CHAPTER 1

INTRODUCTION

1.1 PREAMBLE

Rivers constitute an important means of transport in Eastern India comprising of North Eastern States, West Bengal and parts of Bihar. India embarked upon a large programme of agricultural and industrial production which was resulted in substantial increase in the movement of cargo traffic. In addition to the above, the change in economic policy and rapid increase in industrialization during the past and present decade created huge impact on existing traffic movement by various modes. Due to the surge in road traffic, Govt. of India focussed attention in widening and relaying of National Highways including construction of major time bound projects such as Golden Quadrilateral and other express corridors. In similar fashion, dedicated rail corridors for the movement of goods by rail are in the implementation stage by the Government. Hence, it is evident that all modes of transport need to be developed and the vital role which rivers can play in meeting the ever increasing transport needs for a faster economy could not be ignored.

Water based transport is effective as generally speaking, operating costs of fuel are low and environmental pollution is lower than for corresponding volumes of movement by road, rail or air. A major advantage is that the main infrastructure "the waterway" – is often naturally available, which then has to be trained, maintained and upgraded. Transport over waterways is especially effective when the source and/or destination are waterfront locations.

The potential for this mode of transport has been unquestioned over the years and it forms a significant fraction of ton-km of movement in countries across the world. It is reported that Inland Water Transport (IWT) movement constitute 20% and 32% in Germany and Bangladesh respectively. However, it is noted that IWT plays a very marginal part (0.15%) in India. Inflation is one of the important problems which the country is facing today in which transport cost of commodities is an important factor. Numerous

studies have argued that Inland Waterways are per se a desirable and environmental friendly mode of transport.

IWT is being more energy efficient in comparison with other modes of transport which can help in reducing the transport cost and prices of commodities. For instance, it is observed that a litre of fuel can transport cargo 20 km by road, 80 km by rail and around 100 km by water. Thus, IWT is the least energy consuming and energy efficient mode of transportation in addition to many other inherent advantages. IWT generates more employment per unit of investment in comparison with other forms of transportation. Investments in this sector have not equalled those in rail in early years and road in more recent times, there are proposals for investing in this sector.

Keeping in mind the various advantages of inland waterways such as cost effectiveness, relative fuel efficiency and importance of mobility besides welfare and development of remote countries, a number of countries are now taking initiatives to make better use of the existing capacity and making investments in IWT. Several development projects aimed at enhancement of IWT infrastructure and operations are underway in Asia despite the recent declining trend in the usage of the region's inland waterways.

1.2 IWT IN INDIA

Asia is generously endowed with navigable inland waterways. These waterways can play a vital role in the economic development and welfare of inhabitants of rural remote areas of this region by providing accessibility and transport at least cost.

Historically, at least on some geographical sectors, IWT has been a viable mode of freight transport. Currently, five major waterways in the country have been designated as National Waterways (NW). NW-1: Ganga-Bhagirathi-Hooghly system, NW-2: Brahmaputra system in Assam, NW-3: West Coast canal system in Kerala, NW-4: Godavari - Krishna rivers & Canals between Kakinada and Puduchery and NW-5 : Brahmani river & Mahanadi delta system along with East Coast Canal. Commercially, the most important sector is the small tidal riverine system in Goa comprising Zuari and Mandovi rivers and the Cumbarjua

canal. A number of possibilities do exist in terms of in-principle navigable waterways, but the ones that offer some potential (a mix of feasibility and some traffic possibilities) are the riverine inlets along the coast, especially the ones near ports and some of the canal systems as part of larger water resource development projects. A further possibility can conceivably open up if and when the river interlinking project in the country is found viable.

The transportation of goods in an organised form is confined to West Bengal, Assam, parts of North East region and Goa in India. The 7th Plan was an important landmark in the development of IWT. The expenditure on this sector in the plan was Rs. 131. 85 crores which were more than the expenditure incurred right up to the end of 6th plan. The following objectives were laid down in the 7th plan for development of IWT sector:

- Development of IWT in the regions where it enjoys natural advantage,
- Modernisation of vessels and country crafts to suit local conditions, and
- Improvement in the productivity of assets.

The Inland Waterway Authority has been set up which was a big step forward in helping the accelerated development of IWT. India has about 14,500 km of inland waterways network comprising of rivers, lakes and canals. A comprehensive look has been given for effective and targeted revival and development of the inland water transport as a system and conceptual projection was made in the Working Group Report for the 10th Plan suggesting a total investment of about Rs. 5665 crores from the budgetary support, raising of bonds by IWAI, private investments and external funding. However the approved plan outlay was Rs. 903 crores.

As per 11th Plan, about 45 million tons of cargo (2.5 BTKM) is being moved annually by IWT. Inland Waterways Authority of India (IWAI) was constituted in 1986 for the development and regulation of inland waterways for shipping and navigation. However, most waterways suffer from navigational inadequacies such as shallow waters, narrow width, siltation, and bank erosion. Consequently, its operations are currently restricted to

about 5200 km of major rivers and 485 km of canals suitable for mechanized craft operations. At present, organized cargo transportation is spread over the Ganga River in NW-1, the Brahmaputra River in NW-2 West Coast Canal in NW-3, and Goa and Mumbai waterways. The States covered are Uttar Pradesh, Bihar, Jharkhand, and West Bengal under NW-1; Assam under NW-2; and Kerala under NW-3. A number of private operators provide their services in all the above NWs whereas the public sector Central Inland Water Transport Corporation operates on NWs 1 and 2.

With global economy and the WTO regime, there would be greater movement of goods to and fro. This had created a heavy pressure on the already burdened road and rail transport systems. There is limit for expansion of rail and road capacity on account of constraints available land, high cost and environmental factors. In these conditions, IWT can play a supportive role for rail and road movement. The cost effectiveness of IWT can be addressed from the fact that the development of 1 km of highway costs around 7 crores whereas the same amount may be sufficient to develop around 50 km of waterways. There are some hazardous commodities and Over Dimensional Cargo (ODC) which can not be allowed to be transported on road. In view of the above constraints, the development of IWT has been relevant in today's context.

In view of the thrust given to IWT mode as explained above, IWAI has proposed to take up the study to prepare Detail Project Report for development of Lakhipur – Bhanga stretch of Barak River for Shipping and Navigation as per the scope of work elaborated in the subsequent section.

1.2.1 Early IWT History Developments in Assam

The first voyage to Assam was made by the vehicle *Lucknow,* under Captain Fox, which left Calcutta on *16th September in 1860.* Tea was in fact indigenous in Cachar, but it was only brought to notice in 1855. In 1863 the India General (IG) therefore dispatched the *Agra* on a voyage to Cachar. The Assam pioneers included three members of that family George Williamson senior, George Williamson junior, Capt. J. H. Williamson and Capt. Williamson. But in 1862 Capt. Williamson left IG and formed a rival concern, the *New Rivers Company.*

On 5th October 1864 Calcutta was stricken by a cyclone of unpredicted violence, most of the sailing vessels in port began hurriedly to take in all unnecessary canvas and batten down hatches. There were 192 vessels excluding boats, at the time in port and most of them were stranded and wrecked. Fortunately for the India General (IG), few of its vessels were in Calcutta at the time and it suffered very little loss. The *Oriental Steam Navigation Company* and the *Commercial Navigation Company* went out of business at once. The *Bengal Rivers Company* got amalgamated with IG. In *1867,* IG acquired 4 steamers, 9 flats and 2 hospital ships and at the same time the Ganges Company found itself in financial difficulties and ceased to operate by selling 3 steamers and 2 flats to IG. The only company now remaining is *RS Company* as a competitor to IG. In *1869* the fleet of the IG consisted of 16 steamers, and 32 flats. But before that in *1864* Capt. C. J. Scott had become the Secretary.

The withdrawal of the navigation from Allahabad route was because of two factors, The East Indian Railway *(1864)* and the level of river in the dry season had fallen sufficiently to make navigation difficult.

By the year *1873,* the normal route for passengers to Assam or East Bengal from Calcutta was by train to Goalundo and then by steamer. Capt. Scott was a man of great energy and spirit of enterprise and in *1870*, with the support of the Directors; he sought to obtain a subsidy from the chief Commissioner of Burma for the establishment of a service on the Irrawadi. After a long time Williamson left the RS Co. and in *1873* an equally

important change took place in the management of the IG. Up to that date the company had been managed by its directors and the Commander-Secretary, but in that year management was entrusted to a Calcutta firm *Schoene, Kilburn and Co.,*

Developments made increasing demands on dockyard facilities and in *1879* the IG took a lease of a plot of land three miles down the river from Garden Reach, known as Raja Bagan. In *1879* RSN also began to augment its fleet and became a potentially serious rival to the IG, but a more immediate threat came from the Eastern Bengal Railway Company's flotilla which conveyed goods from the East Bengal jute districts. In *1879* two river companies petitioned parliament against the competition by public enterprise but before any action was taken in *1880* the flotilla was withdrawn from Cachar.

- **Competition and Cooperation**

By *1880* the RSN had increased its fleet to a level which enabled it to compete on equal terms with the IG Company and the story of the next decade is one of the fluctuating relations between the two companies. In *1874* Assam was separated from Bengal and became a Chief Commissionership. The Assam Government was thus in a stronger position to exert pressure and in *1880* it threatened to put on its own steamers for this service. But IG resisted this pressure where RSN grasped the opportunity and entered into a contract by which it undertook to establish a fast daily 'single-handed'. In *1883* two river companies came to *"Joint Purse Agreement"*

Outside competition came from the *Assam Railways* and *Trading Company*. The Government of Assam agreed to make a subvention to such a project and in *1879* a proposal to form the Assam Railways Company was mooted. In *1880* Benjamin Piercy a railway engineer in England took interest in it and by *1884* the line to the coal fields was completed. The carrying capacity of RSN and IG would be inadequate. *Assam Railways* and *Trading Company* decided to have their own fleet which could also be used for the transport of tea chests from Dibrugarh to Calcutta. In 1887 the *RSN Company* purchased the fleet and the *AR and T Company* withdrew from the river. The IG declined to participate in the purchase. In *1882* negotiations between the EB Railway and the IG resulted in what was known as the Combined Service Agreement.

Increased fleets naturally required a corresponding expansion of dockyard facilities and in *1859* the IG was able to extend it by buying adjacent premises belonging to the Bengal Coal Company. RSN also made a change in its dockyard arrangements. In *1865* one David Ezra had sold to William Mackinnon a site at Garden Reach – a locality in which wealthy European merchants of Calcutta had their weekend villas. In *1889* an agreement provided first that on all services the Companies should have equal fleet and equal profits. The Joint Steamer Companies and agreement between them was fully honoured. IG Company constructed its first stern wheeler, the *Nemotha,* built by John King and Co. in 1888. IG repurchased a fleet for half a sale price which it had sold to the *Irrawaddy Flotilla Company* a year before. There was also the fact that reduced coal consumption and the use of flats carrying larger cargoes at the same draft of water as those of *1864*, had modified the economic factors which had led to the closure of the Ganges service. In *1897* its fleet of about 12 steamers and launches was purchased by the Joint Companies and in *1897* they opened a mail service between *Narayanganj, Chandpur, Barisal* and *Khulna* via the *Kaleegunga* and *Madhumatee*. The Joint Purse Agreement which in *1889* had applied only to main line and dispatch services. At the end of the century the whole constitution of the IG was taken under control of London.

Throughout 19th century, transport infrastructure of the Sylhet District (in Bangladesh) including Karimganj remained underdeveloped. As a result, trade flowed mainly through waterways. Barak and its tributaries having links with the major rivers of Bengal played the dominant role in transporting goods to Sylhet, Habiganj and Nabiganj (the last two were important trade marts on the Kushiara branch of River Barak) and then to other parts of Bengal. The steamers of the Eastern Bengal Railway Company used to ply at frequent intervals between Goalandoi and Cachar. Initially, commodities were transported from Lakhipur to Karimganj by country boat, then from Karimganj to Sylhet. There were transit ghats for loading and unloading the goods and passengers on the river banks. Bhairab Bazar, on the bank of river Meghna, was an important transit point for Barak-Surma region and Bengal trade. In fact during 1880-1890 river borne trade of Assam amounted to 50.1 per cent of her total imports from and 63.9 per cent of her total exports to Bengal. Forty vessels from five to six hundred tons load each were exported annually from Bengal to Assam, mainly with salt, betel and tobacco. The major import items were

silk, muga, ivory and timber. This vibrant river borne trade gradually gave way to railways in early 20th century.

The multi-modal connectivity of Karimganj with Sylhet remained in place even after the partition of the country. The Indo-Bangladesh waterways via Karimganj district remained operational till the Indo-Pakistan war of 1965. With the sealing of border following the war, the volume of trade via waterways had declined. With the emergence of Bangladesh, the cross border riverine trade was revived. Karimganj Inland Waterway Terminal (IWT) was constructed in the late 1980's by the Central Inland Water Transport Corporation of India. Since, July 1999, it is being used throughout the year. Ferry service from Karimganj is now an important channel for the export of coal and other tradable commodities to Bangladesh.

Hence, IWT operation to North East was started long back and considered to be the backbone of transportation of men and material to Bengal regions.

1.3 SCOPE OF WORK

Based on the above observation, the following scope of work has been proposed by IWAI:

(1) To study/analyse (a) the Techno Economic Feasibility Study (TEFS) report prepared by RITES in January, 1999; and (b) the hydrographic survey charts prepared by IWAI during 1991 of this waterway.

(2) To collect and study/ analyze the available data/ reports for the past 20 years regarding water level, discharge, velocity, bed and bank material, topographic data etc. of Barak River from Tipaimukh dam site to Karimganj from various sources like Central Water Commission (CWC), Brahmaputra Board, concerned State Departments, National Remote Sensing Agency, Survey of India, Tipaimukh Dam Authorities etc.

(3) To conduct Thalweg Survey (longitudinal hydrographic survey along deepest part of navigation channel) from Tipaimikh dam site to Karimganj stretch of the river during low water season (Jan/Feb), prepare the Thalweg charts in 1: 50,000 scale

and identify the shoals (shallow areas) for 1.6 m, 2 m and 2.5 m depth below chart datum.

(4) To undertake cross-section surveys from bank to bank (up to normal HFL) at 500 m interval in the river stretch between Lakhipur and Bhanga during lean water season (Jan/Feb) and prepare survey charts in 1:5,000 scale.

(5) To assess the discharge requirement for Least Available Depths (LAD) of 1.6 m, 2 m and 2.5 m below chart datum and availability of water for navigation during pre and post Tipaimukh dam scenario. Give a separate chapter/section on this in the report.

(6) To study the cargo potential for IWT mode through this waterway based on TEFS Report – 1991 of RITES and to update it by conducting traffic O-D surveys as required and give in detail the cargo that can be divertible to IWT mode upon development of the waterway. Also provide traffic projections for time horizons of 5, 10 & 15 years. Give the origin and destination of each identified cargo along with basis/source.

(7) Based on the data of river characteristics collected as per item (iii) above, sufficient details as per the following may be provided:

A. <u>Waterway development</u>

a) Optimum dimension of the navigation channel which can be developed by undertaking river conservancy work (dredging, bandalling), river training, bank protection etc. Specifically give the requirement of dredging and bandalling (with details of calculation) to provide and maintain navigation channel with LAD of 1.6 m, 2.0 m and 2.5 m all-round the year including details such as disposal of dredged material etc.

b) Suggest the proposed Class of waterway in reference to IWAI (classification of inland waterways in India) Regulation 2006, for horizontal and vertical clearances for the cross structures such as bridges, cables etc.

c) Collect data & study the existing rail bridges, road bridges, foot bridges, power cables etc crossing the river between Lakhipur and Karimganj and recommend measures required to permit uninterrupted navigation along the river.

B. IWT terminals

a) Based on the cargo potential and other considerations necessary for locating an IWT terminal, provide extent of requirement of land for setting up of IWT terminals at Silchar and Lakhipur. Study viable alternate sites for the same and suggest two specific alternative sites for each, assigning first and second priorities. Collect details of land ownership etc and give the same in the report with source and supporting documents. Carryout preliminary topographic survey and give layout of plan for all suggested locations clearly indicating all facilities e.g jetty, approach to jetty, bank protection, covered and open storage, roads, office, sentry hut, boundary wall, bank protection, bunkering facility, water facility, turning circle for IWT vessels location of depth contours of 2m and 2.5m in the river near the terminal sites etc.

b) Study the provision of such requirements at existing terminals at Badarpur and Karimganj, and suggest further improvement required.

c) Provide preliminary engineering design, and drawings for setting up of terminals with related facilities including mechanical loading/ unloading at Silchar and Lakhipur and augmentation/ improvement of existing facilities at Badarpur and Karimganj. Also indicate the inter modal cargo transfer facilities required at these terminals.

C. Navigation aids

a) Suggest in sufficient details, requirement of 24 hrs navigation facilities including day marks, buoys with lights, lights on masts at banks, DGPS stations, buoy laying vessels, rescue vessel etc., along with their dimensions/drawings and numbers with justification.

b) Suggest types of communication facilities required on the cargo vessels etc

D. Cargo vessels

a) Suggest economical size of cargo vessels for the cargo as assessed under item 3. Work out details of the type of vessels, their number and cost. While suggesting the design vessel, the requirement of transit through Bangladesh, particularly depth/ width availability in the Protocol routes, seasonality of movement etc., are to be carefully considered.

b) It may be noted that cost of cargo vessels need not be included in the cost of development of the waterway since it shall be assumed that the cargo vessels shall be owned and operated by the private sector based on demand to be created by developing the waterway as proposed in the DPR.

E. Other facilities

a) Suggest in adequate details, other required infrastructural facilities such as repair facilities, fuel and fresh water bunkering, channel patrol, security, enforcement of rules and regulations, pilotage, issue of navigation notices, navigation charts, warnings, rescue and salvage, pollution control measures etc.

(8) To prepare preliminary engineering designs, the data about soil characteristics shall be collected from the local sources based on the structures constructed nearby. In addition, wherever required, consultant may obtain soil data through trial pits/plate load test etc and preliminary design shall be based thereon.

(9) To assess the environmental impacts due to these development works and suggest suitable environmental management plan (EMP) to mitigate the adverse impacts, if any, including its cost. Only rapid EIA/EMP study is envisaged for which one season data shall be sufficient. However, all necessary information should be given in the report to enable IWAI to approach concerned authorities for getting environmental clearance for undertaking the works proposed in the DPR, if so required.

(10) To prepare cost estimates for the entire proposed infrastructure, including

mechanical handling, and other allied facilities with proper justification that the suggested solution is the optimum one.

(11) To provide estimated cost of annual recurring/maintenance works with sufficient basis/justification.

(12) To prepare detailed time schedule for the whole project indicating the time requirement of the various components of the project from inception till commissioning. Suggestion shall also be given for executing the project in different phases with spilt up of the works and the costs thereto, cargo potential and EIRR/FIRR for each phase independently.

(13) To study and recommend necessary organizational structure and manpower required for execution of the project and its maintenance thereafter.

(14) To study the existing freight and tariff structure for rail, road and IWT mode and recommend a suitable freight structure for IWT together with its basis and subsidies, if any, that may be necessary in the initial years.

(15) Suggest user charges for using the waterway, terminals and other infrastructural facilities, which can be levied by IWAI on the operators/users without adversely affecting the commercial viability of IWT operations.

(16) Suggest short and long-term measures, which will attract shippers to the IWT mode on a continuing basis, including identification of industries that are / could be located on banks.

(17) Workout Economic Internal Rate of Return (EIRR) considering the employment generation, , fuel saving, saving in noise pollution and accidents, carbon credit which can be earned, savings in repair and maintenance of roads, saving in land acquisition etc compared to road and railways for the projected traffic potential by IWT mode. Detailed working sheets should be given for this.

(18) Workout Financial Internal Rate of Return (FIRR) for the following options:

a) For the operators – Considering the rate they can charge for transportation of the goods by inland vessels and the user charge they shall pay to the IWAI.

b) For the IWAI - Based on user charges proposed to be levied by IWAI from the operators for use of waterway, terminal etc.

c) To prepare the DPR covering all the above items and submit 15 copies.

CHAPTER 2

DETAILS OF STUDY AREA AND SITUATIONAL ANALYSIS

2.1 INTRODUCTION

East India has many large and small rivers providing facilities for water transport especially in its plain parts and in flat river valleys of the large rivers in hills. From the ancient period until the roads were constructed, the rivers of Brahmaputra and Barak plains were commonly used as the mode of transportation of goods and passengers. During the British period, Brahmaputra river and Barak- Surma – Kushiyara - Meghna river systems were extensively used for transport and trade between North-East (NE) India and Kolkatta port. These rivers became important carriers of trade with the growth of tea industry.

It is estimated that NE region has about 1800 km of river routes that can be used by streamers and large country boats. The inland water transport departments of both the state and central governments have been trying to improve the water transport system in the region. The river Brahmaputra has several small river ports like Sadiya, Dibrugarh, Disangmukh, Neamati, Tezpur, Pandu-Guwahati, Jogighopa and Dhubri. There are more than thirty pairs of ferry-ghats on river Brahmaputra transporting men and material besides the above river ports. The River Barak has also small ports at Karimganj and Badarpur along with ferry services at several places.

Besides, the major tributaries of Brahmaputra namely Lohit, Dhansiri and Subansiri, rivers of Tripura namely Gumti and Haora, Tizu river in Nagaland, Kolodyne river in Mizoram etc., are having good navigation potential. These rivers can be developed for better utilization of both cargo and passenger transportation.

2.2 PRESENT TRANSPORT NETWORK

North Eastern region of India comprises of seven states viz., Assam, Meghalaya, Manipur, Tripura, Nagaland, Arunachal Pradesh and Mizoram as shown in Figure 2.1. This region is connected by land with the rest of India through West Bengal. The surface transport system for movement of cargo/passengers to and from the NE states consists of road, rail and waterways. As far as cargo movement is concerned, most of the cargo originates from Kolkata and terminates at Guwahati and vice-versa. From Guwahati, the cargo gets distributed to various destinations of NE states. The transport links to states particularly Mizoram, Tripura, Manipur and Nagaland are affected many times by floods, landslides, blockages of roads and local agitations.

Figure 2.1 North East Region States

2.2.1 RAILWAYS

Railway Transport in NE India has a traditional history. The construction of railway line in Assam started during 1881 – 84 and yet the railway network in this region is not well developed. At present about 2500 km of railway network is available accounting for a density of 9 km of track per 1000 km^2 of area. Only 1376 km of railway line are broad gauge out of 2500 km and other remaining meter gauge tracks. As stated above, railway line laying was started in the eastern part of Brahmaputra valley in the early 1880 by then British Government and Companies. They constructed railway lines connecting tea, coal, oil and timber producing areas with river ports on Brahmaputra and Barak River. The first railway line was constructed between Dibrugarh – Sadia during 1882 – 1884 connecting tea, timber, coal and oil producing areas of the present Tinsukia district with the river port of Dibrugarh. This was followed by Jorhat provincial railway in 1885.

It was 1895 that the region was first linked with outside by constructing a line from Eastern Bengal (presently Bangladesh) to Badarpur in Barak Valley. The railway line from Guwahati to Lumding began construction in 1897 and Dhubri was linked with Calcutta in 1902. The hill section of railway linking Lumding of the Brahmaputra valley with Badarpur of Barak valley across hill ranges of the North Cachar Hills district was constructed in 1903 through 37 number of tunnels with a length of 519 km.

Upper Assam was linked with Eastern Bengal with the completion of track between Tinsukia and Lumding during 1904. Thus, it is seen that most of railway lines that are found today in NE India were laid down 50 years back through Brahmaputra and Barak valley. After Bangladesh partition, Assam link railway line was constructed via Siliguri station of West Bengal with an establishment of Northeast Frontier Railways.

2.2.2 ROADWAYS

Roadways are most important than others in NE India because they can reach even isolated villages over the hills. In NE States, Assam has the longest length of roads in terms of km. The total distance of all roads in Assam (including NH, PWD and other roads) is 40,342 km. The length of National Highway is 2841 km. As per Statistical Handbook of Assam (2010), the road length per 100 km^2 of Assam's geographical area works out to 51. In the Barak valley, the road system was earlier linked with Sylhet district (in Bangladesh). But the partition of India adversely affected the transport and communication system of Assam. National Highway 44 connects Agartala, Karimganj and Badarpur with Shillong via Jowai. National Highway 53 links Silchar with Lakhipur and Jiribam in Manipur. The following table 2.1 projects the National Highways connecting different places in PIA.

Table 2.1 National Highway Connecting PIA

Sl. No.	National Highway	From	To	Distance	Passing thro'
1	44	Shillong	Agartala	495 km	Badarpur and Karimganj
2	53	Badarpur	Imphal	320 km	Silchar, Lakhipur and Jiribam
3	54	Silchar	Tuipang	560	Aizwal, Silchar.

2.3 EXISTING WATERWAY NETWORK

Two waterway routes exist connecting NE state of Assam through the waterways in Bangladesh as shown in Figure 2.2. Navigation through Bangladesh is governed by the Protocol Agreement between India and Bangladesh. The first route is from Kolkata to Guwahati (1439 km.) through River Brahmaputra and the second route is between Kolkata and Karimganj (1233 km.) through River Kushiyara & Barak.

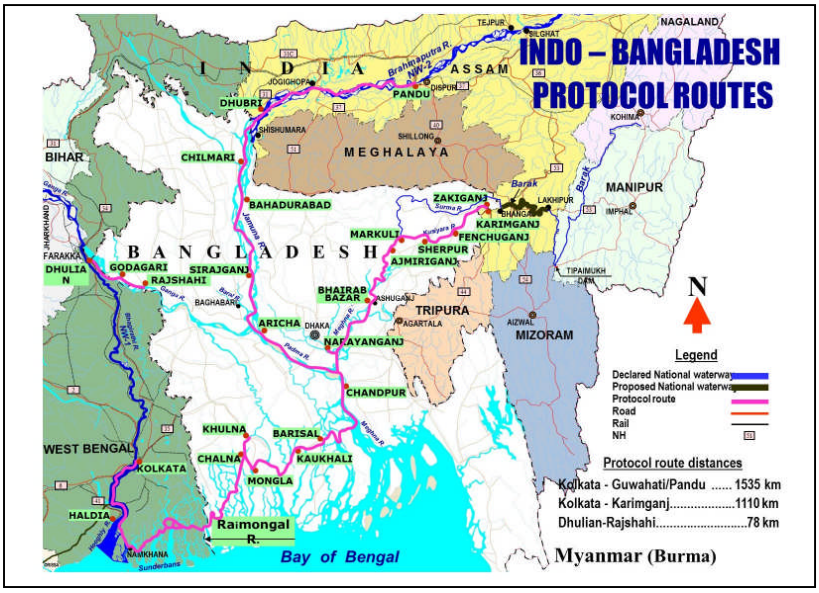


Figure 2.2 Indo – Bangladesh Protocol Routes

2.4 BARAK RIVER SYSTEM

Barak river system is the second largest river system in the North Eastern Region. It originates from south of Kohima in Nagaland near Nagaland - Manipur Border. After traversing through Nagaland, Manipur and Assam, it splits at Bhanga into two streams called Surma and Kushiyara. There two streams rejoin at Markuli in Bangladesh and thereafter the river is called Meghna. Barak - Meghna river system has a total length of 900 km (origin to upstream Chandpur in Bangladesh). Out of this, 524 km is in India, 31 km on Indo- Bangladesh Border and the rest is in Bangladesh. Out of 524 km in India, 403 km u/s of Lakhipur is in the hilly terrain and is not navigable. Thus the navigable portion of Barak River in India remains only 121 km as shown in Figure 2.3.

The Barak River had been used as a waterway route for North- East Region since long time. Regular cargo transportation between Kolkata / Haldia ports in West Bengal and Karimganj/Badarpur terminals on Barak river in Assam used to take place till eighties and ninetees. Even now some barges do ply in this route. The Kolkata- Karimganj route is already a part of the Indo- Bangladesh Protocol on Inland Water Transport transit and trade.

Barak River (Lakhipur - Bhanga) lies entirely in the State of Assam, the development of Inland Water Transport (IWT) mode on this stretch will also serve the transportation needs of Manipur, Mizoram and Tripura. The National Highway-53 connects Lakhipur and Imphal, while NH-54 connects it with Aizwal and NH-44 connects Karimganj and Agartala. Thus, development of river Barak shall provide an alternate connectivity to these states with rest of India. At the moment, transport service in these States is rendered mainly by road and rail. The goods are transported with extreme difficulty/ delay due to traffic congestion and longer routes. The waterway has a distance advantage over rail and road modes. Thus, development of the navigable stretch of Barak River shall therefore provide vital alternate mode of transport to the region. It shall also provide port connectivity to a vast area of north-east through the existing Indo-Bangladesh IWT & Trade Protocol Routes.

To assess the viability of navigation in the Karimganj - Lakhipur stretch of Barak river, IWAI had carried out hydrographic survey during 1991. Thereafter, a Techno-Economic Feasibility Study (TEFS) was also got conducted by IWAI through M/s RITES in 1998. TEF Study established the technical and commercial viability of navigation in the Lakhipur - Karimganj stretch of Barak River and suggested various details of development of fairway, terminal and navigational aids.

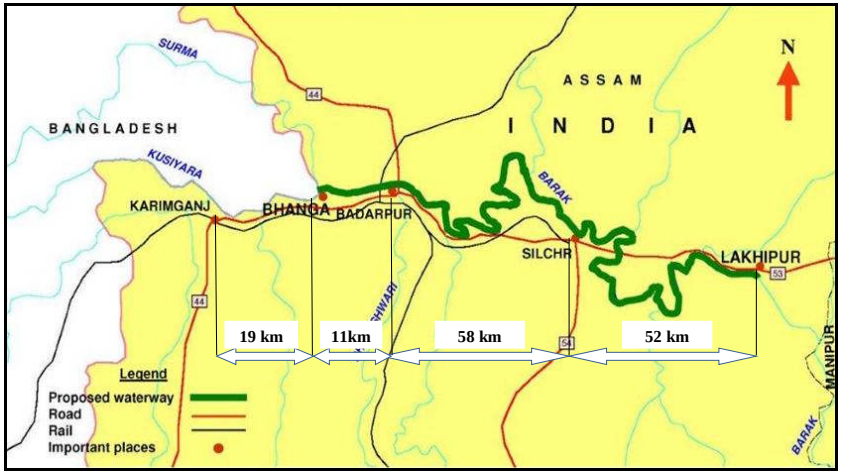


Figure 2.3 Baseline Map showing Barak River System in Assam (Distance by River flow Route)

Based on the TEFS report, a proposal to declare the Lakhipur - Karimganj (140 km) Stretch of river Barak in Assam as National Waterway was prepared and submitted to the Government of India for consideration by IWAI. However, it was decided that the stretch of Barak River between Karimganj and Bhanga was a common international boundary between India and Bangladesh, it will be desirable to consider the declaration proposal only for Lakhipur -Bhanga stretch of Barak river. The proposal to declare Lakhipur - Bhanga stretch as National Waterway is in active consideration of the Government.

