders, etc could be transported using River Sea Class ships in the Tamaraparani River to VOC Port. Presently, about 1 mnTonnes of these commodities are transported to VOC port using road route to Zone B of port. The Zone B of VOC Port is an old port located closer to city. About 1 mnTonnes of cargo is available annually.
Total	32.4		

Table 42: Opportunity for river movement of commodities handled at VOC Port

5.4 Existing Industries along Waterway

The industries located on the banks of rivers in South India could have generated business potential for waterways movement. However, absence of water around the year along with well-developed road infrastructure has rendered waterways commercially less attractive for transportation. All the commodities traded on the coast as well as overseas trade was studied. It was found that the majority of trade using VOC Port uses roadways for last mile connectivity on land. One of the primary regions for this has been the development of large industrial base around Port. Following section broadly describes commodities breakup of VOC Port and evaluates their potential to use river for Inland connectivity.

Figure 17: Port connectivity of Major Industrial Clusters via Tamaraparani River

District	Industrial Area	Distance from Industrial Area (km)			Opportunity
		To River	River - Port	Direct to Port	
Tuticorin	SIDCO, Tuticorin	17	20	6	No
	SIDCO, Kovilpatti	56	78	72	No
	SIPCOT Phase-I Tuticorin	25	20	13	No
Tirunelveli	SIDCO, Pettai	6	80	66	May be
	SIDCO, Kadayanallur	55	80	119	No
	Valliyur	40	45	96	No

Table 43: Distance Comparison between Roadways & Waterways (Tamaraparani River)

5.4.1 Tuticorin

TIDCO has developed two industrial estates in the district at Tuticorin and Kovilpatti. TIDCO, Tuticorin spans in an area of 24 acres with 20 units in operation. TIDCO,

Kovilpatti surrounds an area of 86 acres with 78 units in operation. SIPCOT has developed an industrial estate in Tuticorin in an area of 1,033 acres. All the three industrial estates are at significant distance from the river and cannot utilize the river potential for movement of goods.

Industrial Estate	Land Acquired (in acres)	No of Plots	No of Units
TIDCO, Tuticorin	24	40	20
TIDCO, Kovilpatti	86	87	78
SIPCOT Phase-ITuticorin	1,033	86	79

Table 44: Major Industrial Areas in the districts

SIPCOT is coming up with Phase-II in Tuticorin which will require an aggregate of 1,180 acres of land.

Products	Major Clusters	No of Units	Turnover (Rs Cr)
Safety Matches	**Kalugumalai**	**250**	**10**
Safety Matches	**Kovilpatti**	**375**	**300**
RMG Goods	**Puthiamputhur**	**360**	**100**
Salt	**Tuticorin**	**2,250**	**150**

Table 45: Major industrial cluster in Tuticorin

There are two clusters of safety matches in the district – one at Kalugumalai and the other at Kovilpatti. RMG goods manufacturing is concentrated in Puthiamputhur. There are 360 units operating in the cluster with a total turnover of Rs 100 Cr. Salt pans are concentrated in Tuticorin with an annual turnover of Rs 150 Cr. All the clusters are located far off from Tamaraparani River.

Major products exported from the district are salt, frozen sea food, safety matches, cement, minerals and chemicals.

5.4.2 Tirunelveli

Industrial Area	Land Acquired (in acres)	No of Plots	No of Units
Pettai	51	18	71
Kadayanallur	10	13	7
Valliyoor	40	124	20
Total	101	155	91

Table 46: Major Industrial Areas

There are three industrial areas developed in the district with a total span of more than 100 acres. Pettai Industrial area is the largest one with an aggregate of 51 acres. There are 71 units operating in the industrial estate. The industrial area is located at a distance of 6 km from Tamaraparani River. Other industrial areas are located at Kadayanallur and Valliyoor which are significantly far from the river. Two additional industrial estates are proposed to be developed in the district at Kurukkalpatti in Melaneelithanallur block and Ponnakudi in Nanguneri block.

A SEZ has been developed in an area of 2,500 acres at Nanguneri beneath the Western Ghats which is at a distance of 30 km from district headquarters.400 acres have been allotted to ELCOT (A Government of Tamil Nadu undertaking) for setting up of an IT Park in the SEZ. An additional IT Park is being set up by ELCOT in a span of 500 acres at a distance of 20 km from district headquarters.

There are two major clusters of rice mill and brick manufacturing in the district. Keelapavoor is rich in rice mills with an aggregate of 163 units in operation. Brick manufacturing is concentrated in Sankarkovil and Vasudevanallur blocks with 125 units in operation.

Products	Major Clusters	No of Units	Turnover (Rs Cr)
Rice Mill	Keelapavoor	163	1575
Brick	Sankarankovil, Vasudevanallur	125	125

Table 47: Major Industrial Clusters

Source: MSME Development Institute

A rice mill cluster is proposed to be developed by Thamiraparani Rice Mill Cluster Pvt Ltd at Alangur at cost of Rs 10 Cr.

Palayamkottai, Manur, Shenkottai, Sankarkovil are Abasamudram are the leading blocks of Tirunelveli in terms of industrialization. Major items produced in the district are cement, cotton yarn, cotton seed oil and sugar. Major products exported from the district are coir products, processed Gherkins, cashew products, RMG goods and herbal products.

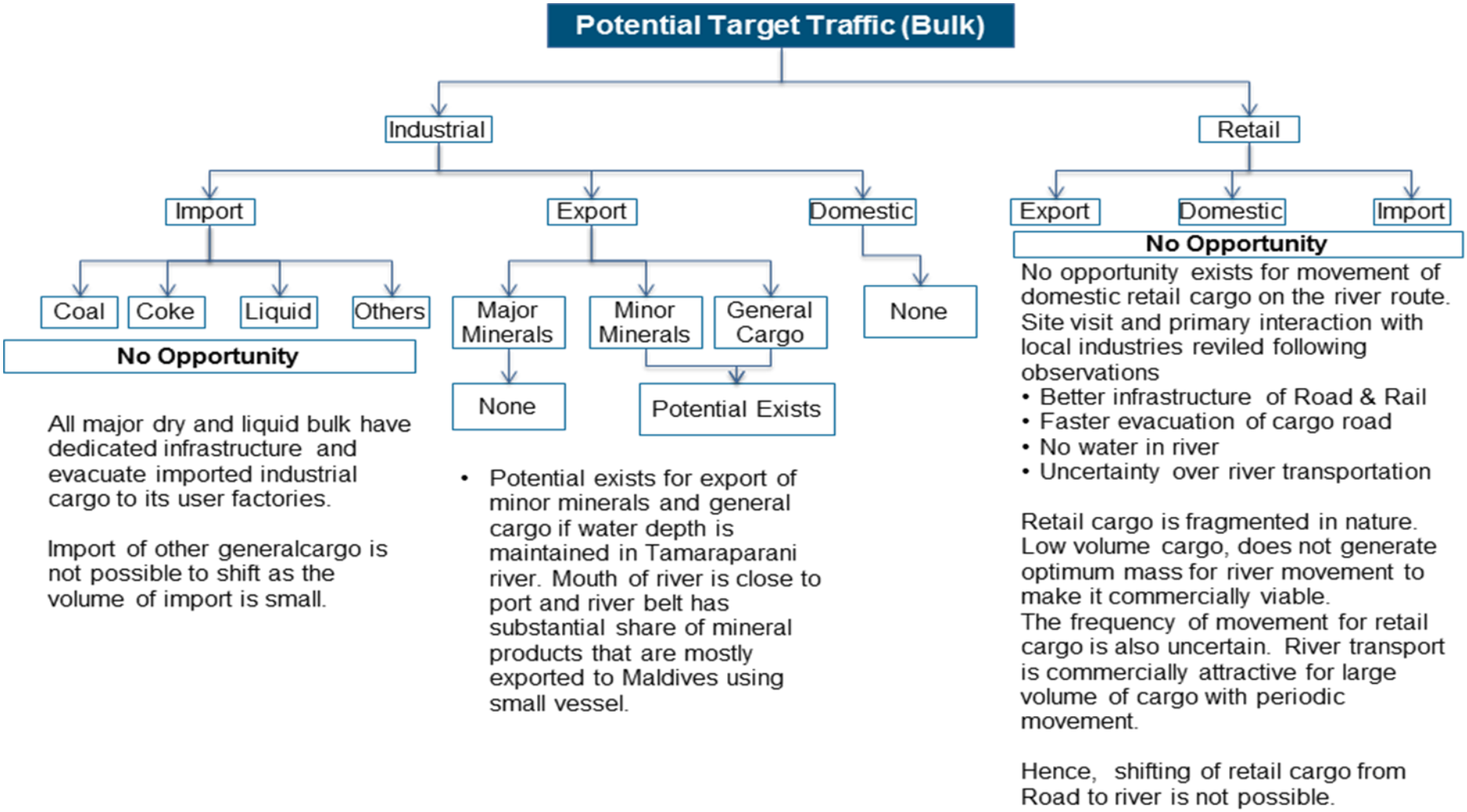


Figure 18: Potential Trade Traffic for Bulk Commodities

5.5 Existing Jetties and Terminals (with conditions and facilities)

The VOC port is located closer to the mouth of Tamaraparani River. It flows at a distance of 25 km to the south of VOC Port. The cargo can be evacuated at the port into small barges to move it down the river to reach hinterlands in Tuticorin and Tirunelveli districts. Pettai SIDCO in Tirunelveli lies at a distance of about 6 km from the river. All other industrial locations in both the districts are located significantly far from the river. Cotton yarn is manufactured in large volume in Tirunelveli. Limestone deposits are concentrated in Rastha, Thalaiyoothu, and Sankarnagar and Padmaneri. These locations are located within 20 km from the river. These can be transported via river to Tuticorin port in barges. Road is considered to be most expensive mode of transportation with uncertainty in delivery of cargo due to congestion at Road. Hence, the potential to shift cargo from Road to Rivers would be maximum in case of road.