Since TEF report was prepared about 12 year back (1999), many data might have undergone changes and it is not desirable that these may be used for execution of the project without updation. Therefore, for taking up the developmental works for declaration of the waterway as National Waterway, it becomes necessary to prepare a Detail Project Report (DPR). Accordingly, M/s Larsen & Toubro Limited has been entrusted by IWAI to prepare DPR for development of Lakhipur - Bhanga stretch of river Barak for shipping and navigation vide work order No. IWAI/PL-9(2)/BARAK-DPR/2010 dated 06.01.2011.

2.5 PRELIMINARY SURVEY IN THE STUDY AREA

After getting acquainted with the TOR, preliminary survey was carried out to familiarise with the actual field conditions. Consultant Team visited the study area from Tipaimikh to Karimganj and planned for carrying out Hydrographic including longitudinal section, Cross Section of Barak river and topographic survey for the proposed IWT terminals at Silchar and Lakhipur. Existing CIWTC Terminals at Badarpur and Karimganj were studied for proposing suitable improvements for loading and unloading of project cargo.

The present use of Barak River at Lakhipur for transportation of passenger and goods is shown in Figure 2.4. Present flow condition of Barak River upstream of Bhanga is shown in Figure 2.5 and IWT terminal presently available at Badarpur and Karimganj is shown in Figure 2.6 and 2.9.

Figure 2.4 View of Barak River at Fullertol Ferryghat, Lakhipur

Figure 2.5 View of Barak River upstream of Bhanga

Figure 2.6 View of IWT Terminal at Badarpur

Figure 2.7 View of CIWTC Terminal at Karimganj during Flood

Figure 2.8 View of Cargo Handling Yard & Covered Storage Shed in CIWTC Terminal at Karimganj

Figure 2.9 View of Gangway with Floating Pontoon arrangement in CIWTC Terminal at Karimganj during lean season flow

The existing infrastructure facilities available at Badarpur IWT Terminal maintained by CIWTC are shown in Figure 2.10 to 2.13.

Figure 2.10 View of Covered Shed at CIWTC Terminal at Badarpur

Figure 2.11 View of Covered Shed at CIWTC Terminal at Badarpur

Figure 2.12 View of Gangway Arrangement in CIWTC Terminal at Badarpur during Flood flow

Figure 2.13 View of Admin Building in CIWTC Terminal at Badarpur

2.5.1 G&D Site Locations

Table 2.2 shows the locations of water level measurement gauges installed and being measured by Central Water Commission. Figure 2.14 and 2.15 show the location of CWC gauging station at Lakhipur and Annapurna Ghat, Silchar.

Table 2.2 G&D Site Locations

S.No	G&D Site Location	Description of Landmark
1	Lakhipur	Situated at the river bank at the gauge site of Central water Commission near River Dale school, Lakhipur
2	Annapurna Ghat (A.P.Ghat)	On top of RCC pillar present in the entrance of Annapurna Mandir near Railway goods yard, Silchar
3	Badarpur Ghat (B.P.Ghat)	Situated on top of the protected masonary structure in front of CWC site office, Badarpur Ghat.

Figure 2.14 View of CWC Water level observation site at Lakhipur

Figure 2.14 View of CWC Water level observation site location at A.P. Ghat during Flood flow.

CHAPTER 3

DATA COLLECTION & HYDROGRAPHIC SURVEY

3.1 DATA COLLECTION

The following criterion was proposed for the data collection based on the review of TEFS and field visit in addition of Thalweg and cross section survey in Barak River:

- Thalweg survey in Barak River for the stretch between Tipaimikh and Karimganj with one sounding line along the deepest part of the river.
- Cross section survey at 500 m interval in Barak River for the stretch between Lakhipur and Bhanga.
- It was proposed to collect the hydraulic and hydrological data required for the identification of navigable waterway through CWC, Assam State Public Works/Irrigation/Water Resources Department, Tipaimikh dam authorities etc.
- Traffic studies including vessel/fleet analysis
- Preliminary design of Terminals at identified locations: Badarpur, Silchar and Lakhipur.
- Rapid EIA studies: Rapid EIA shall include the establishment of the Baseline Environment Status in terms of Water, Sediment, Air and Noise. The samples (Water, Air, Noise and Sediment) shall represent the entire area including the impact due to cargo handling, shipping and navigation, dredging, constructions etc.

3.2 SECONDARY DATA COLLECTION

The following secondary and primary data were proposed and collected from various Govt. Organisaitons/Departments as shown in Table 3.1.

Table 3.1 List of Secondary & Primary Data collected

SL. NO	DATA TYPE	SOURCE/AGENCY
1	Topographic information: cross-sections / longitudinal profiles / Thalwegs	Collected from IWAI
2	Water levels – historical data	CWC and Tipaimikh Dam authority. Request for providing Barak River basin has been submitted by Consultant and the same was rejected with an instruction to send the letter from IWAI. Hence, Chief Engineer, IWAI had written a letter with secrecy undertaking to Chief Engineer, CWC, Shillong during the month of July 2011 requesting hydrological and hydraulic data for Barak Basin. The decision for providing the Data by CWC is still pending with C.E., CWC, Shillong. Reminders have been sent through Director, IWAI, Guwahati office in this regard.
3	Water discharges – historical data (stage/discharge curves)	
4	Sediment data – samples of bed material and suspended material –	
5	Data pertaining to demographic particulars and local developments in study area	Collected from Govt. of Assam.
6	Goods Traffic flows by various transportation modes such as rail, road and IWT	Collected from various Govt. Agencies such as Railways, Dy. Director, Economics & Statistics, Silchar, CIWTC Terminal at Karimganj in Assam, West Bengal and other NE states
7	Sample O-D survey and data collection	Carried out with help from Addl. Deputy Commissioner, Cachar District, Govt. of Assam and other local agencies
8	Commodity wise statement of traffic including cement and coal movement etc.	Collected from various local agencies, trade unions and other Private organisations
9	Traffic flows to proposed IWT Terminals at Lakhipur, Silchar and Badarpur	Interacted with Local agencies/Deputy Commissioner, Cachar and Karimganj District authority.

3.2.1 Hydrological/Hydraulic Secondary Data Collection

Request for providing Water level, discharge, sedimentation observation, currentmeter observation, etc., at G&D Stations observed by concerned Subdivisions located at Lakhipur, AP Ghat and Badrapurghat of Megna Investigation Division, Central Water Commission, Shillong has been submitted to Chief Engineer, CWC, Shillong during the month of March 2011. Subsequently, CWC had informed the Consultant to request IWAI to send official request letter along with necessary secrecy undertaking during June 2011. As per the advice of CWC, Consultant requested Chief Engineer, IWAI to provide a letter for data request. The same has been submitted with CWC, Shillong in person through Representative from O/o The Director, IWAI, Guwahati during July 2011. Several reminders were also sent through IWAI, Guwahati office. The request submitted with CWC is still pending for providing required data. Otherway, Consultant team was able to get daily water level observation Gauging site at Lakhipur, AP Ghat and BP Ghat during the period 2006 to 2010.

Meanwhile, Consultant Team have made a requisition to O/o The Chief Engineer, Water Resources Department, Govt. of Assam for providing the above required data for carrying out basic water availability study. Due to the continuous persuasion of the Consultant Team, CE, WRD., Govt. of Assam has accorded his permission to provide the data during August 2011 upon submission of standard secrecy undertaking from the Consultant Side. The data was provided during first week of October 2011 by the Concerned Additional Chief Engineer, Cachar & Hills Water Resources, Water Resources Department, Govt. of Assam at Silchar has been used for analysis.

3.3 THALWEG AND CROSS SECTION SURVEY IN BARAK RIVER

Hydrographic survey was carried out in Barak River for the following three river stretches.

(i)	Tipaimikh to Lakhipur	98.6 Km
(ii)	Lakhipur to Bhanga	121.0 Km
(iii)	Bhanga to Karimganj	20 Km

Thalweg survey for the stretch between Tipaimikh and Karimganj with one sounding line along the deepest part of the river and Cross section survey at 500 m interval in Barak river for the stretch between Lakhipur and Bhanga was carried out. The details of the survey and vessel used for carried out the survey are briefly in the following sections:

The detailed hydrographic survey was conducted as per GIHS Specification with GPS Position fixing and with recording type Echosounder for sounding. The horizontal control was made from the charts generated from satellite imageries of the corresponding river stretches, suitably updated with prominent features from SOI Topo sheets. Suitable method of traversing was adopted wherever satellite imageries are not available and charts were updated. The vertical control was established with respect to sounding datum which was established at all gauge stations. Datum values were recorded with respect to MSL.

- Continuous sounding lines were run from bank to bank i.e., 0 m contour to 0 m contour up to normal HFL at 500 m interval from Lakhipur to Bhanga in river Barak (121 km) and survey charts were prepared in 1:5000 scale.

- Single line longitudinal survey for the river stretch from downstream of proposed Tipaimikh dam and Karimganj to identify the most suitable navigational channel. Thalweg chart in 1:50000 scale was prepared showing the contours of 1 m, 1.5 m and 2 m.
- Every shoal having less than 2m depth below chart datum, rocky outcrops etc, are indicated on the charts.
- Water level at the time of survey, river bank and shoals in the during the traversing were recorded.
- Benchmarks were established by engraving on prominent objects like bridges, culvert, nearby school etc., for future recovery. The same were connected by levelling and levels were estabilished with respect to MSL at 10 km interval. The accuracy of the levelling was corrected by connecting the levels to the Bench marks available enroute established by CWC and Water Resources/ IWT departments of Govt. of Assam.

- All prominent objects and features along the river stretches are fixed on the charts including existing rail bridges, road bridges foot bridges, power cables etc., which are crossing the river between Lakhipur and Karimganj.
- Horizontal and vertical dimensions with respect to HFL at all cross structures, power cables, telephone cables etc. were collected and indicated on the chart.
- Availability of berthing place if any and approach roads etc., were indicated on the charts.
- High bank lines are marked on the chart and permanent features up to 50 m distance from high water line were collected and indicated on the charts.
- Condition of the banks whether protected or unprotected are indicated on the chart.
- Topographic survey with 1m contour interval was carried out for the identified lands at Lakhipur, Silchar, Badarpur, & Karimganj for the proposed construction of IWT Terminals.

3.3.1 Conduct of Survey

One Hydrographic survey team under two number of Class I Hydrographic Surveyors and one land survey team under another Hydrographic surveyor were employed for conducting the field work.

3.3.2 Horizontal Control

Ground control was achieved by remote sensing techniques. Geo coded satellite imageries for the area to be surveyed was obtained from National remote sensing agency (NASA), Hyderabad by superimposing the satellite imageries on the SOI Topo sheet of the survey area on a scale 1:50000. The Layout of the river was digitised and the distortion was adjusted in accordance with real field data.

In the field, point to point measurement was done along the line of navigation and each cross section was related to prominent objects in the chart. Cross sections are taken

at 500 m interval apart. The linear measurements and position fixing were done by Global Positioning System. The width and cross section spot heights of existing waterway were observed by using Trimble 5600 Total station. The cross sections were guided by transit method using two flags.

3.3.3 Vertical Control

For determination of depth, Bathy 500 DF Echosounder was used. Sounding datum was established by simultaneous water level observations at sounding site and Central Water Commission Gauge station located at Lakhipur, A.P Ghat and Badarpur Ghat. The Chart Datum (CD) was found out by applying range corrections at the reference station of CWC.

3.3.4 Chart Datum

In case of a river, the bed profile along the length of river varies widely and depended on many factors like discharge, river width, bed slope, soil properties, bank bed etc. Therefore, low water line and bed profile do not maintain a constant relation along the length of the river but varies in different stretches. Thus chart datum strictly cannot be horizontal but will have to be sloped or stepped. Hence, the chart datum has been selected as slopped having different gradient in different stretches which roughly matching LWL above the bed profile.

3.3.5 Method Used For Finding Chart Datum

The lowest value of water level at the CWC stations was noted at CWC G&D stations during the survey. Taking into account of 95% occurrence, the chart datum of the reference CWC station adopted are:

Lakhipur	:	13.25 m above MSL
A.P Ghat	:	9.25 m above MSL
Badarpur Ghat:		7.00 m above MSL

Intermediate gauge stations were established at every 10 km interval. The water levels related to MSL were observed at these gauges during survey. CD value for intermediate stations was determined by interpolation technique. The difference in water level and the CD at the known gauge station were applied to the observed water level to obtain the local datum for sounding for that respective sub stretch applying respective reduction factor. Actual soundings were reduced by applying this factor and are presented in Table 3.2

Table 3.2 CD value for different gauge stations

Sl. No	Name of Station	Chainage from Lakhipur	Chart Datum (above MSL)
1	Lakhipur	0	13.25
2	Chirimukh	10	12.59
3	Nandpur	20	11.92
4	Dhamli	30	11.25
5	Badri Ghat	40	10.59
6	Sadar Ghat	50	9.92
7	A.P Ghat	60	9.25
8	Chandapur	70	8.80
9	Raypur	80	8.35
10	Ganigram	90	7.90
11	Kalinagar	100	7.45
12	Badarpur Ghat	110	7.00
13	Malua	120	6.55

3.4 ESTABLISHMENT OF TBM

Temporary Bench marks (TBM) were established throughout the river stretch along the high banks at an approximate interval of 10 km. These TBMs were connected to CWC Benchmark at Lakhipur from where the survey was commenced. The levelling done for connecting the TBMs were closed at available enroute CWC bench mark station and the closing error thus obtained was distributed stretch wise. The BM value observed at CWC Gauge site is presented in Table 3.3.

Table 3.3 List of CWC Gauging Site with BM Values

S.No	G&D Site Location	Description	Value(above MSL)
1	Lakhipur	Situated at the river bank at the gauge site of Central water Commission near River Dale school, Lakhipur	27.091
2	Annapurna Ghat (A.P.Ghat)	On top of RCC pillar present in the entrance of Annapurna Mandir near Railway goods yard, Silchar	21.565
3	Badarpur Ghat (B.P.Ghat)	Situated on top of the protected masonary structure in front of CWC site office, Badarpur Ghat.	18.340

3.4.1 Establishment of Water level Gauges

In addition to the three CWC gauges, ten gauges were erected in between Lakhipur and Bhanga. With respect to the datum values at three CWC gauges, the datum values of erected gauges were found out by simple interpolation technique. The observed readings taken during the survey are presented in Table 3.4.

Table 3.4 Observed Temporary Gauge Data

CHIRIMUKH (10 Km)					
Date	Time	Water Level	Date	Time	Water Level
04/05/2011	0700	15.41	05/05/2011	0700	1561
	0800	15.41		0800	15.61
	0900	15.42		0900	15.61
	1000	15.42		1000	15.61
	1100	15.43		1100	15.62
	1200	15.43		1200	15.62
	1300	15.44		1300	15.62
	1400	15.44		1400	15.61
	1500	15.45		1500	15.61
	1600	15.46		1600	15.60
	1700	15.47		1700	15.60
	1800	15.48		1800	15.60

NANDPUR(20)			DHAMLI(30)		
Date	Time	Water Level	Date	Time	Water Level
06/05/2011	0700	13.38	07/05/2011	0700	12.72
	0800	13.38		0800	12.72
	0900	13.37		0900	12.72
	1000	13.37		1000	12.71
	1100	13.35		1100	12.71
	1200	13.33		1200	12.71
	1300	13.30		1300	12.71
	1400	13.29		1400	12.71
	1500	13.29		1500	12.71
	1600	13.28		1600	12.71
	1700	13.28		1700	12.71
	1800	13.27		1800	12.71
BADRI GHAT(40)					
Date	Time	Water Level	Date	Time	Water Level
08/05/2011	0700	12.91	09/05/2011	0700	12.71
	0800	12.91		0800	12.69
	0900	12.91		0900	12.69
	1000	12.92		1000	12.67
	1100	12.92		1100	12.65
	1200	12.92		1200	12.64
	1300	12.92		1300	12.61
	1400	12.92		1400	12.60
	1500	12.92		1500	12.60
	1600	12.92		1600	12.59
	1700	12.92		1700	12.57
	1800	12.92		1800	12.54

SADAR GHAT(50)		
Date	Time	Water Level
09/05/2011	0700	11.67
	0800	11.65
	0900	11.64
	1000	11.63
	1100	11.60
	1200	11.58
	1300	11.58
	1400	11.55
	1500	11.53
	1600	11.51
	1700	11.49
	1800	11.46

CHANDPUR(70)					
Date	Time	Water Level	Date	Time	Water Level
12/05/2011	0700	9.68	13/05/2011	0700	9.64
	0800	9.68		0800	9.64
	0900	9.68		0900	9.64
	1000	9.68		1000	9.64
	1100	9.68		1100	9.64
	1200	9.67		1200	9.63
	1300	9.67		1300	9.63
	1400	9.67		1400	9.63
	1500	9.67		1500	9.63
	1600	9.66		1600	9.63
	1700	9.66		1700	9.62
	1800	9.66		1800	9.62

RAYPUR(80)					
Date	Time	Water Level	Date	Time	Water Level
13/05/2011	0700	9.10	14/05/2011	0700	8.89
	0800	9.08		0800	8.89
	0900	9.04		0900	8.88
	1000	9.02		1000	8.87
	1100	8.99		1100	8.87
	1200	8.98		1200	8.86
	1300	8.98		1300	8.85
	1400	8.97		1400	8.84
	1500	8.96		1500	8.83
	1600	8.95		1600	8.82
	1700	8.94		1700	8.81
	1800	8.93		1800	8.81

GANIGRAM(90)			KALINAGAR(100)		
Date	Time	Water Level	Date	Time	Water Level
15/05/2011	0700	8.68	16/05/2011	0700	7.71
	0800	8.68		0800	7.72
	0900	8.67		0900	7.73
	1000	8.67		1000	7.73
	1100	8.67		1100	7.74
	1200	8.67		1200	7.75
	1300	8.67		1300	7.78
	1400	8.67		1400	7.78
	1500	8.66		1500	7.80
	1600	8.66		1600	7.81
	1700	8.66		1700	7.82
	1800	8.66		1800	7.82

MALWA(120)		
Date	Time	Water Level
18/05/2011	0700	7.32
	0800	7.32
	0900	7.32
	1000	7.32
	1100	7.31
	1200	7.31
	1300	7.31
	1400	7.31
	1500	7.30
	1600	7.30
	1700	7.30
	1800	7.30

3.5 WATERWAY OBSERVATION

3.5.1 Lakhipur to Chirimukh (Ch. 0-10 km)

This stretch has been covered in Sheet No. 1 and Sheet No. 2. A road bridge is under construction at Ch. 0.5 km. The land identified for the proposed Lakhipur IWT Terminal is at Ch 7.5 km on right bank. A rainfed river Chiri joins at Ch 9.8 km as right bank tributary. The Depth was observed varying from 0.2 to 12.4 m and width from 100 to 250 m.

3.5.2 Chirimukh to Nandpur (Ch. 10- 24 km)

This stretch has been covered in Sheet No. 3 and Sheet No. 4. Two major bends fall in this zone at Ch 18.5 and 23.0 km. River Sonai joins as tributary on left bank at Ch 18.5 km. Depth varying from 0 -11.5 m and width from 100 to 250 m.

3.5.3 Nandpur to Dudhpatli (24-61 Km)

This stretch has been covered in Sheet No. 5 - 8. This stretch has eleven bends. Two of them being critical at Ch 27.9 and 44.7 km. IWT ferry services are existing across the river at Badri Ghat. A double lane road bridge crosses the river at Sadar Ghat near Silchar. High Tension line crosses the river at Ch 52.3 km. One rainfed river namely Madhura joining as right bank tributary at Ch. 54.8 km. Assam IWT mechanised ferry services are found in operation at Madhura ghat and AP ghat. The depth is varying from 0.2 to 17.3 m and the width varying from 106 to 230 m.

3.5.4 Dudhpatli to Rani Ghat (Ch. 61- 77.7 km)

The river stretch has been covered in Sheet No. 09 - 10. River has more bends and one of them is critical at Ch. 64.0 km. One rainfed river namely Jatinga joins as right bank tributary at Ch 69.1 km. A single line rail bridge crosses the river at Ch 61.4 km. A double line road bridge crosses the river at Ch. 75.6 km. Assam IWT mechanised ferry services are found in operation at Jatinga Ghat. High tension line at Ch 61.6 km crosses the river. Depth varying from 0.1 to 18.6m and width from 112 to 340 m.

3.5.5 Ranighat to Sripur (Ch. 77.7-97.2 km)

The river stretch has been covered in Sheet No. 11-12. River has two main bends at Ch. 82 km and 91.5 km and the latter bend was observed as critical. A rainfed river namely Ghagra joins as tributary at Ch 92.5 km in left bank. Assam IWT mechanised ferry service is found in operation at Ch 86.21 km. Depth varying from 0.2 to 12.5 m and width from 120 to 240 m.

3.5.6 Sripur to Badarpur (Ch. 97.2 -109 km)

The river stretch has been covered in Sheet No. 13-14. Two rainfed rivers namely Katakhal and Dhaleswari joins as left bank tributaries at Ch 99.1 and 105.2 km respectively. This stretch has mainly two bends at Ch 99.0 and 108 km respectively. A high tension power line crosses the river at Ch. 109 km. Bank protection is provided at left bank at Ch. 99.3 to 99.9 km. Depth varying from 0.9 to 16.9 m and width from 130 to 250 m.

3.5.7 Badarpur to Maula (Ch. 109 - 120 km)

The river stretch has been covered in Sheet No. 15-16. A double lane road bridge crosses the river at Ch 109.5 km. A Single line rail bridge crosses the river at Ch 110.2 km. A bridge is under construction at Ch 110.25 km. Badarpur CIWTC terminal located at Ch. 110.8 km. A small rock outcrop was visible at middle of the channel at Ch. 115.4 km. Bank protection was provided in left bank at Ch. 111.5 to 112.8 km. Two small bends were observed at Ch. 116.5 and 118.9 km. Depth varying from 0.4 to 19.1m and width from 130 to 350 m.

3.6 GHATS

16 number of Ferry ghats exist along the stretch of the river for transportation of passengers and materials across the river. Table 3.5 shows the list of Ferry service ghats available in Barak river between Lakhipur- Bhanga and other ferry ghats are shown in Drawing: 1000 enclosed.

Table 3.5 List of Ferry Service Ghats

Sl. No	NAME OF GHAT	DISTANCE FROM LAKHIPUR	REMARKS (Type of Country vessel being used)
1	Fulertal Ghat	0	Mechanised/wooden Boat
2	Silghat	10.48	Mechanised/wooden Boat
3	Baskandi Ghat	13.7	Wooden Boat
4	Sonai Ghat	24.04	Wooden Boat
5	Sonabari Ghat	35.11	Mechanised/wooden Boat
6	Badri Ghat	41.21	Mechanised/wooden Boat
7	Sadar ghat	51.62	Wooden Boat
8	Madhura Ghat	54.72	Mechanised/wooden Boat
9	AP Ghat	57.38	Mechanised/wooden Boat
10	Bali Ghat	68.22	Wooden Boat
11	Jatinga Ghat	69.12	Mechanised/wooden Boat
12	Rani Ghat	75.61	wooden Boat
13	Raypur Ghat	80.18	Wooden Boat
14	Rajnagar ghat	86.21	Mechanised/wooden Boat
15	Badarpur ghat	110.51	Wooden Boat
16	Malua Ghat	119.14	Wooden

3.6.1 Ferry crossings

There are 8 number of mechanised ferry crossing stations existing in the river stretch. These are operated by Assam Inland Water Transport department. In addition to these, country crafts are found in operation at many places for both crossing the river and carrying materials from place to place.

3.7 BEND

There are 3 number of critical bends observed in Lakhipur-Bhanga river stretch the same are presented in Table 3.6.

Table 3.6 List of Critical Bends observed in Lakhipur – Bhanga stretch of Barak River

Sl.No	Name of Place	Chainage from Lakhipur	Bend radius in Meter
01	Rangpur	44.8	240
02	Topkhana	64.0	200
03	Ganigram	91.5	300

3.8 BED SLOPE

The average slope of the river stretch from Lakhipur to Silchar is 1 in 14500 (i.e 6.89cm/km). The average slope of the river stretch from Silchar to Badarpur Ghat is 1 in 23288 (i.e 4.29 cm/km)

3.9 BRIDGES OBSERVED ACROSS WATERWAY

Major Railway and Road bridges were observed during the Hydrographic survey carried out between Lakhipur and Bhanga. Table 3.7 shows the list of bridges along with horizontal and vertical clearances available during flood seasons are presented.

Table 3.7 List of Bridges observed across Waterway

S. No.	LOCATION	DISTANCE FROM LAKHIPUR IN km	TYPE	HORIZONTAL CLEARANCE IN 'm'	VERTICAL CLEARANCE IN 'm' (above HFL)
1	Lakhipur	0	Bridge Under Construction (Rail Bridge connecting Jiribam)	-	
2	Silchar	52.31	Double Lane RCC Road Cantilever Arc Type Bridge	50.605	10.1
3	Masimpur	61.36	Steel Rail Bridge(Single Line)	54.3	5.1
4	Ranighat	65.68	Double Lane RCC Road Bridge	35	8.7
5	Badarpurghat	109.57	Double Lane RCC Road Bridge (Towards Shillong & Guwahati)	96.5	12.5
6	Badarpurghat	110.2	Steel Rail Bridge(Single Line)	83.1	10.4
7	Badarpur Ghat	110.25	Bridge Under Construction	-	

3.10 LIST OF SHOALS/ROCK OUTCROP OBSERVED IN WATERWAY

The following are the details of shoals/rock outcrop observed during the topographic and hydrographic survey carried out in Barak River.

Easting	Northing	Remark
Bhanga to Rajnagar		
458414.49	2751470.34	Big Sand patch (of size app. 200 x 50 m) LHS
458783	2751581	Sand patch LHS
452930	2750031	Stone in between River
454872	2751382	Rock in between river
Rajnagar to Silchar		
472800	2755294	island both side
480393	2745551	island in RHS
Silchar to Lakhipur		
480399	2745546	Island LHS
482457	2741277	Island RHS
493433	2743861	Chirimukh river meets Barak on LHS
Lakhipur to Tipaimukh		
503250.47	2740717.95	About 10mtr high stone in between river
508345.44	2721971.37	shallow Area
508290.11	2719586.63	sand patch left hand side
506708.90	2715290.14	sand patch left hand side
504369.45	2705365.88	Sand dune RHS
503862.27	2700948.73	Sand dune LHS
502107.74	2699440.63	Sand dune LHS
502593.20	2697375.66	Gravel dune RHS

501970.78	2695867	Gravel dune LHS
501717.04	2693371	Sand dune LHS
500703.84	2685449.73	Gravel dune RHS
501896.35	2680235.53	Marked Dam in Bank of River bank
502256.09	2680327.17	Meeting of two rivers at Tipaimukh

3.11 HYDROGRAPHIC CHARTS

Continuous sounding lines were run from bank to bank i.e., 0 m contour to 0 m contour up to normal HFL at 500 m interval from Lakhipur to Bhanga in river Barak (121 km) and survey charts were prepared in 1:5000 scale. Based on the cross section charts prepared, deepest part of the channel was identified. The identified Thalweg was continuously traversed with longitudinal survey with single line sounding. The soundings were reduced to CD. The Hydrographic charts, both LS and CS lines were plotted for 1:50,000 and 1:5000 scales respectively as per terms of reference. The completed charts are attached separately as Annexure to this report.

CHAPTER 4

TRAFFIC STUDIES

4.1 INTRODUCTION

Assam (Assamese অসম [Asom]), also Assam Valley and formerly the Assam Province (during British India) is one of the most culturally and geographically distinct regions of the country. Assam though one of the original provinces of British ruled Indian sub-continent and present day India having its legislature that dates back to 1937, the present day Assam had undergone numerous territory alignment changes with its state map being altered highest number of times when compared to any other provincial level changes that has happened in Independent India. Known for exquisite natural resources, geography and its important role in India's freedom struggle, Assam has its capital as Dispur, a specialized city circuit region located on the outskirts of its largest metropolis, Guwahati.

Assam is situated in the North East region of India bordering seven states viz., Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and West Bengal and two countries viz., Bangladesh and Bhutan. With a geographical area of 78,438 km^2, about 2.4 % of country's total geographical area provides shelter to 2.2 % population of the Country. Most of the state's population lives in the lush and verdant valleys of its two major river systems in the 24 districts of the Brahmaputra valley and 3 districts of the Barak valley. Less densely populated are the two hill districts of Karbi-Anglong and the North-Cachar Hills, set in the low lying hills that separate the two valleys. For administrative and revenue purposes, the state has 27 districts including Kamrup (Metro) district and four districts under Bodoland Territorial Council (BTC) areas viz., Kokrajhar, Chirang and Udalguri.

4.2 PROJECT INFLUENCE AREA

Barak River is the principal river of Cachar or Barak Valley and is also known as Barokaro. The Barak River has a length of nearly 190 km in the Barak Valley. The Project Influence Area (PIA) of the proposed development of Lakhipur- Bhanga stretch of Barak River comprises three districts namely Cachar, Hailakandi and Karimganj, few districts of

Meghalaya, Manipur and Tripura. Total PIA of Cachar (3786 km^2), Hailakandi (1327 km^2) and Karimganj (1809 km^2) districts is 6922 km^2.

4.3 DEMOGRAPHIC PROFILE OF PIA

According to Census of India (2011), the population of Assam stands at 3,11,69,272. The decadal growth of the State's population works out to 16.93 % during 2001-2011 as against 17.64 % for the country as a whole.

The secondary data pertaining to demographic profile, socio-economic profile, urbanisation, etc of the PIA were collected to bring out the socio-economic characteristics in a broader way. Table 4.1 presents the demographic profile of PIA.

Table 4.1 Demograpahic Profile of PIA

Sl. No	District	Population		Percentage Decadal Growth Rate		Population Density per Sq.km	
		2011	2001	1991-01	2001-11	2011	2001
1	Cachar	17,36,319	14,44,921	18.89	20.17	459	382
2	Hailakandi	6,59,620	5,42,872	20.89	21.44	497	409
3	Karimganj	12,17,002	10,07,976	21.87	20.74	673	557

Source: Statistical Hand Book, Assam, 2010 and Census of India

4.3.1 Urbanisation and Occupational Structure

The extent of urbanisation is measures in terms of percentage of urban population to total population. As per population census of 2001, the rural population of the state was 87% of the total population. All the 3 districts of Assam falling in the PIA have shown lower urbanisation than the state level of 13 percent as per 2001 census.

The work force classification of population by economic activity according to the result of population census 2001 reveals that out of total population, 85% were main workers and 15 % were marginal workers. The distribution of main work force reveals that major share is engaged in agriculture and allied activities. The total share of work force employed as cultivators and agricultural labour. This shows that Assam state's economy is mainly agriculture based.

4.4 EXISTING PRIMARY TRAFFIC MODES

PIA vis-à-vis Barak Valley is served by all the three surface modes of transport ie., rail, road and IWT. The rail and road services are available nearly all through the year. But, IWT services are operated between May and November. IWT services are stopped after November because of insufficient Least Available Depth (LAD) for the movement of vessels. IWT services are confined to cargo movement only from/to Kolkatta/Haldia through Indo-Bangladesh Protocol Route. More number of country boats are operating on the stretch of Tipaimukh to Karimganj transporting both passenger and goods traffic on short leads. This short lead IWT movement is not considered because of its insignificant share in the total traffic and difficulty in gauging the exact quantum of cargo being transported.

4.5 INLAND WATER TRANPORT IN BARAK VALLEY

IWT services on river Barak has a long history. Mechanised vessels were introduced in the river as early as 1863 during British period. These vessels were used for transporting men and material from/to Calcutta to the newly set up tea estates in Barak Valley. These services from Calcutta to Silchar were operated by River Stream Navigation Company till 1965.

Large scale movement of passengers using IWT mode in the organised and unorganised sectors. It is estimated that 30 million people are using the organised sector and 20 million use unorganised sector every year in NW-2 and Barak valley.

Table 4.2 shows the total cargo movement through Protocol route. This includes the portion of cargo diverted through NW-2. Indo-Bangladesh protocol transit and trade was handed over by CIWTC to IWAI on 8th September 2003. Figure 4.1 shows the development/progress of IWT cargo movement during 2003 to 2011 through Protocol route.

Table 4.2 DETAILS OF CARGO MOVED THROUGH INDO-BANGLADESH PROTOCOL ROUTES (YEAR 2003 TO JANUARY 2010)

YEAR	TOTAL MOVEMENT (M.T.)
2003	220632
2004	322872.61
2005	555972.16
2006	753277.74
2007	889348.14
2008	884451.364
2009	1338659.135
2010	1496359.924
2011 (upto July)	**1004375.592**

Source: IWAI and CIWTC Records, Kolkatta

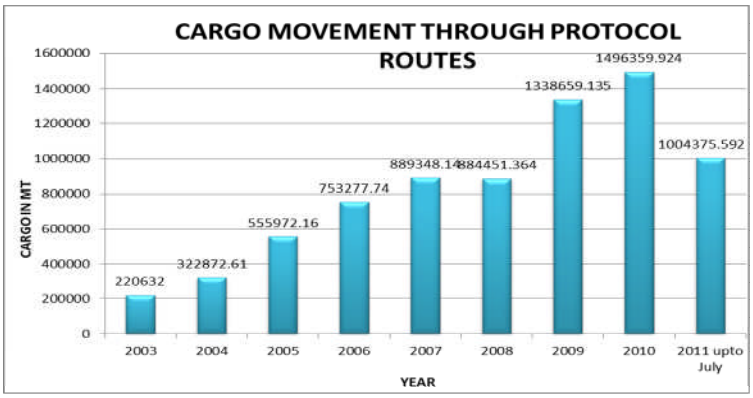


Figure 4.1 Progress of Cargo Movement through Protocol Routes

4.5.1 IWT Services in Barak River

IWT operation on Barak River is seasonal. Even prior to 1965, these services used to be suspended for 2 to 3 months every year due to non-availability of Least Available Depth (LAD). In general, vessels having draft of 1.85 m could ply between May and October from Calcutta to Silchar. During lean periods, the cargo movement was also carried out involving transhipment to smaller boats which were able to ply with draft of even less than 1 m. Normally these services operated between Markuli and Silchar from Nov. to Feb every year. Table 4.3 presents the total cargo carried from/to Karimganj and Badarpur terminals for the year 2011 (till Dec). Table 4.4 presents the yearwise traffic handled from Badarpur and Karimganj IWT terminals to/from Kolkatta/Haldia via. Bangladesh. Table 4.3 shows the quantities of coal and fly ash despatched/received from/at Badarpur and Karimganj IWT Terminals.

Table 4.3 VESSEL WISE CARGO MOVEMENT WITH VESSEL DIMENSION MOVED FROM KARIMGANJ AND BADARPUR DURING 2011

Sl.No	Name of vessels	Dimensions in m	Carrying capacity (MT)	Cargo carried*	
				Up (Fly ash)	DN (coal)
1	MV TLN 22	43.6X8.22X3.5	283.5	420	243
2	MV QUAMI 2	45.75X8.55X3.66	283.5	380	195
3	MV FARHAD 1	44.19X7.92X3.3	310	250	135
4	MV TLN 16	45.75X8.75X3.66	330	275	160
5	MV ALSIMIT 4	41.46X7.92X2.99	-	215	172
6	MV MARINE 7	42.68X8.54X2.9	-	190	0
7	MV RABINDRANATH TAGORE (IWAI)	54.6X9.6X11	-	295	300

Source : CIWTC, Kolkatta

**Note: Data pertaining to total cargo carried to/from Badarpur/Karimganj was provided by CIWTC, Kolkatta and the exact number of trips by vessels for carrying the cargo was not provided.*

Table 4.3 YEARWISE QUANTITY AND COMMODITY HANDLED & OF VESSELS DEPLOYED FROM KARIMGANJ & BADARPUR DURING 2000-01 TO 2010-11

DETAILS											
	CIWTC			IWAI			BANGALADESH			TOTAL	
Year	No .of Vessel	Commodity	Qty	No .of Vessel	Commodity	Qty	No .of Vessel	Commodity	Qty	No .of Vessel	Qty (MT)
2000-01	-	-	-	-	-	-	31	coal	9205	31	9205
2001-02	3	Detergent, Bamboo	1264	-	-	-	49	coal	10540	52	11804
2002-03	1	Detergent, Poultry feed	458	-	-	-	49	coal	12746	50	13204
2003-04	-	-	-	-	-	-	18	cement, coal	8001	18	8001
2004-05	6	cement	3327	1	cement	300	6	Lime stone, Saly, GI sheet	3136	13	6763
2005-06	-	-	-	-	-	-	-	-	-	-	-
2006-07	5	Fly ash		2	Edible oil	586	2	Fly ash	450	9	3694
2007-08	11	E. oil, Fly ash, Clinkere	4449	1	Edible oil	277	5	Fly ash, cement	3476	17	8202
2008-09	4	E.oil, Fly ash	2147	2	Bitumine,E.oil	744	-	-	-	6	2891
2009-10	5	Cut, Bamboo, Fly ash	2593	2	Bamboo, fly ash	500	4	Fly ash	2192	11	5285
2010-11	1	Food grains	550	2	Edible oil	659	1	Iron spares	590	4	1799
2011-12, upto Dec-11'	-	-	-	1	fly ash, coal	595	6	Fly ash, coal	2635	11	4072

Source : IWAI & CIWTC, Kolkatta – Produced with the permission of CIWTC & IWAI, Kolkatta.

4.6 Road Connectivity & Traffic Survey

PIA is well connected with road network. Presently road is the only mode available throughout the year for goods and passenger traffic. Meter gauge railway network is available in the PIA and the same is being under conversion into broad gauge. Although major share of traffic is being handled by road transport to and from various parts of the Country, but recorded information available at various Check Gates such as Srirampur Check gate, Digorkhal check gate, etc., did not provide various streams of cargo movement. The traffic which will likely be moved to through river Barak in the event of its being made navigable, shall only be the diverted traffic from road transport. An attempt was made to quantify the commoditywise Origin-Destination (OD) movement by road transport since no representative recorded information is available with Transport Authority, Govt. of Assam. It was observed that major share of traffic coming from various parts of the country especially from outside by road.

North East cargo is coming to Guwahati, from where it is further despatched to various destination in the North East including to PIA and to Manipur, Mizoram and Tripura. The similar remarks will hold good for return traffic from North East. At selected check gate, sample goods OD surveys were conducted for 28/48 hours. Loaded goods vehicle were intercepted and information recorded through personal interview with the vehicle crew. Details regarding the origin and destination of commodity carried and its weight were collected from each goods carrier. The raw data collected through this survey has been furnished as Annexure.

The commodity wise classification and processed data including traffic projection are presented in the subsequent sections. It is noted that the OD survey has been conducted during first week of July 2011. Monsoon rains were just commenced and the same was affected the transportation of coal from Meghalaya. Hence, major coal movement was not happened as expected. The cargo projection as per the earlier TEFS report for barak river is presented in Table 4.4.

Table 4.4 Cargo Projection for River Barak

Sl. No	Commodity	TONNE KMS (Lakhs)		
		2001-02	2006-07	2011-12
1	Bamboo	39	55	75
2	Bamboo chips	96	151	220
3	Bamboo Products	60	89	125
4	Cement	1252	1496	1195
5	Cement concrete Products	10	15	22
6	Coal	626	999	1529
7	Edible Oil	46	81	127
8	Fertilizers	109	166	248
9	Iron & Steel	1559	1711	828
10	Iron Pipes	92	155	238
11	Machinery Parts	210	296	463
12	Other Misc. Cargo	149	181	220
13	Paper and goods	371	588	883
14	Household goods	18	22	26
15	Pulses	60	83	143
16	Rice	913	1374	2328
17	Rubber	51	77	122
18	Stone & Chips	310	434	620
19	Sugar	102	159	233
20	Tea & Coffee	82	129	205
21	Wheat and flour	20	30	50
22	Wood and Timber	22	38	57
	Total	6197	8329	9957

4.6.1 Constituents of Commodity Group

The Origin-Destination (OD) survey of goods vehicles was conducted at Digorkhal check gate located on Badarpur – Guwahati Road near Badarpur, which is the Barak valley entry point for goods vehicles by road. The goods/commodities have been categorized in different groups as given in Table 4.5.

Table 4.5 Commodity Group Categorization

ID No.	Commodity Group	Commodity
1	Cereals/ Cash Crops	Wheat, Rice, Bajra, Jawar, Millets, Maize, Gram, Pulses, sugarcane, cotton, Barley, Oil Seed, Tobacco, dry chillies and others.
2	Chemicals	Fertilizers, Wine, Beveage & Soft drinks, Acids, etc.
3	Perishable Commodities	Fruit, Vegetables, Daily & Poultry Products, Fish and Meat
4	Petrochemical products	Petrol, Diesel, Kerosene and LPG
5	Livestock	Animals, Oil cake and Bhusa
6	Construction Material & Other Raw material	Sand, Stone, Bricks, Iron , Steel, Cement, Marble, Stone slab, Hardware, Fitting & Fixtures, timber & furniture items, machinery light & heavy, paper mill raw material, etc.
7	Conventional fuels	Coal and firewood
8	Minerals	Lime stone, iron and copper ore, etc
9	Consumer and other goods	Consumer goods, Appliances, Edible oil, refined oil, paper products, Jute products, Tea, finished products from Manipur, Mizorom and Tripura, etc.
10	Other Items	Other minor goods and ODC Movement.

As a part of traffic survey, the total number of goods vehicles passing at the survey location were counted and interviewed continuously for 3 days. The respective commodity and its weight (in tonnes) were noted.

4.6.2 Goods Movement by Railways

Survey was carried out to assess the goods movement by railways. Table 4.6 to 4.11 show the commodity which is presently transported by railways.

Table 4.6 Inward Movement of Goods by Railway at Silchar Railway Station

Sl. No	FY 2010-11	Commodity	Tonnes
1	April	**Group 1:**	70807
2	May	Fertilizers, Cement, Bituminous	12151
3	June	products	17782
4	July	**Group 2:**	48721
5	August	Vegetable: Potato	23930
6	September	**Group 3:**	26054
7	October	Salt, Rice, Wheat, Joguli, Plastic goods	20820
8	November	**Group 4:**	40290
9	December	Military Goods & Purchal	32777
10	January		13104
11	February		17040
12	March		22736
		Total Movement/annum	3,46,212
		Average Inward Movement/month	**28851**

Table 4.7 Outward Movement of Goods by Railway at Silchar Railway Station

Sl. No	Commodity	Tonnes/Month	Destination
1	Cement	1000	Tripura
2	Stone and aggregates	1300	Tripura
3	Local Rice	200	Tripura
4	Tea	1000	Via Guwahati to Kolkatta & North
	Average Outward	3300/month	
	Annual Outward Cargo	39,600/year	

Table 4.8 Inward Movement of Goods by Railway at Karimganj Railway Station

Sl. No	Commodity	Tonnes/Month	Origin
1	Sugar	2100	U.P. & North
2	Fertilizer	4200	Kolkatta
3	Salt	1200	Kolkatta/Gujarat
4	Potato	800	Via Guwahati from Kolkatta & U.P.
	Average Inward	8300/month	
	Annual Inward Cargo	99,600/year	

Table 4.9 Outward Movement of Goods by Railway from Karimganj Railway Station

Sl. No	Commodity	Tonnes/Month	Destination
1	Fertiliser	500	Tripura
2	Stone and aggregates	650	Tripura
3	Local Rice	300	Tripura
4	Other local products/packed items	770	To Tripura
	Average Outward	2220/month	
	Annual Outward Cargo	26,640/year	

Table 4.10 Inward Movement of Goods by Railway at Badarpur Railway Station

Sl. No	Commodity	Tonnes/Month	Origin
1	Sugar	1700	U.P. & North
2	Fertilizer	2800	Kolkatta
3	Salt	900	Kolkatta/Gujarat
4	Potato & Other raw material for paper mill	740	Via Guwahati from Kolkatta & U.P.
	Average Inward	6140/month	
	Annual Inward Cargo	73,600/year	

Table 4.11 Outward Movement of Goods by Railway at Silchar Railway Station

Sl. No	Commodity	Tonnes/Month	Destination
1	Cement	2000	Tripura/Guwahati/Megalaya
2	Paper Products	1500	Guwahati/West Bengal
3	Local Rice	350	Tripura/Guwahati
4	Tea	700	Via Guwahati to Kolkatta & North
	Average Outward	4550/month	
	Annual Outward Cargo	54,600/year	

4.6.3 Goods Movement by Road

Survey was carried out to assess the goods movement by road. Table 4.12 shows the commodities which are presently transported by road.

4.7 PROPOSED TRAFFIC TO IWT TERMINALS

Based on the various modes of divertable traffic, Karimganj IWT terminal will be expected to cater to a whole range of traffic related to Karimganj district and Tripura state. Badarpur terminal will attract traffic from Cement, Paper industries and coal transported from Meghalaya. Fly ash from Haldia/Bangladesh would be the incoming cargo for cement industries. Silchar being a re-distribution centre will handle traffic for Silchar district and Manipur state. Lakhipur terminal is proposed to attract traffic for some parts of Silchar district and Manipur State. Bamboo and products will be the return cargo from Lakhipur to Badarpur Paper mills and further towards Bangladesh.

Based on the traffic studies, Terminal wise origin/terminating traffic which may be diverted to IWT mode of transportation is proposed in Table 4.9. Practically the traffic tonnage presented in Table 4.9 may not be available for IWT mode due to various operational constraints including vessel availability, development of required infrastructure with a time frame, draft availability, Protocol constraints etc. Hence, around 30 to 50 % this traffic may be expected to be transported via IWT mode. It is also observed that full potential of IWT mode can be achieved once the waterway is fully developed and other protocol constraints addressed in the course of time.

Table 4.12 Commodity wise Cargo Movement by Road

Commodity Group	Commodity	Silchar (in tons)		Badarpur(in tons)		Lakhipur (in tons)		Karimganj (in tons)	
		Inward	Outward	Inward	Outward	Inward	Outward	Inward	Outward
Cereals/ Cash Crops	Wheat, Rice, Bajra, Jawar, Millets, Maize, Gram, Pulses, sugarcane, cotton, Barley, Oil Seed, Tobacco, dry chillies and others.	100800	70560	67200	47040	100800	70560	67200	47040
Chemicals	Fertilizers, Wine, Beveage & Soft drinks, Acids, etc.	72000	50400	48000	33600	72000	50400	48000	33600
Perishable Commodities	Fruit, Vegetables, Daily & Poultry Products, Fish and Meat	43200	30240	28800	20160	43200	30240	28800	20160
Petrochemical products	Petrol, Diesel, Kerosene and LPG	43200	30240	28800	20160	43200	30240	28800	20160
Livestock	Animals, Oil cake and Bhusa	14400	10080	9600	6720	14400	10080	9600	6720
Construction Material & Other Raw material	Sand, Stone, Bricks, Iron , Steel, Cement, Marble, Stone slab, Hardware, Fitting & Fixtures, timber & furniture items, machinery light & heavy, paper mill raw material, etc.	100800	70560	67200	47040	100800	70560	67200	47040
Conventional fuel, Minerals	Coal and firewood	108000	0	198000	0	0	0	54000	
	Lime stone, iron and copper ore, etc								0
Consumer and other goods	Consumer goods, Appliances, Edible oil, refined oil, paper products, Jute products, Tea, finished products from Manipur, Mizorom and Tripura, etc.	27000	18900	18000	0	27000	18900	18000	12600
Other Items	Other minor goods and ODC Movement.	NOT CONSIDERED							

Table 4.9 Terminal wise Divertable Traffic Cargo Projection

Sl. No	Terminal	Originating			
		2011-12	2015-16	2020-21	2025-26
1	Lakhipur	3353	3787	4542	5392
2	Silchar	47957	62037	83144	108147
3	Badarpur	320210	429313	593360	788148
4	Karimganj	141127	185354	252904	334084

Sl. No	Terminal	Termination			
		2011-12	2015-16	2020-21	2025-26
1	Lakhipur	210658	216961	224840	232719
2	Silchar	273609	393577	589550	836646
3	Badarpur	47079	66398	97537	136444
4	Karimganj	200460	281002	409892	570131

CHAPTER 5

VESSEL SIZE ANALYSIS & STUDY

5.0 INTRODUCTION

The major principal parameters governing Inland Waterway Fleet designs are:

- Terminal facilities and obstructions enroute,
- Waterway characteristic like river course, depth of water, radius of bends, current/velocities of water etc.,
- Navigational aspects and improvements to navigation,
- Cargo characteristic like type of cargo, quantum of cargo and distance of transportation,
- The vessel dimension like length, beam, moulded depth, minimum and maximum draft,
- Haulage distace
- Physical constrains like clearance under bridges, navigation locks size etc., and
- Capital, operation and maintenance cost.

5.1 FACTOR GOVERNING DESIGN PARAMETER

5.1.1 Cargo Characteristics

The cargo consist of construction material (cement, sand, stone, iron, steel etc.), cereals/cash crops (wheat, rice, pulses, sugar, tea, etc.), livestock (animal, oil cake, etc.), chemicals (fertilizer, wine etc.), mineral ore (coal, lime stone, iron etc.), others (consumer goods, Jute, bamboo products, kirana/perchun appliances, edible oil, paper products etc.) The volume of total cargo originating and terminating from different terminal is shown in Traffic Studies chapter.

For quick movement of general cargo, it would be necessary that it stays for minimum time in the loading/unloading terminals and not wait long time for vessels. To achieve objective by selecting a craft size so that at least one craft moves every 5 days from terminal towards destination.

5.1.2 Cargo Factors

The following cargo factors influence the design parameters:

- Volume and nature of cargo i.e. the cargo mix to be transported,
- Method of cargo handling facilities required or available,
- Average lot size and length of Haul,
- Balance of out and return cargo, and
- Requirement for protection against weather.

5.1.3 Waterway and Other Features

The field investigations done in the total stretch of the river bring out the following characteristic of the waterway which shall influence selection of the vessel for transportation.

- Variation in vertical clearance is available in majority of the bridges/crossings except a railway bridge at Masimpur near to Silchar where around 4 to 5 m of vertical clearance may only be available during floods.
- River width all along the waterway available throughout the year. But width of waterway in few places may not be sufficient for turning of vessels/ two way operations during lean season. This could be achieved through periodical dredging.
- Between Silchar and Badarpur, some shallow water depths are available and some stretches sufficient navigational depth available.
- Radius of bends.
- Current velocities.

Hence, the waterway condition during lean season would dictate the selected vessel to have shallow draft to ensure navigation all around the year.

5.1.4 Physical Constraints

To navigate the river, the existing structures for which vertical and horizontal clearances are to be studied for effective vessel design on the water transport route.

5.1.5 Operational Factors

The following factors are generally considered as operational factors in the process of study on vessels for IWT.

- Speed of vessel under varying hydraulic condition,
- Relation between speed, propulsive power and energy consumption,.
- Rate of loading and unloading of cargo,
- Time lost in transit, change of pilot at beats, cargo transfer, crossing of state or International border,
- Number of unworkable days per year, and
- Susceptibility of vessel to damage and crew efficiency.

5.2 TYPES OF VESSELS

For Inland Water Transportation, there are mainly two types of vessels namely self-propelled barges and dumb barges in tow. These two common vessels used for IWT are briefly discussed below.

5.2.1 Self Propelled Barge

Self-propelled cargo boats move under their own power and attain a higher speed than dumb barges in tow. These boats are also more effective against strong currents and are designed to meet particular requirement of traffic and route. In Shallow River, low draught vessels are designed with twin screws in tunnels. These vessels are not economical to run in deeper waters. Similarly vessel designed for deeper draft cannot be used in Shallow River. Costly cargoes which can stand a high freight rate like perishable goods requiring scheduled navigation are transported by self-propelled river vessel. These vessels have a low turnaround time in IWT ports (since no time is lost in anchoring and making up tows), are speedy and can call at many ports along the enroute. With proper scheduling of sailing of such vessels and full cargo availability, these can be an economic proposition inspite of the high cost of procurement.

5.2.2 Dumb Barge

Dumb barges are cheap and apart from being used for carriage of cargo, are also used for storing, as floating warehouses or even as pontoon jetties. These vessels require very little care and withstand rough handling. Small dumb barges do not normally have any permanent crew and lie unattended. Transportation of cargo in dumb barges is a slow process and there is normally no fixed schedule. Hence, bulk, unpacked and imperishable cargo is transported in such barges which offer a low freight rate. In Europe and USA. river transportation is normally carried in dumb barges in private sector.

5.2.3 Towing Arrangement

Dumb barges are grouped together to form flotilla which are towed by river tugs. Three methods of towing have been used internationally depending upon channel depth and width as well as the weather conditions experienced along the route. The following are the general methods.

- Towing astern,
- Towing alongside, and
- Push towing.

The first method, towing astern or pull towing has been used in European waters. A long towline is paid out from the river tug (moving in front) to the foremost barges of the flotilla. The flotilla may be made up of a number of rows of barges secured to each other or held together by a tie line passed from barge to barge. Sometimes, barges may be tied to the center barge alongside. In this system, the propeller race of the tug impinges on the front thus increasing the resistance of the barge flotilla. Due to this, there can be an augmentation of resistance as high as over 80% of the individual barge.. To reduce this increase in resistance, a minimum length of towline equal to 1.25 times the length of the tug is recommended. This increases the total length of tow considerably. Further, when the tow is to take a turn, the radius of bend must be quite large. Therefore, this form of transportation is good where only long straight stretches of waterway are available.

In towing alongside or abreast, one barge is secured fast to one side of the tug or two barges are secured to either side of the tug. This is an efficient method of towing, the only disadvantages being that the width of the waterway required should be more to accommodate flotilla of twin barge width. The conventional method on the NW -1/river Ganga in India has been towing abreast or side towing.

In push towing, flotilla, consisting of a number of barges arranged abreast and in row, is formed by securing all the barges to one another tightly. The pusher tug pushes the flotilla from behind. The propeller race does not affect resistance. Since all the barges and tugs are close together, the incidence of increasing in resistance due to inference is minimum. This system is prevalent in USA and is now being adopted in Europe and elsewhere including India (eg. CIWTC) for its obvious advantages over pull towing. The individual units of barges are normally full with rectangular bilge with/without end shapes.

5.2.4 Towing Tug

River tugs are designed and built as per particular requirements. The designs are different for pull towing and push towing. In push towing, the foredeck is made square to facilitate matching of barge end. Bollards and fairleads are mostly in the forward. In pull towing, the mooring arrangements are astern and there is arrangement for paying out rope (winch or capstan). Either of the tugs can be used for side towing by suitable provision of bollards on their sides.

Various types of propulsion systems have been used on river/canals. The systems most extensively used are paddle wheel propulsion, propulsion with other sophistication such as multiple propellers and rudders, “Kort” nozzles, raised tunnels and rudder-propeller propulsions.

The paddle wheel propulsion has disappeared since quite long from most of world waterway although it offered good maneuverability, good stopping and backing abilities, easy repair without dry docking and its suitability of use in shallow water with efficient propulsion. The disadvantage which outweighed its advantages was heavier hull construction with associated problems, big reduction gear and overall low efficiency.

The propeller propulsion system consisting of propellers and complete rudder system comprising of normal rudder behind propellers and flanking rudder in the front of propellers for reverse and stopping maneuvers is being widely used. In number of shallow draft vessels, with this type of propulsion, Kort nozzles and raised tunnels have been provided with propeller of lower diameter to get better efficient and thrust, provide protection to waterway bottom and the banks and to protect the propeller from damage. However, construction is difficult in case of tugs provide with Kort nozzle or tunnel.

The third type i.e. rudder propeller system was initially developed for motorizing dumb barges and small vessels with ready-to-install unit but it has been developed for propelling even the bigger size vessels. The advantage of this type is its high maneuverability, simple installation without requiring floating dry docking facilities. The disadvantages are lower efficiency as compared with system of fixed propeller with nozzles, vulnerability of freely suspended propulsion arm and complicated machinery parts.

In pull towing, the propeller race of the tug impinges on the front barge thus increasing considerably the resistance of the barge fleet. Moreover, pull towing requires deployment of crew for steering the towed barges and has, in addition, the disadvantages of being less maneuverable.

5.2.5 Push Tug

The important parameter for selection of the tug is the power requirement which depends upon the displacement of tug and barges, the maximum dimension of the convoy, current velocity, the parameters of waterway and the speed. Out of these factors speed largely governs the power requirement. Researchers have suggested limiting value of speed in shallow and narrow canals. In shallow water of unrestricted width, the economic speed in m/s should be less than $2.5*\sqrt{h}$ where H is the depth of water. In narrow canals, economic speed should be less than $1.2*\sqrt{A/C}$ for a blockage ratio of 5 (The ratio of wet canal cross section to area of submerged mid ship section) where A and C are canal cross section and canal perimeter respectively. The blockage ratio should not be less than 4.5 to prevent erosion of canal bed and slopes caused due to return currents and waves. Thus the mid ship

cross section on this route should be less than 13.67 m^2. The vessel speed on the above consideration should not be higher than 6.12 knots/hr in river section and 2.68 knots/hr in canal section. The power requirement of push tug has been based on the speed in river section.

In push towing, barges are lashed together by wire ropes to form a single unit and this, in turn, is lashed rigidly to the towing knees of the pusher tug. The tug working at the rear can handle a fleet of barges at a greater speed and with greater control is possible in pull towing operation. The tug is equipped with a set of steering and flanking (backing) rudders which afford maximum control for forward, backward and sideward movements as are required in restricted channels. For this reason, push towing has been recognized as the most efficient. It requires 20% less power than pull towing for comparable loads.

5.2.6 Towed Flotilla v/s Self Propelled Vessel

The merits and demerits of both alternatives that will help in making final choice are:

(i) In a towed flotilla, the cargo carrying unit and the engine unit are separate. Therefore, they can be scheduled independent of each other and thus ensure maximum transport efficiency. As the self-propelled vessels are expected to be more economical over long lead, both the alternatives have to be compared for cargo transportation.

(ii) In towing system when towing unit is down for engine survey, maintenance and repair, the cargo units need not be down and can be moved with another available towing unit, whereas in self-propelled barge system, one engine unit is always tied up with cargo unit.

(iii) Flotilla can be formed with varying units of barges. Therefore, this system can adjust to a fluctuating or uncertain transportation environment in an efficient manner. This system efficient is much higher since only limited numbers of barge that can be fully loaded are utilized. But this cannot be done for self-propelled vessels. If regular cargo is available in sufficient quantity, transport efficiency of self-propelled vessel can be more than flotilla.

(iv) Dumb barges are simply and less expensive to build and comparatively few towing tugs are required to operate the flotilla combination. Self-propelled barges are

comparatively larger vessels and are more complex for building since the engine; supporting bunkers and crew accommodation are to be housed. The procurement price is generally 3 to 3.5 times that of a dumb vessel of same capacity.

(v) It is well known in naval architecture that long slender vessels experience less resistance in motion. Well designed (ends properly shaped) dumb barges in flotilla experience proportionately less resistance than single vessels. Two single units in tandem experience 1.36 times the resistance of a single unit and a flotilla of 4 barges with two abreast in two rows experience 3.16 times the resistance of a single unit. The average resistance per single barges in a flotilla can be taken as 0.75 times that of a single barge on its own. With this resistance there would be net saving of 25% fuel, if barges are well designed and are moved in closely packed flotillas as against self-propelled barges.