5.5.1 VOC Port

VO Chidambaranar Port is an artificial all weather port located in Tuticorin district. It is one of the three major ports in the state. The strategic location of the port lies close to East-west international sea route. It has an annual handling capacity of 45 million tonnes. It acts as a gateway to South India, predominantly Tamil Nadu and Kerala. The port chiefly caters Dry bulk and containerized goods. The port handles close to 0.6 million containers for its own hinterland. Most of the containers are destined to locations in south of the state. A large part of it can be diverted to the river routes.

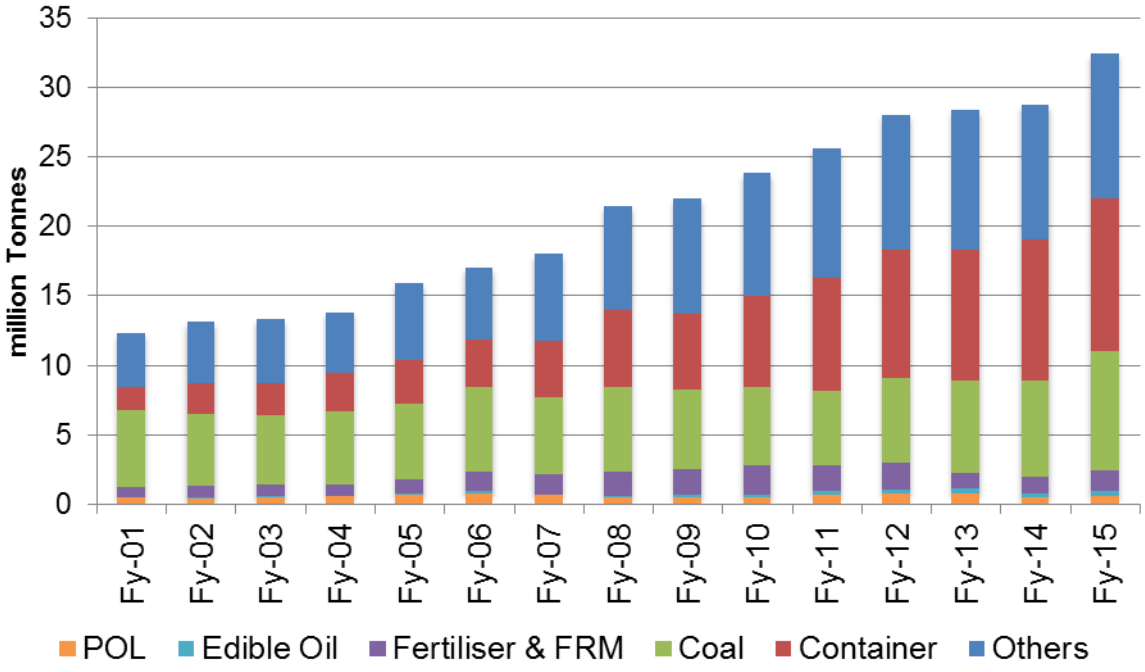
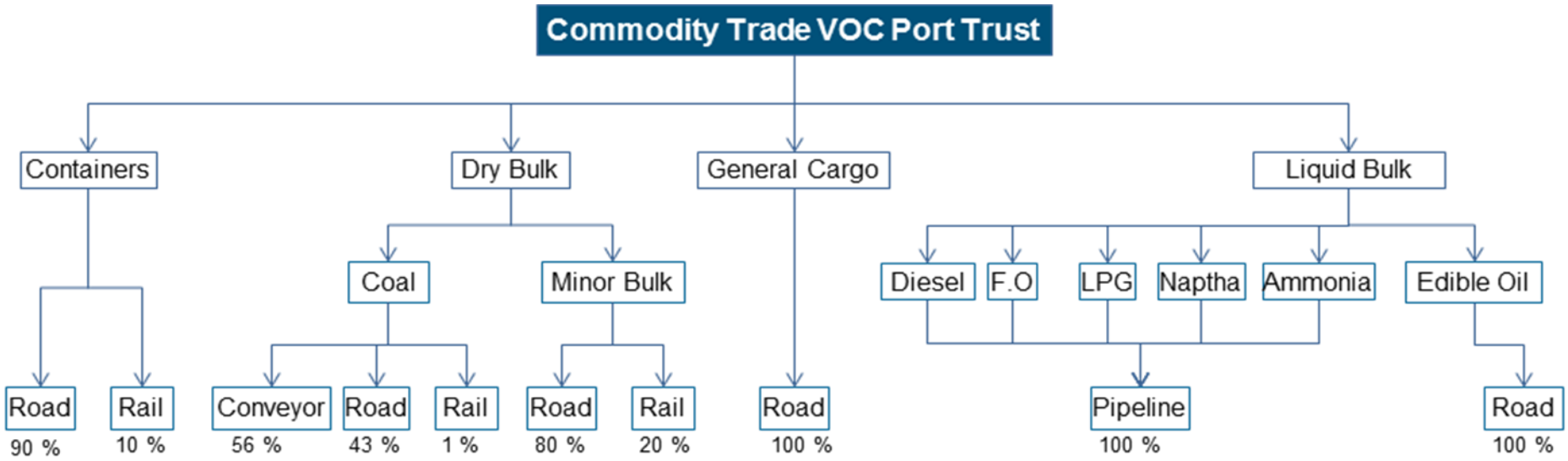


Figure 19: Commodity wise cargo growth of VOC Port



Opportunity for shifting cargo from land to waterwayspredominantly for commodities that are mostly carried by Road movement. Due to multiple handling involved in moving cargo using Multi-Modal route shifting cargo of Rail route to waterways becomes challenging. Especially, Railways has well developed infrastructure till the final destination. On the other hand, river does not have penetration to the final landing point for cargo.

Similarly, Cargo that are evacuated from port using conveyor mode or pipelines cannot be shifted to waterways. All liquid commodities, mostly petroleum products, are transported using pipelines. There is a set infrastructure for the same. Hence, it would not be possible to shift them.

As can be seen in the above flow chart, there exist potential to shift minor bulk cargo and general cargo using river route.

Figure 20: Commodity Wise Mode of Transportation Used

Following chart shows movement of cargo by various modes of transportation from VOC Port to the hinterland.

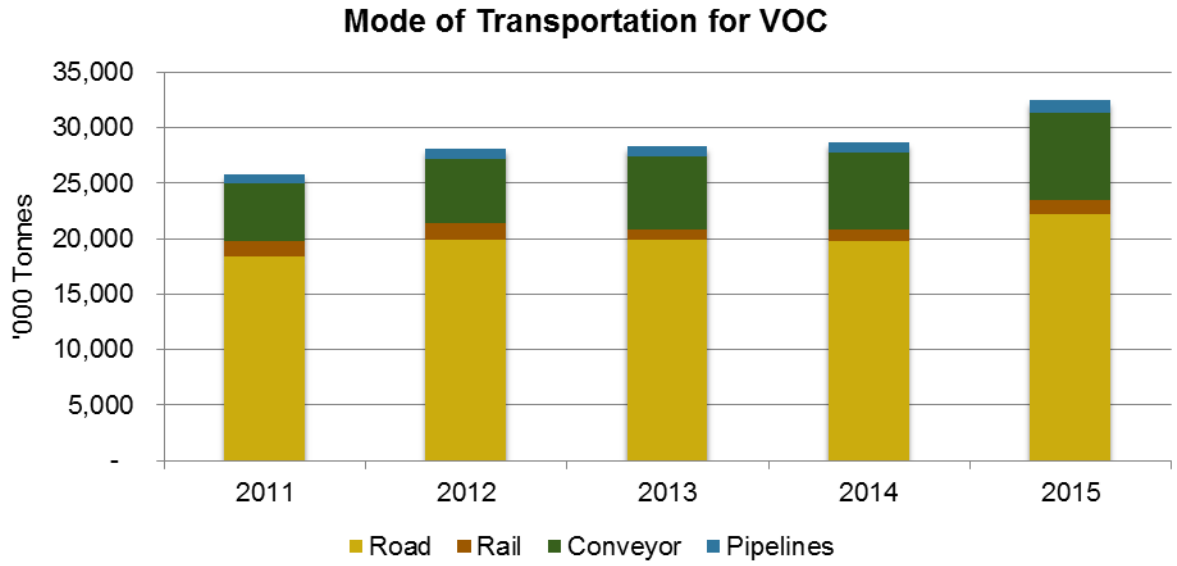


Figure 21: Various Modes of Transportation

Majority of the bulk commodities handled at VOC Port Trust is located close to port. VOC is predominantly bulk and container port with very less share of liquid cargo. There exists large power plant in port limits. Transportation of imported coal to these power plants is undertaken using conveyor belt. Hence, no opportunity exists for shift of cargo to river route.

Petroleum products are handled and later evacuated using pipelines. Most of the consumption centres for petroleum products are located in surrounding areas. Hence, it does not generate any opportunity for river transportation. The port has a well-developed pipeline infrastructure for distribution of imported petroleum products in the hinterland. The existing capacity of pipelines is adequate to accommodate future expansion and cargo growth for VOC Port Trust.

Among liquids, VOC Port imports more than 250,000 tons of edible oil annually. The distribution of edible oil to the local refineries takes place using the roadways. Most of the edible oil refineries are located on the northern side the port in the radius of 200 km. Hence, it becomes logistically challenging to use waterways for transportation of these commodities. It takes a maximum of 3 hours to 4 hours for imported edible oil to reach edible oil refineries. Use of waterways to reach last mile connectivity would deal final delivery of edible oil to the refineries. Hence, shifting of Edible oil to river route is not possible.

All the industrial zones located around rivers use containers for movement of their products. The road infrastructure for movement of containers is found to be very efficient. Finished products for export are sent to port directly from the factory using roadways. Hence, the users of industries in the hinterland did not show any interest in shifting their products to river route. The first apprehension for them was absence of water in the river.

Even if government ensures minimum depth of water available, the companies are not keen to shift to river route for container cargo.