(vi) A dumb barge can remain unattended in voyage and need not house any crew member. For a flotilla of 2 barges and one towing 4 crew members are sufficient. But for 2 independent self-propelled vessels at least 8 crew members would be required. Thus crew wage bill is reduced by half in case of towed system.

(vii) Maintenance for a flotilla system is easier and cheaper since barges are repaired separately from tugs. Downtime due to repair is also reduced.

5.3 TRAFFIC

As per traffic studies, estimated traffic through 4 IWT terminals on Barak River are as follows as per Table 4.4 which is represented here.

Terminal wise Origin /Destination of Traffic Cargo Projection

Sl. No	Terminal	Originating					
		2001-02	2006-07	2011-12	2015-16	2020-21	2025-26
1	Lakhipur	-	-	3252	3787	4542	5392
2	Silchar	-	-	47957	62037	83144	108147
3	Badarpur	-	-	320210	429313	593360	788148
4	Karimganj	-	-	141127	185354	252904	334084

Sl. No	Terminal	Termination					
		2001-02	2006-07	2011-12	2015-16	2020-21	2025-26
1	Lakhipur	-	-	210658	216961	224840	232719
2	Silchar	-	-	273609	393577	589550	836646
3	Badarpur	-	-	47079	66398	97537	136444
4	Karimganj	-	-	200460	281002	409892	570131

5.4 OPTIMAL VESSEL SIZE

Keeping in view the channel parameters and propulsion system as discussed above, the following 300 tonnes of vessels are proposed for the proposed waterway.

300 tonnes vessel is recommended for channel 40 m wide x 1.6 m LAD and attract private entrepreneurs to divert the traffic-load from rail/road sector and this vessel will carry 300 tonnes when restricted draught D = 1.2m in lean season. The actual nos. of the 300 tonnes to start the IWT operation will depend on the availability of funds.

Principle particulars of these self-propelled vessels for operation on river are:

300 tonne vessel

Length over all	=	45.00 m
Breadth	=	8.00 m
Draught	=	1.20 m
Cargo capacity	=	300 tonnes when 1.2m max draft.
Propulsion system	=	Marine diesel engine with propeller 2 no's
Output	=	250 BHP

CHAPTER 6

WATERWAY STUDIES & DEVELOPMENT

6.1 INTRODUCTION

In most of the countries where inland navigation is developed such as in Europe, China, Russia etc., the waterways have been classified in different classes depending on their physical characteristics and development potential in future. Generally, with larger waterway dimensions bigger IWT vessels can operate resulting in lower shipping cost per tonne of cargo as compared to the shipping cost of smaller vessels. One of the important factors contributing to lower shipping cost by operation of bigger vessels is the improvement in power to load ratio, i.e. capacity of cargo carrying per unit of engine power. Hence, every waterway should be developed to larger dimensions (depth and width of navigation channel) subject to the physical characteristics of the waterway. However, for developing a waterway to larger dimensions (in other wards waterway of higher class) additional investment would be required. Therefore, there would be an optimum waterway class for a particular waterway whereby total cost to the system (i.e., increase in cost due to development work vis-a-vis reduction in shipping cost) is minimum. This optimum solution is required for each waterway and for this purpose classification of waterways would facilitate planning for the optimum class of the waterway and its development.

6.2 HYDROGRAPHIC SURVEY

Hydrographic survey on river Barak was carried out from Tipaimukh to Karimganj and the survey alignment is given in Figure 6.1. The details of survey equipment, methodology and other observations were explained in Chapter 3 above. The single line soundings were recorded in the deepest part of the river from Tipaimukh to Karimganj and cross section at every 500 m intervals from Lakhipur to Bhanga. The results of the survey and observations are used in this Chapter to perform waterway analysis.

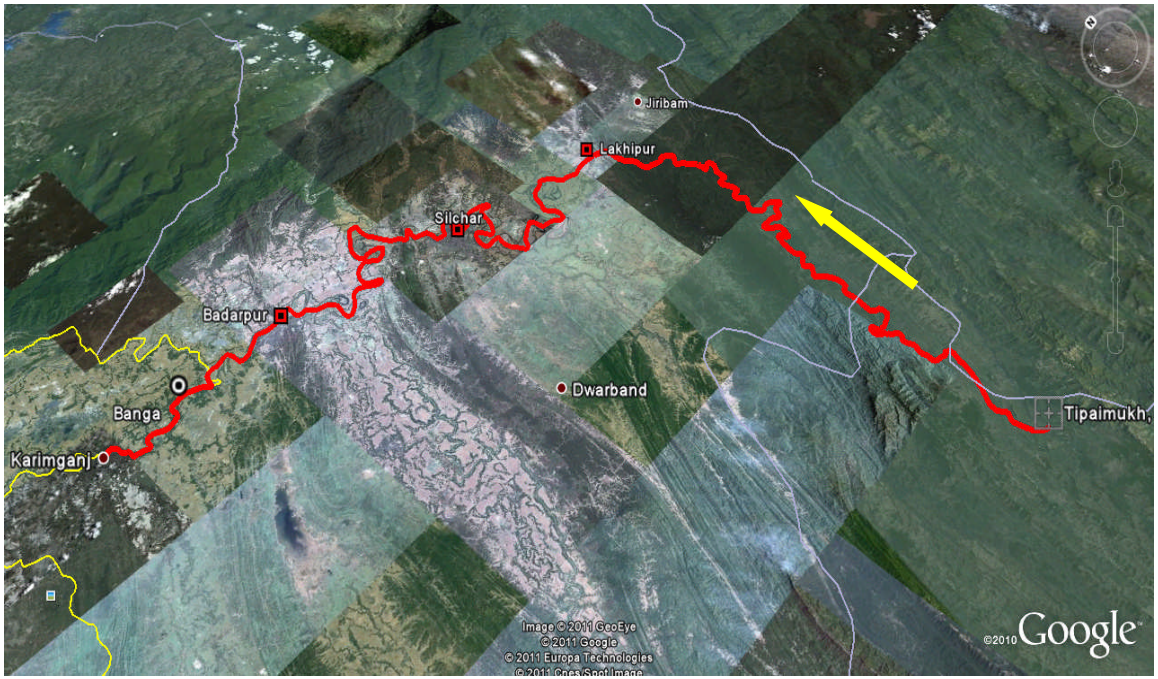


Figure 6.1 Hydrographic survey alignment in Barak River

5.3 BARAK RIVER HYDROLOGY

Study of availability of navigational depths during different seasons in a year is essentially required for planning waterway development. It was proposed to analyse the historical water level and discharge data on the Barak river. The hydrological data such as water level, discharge and sediment load observed at available gauging stations located at Lakhipur, Annapurna Ghat (AP Ghat) and Badarpur Ghat (BP Ghat) were collected from Central Water Commission, Water Resources Department, Govt. of Assam and other related sources through official and other procedures.

6.3.1 Analysis of Hydrological Data

The monthly maximum and minimum water levels observed in the above mentioned gauging stations during 2006 to 2010 were collected and presented in Table 6.1 to 6.3. Yearly maximum and minimum water levels observed in the above gauging stations during the years 1976 to 2010 is also presented in Table 6.4 and graphically represented in Figure 6.2 to 6.4.

Table 6.1 Monthly observed Water levels on Barak River at Lakhipur during 2006 -2010

	OBSERVED WATER LEVEL DATA									
Year	**2006**		**2007**		**2008**		**2009**		**2010**	
Month	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**
JAN	14.58	14.38	14.08	13.86	17.91	14.59	14.48	14.29	14.35	14.12
FEB	14.67	14.12	14.74	13.90	14.74	14.32	14.20	13.97	14.11	13.95
MAR	14.16	13.80	14.01	13.69	15.25	14.16	14.21	13.80	16.70	13.92
APR	14.98	13.74	17.65	13.61	15.18	13.93	15.41	13.91	21.01	14.64
MAY	21.57	13.87	21.19	14.48	15.21	13.74	14.95	13.98	22.53	16.81
JUN	24.52	17.14	25.15	15.89	22.43	14.50	19.72	14.57	-	-
JUL	22.84	19.32	22.95	18.58	22.18	18.82	21.96	16.04	-	-
AUG	20.14	16.71	25.14	17.70	24.20	20.38	23.30	18.41	-	-
SEP	19.12	16.28	25.77	18.38	23.37	18.28	23.33	16.80	-	-
OCT	19.14	15.08	22.55	16.84	21.32	16.22	21.15	15.88	-	-
NOV	14.50	14.40	18.37	13.81	16.68	14.88	15.82	14.79	16.48	15.29
DEC	14.40	14.09	15.79	15.11	14.88	14.50	14.78	14.37	15.98	14.81

Source: CWC, Silchar

Table 6.2 Monthly observed Water levels on Barak River at AP Ghat during 2006-2010

	OBSERVED WATER LEVEL DATA									
Year	**2006**		**2007**		**2008**		**2009**		**2010**	
Month	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**
JAN	9.80	9.68	9.35	9.02	10.41	9.94	9.74	9.43	9.53	9.16
FEB	9.95	9.35	9.88	9.06	10.25	9.59	9.43	9.06	9.16	8.98
MAR	9.42	9.06	9.21	8.89	11.32	9.48	9.53	8.82	12.70	8.94
APR	11.80	9.01	14.22	8.79	11.20	9.40	12.28	8.41	17.73	10.27
MAY	18.09	9.31	17.70	9.90	12.55	9.35	11.07	9.38	18.45	12.97
JUN	20.64	14.19	20.84	12.39	18.17	11.48	15.22	10.65	20.69	16.34
JUL	18.90	16.16	18.95	14.86	18.16	15.93	17.39	12.20	19.38	16.56
AUG	16.80	12.75	20.62	14.09	19.85	17.26	19.48	15.42	19.50	16.18
SEP	15.31	12.32	21.37	15.50	19.58	15.13	19.06	12.93	20.34	17.76
OCT	15.04	15.49	18.40	12.47	17.40	11.90	16.88	11.47	20.45	14.65
NOV	10.48	9.74	14.03	11.17	13.10	10.32	11.48	10.06	11.92	10.57
DEC	9.70	9.37	11.13	10.32	10.30	9.75	10.04	9.54	11.28	9.86

Source: CWC, Silchar

Table 6.3 Monthly observed Water levels on Barak River at BP Ghat during 2006-2010

	OBSERVED WATER LEVEL DATA									
Year	**2006**		**2007**		**2008**		**2009**		**2010**	
Month	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**
JAN	-	-	-	-	8.13	7.78	7.70	7.39	7.27	6.87
FEB	-	-	-	-	8.07	7.47	7.38	7.02	6.86	6.73
MAR	-	-	-	-	9.17	7.35	7.27	6.86	10.60	6.57
APR	-	-	-	-	9.04	7.10	10.79	6.99	15.56	8.48
MAY	-	-	-	-	10.85	7.13	9.45	7.46	15.90	11.55
JUN	-	-	-	-	15.18	9.70	12.70	9.32	-	-
JUL	-	-	-	-	15.32	13.81	14.85	10.27	-	-
AUG	-	-	-	-	17.14	14.35	16.76	13.87	-	-
SEP	-	-	-	-	17.04	13.09	16.05	11.01	-	-
OCT	-	-	-	-	14.75	9.80	14.23	9.27	-	-
NOV	-	-	-	-	10.76	8.30	9.18	7.85	10.28	10.78
DEC	-	-	-	-	8.28	7.70	7.82	7.22	9.48	7.92

Source: CWC, Silchar

Table 6.4 Yearly observed Water levels on Barak River at BP Ghat during 2006-2010

Year	Observed Water levels					
	Lakhipur		AP Ghat		BP Ghat	
	Max	Min	Max	Min	Max	Min
1975	28.38	16.98	20.1	8.6	NA	NA
1976	24.18	11.22	21.05	8.84	17.55	6.83
1977	22.36	11.04	19.78	8.69	17.07	6.56
1978	21.15	11.54	19.18	8.67	16.8	5.97
1979	23.26	10.88	20.87	8.89	17.59	5.89
1980	22.16	11.6	19.73	9.31	16.67	6.25
1981	23	11.84	20.23	9.47	17.04	6.75
1982	22.32	11.95	20.05	8.97	17.04	6.57
1983	26.06	11.86	20.64	8.86	17.44	7.01
1984	21.22	11.5	19.31	8.69	16.27	6.36
1985	24.18	11.82	21.45	9.06	18.04	6.79
1986	24.56	11.4	21.77	9.34	17.9	6.49
1987	22.08	12.16	19.47	9.47	17.05	7.09
1988	22.75	12.38	20.65	9.11	17.62	6.4
1989	25.6	11.8	21.84	8.88	18.13	6.45
1990	22.92	11.82	20.3	9.29	17.37	6.85
1991	24.46	11.6	21.57	9.25	18.17	6.85
1992	22.8	11.28	20.21	9.48	16.85	7.27
1993	22.76	10.74	20.62	9.5	18.07	7.02
1994	20.28	10.58	19.18	9.15	16.6	7.1
1995	20.4	9.85	19.64	8.58	16.72	6.58
1996	21.22	11.34	20.28	10.34	17.25	9.15
1997	22.56	10.08	21.03	9.09	17.7	7.46
1998	21.9	10.7	20.29	9.48	17.57	7.01
1999	20.8	9.7	19.76	8.74	16.87	6.83
2000	21.5	10.08	20.42	8.95	17.41	7.06
2001	22.94	11.73	20.54	8.8	17.52	6.97
2002	20.6	9.99	19.99	8.99	17.2	6.89
2003	20.8	9.85	19.81	8.93	17.23	6.85
2004	22.89	11.74	21.59	8.98	18.33	6.95
2005	22.88	11.75	19.09	9.13	16.18	7.27
2006	29.5	13.74	20.64	9.01	17.73	7.05
2007	25.77	13.61	21.37	8.79	18.48	6.71
2008	24.2	13.74	19.85	9.35	17.13	7.1
2009	23.33	13.8	19.48	11.07	16.76	6.86
2010	22.53	13.92	20.69	8.94	15.9	6.57

Source: CWC, Silchar

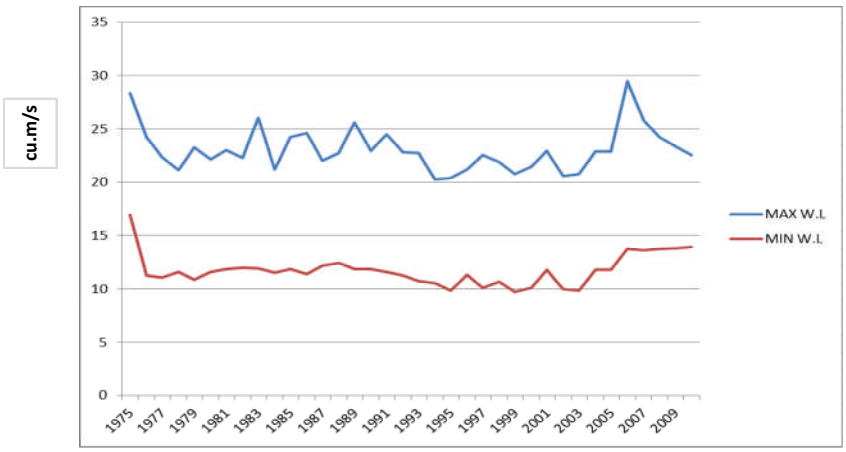


Figure 6.2 Water level variations in Barak River at Lakhipur

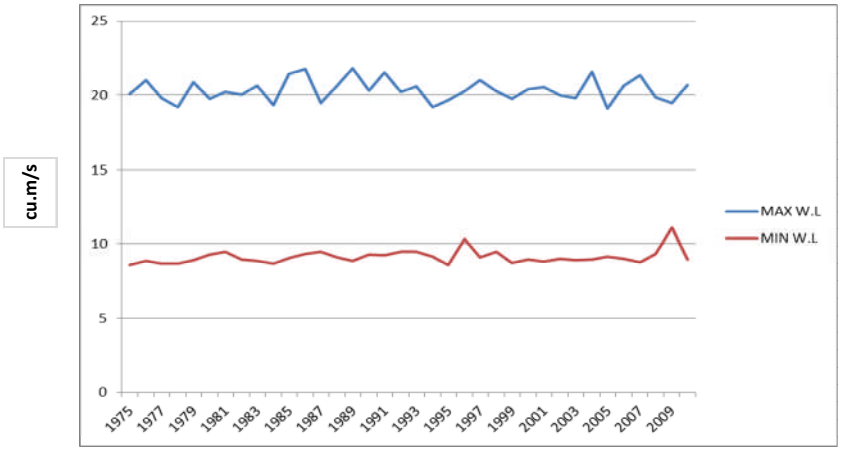


Figure 6.3 Water level variations in Barak River at AP Ghat

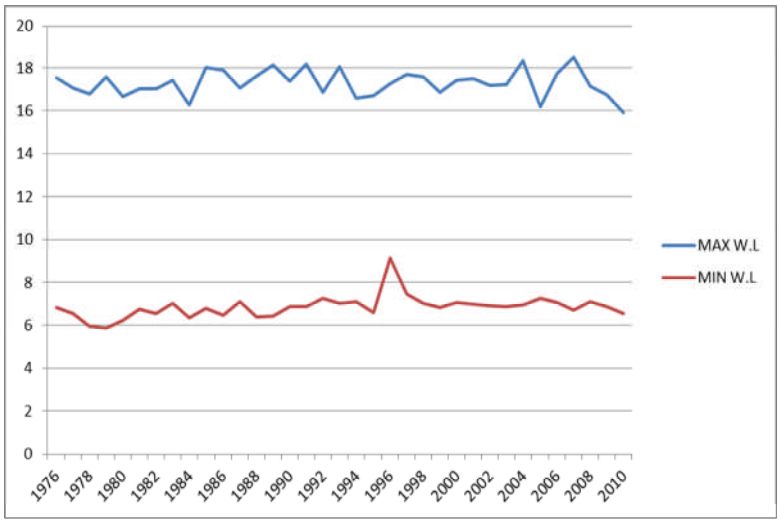


Figure 6.4 Water level variations in Barak River at AP Ghat

Based on the above water level observations, it observed that the variation of water level between flood and lean flow period seem to be slightly on higher side. Based on the above analysis, the following differences in water levels between maximum and minimum values were observed for year 2006 – 2010. The result is presented in Table 6.5. From this table, it is observed that low water levels are generally observed during Dec to March. The water level in the river varies by an average of 11 m over a year from lean season to flood season.

Table 6.5 Difference in Maximum and Minimum Water level observed

Location	Lakhipur	A.P.Ghat (Silchar)	B.P.Ghat (Badarpur)
Maximum Water level	25.77	21.37	17.14
Minimum Water level	13.61	8.41	6.57
Difference	**12.16 m**	**12.96 m**	**10.57 m**

6.3.2 Analysis of Discharge Data

The yearly maximum and minimum discharge observed in the above mentioned gauging stations during 1975 to 2000 were collected and presented in Table 6.6 to 6.8 and graphically represented in Figure 6.5 to 6.7. From the discharge table, it was observed that lean discharge of 21.17 m^3/s at Lakhipur, 41 m^3/s at AP Ghat and 47.93 m^3/s at BP Ghat were measured at gauging stations. This tendency of the water levels and discharges during lean season are particularly important for planning the waterway development and designing the IWT terminal facilities.

Table 6.6 Statement of Yearly Maximum and Minimum Discharge at Lakhipur

STATEMENT OF MAXIMUM & MINIMUM DISCHARGE				
River: Barak	SUB-DIVISION: Badarpur Inv. (F.C.) Sub-Div., Badarpur.			
SITE: Lakhipur	DIVISION: Cachar Investigation Division, Badarpur.			
Year	Max.Discharge (m3/s)	DATE	Min.Discharge (m3/s)	DATE
1975	2362.84	28/7/75	87.73	12/4/75
1976	2156.14	25/7/76	211.54	3/3/76
1977	1825	4/7/77	359	26/12/77
1978	1430	5/8/78	317	24/3/78
1979	2641	14/9/79	92	23/11/79
1980	1724	27/6/80	45.3	23/2/80
1981	3084	10/9/81	123	31/12/81
1982	1847.35	5/7/82	109	18/2/82
1983	2064.15	20/6/83	98.69	19/2/83
1984	1928.94	30/6/84	56.4	3/4/84
1985	2522.87	21/6/85	82.14	16/3/85
1986	1750.28	11/10/86	96.75	24/2/86
1987	1968.72	7/9/87	74.59	3/4/87
1988	4302.13	21/8/88	159.99	16/2/88
1989	4799.68	10/8/89	121.81	20/3/89
1990	1363.58	13/7/90	85.57	5/2/90
1991	1836.52	11/5/91	88.58	29/3/91
1992	692.02	12/9/92	69.05	30/11/92
1993	2380.04	24/7/93	66.02	31/12/93
1994	507.74	16/8/94	31.69	31/12/94
1995	589.41	15/8/95	21.17	15/2/95
1996	860.54	18/8/96	83.59	26/10/96
1997	932.6	13/8/97	42.36	3/5/97
1998	966.21	10/6/98	88.2	30/12/98
1999	880.8	17/7/99	62.93	14/3/99
2000	916	9/9/2000	50.8	5/4/2000

Table 6.7 Statement of Yearly Maximum and Minimum Discharge at A.P.Ghat

STATEMENT OF MAXIMUM & MINIMUM DISCHARGE				
River: Barak	SUB-DIVISION: Badarpur Inv. (F.C.) Sub-Div., Badarpur.			
SITE: A.P. Ghat	DIVISION: Cachar Investigation Division, Badarpur.			
		Unit in cubic meter/Sec.		
Year	Max.Discharge	DATE	Min.Discharge	DATE
1975	NA	NA	NA	NA
1976	6165.89	15/6/76	86.93	28/2/76
1977	3743.7	28/6/77	97.23	28/3/77
1978	2320	5/8/78	85.54	18/4/78
1979	3583.78	13/9/78	82.41	29/4/79
1980	2786.9	8/6/80	123.33	31/12/80
1981	3229	9/9/81	82	31/12/81
1982	2559	6/7/82	90	1/1/82
1983	4143	30/8/83	41	6/1/83
1984	2829	20/5/84	58	1/4/84
1985	3391.77	20/6/85	86.1	16/3/85
1986	3417.82	10/10/86	66.41	28/3/86
1987	3107	31/7/87	120	31/12/87
1988	5279.78	21/8/88	770	11/4/88
1989	6282.64	2/8/89	84.75	22/3/89
1990	5012.06	18/8/90	93.44	22/3/90
1991	5801.95	10/5/91	106.7	25/3/91
1992	4721.14	17/10/92	141.71	18/3/92
1993	5244.63	23/7/93	135.4	14/2/93
1994	3363.15	16/8/94	103.43	7/3/94
1995	3075.45	15/8/95	88.09	29/3/95
1996	4335.45	18/8/96	44.01	1/5/96
1997	4821.45	13/7/97	129.44	3/5/97
1998	4010.01	27/8/98	180.2	17/2/98
1999	3551.02	18/7/99	105.51	2/5/99
2000	3766.46	9/9/2k	105.38	1/3/2k
2001	3341.56	8/6/01	105.33	28/4/01
2002	3219.5	16/8/02	106.73	26/3/02
2003	3179.67	14/6/03	114.94	12/04/03
2004	3788.4	22/7/04	114.52	10/3/04
2005	2765.75	28/8/05	131.44	5/3/05
2006	3770.4	14/06/06	122.25	3/4/06
2007	3763.9	11/9/07	105.59	19/3/07
2008	3038.1	1/9/08	115.22	4/5/08

Source: Brahmaputra Board, Guwahati

Table 6.8 Statement of Yearly Maximum and Minimum Discharge at B.P.Ghat

STATEMENT OF MAXIMUM & MINIMUM DISCHARGE				
River: Barak	SUB-DIVISION: Badarpur Inv. (F.C.) Sub-Div., Badarpur.			
SITE: Baradpur Ghat	DIVISION: Cachar Investigation Division, Badarpur.			
			Unit in cubic meter/Sec.	
Year	Max.Discharge	DATE	Min.Discharge	DATE
1975	NA	NA	NA	NA
1976	7786.08	15/6/76	71.34	27/2/76
1977	4961.96	29/6/77	71.04	11/377
1978	4721.88	5/8/78	76.99	4/3/78
1979	7049.93	14/9/79	74.53	8/3/79
1980	4212.88	8/6/80	74.63	17/2/80
1981	5752.01	13/9/81	82.7	1/3/81
1982	3648.48	07/7/82	69.42	5/3/82
1983	3599.61	30/8/83	47.93	21/3/83
1984	3152.94	4/7/84	56.65	21/3/84
1985	6810.9	25/6/85	87.42	1/3/85
1986	5661.57	12/10/86	79.51	27/2/86
1987	5038.45	2/8/87	49.36	4/3/57
1988	6517.5	21/8/88	114.04	20/2/88
1989	7124.17	3/8/89	85.58	15/3/89
1990	4396.66	18/8//90	99.3	20/2/90
1991	7416.69	12/5/91	96.28	30/3/91
1992	3370.84	16/10/92	136.81	18/3/92
1993	7133.82	24/7/93	121.62	13/8/93
1994	2834.58	15/8/94	112.62	14/3/94
1995	2983.87	19/8/95	73.1	28/3/95
1996	3871.88	19/8/96	193.65	25/10/96
1997	5450.79	13/7/97	146.3	21/5/97
1998	5027.18	9/6/98	103.7	22/3/98
1999	3157.5	20/7/99	89.19	7/3/99
2000	3799.04	9/9/2k	106.17	29/1/2k
2001	4165.38	8/6/01	84.63	28/4/01
2002	3374.12	17/7/02	75.23	10/3/02
2003	3503.48	14/6/03	73.09	12/3/03
2004	5950	22/7/04	188.05	22/4/04
2005	1853.97	25/7/05	115.02	12/2/05
2006	4053.23	14/6/06	64.73	31/12/06
2007	6805.59	12/9/07	64.73	1/2/07
2008	3445.96	26/8/08	92.17	30/4/08

Source: Brahmaputra Board, Guwahati

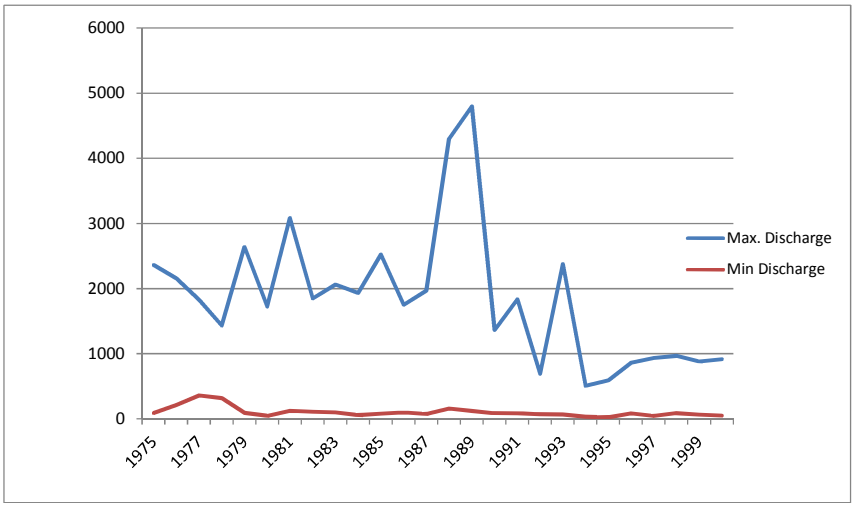


Figure 6.6 Graph showing Discharge variation in Barak River at Lakhipur

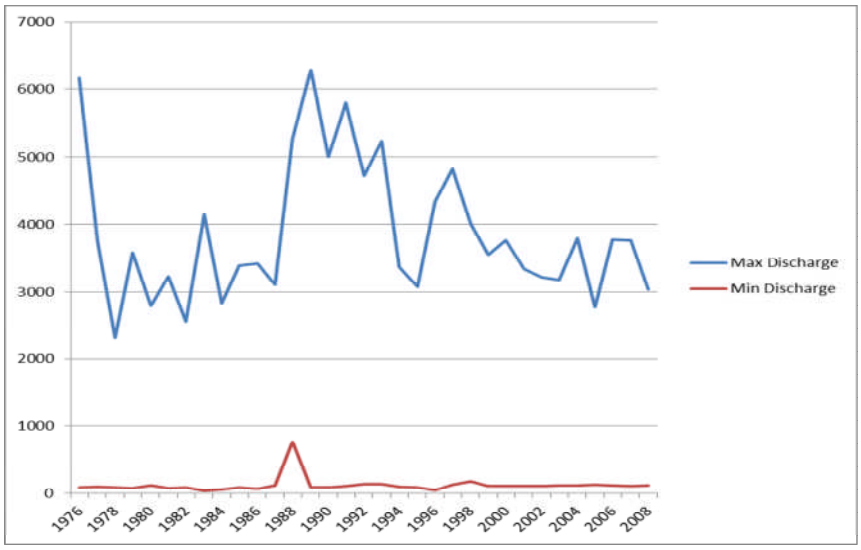


Figure 6.6 Graph showing Discharge variation in Barak River at A.P.Ghat

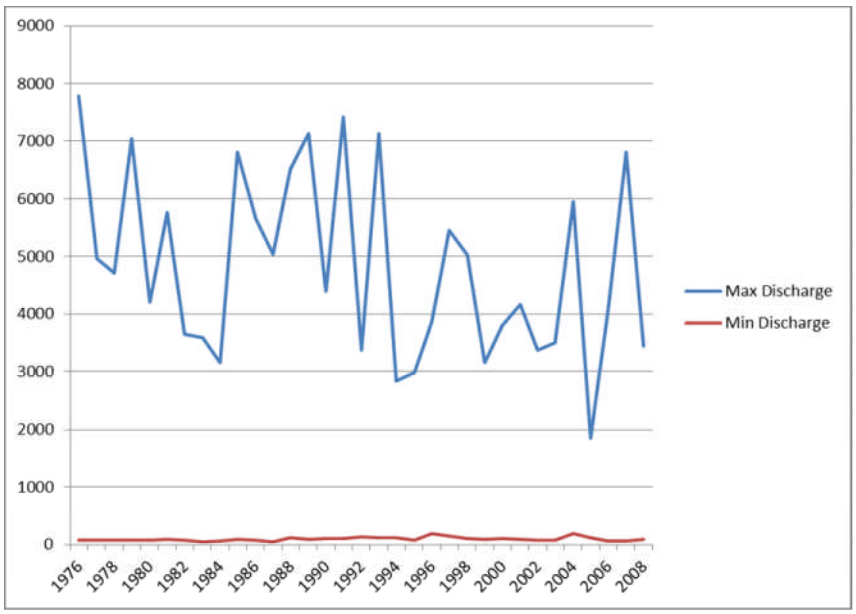


Figure 6.7 Graph showing Discharge variation in Barak River at B.P.Ghat

Minimum Discharge Requirement

Considering the above minimum discharge available during the lean flow season, the discharge available for 40 m x 1.6 m dredged channel was estimated. The lean discharge of 21.17 m^3/s at Lakhipur was compared with the actual discharge required for the dredged channel and the calculations are given below:

Actual discharge available = 21.17 m^3/s

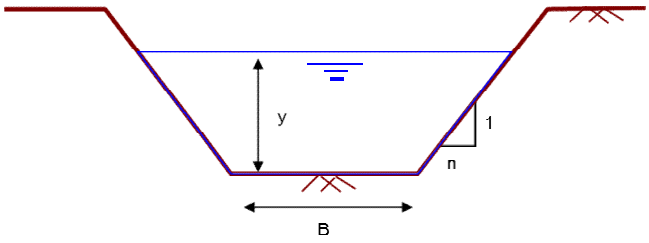
Design discharge required = 31.3 m^3/s

Hence required discharge for maintaining 1.6 LAD may not be available at Lakhipur to Silchar reach during lean season. This analysis required to be performed based on daily observed discharge at Lakhipur during detail engineering. The discharge from tributaries of Barak river downstream of Lakhipur to Silchar need to be observed on daily basis and the same is required to be analysed for checking the discharge availability for maintaining 1.6 m LAD during lean season.