Coal movement from VOC is either using Conveyor belt or railways. VOC port has large power plants in its port limits. Hence, Coal does not offer any opportunity for VOC. Industrial coal is transported using railway. The location of power plants is far away from VOC port Trust. Hence, movement of Coal for industrial use using Tamaraparani River is not possible.

5.6 Preliminary traffic identified – within 50km

As seen above, Tuticorin & Tirunelveli are the two districts near Tamaraparani River. There are 2 SIDCO's (one each in both districts) within 50 kilometres of the river, and thus some traffic is generated from here. While trade is happening, it is all being conducted via road and rail and not via waterways.

5.7 Existing cargo movement

As part of our study, we've had discussions with industries and locals situated around the Ponniyar River. All our discussions indicated that there's no existing cargo movement in the river.

5.8 Prominent City / Town / Places of Worship / Historical places for Tourism

Tuticorin City

The river is close to Tuticorin or Tuticorin, a port and an industrial city in Tuticorin district. The place is famous for the VOC port, named after freedom fighter V.O. Chidambaram Pillai. VOC port is among the 12 major ports in the country. The port is operational throughout the year. Tuticorin is 10 kilometer away from Tamaraparani River.

Tiruchendur temple

The temple is one among the six sacred temple complexes that are based near seashore. Also, it is the only temple in Tamil Nadu with a separate bus terminal. In terms of wealth, Tiruchendur is one of the richest temples in the state. The temple is located at a distance of 40 kilometer from Tuticorin and 75 kilometer north east of Kanyakumari. The distance between the Tiruchendur temple and Tamaraparani river is 17 kilometer.

Sankara Rameswarar Temple

This famous temple of Lord Shiva was built over 700 years ago. Sankara Rameshvara is a form of Lord Shiva. The temple is known for its Prathosam Pooja; Prathosam is that time of the month, which is considered as the best time to worship Lord Shiva. The place is located __ kilometer away from Tamaraparani river.

Hare Island

This leisure island attracts both local and foreign tourists. Spread across 1.29 kilometer, the island is the largest in the Gulf of Mannar. During the Pongal festival (January), the island attracts a large number of tourists. The island is a part of The Gulf of Mannar Marine National Park. Hare Island is 22.5 kilometer away from Tamaraparani river.

Roche Park

This is a popular park for holiday seekers. It is named after John Ladislaus Pitchaiya Roche Victoria, a famous politician and businessman from Tuticorin. This small park is located 4 kilometer from Tuticorin city. Roche Park is 23 kilometer from Tamaraparani River.

Church of Lady of Snow

This 300-year old church is dedicated to Our Lady of Snows, a title of Mother Mary. The church has a beautiful wooden statue of Mother Mary. It was built during the 16th century in the Portuguese architecture. Church of Lady of Snow is located 17 kilometer away from Tamaraparani River. The place is also close to NH-7A & SH-49.

Kazhugumalai

This area is famous for a Jain cave temple and architecture. Here you can see a rock cut Kalugasalamoorthy Temple, monolithic Vettuvan Koil, and Kalugumalai Jain Beds. The average elevation of this place is 344 feet. Kazhugumalai also has a huge church. It is 53 kilometer from Tamaraparani River.

Kulasekarapattinam Mutharamman Temple

This 300-year old temple is known for its 10-day Dussera festival. It is located 13 kilometer from Tiruchendur temple. Each year, more than 150,000 devotees come here to celebrate the Navarathiri festival. In the temple, the vigraham (an image of a deity) of Goddess Muththaramman and Swami Nganamoorthiswarar is installed, combined with each other. According to the temple website, such a combined vigraham cannot be seen anywhere else. The temple is 25 kilometer away from Tamaraparani River, and is close to SH-176.

Tirunelveli City

This place is an ancient city, which is nearly 2000 years old. Tirunelveli city is a part of a district with the same name. Tirunelveli has several historical monuments.

Kanthimathi-Nellaiappar Temple

Kanthimathi-Nellaiappar Temple is a temple for Lord Shiva. The twin temple, comprising Kanthimathi Temple and Nellaiappar temples, is spread over an area of more than 14 acres. The gopuram or the monumental tower of this temple has a length of 850 feet and width of 756 feet. Some of the popular attractions of the temple are its musical pillars and beautiful sculptural creations. The history of the temple dates back to 700 A.D.
Kanthimathi-Nellaiappar Temple is only 3.5 kilometer from Tamaraparani River.

Kutralam

Kutralam is a small town in the Tirunelveli district. The place has several waterfalls and health resorts, and is known as the Spa of South India. Between June to September, the area experiences a lot of rainfall, making it a pleasure to watch. Peraruvi, the main falls, is 60 feet. The waterfalls are 54 kilometres from Tamaraparani River.

Papanasam

Papanasam is a popular picnic spot, located 60 km from Tirunelveli. The place is famous for tourist spots such as Agasthiyar Falls, Siva Temple, and Papanasam dam &

hydroelectric power plant. Agasthiyar Falls are formed upon the Tamaraparani river reaching the plains of Tamil Nadu. The waterfall's head at 125 feet is a lake named Kalyanitheertham. Near this lake, there's a temple dedicated to Lord Shiva.
Papanasam is 39 kilometer from Tamaraparani River.

Memorial fort, Panchalankuruchi

The Panchalankuruchi fort measures an area of 35 acres. The memorial fort was built in 1974, in memory of Veerapandiya Kattabomman, a great warrior who revolted against the British Empire during 17th century A.D. Near the fort is a temple of Sri Devi Jakkammal, the hereditary goddess of Kattabomman. The fort is situated 33 kilometer from Tamaraparani River.

Baana Theertham falls

One of the hidden gems of Tirunelveli, the falls flows into the Karaiyar dam (49 kilometer from Tirunelveli). The falls is a popular choice for those looking for a fresh herbal bath, as it is believed that the water from the falls has healing properties. People also enjoy a boat ride on the dam. These falls are situated nearby to Tamaraparani River.

Kalakadu Wild Life Sanctuary

The only tiger reserve in Tamil Nadu, Kalakaduwas declared as a tiger reserve in the year 1988. Apart from being a tiger reserve, the sanctuary is also famous for chital, sambar and lion-tailed macaque. The sanctuary also offers boat rides, bird watching and trekking in the jungles of the reserve. Kalakadu Wild Life Sanctuary is at a distance of 59 kilometer from Tamaraparani River.

5.9 Availability of Passenger Ferry Services

To reach Baanatheertham waterfalls, one has to take a boat inside Karaiyar dam. The boat ride takes 20 minutes.

5.10 Available and probable Water Sport Recreational Facilities

Tuticorin has a unique natural formation that makes it ideal for water sports. In a report titled Vision 2025 for Tuticorin, prepared by the Madras Consultancy Group for CII, there's a mention of developing water sports activity near Roche Park and Hare Island. One of the main reasons for this proposal is that the water is calm around the suggested area.

6 Observations, Inferences and Conclusions

6.1 Waterway

The total length of the river under present studies is detailed below:

64 km length of the river from Sulochana Mudalir bridge, Tirunelveli to confluence with Bay of Bengal near Punnaikayal (National Waterway 99)	**8°43'43.17"N, 77°42'53.94"E**	**8°38'24.90"N, 78° 7'37.85"E**

6.2 Length

The length of waterway under present studies under consideration is 64 km.

6.3 LAD

LAD (m)	0-9.3	9.3-20	20-30	30-40	40-50	50-64	Total
< 1.0	5.18	5.22	5.94	7.91	8.48	9.78	42.51
1.0 -1.2	0.19	1.22	1.01	0.32	0.60	1.09	4.43
1.2 - 1.4	1.03	0.47	0.84	0.67	0.56	0.70	4.26
1.4 - 1.7	1.13	2.34	0.63	0.80	0.25	0.38	5.52
1.7 - 2.0	1.1	1.28	0.48	0.29	0.17	0.27	3.59
> 2.0	0.6	0.08	1.07	0.00	0.00	0.03	1.79

Table 48: LAD for the River Stretch

6.4 Cross-Structures

Nos.	**Horizontal clearance**	**Vertical clearance**
15 Existing and 1 under construction bridge between chainage 6 to 64 km	Varying from 3 to 25 meters	Varying from 2.0 to 7.75 meters
High Tension and Electric Lines		
Nos.	**Horizontal clearance**	**Vertical clearance**
17 High Tension and Electric Lines between chainage 5 to 63 km	Varying from 200 to 350 meters	Varying from 5.25 to 19 meters

Table 49: Details of Cross Structure on River

6.5 Water availability

Results of analysis of CWC gauge –Discharge data for assessing period of availability (% days in year) for different discharge ranges is presented in Table 48. Percentage of days in year for availability of discharge at this gauge site in excess of certain values is presented on a plot in Figure 21. These results indicate following:

Sr	Discharge (m^3/s) in excess of	Availability period in % days in year	Depth estimated from gauge and river cross section
1	10 m^3/s	36 % (about 130 days)	Depth 1.20 m

2	20 m^3/s	10.4 % (about 36 days)	Depth 1.40 m
3	40 m^3/s	5.4 % (about 20 days)	Depth 1.60 m
4	100 m^3/s	2.8 % (about 10 days)	Depth 2.20 m

Table 50: Water availability results

The above table shows that the discharge excess of 10 cumecs occurs for 36% days of the year. Similarly, the discharge in excess of 20 cumecs, 40 cumecs and 100 cumecs occurs for 10.4%, 5.4% and 2.8% days of a year respectively. The estimated depths for 10, 20, 40 and 100 cumecs are also shown in the above table.

The depths from the above table are estimated from the Gauge –Discharge curve and the river cross-section at gauging station at Murappanadu as per CWC data. The Murappanadu gauge is located on upstream of Kaliyavur weir (about 200 m upstream). As a result, the even for the lower discharges, the depths of the order of 1 m or more are possible.