Water carring capacity of dredged section (for Lakhipur – Silchar Stretch)

Consider the discharge

Discharge	Q =	21.7cum/s	
Type of channel		Natural stream	
Manning's coefficient	n =	0.025	
Bed width	B =	40m	
Side slope (1v:nH)		5	
Depth of flow		1.600m	
Bed Elevation		0.000m	
Water surface Elevation		1.600m	
Area of flow		76.800sqm	
Wetted perimeter		56.317m	
Hydraulic mean depth		1.364m	
Bed slope		0.00007	1 in 14500
$Q = 1/nAR^{2/3} s^{1/2}$		31.373cum/s	> 21.7
Difference in actual & estimated discharge		-9.673cum/s	
Velocity of flow	v =	0.408m/s	



The lean discharge of 41 m^3/s at AP Ghat was compared with the actual discharge required for the dredged channel and the calculations are given below:

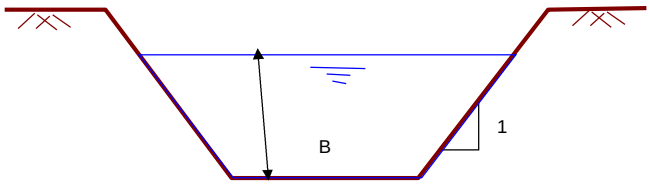
Actual discharge available = 41 m^3/s

Design discharge required = 24.75 m^3/s

Hence required discharge for maintaininag 1.6 LAD is available at Silchar to Bhanga reach throughout the year. The calculation carried out for the same is presented below.

Water carring capacity of dredged section (from Silchar to Bhanga stretch)
Considering the discharge

Dischare	Q =	41	Cum/s	
Type of channel		Natural stream		
Manning's coefficient	n =	0.025		
Bed width	B =	40	m	
Side slope (1v:nH)		5		
Depth of flow		1.600	m	
Bed Elevation		0.000	m	
Water surface Elevation		1.600	m	
Area of flow		76.800	sqm	
Wetted perimeter		56.317	m	
Hydraulic mean depth		1.364	m	
Bed slope		0.00004		1 in 23288
$Q = 1/nAR^{2/3} s^{1/2}$		24.755	cum/s	< 41
Difference in actual & estimated discharge		16.245	cum/s	
Velocity of flow	v =	0.322	m/s	



6.3.3 Depths for Navigation

The reduced depths below the Chart datum were used to assess the navigation depths and discussed in Chapter 3. These reduced depths below chart datum indicate that these depths would be ensured even during dry season on long term basis.

6.4 WATERWAY DEVELOPMENT

The classification of waterways by Inland Waterway Authority of India is discussed below:

Class I : Waterways with navigable channel of minimum depth 1.2 m, bottom width 30 m (in case of rivers) and depth 1.5 m, bottom width 20 m (in case of canals) with minimum radius at bends 300 m, minimum vertical clearance 4 m, and horizontal clearance between piers 30 m, (in case of rivers) and 20 m, (in case of canals).

Class II: Waterways with navigable channel of minimum depth 1.4 m, bottom width 40 m, (in case of rivers) and depth1.8 m, bottom width 30 m, (in case of canals) with minimum radius at bends` 500m, in minimum vertical clearance 5 m, and horizontal clearance between piers 40 m, (in case of rivers) and 30 m, (in case of canals).

Class III: Waterways with navigable channel of minimum depth 1.7m, bottom. Width 50, m,_(incase of rivers) and depth 2.2 m bottom width 40 m, (in case of canals) with minimum radius at bends 700m minimum. vertical clearance 7 m, and horizontal clearance between piers 50 m, (in case of rivers) and 40 m, (in case of canals).

Class IV: Waterways with navigable channel of minimum depth 42.0 m, bottom width 50 m, (incase of rivers) and depth 2.5m, bottom width 50 m, (in case of canals) with minimum radius at bends 800m, minimum vertical clearance 10 m, and horizontal clearance between piers 50 m, (in case of rivers) and 50 m, (in case of canals).

Class IV (A): Waterways on rivers only with navigable channel of minimum depth 2.0 m, bottom width 80 m, with minimum radius at bends 800 m, minimum vertical clearance 10 m, and horizontal clearance between piers 80 m.

Class V: Waterways with navigable channel of minimum depth 2.75m, bottom width 60 m, (in case of rivers) and depth 3.5 m bottom width 60 m, (in case at canals) with minimum radius at bends 900m, minimum vertical clearance 10 m, and horizontal clearance between piers 60 m, (both in case of rivers and canals).

Class V (A): Waterways on rivers only with navigable channel of minimum depth 2.75 m, bottom width 100 m, with minimum radius of bends 900 m, minimurrm vertical clearance 10 m, and horizontal clearance between piers 100 m.

On all the above cases:

a) Minimum depth of channel should be available for 95% of year.

b) Vertical clearance over the waterway should be available in at least central 75% portion of each of the spans in entire width of the waterway during lean season.

The present classification of Inland Waterways in India by Inland Waterways Authority of India is shown below in Table 6.9.

Table 6.9 Classification of Inland Waterways in India

Classificat. Of Waterway	Tonnage (DWT) of SPV (T)	Barge Units			Minimum Dimensions of Navigational channel in lean season				Radius at Bend (m)
					Rivers		Canals		
		Dimension of single Barge (LxBxD) (m)	Dimension of Barge units (LxBxD) (m)	Tonnage of Barge units (DWT) (T)	Depth (m)	Bottom .width (m)	Depth (m)	Bottom width (m.)	
I	100	32 x 5 x1.0	80x5x1.0	200	1.2	30	1.5	20	300
II	300	45x8x1.2	110 x 8 x 1.2	600	1.4	40	1.8	30	500
III	500	58 x 9 x1.5	141 x 9 x 1.5	1000	1.7	50	2.2	40	700
IV	1000	70x12.x1.8	170 x.12x1:8.	2000	2.0	50	2.5	50	800
V	1000	70 x 12 x1.8	170 x 24 x1.8	4000	2.0	80			800
VI	2000	86 x 14 x2.5	210 x 28 x 2.5	4000	2.75	60	3.5	60	900
VII	2000	86 x 14 x2.5	210 x 28 x 2.5	8000	2.75	100		_	900

Based on the study explained in Section 5.4 of Chapter 5 above and further to the recommended classification of waterways by IWAI as per Table 6.9, the development of waterway between the stretch from Lakhipur to Bhanga in River Barak is classified under Class II Waterway.

6.4.1 Minimum clearance for cross structures

The vertical clearance of a bridge or any other cross structure comprises of the height of the fixed points of an empty vessel (air draught above the Navigational High Water Level (NHWL) plus overhead tolerance. The overhead tolerance is closely related to the safety of the vessel passing through such structures and is determined by several factors such as the wave variation, draught variation caused by vessels motion, back water caused by piers, the errors of observed water level and vessel's draught etc.

Generally recommended overhead tolerances are:

For rivers in plains:

- 0.3 m for 100 / 300 T vessel
- 0.5 m for 500 11000 T vessel
- 1.0/1.5 m for 2000/3000 T vessel

For rivers in hilly:

- 0.5 m for 100/300 T vessel

And mountainous areas:

- 1.0 / 1.5 m for 500/3000 T vessel

For cross-structures like bridges, the horizontal clearance between piers have been kept same as bottom width of the channel for river/canal to permit unhindered two-way navigation.

For fixing vertical clearance, the calculation of Navigational High Water Level (NHWL) is an important factor so as to reduce the cost of cross-structures without causing unacceptable effect to the shipping operation. This has been defined as under:

Rivers: Highest flood level at a frequency of 5% in any year over a period of last twenty years

Canals: The designed full supply level

As per Chinese Standards, minimum clearance of 11 m has been specified for Waterway of 2000 tons capacity. However, in European classification, the minimum specified vertical clearance is 9.1 m. IWAI / MOST have specified a clearance of 10.0 m for 1000 T/2000 T vessel; 7 m for 500 T vessel and 5 m for 300 T vessel.

6.5 FAIRWAY DESIGN

The basic parameters considered for the fairway design are:

- Depth
- Width
- Side slopes
- Bends

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

6.5.1 Depth of a Channel

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

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

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

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

6.5.2 Width of a Channel

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

W = BM+BM1 + C+2C1

Where

W = Navigation channel width for two-way navigation.

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

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

C = Width of separating zone.

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

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

BM = 1.3 B to 3.0 B

BM = BM1

C = 0.5 B to 1.0 B

C1 = 0.3 B to 1.5 B

Where B = Beam of a design vessel.

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

BM = 1.4 B

BM = BM1

C = 0.5 B

C1 = 0.5 B

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

6.5.3 Slopes

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

6.5.4 Width Allowance at Bends

In bends, the width of the fairway should be more than the width of the canal that is designed for a straight reach to allow for a drift of the vessel in a curved portion of the waterway. It means that the vessel occupies a greater width in bends than in a straight stretch of the waterway. The drift of the vessel depends on the radius of the bend, the speed of the vessel, wind forces, the flow pattern and the loading of the vessel.

The drift angle is larger for vessels traveling in the downstream than the upstream direction. The drift angle is inversely proportional to the bend radius 'R', that is, the larger the radius the smaller the value of drift angle. Unloaded ships normally subjected to more drift and consequently take up a greater width in bends than loaded ships and therefore the proposed allowance at the keel level of the unloaded ships is larger than the loaded ships.

The guidelines for width allowance in bends proposed by Delft Hydraulics are described in Table 6.10.

Table. 6.10 Guideline for width allowance at bends

Quality of the cross-section	Minimum radius permitted	At keel level of up going loaded ship	At keel level of down coming unloaded ship.
Normal cross-section	R/L = 6	0.5 L^2 / R	L^2 / R
Narrow cross-section	R/L = 4	0.5 L^2 / R	L^2 / R

The norms for desirable bend radius as per Dutch guidelines are 4 L for narrow and one-way sections and 6L for normal section (L - overall length of barge unit). The Chinese norms for minimum bend radii are in the range of 4L to 5L. The proposed bend radii for the present waterway are 5L.

The minimum radius of the adopted bend is 350 m. Wherever the radius of the bend is less than 5 times of the length of the designed vessel i.e. 5x62.8 = 314, additional widths are provided for free maneuverability of the vessel. The additional width provided in the present fairway system for a designed vessel is:

$\Delta b = L^2 / R = 62.8^2 / 314 = 12.56$ m

As per the design criteria discussed above the channel dimensions for the proposed waterway is presented in Table 5.11. It is proposed to fix the channel with 40 m base width and side slope of 1:5 with LAD of 1.6 m. At bends, the proposed channel width would be 60 m with side slope of 1:5.

Table 6.11 Design channel dimension for various capacities of vessels

Channel	600 tons vessel	300 tons vessel	100 tons vessel
Bottom width	40 m	40 m	25 m
Depth below CD	2.0m	1.6m	1.2m
Side slopes	1:5	1:5	1:5

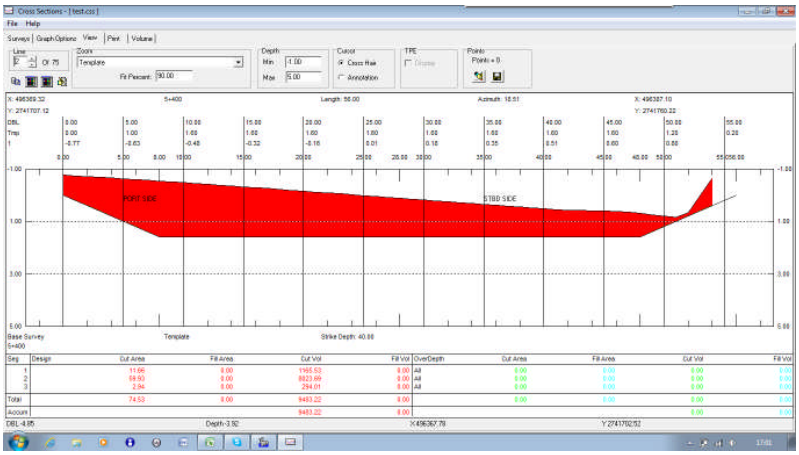
6.5.5 Dredging of Navigational Channel

The dredging quantities for the above design channel have been worked out based on the bathymetric surveys carried out. The dredging quantities for the proposed 40 m channel and 60 m channel at bends with side slope of 1:5 was worked out. The dredging quantity was worked out with manual calculation as well as by software. Table 6.12 presents the dredging quantity for the proposed navigation channel in Barak River.

Table 6.12 Dredging Quantity for the proposed navigational channel

Sl.No	Channel Dimenstion	Dredging Quantity
1	Bottom Width = 40 m Bottom width at bends = 60 m LAD considered = 1.6 m Side Slope = 1 in 5	2.6 Million m^3

The dredging quantity was estimated using HyPack using the actual reduced soundings as per CD. The centre line of the channel was considered as per the Longitudinal sounding lines observed during the Thalweg survey connecting deepest part of the navigational channel. Proper adjustments were carried out to fit the channel suitably in such a way that dredging quantity shall be minimum using the deeper parts of the channel. Due consideration was given for shoals identified during the survey. The sample calcuations and results obtained for dredging estimation is presented below and in Table 6.13 and 6.14.



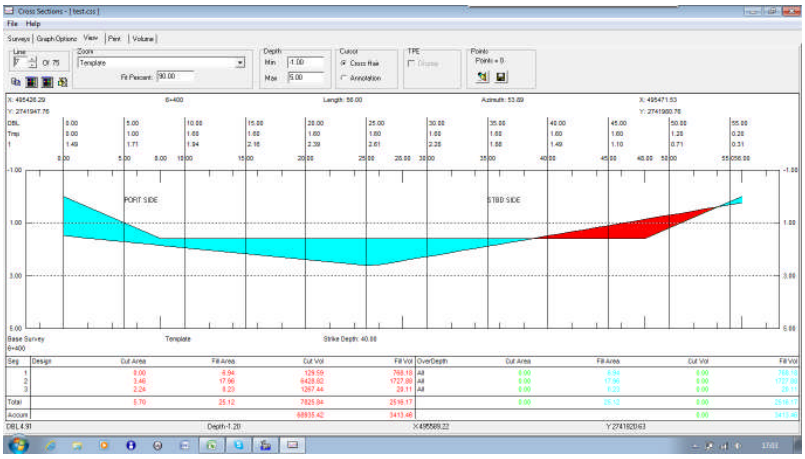


Figure 6.8 Sample Results of Dredging Calculation

Table 6.13 Detailed Breakup of Estimated Dredging Quantity

DETAILED BREAK UP OF DREDGING REQUIREMENT FOR LAKHIPUR TO BHANGA STRETH OF BARAK RIVER				
SL.NO	**STRETCH AND CHAINAGE DETAILS**	**QUANTITY (in cu.m)**	**QUANTITY (in Lakh cu.m)**	**Implemen-tation**
1	Lakhipur to Chirimukh (Ch: 0 to 10 km)	181320	1.81	**Phase II**
2	Chirimukh to Nandpur (Ch: 0 to 20 km)	192001	1.92	
3	Nandpur to Dhamali (Ch: 20 to 30 km)	126080	1.26	
4	Dhamali to Berenga(Ch: 30 to 40 km)	145552	1.46	
5	Berenga to Silchar Bridge (Ch: 40 to 50 km)	249931	2.50	
6	Silchar Bridge to Masimpur (Ch: 50 to 60 km)	239886	2.40	**Phase I**
7	Masimpur to Chandpur (Ch: 60 to 70 km)	254658	2.55	
8	Chandpur to Raypur (Ch: 70 to 80 km)	271927	2.72	
9	Raypur to Ganirgram (Ch: 80 to 90 km)	252078	2.52	
10	Ganirgram to Sripur (Ch: 90 to 100 km)	276333	2.76	
11	Sripur to Badarpur Ghat (Ch: 100 to 110 km)	198342	1.98	
12	Badarpur Ghat to Bhanga (Ch: 110 to 121 km)	234898	2.35	
	Total (Rounded Off)	2623004	26.23	

Table 6.14 Breakup of Estimated Dredging Quantity for Barak River Stretch

Sl. No	**River Stretch**	**Length (km)**	**LAD (m)**	**Bottom Width of Channel (m) with side slope 1 in 5**	**Dredging Quantity (cum)**	**Cost (at Rs. 250/cum)**	**Cost in Cr.**	**Number of Shoals observed (Both Major & Minor)**
1	Lakhipur - Silchar	52	1.6	40 m	894883.26	223720815	22	11
2	Silchar - Badarpur	58	1.6	40 m	1294879.85	323719963	32	17
3	Badarpur to Bhanga	11	1.6	40 m	433341.90	108335475	11	3
	TOTAL	121			2623105.01	655776253	65	31

6.5.6 Selection of dredging equipment

The capital dredging is usually carried out with a cutter-suction dredger whereas maintenance dredging will be carried out with a trailing suction hopper dredger. There. are various types of dredgers available in the market viz., suction dredger, bucket dredger, grab dredger, backhoe / dipper dredger, water injection dredger, pneumatic dredger etc. While most of these dredgers are ideally suit for sea conditions to dredge harbour and approach channels, the selection of a dredger for inland waterway is rather critical due to various mobility factors, seasonal variation of water levels (floods/dry season) and shallow depths.

The cutter suction dredgers having conventional centrifugal pumps or modern jet pumps will be more effective to dredge out the material. In a cutter-suction dredger or CSD, the suction tube has a cutter head at the suction inlet, to loosen the bed and transport it to the suction mouth. The cutter can also be used for hard consolidated type of bed. The dredged soil is usually sucked up by a wear resistant centrifugal pump and discharged through a pipe line or to barge.

Alternately the modern amphibious cutter suction dredger is also suitable for the Barak waterway. The amphibious dredger can be road transportable, able to unload itself from the truck/lorry and can dredge rivers/canals having depths of 2.0 to 3.0 m. These dredgers can walk into the river and even in dry .portions of the river during lean period. The dredgers can also be disassembled for transportation to other locations. These dredgers are indigenously available in India. Specifications of typical dredging equipment suitable to the Barak waterway are indicated below:

- Length overall 20 m
- Width 4.1 m
- Dredging depth 6m
- Suction pipe 325 mm
- Discharge pipe 300 mm
- Installed capacity 350 kw
- Cutter power 50 kw
- H.P 500 BHP
- Draft 1 m
- Rated output with 500 m pipe line 200 cu m / hour

The low draft amphibious dredgers with bucket arrangement to remove the material are also ideally suitable. Specifications of typical amphibious bucket dredger are given below:

- Length overall 9.5 m
- Beam 2.5 m
- Dredging depth 2.75 m over stern
- Draft 0.5 m
- Weight 7.5 MT
- BHP 63 BHP
- Reach 7 m
- Bucket capacity 200 litres.

In the case of bucket dredger, hopper tugs/barges are required to transport the material to disposal grounds. The type of dredging effort (either floating or mobile shore based) will, however, depend on the detailed investigations on the availability of indigenous equipment, disposal area, and environmental impact.

6.6 AIDS TO NAVIGATION

The navigation channel goes on shifting due to changes in river morphology depending on season with untrained river like Barak. On this kind of waterway, one of main problem is safety and ease of traffic. This can be achieved by providing proper marking to indicate where it is safe to navigate and where shallows, snags etc., exist. The channel marking is also very important for the safety and speed of navigation since the current velocity is much lower in the inner bends of a curved channel than the outer bend. If proper markings are provided, ships/vessel sailing upstream will take the inner bends with relatively less head current, thus making better speed. The ship sailing downstream in the outer bend will get the advantage of current. The main approach of the problem of making of shifting nature of navigable channel is to have the simple marks which could be shifted easily with less manpower and equipment.

As per the international convention, the aids to navigation are a device external to a craft, designed to assist in determination of position of the craft or a safe course or to warn of dangers. Whereas, navigational aids are the equipment on board a ship.

6.6.1 Proposed aids to navigation system on river Barak

The system and different type of navigation marks proposed are given as follows:

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

The terms used as left and right shall respectively mean to the left and to the right of an observer facing downstream.

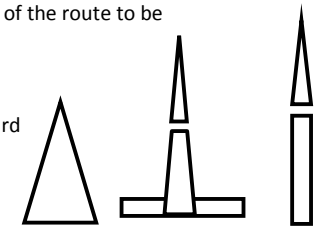
The typical schematic sketches of the aids to navigation/navigational marks proposed to be erected in river Barak can be seen in the following figures.

6.6.2 Navigational Aids Proposed For River Barak

1. Lateral marks: To mark the left and right sides of the route to be

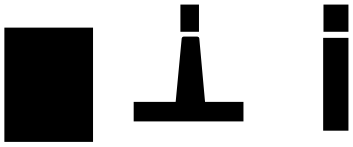
a) Left:

Colour: white
Shape: conical pillar or spar
Top mark: single, white cone, point upward
Light:
Colour: green
Rhythm: single flashing



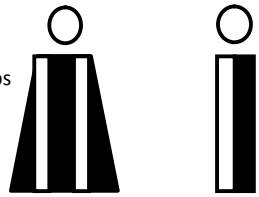
b) Right:

Colour: red
Shape: cylindrical (can) pillar or spar
Top mark: single red cylinder (can)
Light:
Colour: red
Rhythm: single flashing



2. Bifurcation marks:

Colour: red and white vertical strips
Shape: truncated cone, pillar or spar
Top mark: single sphere with red and white vertical strips
Light:
Colour: white
Rhythm: group flashing with three flashes

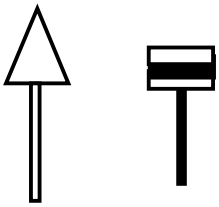


3. Shore marks:

3.1 Bank-wise marks:

Left bank marks:

Colour: white
Shape: post with top mark
Top mark: conical
Light:
Colour: green

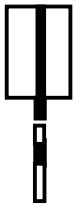


Right bank marks:

Colour: red/white top mark red post
Shape: post with top mark
Top mark: cylindrical
Light:
Colour: red
Rhythm: single flashing

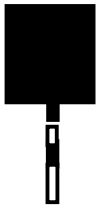
4. Crossing marks:

To indicate crossing & alignment of the channel from one bank another.
Left bank:



Colour: white top mark, black post.
Shape: post with top mark
Top mark: two squares facing upstream & downstream
Light:
Colour: white
Rhythm: Morse code "A"

Right bank:



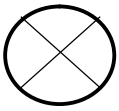
Colour: red top mark, red/white post.
Shape: post with top mark
Top mark: two squares facing upstream & downstream
Light:
Colour: white
Rhythm: Morse code "N"

5. Marks of prohibited areas: To indicate no permission of entry.
Colour: white with red border and slant,
hape: circular
Light:

Colour: green

Rhythm: quick flashing light.

6 Marks on bridges: TO indicated passage through bridges.

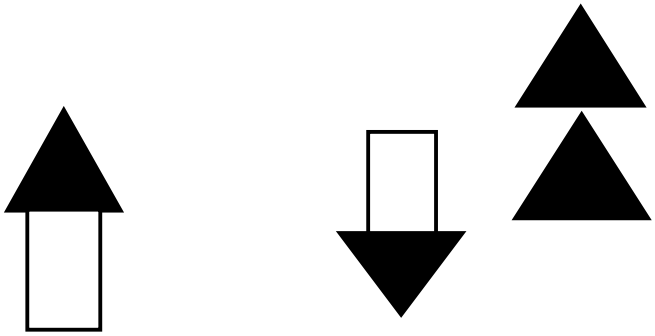


No pass

pass

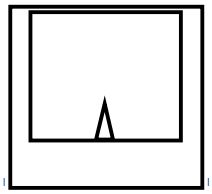
7. Sound signal marks: To indicated use of horning or other sound signal.
Colour: white board with black horn figure.
Shape: hexagon
Light:
Colour: green
Rhythm: quick flashing light.

8. Marks for traffic control: TO up bound or down bound vessels in one way or sequential passage or to prohibit navigations. In one way or sequential passage navigations.



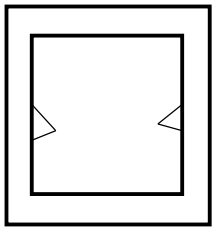
up bound **down bound**

9. Depth indication marks*:*
To indicate the shallow areas or where Depth of water limited



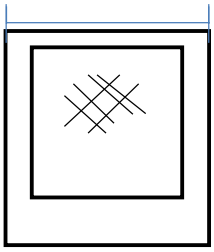
Depth of water limited

10**.** Width indicator marks: TO indicate the areas where the Width of channel Limited



11. River training marks: To indicate the areas where

The river training works
Viz. Bandallling etc.
Are in progress to the navigator.



These aids to navigation are to be provided along the river at various locations as per detail engineering study.

Shoals/sand chars:

The aids to navigation have to be provided at various shoals present in river Barak which creates hazards to safe navigation to vessel/ship plying in the river. The details of some prominent shoals that are encountered during navigation in the navigation channel of river have to be property marked for early warning to the navigator are listed in the Chapter 3.

CHAPTER 7

TERMINAL PLANNING

7.1 MASTER PLAN AND DESIGN OF IWT TERMINAL

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

7.2 PLANNING CONSIDERATIONS

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

(i) Berthing Facilities for vessels

(ii) Cargo Storage Facilities

(iii) Cargo Handling Facilities

(iv) Other ancillary Facilities

7.2.1 Terminal Facilities

The type of cargo handling system required at the terminal is generally dependant on the type of cargo, the annual volume required to be handled and the size of the vessels. The various type of cargo foreseen to be handled at the proposed IWT Terminals are primarily grouped into:

(i) Incoming Cargo, and

(ii) Outgoing Cargo.

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

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

7.2.2 Basic Assumption for IWT Terminal Planning

The following simple basic assumptions were considered for the purpose of IWT terminal planning:

(i) Terminal facilities are planned for the initial traffic projected for base year 2012-13 and shall be expanded in the subsequent development phase upto the planned year 2026-27. System is planned that any additions to the facility will be possible for handling future traffic. Terminal facilities are planned and can be expanded to the ultimate traffic projected for the year 2026-27.

(ii) Based on the water level data analysis, the designed master plan has been considered available for berth operation of 300 days per year.

(iii) Average time required for to and fro movement from anchorage to berth, berthing time and other formalities is considered as 1 to 2 hour per vessel.

(iv) Storage capacities provided at the facility will be adequate to guarantee loading and unloading of cargo during disruption of traffic.

(v) Maximum truck size assumed is 10 Tonnes pay load.

(vi) All bulk cargo which is not affected by weather will be stored in open stock pile.

(vii) The storm water drain proposed at the terminal shall discharge into the river

7.3 IDENTIFICATION OF IWT TERMINALS

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

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

7.3.1 Proposed Terminal Locations

As per the TOR, it was proposed to identify suitable location for construction of IWT Terminal for loading/unloading of cargo at Lakhipur, Silchar and Badarpur. It was evident that CIWTC has been operating terminals at Badarpur and Karimganj. Hence it was decided to develop new terminals at Lakhipur, Silchar and the existing terminals at Badarpur and Karimganj are proposed to be upgraded with modern facilities.

7.3.2 IWT Terminal at Lakhipur

The land identified as per TEFS study report at Lakhipur was at Fullertol Ferryghat. During the site visit and further investigations, it has been observed that the proposed land near Fullertol ferry ghat was occupied with permanent habitations. Hence suitable sites were identified in and around Lakhipur having connectivity to main road. The following 3 lands presented in Table 7.1 were identified at Lakhipur for selecting a suitable site for the proposed IWT Terminal.