The above analysis indicate that depths of the order of 1.2m will prevail for period over 120 days when discharge will exceed 10 m^3/s. The river slope is relatively flat (1/2900). There is already 6 weirs/barrages/Check Dam on this river. Raising the crest of existing weirs and if required construction of new weirs and some dredging will improve the depths available and as well duration. In general, the flow width of the river as per Google images varies from 120 m in lower reach to about 40 to 50 m in upper reach.

No of Days / Years	Range of Discharge (m^3/s)																
	0 to 2	2 to 5	5 to 10	10 to 15	15 to 20	20 to 40	40 to 60	60 to 80	80 to 100	100 to 120	120 to 140	140 to 150	150 to 200	200 to 300	300 to 500	500 to 1000	1000 to 2500
1977	5	1	14	2	3	4	4	1	2	2	1	0	0	0	0	0	0
1978	28	95	110	61	28	21	2	0	0	1	4	0	3	6	6	0	0
1979	52	78	59	67	33	17	5	4	5	2	4	0	4	7	13	9	6
1980	49	109	121	58	16	6	1	2	0	0	1	1	0	1	0	1	0
1981	44	105	119	58	6	21	3	4	2	1	0	0	1	1	0	0	0
1982	60	134	96	43	22	4	2	0	1	0	0	0	2	1	0	0	0
1983	137	79	70	50	18	9	0	0	1	1	0	0	0	0	0	0	0
1984	26	110	100	47	28	18	8	3	4	2	0	1	4	4	5	2	3
1985	38	100	137	51	15	16	2	4	0	1	0	0	1	0	0	0	0
1986	14	133	130	58	19	7	1	2	1	0	0	0	0	0	0	0	0
1987	114	47	87	63	24	18	2	5	0	3	0	1	0	1	0	0	0
1988	14	102	142	68	23	14	1	0	0	0	1	0	1	0	0	0	0
1989	72	74	115	60	26	12	4	2	0	0	0	0	0	0	0	0	0
1990	25	87	148	43	19	14	7	5	6	1	3	0	4	1	2	0	0
1991	2	70	132	82	29	21	12	7	4	2	2	0	1	1	0	0	0
1992	25	111	104	49	25	14	10	6	4	2	3	1	2	3	4	1	2
1993	12	97	94	70	26	23	11	3	4	4	3	0	3	7	3	3	2
1994	2	12	97	115	54	54	10	5	5	2	3	0	3	1	2	0	0
1995	1	74	167	73	31	11	6	0	1	0	1	0	0	0	0	0	0
1996	116	114	84	23	12	13	2	0	0	0	1	1	0	0	0	0	0
1997	91	83	89	31	10	15	5	4	3	5	3	2	10	11	2	1	0

No of Days / Years	Range of Discharge (m^3/s)																
	0 to 2	2 to 5	5 to 10	10 to 15	15 to 20	20 to 40	40 to 60	60 to 80	80 to 100	100 to 120	120 to 140	140 to 150	150 to 200	200 to 300	300 to 500	500 to 1000	1000 to 2500
1998	2	45	191	69	23	20	5	1	1	3	1	1	1	1	1	0	0
1999	34	106	90	57	35	23	11	4	4	0	1	0	0	0	0	0	0
2000	8	84	115	75	44	25	6	1	2	1	1	1	2	1	0	0	0
2001	26	111	139	47	20	12	1	3	1	0	0	0	0	2	0	0	0
2002	14	142	116	47	27	10	1	2	1	2	0	1	0	2	0	0	0
2003	16	164	80	37	33	31	1	1	0	0	1	1	0	0	0	0	0
2004	53	78	92	69	23	24	5	2	3	0	1	1	3	4	5	2	1
2005	11	35	119	140	37	5	2	4	1	2	1	1	1	1	4	1	0
2006	0	42	127	78	35	30	4	2	7	5	1	4	4	9	13	3	1
2007	0	31	181	99	19	23	2	3	2	0	1	0	2	1	1	0	0
2008	3	43	101	84	48	33	13	7	5	6	7	1	4	6	4	1	0
2009	0	45	161	84	33	22	9	3	4	3	0	0	0	1	0	0	0
2010	2	53	143	103	43	15	1	1	1	1	1	1	0	0	0	0	0
2011	7	80	112	102	37	17	5	2	1	0	1	0	0	0	1	0	0
2012	7	51	46	36	6	6	0	0	0	0	0	0	0	0	0	0	0
N	1110	2925	4028	2299	930	628	164	93	76	52	47	19	56	73	66	24	15
ƐN	12605																
% occurrence	8.81%	23.21%	31.96%	18.24%	7.38%	4.98%	1.30%	0.74%	0.60%	0.41%	0.37%	0.15%	0.44%	0.58%	0.52%	0.19%	0.12%

Table 51: Availability for days for discharge in different range at Murappanadu gauge station on Tamaraparani River

As there are various gaps in the available data, therefore in above years the total days does not add up to 365. The daily gauge discharge data has been collected from CWC. The table shows the availability of ranges of discharge and their occurrence in days in each particular year.

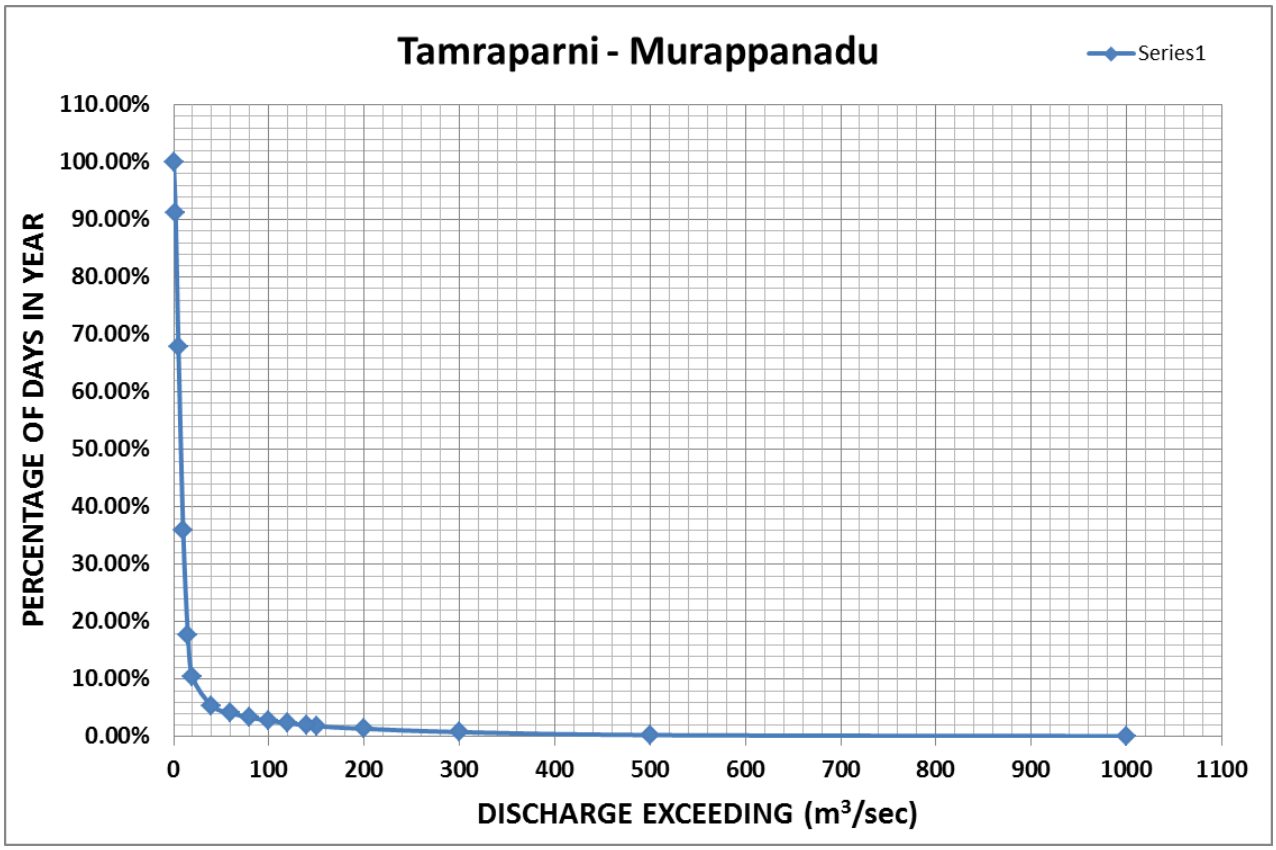


Figure 22: Period of exceedance of discharge in percentage of days in year for Tamaraparani River at Murappanadu gauging station

6.6 Cargo / Passenger / Tourism / Ro-Ro Facility

From figure 16, it can be seen that potential exists for minerals and general cargo. Mouth of the river is close to the port and River has substantial share of minerals products that are mostly exported to Maldives using small vessels.

Potential exists for minerals & boulders which are minor & fragmented segment. A large volume of stones, boulders, etc. could be transported using River Sea Class ships in the Tamaraparani River to VOC Port. Presently, about 1 mn Tonnes of these commodities are transported to VOC port using road route to Zone B of port. The Zone B of VOC Port is an old port located closer to city. About 1 mn Tonnes of cargo is available annually. Limestone, Rough stone, garnet and granite may be transported from trivenveli district using inland waterway.

As there are a number of towns around the river for which passenger, Tourism and Ro-Ro facilities can be developed can be developed.

6.7 Classification of waterway: Suitable for Navigation

0-9.3 km (river mouth to Latchipuram check dam)

This is Tidal reach where bathymetry survey is carried out. This reach has the potential to be developed as class I waterway with little dredging for 365 days in a year.

9.3 - 25.7 km (Latchipuram to Srivaiguntam weir)

Latchipuram check dam exist at downstream end and srivaiguntam weir forms the upstream end of this stretch. Controlled flow at upstream and check dam at downstream ensure availability of water for about 1-2.5 m depth (raw depth) all round the year (365 days).

25.7 – 45.94 km (Srivaiguntam Weir – Kaliyavur weir)

srivaiguntam weir exists at downstream end and Kaliyavur weir forms the upstream end of this stretch. Pakapatti weir also exist at chainage of about 40.60 km. Controlled flow at both the ends ensure availability of water for about 1 -2.5 m depth (raw depth) all round the year (365 days).

45.94 – 64 km (Kaliyavur weir- Sulochana Mudliar Bridge)

Navigation is feasible for about 245 days (8 months) in year with little capital dredging at some shallow reaches as about 1 m depth is available without dredging at Murappanadu gauge station. Actual availability of depth of water all along the river stretch will only be commented after having cross-section data of the river in Stage II.

6.8 Proposed alternative methods for making waterway feasible

Navigation can be developed for class-I channel and further can be improved to Class II channel. As detailed in para 6.5, there are already 6 weirs/barrages/Check Dam on this river. Raising the crest of existing weirs/structures and if required construction of new weirs and some dredging will improve the depths available and as well duration. None of the existing dams/anicut/barrage has navigational lock. Provision of locks will be required on each weir/barrage.

Detail bathymetry & river cross section survey during stage 2 studies will be helpful for designing of waterway

6.9 SWOT Analysis

Strength:	Weakness
• Availability of water depth (150days, i.e. 6 Months in a year) • Depths of about 1m are available without dredging for about 6-7 months. Hence minimal dredging is required for class I navigation. • Cargo potential exists as nearby port is Tuticorin and various industries exists along the river	• Existing cross-structures (16 bridges & 6 Weirs/barrages), requiring navigation locks, modification and reconstructions of some bridges
Opportunities	**Threats**
• Raising the crest of existing weirs and/or construction of new weirs or some dredging will improve the depths available and as well duration thereby class-II channel may be developed and further can be improved to Class III channel. • Cargo (Granite, Rough stone, Garnet) • Possibility of Tourism and local ferry services	• Closing of river mouth due to littoral drift along east coast.

6.10 Recommendation for going into Stage-II

As traffic potential for Granite, Rough stone and Garnet exist and Tuticorin port exists very near to river mouth. As depths of about 1 m are available without dredging for 6-7 months, we recommend Stage II studies (Detailed studies and investigations) to examine the possibility of various alternative methods (Like raising the height of existing weirs, construction of locks, etc.) to make the waterway feasible all-round the year for class I and Class II navigation.

Annexures

Annexure 1: Soil Samples

Soil Texture		
Sl No.	**Chainage(Km)**	**Soil texture**
1	0-10	Sandy
2	10-20	Sandy
3	20-30	Sandy
4	30-40	Sandy
5	40-50	Sandy
6	50-60	Sandy
7	60-70	Sandy with Rocks

Annexure 1: Soil characteristics for the River

Annexure 2 : River - Tamaraparani																											
Sl No.	Chainage (Km)	Max Water Level	Minimum Water Level	Types of Crops & Industry	Ferry/Prominent Tows City/Jetty/Terminal		Utility/Pipelines		Historical and tourist places		Bridges Name with VC & HC		HC /Electric Line	Permananent Structure in Corridor of River		Bank Condition	Critical Areas/Not approachable		Local Name of River	Dams		HFL details		Remarks	Other Details
					Details	Position	Name	Position	Name	Position	Name	Position	Position	Details	Position		Details	Position		Details	Position		Position		
1	0.0	Maximum Water Level 2 to 3 m in rainy season	0.3Minimum water level varies from 0.3m to 0.5m	-	Sea Mouth	-	-	-	-	-	-	-	-	-	-	-	-	-	THAMIRABARANI	-	-	-	-	Mouth approximately closed even after presence of two breakwaters at river mouth. Left bank near breakwater eroded and river oufall shifter behind left bank breakwater.	
2	0.3			-	Punnaikayal Fishing Jetty	08°38'13.91"N, 78°07'20.66"E	-	-	-	-	-	-	-	-	-	-	-	-						Existing fishing jettey, Auction hall on Right Bank	
3	3.8			-	-	-	-	-	-	-	-	-	-	-	-		Sand Barrier across river	08°38'12.55"N, 78°05'40.13"E						Bund made by locals for storing freshwater	
4	5.2			-	-	-	-	-	-	-	-	-	08°38'09.70"N, 78°05'00.75"E	-	-	-	-	-								
5	6.8			-	-	-	-	-	-	-	-	-	-	Water Intake Tower -2	08°37'39.99"N, 78°04'14.40"E										
6	6.9			-	-	-	-	-	-	-	Authoor New Road Bridge	08°37'37.67"N, 78°04'09.27"E	-												
7	7.0			-	-	-	-	-	-	-	Authoor Old Road Bridge	08°37'37.51"N, 78°04'10.58"E	-												
8	7.1			-	-	-	-	-	-	-	-	-	-	Water Intake Tower-1	08°37'36.48"N, 78°04'06.10"E										
9	8.1			-	-	-	-	-	-	-	-	-	08°37'18.65"N, 78°03'35.52"E												
10	9.4			-	-	-	-	-	-	-	-	-	-							Latchumipuram Check Dam	08°37'23.94"N, 78°02'53.57"E					
11	9.6			-	-	-	-	-	-	-	-	-	08°37'24.05"N, 78°02'49.09"E												
12	10.0			-	-	-	-	-	-	-	-	-	08°37'22.72"N, 78°02'33.72"E												
13	13.0			-	-	-	-	-	-	-	Eral Bridge	08°37'04.11"N, 78°01'11.00"E	-											Rd bridge and low lvl cause way over pipes on downstream	Eral Bridge 10.5 m wide
14	16.0			-	-	-	-	-	-	-	-	-	08°37'11.50"N, 77°59'54.14"E							Kurangini Check Dam	08°37'09.75"N, 77°59'49.51"E					
15	16.6			-	-	-	-	-	-	-	-	-	08°37'02.67"N, 77°59'28.47"E												
16	17.7			-	-	-	-	-	-	-	Temporary Bridge made of Bricks and sand	08°36'35.10"N, 77°59'08.01"E	-												
17	21.4			-	-	-	-	-	-	-	Alwarthopu Bridge	08°36'25.78"N, 77°56'38.19"E	-												Alwarthopu Bridge Water flowing in a width of 200m
18	25.0			-	-	-	-	-	-	-	-	-	-	-						Srivaiguntam Dam						
19	25.6			-	-	-	-	-	-	-	Srivaiguntam New Road Bridge,	08°37'21.63"N, 77°54'36.38"E	-												10.5 m wide
20	25.7			-	-	-	-	-	-	-	Srivaiguntam Old Road Bridge,	08°37'28.41"N, 77°54'33.28"E	-							08°37'28.41"N, 77°54'33.28"E					

Sl No.	Chainage (Km)	Max Water Level	Minimum Water Level	Types of Crops & Industry	Ferry/Prominent Tows City/Jetty/Terminal		Utility/Pipelines		Historical and tourist places		Bridges Name with VC & HC		HC /Electric Line	Permananent Structure in Corridor of River		Bank Condition	Critical Areas/Not approachable		Local Name of River	Dams		HFL details		Remarks	Other Details
					Details	Position	Name	Position	Name	Position	Name	Position	Position	Details	Position		Details	Position		Details	Position		Position		
21	26.2			-	-	-	-	-	-	-	-	-	-	Water Intake Tower -2	08°37'44.35"N, 77°54'35.57"E									
22	26.3			-	-	-	-	-	-	-	-	-	-	Water Intake Tower-1	08°37'45.72"N, 77°54'34.33"E									
23	27.0			-	-	-	-	-	-	-	-	-	08°38'06.01"N, 77°54'19.49"E											
24	33.2			-	-	-	-	-	-	-	KongarayaKurichi Bridge Under construction	08°39'06.18"N, 77°51'30.57"E	-										bushes on both banks, water flowing at center of river	KongarayaKurichi Bridge
25	34.0			-	-	-	-	-	-	-	-	-	08°39'15.44"N, 77°51'15.08"E											
26	40.6			-	-	-	-	-	-	-	-	-	-							Pakkappati Dam	08°42'31.90"N, 77°50'19.79"E				
27	41.1			-	-	-	-	-	-	-	Murappanadu Old Road Bridge,	08°42'46.55"N, 77°50'20.41"E	-											Road Bridges 2@7.5+1.5x2 Water flowing in a width of 80m
28	41.3			-	-	-	-	-	-	-	Murappanadu New Road Bridge,	08°42'45.84"N, 77°50'12.32"E	-											
29	42.1			-	-	-	-	-	-	-	-	-	08°42'48.56"N, 77°50'10.13"E											
30	42.5			-	-	-	-	-	-	-	-	-	-									22.88m on 14Nov 92	08°42'56.10"N, 77°50'01.23"E		
31	42.4			-	-	-	Water pipeline bridge. VC-6m, HC-10m	08°43'04.12"N, 77°49'58.41"E	-	-	-	-	-												
32	43.0			Paddy	-	-	-	-	-	-	-	-	08°43'16.02"N, 77°49'56.89"E											
33	48.2			Paddy	-	-	-	-	-	-	-	-	-	WATER INTAKE TOWER	8 45 50.75N, 77 49 21.34E									
34	48.3			Paddy	-	-	-	-	-	-	-	-	-	-	-					DAM-KALIYUVAR	8 45 46.26N, 77 49 19.49E				
35	48.3			Paddy	-	-	-	-	-	-	-	-	8 45 54.51N, 77 49 09.23E	-	-										
36	48.5			Paddy	-	-	-	-	-	-	-	-	8 46 01.50N, 77 49 09.83E	-	-										
37	49.5			Paddy	-	-	-	-	-	-	-	-	8 46 24.45N, 77 48 57.93E	-	-										
38	50.3			Paddy	-	-	-	-	-	-	-	-	-	-	-					Check Dam	8 46 44.93N, 77 48 40.53E				
39	50.5			Paddy	-	-	-	-	-	-	Sivalaperi Road Bridge	08°46'51.05"N, 77°48'35.52"E	-	-	-								HT Line, Water flowing though half river width, bushes in river bed	Water flowing in a width of 220m
40	50.8			Paddy	-	-	Water pipeline bridge. VC-6m, HC-9m	08°46'50.38"N, 77°48'33.72"E	-	-	-	-	-	-	-								Water flowing though half river width, bushes in river bed, Intake well	
41	50.9			Paddy	-	-	-	-	-	-	-	-	08°46'52.16"N, 77°48'31.06"E	Water Intake Tower	08°46'52.16"N, 77°48'31.06"E									
42	55.9			Paddy	-	-	-	-	-	-	-	-	08°46'36.58"N, 77°45'52.18"E	-	-									