Table 7.1 Land identified for Lakhipur IWT Terminal

Sl. No	Location at Barak River	Terminal Locations	Remarks
1	Land identified at Hmarkhawlien upstream of Fullertol Ferryghat. Located 500 m from NH 53. 1 km approx. of katcha road needs to be developed.	Located at Right Bank of Barak River having stable river bank with rock outcrop.	Suitable Land for IWT Terminal. Land is being used by nearby Primary School. Forest cover needs to be removed for jetty and gangway approach. 1.5 km of road needs to be widened which passes through habitation area.
2	Identified at Sapermoyna, downstream of Lakhipur Ferry ghat on the way to Old Silchar Road. Presently land identified is being used for Agricultural purposes. Entire land needs to be acquired from Private Parties. 1 km of new road needs to be developed.	Located at Right Bank of Barak river having stable river bank and water flow. Approx. 3 km away from main Lakhipur – Silchar road junction.	Suitable land for IWT Terminal. Agricultural and Private Land. Entire land area needs to be acquired. 0.5 km of new road needs to be laid and another 3 km of Old Silchar Road required to be widened. This road passes through Lakhipur market area.
3	Identified at Talalgram, 5 km downstream of Lakhipur-Silchar main road junction. Presently the land is used for agriculture. Part of the land is patta land which needs to be procured.	Located at Right bank of barak river. Having stable bank and not having flow throughout the year. Hence, this land may not be useful for IWT terminal planning.	Land is located on concave side of river meandering. Hence, this land is not suitable for locating a terminal.

The Terminal land as per above table is presented in Figure 7.1 to 7.2. The location of land identified at Hmarkhawlien, Lakhipur has been presented in separate location maps attached subsequently in this Chapter for easy reference and identification. Land identified at Hmarkhawlien upstream of Fullertol Ferryghat is recommended for proposed IWT Terminal at Lakhipur considering the proximity to National Highway 53 which connects Imphal, Manipur.

Figure 7.1 View Identified Land for IWT Terminal at Hmarkhawlien, Lakhipur .

Figure 7.2 View of Barak River from Identified Land for IWT Terminal at Hmarkhawlien, Lakhipur

The location of the identified land at Lakhipur for proposed IWT terminal was surveyed and the survey drawing is enclosed as Annexure.

7.3.3 IWT Terminal at Silchar

The land identified for setting up of IWT Terminal at Silchar is under control of Govt. of Mizoram and CIWTC covered godown exists. The area has been surveyed and the feasibility of setting up of a new terminal was studied. Another suitable land was also identified downstream of Masimpur, near Silchar for setting up of IWT Terminal. This land is located 15 km outside of Silchar Town and hence it was not considered. Hence, the land at Silchar under CIWTC name is proposed to be the suitable site for setting up of IWT Terminal.

Lakhipur & Silchar IWT Terminals are proposed to be constructed with the following infrastructure facilities for operation.

(i) Steel Gangway approximately 3 m wide and 50 m in length resting on a floating pontoon. The detailed engineering & design of gangway arrangement shall be carried out during the construction stage. The preliminary layout shown in Annexure drawing is proposed for the DPR purposes only.
(ii) Administration Building and Bank protection arrangement,
(iii) Covered Storage Shed/Transit Shed,
(iv) Open storage area ,
(v) Security Shed,
(vi) Fort lift Trucks(3T capacity), Pay loaders & Dumper tracks, and
(vii) Weight bridge, Watch and ward, Compound wall, Fire fighting arrangement, Electrical & PH Facilities including DG.

7.3.4 Upgrading Badarpur and Karimganj Terminals

As far as Badarpur and Karimganj IWT Terminals, the existing infrastructure facilities available at CIWTC Terminals may be utilised with further expansion/modification plan. The Consultant proposes modification of existing CIWTC Terminal at Badarpur and Karimganj and master plan for all the proposed IWT terminals and prepared and attached as Drawings.

7.3.5 Badapur IWT Terminal

Badarpur IWT Terminal has the following infrastructure facilities for operation. The following components are available at the terminal.

(i) Steel Gangway approximately 2.5 m wide and 30 m in length resting on a floating pontoon
(ii) Administration Building (Admin Building)
(iii) Covered Storage Shed/Transit Shed (1 No)
(iv) Open storage area
(v) Security Shed and Staff quarters
(vi) Shed for crane
(vii) Shed for Electrical & Mechanical Maintenance.
(viii) Service road of approximately 4 m width and 50 m length connecting terminal with NH 44.

Based on the detail survey, it was observed that Badarpur IWT Terminal is well connected with NH 44 - Shillong to Agartala via Badarpur and Karimganj. Further, the Silchar-Badarpur-Lumding broad gauge railway line is planned to be completed by December 2013 and the Badarpur Railway Station shall be declared as full-fledged railway subdivision with all modern facilities under Northeast Frontier Railway.

This railway line branches at Badarpur and proceeding further to Agartala. Hence, Badarpur IWT Terminal can well be developed as a Multi Model Transport Hub having proximity to Rail, Road and IWT modes of Transportation. As per the above discussion, it is proposed to connect the Badarpur IWT terminal with the adjacent railway line.

The proposed upgradation of Badarpur IWT Terminal shall act as a hub for the proposed waterway development in Barak River between Lakhipur and Karimganj stretch. The proposed railway line connectivity to the nearby Badarpur Rail Line and Badarpur Railway station is shown in Figure 7.3.

7.3.6 Upgrading Infrastructure Facilities at Badarpur & Karimganj Terminals

Further to the detailed study, the existing infrastructure at Badarpur Terminal are observed to be not suited for developing a multi model transport hub connecting all modes of transport. Hence, the following facilities are proposed in this report and necessary block cost estimate is considered. Similar facilities are also proposed for upgrading the existing facilities at Karimganj terminal.

(i) Basic facilities for Admin Building including Furniture and Fixures,
(ii) Widening of Approach Pavement connecting NH 44,
(iii) Gangway and Floating Pontoon renovation,
(iv) Renovation of Bank protection and covered shed,
(v) Cranes with 5T capacity(10cycles/hr,18m outreach,
(vi) Fort lift Trucks(3T capacity), Pay loaders & Dumper tracks, and
(vii) Weight bridge, Watch and ward, Compound wall, Fire fighting arrangement, Electrical & PH Facilities including DG.

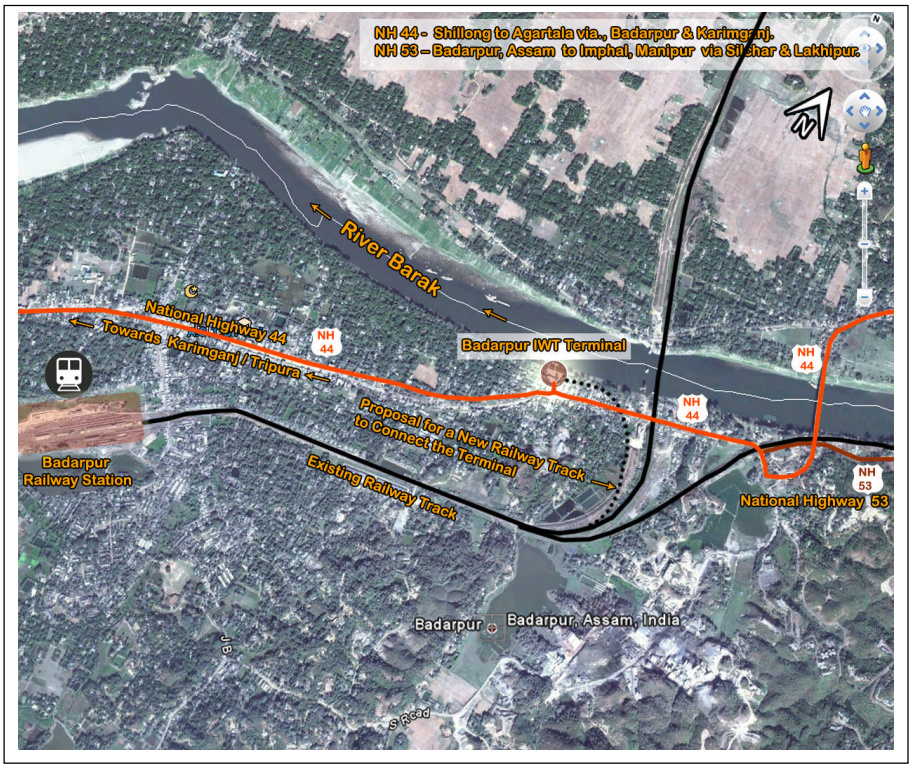


Figure 7.3 Proposed Railway Line Connectivity from Badarpur IWT Terminal

7.4 TERMINAL PLANNING

Based on the above consideration, traffic projections, terminal planning requirements and equipment required for cargo handling, Lakhipur and Silchar IWT terminals have been planned with the following components. The master plan prepared for the proposed Lakhipur IWT Terminal for Land identified as No. 1 and 2 (from Table 7.1) is enclosed herewith as Drawings in the subsequent pages.

7.4.1 Issues in Fixing the Appropriate Level for Approach Gangway

Based on the analysis and observation from the water level data, there is a difference in level of 11 to 12 m compared to the lowest and highest flood levels. This high difference in water levels had yielded a high slope in gangway arrangement which questions the use of gangway arrangement for round the year operation of proposed IWT Ports. Hence, two alternative preliminary options were designed and presented in the drawings.

7.5 PORT INFRASTRUCTURE DESIGN

The terminal has been proposed with suitable mooring facilities, fire fighting water line, water supply pipeline, power line for shore connection to barges, fenders etc. Preliminary planning and master plan are proposed in the DPR stage and further detailed engineering of the various terminal structures including civil and mooring facilities shall be done based on detailed site specific investigation as per the relevant IS codes. It is envisaged and proposed that to the extent possible, all shore/river bank based buildings / godown are prefabricated, pre-engineered type conforming to the best standards in vogue in logistic / supply chain industry.

As per the standards of IWT terminal logistics, the following infrastructure facilities are proposed for the proposed terminal at Lakhipur and Silchar.

(a) Covered godown, and

(b) Ancillary buildings like office + customs station + security area + stores + enclosures for utilities like generator, water supply/firefighting systems, etc., are considered respectively and suitably planned.

The spaces mentioned as (a) and (b) above consist of different units are planned and are shown in Annexure “Drawings”.

The Master Plan and Layout showing the different infrastructure facilities required for proposed IWT Terminal are given in Annexure “Drawings”.

CHAPTER 8

PROJECT COST

8.1 CAPITAL COST

The project cost estimates for development of IWT system including O&M of the system have been worked out. The cost estimates for development of the system are considered as Capital cost while for operation of the system is termed as maintenance or operating cost.

8.2 CAPITAL AND OPERATING COST

The capital costs have been worked out primarily for development of various structures towards construction of Gangway arrangement, ground levelling works, office complex, storage sheds, pavements, public health arrangements, electrical, fire fighting, etc., manufacturing/procurement of new vessels as per the traffic projections and as per the design criteria were considered. Capital dredging has been envisaged during project inception stage since adequate depths are not available for the round the year navigation and the river was silted up over the years. Since siltation is a recurring phenomenon, a provision has been made in the O&M cost towards maintenance of channel. The dredged channel needs to be identified with channel marking for which Aids to navigation has been proposed suitably. Operating cost estimate is essential to run the system developed. The O&M cost of the systems have been considered. Table 8.1 to 8.4 provide Capital Cost of various project components and other section gives O& M staff requirement.

8.3 BASIS OF COST

The basis of cost estimates worked out as per following:

(i) Standard Schedule of Rates 2010-11 of PWD, Govt. of Assam considered for various works;

(ii) Market surveys and enquires

(iii) Judgement based on Consultant's Experience

Table 8.1 Capital Cost for Lakhipur IWT Terminal

Sl.no.	Description	Quantity	Rate (Rs)	Amount (`) (Lakhs)
1	Admin building	1	50	50
2	Pavement including open storage yard, cutting and filling	4000	2000/sqm.	80
3	Approach Jetty & Gangway (size 60 m length with 2.5 m width)	2 nos.	50 Lakhs/gangway	100
4	Floating Pontoon (72 m x 9m)	1	160 Lakhs	160
5	Bank protection	1000 m		100
6	Covered Prefabrication Shed	2000 sqm	2500/sq.m	50
7	Cranes 5T capacity(10cycles/hr,18m outreach	2 Nos	80 lakhs	160
8	Fort lift Trucks(3T capacity)	2 Nos	10 lakhs	20
9	Pay loaders	2 Nos	30 lakhs	60
10	Dumper tracks	2 Nos	30 lakhs	60
11	Weight bridge	1 Nos	15 lakhs	15
12	Watch and ward	3m*3m	9000 /sq.m	1
13	Development of Access road	1.5 km	35 Lakhs/km	105
14	Compound wall	LS	LS	12
15	Land Acquisition	2 Hec.	30 Lak/ha	60
16	Fire fighting arrangement	LS	LS	2
17	Electrical & PH Facilities including DG	LS	LS	15
18	Cost of Detail Engineering	4%		39
19	Construction supervision	8%		78
	Total cost			1132

Table 8.2 Capital Cost for Silchar IWT Terminal

Sl.no.	Description	Quantity	Rate (Rs)	Amount (`) (Lakhs)
1	Admin building	1	50	50
2	Pavement including open storage yard, cutting and filling	4000	2000/sqm.	80
3	Approach Jetty & Gangway (size 60 m length with 2.5 m width)	2 nos.	50 Lakhs/gangway	100
4	Floating Pontoon (72 m x 9m)	1	160 Lakhs	160
5	Bank protection	1000 m		100
6	Covered Prefabrication Shed	2000 sqm	2500/sq.m	50
7	Cranes 5T capacity(10cycles/hr,18m outreach	2 Nos	80 lakhs	160
8	Fort lift Trucks(3T capacity)	2 Nos	10 lakhs	20
9	Pay loaders	2 Nos	30 lakhs	60
10	Dumper tracks	2 Nos	30 lakhs	60
11	Weight bridge	1 Nos	15 lakhs	15
12	Watch and ward	3m*3m	9000 /sq.m	1
13	Widening of Access road	1 km	35 Lakhs/km	35
14	Demolition of existing buildings	LS		50
15	Compound wall	LS	LS	12
16	Land Acquisition	1 Hec.	60 Lak/ha	60
17	Fire fighting arrangement	LS	LS	2
18	Electrical & PH Facilities including DG	LS	LS	15
19	Cost of Detail Engineering	4%		41
20	Construction supervision	8%		81
	Total cost			1152

Table 8.3 Capital Cost for Improvement of Badarpur IWT Terminal

Sl.no.	Description	Quantity	Rate (Rs)	Amount (`) (Lakhs)
1	Basic facilities for Admin Building including Furniture and Fixures, improvement	1	20	20
2	Approach Pavement	LS	LS	20
3	Gangway and Floating Pontoon renovation Renovation	2 nos.	25 Lakhs	25
4	Bank protection	1000 m	LS	100
5	Covered Shed Renovation	LS	LS	2
6	Cranes 5T capacity(10cycles/hr,18m outreach	2 Nos	80 lakhs	160
7	Fort lift Trucks(3T capacity)	2 Nos	10 lakhs	20
8	Pay loaders	2 Nos	30 lakhs	60
9	Dumper tracks	2 Nos	30 lakhs	60
10	Weight bridge	1 Nos	15 lakhs	15
11	Watch and ward	0	0	0
12	Widening of Access road	100 m	10	10
13	Demolition of existing buildings	LS		0
14	Compound wall	LS	LS	12
15	Land Acquisition	LS.		10
16	Fire fighting arrangement	LS	LS	2
17	Electrical & PH Facilities including DG	LS	LS	3
	Total cost			519

Table 8.4 Capital Cost for Improvement of Karimganj IWT Terminal

Sl.no.	Description	Quantity	Rate (Rs)	Amount (`) (Lakhs)
1	Basic facilities for Admin Building including Furniture and Fixures, improvement	1	20	20
2	Approach Pavement	LS	LS	20
3	Gangway and Floating Pontoon renovation	2 nos.	25 Lakhs/each	50
4	Bank protection	1000 m	LS	100
5	Covered Shed Renovation	LS	LS	2
6	Cranes 5T capacity(10cycles/hr,18m outreach	2 Nos	80 lakhs	160
7	Fort lift Trucks(3T capacity)	2 Nos	10 lakhs	20
8	Pay loaders	2 Nos	30 lakhs	60
9	Dumper tracks	2 Nos	30 lakhs	60
10	Weight bridge	1 Nos	15 lakhs	0
11	Watch and ward	0	0	0
12	Widening of Access road	100 m	10	10
13	Demolition of existing buildings	LS	0	0
14	Compound wall	LS	LS	0
15	Land Acquisition	LS.		0
16	Fire fighting arrangement	LS	LS	2
17	Electrical & PH Facilities including DG	LS	LS	3
	Total cost			507

8.3.1 Capital Cost Estimate For Dredging

Fairway Development has been estimated as follows:

Dredging			(Rs in Cr)
Capital dredging @ Rs 250/ cu.m for 26 lakh cu.m		-	65.00
Navigational Aids, 200 Lights at 14,000/ light		-	0.28
Cost of Vessels			
1 Unit of Cutter suction dredger-	1 X Rs. 17.50 Cr	-	17.50
(with tugs and work boats)			
1 Survey Launch	1X Rs.2 Cr	-	2.00
1 Inspection cum multipurpose boat	1 x Rs0.50 cr	-	0.50
	Total	-	85.28 Cr.

8.3.2 Estimate For Annual Maintenance

A) **Dredging**

Considering annual Maintenance Dredging quantity of 10% of capital dredging (say 2.6 Lakhs cu.m)

	(Rs in lakhs)
Running Charges for survey launch @ Rs18 Lakhs per annum	= 18 .00
Running Charges for dredgers @ Rs 51 Lakhs/ CSD	= 51.00
Running charge for inspection boat @ Rs9 Lakhs per annum	= 9.00
Manning Charges @Rs 25 lakhs/ CSD x 1 + @ Rs7 lakhs/ survey launch x 1 + @ Rs 5 Lakhs/ inspection boat x 1	= 37.00
Total	= Say Rs 115 lakhs

B) **Navigational aids**

i) Channel marking

Erection- 200 marks @ Rs.395/- per mark	=	0.79	
Maintenance – 200 x 6 months x Rs.458/	=	5.50	
ii) Night navigation with country boats fitted with lights			
Erection 150 nos x Rs4058/-	=	6.09	
Maintenance 150 nos x 12 months x Rs4058/-	=	73.05	
Total	=	85.43	**Say Rs.86 lakhs**

C) **Terminals.**

@ Rs. 15 lakhs per terminal p.a., the annual maintenance charge for 3 terminals will be Rs. 45 lakhs.

Say Rs 45 lakhs

D) **Office**

Manpower	**= 50.00**	
Office	= 20.00	
Total	70.00	**Say Rs 70 lakhs**

Total O&M Cost = 316 Lakhs/year

Table 8.5 O& M Staff Requirement

Sl. No	Description	Quantity
1	crane operation	2
2	Fort lift truck operator	2
3	Pay loader operator	2
4	Dumper truck operator	2
5	Electrical supervisor	2
6	Weigh bridge operator	2
7	Maintenance staff	
	➢ Mechanical	2
	➢ Electrical	2
	➢ Civil	2
	➢ Skilled	3
	➢ unskilled	3
8	Office staff	
	➢ Terminal manager/Supervisor	1
	➢ Clerical staff	2
9	Security staff	3
	Total	**30**

8.3 TOTAL COST

The total cost of the project was estimated vide capital cost for construction of IWT Terminals, cost towards waterway development and O&M charges taking as 2011-12 as base year.

Table 8.6 Total Estimated Cost at 2012 Price

Sl. No	Item	Description	Cost (in Cr)
1	**Capital Cost**	Development of IWT Terminal at Lakhipur	11.32
		Development of IWT Terminal at Silchar	11.52
		Upgrading existing IWT Terminal at Badarpur	5.17
		Upgrading existing IWT Terminal at Karimganj	5.07
		Dredging & cost of vessels	85.28
		Development of Railway line connectivity to Badarpur Terminal for around 4 km length	5.00
	Total Capital Cost		123.36
2	O&M	Maintenance cost	3.16

8.4 PROPOSED ORGANISATION STRUCTURE OF MAINTENANCE & MANAGEMENT OF BARAK WATERWAY DEVELOPMENT

The proposed development of Barak River waterway between Lakhipur to Bhanga shall be developed and maintained by a separate Project Management Unit (PMU) under the jurisdiction of Director, Inland Waterways Authority of India, Guwahati. The development of this water is planned in two phases and the same is elaborated in the subsequent sections. The proposed PMU organisation structure is presented in Figure 8.1.

8.5 PROJECT SCHEDULE

The time schedule for construction activities of the project is considered as three years. The proposed project schedule is presented below. The capital cost of the project shall be incurred in phases during the construction period and the same is presented in Figure 8.2 and 8.3 as approved by EFC.

8.6 EFC RECOMMENDATION ON PROJECT IMPLEMENTATION

Based on the Draft Final Report submitted for the development of Lakhipur-Bhanga stretch of Barak River for shipping & navigation, EFC recommended the following implementation schedule to develop the waterway in two phases.

Phase-I:

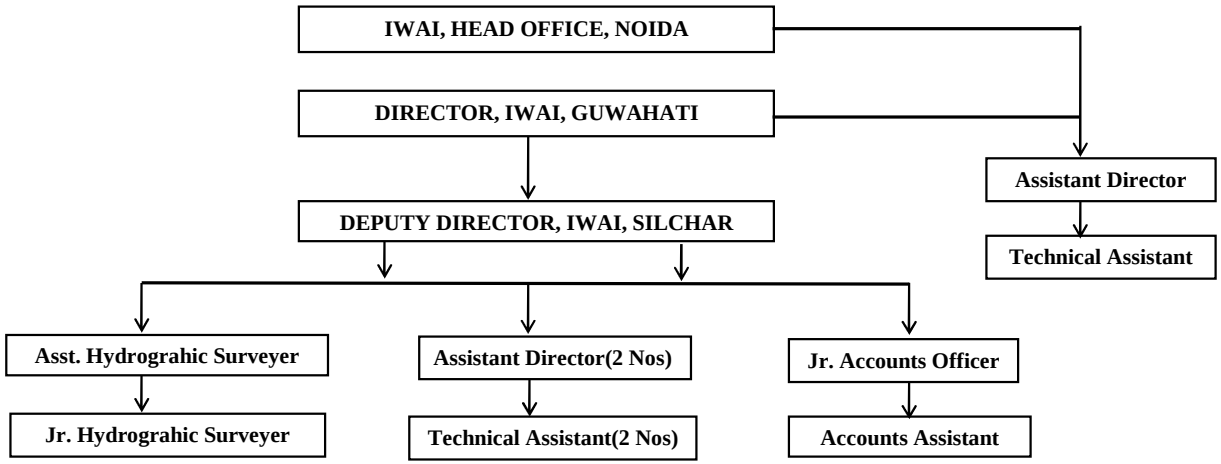
- Development of Bhanga- Silchar (70 km) stretch with upgradation of existing terminals at Karimganj & Badarpur and provision for floating terminal at Silchar.

Phase-II:

- Development of Silchar- Lakhipur (51 km) stretch with setting up of new terminals at Silchar & Lakhipur after making assessment on a realistic basis of the potential of cargo in the upstream stretch.

MANPOWER REQUIREMENT
(Total Number of Posts – 11*)

ORGANISATION STRUCTURE OF PROJECT MONITORING UNIT (PMU)



*Note: 11 Posts to be created and supporting staff to be engaged on contract/outsourcing basis.

Figure 8.1 Organisation Structure of Project Management Unit (PMU)

Sl. No	Activities	1st Year	2nd Year	3rd Year
1	Setting up of PMU Office at Silchar			
2	Fairway Development between Bhanga to Silchar			
(a)	Capital Dredging			
(b)	Procurement of Hardware & Other Equipments			
3	Procurement & Installation of Navigational Aids			
4	Setting up of IWT Terminals			
(a)	Upgrading Karimganj and Badarpur Terminals			
	Railway Connectivity Planning & Land Acquisition			
(b)	Setting up of Floating Terminal at Silchar			
Note: Activity includes captial dredging, navigational aides, construction of terminals, supply of dredger, survey launch, inspection vessel to be completed in 36 months from the date of award of work by PMU followed by Maintenance and Management				

Figure 8.2 Phase I – Implementation Schedule for Development of Barak Waterway

Sl. No	Activities	1st Year	2nd Year
1	Fairway Development between Silchar to Lakhipur		
(a)	Capital Dredging		
(b)	Railway Connectivity to Badarpur Terminal		
2	Procurement & Installation of Navigational Aids		
3	Setting up of IWT Terminals		
(a)	Construction of Silchar Terminal		
(b)	Construction of Lakhipur Terminal		
Note: Activity includes captial dredging, navigational aides, construction of terminals to be completed in 24 months from the date of award of work by PMU followed by Maintenance and Management			

Figure 8.3 Phase II – Implementation Schedule for Development of Barak Waterway

Accordingly, the development cost of implementation for Phase I and II are presented in Table 8.7 and 8.8. The annual maintenance cost and phasing of expenditure is presented in Table 8.9 and 8.10. Based on these revised expenditure phasing, the project implementation schedule is revised and presented.

Table 8.7 Cost of Development in Phase I as per 2012 Price

Sl. No	Capital Works	Rs. In Crores
1	Capital dredging	43.20
2	Vessels	19.00
3	Navigational aids	0.16
4	Miscellaneous	0.40
5	**Terminals**	
	Floating terminal at Silchar	2.00
	Badarpur (upgradation)	5.17
	Karimganj (upgradation)	5.07
	Total	**75.00**

Phase-I proposed to be completed in 3 years

Table 8.8 Cost of Development in Phase II as per 2012 Price

Sl. No	Capital Works	Rs. In Crores
1	Capital dredging	22.37
2	Vessels	NIL
3	Navigational aids	0.12
4	Miscellaneous	NIL
5	**Terminals**	
	Silchar IWT Terminal	9.52
	Lakhipur IWT Terminal	11.32
	Railway connectivity to Badarpur Terminal	5.00
	Total	**48.33**

Phase-II proposed to be completed in 2 years after completion of Phase-I

Table 8.9 Annual Maintenance Cost as per 2012 Price

Sl. No	Description of work	Cost in Rs. Crore
1	Maintenance Dredging	1.15
2	Navigational Aids	0.86
3	Terminals	0.45
4	Manpower & Office	0.70
	Total	**3.16**

Table 8.10 Phasing of Expenditure for Phase - I

Sl. No	YEAR	Rs. Crores
1	**2013-14**	**15.00**
2	**2014-15**	**25.00**
3	**2015-16**	**35.00**
	Total	**75.00**

Balance amount of Rs 48.30 crores will be spend in 2 years after completion of Phase I.

CHAPTER 9

COST BENEFIT ANALYSIS

9.1 INTRODUCTION

The cost benefit analysis and economic analysis is carried out to gauge the viability of the investment on the proposed development of Inland water Transport (IWT) on the identified river stretches duly taking into account the various benefits likely to accrue to the IWT users as well as the different types of stakeholders in the project influence area. Further, in economic analysis project costs and benefits are assessed from the point of view of the economy. This chapter presents methodology inputs and result of economic appraisal as per the base year traffic forecasts during the design life of the project.

9.2 APPROACH AND METHODOLOGY

The inland waterways with all the proposed improvement /development have been be considered for studying the cost and benefit. In this methodology, while the cost of with the project scenario (i.e. capital, replacement, maintenance cost of channel and terminal and capital and operating cost of vessels) represents the project cost. . These project costs and benefits have been worked out for each yea of the project life and discounted to arrive at economical internal rate of return (EIRR). The cost and benefit streams have been worked out for 30 years commencing from the year 2012-13. While the first three year relate to construction period, the remaining 27 year represent project economic life or operating year. In the last year of operation, due credit is given to the residual value of the assets. In case of the economic life of an asset is less than 30 years, its replacement cost is provided in the year in which it is due.

In economic appraisal, all the project costs and benefits are expressed in their economic terms (or in terms cost of resource consumption) rather than financial/market prices which are used in financial appraisal. This is because the market/financial prices of a commodity/services do not reflect their true value to the economy due to market distortions traceable to administered prices, taxes, subsidies, etc. another important factor in economic appraisal is the discount rate (or cut-off rate) used for discounting future economic cost and benefit of the project to their present value. The discount rate

represents opportunity cost of capital in economic appraisal.

9.3 FINANCIAL AND ECONOMIC APPRAISAL

Based on the traffic forecast presented, the following project cost and benefits have been considered for financial and economic appraisal.

9.4 PROJECT COST AND BENEFITS

Various items of project cost for the IWT alternative included incremental expenditure are:

- The development of infrastructure facilities (waterway and terminal) and their operation and maintenance (O&M),
- Acquiring vessels and their annual O&M costs and
- User cost-mainly cost of additional handling and local haulage at both (originating as well as terminating) IWT terminal.

The project benefits comprise the cost of next best alternative foregone (in this case road transport) in case the project is taken up. Details of project costs and benefits are as under.

9.4.1 Project Costs

a) Capital cost

s.no	Cost category	Detailed item of cost
1	**Waterway**	1.1 Land acquisition
		1.2 Dredging and equipment
		1.3 Aids to navigation
2	**Terminal**	2.1 Civil works including land acquisition
		2.2 Mechanical handling facilities
		2.3 Miscellaneous

A summary picture of the capital costs and their phasing for the Barak river stretch considered for financial and economical appraisal.

Table 9.1 Capital cost estimates for IWT development for Barak River

s.no	Name of river	Capital cost (in Cr.)					
		Total cost	2012-13	2013-14	2014-15	2020-21	2025-26
1	Waterway	85.28	35	30	20.28	---	---
2	Terminal	38.08	25	6.73	6.35	---	---
	Total	123.36	60	36.73	26.63	------	---

A summary of the percentage share of capital cost on waterway, terminal and vessel is given in table 9.2

Table 9.2 Percentage composition of capital cost for IWT development for Barak River

waterway	Terminal	Total
69 %	31	100.00%

b) Operating mad maintenance (O&M) costs:

These costs refer to various items of costs that are required for maintenance and operation of the capital assets referred to above. By nature, these costs are recurring in nature and are estimated on annual basis. Major items of the O&M costs are:

- manpower
- repair& maintenance
- fuel& consumables
- over heads

The assumptions and parameter estimates underlying the O&M costs for vessels and terminals are presented cost chapter. Summary estimates of O&M costs are given in table 9.3. As the construction period is 3 years, operating cost will be incurred from 2012-13.

Table 9.3 Summary 0f Estimated O&M Costs

Sl. No	year	O& M Cost/year in Lakh
1	2012-13	316.00
2	2013-14	331.80
3	2014-15	348.39
4	2015-16	365.81
5	2016-17	384.10
6	2017-18	403.30
7	2018-19	423.47
8	2019-20	444.64

9.4.2 Project benefits

The introduction of the IWT will yield tangible and non-tangible saving due to equivalent reduction in road traffic and certain socio-economic benefits. These include saving in road construction and maintenance, vesicle operation costs, travel time and other socio-economic benefits of travel time, better accessibility, better comfort and quantity of life, increase in mobility etc.

The direct and indirect benefits of the project are following

- Reduced road stress.
- Better accessibility to facilities in the influence area.
- Economic stimulation in the micro region of the infrastructure.
- Increased business opportunities.
- Overall increased mobility.
- Facilitating better planning and up-gradation of influence area.
- Saving in vehicle operating costs of buses and other vehicles that are using the existing transport network after the IWT is introducing due to decongestion effect on road stress.
- Saving in time of passenger of existing mode3s, because of reduced congestion on road.
- Saving on account of reduction of vehicular pollution.

For the purpose of the study only saving in vehicle operating cost of moving goods by road vehicles has been considered.

As indicated earlier, the project benefits comprise the total cost of moving the same by next best alternative (i.e. road transport in the present case) in case the IWT is not developed on the identified river stretches. The cost of moving the project IWT traffic by road for normal commodity movement in state highway of two lanes is considered Rs. **2.5/ton per km.** The same cost has been considered for the economic analysis.

9.5 ECONOMIC & FINANCIAL INTERNAL RATE OF RETURN (E& FIRR)

The revenue has been worked out by considering the traffic of commodity movement by IWT as Rupees one per ton per km. The cost and revenue streams of financial analysis are presented in table 9.5. The FIRR for the river stretches of IWT system is worked. This analysis shows that the project is financially viable on the basis of tariff of commodities traffic alone.

Table 9.5 FIRR for IWT for Barak River

S.no	Year	Capital cost (IN LAKHS)	Additional cost (in Lakhs)	O&M expenses (in Lakhs)	Total out flow	Estimated traffic (Lak. Ton)	Revenue generation in IWT (in Lakhs)	Net cash flow (financial)
1	2012-13	6000		316.00	6316.00			-6316.00
2	2013-14	3673		363.40	4036.40			-4036.40
3	2014-15	2663		417.91	3080.91			-3080.91
4	2015-16			480.60	480.60	497741	4977.41	4496.81
5	2016-17			552.69	552.69	522628	5226.28	4673.59
6	2017-18			635.59	635.59	548759	5487.59	4852.00
7	2018-19			730.93	730.93	576197	6553.72	5822.79
8	2019-20			840.57	840.57	605007	6881.40	6040.84
9	2020-21		3000	966.65	3966.65	635257	7225.47	3258.82
10	2021-22			1111.65	1111.65	667020	7586.75	6475.10
11	2022-23			1278.40	1278.40	700371	7966.08	6687.69
12	2023-24			1470.16	1470.16	902307.6	9023.08	7552.92
13	2024-25			1690.68	1690.68	947423	9474.23	7783.55
14	2025-26			1944.28	1944.28	994794	9947.94	8003.66
15	2026-27			2235.92	2235.92	1044534	10445.34	8209.42
16	2027-28		3000	2571.31	5571.31	1096761	10967.61	5396.29
17	2028-29			2957.01	2957.01	1204684.4	12046.84	9089.84
							FIRR	**27.73%**

9.6 ECONOMICAL INTERNAL RATE OF RETURN (EIRR)

Based on the traffic forecasts, estimated project costs and benefits in economic cost terms, cost and benefits streams have been worked out for the entire project life including 3 years of construction period for Barak river stretch. The cash detail of cost and benefit streams of economic analysis is presented in table 9.6. The EIRRs and IRR are theoretically same since the economic benefits are intangible benefits considering the local socio-economic conditions for the Barak river stretch of IWT system.

Table 9.6 EIRR FOR IWT FOR BARAK RIVER

S.no	Year	Capital cost (IN LAKHS)	Additional cost	O&M expenses(in Lakhs)	Estimated traffic (In Lak ton)	Revenue generation in IWT (in Lakhs)	Saving in road transport	Net cash flow (economic)
1	2012-13	6000		316.00				-6316.00
2	2013-14	3673		363.40				-4036.40
3	2014-15	2663		417.91				-3080.91
4	2015-16			480.60	497741	4977.41	2488.70	6985.52
5	2016-17			552.69	522628	5226.28	2613.14	7286.73
6	2017-18			635.59	548759	5487.59	2743.80	7595.80
7	2018-19			730.93	576197	5761.97	2880.99	7912.03
8	2019-20			840.57	605007	6050.07	3025.04	8234.54
9	2020-21		3000	966.65	635257	6352.57	3176.29	5562.21
10	2021-22			1111.65	667020	6670.20	3335.10	8893.66
11	2022-23			1278.40	700371	7003.71	3501.86	9227.17
12	2023-24			1470.16	902308	9023.08	4511.54	12064.46
13	2024-25			1690.68	947423	9474.23	4737.11	12520.67
14	2025-26			1944.28	994794	9947.94	4973.97	12977.63
15	2026-27				1044534	10445.34	5222.67	15668.01
16	2027-28		3000		1096761	10967.61	5483.80	13451.41
17	2028-29				1204684	12046.84	6023.42	18070.27
EIRR								38%

CHAPTER 10

RAPID ENVIRONMENTAL IMPACT ASSESSMENT

10.1 INTRODUCTION

Rapid Environmental Impact Assessment (REIA) is used to determine the type and level of effects an existing facility is having or a proposed project would have on its natural environment. Its objectives include:

(i) To decide if the effects are acceptable or have to be reduced for continuation of the facility or proceeding with the proposed project,

(ii) To design/implement appropriate monitoring, mitigation, and management measures,

(iii) To propose acceptable alternatives, and

(iv) To prepare an Environmental Management Plan (EMP).

The adequacy of an EIA is based on the extent to which the environmental impacts can be identified, evaluated, and mitigated. An EIA is a standard requirement for projects requiring a major change in land use or those which are to be located in environmentally sensitive areas.

Assam is located between 24°08' N - 27°59' N latitude and 89°42' E- 96° 01' E longitude covering an area of 78, 523 km^2. Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya, West Bengal, Bangladesh and Bhutan surround it. The State of Assam consists of 24 districts for administration. The geology has endowed the state with many hills and rivers. These have tremendous influence on the soil quality, drainage pattern, landuse, vegetation pattern, population pattern, culture, etc.

The state can be divided into three distinctive geographic parts. The first one being the long and narrow Brahmaputra valley or Assam valley. The river Brahmaputra flows from East to West for about 700 km within the state and has great role in the land formation, hydrology, ecology, population distribution, culture and economy of the valley and the state. The Barak, another largest river of the state has created the Barak Valley in the southern end of the state. Barail range and Karbi Plateau has separated these two river systems.

Cachar district of Assam is located in the central part of the Barak valley on southern part of Assam. It is bounded by 24° 22' N and 25° 8' N Latitudes and 92° 24' E and 93° 15'E Longitudes and covers an area of 365 km^2.

10.2 GEOLOGY AND GEOGRAPHY

Physiographically, the area consists of hilly terrain surrounded by the border on all sides with bowl shaped synclinal valley elongated towards south. The main river system is Barak River with its tributaries in the North and South. Other tributaries are Madhera, Chiri, Jatinga, Kalain and Seema.

Geologically, the district can be divided into two major groups, i.e. unconsolidated deposits comprising alluvial deposits of Sub-Recent to Recent age and semi-consolidated Tertiary deposits of Bhaban, Bokabil, Girujan/ Tipam, Dupitila and Dihing formations of Miocene to Pliocene age. The alluvial deposits containing in the central parts mainly comprises of sand, silt and clay with gravel and occasional coal bands. The semi-consolidated rocks are exposed in the form of hillocks comprising shale, sandstone, ferruginous sandstone, mottle clay, pebble bed and boulder beds etc.

10.2.1 Geomorphology and Soil Type

The area consists of resistant structural hills in the borders with an elongated valley in the central part. The general trend of the hills is NE-SW. Structural features like hog's back and steep escarpments are commonly present. The valley area comprises of low land with swamps and alluvial flat land. The southern part has number of field depressions and

these are permanent water bodies commonly known as 'beel'.

The soil of the district varies from alluvial to lateritic in nature. Texture is generally clayey loam to clay. The pH ranges from 4.5 to 6.0. The river line tracts are found to be loamy to sandy loamy in nature. The hilly tracts are covered by lateritic soil.

10.3 RAINFALL AND CLIMATE

The district receives heavy annual rainfall of the tune of 3,874.5 mm. The maximum rainfall occurs during monsoon period between May to August. The district experiences a sub-tropical and humid climate. The temperature varies from 12^0 C in winter to 35^0 C in summer. The humidity varies from 32% to maximum of 98% during July and October.

The estimated Annual replenishable ground water resources are 2239.21 Mm^3 against net annual ground water draft of 32.65 Mm^3. The projected demand for domestic and industrial use of ground water upto 2025 is only 52.46 Mm^3. The stage of ground water development in the district is only 2%.

10.4 TOPOGRAPHY

The two major floodplains, viz., Chatla and Shonbeel are in the catchments of Ghagra and Singla rivers, respectively. These rivers are tributaries of River Barak. The topography comprises extensive low-lying areas with numerous small hillocks strewn in between. The human habitations are confined to these hillocks.

10.4.1 Vegetation

The floodplains originally had rich vegetation with Barringtonia acutangula as the dominant species. This tree can withstand prolonged water logging and is a common swamp forest species in this region. Large scale removal of this species was initiated in the 1960-70s and now a few patches remain. The other common trees include Lagerstroemia flosreginae and Vitex spp. Reeds such as Erianthus raveneae and Phragmites karka are also found.

10.5 POPULATION

As per 2001 census, the population of the district is 14,44,921 and the density of population is 382 persons per sq. km. The percentage of literacy is 67.82. As per land record, the district has total cultivable area of 1,175.26 ha. Net area sown is 1,154.89 ha and current fallow is 60.73 ha. The district is much occupied by marshy land.

One of the major ethnic groups in the Barak Valley floodplains, especially Chatla and Shonbeel, are the Kaivartas, a fisher-cultivator community. The property regime in the floodplains is also unique: when it is covered with water in the monsoon, it is treated as a 'Common Property Regime' (CPR) with community fishing rights. However, after the water recedes, the land reverts to a 'Private Property Regime' (PPR) with restoration of individual property rights. The other floodplains are inhabited by a plethora of Hindu and Muslim communities who also earn their livelihood through fishing and agriculture.

10.6 PRIMARY SECTOR

Barak Valley derives its name from River Barak that along with its tributaries drains its 6922 sq. km in area south of the Borail range of mountains in the state of Assam, North East India. The valley comprises the three districts of Cachar, Hailakandi and Karimganj and is bounded by the North Cachar Hills district of Assam and the state of Meghalaya to the north, the state of Manipur and Mizoram to the east and south respectively and the state of Tripura and the Sylhet district of Bangladesh to the west.

The area are under different types of wetlands in the Barak Valley districts of Cachar, Hailakandi and Karimganj. The total wetland area is 13737.5 ha which in turn represents about 14 % of the total natural wetland area in the state of Assam. It may also be seen that seasonally inundated floodplains are the most important type of wetlands in this area. Together they are known to comprise 42.75 % of the total area under floodplain wetlands in the State of Assam, although Barak Valley comprises a mere 8.8 % of the total geographic area of Assam. Thus, these floodplain ecosystems play a significant role in the economy of these three districts in terms of their overriding importance as repositories of fish, as habitats for resident and migratory birds, for storing excess flood water and for supplying irrigation water to nearby fields in the dry season. Chatla in Cachar and Shonbeel in Karimganj district are the two major floodplain wetlands of Barak Valley. While Chatla has an area of around 10 km^2, Shonbeel is the largest floodplain wetland in Assam having an area of 15 km^2. Besides these two, the other important floodplains include the Jabda and Lucca Haors in Cachar, Bakri Haor in Hailakandi and Anair Haor in Karimganj district. The floodplains are locally called Haors or Beels.

10.7 FLOODPLAIN ECONOMY

Barak Valley experiences a subtropical monsoonic climate with an annual rainfall ranging between 2500-3300 mm. About 80-85 % of this rainfall occurs during the months of April/May-September/October. December and January are normally the driest months. Pre-monsoon rains often accompanied by thunder and hail occur in April-May and the monsoon arrives in early June and continues till September, although heavy rains may also occur in October. The seasonal pattern of rainfall and its variations from year to year govern the flood pulse and determine the extent and duration of inundation of the floodplains by the overflowing river waters. These in turn have profound effects on both capture fishery and agriculture in the floodplains. Heavy pre-monsoon rains may cause early floods in April-May when excess river water inundates the floodplains and destroys the ripening summer rice that is harvested in April. For example, between 1996 and 2005, heavy pre-monsoon rains in 1996, 2000 and 2004 inflicted severe damage on the crops, thereby causing economic distress to the farmers. Severe hailstorms during this season can also have adverse effects.

10.7.1 Agriculture

Econony of Karimganj district is agrarian in character with as much as 60% of the active workforce engaged in cultivation. Together with Farming, Livestock, Fishery, Forestry etc, the Primary sector of economy engages a total of 68% of active workforce. But the net area sown at around 35% of the total land area has remained more or less stagnant for years due to low rate of multiple cropping, which again, is the result of poor irrigation facility, even though the district is fed by three perennial rivers, large swamps and watersheds. As a consequence, the productivity is rather low. For example, in 1997-98, winter Rice - the main farm product - registered a productivity of 1,759 Kg/Ha. Sugarcane, areca nut, vegetables etc are also significant farm products. Sugarcane production in 1995-96 was put at 121,355 M.T. while areca nut production was 1,083 M.T. Other cultivated crops are large in variety, but low in quantity having little marketable surplus. Leaving 30% of total land area under forest, the remaining 35% is either barren, fallow or uncultivable wasteland.

The late arrival of the monsoon is during the early June and the rainfall is more or less evenly distributed over July-September, successive flood pulses inundate the floodplains, resulting in the entry of a large number of potamodromous (fishes that migrate from the river to the floodplains) species of fishes, and the consequent boom in fish capture and trade. In contrast, less than average rainfall during July-September, such as that in 2003 and 2005, resulted in reduced fish catch and brought in economic depression. Adequate rains in September-early October is also vital for agriculture, as in the absence of rain, the ground becomes too hard and dry, hampering the sowing of rice seeds in November and the planting of saplings in January. Thus inundation of the floodplain till early or mid-October is necessary for both fishery and agriculture.

Farmers growing summer rice do not use any synthetic fertilizers. They depend on the natural fertility of the soil which gets replenished annually by alluvial deposits brought in by the floodwater. It was also noted that the consumption of NPK in Assam as a whole is very low (6.9 kg/ha) compared to the national average (67.1 kg/ha), and it is still lower in Barak Valley.

From the month of October, water recedes from the floodplains and the land is exposed barring a few depressions where some water is retained till about January. These depressions are often called beels, although this term may be rather loosely used to denote the whole floodplain as well. The cultivable land is now prepared for agriculture- mostly for growing summer or boro rice. Private property rights are now re-established in the floodplain.

However, the major constraint for agriculture is the scarcity of water. In the absence of any irrigation facilities, the farmers face great difficulty in procuring water. Only those plots located in the lowest elevations in the floodplain have easy access to water-filled depressions or small natural water channels that they can impound to obtain water.

Plots in the middle and upper layers of the floodplain suffer from acute water scarcity. Pumping up water from distant sources is both costly and cumbersome and can be afforded by few. Thus a paradoxical situation exists where the lower plots have better access to water but are exposed to a greater risk of inundation by pre-monsoon floods in April that would destroy the crop. In contrast, the middle and upper plots are relatively safe from pre-monsoon floods, but are constrained by the scarcity of water in winter.

The situation has worsened over the years as deforestation in the catchments of the feeder streams and rivers, especially in the hills, has led to soil erosion and deposition of silt in the watercourses that drain the floodplains. The floodplain lakes that used to retain water in the dry season have also become progressively shallower due to silt deposition and/or due to reclamation for agriculture.

Water scarcity has reached such a state that many floodplain farmers, especially those having land in the middle and upper zones, are converting their land into 'semi-natural' fisheries. Fishes enter these impoundments along with floodwater and are trapped inside. They are then allowed to grow through the monsoon. The fishes mostly thrive on natural food in the systems, although some farmers provide some supplementary feeds, and may also release some additional carp fries or fingerlings. These fishes are harvested in the post-monsoon and winter. Thus the farmers are desperately trying to earn their

livelihood by opting for fisheries in place of agriculture. Some farmers in the middle and upper elevations have started growing winter rice, locally called shail or shali, which grows through the monsoon and is harvested in December.

However, they are also totally dependent on good monsoon rains, failing which the plants suffer from water stress during October-November. To cope with this problem, some farmers apply a thin layer of urea in November to enhance maturation of the paddy and try to save the crop.

The absence of effective and sustainable water resource management in the floodplains of Barak Valley has led to the pauperization of the fisher-cultivators in this area. On the one hand, over-fishing has depleted the natural stock and prevented its regeneration, leading to serious decline in fish density and the size of fishes in the catch. To counter this, the fishers have gone on reducing the mesh size of the nets to capture small fishes. This in turn has further depleted the fish stock. On the other hand, agriculture has also suffered due to water scarcity. The impoverished condition of the floodplain farmers is reflected in the low per capita income in Chatla and Shonbeel floodplains.

Many farmers including their family members have started migrating to the nearby cities to find work in construction sites, as rickshaw pullers and as other petty labour. Those who can afford have opted for small trade. It is indeed deplorable that the womenfolk who being proficient in weaving, made fish nets, produced dried fish, and husked rice in a fairly prosperous and largely non-monetized economy, are now compelled to work as manual labours. It may be seen that a large section of the people are still dependent on fishing and farming, although a considerable proportion have gone for wage labour in the dry season instead of farming. However, in the monsoon, they still engage in fishing in the common property fishing area as it is not only a means for livelihood, but integrated into their culture. The situation has been exacerbated by the decrease in landholding size, which is much lower than the Barak Valley average. The productivity of summer rice is also somewhat low, ranging from c 700-1150 kg/ha against a Barak Valley figure of 1180-1970 kg during 1991-2000.

10.7.2 Plantation

Among plantation crops, Tea and Rubber are the major ones with the turnover of the former being 77 Lakh Kg. and the latter, about 1 Lakh Kg. The total land area under 27 tea gardens in the district is about 25,000 Hectares, although only about one-third of this land is under actual tea plantation. Rubber plantation in the district is relatively new and occupies only a fraction of the land under tea plantation. Most of tea and almost whole of the rubber output is exported to other states/countries.

10.7.3 Fishing

Karimganj District has huge potential for fishery, being endowed with a large number of rivers, swamps, ponds and other natural water bodies. There are 49 registered beels covering a total area of 4,420 Hectares and about 23,535 smaller ponds and lakes covering another 3,545 Hectares. Besides, there are 7 river based fisheries in operation. Total Fish production in the district in 1997-98 was 8372.97 M.T. Besides, about 176.338 Million fry and fingerlings were also produced in the same year. In spite of this, the district is far from being self-sufficient in fish production, particularly, owing to the huge consumption of the item. Large quantities of fish is imported from distant states of Uttar Pradesh, Andhra Pradesh and also neighbouring country of Bangladesh.

10.7.4 Farming

Livestock and Poultry occupy an important place in the rural economy and also act as household assets. Cattle, buffalo, goat, sheep, pig etc are the most common livestock animals while hen and duck comprise the poultry birds. However, egg production is very much deficient and therefore imported from other states in large quantity.

10.7.5 Forestry

Timber, Bamboo, Cane, Stone, Sand are the major forest products of the district. The district has about 54 thousand hectares of forest area covering almost 30% of the total

area. The forests are rich in various costly timbers like teak, sundi, gamari etc. Huge quantity of bamboo is harvested and supplied regularly to paper mill in the neighbouring Hailakandi District. However, in the last few years, restrictions have been imposed on cutting of trees to prevent large scale deforestation and as a result, timber production has gone down considerably.

10.8 SECONDARY SECTOR

There is no large or medium scale industry in the district except cement and paper factories. The only sugar mill located at Chargola near Ratabari is closed for more than a year. A number of industries like textiles, polythene etc. set up in the Badarpur Industrial Estates a few years back have mostly closed down due to infra-structural problems. All existing industries in the district are in the small or cottage sector. Tea processing, Food Products, Bamboo & Cane Products, Saw & Plywood, Weaving etc. are the industries comprising the entire Secondary Sector of economy. Cane furniture, mats, decoration pieces manufactured in the cottage industries of Karimganj are supplied to all over India and are in great demand all over.

10.8.1 Oil & Natural Gas exploration

Oil and Natural Gas Corporation (ONGC) has been engaged in exploration works at several drilling sites in the district. There are indications of large reserve of natural gas in the region. Already natural gas is being drilled on commercial basis from one drill site at Adamtilla in Patharkandi Block. A small gas-turbine based power station with an installed capacity of 15 MW has been set up at that location by DLF Corporation to generate and distribute eletricity, which has been functioning for the last 3 years.

10.8.2 Tertiary Sector

The Tertiary Sector of Economy is a key sector constituted by:

- Construction (engaging 2.30% of Active Workforce),
- Trade & Commerce (9%),
- Transport & Communication (3.30%),
- Other Services (11.50%)

10.8.3 Trade & Commerce

As per general Census held in 2001 and 2010, around 9% of the active workforce in Karimganj district is engaged in trade and commerce. Before independence, Karimganj towm was an important centre for trade and commerce in the entire region due to good communication links both by rail and by steamer services through what is now Bangladesh. Direct trade links with Calcutta snapped after partition of the land in 1947 and gradually the importance of Karimganj as a trading centre also lost its glory. The direct rail service was totally stopped and the steamer service continued in a limping manner. Presently the rail link through Badarpur-Lumding-Guwahati-New Jalpaiguri/Siliguri is the only railway link, albeit a very long one, connecting Karimganj to the rest of the country. Similarly, the national highway through Badarpur-Shillong-Guwahati is the only viable road link available. In view of the immense importance of this road link on the entire economy of this region, the road has been considerably improved, making it more stable, wider and fewer landslides prone.

Karimganj has to has to depend on the supply from rest of India for most of the items of daily need, such as food grains, spices, sugar and other food items, textiles & garments, construction materials, automobiles & auto-parts, stationery items and so on. The supply of Kerosene, Petrol, diesel, L.P.G., paper etc comes from other parts of Assam.

Among the export items, tea, bamboo & bamboo products, cane & cane products, forest products like timber & stone, areca nut (betelnut) are the major ones. Internal trade in the district has been seriously hampered by very bad road conditions, border area restrictions on trade, low productivity of agricultural sector, poverty of mass population keeping down demand, low credit disbursement from banks and so on.

However, international trade with Bangladesh has picked up considerably in the recent years and promises to grow further. At present a large number of items like food items, fruits, coal and other products of daily use, mostly sourced from outside the district are exported to Bangladesh through two border points in Karimganj. While Kalibari Ghat on River Kushiara in Karimganj town is utilised for supplying goods by boats and small

steamers, Sutarkandi border point - about 12 Km away from Karimganj Town is extensively used for direct road transportation of export items.

An International Trading Centre and Free Trade Zone in Sutarkandi is proposed to be set up raising great expectations about a new boost to the local economy. Last year, exports worth about Rs. 50 Crores were carried out through Karimganj Border, which resulted in considerable foreign exchange earnings.

According to exporters based in Karimganj, given some diversification of traded goods, a little tax inducements from Government, improvement of roads and other infra-structure, the volume of border trade can go up manifold from its present level. Apart from the current products like coal, foodgrains, spices, sugar, fruits and vegetables etc - which are sourced from outside, many other locally available items like paper, bamboo, stone etc may have large export potential.

10.8.4 Problems and Prospects

The district suffers from lack of infra-structure and poor communication facilities. The main sector of economy - agriculture - is primitive in nature with poor productivity. In the other sectors too, lack of entrepreneurship, low credit-deposit ratio, erratic electricity, unusable roads during monsoon, periodic floods etc. have stifled development.

High population density (457 per Sq.Km in 1991, 475 in 2001) - which is second highest in the entire North-East, puts additional pressure on the limited cultivable land. The problems of transport can be overcome by developing the water ways that shall serve as the crucial route for trade and commerce.

10.9 WATER QUALITY

Minor drinking water supply schemes in most of the Barak Valley floodplains are available, including Chatla and Shonbeel. There are very few borewells and these are

mostly located on the outer fringes, near main roads or markets. Inside the floodplains, people obtain water for drinking and other domestic purposes from river/dugwells. In Chatla and Shonbeel, around 60 and 67 per cent respectively, of these dugwells are in the form of shallow and turbid mud holes, while the rest (40 and 33%, respectively) are paved.

Table 10.1 Location of Water Samples taken in River Barak

S.NO.	LOCATION	LATITUDE	LONGITUDE
1	Lakhipur Bridge	22°47'22.8"N	93°00'51.96"E
2	Kushipur	24°47'36.73"N	92°57'14.14"E
3	Silchar Road Bridge	24°49'50.50"N	92°48'18.19"E
4	Rail bridge east of silchar	24°51'6.05"N	92°46'24.71"E
5	Rani Ghat	24°54'1.94"N	92°42'36.55"E
6	Badarpur	24°52'32.65"N	92°35'0.84"E
7	Banga	24°52'47.17"N	92°30'34.21"E
8	Karimganj	24°52'32.03"N	92°21'43.07"E

Enumeration of faecal coliforms in both borewells and dugwells reveal that only 19.6 % of these drinking water sources have less than 10 faecal coliform CFUs (colony forming units) and may therefore be considered safe to consume. Another 13 per cent have moderate contamination, having 11-100 CFU faecal coliforms. However, 28.3 and 39.1 % of the sources have between 101-1000 and more than 1000 CFU faecal coliforms. Only some of the borewells have low contamination, while all the dugwells sampled are contaminated to varying degrees. As a result of such heavy and widespread contamination, incidences of diarrhea are very common in the floodplain villages. Location of water samples taken in Barak river is shown in Table 10.1 and Table 10.2 shows the water quality parameters observed for the samples collected.

Table 10.2 Water Quality Parameter For River Barak

PHYSICAL								
Sample number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Colour	Silty	Silty / Clear	Silty	Clear	Silty	Clear	Silty	Clear
E.C. (µmhos/cm)	208	171	74	127	0	54	69	147
Odour	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
pH	8.50	8.50	7.22	7.68	6.30	6.85	7.03	7.55
TDS (mg/L)	400	320	205	163	40	68	46	100
Temperature (deg C)	31.7	32.6	26.7	21.8	23.0	18.0	26.0	20.7
Turbidity (NTU)	28.90	6.70	205.0	2.94	1.30	0.20	-	-
CHEMICAL								
Calcium (mg/L)	27.52	39.9	12.54	21.40	0.29	6.28	12.9	14.98
Chloride (mg/L)	16.00	21.08	39.80	11.29	3.02	2.01	8.50	12.78
Carbonate (mg/L)	0.30	2.40	0.03	0.48	0.00	0.00	0.00	1.33
Bi-carbonate (mg/L)	67.99	111.8	35.35	61.68	9.52	41.48	41.48	61.25
Potassium (mg/L)	1.84	4.25	1.06	1.64	0.40	0.60	1.12	4.22
Magnesium (mg/L)	9.29	40.52	5.26	7.87	0.11	0.40	4.65	7.25
Sodium (mg/L)	4.90	8.15	3.65	5.18	0.90	2.80	3.86	7.39
Sulphate (mg/L)	-	-	-	-	-	-	-	-
Amm. nitrogen mg/L	-	-	-	-	-	-	-	-
Nitrite+Nitrate (mg/L)	-	-	-	-	-	-	-	-
Phosphate (mg/L)	-	-	-	-	-	-	-	-
BOD (mg/L)	-	-	-	-	-	-	-	-
COD (mg/L)	-	-	-	-	-	-	-	-
Iron (mg/L)	-	-	-	-	-	-	-	-
Boron (mg/L)	-	-	-	-	-	-	-	-
Flouride (mg/L)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
CHEMICAL INDICES								
Hardness-Ca (as CaCO3/L) (mg/L)	0.00	0.00	-	-	-	-	-	-
Total hardness (as CaCO3/L)	72.63	98.00						
SAR(-)	-	-	-	-	-	-	-	

10.9.1 Biota

River Barak is the second largest river of northeast India. It has a number of tributaries such as Jiri, Chiri, Madhura, Jatinga, Harang and others on its north and Sonai, Ghagra, Katakhal, Dhaleswari, etc. on its south bank. Downstream of Badarpurghat, the river itself bifurcates into two branches, viz., Surma and Kushiara to subsequently flow into Bangladesh and form a part of the Meghna river system.

Enhanced retention of water is also expected to attract migratory birds that earlier used to flock to these areas in large numbers in the winter, but whose numbers have severely declined in the recent years. These include several threatened species such as Baer's Pochard (Aythya baeri), Gadwall (Anas strepera), Bar Headed Goose (Anser indicus), Geylag Goose (Anser anser), Brahminy Duck (Tadorna ferruginea) and others. Besides bringing about biodiversity conservation, this could also open up the prospects for eco-tourism and provide gainful employment to the local people in various ways.

An integrated forest restoration and soil conservation in the hills as well as in the lowlands along with proper management practices in micro-watershed development and land use planning to prevent silt deposition in water courses. Special efforts should be made to restore the Barringtonia acutangula forests in the floodplains in order to enhance water and nutrient retention as well as to attract the potamodromous fishes in larger numbers to the floodplains because of increased allochthonous food resources. In the domestic front, microbiologically safe water could be provided through rainwater harvesting in the rainy season and solar water purification in the dry, sunny days. An impending ecological, economic and socio-cultural crisis in the Barak Valley floodplains can only be averted by well-concerted efforts on several fronts with adoption of measures that should ideally spring from the bottom rather than being imposed from the top.