Sl No.	Chainage (Km)	Max Water Level	Minimum Water Level	Types of Crops & Industry	Ferry/Prominent Tows City/Jetty/Terminal		Utility/Pipelines		Historical and tourist places		Bridges Name with VC & HC		HC /Electric Line	Permananent Structure in Corridor of River		Bank Condition	Critical Areas/Not approachable		Local Name of River	Dams		HFL details		Remarks	Other Details
					Details	Position	Name	Position	Name	Position	Name	Position	Position	Details	Position		Details	Position		Details	Position		Position		
43	59.7			Paddy, Banana	-	-	-	-	-	-	NH-7 HIgh Way Bridge	08°45'21.36"N, 77°44'19.45"E	-	-	-									2 damaged intakes on downstream, small creek flowing and remaining portion of bed filled with bushes & boulders. Dense vegetaton on both banks, Some persons were found taking bath in creek.	Road Bridges 2@7.5+1.5x2 Water flowing in a width of 110m
44	60.2			Paddy, Banana	-	-	-	-	-	-	-	-	08°45'14.02"N, 77°43'59.05"E	-	-										
45	62.6			-	-	-	-	-	-	-	-	-	08°44'22.20"N, 77°43'10.09"E	-	-	Rocky shore with long grasses	-	-		-	-	-	-	Rocky shore with long grasses	
46	62.7			-	-	-	Water pipeline bridge	08°44'20.72"N, 77°43'09.29"E	-	-	Vanarpettai Bridge	08°44'20.72"N, 77°43'09.29"E	-	-	-	-	Rocky shore with long grasses	-	-		-	-	-	-		
47	64.0			-	Tirunelveli City	08°43'52.56"N, 77°42'50.03"E	-	-	-	-	Kokarkullam Bridge	08°43'42.05"N, 77°42'54.84"E	-	-	-	-	Rocky shore with long grasses	-	-		-	-	-	-	Small Creek flowing below one of the spans, sandy river bed and dense bushes,buildings on one side of bridge	Kokarkullam Bridge/ Sulochna Mudliyar Bridge (T-beam & Slab Bridge) Water flowing in a width of 70m

ANNEXURE 3:- PHOTOGRAPHS OF CROSS-STRUCTURES ON TAMARAPARANI RIVER

1: Breakwaters at River Mouth

2: Punnikayal Fishing Jetty at chainage 0.3 km

3: **Earthen Bund (Sand Barrier) made by local across the river at Chainage 3.8 km to store fresh water**

4: **Authoor New Road Bridge (Chainage 6.9 km)**

5: **Authoor old Road Bridge (Chainage 7 km)**

6: **Water Intake at chainage 7.1 km**

7: **Latchumipuram Check Dam at Chainage 9.4 km**

8: New Constructed Eral Bridge at Chainage 13 km

9 : View of Kurangani Dam at chainage 16 km

10: **Alwarthopu Road Bridge at chainage 21.4 km**

11: **Srivaiguntam New Road Bridge at chainage 25.6 km**

12: Srivaiguntam old Road Bridge at chainage 25.7 km

13: **PWD Srivaikutum anicut at chainage 25.7 km**

14: **PWD Srivaikutum anicut at chainage 25.7 km**

15: Road Bridge under Construction at Chainage 33.2 km

16: Pakapattai weir at chainage 40.6 km

17: Old Murappanadu Bridge at chainage 41.1 km

18: Murappanadu New Road Bridge & Footbridge at 41.3 km

19: Water pipeline bridge at chainage 42.4 km

20: **KALIYUVAR Regulator at Chainage 48.3 km**

21: NH-7 Highway Bridge at chainage 59.7 km

22: Kokarkullam Bridge/ Sulochna Mudliar Bridge at chainage 64 km

Annexure 4: Source Data Table for *Figure 10: Riverbed profile from the Estuary (CH-9.4) up to (CH-64)*

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
9.352	0.24	2.00	3.50
9.442	0.28	2.00	3.54
9.539	0.30	2.01	3.59
9.638	0.29	2.01	3.64
9.733	0.27	2.02	3.69
9.833	0.50	2.02	3.74
9.933	0.45	2.03	3.79
9.955	0.60	2.03	3.80
10.026	0.75	2.03	3.84
10.120	0.65	2.04	3.88
10.212	0.55	2.04	3.93
10.306	0.30	2.05	3.98
10.401	0.40	2.05	4.02
10.497	0.35	2.06	4.07
10.593	0.45	2.06	4.12
10.689	0.50	2.07	4.17
10.731	0.51	2.07	4.19
10.786	0.55	2.07	4.22
10.885	0.60	2.08	4.27
10.988	0.45	2.08	4.32
11.086	0.35	2.09	4.37
11.184	0.50	2.09	4.42
11.282	0.60	2.10	4.46
11.382	0.35	2.10	4.51
11.482	0.25	2.11	4.56
11.582	0.50	2.11	4.61
11.682	0.60	2.12	4.66
11.782	0.55	2.12	4.71
11.883	0.60	2.13	4.77
11.915	0.63	2.13	4.78
11.974	0.70	2.13	4.81
12.073	0.80	2.14	4.86
12.155	0.85	2.14	4.90
12.248	0.70	2.14	4.95
12.317	0.90	2.15	4.98
12.405	1.20	2.15	5.03
12.470	1.10	2.16	5.06
12.586	1.30	2.16	5.12

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
12.674	1.38	2.17	5.16
12.765	1.40	2.17	5.21
12.865	1.45	2.18	5.26
12.963	1.35	2.18	5.31
13.057	1.22	2.19	5.35
13.150	1.30	2.24	5.40
13.251	1.35	2.30	5.45
13.347	1.45	2.36	5.50
13.444	1.50	2.42	5.55
13.479	1.51	2.44	5.56
13.563	1.45	2.49	5.61
13.662	1.40	2.55	5.65
13.760	1.60	2.61	5.70
13.866	1.65	2.67	5.76
13.961	2.50	2.73	5.80
14.057	2.35	2.78	5.85
14.154	2.65	2.84	5.90
14.250	2.55	2.90	5.95
14.347	2.75	2.96	6.00
14.451	2.92	3.02	6.05
14.549	3.12	3.08	6.10
14.648	3.25	3.14	6.15
14.780	3.30	3.22	6.21
14.880	3.35	3.28	6.26
14.997	3.40	3.35	6.32
15.093	3.51	3.41	6.37
15.093	3.60	3.41	6.37
15.193	3.45	3.47	6.42
15.301	3.40	3.53	6.47
15.419	3.35	3.60	6.53
15.482	3.46	3.64	6.56
15.517	3.60	3.66	6.58
15.613	3.57	3.72	6.63
15.782	4.25	3.82	6.71
15.873	4.94	3.87	6.76
15.881	4.85	3.88	6.76
15.984	4.70	3.94	6.82
16.084	4.70	4.00	6.87
16.084	4.75	4.85	7.00

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
16.183	4.65	4.85	7.01
16.282	4.62	4.86	7.01
16.389	4.45	4.86	7.02
16.487	4.35	4.86	7.02
16.585	4.62	4.87	7.03
16.683	4.55	4.87	7.03
16.780	4.25	4.87	7.04
16.880	4.35	4.87	7.04
16.980	4.25	4.88	7.05
17.080	4.32	4.88	7.06
17.180	4.23	4.88	7.06
17.280	4.15	4.89	7.07
17.380	4.25	4.89	7.07
17.478	4.18	4.89	7.08
17.576	4.05	4.90	7.08
17.659	4.10	4.90	7.09
17.669	4.02	4.90	7.09
17.740	4.05	4.90	7.09
17.828	4.15	4.90	7.10
17.915	3.50	4.91	7.10
18.003	3.35	4.91	7.11
18.112	3.00	4.91	7.11
18.206	3.15	4.92	7.12
18.220	2.90	4.92	7.12
18.305	3.12	4.92	7.12
18.405	3.00	4.92	7.13
18.504	3.35	4.92	7.13
18.604	3.25	4.93	7.14
18.711	3.40	4.93	7.15
18.811	3.42	4.93	7.15
18.893	3.48	4.94	7.16
18.910	3.50	4.94	7.16
19.010	3.65	4.94	7.16
19.125	3.75	4.94	7.17
19.224	3.81	4.95	7.18
19.284	3.89	4.95	7.18
19.324	3.75	4.95	7.18
19.424	3.62	4.95	7.19
19.523	3.85	4.96	7.19

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
19.623	3.77	4.96	7.20
19.723	3.95	4.96	7.20
19.822	4.12	4.97	7.21
19.947	4.25	4.97	7.22
20.047	4.15	4.97	7.22
20.146	4.35	4.98	7.23
20.246	4.50	4.98	7.23
20.331	4.55	4.98	7.24
20.430	4.63	4.98	7.24
20.432	4.75	4.98	7.24
20.514	4.61	4.99	7.25
20.614	4.50	4.99	7.25
20.713	4.25	4.99	7.26
20.814	4.35	5.00	7.26
20.914	4.20	5.00	7.27
21.013	4.15	5.00	7.27
21.113	4.05	5.01	7.28
21.213	3.95	5.01	7.29
21.312	3.98	5.01	7.29
21.413	3.75	5.01	7.30
21.512	3.86	5.02	7.30
21.609	3.70	5.02	7.31
21.616	3.76	5.02	7.31
21.697	3.86	5.02	7.31
21.794	3.97	5.03	7.32
21.891	4.25	5.03	7.32
21.987	4.56	5.03	7.33
22.032	4.73	5.03	7.33
22.100	4.62	5.04	7.34
22.198	4.40	5.04	7.34
22.297	4.75	5.04	7.35
22.395	4.93	5.05	7.35
22.493	5.10	5.05	7.36
22.589	5.30	5.05	7.36
22.621	5.59	5.05	7.36
22.689	5.30	5.05	7.37
22.788	5.75	5.06	7.37
22.888	6.10	5.06	7.38
22.911	6.44	5.06	7.38