10.9.2 Molluscs

Benthic macroinvertebrates are common inhabitants of lakes and streams where they are important in moving energy through food webs. These organisms usually inhabit bottom substrates for at least part of their life cycle; and they are large enough to be retained by a mesh size of 200- 500 µm.

A total of 16 (sixteen) taxa were recorded in the eight sampling sites during the period of study. The molluscan community was represented by two classes, viz., Gastropoda and Bivalvia. Gastropoda was represented by two orders, viz., Mesogastropoda and Basommatophora; three families; six genera; and thirteen species. Class Bivalvia also had two orders, viz., Unionida and Veneroidea; two families; and three genera with one species each.

Among the gastropod species, Brotia costula episcopalis (Lea) was the most ubiquitous, being present in 7 of the 8 sampling sites. Bellamya crassa (Benson) and Thiara (Tarebia) granifera (Lamark) also had a fairly wide distribution, as they were recorded at 8 and 7 sites, respectively. On the contrary, Bellamya bengalensis f. typica (Lamark), Paludomus (P) conica kopilliensis Nevill., and Thiara (Thiara) scabra (Mueller) were found in 2 sites, and Brotia (Antimelania) costula (Rafinesque), Paludomus (P) conica (Gray) and Indoplanorbis exustus (Deshayes) in 3 sites only. Between these two extremes, species like Bellamya dissimilies (Mueller) and Paludomus (P) ornatus Benson were recorded in 5 sites each, while those like Thiara (Melanoides) tuberculata (Mueller) and Lymnaea (Pseudosuccinea) acuminate f. typical (Lamark) were present in 4 sites each.

The bivalve fauna was less rich with 3 species only. Of these, Lamellidens marginalis (Lamark) was the most common. The other two species, viz., Parreypsia favidens (Benson) was encountered in 2 sites, while Corbicula striatella Deshayes was recorded in a single site. Among the stenoecoeus species, the gastropod Paludomus (P) conica kopilliensis Nevill was found to be confined to station 1 on river Chiri, a tributary of R. Barak, and station 2 near Kashipur. Till these areas, the river is not much impacted by human interference, at

least in terms of entry of urban sewage.

This perhaps reflects the pollution sensitive nature of this species. Similarly, Corbicula striatella (Deshayes) was found only at station 5 on R. Ghagra. This south bank tributary of R. Barak that forms the extensive Chatla floodplain wetland does not have any major urban centres in its catchment and mainly flows through tea garden areas. It is, therefore, relatively free from the adverse effects of large volumes of untreated sewage. Activities like stone and sand quarrying are also negligible in this area.

The distributional pattern of Bellamya bengalensis f. typica (Lamark) is interesting as it is found in R. Barak at Kashipur, which is a relatively unimpacted site, and in R. Kushiara at Karimganj, which is highly impacted due to the entry of untreated urban sewage, but not in any other site. Similarly, Parreypsia favidens (Benson) was recorded only at station 4, which is on R. Barak near Sadarghat at Silchar, and in R. Ghagra (station 5), which is a relatively undisturbed site.

Thiara (Thiara), scabra (Mueller) was only recorded at station 4 and station 5. It can probably be suggested that this species may be a pollution tolerant one that thrives only at organically enriched stretches of rivers. R. Barak at Silchar near Sadarghat (station 4) harboured a high molluscan diversity in terms of number of taxa. Higher biodiversity in the midstream might have occurred due to a broad meander of the river.

Among the different sites, the diversity of mollusca was found to be low in R. Katakhal as well as R. Barak at Katakhal because of severe and extensive bank erosion which resulted in sedimentation of the river bed adversely affecting the benthic communities. Thus it is obvious that both gastropod and bivalve communities found to inhabit the different sites on R. Barak and its tributaries are represented by a range of species with differential response to habitat degradation.

10.9.3 Flora

Indian flora fluctuates from the Western Himalayan and Assamese, from the species of the Indus Plain to those of the gangetic plain, from the Deccan and Malabari to the vegetation of the Andamans. The floral treasure ranges from the Alpine to the temperate thorn, from the coniferous to the evergreen, from scrubs to deciduous forests, from thick tropical jungles to cool temperate woods.

The Western Himalayan biosphere is bouncy with Chirpine and other conifers deodar, blue pine, spruce, silver fir, and junipers. The Eastern Himalayan region consists of oaks, laurels, maples, rhododendrons, alder, and birch and dwarf willows. The Assam region is full of evergreen forests with lots of bamboo and tall grasses.

10.10 ENVIRONMENTAL IMPACT ASSESSMENT

Generally the development of waterways causes various environmental problems which may have effects on land, water and air. The main activity which would cause the effects are dredging, ship traffic and infrastructure development.

10.10.1 Impact of movement of barges

From the analysis of the projected traffic, it has to be presumed that no hazardous / toxic materials are proposed to be transported. Edible oil to an extent of 12000 tonnes and fertilizer to an extent 21000 tonnes per annum will form part of the cargo and this to be catagorised hazardous material due to its inflammable and poisonous nature. Spillages of oil may occur due to accidents and this would pose a problem from an environmental angle. In the past it has been observed that such spillages have caused on the surface of water which has adversely affected the aquatic and terrestrial ecology of the river. Therefore burning spilled oil will not be the solution for oil removal.

Burning of oil will also cause air pollution problems due to emission of carbon monoxide (CO), sulphur di oxide (SOX), particulate matter, Hydro Carbons (HC) and smoke in the area. Therefore to overcome these problems, skimming boats are recommended and oil removal traps are suggested. Bacterial/ biological method could be tried for oil removal.

The handling of chemicals, cement and other materials may cause water and air pollution problems near the food grains, pulses, coal, edible oil, iron/steel, cement, jute, fertilizers, provisions& household goods, forest products, paper & paper goods, machinery & parts, stone boulders and chips and other miscellaneous commodities.

These materials will be lifted and transported from vessels to storage area manually/ mobile cranes, trucks. It is recommended that these materials should not fall in the water or suspended in the air.

10.10.2 Impacts of dredging on the river environment

In gravel bed rivers there are permanent features which remain stable over a range of flows; for example, pools, riffles, point bars, floodplains and bankside vegetation. Dredging the channel bed with a mechanical digger usually destroys, or at least disrupts, these features, creating a more uniform, less stable and less diverse environment.

The suspended sediment load and turbidity of a river are increased during the removal of bed or bank material and as a consequence other water quality characteristics, such as temperature, are affected. The effects may persist for some distance downstream. Settling out of the material in suspension will alter the composition of the substrate. It has to be noted that in the river Barak there is high amount of suspended material and this may slightly rise. The effect of the rise in suspended material has to be studies in detail. This has to involve studies in water quality for all the four seasons.

Deposition of dredged material on the bankside effectively creates a barrier between the floodplain and the river. In addition, this material may be eroded and washed back into the river if left unconsolidated. So proper protective measures has to be made to secure that there will not be flooding and also subsequently there shall be an effective barrier to prevent the rivers flooding during the monsoons.

The loss and alteration of natural habitats caused by dredging operations can have ecological impacts, in short term. But the flora-fauna studies imply that it will not be the case for long term. It has to be noted that the fishing grounds may get affected due to the movement of barges as the area under fishing now will be used for the barge traffic.

10.10.3 Impacts of dredging on in-stream biota

River Barak is the largest river in north east part of India (length 900 km). The project is 140.25 km from Karimganj to Lakhipur. Most part of the river bed consists of clay and mixed sand and in some stretches rock out crops are visible. As the hydrographic survey revealed available depth from 0.2 to 18.6 m with some stretches of visible rock out crops river conservancy works viz bandalling and dredging have been recommended at this stage.

The dredging of river might cause many effects due to re-suspension of dredged material. These effects are higher concentration of toxic substances in water; reduce available oxygen levels and sunlight penetration. These effects might have further impacts on bathymetry of river, river fisheries, eutrophication and food resources. The dredged material should be disposed off on appropriate sites which have to be identified through field surveys as the part of the river will be dredged at the identified points, the resultant effect on the river water quality will not be significant. In view of the above in order to keep the environment free from pollution by the dredged soil, it is recommended that these soils be disposed off in low lying areas adjoining the river course providing city areas or any other areas without creating environmental degradation.

10.10.4 Fish

Due to the availability of fresh water in river Barak, a number of fish species are found in the river. Part of the river water will be utilized for the purpose in a navigation channel. This channel could not be utilized for fisheries purposes due to vessel traffic. The fish will migrate to other streams. However other portion of the river could be used for fisheries purpose. The navigation would have insignificant effect on fishery development in river Barak.

Apart from the above mentioned, pollution substrate removal will inevitably affect spawning, which takes place in gravel substrates and juvenile fish which inhabit the substrate. Substrate siltation is the settling of fine sediment on to the substrate. This is known to affect the spawning, incubation and emergence of certain fish species. Fine sediment can reduce the suitability of gravels for spawning and as a habitat for young fish by:

- Reducing the inter-gravel flow and therefore the oxygen supply, and increasing the temperature in the gravel
- Infilling the interstitial spaces and thus trapping eggs and young fish;
- Reducing cover and food source for mature fish; females may be prevented from digging and laying eggs.

Increased turbidity reduces light penetration and therefore primary productivity, which has a knock-on effect throughout the food chain. Most fish species will migrate under increased turbidity conditions and many will have a reduced capacity to find and capture prey.

Channel morphology alteration can have a number of impacts on local fish populations:

- Disturbance of bank vegetation or the substrate removes cover and shade; this makes fish more susceptible to predators, and increases light penetration and hence water temperature, which will cause fish to migrate;
- Loss of sites in gravel substrates are usually situated at the upstream end of riffles/downstream end of pools, where there is a downward movement of water;
- Reduction in areas of shelter from high velocity flows.

10.10.5 Macroinvertebrates

Species such as mayflies (Ephemeroptera), caddisflies (Trichoptera) and stoneflies (Plectoptera) are adapted to live in crevices beneath and between stones, particularly in riffle areas. The presence of silt on stones is capable of reducing invertebrate abundances for prolonged periods. The major impacts of siltation are to increase species mortality and to alter community structure by:

- Blocking interstitial spaces, causing oxygen-depletion and hence species mortality;
- Coating stones and thereby reducing the number of attachment points for larvae and reducing their feeding success;
- Allowing alternate benthic species to survive in preference to attachment species;
- Reducing interstitial volume available to invertebrates.
- Suspended sediment and turbidity increases will:
- Reduce primary productivity, thus reducing the amount of energy available to macroinvertebrates and organisms higher up the food chain;
- Tend to induce invertebrate drift, thus reducing instream benthos populations in the dredged reach and possibly also downstream;
- Clog the food filtering and trapping apparatus of stream insects.

There is limited information on the physical habitat requirements of macro invertebrates, but shallower water depth will favour some species due to the associated increase in temperature.

10.10.6 Other wildlife

No forest is destroyed either due to navigation or establishment of port facilities. Reduced primary productivity and reduced invertebrate and fish populations can affect local mammal and bird populations which rely on these sources of food.

Material deposited on the river banks affects the hydrological continuity which exists between the river channel and the floodplain. Dredging may tend to disturb or destroy suitable feeding and nesting sites of birds.

Amphibians may lose habitat diversity and spawning areas, though drying out may also eliminate predatory fish such as pike (Esox lucius).

10.10.7 Vegetation

River wetland plants are able to survive in a range of habitats. Some aquatic plants, such as bladderworts (Utricularia), prefer slow-flowing or stagnant deep water; others, such as narrow-leaved water parsnip (Berula erecta), favour fast-flowing shallow water. On the river banks, species like pendulous sedge (Carex pendula) inhabit the area above the water-level, while others, including small-sweet grass (Glycerine declinata), prefer

submerged conditions. Dredging operations can physically disturb, or remove entirely, any vegetation situated instream or upon the banks. Spraying of herbicides, such as glyphosate, will drastically reduce plant species diversity and, while reducing the number of certain problem species, it can have a knock-on effect upon fauna and other plant life.

10.11 REHABILITATION

There will be some impact on the settlements due to the construction of new terminals with suitable infrastructural facilities. It is estimated that the land required for the major terminals will be of the order of 2.5 hectares. Some acquisition of land may also become necessary, but no serious problems of deforestation or displacement of human dwellings or settlements are anticipated. So also no serious disturbance of the natural habitats for flora and fauna is anticipated.

10.12 ALTERNATIVE APPROACHES AND RECOMMENDATIONS

The impacts of dredging work can be minimised by a number of techniques. Bank stabilisation and cover can be improved at water-level by the placement of temporary log or board overhangs, artificial metal or fibreglass overhangs, tree or brush retards and riprap. These may be used in conjunction with the re-vegetation of deposited material on the bankside. The structures can then be removed when the banks become stable and cover is re-established.

Deposition of dredged material should be away from the channel edge to limit damage to streamside habitats. This also allows a degree of flooding to occur on the floodplain, thereby creating opportunities for wet grassland, scrub/wet woodland, wetlands and seasonally grazed rough grass. Where possible, biotechnical engineering for example geotextiles may be used to help stabilise the material and aid re-colonisation. Other possibilities include: drying and spreading the spoil over adjacent land, which can improve soil fertility in some cases, but may also smother important flora and habitats; excavating a trench and infilling it with spoil, thus minimising disturbance to agriculture and the local environment; dumping off-site is possible but expensive, using spoil to create artificial wetlands.

If rip-rap is used for bank stabilisation, it must extend below the toe of the underwater slope of the bank to prevent undercutting. The structure can also be covered by soil and re-planted to improve habitat diversity and aesthetic value.

Re-creation of morphological diversity can be achieved by re-instating the pool-riffle sequence. This is possible with careful use of instream deflectors and boulders to encourage areas of scour and deposition. Morphological characteristics similar to those prior to excavation should be created, particularly with regard to the substrate

The use of settling ponds and bunds creates a pool of slow-flowing water, allowing sift and sand to settle out. Although this reduces the downstream impacts during dredging works, the dredged reach does not benefit, and there may be further downstream impacts once the bunds are removed.

Disturbance can be minimised if mechanical excavators work from one bank. If the channel is too wide, the digger must work within the channel. Disruption can be minimised by diverting the river down one side of the channel and dredging the other side while it is 'dry. This can be used for the areas where the depth is less and has the prospect to be developed as the main channel for transport. During flood the old channel can also act as flood overflow stream. Smaller plant equipment generally limits the level of impact on bankside and instream habitats.

Selective scrub and vegetation removal is preferable to total clearance. Similarly, sensitive spraying of herbicide can be achieved. The removed vegetation should be stored and replaced on unconsolidated banks, or native species re-planted. This should be timed to allow the vegetation to take root. If the channel margins are left untouched, a small amount of marginal vegetation and undredged bed will allow more rapid recolonisation.

Ultimately, implementation of mitigation techniques involves a trade-off between their lesser impacts and those of a more serious nature arising from dredging within the active channel. All work should be timed to avoid sensitive periods in the life-cycles of instream and riparian flora and fauna. For example, salmonids use gravels for spawning in the autumn, egg incubation in the winter and emergence of young fish in the spring.

There is a dearth of empirical information relating to the effects of dredging operations on Indian rivers. The monitoring of future works would assist in drawing up further management guidelines aimed at reducing environmental impacts. There remains the need for a more strategic, catchment-based and environmentally sensitive approach to river maintenance.

10.13 PROBABLE AREAS OF COMBINED EFFECT DUE TO DEVELOPMENT OF WATER WAYS

- **Upper catchment – pristine**

This picture shows a typical upper catchment stream in a healthy condition. Many of the features (vegetation, rocks, the pool shape and slope) seen in this picture show how a wide variety of animal and plant life (biodiversity) are supported in this type of environment.

It's also a good idea to think about what features resulting from human impacts on our waterways are not present in this picture (for example, vegetation removal, stock access and discharges).

- **Trees**

The amount and location of vegetation (particularly trees) along waterway edges fulfils a number of functions (listed below) which help support other plant and animal life in waterways.

- Root structures provide bank stability (erosion control).
- This in turn improves water clarity due to stable soils not crumbling into the water. Clearer water enables aquatic prey and predators to see, navigate or hide.
- Shade from tree foliage lowers temperatures. High temperatures interfere with oxygen water uptake and the instream temperature range influences animal distribution. For example, if the temperature is too high (greater than 25 °C) then animals become stressed and die.
- Trees provide a habitat for animals living in and around the stream. What places can you see in the picture which would provide a home for these animals?
- Trees can be a food source for animals in and around the stream. For example, the branches lying in the stream.
- Different layers of vegetation at different levels combined with vegetation stability

help prevent weeds, floral plant pests, leaves and debris clogging up the area and affecting native plant growth.

- Decaying matter provides another food source and contributes to the chemical balance of the soil.
- Tree canopies block rain, reducing run-off from surrounding land use.
- Bird life diversity is improved due to birds spreading seeds which increase new growth of native trees and shrubs.
- Areas with a large number of trees also have a beneficial effect on the water cycle, including oxygen release (photosynthesis) and increasing the release/loss of water vapour to the atmosphere as moisture evaporates from tree foliage.

Rocks (substrate)

- Rocks of various sizes provide shade/shelter/protection for fauna.
- Erosion control is created by less mobile instream rocks and large rocks which provide bank stability. Rock composition also influences erosion rate and chemical balance of the water.
- The gaps between rocks provide habitat space and rock variety influences flow patterns in the water (slow, medium, fast), creating a choice of different habitats.
- Exposure to light and atmospheric moisture affects the amount of mosses/liverworts and algal cover present. These organisms are a food source for some of the animals living in and around the stream.

Water flow

- Water flow is affected by the meandering nature of channel – how wide it is and its twists and turns. These channel characteristics offer many different niche options for aquatic life. For example, rapids (riffle), running water areas and calmer pool environments provide a number of different habit options for aquatic fauna.
- Typically streams have V-shaped channels (not visible in these pictures). This influences water speed and the level of stream bank erosion.
- The slope or gradient of the stream determines run off speed (visible as rapids or 'riffles') which enables oxygen uptake in the water.
- Natural high rainfall events. Water coming into and being retained in the upper

catchment influences the time taken for peak water levels to be reached. These water levels also influence the rate at which water subsides further downstream. Poor use of the land (for example, widespread tree removal, inappropriate culvert installation) can lead to increased erosion and flood risks to land and property below.

Other factors

- A large buffer zone between waterway and its surrounding land use provides a good natural filter of nutrients.
- Controlling or eradicating animal pests such as possums, ferrets and stoats helps to establish and maintain populations of mainly ground-dwelling native birds. There is also less risk of diseases being passed on (for example, Bovine Tuberculosis).
- The steep gradient restricts people's access to the upper reaches of the stream, lessening the chance of human activities impacting on the area.

10.13.1 Middle catchment – moderate impact

This picture shows how biodiversity has been affected in some way by human activity which has changed the natural features of the stream (for example, farming). It is important to distinguish these effects from natural processes.

Trees

- Fewer trees around this stream means less shade and a rise in instream temperature. There is also more available light, increasing the growth of algae and other organisms that live attached to underwater surfaces.
- Fewer overhanging trees means less fallen debris for as a food source for animals in and around the stream. The soil's chemical balance is affected and there are few shaded habitat areas.
- The water clarity is slightly less than that of the pristine stream. This is because there is a greater flow of water moving through the channel, stirring up mud and increasing the amount of suspended sediment in the water.
- The rolling hills in the background are an example of how geographical features can increase the chances of runoff with contaminants ultimately ending up in the stream.

- The exotic (non-native) forest in the background demonstrates land uses which aren't 'environmentally' suited to dairy herd or dry stock grazing and represent a quick 'remedy' to land stabilisation (particularly near headwaters).
- A buffer zone showing riparian planting between land use and the water demonstrates the value of blocking nutrients from runoff (particularly Phosphorus which is bound up in sediment). The plants along the banks of the stream take up the nutrients instead outside the instream environment.
- The banks are still stable as the hardy grasses are able to withstand high water levels yet still bind the soil together.

Rocks

- Rocks in this section of the stream are smaller in size in comparison with the pristine catchment, due to natural abrasion. However channel alteration can influence flows which in turn affects the natural erosion rate.
- Most rocks are of similar sizes, limiting the variety of instream habitats.
- The habitat is less stable because smaller rocks are more mobile.

Water Flow

- There is greater water flow in the stream at this catchment level due to other streams flowing into it (tributary contribution). This leads to higher erosive energy along the streambanks, threatening stability.
- Some twists in the stream's path ('meanders') are still apparent, providing variable habitat to animals in fast, slow, deep and shallow flow areas. Discuss how animals also adapt to these conditions, for example, mayflies and stoneflies that thrive in fast flows have flattened bodies.
- Nutrient and sediment runoff into the stream is increased by the number of contributing tributaries within the catchment, particularly by those not protected from runoff themselves.

Other Factors

Note that dairy stock is fenced off from the stream, preventing effluent getting directly into the waterway.

- Waterways which are surrounded by land easily accessed by people can suffer from the effects of related activities. For example, nearby houses, roading, quarrying, water extractions (irrigation), water discharges (treated effluent systems) and the possible introduction of plant and animal pests such as mosquito fish and rats.

10.13.2 Lower catchment – high impact

This last picture shows features common to rivers (not streams) nearing the coast.

- This river contains a large volume of water from all contributing tributaries. High flows can have flooding risks for urban areas nearby. Flooding issues to consider include stopbanks and flood gates.
- The lower land gradient results in water lying around for significant amounts of time. Consider how flooding issues relate to land use considerations.
- This river's water is murkier than that of the other two catchments. This is caused by the change in substrate (mainly sand/silt substrate) which is highly mobile.
- There are less trees and shrubs on the banks, increasing water temperature and instream productivity.
- Inherited problems (from upstream tributaries), for example, sediment load from upstream erosion and high number of discharges to water.
- This picture also highlights the importance of wetland type flora to birds and native fish species.
- Stock exclusion is also depicted and the flatter nature of the land contour has implications for runoff.
- Water velocity and possible tidal (saline) effects may affect river fauna and flora.
- Discuss flood prevention measures (flood gates, spill-ways and stop banks) (not visible in this picture).
- Discuss how native fish migration can be assisted. For example, clear passage throughout the waterway allows fish to get through to the upper catchment while perched culverts hinder them.
- Increased recreational use can affect a river, stirring up sediment and disturbing animals and plants in and around the river area.
- Flow characteristics are very similar – mainly 'run' type flow.

10.13.3 Advantages of the proposed project

Development of inland water transport has to be encouraged considering the comparative advantage over other means of transport. It is an established fact that it requires less power to move an equivalent tonnage on waterways and that a barge has the lowest relative dead weight and minimum functional resistance.

One horse power can move 150kg on road, 500kg on rail and 4000kg on water. A recent study on water transport has established that the fuel consumption per ton km for water transport is 0.0056 liter of HSD and that of rail and road is 0.01 and 0.4 liter respectively. Thus water transport has a clear margin over all other mode of transport in terms of energy consumption and is therefore very efficient in fuel consumption. It has to be appreciated that fuel consumption for water transport will be comparatively less in relation to transport by rail or road. This will mean an overall reduction of pollution apart from being a general economic benefit to the nation. Apart from fuel saving, the air pollution will be reduced significantly in the region due to change in the mode of transportation from surface to water navigation. This will have a positive impact on the quality of air and consequently on the environment.

However certain pollutants such as CO, NOX, HC and SPM emitted from engine exhaust will increase in and around the river. It is therefore proposed to use control devices at the exhaust pipe such as after burners, catalytic converters exhaust gas diluter/ recirculators etc., to avoid air pollution problems from handling of materials appropriate chute are recommended from ship to storage.

10.13.4 Conclusions and recommendations.

Taking into consideration all environmental aspects involved for development of IWT from Karimganj to Lakhipur, there is not much room for any significant negative impact as per the following:

- There would be considerable reduction of pollution from vehicular traffic when inland water transport is developed to take over a major portion of the road traffic.
- There would be considerable savings in cost of fuel foreign exchange in so much as water transport is quite energy saving.
- The conservancy measures required for development of navigation do not cause any permanent changes in the river regime, nor would it interfere with other activities and schemes proposed to achieve other objectives.

CHAPTER-11

CONCLUSION AND RECOMMENDATIONS

11.1 GENERAL

The viability of Island Water Transport project for introduction of navigation on any waterway can be judged by both technically and commercially. The technical viability of the project can be assessed based on availability of discharges to maintain navigable depth in a design channel suitable to ply design vessel. The commercial viability of the project can be gauged based on traffic potential and its growth over the project period and return on investment made besides several others socio-economic benefits such as employment generation, poverty alleviation in rural areas and so on. The recommendation for implementation of the project is based on the trade-off between costs to be incurred and benefits derived.

11.2 STRATEGIC JUSTIFICATION

IWT is an all-weather and reliable mode of transport, which is not only cost effective and environment friendly but also best suited for bulk goods, Over Dimensional Cargo (ODC) and hazardous cargo. The Inland Water Transit and Trade Protocol (IWT&T) Routes connect Karimganj on Barak with Haldia and Kolkatta.

Navigation upstream of Karimganj is not being done on all-year-round-basis, as the river does not have adequate depth. Once the waterway is declared as National Waterway, existing terminals at Karimganj and Badarpur on Barak River can be used effectively and the Barak River can be further developed up to Lakhipur for movement of cargo by IWT mode.

11.2.1 Distance Advantage over Other Modes of Transportation to NE Region

As the proposed stretch is in Assam, its development will cater to the transportation requirement of Manipur, Mizoram, Nagaland, Tripura and Arunachal Pradesh also. The development of river Barak would provide an alternate connectivity to these States, which are dependent on only road/rail connectivity passing through the narrow 'chicken neck' at Siliguri.

Generally between an origin and destination, the river routes have longer length compared to road and rail. However, in case of south Assam and adjoining States of NER, the river distance between Kolkatta and various stations on Barak River through Bangladesh waterways under IWT & T Protocol is less than the rail and road routes which pass through the Chicken Neck bypassing Bangladesh. Comparison of such distances is given below.

Transport Mode	Road (in km)	Rail (in km)	IWT (in km)
From Kolkatta to			
Karimganj	1488	1384	1110
Badarpur	1468	1363	1140
Silchar	1498	1393	1199
Lakhipur	1531	NA	1250

11.2.2 Alternate Mode of Transport

At the moment, transport service is rendered mainly by road and rail transport in the influence zone of the project area. The goods are transported with extreme difficulty/delay due to traffic congestion and longer road routes. The waterway also has a distance advance over rail and road modes. Thus, this development will provide vital alternate mode of transport to this NE region.

11.2.3 Port- hinterland Connectivity

The proposed waterway shall provide port-connectivity to a vast area of north-east through the existing Indo-Bangladesh Protocol Route.

11.2.4 Environment Friendly and Safe Mode

The IWT mode being more fuel efficient and less polluting than road transportation, increase in transportation by this mode shall help in reduced air pollution, noise pollution, besides being safer. It is also best suited for transportation of bulk goods, ODC and hazardous cargo.

11.3 SYNOPSIS OF THE STUDY AND ANALYSIS

The following sections summarize the outcome of studies carried out in technical and financial aspects.

11.3.1 Traffic Study

The traffic survey conducted in hinterland of river Barak have shown that about 12 lakhs tonne of the traffic has been identified for movement in the base year (2012-13) and the projected traffic for the year 2025-26 will be around 30 lakhs tonnes through Lakhipur, Silchar, Badarpur and Karimganj IWT Terminals. Inland Water Transport terminals are recommended at two locations viz, Lakhipur and Silchar and the existing termianls at Badarpur and Karimganj are proposed for upgradation to handle the projected traffic on a more conservative side.

11.3.2 Thalweg Survey & Hydrology Study

The hydrographic survey and hydrological investigation carried out on river Barak for a length of about 121 km from from Lakhipur to Bhanga have revealed that the waterway is feasible for navigation for about 300 days in a year (80% of the days per annum) till Silchar and 240 days till Lakhipur based on the discharge study for the dredged channel. The design channel recommended for development is with LAD of 1.6m, bottom width 40 m which is suitable to ply 300 tons vessel.

11.3.3 Development Cost and Cost-Benefit Analysis

The capital cost for development of the system components of the project viz., development of the design waterway, construction of IWT terminals and procurement of vessels has been worked out as Rs 123.36 crores and the estimated operating cost per annum is Rs 3.16 crores for the base year 2012-13.

The cost benefits analysis and financial internal rate of return (FIRR) on investment have revealed that the returns on the project are encouraging. However, the economic internal rate of return (EIRR) on the project is worked out as 27.73 %. The economic appraisal and the resultant EIRR clearly indicate that investment on development of IWT on Barak River will be economically viable thorough the cut of rate is 12% as set out by the planning commission considering the inherent advantages of IWT mode of transport. ***The results need to be interpreted and used with care especially because of the various non-quantifiable benefits of IWT.***

The consideration of the project for implementation may be viewed from the point to the fact that if investment are made in the development of IWT-a fuel efficient mode, the associated cost of moving the projected traffic volumes by IWT instead of road transport would cost less to the economy thorough the preferred opportunity cost of capital as set out by the Planning Commission, Government of India is 12%, the following advantages of IWT need to be given due weightage while taking appropriate investment

decisions.

- Higher unit capacity per unit fuel consumption of IWT vis-à-vis road.
- Pollution levels created by IWT for moving a unit quantity are much less when compared to road.
- IWT is almost accident free.

Further the Barak waterway can be developed as international waterway since the river also traverse in Bangladesh territory. From this angle, the bilateral trade between India and Bangladesh would be further strengthened for which certain traffic has already been identified and considered in the study. Another important aspect need to be considered is that the Barak River will also become a feeder waterway to National Waterway No.2 once developed.

In the context of ever increasing fuel demand in the transport sector, mainly road transport which is least fuel efficient, there is pressing need to promote fuel efficient modes like IWT and recommend measures to increase its share in the total freight movement. This will go a long way in containing energy demand and saving scarce foreign exchange reserves.

In the light of the above, it is recommended that the Barak waterway should be developed for IWT operations by Inland Waterway Authority of India, the apex body for development of waterway in India. The integrated Barak waterway with National Waterway 2 may further enhance its viability. Given the above, it is recommended that the IWT systems should be taken up for development of local/regional economy as this mode has great potential in terms of employment generation and other socio-economic developments in North Eastern States of India.