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
22.989	6.35	5.06	7.39
23.108	6.25	5.07	7.39
23.217	6.40	5.07	7.40
23.328	6.25	5.07	7.40
23.415	6.34	5.08	7.41
23.511	6.25	5.08	7.41
23.615	6.34	5.08	7.42
23.706	6.20	5.09	7.43
23.824	6.15	5.09	7.43
23.901	6.16	5.09	7.44
23.919	6.20	5.09	7.44
24.021	6.25	5.10	7.44
24.133	6.36	5.10	7.45
24.232	6.50	5.10	7.45
24.326	6.45	5.11	7.46
24.384	6.32	5.11	7.46
24.474	6.35	5.11	7.47
24.548	6.42	5.11	7.47
24.641	6.50	5.11	7.48
24.720	6.45	5.12	7.48
24.806	6.35	5.12	7.49
24.889	6.40	5.12	7.49
24.970	6.43	5.13	7.50
25.050	6.51	5.13	7.50
25.052	6.25	6.30	8.30
25.099	6.10	6.30	8.32
25.198	5.95	6.31	8.36
25.262	5.72	6.32	8.38
25.295	5.70	6.32	8.39
25.391	5.50	6.33	8.43
25.491	5.35	6.34	8.47
25.586	5.20	6.34	8.50
25.682	5.06	6.35	8.54
25.780	5.06	6.36	8.58
25.873	4.76	6.37	8.61
25.968	4.61	6.37	8.65
26.065	4.46	6.38	8.69
26.161	4.32	6.39	8.72
26.194	5.26	6.39	8.74

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
26.259	5.15	6.40	8.76
26.361	5.20	6.40	8.80
26.460	5.35	6.41	8.84
26.534	5.25	6.42	8.86
26.634	5.15	6.43	8.90
26.635	5.14	6.43	8.90
26.728	4.95	6.43	8.94
26.828	4.75	6.44	8.98
26.928	4.82	6.45	9.01
26.998	4.45	6.46	9.04
27.096	4.20	6.46	9.08
27.178	4.05	6.47	9.11
27.278	3.95	6.48	9.15
27.364	3.86	6.48	9.18
27.454	3.50	6.49	9.22
27.552	3.35	6.50	9.25
27.652	3.25	6.55	9.29
27.752	3.35	6.59	9.33
27.842	3.40	6.64	9.36
27.934	3.55	6.68	9.40
28.015	4.63	6.72	9.43
28.034	4.75	6.73	9.44
28.128	4.88	6.77	9.47
28.222	5.00	6.82	9.51
28.322	5.25	6.86	9.55
28.400	5.35	6.90	9.58
28.499	5.50	6.95	9.61
28.550	5.54	6.97	9.63
28.584	5.65	6.99	9.65
28.669	5.78	7.03	9.68
28.753	6.00	7.07	9.71
28.835	6.19	7.11	9.74
28.840	6.10	7.11	9.74
28.940	6.35	7.16	9.78
29.040	6.50	7.20	9.82
29.139	6.68	7.25	9.86
29.239	6.95	7.30	9.90
29.318	7.22	7.33	9.93
29.339	7.15	7.34	9.93

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
29.436	7.05	7.39	9.97
29.530	7.15	7.43	10.01
29.629	7.22	7.48	10.04
29.728	7.15	7.53	10.08
29.749	7.25	7.54	10.09
29.814	7.15	7.57	10.12
29.914	7.00	7.62	10.15
29.927	7.26	7.62	10.16
30.014	7.10	7.66	10.19
30.095	7.15	7.70	10.22
30.209	7.00	7.76	10.27
30.285	7.11	7.79	10.29
30.381	6.95	7.84	10.33
30.479	6.90	7.88	10.37
30.562	6.95	7.92	10.40
30.577	7.20	7.93	10.41
30.674	7.45	7.98	10.44
30.769	7.65	8.02	10.48
30.860	7.70	8.06	10.51
30.890	7.86	8.08	10.53
30.957	7.95	8.11	10.55
31.066	8.10	8.16	10.59
31.170	8.45	8.21	10.63
31.258	8.65	8.25	10.67
31.360	8.80	8.30	10.70
31.443	9.12	8.34	10.74
31.447	9.25	8.34	10.74
31.545	9.15	8.39	10.77
31.642	9.05	8.43	10.81
31.741	9.15	8.48	10.85
31.782	9.21	8.50	10.87
31.843	9.10	8.53	10.89
31.940	9.05	8.57	10.93
32.024	8.75	8.61	10.96
32.116	8.65	8.66	10.99
32.230	8.45	8.71	11.04
32.336	8.25	8.76	11.08
32.409	8.01	8.80	11.10
32.418	8.25	8.80	11.11

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
32.518	8.46	8.85	11.15
32.600	8.62	8.89	11.18
32.705	8.80	8.94	11.22
32.800	8.90	8.98	11.25
32.828	9.20	8.99	11.26
32.888	9.05	9.02	11.29
32.992	8.75	9.07	11.33
33.090	8.15	9.12	11.36
33.153	7.99	9.15	11.39
33.185	7.65	9.16	11.40
33.276	7.97	9.21	11.43
33.369	8.35	9.25	11.47
33.473	8.73	9.30	11.51
33.477	8.85	9.30	11.51
33.584	8.88	9.35	11.55
33.686	8.70	9.40	11.59
33.790	8.83	9.45	11.63
33.890	8.95	9.50	11.67
33.973	9.06	9.54	11.70
33.988	9.10	9.54	11.71
34.087	9.15	9.59	11.74
34.183	9.12	9.63	11.78
34.281	9.05	9.68	11.82
34.397	9.11	9.74	11.86
34.415	9.10	9.74	11.87
34.494	9.05	9.78	11.90
34.589	9.15	9.83	11.94
34.691	9.12	9.87	11.97
34.788	9.05	9.92	12.01
34.876	9.35	9.96	12.04
34.979	9.56	10.01	12.08
35.084	9.85	10.06	12.12
35.189	9.95	10.11	12.16
35.285	10.10	10.16	12.20
35.360	10.23	10.19	12.23
35.382	10.10	10.20	12.24
35.482	10.25	10.25	12.28
35.582	10.35	10.30	12.31
35.682	10.50	10.34	12.35

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
35.783	10.70	10.39	12.39
35.807	10.91	10.40	12.40
35.880	10.95	10.44	12.43
35.978	10.55	10.48	12.46
36.075	10.40	10.53	12.50
36.081	10.46	10.53	12.50
36.165	10.50	10.57	12.54
36.265	10.35	10.62	12.57
36.302	10.44	10.64	12.59
36.356	10.40	10.66	12.61
36.428	10.50	10.70	12.64
36.505	10.55	10.73	12.67
36.612	10.25	10.78	12.71
36.729	10.05	10.84	12.75
36.831	9.85	10.89	12.79
36.933	9.60	10.93	12.83
37.025	9.55	10.98	12.86
37.131	9.60	11.03	12.90
37.243	9.43	11.08	12.95
37.320	9.40	11.12	12.98
37.415	9.54	11.16	13.01
37.421	9.45	11.17	13.01
37.519	9.35	11.21	13.05
37.617	9.56	11.26	13.09
37.711	9.75	11.30	13.13
37.810	9.88	11.35	13.16
37.913	10.10	11.40	13.20
38.016	10.05	11.45	13.24
38.118	10.15	11.49	13.28
38.175	10.26	11.52	13.30
38.211	10.11	11.54	13.32
38.318	10.35	11.59	13.36
38.411	10.42	11.63	13.39
38.504	10.55	11.68	13.43
38.598	10.65	11.72	13.46
38.693	10.85	11.77	13.50
38.749	11.22	11.79	13.52
38.803	11.15	11.82	13.54
38.908	11.20	11.87	13.58

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
39.008	11.45	11.91	13.81
39.108	11.50	11.96	14.05
39.169	11.63	11.99	14.19
39.205	11.65	12.01	14.27
39.300	11.55	12.05	14.49
39.405	11.85	12.10	14.73
39.505	12.00	12.15	14.96
39.611	12.65	12.20	15.21
39.725	12.95	12.25	15.47
39.822	13.20	12.30	15.70
39.912	13.85	12.34	15.91
40.006	14.50	12.39	16.12
40.108	14.95	12.44	16.36
40.206	15.20	12.48	16.59
40.302	15.55	12.53	16.81
40.407	15.65	12.58	17.05
40.430	15.96	12.59	17.11
40.504	16.05	12.62	17.28
40.601	16.25	12.67	17.50
40.601	16.25	16.50	18.00
40.696	16.30	16.52	18.04
40.775	16.25	16.53	18.07
40.880	16.35	16.55	18.11
41.003	16.40	16.58	18.16
41.018	16.49	16.58	18.17
41.073	16.50	16.59	18.19
41.162	16.65	16.61	18.22
41.268	16.35	16.63	18.26
41.366	16.25	16.65	18.30
41.374	16.00	16.65	18.31
41.458	16.15	16.67	18.34
41.551	16.25	16.69	18.38
41.640	16.35	16.70	18.41
41.729	16.00	16.72	18.45
41.864	16.25	16.75	18.50
41.962	16.30	16.77	18.54
42.066	16.25	16.79	18.58
42.183	16.11	16.81	18.63
42.258	16.05	16.82	18.65

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
42.359	15.95	16.84	18.69
42.467	16.00	16.87	18.74
42.566	16.05	16.89	18.78
42.668	16.10	16.91	18.82
42.767	15.95	16.92	18.86
42.865	15.85	16.94	18.90
42.964	15.90	16.96	18.93
43.065	15.95	16.98	18.97
43.168	16.10	17.00	19.01
43.270	15.05	17.02	19.05
43.371	15.75	17.04	19.10
43.476	15.70	17.06	19.14
43.534	15.84	17.07	19.16
43.561	15.90	17.08	19.17
43.633	15.80	17.09	19.20
43.721	15.85	17.11	19.23
43.820	15.95	17.13	19.27
43.953	16.20	17.16	19.32
44.034	16.45	17.17	19.36
44.125	16.65	17.19	19.39
44.244	16.80	17.21	19.44
44.346	16.85	17.23	19.48
44.456	16.93	17.26	19.52
44.570	17.05	17.28	19.57
44.660	17.20	17.30	19.60
44.754	17.15	17.31	19.64
44.761	17.20	17.32	19.64
44.854	17.15	17.33	19.68
44.954	17.05	17.35	19.72
45.054	17.20	17.37	19.76
45.153	17.25	17.39	19.90
45.253	16.98	17.41	20.05
45.282	16.82	17.42	20.09
45.354	16.90	17.43	20.20
45.453	16.92	17.45	20.34
45.546	16.98	17.47	20.47
45.638	17.00	17.49	20.61
45.720	17.22	17.50	20.73
45.803	17.35	17.52	20.85

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
45.831	17.30	17.53	20.89
45.896	17.32	17.54	20.98
45.980	17.45	17.55	21.10
46.034	17.52	17.56	21.18
46.119	17.90	17.58	21.30
46.168	18.22	17.59	21.38
46.230	18.35	17.60	21.47
46.308	18.94	17.62	21.58
46.354	19.50	17.63	21.65
46.413	19.82	17.64	21.73
46.487	20.05	17.65	21.84
46.531	20.36	17.66	21.90
46.575	20.21	17.67	21.97
46.631	20.15	17.68	22.05
46.772	20.45	17.71	22.25
46.934	20.82	17.74	22.49
47.039	20.96	17.76	22.64
47.150	21.00	17.78	22.80
47.179	21.04	17.79	22.84
47.244	21.45	17.80	22.94
47.343	21.56	17.82	23.08
47.444	21.62	17.84	23.23
47.536	21.75	17.86	23.36
47.629	21.92	17.88	23.49
47.723	21.86	17.90	23.63
47.816	21.74	17.91	23.76
47.909	21.96	17.93	23.90
48.001	22.03	17.95	24.03
48.059	22.32	17.96	24.12
48.154	22.41	17.98	24.26
48.243	22.55	18.00	24.38
48.254	22.50	18.00	24.40
48.254	22.50	23.00	25.40
48.374	22.12	23.05	25.52
48.519	21.75	23.10	25.67
48.586	21.33	23.13	25.74
48.651	21.54	23.15	25.80
48.751	21.75	23.19	25.90
48.903	21.96	23.25	26.06

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
49.017	22.21	23.29	26.17
49.112	22.45	23.33	26.27
49.235	22.76	23.38	26.39
49.385	23.10	23.44	26.54
49.495	23.65	23.48	26.65
49.557	23.87	23.50	26.72
49.627	23.96	23.53	26.79
49.760	24.01	23.58	26.92
49.862	24.09	23.62	27.02
49.963	25.01	23.66	27.13
50.063	24.86	23.70	27.23
50.158	24.92	23.73	27.32
50.278	24.88	23.78	27.44
50.333	24.97	23.80	27.50
50.333	24.97	26.00	27.50
50.376	24.95	26.00	28.50
50.476	24.91	26.01	28.50
50.576	25.10	26.01	28.51
50.676	25.16	26.02	28.51
50.777	25.18	26.02	28.52
50.877	25.21	26.03	28.52
50.920	25.13	26.03	28.52
50.977	25.20	26.03	28.53
51.076	25.25	26.04	28.53
51.176	25.36	26.04	28.53
51.275	25.46	26.05	28.54
51.374	25.59	26.05	28.54
51.473	25.78	26.06	28.55
51.579	25.49	26.06	28.55
51.679	25.68	26.07	28.55
51.757	25.61	26.07	28.56
51.779	25.62	26.07	28.56
51.878	25.68	26.08	28.56
51.988	25.78	26.08	28.57
52.088	25.88	26.09	28.57
52.151	25.96	26.09	28.57
52.190	25.91	26.09	28.58
52.277	25.88	26.10	28.58
52.368	25.61	26.10	28.58

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
52.444	25.59	26.11	28.59
52.534	25.68	26.11	28.59
52.632	25.77	26.11	28.59
52.736	25.61	26.12	28.60
52.833	25.65	26.12	28.60
52.840	25.61	26.13	28.60
52.935	25.88	26.13	28.61
53.034	26.05	26.14	28.61
53.133	26.12	26.14	28.62
53.231	26.26	26.14	28.62
53.315	26.43	26.15	28.62
53.331	26.25	26.15	28.62
53.431	26.91	26.15	28.63
53.530	26.80	26.16	28.63
53.630	26.78	26.16	28.64
53.731	26.31	26.17	28.64
53.831	26.08	26.17	28.64
53.936	26.05	26.18	28.65
53.987	25.96	26.18	28.65
54.046	25.91	26.19	28.65
54.146	25.88	26.19	28.66
54.246	25.86	26.20	28.66
54.270	25.99	26.20	28.66
54.345	25.84	26.20	28.67
54.353	25.77	26.20	28.67
54.445	25.98	26.21	28.67
54.545	25.83	26.21	28.67
54.647	25.81	26.22	28.68
54.746	25.74	26.22	28.68
54.840	25.59	26.23	28.69
54.846	25.69	26.23	28.69
54.946	25.73	26.23	28.69
55.045	25.98	26.24	28.69
55.103	26.45	26.24	28.70
55.145	26.32	26.24	28.70
55.246	26.05	26.25	28.70
55.346	25.88	26.25	28.71
55.436	25.80	26.26	28.71
55.444	25.86	26.26	28.71

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
55.544	25.73	26.26	28.72
55.644	25.63	26.27	28.72
55.718	25.56	26.27	28.72
55.718	26.50	26.27	28.72
55.744	26.21	26.27	28.72
55.844	26.18	26.28	28.73
55.946	26.09	26.28	28.73
55.986	25.92	26.28	28.73
56.042	25.83	26.29	28.74
56.153	25.74	26.29	28.74
56.250	25.86	26.30	28.75
56.348	25.91	26.30	28.75
56.448	26.05	26.31	28.75
56.548	26.13	26.31	28.76
56.642	26.22	26.32	28.76
56.647	26.29	26.32	28.76
56.747	26.35	26.32	28.77
56.847	26.42	26.33	28.77
56.948	26.51	26.33	28.77
56.984	26.57	26.33	28.78
57.048	26.61	26.34	28.78
57.145	26.68	26.34	28.78
57.219	26.64	26.34	28.79
57.246	26.61	26.35	28.79
57.340	26.52	26.35	28.79
57.434	26.59	26.36	28.79
57.531	26.68	26.36	28.80
57.621	26.82	26.36	28.80
57.737	26.74	26.37	28.81
57.829	26.79	26.37	28.81
57.942	26.68	26.38	28.82
58.044	26.61	26.39	28.82
58.055	26.56	26.39	28.82
58.144	26.26	26.39	28.82
58.244	26.05	26.40	28.83
58.342	25.74	26.40	28.83
58.427	25.25	26.40	28.84
58.442	25.18	26.41	28.84
58.541	25.21	26.41	28.84

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
58.637	25.26	26.42	28.84
58.647	25.23	26.42	28.85
58.691	25.28	26.42	28.85
58.725	25.32	26.42	28.85
58.777	25.45	26.42	28.85
58.872	25.56	26.43	28.85
58.986	25.78	26.43	28.86
59.083	25.88	26.44	28.86
59.178	26.00	26.44	28.87
59.280	25.88	26.45	28.87
59.346	25.82	26.45	28.87
59.383	25.62	26.45	28.88
59.475	25.73	26.46	28.88
59.565	25.66	26.46	28.88
59.652	25.57	26.47	28.89
59.748	25.51	26.47	28.89
59.820	25.59	26.47	28.89
59.853	25.45	26.48	28.90
59.925	25.39	26.48	28.90
60.040	25.31	26.49	28.90
60.142	25.23	26.49	28.91
60.152	25.14	26.49	28.91
60.243	25.22	26.50	28.91
60.344	25.48	26.50	28.92
60.444	25.69	26.51	28.92
60.445	25.83	26.51	28.92
60.546	25.68	26.51	28.92
60.648	25.26	26.52	28.93
60.668	24.97	26.52	28.93
60.746	25.36	26.52	28.93
60.878	25.56	26.53	28.94
60.932	25.88	26.53	28.94
61.053	26.05	26.54	28.95
61.157	25.75	26.54	28.95
61.254	25.36	26.55	28.95
61.355	25.06	26.55	28.96
61.459	24.85	26.56	28.96
61.571	24.68	26.56	28.97
61.639	24.54	26.57	28.97

Chainage (km)	River Bed Level w.r.t MSL (m)	Adopted C.D. w.r.t MSL (m)	H.F.L. w.r.t MSL (m)
61.673	24.65	26.57	28.97
61.766	24.88	26.57	28.98
61.860	24.98	26.58	28.98
61.863	25.03	26.58	28.98
61.965	25.23	26.58	28.98
62.074	25.36	26.59	28.99
62.175	25.48	26.59	28.99
62.248	25.34	26.60	29.00
62.300	25.23	26.60	29.00
62.307	25.30	26.60	29.00